This paper summarizes results of subsidence surveys over longwall, shortwall, and room-and-pillar panels in New South Wales, Australia. Underground extraction is related to surface subsidence.

Keyword(s): vertical displacement, horizontal displacement, mine design, coal mining, longwall, shortwall, room-and-pillar

Location(s): Australia

Kapp, W. A. A Study of Mine Subsidence at Two Collieries in the Southern Coalfield, New South Wales. IN: Proceedings, Australasian Institute Mining & Metallurgy, no. 276, December, 1980, p. 1-11.

Urban development to the south of Sydney is approaching areas of current and proposed coal mining. Already some structures and residential areas are affected by mining subsidence. Subsidence resulting from either conventional pillar extraction methods or longwall mining has been monitored for 15 years to enable the characteristics of the surface deformation to be determined. The vertical and horizontal displacements of survey stations on the surface are monitored and the results are used to calculate subsidence, changes in slope of the surface, curvatures along the subsidence profile, and the tensile and compressive strains. These features are in turn related to the underground extraction to give a description of surface subsidence and the development of subsidence with time.

Keyword(s): coal mining, vertical displacement, horizontal displacement, active mines, monitoring methods, time factor, longwall, pillar extraction

Location(s): Australia

Kapp, W. A. Subsidence from Deep Longwall Mining of Coal Overlain by Massive Sandstone Strata. IN: Proceedings, Conference of Australasian Institute Mining & Metallurgy, July, 1981, Sydney, New South Wales, p. 229-246.

Mining is taking place at increasing depths of cover on the Southern Coalfield beneath predominantly massive sandstone strata. Within the next 20 years, there will be longwall mining at depths greater than 600 m. As the Sydney metropolitan area continues to expand and as coal mining approaches these urban areas subsidence will continue to become an increasingly important aspect of coal mining research.

Keyword(s): longwall, coal mining, geologic features, prediction, surface structural damage, land-use planning, pillar extraction, survey methods, vertical displacement, horizontal displacement, pillar strength, monitoring methods, pipelines

Location(s): Australia

Kapp, W. A. A Review of Subsidence Experiences in the Southern Coalfield, New South Wales, Australia. IN: State-of-the-Art of Ground Control in Longwall Mining and Mining Subsidence, September, 1982, Y.P. Chugh and M. Karmis, eds., SME-AIME, p. 167-182.

Coal is being mined from beneath residential areas, structures, bodies of water and other surface features in the coalfields to the north, south and west of Sydney. The particular problems faced by mine operators in these areas vary considerably due to differences in the overlying strata, the variation in the depths of cover and also depend on the number of seams being mined.

Keyword(s): coal mining, surface structural damage, surface water, geologic features, multiple-seam extraction, prediction, empirical model, inflow

Location(s): Australia

Kapp, W. A. Mine Subsidence in the Newcastle District, New South Wales. Transactions Institution of Engineers, Australia, CE27, no. 4, 1985, p. 331-340.

Coal is being mined from seams below urban areas around the City of Newcastle. When subsidence occurs as a result of this mining, homes and other structures can be affected. The massive and strong conglomerates of the Newcastle area have a significant effect on the value of the maximum subsidence, and an empirical method to predict subisdence and strain has been developed. Panel and pillar mining layouts are designed for maximum coal recovery consistent with small values of maximum subsidence. Longwall extraction is now taking place, using empirically established guidelines, beneath the Pacific Ocean, Lake Macquarie, and their shorelines.

Keyword(s): coal mining, prediction, empirical model, survey methods, vertical displacement, horizontal displacement, surface structural damage, geologic features, longwall

Location(s): Australia

Kapp, W. A. Mine Subsidence in New South Wales: Its Effects on Surface Features and Structures. IN: Proceedings, SANGORM Symposium: The Effect of Underground Mining on Surface, Sandton, South Africa, October, 1986, International Society for Rock Mechanics-South African Group, 18 p.

Coal is being mined from beneath residential areas, structures, bodies of water and other features in the coalfields to the north, south and west of Sydney. The mining layout and the local geological setting are the two main factors influencing the nature of ground movements and subsidence. Locally established empirical guidelines assist in the planning of mine layouts in areas where subsidence is an important consideration.

Keyword(s): surface structural damage, coal mining, pillar extraction, surface water, mine design, finite element, mathematical model, modeling, land-use planning, inflow

Location(s): Australia

Kapp, W. A., P. Kennerley. Subsidence and Strata Control Under Stored Waters in the Southern Coalfield, New South Wales. IN: Proceedings, Symposium on Ground Movement and Control Related to Coal Mining, Illawarra, Australia, August, 1986, N.I. Aziz, ed., Australasian Institute of Mining and Metallurgy, p. 341-351.

Valuable coal reserves in the Southern Coalfield lie beneath stored waters. A study was made of two different mining methods, bord-and-pillar and pillar extraction, for use under stored waters within the limits specified by the NSW Dam Safety Committee. Pillar monitoring and mathematical modeling approaches demonstrate that recovery of coal using these layouts can be improved above that specified, without affecting long-term stability of the surface structures.

Keyword(s): coal mining, surface water, room-and-pillar, pillar extraction, monitoring methods, modeling, mathematical model, active mines

Location(s): Australia

Karfakis, M. G. Mechanisms of Chimney Subsidence Over Abandoned Coal Mines. IN: Proceedings, 6th International Conference on Ground Control in Mining, June 9-11, 1987, S.S. Peng, ed., Department of Mining Engineering, West Virginia University, Morgantown, p. 195-203.

Chimney subsidence is defined, and the factors controlling the development of subsidence sinkholes are identified. The mechanisms involved in chimney development and means of early identification of impending chimney subisdence are discussed.

Keyword(s): abandoned mines, surface structural damage, coal mining, roof stability

Location(s): Pennsylvania, Wyoming, North Dakota, Illinois, Colorado, Appalachian Coal Region, Illinois Coal Basin, Rocky Mountain Coal Region, United States

Karfakis, M. G., G. Beach, J. C. Case. Subsidence Problems in Wyoming and Their Social Impact. IN: Proceedings National Symposium on Mining, Hydrology, Sedimentology and Reclamation, December 7-11, 1987, Springfield, IL. University of Kentucky, Lexington, p. 209-215.

The paper gives a brief background on the geology of the Wyoming mining districts and on the mining method used. Subsidence characteristics, types, possible mechanisms and factors are discussed. The potential socio-economic impacts on communities are presented. Subsidence occurrences in various locations are reviewed. Past, present and future subsidence mitigation projects are outlined. Future needs of subsidence prone areas, such as prediction, risk evaluation, and monitoring are assessed.

Keyword(s): abandoned mines, coal mining, surface structural damage, land-use planning, land mitigation, historical, hydraulic backfilling, grouting

Location(s): Wyoming, Rocky Mountain Coal Region, United States

Karfakis, M., S. Barnard, J. Murphy. Subsidence Abatement Projects in Wyoming--An Overview. IN: Conference on Mine Induced Subsidence: Effects on Engineered Structures, Nashville, TN, May 11, 1988, ASCE Geotechnical Special Publication No. 19, p. 33-52.

Abatement projects were undertaken to prevent or minimize further subsidence in Wyoming communities. The paper gives a brief historical background on local mining activity. Subsidence characteristics and occurrences in various communities are presented. Locations of key abatement projects and reasons for their selection is given. Selection criterion for backfilling and grouting methods and the techniques themselves are presented. Problems encountered are discussed. Successful projects are analyzed. Recommendations for future projects are given.

Keyword(s): hydraulic backfilling, grouting, abandoned mines, coal mining, engineering, land mitigation, reclamation

Location(s): Wyoming, Rocky Mountain Coal Region, United States

Karfakis, M. G., K. D. Basham, B. A. Suprenant, W. L. Johnson. Specifications and Recommendations for Residential Construction Subject to Ground Movements Related to Mine Subsidence. Report to Department of Environmental Quality by University of Wyoming, Mining Engineering, 1988, contract no. 5/38781.

This document is intended as a simplified guide to help contractors, building inspectors, city officials, and homeowners. The purpose is to provide guidelines, principles, criteria, and recommendations that will enable the architectural engineering and construction professions to design and construct buildings to minimize damage due to ground movements related to mine subsidence.

Keyword(s): insurance, surface structural damage, construction, foundations, utilities, abandoned mines

Location(s): Wyoming, Rocky Mountain Coal Region, United States

Karfakis, M. G., E. Topuz. Mechanism of Residual Subsidence Triggered by Post-Abandonment Flooding. IN: Mine Subsidence - Prediction and Control, National Symposium, 33rd Annual Meeting of the Association of Engineering Geologists, October 2-3, 1990, C.D. Elifrits, ed., Pittsburgh, PA, p. 21-25.

Residual subsidence is a major concern over abandoned mine lands. The risk and duration of residual subsidence is of particular importance from the standpoint of damage to structures built after the mine has been abandoned, especially in cases where the surface land is believed to be stabilized. This paper presents an analytical evaluation of the interaction of various factors contributing to subsidence and includes the effects of water on the geotechnical properties of mine rocks.

Keyword(s): abandoned mines, surface structural damage, subsurface water, coal mining, pillar strength, overburden, geotechnical

Location(s): United States

Karfakis, M. G., E. Topuz. Post Mining Subsidence Abatements in Wyoming Abandoned Coal Mines. Mining Science and Technology, v. 12, no. 3, May, 1991, p. 215-231.

Coal has been mined continuously in Wyoming since 1865. Nearly all the coal produced in the first 90 years of mining was from underground bituminous mines. Subsidence has been a threat in Wyoming since the beginning of coal mining, constituting an extreme danger to public health, safety, and property. As a consequence, Wyoming mine subsidence problems qualify for the highest priority of funding under the Surface Mine Control Reclamation Act of 1977.

Keyword(s): abandoned mines, coal mining, bituminous, hydraulic backfilling, grouting, historical, room-and-pillar, pillar extraction, land-use planning

Location(s): Wyoming, Rocky Mountain Coal Region, United States

Karlsrud, K., L. Sander. Subsidence Problems Caused by Rock-Tunnelling in Oslo. IN: Evaluation and Prediction of Subsidence, Proceedings International Conference, Pensacola Beach, FL, January, 1978, S.K. Saxena, ed., ASCE, New York, 1979, p. 197-213.

A new railroad tunnel connecting the east and west bound lines out of the city of Oslo is presently under construction. One part of this tunnel goes through bedrock at a depth of 20 to 40 meters below ground surface. Above and along the tunnel, there are a number of clay filled depressions in the bedrock. Past experience has shown that leakage in connection with tunnels or excavations very easily can cause reduction of pore water pressures in a relatively thin sandy layer normally found at the bottom of these depressions and thus cause consolidation (subsidence) of the clay layer.

Keyword(s): surface subsidence damage, subsurface subsidence damage, tunnelling, geologic features

Location(s): Norway

Karmis, M., C. Haycocks, I. Eitani, B. Webb. A Study of Longwall Subsidence in the Appalachian Coal Region Using Field Measurements and Computer Modeling Techniques. IN: Proceedings 1st Conference on Ground Control in Mining, July 27-29, 1981, S.S. Peng, ed., West Virginia University, Morgantown, p. 220-229.

This paper describes the use of field measurements and computer-modeling techniques to develop basic relationships between longwall subsidence and related parameters. It summarizes subsidence trends of the Appalachian Coal Region, with a brief reference to the zone-area method of prediction.

Keyword(s): vertical displacement, horizontal displacement, survey data processing, longwall, computer, ground control, prediction, modeling, survey methods, zone area, coal mining

Location(s): Appalachian Coal Region, United States

Karmis, M., G. Goodman, C. Haycocks, I. Eitani. Computer Modeling of Mining Subsidence Using the Zone Area Method. IN: Proceedings, 22nd U.S. Symposium on Rock Mechanics, Cambridge, MA, June 29-July 2, 1981, Massachusetts Institute Technology, Cambridge, p. 272-277.

Keyword(s): rock mechanics, computer, zone area, modeling
Location(s): United States

Karmis, M., G. Goodman, C. Haycocks, T. Triplett. The Development and Testing of a Regionalized Subsidence Prediction Model. IN: Proceedings, 17th International Symposium on Computer Applications in the Mining Industry, Denver, CO, April 19-23, 1982, p. 240-252.
Keyword(s): computer, prediction, modeling
Location(s): United States

Karmis, M., C. Haycocks, B. Webb, T. Triplett. Potential of the Zone Area Method for Mining Subsidence in the Appalachian Coalfield. IN: Proceedings, Workshop on Surface Subsidence Due to Underground Mining, Morgantown, WV, November 30-December 2, 1981, S.S. Peng and M. Harthill, eds., Department of Mining Engineering, West Virginia University, 1982, p. 48-59.
This paper deals with the development and testing of a subsidence prediction model, based on the zone area method. The latter technique is a refined development of the influence function and is well suited for computer analysis. Furthermore, such modeling is capable of handling uniform as well as non-uniform extraction patterns and can facilitate both longwall and room-and-pillar mining systems. In addition, since the objective of this study was to develop regional subsidence trends, a comprehensive subsidence data bank is being established for the Appalachian coalfield, which includes published as well as unpublished information on subsidence measurements.
Keyword(s): zone area, coal mining, modeling, influence function, prediction, longwall, room-and-pillar
Location(s): Appalachian Coal Region, United States

Karmis, M., C. Haycocks. Computer Simulation of Mining Subsidence Using the Zone Area Method. Department Mining and Mineral Engineering, Virginia Polytechnic Institute and State University, March, 1983, 62 p.
This report presents a zone area method computer program designed to predict a complete subsidence profile for seam gradients up to 20 degrees. It describes the method and how the program was developed to use it for both longwall and room-and-pillar mining operations.
Keyword(s): vertical displacement, zone area, computer, prediction, longwall, room-and-pillar, modeling
Location(s): Appalachian Coal Region, Illinois Coal Basin, Rocky Mountain Coal Region, United States

Karmis, M., T. Triplett, C. Haycocks, G. Goodman. Mining Subsidence and its Prediction in the Appalachian Coalfield. IN: Proceedings, 24th U.S. Symposium on Rock Mechanics, Texas A & M University, June 20-23, 1983, p. 665-675.
Keyword(s): prediction, coal mining, rock mechanics
Location(s): Appalachian Coal Region, United States

Karmis, M., C. Haycocks, T. Triplett. Ground Settlement and Deformation Characteristics Above Undermined Areas--Experiences from the Eastern U.S. Coalfields. IN: Proceedings 4th Australia-New Zealand Conference on Geomechanics, Perth, Australia, May 14-18, 1984, p. 647-653.
Keyword(s): coal mining, overburden
Location(s): Appalachian Coal Region, United States

Karmis, M., T. Triplett, P. Schilizzi. Recent Developments in Subsidence Prediction and Control for the Eastern U.S. Coalfields. IN: Rock Mechanics in Productivity and Protection, Proceedings 25th U.S. Symposium on Rock Mechanics, Northwestern University, Evanston, IL, June 25-27, 1984, C.H. Dowding and M.M. Singh, eds., SME-AIME, New York, p. 713-721.
This paper presents a summary of the major findings derived from a substantial research effort on mining subsidence carried out, during the past few years, in the southern Appalachian coalfield. The research program encompassed the following major tasks: identification of the most significant factors influencing ground movements above mined openings, collection of subsidence case studies for the southern Appalachian coalfield, development of subsidence and strain prediction techniques for that region, and initiation of a subsidence monitoring program in southwestern Virginia.
Keyword(s): prediction, ground control, coal mining, active mines, rock mechanics
Location(s): Virginia, Appalachian Coal Region, United States

Karmis, M., G. Goodman, G. Hasenfus. Subsidence Prediction Techniques for Longwall and Room and Pillar Panels in Appalachia. IN: Proceedings, 2nd International Conference on Stability in Underground Mining, AIME and University of Kentucky, August 6-8, 1984, p. 541-553.

Keyword(s): prediction, longwall, room-and-pillar, active mines, coal mining

Location(s): Appalachian Coal Region, United States

Karmis, M., P. Schillizzi. Development of a Subsidence Monitoring Program for the Southern Appalachian Coalfield. IN: Ground Movements and Structures, Proceedings 3rd International Conference, University of Wales Institute of Science and Technology, Cardiff, July 1984, J.D. Geddes, ed., Pentech Press, London, 1985, p. 223-239.

The growing recognition of mining subsidence and its associated effects has provoked numerous investigations into the analysis, prediction, and modeling of this phenomenon, using theoretical as well as empirical techniques. However, a careful review of the most prevalent of these techniques demonstrated clearly that such subsidence studies do not describe satisfactorily the type and magnitude of the ground movements experienced in the Appalachian coalfield. The characteristic topographic conditions, the complex lithologic and structural geologic environment, and the local mining methods have all greatly contributed to the rather distinctive subsidence trends encountered in that region. Consequently, to meet the need for representative and accurate subsidence and strain prediction methods, the development of empirical ground deformation models was attempted for the Appalachian region. This task was based on a comprehensive analysis of existing case studies as well as on a detailed and complete subsidence monitoring program.

Keyword(s): survey equipment, survey methods, monitoring methods, monitoring methods, coal mining, active mines, prediction, empirical model, longwall, room-and-pillar

Location(s): Virginia, Appalachian Coal Region, United States

Karmis, M., P. Schilizzi, A. Jarosz. The Development of Ground Subsidence Above Underground Coal Mines in the Appalachian Coalfield and its Prediction Using Empirical Techniques. IN: Proceedings, 2nd Conference on Ground Control Problems in the Illinois Coal Basin, May 1985, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 127-137.

In the past years numerous investigations have been undertaken for the modeling and prediction of surface subsidence, using theoretical as well as empirical techniques. A review of the most prevalent of these techniques demonstrated clearly that such subsidence studies do not describe satisfactorily the type and magnitude of the ground movements experienced in the Appalachian coalfield. To develop a subsidence prediction method applicable to the topographic conditions and the complex lithologic and structural geological environment of coalfields in the eastern United States, a systematic surface movement monitoring program was initiated. This was conducted in Virginia over eight underground coal mines and included seventeen panels.

Keyword(s): coal mining, prediction, empirical model, monitoring equipment, monitoring methods, monitoring design, pillar extraction, room-and-pillar, National Coal Board, influence function

Location(s): Virginia, Appalachian Coal Region, United States

Karmis, M., P. Schilizzi, A. Jarosz. Development and Comparison of Subsidence Prediction Methods for the Eastern U.S. Coalfields. IN: Mine Subsidence, Society of Mining Engineers Fall Meeting, St. Louis, MO, September, 1986, M.M. Singh, ed., SME, Littleton, CO, p. 9-18.

This paper is concerned with subsidence prediction methods and in particular with two techniques, one based on profile functions and the other on influence functions. Profile function methods provide a tool for fast calculation of subsidence on a line across a mine panel. Influence function methods, on the other hand, allow for a more detailed calculation of ground movements, in any mode and at any depth, on a grid or at any specific point.

Keyword(s): coal mining, prediction, profile function, influence function, prediction theories, computer, empirical model, room-and-pillar, longwall

Location(s): Appalachian Coal Region, United States

Karmis, M., A. Jarosz, P. Schillizzi. Monitoring and Prediction of Ground Movements Above Underground Mines in the Eastern US. IN: Proceedings, 6th International Conference on Ground Control in Mining, 1987, S.S. Peng, ed., Department of Mining Engineering, West Virginia University, Morgantown, p. 184-194.

Surface deformations above underground mines and their prediction and control have been the topics of an extensive research effort by Virginia Polytechnic Institute and State University over the past few years. During the initial stages of this research, a number of case studies were collected from the literature, the mining industry, and various government and state agencies. Based on the analysis of this information, appropriate proediction methods were proposed. Although the prediction methods were based on sound concepts, it became evident that their accuracy and implementation were a reflection of the size and quality of the collected case studies and that the data bank was insufficient. In an effort to alleviate these problems, a comprehensive monitoring program was initiated in the coal mines of southwest Virginia.

Keyword(s): monitoring methods, prediction, longwall, room-and-pillar, monitoring design, monitoring equipment, vertical displacement, horizontal displacement, profile function, influence function, zone area, high-extraction retreat, computer

Location(s): Virginia, Appalachian Coal Region, United States

Karmis, M. Predicting Subsidence with a Computer. Coal, December, 1989, p. 54-61.

The prediction of ground movements due to underground mining, the assessment of their impact on surface structures, and their control within acceptable environmental levels are all important considerations during the mine design process. Recent progress in subsidence technology in the United States, particularly that due to an intensive effort in the collection and monitoring of case studies involving subsidence in the coalfields of the eastern United States, has been manifested in the development of some unique capabilities, including the establishment of sound empirical parameters from an extensive data bank. Evaluation of these field data has resulted in the development and validation of subsidence prediction methods, and the incorporation of regional geological as well as mining factors in subsidence predictions.

Keyword(s): prediction, computer, modeling

Location(s): Appalachian Coal Region, United States

Karmis, M., Z. Yu, A. Jarosz. Design Considerations for Subsidence Control. International Journal of Mining and Geological Engineering, v. 8, no. 4, December 1990, p. 357-368.

Procedures for subsidence planning during the mine design stage are presented. The Surface Deformation Prediction System (SDPS) incorporates three different subsidence prediction methods, based on the concepts of the influence function, profile function, and zone area methods. Data from the SDPS are used in the Subsidence Response Modelling Program (SRMP), a large displacement, small strain, nonlinear finite element code, to determine damage levels to surface structures resulting from subsidence. An example is presented of use of the SDPS and SRMP in subsidence design and control.

Keyword(s): modeling, prediction, influence function, profile function, zone area, finite element, surface structural damage, coal mining, mine design, active mines, land-use planning

Karmis, M., Z. Agioutantis, A. Jarosz. Recent Developments in the Application of the Influence Function Method for Ground Movement Predictions in the U.S. Mining Science and Technology, v. 10, no. 3, May, 1990, p. 233-245.

The influence function method was applied to calculate ground deformations caused by underground mining. Empirical subsidence parameters have been developed to facilitate the application of the method to various mining and geological conditions, although site-specific parameters can also be used. Comparisons between measured and predicted subsidence and strain values are presented for different case studies, and demonstrate the applicability of the influence function formulation for predicting surface deformations.

Keyword(s): prediction, influence function, coal mining, horizontal displacement, vertical displacement, geologic features

Location(s): Appalachian Coal Region, United States

Karmis, M., C. Haycocks, Z. Agioutantis. The Prediction of Ground Movements Caused by Mining. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, Morgantown, WV, S.S. Peng, ed., p. 1-9.

This paper reviews the fundamental concepts involved in the development, application, and validation of ground movement prediction methods developed by Virginia Polytechnic Institute and State University. Prediction techniques include empirical or semi-empirical methods, such as the profile function, influence function, and zone area methods, as well as numerical methods, based on a finite element formulation that uses field subsidence data. These techniques have been integrated in a software package for personal computers, which allows for the calculation of any component of ground movement in any direction.

Keyword(s): prediction, computer, prediction theories, empirical model, profile function, influence function, zone area, finite element, modeling, survey data processing, vertical displacement, horizontal displacement, longwall, room-and-pillar

Location(s): Appalachian Coal Region, United States

Karmis, N., C. Y. Chen, D. E. Jones, T. Triplett. Some Aspects of Mining Subsidence and its Control in the US Coalfields. Minerals and the Environment, v. 4, December, 1982, p. 116-130.

This article discusses the influence of geological controls on subsidence, and the effects of subsidence on humans and their environment. A historical review of rules and regulations governing subsidence-related problems is given.

Keyword(s): historical, law, environment, vertical displacement, horizontal displacement, coal mining

Location(s): Pennsylvania, Appalachian Coal Region, United States

Kauffman, P. W., S. A. Hawkins, R. R. Thompson. Room and Pillar Retreat Mining--A Manual for the Coal Industry. U.S. Bureau of Mines IC 8849, 1981, 228 p.

Keyword(s): room-and-pillar, mine design, mine operation, high-extraction retreat, active mines, coal mining

Location(s): United States

Kawulok, M. Investigation of a Precast Concrete Panel Structure Subjected to Mining Subsidence. IN: Large Ground Movements and Structures, Proceedings International Conference, University of Wales Institute of Science and Technology, Cardiff, 1977, J.D. Geddes, ed., John Wiley & Sons, New York, 1978, p. 606-620.

This paper describes an investigation of the influence of ground deformation caused by coal extraction on a block of flats near Katowice in the Upper Silesian Coal Basin. Information on deformation of the ground surface, and on deformation and accompanying stresses in some typical constructional elements of the building is presented on the basis of the obtained results. The paper concludes with a suggested method to interpret the results.

Keyword(s): surface structural damage, coal mining, foundations, construction, active mines, monitoring methods

Location(s): Poland

Kawulok, M. The State of Stress in a Building Constructed of Large Precast Wall Panels Subjected to Mining Subsidence. IN: Ground Movements and Structures, Proceedings 2nd International Conference, University of Wales Institute of Science and Technology, Cardiff, 1980, J.D. Geddes, ed., John Wiley & Sons, New York, 1981, p. 251-263.

A complex investigation was carried out on the effect of coal extraction on a five-story block constructed of large precast wall panels, which included measurements of the deformation of the terrain around the building as well as of the resultant strains in the structure.

Keyword(s): surface structural damage, coal mining, horizontal displacement, vertical displacement, survey data processing, modeling, construction, engineering

Location(s): Poland

Kawulok, M. Protection of a Church Building from the Intensive Influences of Coal Mining. IN: Ground Movements and Structures, Proceedings 3rd International Conference, University of Wales Institute of Science and Technology, Cardiff, 19884, J.D. Geddes, ed., Pentech, London, 1985, p. 314-323.

This paper presents an account of the precautions adopted for a church against predicted ground movements, where the function of the building determined the choice of the practical structural solutions.

Keyword(s): surface structural damage, coal mining, multiple-seam extraction, vertical displacement, horizontal displacement, structural mitigation

Location(s): Poland

Kawulok, M. The Protection of Existing Buildings Subjected to Large Ground Movements. IN: Ground Movements and Structures, Proceedings 4th International Conference, University of Wales College of Cardiff, July 8-11, 1991, J.D. Geddes, ed., Pentech Press, London, 1992, p. 344-355.

Ground deformations caused by coal extraction usually develop as a regular subsidence basin with smooth, continuous edges, although in the case of large ground movements local discontinuities of the terrain appear in the subsidence profile. These deformations pose a great danger to brick buildings that are not protected against nonuniform subsidence of the ground. For the purpose of effective protection of small buildings erected where such ground conditions may develop, a steel truss may be arranged around the perimeter of the external walls. The truss acts like a corset, which braces and strengthens the walls of the building and improves their interaction with the floors.

Keyword(s): coal mining, surface structural damage, structural mitigation, engineering

Location(s): Poland

Kay, D. R., K. E. McNabb, J. P. Carter. Numerical Modelling of Mine Subsidence at Angus Place Colliery. IN: Computer Methods and Advances in Geomechanics, Proceedings 7th International Conference, Cairns QLD Australia, G. Beer, May 6-10, 1991, v. 2, J.R. Booker, and J.P. Carter, eds., Balkema, Rotterdam, p. 999-1004.

A joint case study was initiated in 1987 to improve the prediction of coal mining induced subsidence using mathematical models. Nine different models predicted the subsidence movements of pegs along several surface cross sections and anchors located in a subsurface borehole over a new longwall panel at the Angus Place Colliery, New South Wales, Australia. The study was phased so that later predictions could use the results of earlier monitoring to perform progressive calibrations of the models. The modeling involved an appreciation of complex time dependent subsidence deformation mechanisms over small and large extraction areas with partially yielding chain pillars.

Keyword(s): modeling, mathematical model, longwall, active mines, coal mining, monitoring methods, prediction, time factor, yielding supports, vertical displacement, horizontal displacement, geotechnical

Location(s): Australia

Kay, F. H. Coal Resources of District VII (Southwestern Illinois) (Coal No. 6 West of Duquoin Anticline). Illinois State Geological Survey, Mining Investigation Bulletin 11, 1915, 233 p. Reprinted 1922.

Keyword(s): coal mining, historical

Location(s): Illinois, Illinois Coal Basin, United States

Kay, F. H., K. D. White. Coal Resources of District VIII (Danville). Illinois State Geological Survey, Mining Investigation Bulletin 14, 1915, 68 p.

Keyword(s): coal mining, historical

Location(s): Illinois, Illinois Coal Basin, United States

Kay, S. R. The Effect of Subsidence Due to Coal-Workings Upon Bridges and Other Structures. IN: Institute of Civil Engineers, Minutes of Proceedings, London, v. 135, 1898, p. 114-174.

Keyword(s): surface structural damage, coal mining, historical

Kaye, R. D., E. R. Wooley. Grouting Old Mine Workings. Civil Engineering and Public Works Review, August, 1963, p. 1005.

A 16-story apartment building was constructed on a site with multiple mined-out coal seams.

Keyword(s): surface structural damage, grouting, multiple-seam extraction, engineering, abandoned mines, coal mining, architecture

Kazmann, R. G., M. M. Heath. Land Subsidence Related to Ground-Water Offtake in the New Orleans Area. Gulf Coast Associated Societies Transactions, v. 18, 1968, p. 108-113.

Keyword(s): fluid extraction

Location(s): Louisiana, United States

Keenan, A. M. Longwall Mining of Coal Pitching 30 Degrees. AIME Preprint No. 71-F-336, 1971.

This article discusses the use of longwall mining in seams dipping too steeply for conventional room-and-pillar equipment. Experimental systems have increased production and appear to be especially applicable where depth of cover has previously limited extraction.

Keyword(s): longwall, mine design, geologic features, coal mining

Location(s): United States

Keinhorst, H. Considerations on the Problem of Mining Damages. Gluckauf, v. 70, 1934, p. 149-155 (in German).

Keyword(s): modeling, empirical model, influence function, surface subsidence damage

Location(s): Germany

Keith, H. D., R. C. Batra, P. J. Conroy. Finite Element Analysis of a Longwall Mine. IN: Rock Mechanics: A State of the Art, Proceedings 21st Symposium on Rock Mechanics, University of Missouri at Rolla, May 28-30, 1980, D.A. Summers, ed., p. 9-15.

The work reported herein represents the first phase of an effort to develop finite element modeling techniques that can be used to design the geometry of longwall panel development entries. Three dimensional finite element models of a long-wall mine geometry should provide results close to the field observations.

Keyword(s): rock mechanics, finite element, modeling, longwall, mine design, coal mining, lab testing

Location(s): Illinois, Illinois Coal Basin, United States

Kelleher, J. T., D. J. Van Roosendaal, B. B. Mehnert, D. F. Brutcher, R. A. Bauer. Overburden Deformation and Hydrologic Changes Due to Longwall Coal Mine Subsidence in the Illinois Basin. IN: Land Subsidence, Proceedings 4th International Symposium, Houston, TX, May 1991, A.I. Johnson, ed., IAHS Publication no. 200, p. 195-204.

Subsidence-induced deformation and hydrologic changes were studied at two active longwall coal mines in Illinois using surveying and geotechnical monitoring. Surface subsidence characteristics fall into a range common to other Illinois longwall operations. Subsidence-induced water level fluctuations correlated with mining activity and the passing of the dynamic subsidence wave. Aquifer thickness and lateral extent affected these fluctuations.

Keyword(s): coal mining, longwall, survey methods, monitoring methods, instrumentation, subsurface water, hydrology, geotechnical, vertical displacement, horizontal displacement, overburden, rock mechanics, geophysical, monitoring equipment, geologic features

Location(s): Illinois, Illinois Coal Basin, United States

Kelley, G. C., J. L. Craft. Areawide Mine Subsidence Investigations. IN: Proceedings National Symposium and Workshops on Abandoned Mine Land Reclamation, Bismarck, ND, May 21-22, 1984, L.L. Schloesser, et al., eds., North Dakota Public Service Commission and the University of North Dakota, p. 31-41.

The Office of Surface Mining initiates areawide subsidence investigations in communities where past coal mining has produced multiple surface subsidence events and where there is a likelihood of future subsidence-induced surface effects that represent extreme danger to the public. The purposes of the investigation are to collect all available information concerning the potential for subsidence in the area; identify potential high risk subareas; and, if requested by the state Abandoned Mine Land (AML) authority, recommend remedial abatement. The accumulated information allows a more rapid response time when subsequent sub-sidence events occur. Studies are implemented only after concurrence of the responsible AML authority.

Keyword(s): abandoned mines, coal mining, reclamation, land mitigation, surface structural damage

Location(s): United States

Kenny, P. The Caving of the Waste on Longwall Faces. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 6, 1969, p. 541-555.

A set of definitions, which has been found useful in describing the manner of caving on longwall faces, is proposed. A method of quantifying the description of the caving zone by means of simple observations and measurements is described. The relevance of the manner of caving to roof control is discussed and it is shown that information on the nature and extent of the supported roof may be obtained from studies of caving. Such studies may also yield information on face support requirements, the workability of the coal, the effect of different roof, e.g. massive sandstone, and the in situ strength of rock beds.

Keyword(s): longwall, coal mining, overburden, roof stability

Location(s): United Kingdom

Kent, B. H. Geologic Causes and Possible Preventions of Roof Fall in Room-and-Pillar Coal Mines. Pennsylvania Geological Survey IC 75, Harrisburg, 1974, 17 p.

Keyword(s): roof stability, ground control, room-and-pillar, coal mining, geologic features

Pennsylvania, Appalachian Coal Region, United States

Kentucky Department for Natural Resources and Environmental Protection, Bureau of Surface Mining Reclamation and Enforcement. Permanent Program Regulations for Surface Coal Mining and Reclamation Operations and Coal Exploration Operations. 405 KAR 8:040E, Sec. 26, April, 1982, 52 p.

The subsidence control section covers the legal considerations of subsidence for the state of Kentucky.

Keyword(s): law, mine operation, reclamation, environment

Location(s): Kentucky, Appalachian Coal Region, United States

Kertis, C. A. Reducing Hazards in Underground Coal Mines Through the Recognition and Delineation of Coalbed Discontinuities Caused by Ancient Channel Processes. U.S. Bureau of Mines RI 8987, 1985, 23 p.

Because coalbed discontinuities often pose serious economic and safety problems in underground coal mines, criteria were documented for the recognition and prediction of discontinuities in advance of mining.

Keyword(s): geologic features, mine design, mine safety, coal mining, overburden

Location(s): Pennsylvania, Appalachian Coal Region, United States

Kester, W. M., Y. P. Chugh. Premining Investigations and Their Use in Planning Ground Control in the Illinois Basin Coal Mines. IN: Proceedings, 1st Conference on Ground Control Problems in the Illinois Coal Basin, August 22-24, 1979, Southern Illinois University, Carbondale, 1980, p. 33-43.

The authors conducted premining investigations for four virgin areas and studied ground control problems in several operating coal mines in the basin. Premining investigations involved detailed geologic descriptions of cores and preparation of maps pertinent from a ground control point of view. Specifically, facies changes in the immediate roof, interval to limestone bed, if any, thickness of limestone bed and thickness and nature of shales were mapped. Moisture sensitivity of shales, thickness and nature of underclays, presence of channels, etc. were also considered. Based on geologic description and physical property data on roof, coal, and floor rocks, the authors have developed rating scales for delineating areas with ground control problems overying the Herrin seam.

Keyword(s): geologic features, ground control, floor stability, roof stability, coal mining, geotechnical, lab testing, rock mechanics

Location(s): Illinois, Illinois Coal Basin, United States

Kettren, L. P., K. A. Johnston. Rock Mechanics Studies at Old Ben Coal Company Mine 24. IN: Proceedings, 1st Conference on Ground Control Problems in the Illinois Coal Basin, August 22-24, 1979, Southern Illinois University, Carbondale, June, 1980, p. 208-213.

Rock mechanics studies were performed by Dames & Moore in Old Ben Coal Company's Mine No. 24 as part of a longwall mining demonstration with the U.S. Department of Energy. The demonstration project was designed to introduce longwall techniques to the Illinois Basin where earlier attempts with longwall had failed. Six earlier attempts with longwall methods by Old Ben had been unsuccessful due to roof control problems. The present demonstration included a rock mechanics study designed to observe unusual situations so that corrective action could be taken, to develop guidelines for future longwall efforts, and to evaluate surface subsidence and develop criteria to assist in its prediction.

Keyword(s): rock mechanics, coal mining, longwall, monitoring methods, monitoring equipment, instrumentation

Location(s): Illinois, Illinois Coal Basin, United States

Key, S. W., Z. E. Beisinger, R. D. Krieg. HONDO II--A Finite Element Computer Program for Large Deformation Dynamic Response of Axisymmetric Solids. SAND78-0422, Sandia National Laboratories, Albuquerque, NM, 1978.

Keyword(s): finite element, computer, modeling

Location(s): United States

Khair, A. W., S. S. Peng. Causes and Mechanisms of Massive Pillar Failure in a Southern West Virginia Coal Mine. Preprint 83-378, SME-AIME fall meeting, Salt Lake City, UT, October, 1983, 11 p.

This paper deals with the causes and mechanisms of pillar failure in a coal mine in southern West Virginia. The conclusions are made on the basis of in-mine observations and analysis of mining methods, eyewitness accounts of the sequence of events, topographic and geologic conditions, and mechanical properties of mine roof, coal, and floor.

Keyword(s): coal mining, pillar strength, geologic features, room-and-pillar, roof stability, finite element

Location(s): West Virginia, Appalachian Coal Region, United States

Khair, A. W., R. D. Begley. Model Studies to Develop Criteria of Subsidence Due to the Room and Pillar Mining of Coal. Preprint No. 84-92, SME-AIME Annual Meeting, Los Angeles, CA, February 26-March 1, 1984, 13 p.

Subsidence in room-and-pillar mining was analyzed using models of various extraction ratios and overburden depths along with two types of overburden model material.

Keyword(s): coal mining, modeling, room-and-pillar, mine design, abandoned mines, time factor, overburden

Location(s): Illinois, Illinois Coal Basin, Pennsylvania, West Virginia, Appalachian Coal Region, United States

Khair, A. W., G. S. Begley, R. D. Begley. Study of Subsidence Characteristics Due to Underground Mining of Coal Using a Physical Modeling Technique. IN: Proceedings, 2nd Workshop on Surface Subsidence due to Underground Mining, Morgantown, WV, June 9-11, 1986, S.S. Peng, ed., West Virginia University, p. 270-282.

This paper presents an analysis of surface subsidence characteristics in room-and-pillar mining using physical models and laser holographic interferometry (holometry). The analysis included the effect of various geometric parameters and different overburden materials and resulted in the formulation of a more realistic model material for laboratory simulation of typical geologic overburden.

Keyword(s): modeling, coal mining, room-and-pillar, overburden, physical model

Khair, A. W., R. D. Chaffins, M. K. Quinn. Study of Ground Movements Over a Longwall Mine. IN: Proceedings, 6th International Conference on Ground Control in Mining, June 9-11, 1987, S.S. Peng, ed., West Virginia University, Morgantown, p. 141-155.

This paper presents an analysis of ground movements recorded from longwall operations in the northern Appalachian region in West Virginia. The site chosen for the investigation was selected due to varying heights of overburden and topography and was instrumented for both surface and subsurface measurements. The instrumentation areas consisted of two panels covering various sections with unique geologic and topographic features.

Keyword(s): longwall, monitoring methods, instrumentation, survey methods, survey equipment, horizontal displacement, vertical displacement, monitoring equipment, overburden, prediction, geologic features, finite element

Location(s): West Virginia, Appalachian Coal Region, United States

Khair, A. W., M. K. Quinn, R. D. Chaffins. Effect of Topography on Ground Movement Due to Longwall Mining. Preprint 87-142, SME-AIME Annual Meeting, Denver, CO, February 24-27, 1987.

This paper presents an analysis of the effects of topography on quasi-static and dynamic ground movements and the severity of damage inflicted on surface structures.

Keyword(s): geologic features, surface structural damage, subsurface structural damage, horizontal displacement, instrumentation, angle of draw, coal mining

Location(s): West Virginia, Appalachian Coal Region, United States

Khair, A. W., M. K. Quinn, R. D. Chaffins. Effect of Topography on Ground Movement Due to Longwall Mining. Mining Engineering, August, 1988, p. 820-822.

This paper presents an analysis of the effects of topography on static and dynamic ground movements and severity of damage inflicted on surface structures. A typical site containing varying topographical features (i.e., mountains, hillsides, valleys, and flat bottom land) representing the northern Appalachian region was chosen for the study. Typical subsidence monitoring techniques were employed. Frequent measurements were made as the face advanced.

Keyword(s): coal mining, surface structural damage, geologic features, monitoring methods, active mines, horizontal displacement, vertical displacement, foundations, overburden, instrumentation, survey methods, survey equipment, surface subsidence damage

Location(s): West Virginia, Appalachian Coal Region, United States

Khair, A. W. Prediction of Ground Subsidence in Longwall Mining Areas. IN: Proceedings, 5th International Symposium on Deformation Surveys and 5th Canadian Symposium on Mining Surveying and Rock Deformation Measurements, 1988.

Keyword(s): prediction, longwall

Khair, A. W., P. J. Molesky. Surface Ground Movements Over Longwall Mining in the Pittsburgh Seam. IN: Proceedings 7th International Conference on Ground Control in Mining, August 3-5, 1988, S.S. Peng, ed., p. 303-313.

This paper presents an analysis of surface ground movements recorded from two longwall mines in northern West Virginia that operate in the Pittsburgh seam. The instrumentation areas consisted of four panels, two at each mine, covering various sections with unique topographic features. Vertical and horizontal ground movements were measured at specified intervals to determine subsidence rate, developing and final subsidence profiles, angle of draw, horizontal displacements, and associated strain profiles. A relationship between panel depth and width and the subsidence factor was also developed.

Keyword(s): longwall, coal mining, monitoring methods, instrumentation, vertical displacement, horizontal displacement, survey methods, angle of draw

Location(s): West Virginia, Appalachian Coal Region, United States

Khair, A. W., R. D. Begley. Assessment of Modeling Techniques for Prediction of Subsidence Over Longwall Areas. Preprint 89-14, SME Annual Meeting, Las Vegas, NV, February 27-March 2, 1989, 7 p.

This paper presents an assessment of modeling techniques in predicting subsidence over longwall areas. Extensive instrumentation, both at the surface and subsurface of three longwall mines in northern West Virginia have been made. Ground movements were monitored during a 3-year period until subsidence ceased in these areas. A comparative analysis of empirical subsidence prediction techniques including, graphical (NCB), profile function, and influence functions are presented. A brief geologic and topographic description of each site along with the instrumentation and monitoring program are also presented.

Keyword(s): modeling, prediction, longwall, instrumentation, empirical model, National Coal Board, profile function, influence function, zone area, coal mining

Location(s): West Virginia, Appalachian Coal Region, United States

Khair, A. W., Y. S. Ro. Assessment of Surface Fracture Depth and Intensity Due to Subsidence Over the Longwall Panel Using a Sonic Technique. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed.,Balkema, Rotterdam, p. 723-730.

This paper presents an analysis of fracture depth and intensity due to subsidence over the longwall panel. Sonic reflection techniques were used to determine fracture depth, and a variation of p-wave velocity was used as an indication of the fracture intensity. Instrumentation has been tested for consistency and accuracy first in the laboratory using small scale models, then applied in the field in two mine sites with differing mining geometry and geologic conditions. A new sonic viewer was used for sonic velocity measurements. Regular hammering method was an acoustic source. The results were concurrent with monitored horizontal strain profiles and measured open fractures over the longwall panels.

Keyword(s): longwall, overburden, instrumentation, modeling

Location(s): United States

Khair, A. W. Evaluation of Monitoring Techniques for Ground Movements Over the Longwall Areas. International Symposium on Land Subsidence, December 11-15, 1989, Central Mining Research Station, India, p. 3-17.

This paper presents highlights of the research associated with monitoring surface and subsurface ground movements over longwall mining areas. Extensive instrumentation and measurements have been made over three longwall mines in northern West Virginia during a 3-year period. Various monitoring techniques including full profile borehole extensometers, full profile borehole inclinometers, time domain reflectometry, sonic reflection technique, and a unique mechanical grouting method in addition to standard surveying and water level measurements were used.

Keyword(s): coal mining, longwall, monitoring methods, monitoring equipment, monitoring design, monitoring installation, geotechnical, survey methods, active mines, instrumentation, geologic features, overburden

Location(s): West Virginia, Appalachian Coal Region, United States

Khair, A. W., H.-U. Lim, S. J. Jung. Application of Rock Mechanics Principles to Alleviate a Complex Rock Engineering Problem in a Coal Mine--A Case Study. IN: Rock Mechanics Contributions and Challenges, Proceedings of the 31st U.S. Rock Mechanics Symposium, June 18-20, 1990, W.A. Hustrulid and G.A. Johnson, eds.,Golden, CO. Balkema, Rotterdam, p. 77-84.

This paper presents an analysis of complex ground control problems in a coal mine and potential solutions to alleviate the problems. The analysis includes the study of geology and lithology of the mine, determination of the mechanical properties of the rock and coal associated with the mine, apparent in situ stresses, in-mine observation, and study of the behavior of the roadways through instrumentation and monitoring.

Keyword(s): ground control, coal mining, geologic features, rock mechanics, longwall, roof support

Location(s): Pennsylvania, Appalachian Coal Region, United States

Khair, A. W., S. S. Peng. Engineering to Reduce the Cost of Roof Support in a Coal Mine Experiencing Complex Ground Control Problems. Mining Engineering, August 1991, p. 1062-1066. Discussion by S. Serata and K. Fuenkajorn, November 1992, p. 1369, reply p. 1370.

The mine has a history of cutter roof problems in the entries that has delayed the advance rate of entry development considerably, and the cost of maintaining those entries is very high due to the requirement of very heavy artificial supports.

Keyword(s): engineering, roof stability, roof support, yielding supports, active mines, coal mining, geologic features, longwall, roof bolting

Location(s): Pennsylvania, Appalachian Coal Region, United States

Khair, A. W., R. D. Begley. Mechanistic Subsidence Prediction Model (MSPM). IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 56-65.

A model was developed to predict maximum possible subsidence and subsidence profiles at any cross section within the subsidence influence zone. The model considers mine geometry and geologic and geotechnical properties of the associated areas. Based on extensive field measurements and mechanics of strata behavior, under the action of overburden pressure in the vicinity of the large underground excavation, the vertical plane of influence zone has been divided into five areas: (1) excavated, (2) caved, (3) fractured, (4) highly deformed but continuous, and (5) subsided zones.

Keyword(s): modeling, prediction, geologic features, geotechnical

Location(s): Pennsylvania, Virginia, West Virginia, Appalachian Coal Region, Illinois, Illinois Coal Basin, United States

Khanna, R. R., V. K. Talwar. Despoliation of Surface Lands of Jharia Coalfield by Mining Operations and Underground Fires. Journal Institute of Engineers (India), Mining & Metallurgy Division v. 56, pt. MM, November 2, 1975, p. 57-60.

Keyword(s): surface subsidence damage, coal mining, mine fires

Location(s): India

Kicker, D. C., Z. T. Bieniawski. Improving Design Methodology for Innovative Rock Mechanics Design. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 279-284.

This paper introduces the concept of design theory and methodology as applied to rock mechanics for more innovative and efficient design. This is a "frontier" research area in rock mechanics because although design is a fundamental foundation to all engineering branches, very little attention has been paid to this aspect in mining. In discussing the theoretical premise of design, this paper identifies the principles that form the basis of design activity. Also, from a practical standpoint, the findings from a series of interviews with mine design engineers are presented. These findings lead to the identification of needs arising from overlooked design methodology in practice.

Keyword(s): rock mechanics, mine design, engineering

Kiefner, J. F. Monitoring and Intervention on Pipelines in Mining Subsidence Area. Report to Line Pipe Research Supervisory Committee of the Pipeline Research Committee of the American Gas Association, NG-18 Report No. 155, Task SI 5.0-85, "Monitoring and Intervention on Pipelines in Mining Subsidence Areas," August 8, 1986, American Gas Association Catalog No. L51515, Battelle, Columbus Division, OH, 62 p. plus appendix.

The objectives of this study were to review the effects of longwall mining subsidence on pipelines and to develop concepts for preserving the integrity of pipelines affected by such subsidence. The usual effects on a pipeline of mining-induced subsidence are increased axial and flexural strains affecting its longitudinal strength. In the presence of severe circumferentially oriented defects and added tensile strain, buckling of the pipe may occur. Pipeline operators can use available predictive methods and geophysical data to estimate the potential effects of longwall mining, and they can monitor their pipelines and intervene if necessary to prevent a pipeline failure due to subsidence. The options available to pipeline operators faced with a subsidence problem range from doing nothing to shutting down the line and relaying it after subsidence. More likely, however, the operator will choose to leave the line in service and monitor it with the idea of intervening if necessary to preserve the integrity of the pipeline.

Keyword(s): pipelines, utilities, longwall, coal mining, prediction, structural mitigation, monitoring methods, monitoring equipment, monitoring design, National Coal Board

Location(s): United States

Kiefner, J. F. Pipelines and Subsidence: Effects of Pipeline Strains from Longwall Mining are Analyzed; Exposing Line Reduces Strain During Subsidence. Oil & Gas Journal, June 22, 1987, v. 85, no. 25, p. 44-49; June 29, 1987, v. 85, no. 26, p. 66-68. (Based on a paper presented to the 7th Symposium on Line Pipe Research, American Gas Association, Houston, October 14-16, 1988.)

Adequate monitoring and proper intervention can significantly increase a the chances of a pipeline surviving the strains of soil subsidence in an area of longwall mining. The first of the two articles on the effects of longwall mining on underground pipelines presents a technique for monitoring those effects. The concluding article examines intervention options and discusses the benefits of exposing pipelines in longwall mining areas.

Keyword(s): pipelines, longwall, geophysical, prediction, monitoring methods, monitoring design, monitoring installation, monitoring equipment, National Coal Board, angle of draw, coal mining, utilities, survey methods, instrumentation

Location(s): United States

Kilburg, J. A., J. M. Alvi. Report of Subsurface Exploration and Geotechnical Engineering Investigation, Canterbury Manor Mine Subsidence Investigation, Belleville, Illinois. Geo-Mechanics, Inc., Belle Vernon, PA, GMI Project no. 81114, Report to U.S. Bureau of Mines, March 15, 1982.

This investigation was undertaken to determine the cause of structural damage to at least nine dwellings. Two subsurface aspects which were investigated were the soil conditions and the mining conditions. These conditions were examined to determine which one (or both) may have caused the surface subsidence and accompanying structural damage to the houses. This report contains the results of the investigation as well as recommendations for stabilizing the area to minimize the potential for future subsidence or settlement and damage.

Keyword(s): surface structural damage, abandoned mines, coal mining, geotechnical, engineering, geologic features, room-and-pillar, grouting

Location(s): Illinois, Illinois Coal Basin, United States

King, H. J., H. G. Smith. Surface Movement Due to Mining. Colliery Engineering, v. 31, 1954, p. 322-329.

Laboratory experiments used gelatin models to determine surface effects of mine subsidence.

Keyword(s): surface subsidence damage, modeling, lab testing

King, H. J., M. B. Jones. The Measurement of Mine Subsidence. Mine and Quarry Engineering, v. 22, no. 3, March, 1956, p. 106-113.

The authors discuss a new technique for measuring subsidence and include a detailed description of two instruments constructed by the authors: one designed to measure tilt and strain and the other a simplified model for measuring only strain.

Keyword(s): monitoring equipment, monitoring installation, monitoring methods

Location(s): England

King, H. J., J. T. Whetton. Mechanics of Mine Subsidence. IN: Proceedings, European Congress on Ground Movement, University of Leeds, 1957, p. 27-38.

Experiments were conducted with a gelatin model to determine the relationship between subsidence parameters. Three groups of subsidence factors related to longwall mining are defined: dimensional, geological, and rate factors.

Keyword(s): modeling, longwall, geologic features, lab testing

King, H. J. An Investigation Into the Factors That Control Mine Subsidence. Ph.D. Thesis, University of Leeds, England, October 1958.

Keyword(s): geologic features

King, H. J., J. T. Whetton. Mechanics of Mining Subsidence. Colliery Engineering, pt. 1, June, 1958, p. 247-252; pt. 2, July, 1958, p. 285-288.

The authors intended to study the effect of the longwall extraction process by means of model tests, using a geometrically similar type. Three models were designed and constructed, each of which controlled different variables such as depth, width, and length of panel, and amount of lowering

at the level of the panel. The first article summarizes the results obtained from the three models in respect to surface behavior. As a result of the experimental work, and in view of the reproducibility of the patterns of movement, the second article describes attempts to obtain some empirical expressions in terms of certain variables for flat panels of lowering.
    Keyword(s): modeling, longwall, coal mining, geologic features
    Location(s): United Kingdom

King, H. J., R. J. Orchard. Ground Movement in the Exploitation of Coal Seams. Colliery Guardian, v. 198, April 16, 1959, p. 471-477; v. 198, April 23, 1959, p. 503-508.
    This article reviews early experience and observations of subsidence in Great Britain. The authors point out the concern by the National Coal Board about non-subsidence damage, since in legal disputes, the burden of proof rests with the National Coal Board.
    Keyword(s): surface subsidence damage, National Coal Board, law, coal mining
    Location(s): England

King, H. J. An Examination of the Elements of Surface Displacements Due to Coal Mining Subsidence. Chartered Surveyor, v. 96, no. 8, February 1964, p. 406-411.
    Keyword(s): coal mining, survey data processing

King, H. J., B. N. Whittaker, C. H. Shadbolt. Effects of Mining Subsidence on Surface Structures. IN: International Symposium on Mining and the Environment, London, June 4-7, 1974, Institute of Mining & Metallurgy, London, 1975, p. 617-642.
    This paper describes monitoring techniques used to determine the effectiveness of trenching to reduce the amount of damage to surface structures from underground mining.
    Keyword(s): surface structural damage, structural mitigation, monitoring methods, active mines

King, R. P., D. W. Gentry. Development of Subsidence and Horizontal Strain Model for Longwall Mining at the York Canyon Mine. Preprint 79-85, SME-AIME Annual Meeting, New Orleans, February 18-22, 1979, 5 p.
    The York Canyon Subsidence and horizontal strain models are based on actual field data obtained by monitoring three adjacent longwall panels. These models show that at York Canyon subsidence results in greater ground curvature than predicted by the National Coal Board, and subsidence is located more centrally over the longwall panel. Because of this, greater horizontal strains can be expected. It should be noted that these represent an intensive effort in a restricted area and are not necessarily intended to predict subsidence and horizontal strain results in other mining environments.
    Keyword(s): longwall, coal mining, modeling, horizontal displacement, vertical displacement, National Coal board
    Location(s): New Mexico, Rocky Mountain Coal Region, United States

King, R. P. Evaluation of Surface Subsidence and Horizontal Strain at York Canyon Mine, New Mexico. M.S. Thesis, Colorado School of Mines, Golden, 1980, 197 p.
    The author presents the results of a rock mechanics instrumentation program designed to determine surface response due to longwall mining in thick coal at the York Canyon Mine, near Raton, New Mexico.
    Keyword(s): coal mining, instrumentation, vertical displacement, horizontal displacement, monitoring design, monitoring installation, monitoring equipment, survey methods, survey equipment, survey data processing, rock mechanics, longwall
    Location(s): New Mexico, Rocky Mountain Coal Region, United States

King, R. U. A Study of Geologic Structure at Climax in Relation to Mining and Block Caving. Transactions, AIME, 1946, v. 163, p. 145-155.
    Keyword(s): mine operation, overburden, geologic features
    Location(s): United States

King, W. P., N. W. Green. Mine Subsidence Surveys. IN: Proceedings 4th Annual Symposium on Subsidence in Mines, Wollongong, Australia, February 20-22, 1973, A.J. Hargraves, ed., Australasian Institute Mining & Metallurgy., Illawarra Branch, Paper 2, 1973, p. 2-1--2-12.
    Detailed investigations of subsidence phenomena were commenced on the Southern and the Northern Coalfields (Australia). The principal aim of the work at the Southern Coalfields was to investigate the possibility of more extensive coal extraction than is at present permitted from beneath certain bodies of water contained by dams.

Although some precise surveys of both levels and distances were carried out, most of the work was to third order standards. To handle the massive amount of data produced from the surveying, it was finally decided that all data storage, handling, and processing would be handled by computer. Simple survey methods were used and electronic data processing was applied to the handling of mine subsidence data.

Keyword(s): survey methods, survey data processing, survey equipment, survey design, surface water, coal mining, active mines, longwall, surface structural damage

Location(s): Australia

Kirchner, B. H., G. J. Colaizzi. Remote Video Inspection of Abandoned Coal Mines: Investigation and Backfill Monitoring. IN: Proceedings, Conference on Coal Mine Subsidence in the Rocky Mountain Region, Colorado Springs, October 28-30, 1985, J.L. Hynes, ed., Colorado Geological Survey Special Publication 31, Department of Natural Resources, Denver, 1986, p. 133-142.

The use of remote video for abandoned mine investigations and backfill monitoring is a relatively new concept. Information obtained from the video recordings has been useful for determing the location and concentration of drilling necessary for reclamation measures, orientation and condition of pillars and mine passages, extraction ratios, shaft closure design, etc.

Keyword(s): remote sensing, abandoned mines, photography, backfilling, reclamation, coal mining, monitoring equipment, monitoring methods

Location(s): Rocky Mountain Coal Region, United States

Kistamas, L. Comparative Study of Solid Stowing Methods. Colliery Guardian, v. 207, no. 5350, October, 1963; v. 207, no. 5351, November, 1963, p. 586.

Keyword(s): stowing

Kiusalaas, J., E. K. Albert. SPASID: A Computer Program for Predicting Ground Movement Due to Mining. Report on U.S. Bureau of Mines Contract No. JO295031, August, 1983, The Pennsylvania State University, University Park, 201 p.

This report is a self-contained User Manual for a computer program called SPASID--Subsidence Prediction and System Identification. The program has two primary functions: (1) precalculation of ground movements due to underground mining operations using the influence function method, and (2) computation of influence function and site parameters from measured displacements. The program is written in FORTRAN and does not assume previous knowledge of the influence function method or programming competence.

Keyword(s): computer, prediction, modeling, influence function

Location(s): Pennsylvania, Appalachian Coal Region, United States

Klepikov, S. N., F. N. Borodatcheva, I. V. Matveev. Non-Linear Foundation Behaviour in the Analysis of Frameless Buildings Under the Action of Foundation Displacements. IN: Ground Movements and Structures, Proceedings 2nd International Conference, University of Wales Institute of Science and Technology, Cardiff, 1980, J.D. Geddes, ed., John Wiley & Sons, 1981, p. 275-287.

In this paper, a method is proposed for the three-dimensional design of multi-storied frameless buildings under the action of external loads and horizontal displacements of their footings, taking into account non-linear behaviour. The essence of the method is a conversion of the modules of the building into a system of cross beams whose properties are selected so that the forces and displacements in the beams and the corresponding walls differ by insignificant amounts. The design philosophy for the footings is based on a model with a variable stiffness coefficient.

Keyword(s): surface structural damage, foundations, architecture

Location(s): Soviet Union

Klepikov, S. N., A. V. Mashkin. Soil Mechanics Problems in Undermined Areas. Scientific-Research Institute of Constructional Elements (NIISK) of the Government Committee for Construction (Gosstroi) of the USSR. Translated from Osnovaniya, Fundamenty i Mekhanika Gruntov, no. 1, January-February, 1984, p. 3-5.

Soils in undermined areas experience single or repeated action from rock movements due to underground excavation of useful minerals or construction of different types of underground structures by the covered work method. This paper investigates basic problems in the field of mechanics of undermined soils.

Keyword(s): soils, soil mechanics, surface structural damage

Location(s): Soviet Union

Klezhev, P. E., R. A. Muller, S. E. Shalagov. Investigations of Piled Foundations for Buildings in Areas of Mining Subsidence. IN: Ground Movements and Structures, Proceedings 2nd International Conference, University of Wales Institute of Science and Technology, 1980, J.D. Geddes, ed., John Wiley & Sons, New York, 1981, p. 264-274.

The construction of two five-story experimental residential buildings on piled foundations was carried out to prove the possibility and expediency of building in areas to be undermined in the Karaganda basin. One building is a 56-flat, frameless, large-panel building, and the other is a 68-flat brick building. The series of coal seams being developed at the basin run under the experimental buildings. The seam being mined is at an average depth of 410 meters, and its thickness is 1.4 meters; the roof control method is complete caving.

Keyword(s): foundations, surface structural damage, structural mitigation, construction, coal mining, active mines, geologic features

Location(s): Soviet Union

Kneisley, R. O., K. Y. Haramy. Large-Scale Strata Response to Longwall Mining: A Case Study. U.S. Bureau of Mines RI 9427, 1992, 25 p.

This report summarizes a study of large-scale strata response to longwall mining at a coal mine in the western United States. The study used surface and subsurface measurements, geologic mapping, in situ stress measurements, and pressure cell readings to characterize strata behavior. Preliminary analysis of surface subsidence and time-domain reflectometry (TDR) was used to determine a suggested caving sequence for the main roof. Coal ejected from the face apparently resulted from brittle failures that occurred because of the lack of significant yield zone development. The combination of a strong coal with pronounced directional behavior, low overburden pressures, a good caving roof, and a high-production environment that minimized time-dependent loading apparently reduced yielding of the longwall face.

Keyword(s): active mines, coal mining, longwall, monitoring methods, monitoring equipment, instrumentation, overburden, geotechnical, yielding supports

Location(s): Colorado, Rocky Mountain Coal Region, United States

Knight, A. L., J. G. Newton. Water and Related Problems in Coal-Mined Areas of Alabama. U.S. Geological Survey, Water-Resources Investigations 76-130, April 1977, 51 p. (NTIS PB 271 527)

Keyword(s): hydrology, surface water, subsurface water, coal mining

Location(s): Alabama, United States

Knill, J. L. Rock Conditions in the Tyne Tunnels, North Eastern England. Bulletin Association of Engineering Geologists, v. 10, 1973, p. 1-20.

Keyword(s): tunnelling, geologic features

Location(s): England

Knill, J. L. Foundations on the Coal Measures. IN: Site Investigations in Areas of Mining Subsidence, F.G. Bell, ed., Newnes-Butterworths, London, 1975, p. 149-164.

Keyword(s): foundations, overburden, coal mining

Location(s): United Kingdom

Knothe, S. Rate of Advance and Ground Deformation. Bergakademie, v. 5, no. 12, 1953, p. 513-518 (in German).

Keyword(s): surface subsidence damage

Knothe, S. The Displacement of the Surface Under the Influence of Mining Extraction and Their Theoretical Interpretations. IN: Proceedings, European Congress on Ground Movement, Leeds, England, April 9-12, 1957, London Harrison, p. 210-218.

Keyword(s): surface subsidence damage, modeling

Knothe, S. Observations of Surface Movements Under Influence of Mining and Their Theoretical Interpretation. Colliery Engineering, v. 36, 1959, p. 24-29.

This article presents formulas for the prediction of surface subsidence movements. These formulas are basically trough profile functions derived for critical or super-critical extraction of rectangular areas. The author mentions the influence of partial extraction and stowing on subsidence factors and the use of precalculation methods in the design of harmonious mining systems. The article is primarily directed at a presentation of prediction formulas.

Keyword(s): vertical displacement, prediction theories, empirical model, profile function, influence function, coal mining, partial extraction, stowing, mine design

Knox, G. The Hydraulic Stowing of Goaves. Transactions, Institute of Mining Engineers v. 45, 1912, p. 13.
Keyword(s): stowing, hydraulic backfilling

Knox, G. Hydraulic Filling as Roof Support. Colliery Engineering, v. 34, 1913, p. 225.
This article advocates the adoption of hydraulic backfilling in Britain; filling techniques in Europe are discussed.
Keyword(s): hydraulic backfilling, roof support
Location(s): England, Europe

Knox, G. The Relation Between Subsidence and Packing with Special Reference to the Hydraulic Stowing of Goaves. Transactions Institute of Mining Engineers, London, v. 44, 1912-1913, p. 527-552.
This paper discusses the need for better support systems in mine operations to reduce the number of fatalities caused by roof falls and damage to ground surface due to subsidence.
Keyword(s): hydraulic backfilling, stowing, mine safety, roof support
Location(s): England

Knox, G. Mining Subsidence. IN: Proceedings, 12th International Geological Congress, Ottawa, Canada, 1913, Imprimerie du Government, 1914, p. 797-806.
The ratio between subsidence and draw must be the joint result of forces liberated by the withdrawal of support from underneath strata in the mined area. The larger the proportion of settlement resulting in subsidence, the less can occur in the form of draw, and vice versa. Subsidence will be at a maximum in flat seams and draw at a maximum in vertical seams. The more effective the packing, the less the amount of settling that can take place either as subsidence or draw. As the settlement would be likely to occur slowly, the strata would bend without fracturing.
Keyword(s): vertical displacement, angle of draw, backfilling, overburden, bumps, geologic features
Location(s): United Kingdom

Knox, G., J. D. Pato. Hydraulic Stowing. IN: Proceedings, South Wales Institute of Engineering, v. 27, no. 4, 1921-22, p. 283.
This paper is a history of hydraulic backfilling, with a general resume of techniques employed in Poland.
Keyword(s): hydraulic backfilling
Location(s): Poland

Knox, G. Notes on Mining Subsidence. Colliery Guardian, v. 138, 1929, p. 825-827, 933-935.
Keyword(s): angle of draw, subsurface water, mine design, time factor

Ko, K. C., D. A. Ferguson. Geotechnical and Mine Design Considerations in Multiple Seam Mining. IN: Proceedings, Mini Symposium on the Application of Geotechnical Data to Underground Mine Design, SME-AIME fall meeting, FL, September, 1978, p. 21-32.
Keyword(s): multiple-seam extraction, mine design, geotechnical
Location(s): United States

Kochmanski, T. Integral Theory of Ground Movements Resulting from Extraction. Freiberger Forschunshefte, v. A118, 1959, p. 36-56 (in German).
Keyword(s): modeling, empirical model, influence function, prediction theories

Kochmanski, T., T. Lubina. Analiza Mozliwosci Eksploatacji Pokladu 510 Pod Osiedlem I Rzeka (Feasibility Analysis of Exploiting with Hydraulic Stowage Coal Seam No. 510 Under a Village and River). Przeglad Gorniczy, v. 27, no. 9, 1971, p. 417-423.
Keyword(s): hydraulic backfilling, stowing, surface water, surface structural damage, coal mining, modeling, empirical model, influence function
Location(s): Poland

Kochmanski, T. Comparison of the Accuracy of Three Methods of Calculation According to the Theories of K. Kochmanski, S. G. Avershyn, W. Budryk, and S. Knothe. National Science Association, U.S. Bureau of Mines Special Foreign Currency Scientific Information Program Translation, 1974, 54 p.
This report details the differences between subsidence measured by means of geodetic surveys and subsidence calculated using the Avershyn, Budryk-Knothe, and Kochmanski theories of prediction.
Keyword(s): vertical displacement, prediction, prediction theories, empirical model, profile function, influence function

Koehler, J. R., S. D. Jones, M. J. DeMarco. An Applications Approach to Barrier Pillar Design for Improved Resource Recovery. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural

Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 403-410.

Available barrier pillar design methods do not adequately account for overburden caving characteristics, the timing and magnitude of associated load transfers, the occurrence of unusual geologic features, or the effects of multiple-panel/multiple-seam mining. To address this problem, a barrier pillar study was conducted in a multiple-seam mine setting. Insufficient barrier width resulted in an excessive load transfer to an adjacent/underlying section. Consequent entry and pillar deterioration resulted in the section being prematurely abandoned. This paper proposes an approach based on in situ measurements, which includes mine-specific loading conditions in the barrier design process.

Keyword(s): mine design, overburden, geologic features, multiple-seam extraction, coal mining, longwall, pillar strength, instrumentation

Location(s): Utah, Rocky Mountain Coal Region, United States

Koerner, R. M. Acoustic Emission Monitoring of Land Subsidence. IN: Land Subsidence, Proceedings 3rd International Symposium, Venice, Italy, March 19-25, 1984, A.I. Johnson, L. Carbognin, and L. Ubertini, eds., IAHS Publication No. 151, 1986, p. 225-234.

Acoustic emissions are sounds generated internally in a soil or rock mass as it deforms. These sounds produce stress waves that stimulate transducers implanted at strategic points in, or on, the material being monitored. This paper presents four case histories on relatively local subsidence which utilize the technique. For situations where larger land masses are involved, i.e., areal subsidence, the sensors must be left in place over long time periods and periodically visited. In such cases remote sensing is a definite possibility. Six schemes are presented, based on either continuous or periodic transmission, which include direct coupling, telephone, and airborne concepts.

Keyword(s): remote sensing, fluid extraction, coal mining, monitoring methods, soils, lab testing, abandoned mines, surface structural damage

Location(s): Pennsylvania, Appalachian Coal Region, United States

Kohli, K., T. M. Crandall, R. C. Dollence. Investigation of Subsidence Event Over Multiple Seam Mining Area. IN: Mine Subsidence - Prediction and Control, National Symposium, 33rd Annual Meeting Association of Engineering Geologists, October 2-3, 1990, C.D. Elifrits, ed., Pittsburgh, PA, p. 267.

An investigation was performed to determine the sequence of events causing the 1986 surface subsidence and related structural damage to several homes in Walker County, Alabama.

Keyword(s): multiple-seam extraction, coal mining, surface structural damage, abandoned mines, pillar strength

Location(s): Alabama, United States

Kohli, K. K., S. S. Peng, R. E. Thill. Surface Subsidence Due to Underground Longwall Mining in the Northern Appalachian Coal Field. Preprint No. 80-53, SME-AIME Annual Meeting, Las Vegas, NV, February 24-28, 1980, 8 p.

Keyword(s): longwall, coal mining

Location(s): Appalachian Coal Region, United States

Kohli, K. K., S. S. Peng, R. E. Thill. Surface Subsidence Due to Underground Longwall Mining In the Northern Appalachian Coal Fields. IN: Longwall-Shortwall Mining, State of the Art, R.V. Ramani, ed., SME-AIME, New York, 1981, p. 99-105.

An effort was initiated to contact each individual coal company in the Northern Appalachian Coalfield for any surface subsidence survey data that they might have. These data could then be assembled to aid subsidence engineering design. Data collected included 17 longwall panels and 2 room-and-pillar sections. Information covers survey raw data, underground layout maps, surface topography maps, geological logs showing stratigraphic sequences and thickness of the overburden and, if available, locations and types of surface structures. On-site visits followed collection of data, to study surface terrains and structures.

Keyword(s): coal mining, survey data processing, survey design, longwall, room-and-pillar, surface structural damage, mine design, vertical displacement, horizontal displacement, time factor

Location(s): West Virginia, Appalachian Coal Region, United States

Kohli, K. K., S. S. Peng, R. E. Thill. Subsidence Experiences in the Room-and-Pillar Mines of the Northern Appalachian Coalfield. IN: Proceedings, Conference on Ground Control in Room-and-Pillar Mining, Southern Illinois University, Carbondale, August 6-8, 1980, Y.P. Chugh, ed., SME-AIME, New York, 1982, p. 133-138.

The results of unpublished investigations into surface subsidence from coal mining in the Northern Appalachian Coalfield are summarized. These invesitigations were carried out by various coal companies and the state of Pennsylvania in the 1960s and 1970s. Subsidence data were collected and analyzed from 10 room-and-pillar panels in 5 mines in the Pittsburgh coal seam.

Keyword(s): room-and-pillar, ground control, coal mining

Location(s): Pennsylvania, Appalachian Coal Region, United States

Kohli, K. K., T. Z. Jones. A Simplified Computerized Method to Predict Maximum Subsidence and the Subsidence Profile for the Appalachian Coal Basin. IN: Mine Subsidence, Society of Mining Engineers Fall Meeting, St. Louis, MO, September, 1986, M.M. Singh, ed., SME, Littleton, CO, p. 31-37.

This paper presents a simplified computerized method for the prediction of maximum subsidence and the subsidence profile for the Appalachian Coal Basin using the Hyperbolic Function Profile Method. Several case histories are cited to demonstrate the appropriateness of the predictive method. In addition, sample runs and a detailed listing of the computer program is provided. Other popular subsidence prediction methods are discussed and compared with the Hyperbolic Function Profile Method.

Keyword(s): computer, prediction, modeling, profile function, coal mining, longwall

Location(s): West Virginia, Appalachian Coal Region, United States

Kolesar, J. E., E. C. Palmer, V. A. Scovazzo. Subsidence Monitoring Plan of Longwall Panels--A Case Study, Kitt Mine No. 1. IN: Proceedings, Workshop on Surface Subsidence Due to Underground Mining, Morgantown, WV, November 30-December 2, 1981, S.S. Peng and M. Harthill, eds., Department of Mining Engineering, West Virginia University, 1982, p. 225-229.

This paper details a proposed rock-mass-response instrument plan for a longwall mining operation, including descriptions of instrumentation construction plans and practices.

Keyword(s): monitoring design, monitoring installation, monitoring equipment, instrumentation, longwall

Location(s): West Virginia, Appalachian Coal Region, United States

Kosterin, M. A. Vliyanie Ugla Podeniya I Razmerov Vyrabotki Na Kharakter Mul'dy Sdvizheniya (Influence of the Dip Angle and of the Size of Excavation on the Nature of the Subsidence Trough). Izvestiya Vysshikh Uchebnykh Zavedenij Gornyj Zhurnal, no. 3, 1974, p. 43-49.

Keyword(s): geologic features, mine design

Kot, A., P. Trzcionka, J. Bryla. Praktyczna Metoda Wyznacznia Parametrow Teorii Ruchow Gorotworu (Practical Method for Determining the Parameters of the Ground-Displacements Theory). Przeglad Gorniczy, v. 28, no. 12, 1972, p. 582-587.

Keyword(s): prediction, modeling

Kotze, T. J. The Nature and Magnitude of Surface Subsidence Resulting from Mining at Relatively Shallow Depths on Platinum Mines. IN: Proceedings, SANGORM Symposium, October 21, 1986, Sandton, South Africa, International Society for Rock Mechanics, South African National Group, p. 47-51.

With the advent of total extraction methods on coal mines, the attention has so intensely been focused on what happens when the overburden is relatively soft that there may be a tendency for mining engineers to forget that similar problems can occur even when the overlying measures are strong and competent.

Keyword(s): metal mining, overburden, coal mining, roof support, surface structural damage, survey methods

Location(s): South Africa

Kowalczyk, Z. Effect of Mining Exploitation on the Ground Surface and Structures in Heavily Industrialized and Populated Areas. Canadian Institute Mining & Metallurgy Transactions, Mining Society, Nova Scotia, v. 69, 1966, p. 387-393.

The author describes a proposed subsidence prediction theory that would permit the determination of surface deformations for planned underground exploitation.

Keyword(s): vertical displacement, horizontal displacement, surface structural damage, mine design, prediction theories, engineering, construction, land-use planning

Kraj, W. Proba Uzyskania W Gorotworze Jako Osrodku Sprezysto-Lepkim Niecki St. Knothego (Attempt to Determine if a Rock Mass is Considered as a Viscoelastic Medium in St. Knothe's Subsidence Trough). Archiwum Gornictwa, v. 18, no. 2, 1973, p. 111-121.

Keyword(s): prediction theories, empirical model, profile function

Krantz, G. W., J. C. LaScola. Longwall Mine Subsidence Surveying--An Engineering Technology Comparison. IN: Mine Subsidence Control, Proceedings Bureau of Mines Technology Transfer Seminar, Pittsburgh, PA, September 19, 1985, U.S. Bureau of Mines IC 9042, p. 2-12.

A typical longwall mine subsidence survey monitoring grid was installed at the USBM. Conventional and high-technology surveying systems were developed over the grid during a 1-month period. This investigation evaluated and compared five surveying methodologies available for use in surface longwall subsidence monitoring.

Keyword(s): survey design, monitoring methods, longwall, monitoring design, photography, survey methods

Location(s): Pennsylvania, Appalachian Coal Region, United States

Kratzsch, H. Reduced Subsidence by Planned Extraction. Bergbau-Archiv, Essen, v. 25, no. 5, December 1964, p. 15-21.

This paper examines the influence of the location and sequence of mine workings on the stresses affecting a building.

Keyword(s): mine design, surface structural damage

Kratzsch, H. Der Zeitfaktor in Der Bodenbewegungskunde (Time Factor in Theory of Surface Subsidence). Glueckauf-Forschungshefte, v. 29, no. 6, December 1968, p. 323-330.

Keyword(s): time factor, prediction theories

Kratzsch, H. Bergschadenkunde (Mining Subsidence Engineering). Springer-Verlag, Berlin-Heidelberg-New York, 1974, 582 p.

Keyword(s): vertical displacement, horizontal displacement

Kratzsch, H. Mining Subsidence Engineering. Springer-Verlag, Berlin-Heidelberg-New York, 1983, 535 p.

This book deals with the current state of international knowledge on strata and ground movement over mine workings, including detailed descriptions of the damaging effects to mine shafts and the ground surface.

Keyword(s): vertical displacement, horizontal displacement, surface structural damage, subsurface structural damage, law

Location(s): Germany

Krauland, N., P.-E. Soder. Determining Pillar Strength from Pillar Failure Observation. Engineering & Mining Journal, v. 188, no. 88, August, 1987, p. 34-40.

On the basis of field observations, the process of pillar failure has been divided into six stages, each stage having visually well discernible characteristics. By combining these failure stage observations with pillar load calculations in an advanced stage of mining, mine planning engineers can determine large scale pillar strength for mine design purposes. This method has been applied in room-and-pillar mines of Boliden Mineral AB for pillar dimensioning. Details of the application to the Black Angel Mine of Greenex A/S in Marmorilik, Greenland, are described. The observed large scatter of pillar strength is handled by dividing the ore body into pillar areas with similar conditions with regard to geology, orebody, and pillar geometry, and dip. Stress measurements were conducted in eight pillars having different degrees of fracturing to confirm the calculated load levels for the pillar classes.

Keyword(s): pillar strength, room-and-pillar, coal mining, metal mining, mine design

Location(s): Greenland

Krausse, H-F., H. H. Damberger, W. J. Nelson, S. R. Hunt, C. T. Ledvina, C. G. Treworgy, W. A. White. Engineering Study of Structural Geologic Features of the Herrin (No. 6) Coal and Associated Rock in Illinois. Final Report, Contract No. H0242017, U.S. Bureau of Mines, 1979, 205 p.

Keyword(s): engineering, geologic features, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Kreitler, C. W. Lineation and Active Faulting in the Houston-Galveston Area of Subsidence. Geological Society of America, Abstracts with Programs, v. 7, 1975, p. 180.

Keyword(s): fluid extraction, geologic features

Location(s): Texas, United States

Kreitler, C. W., C. R. Lewis, D. McKalips. Geologic Control of Land Subsidence, Houston-Galveston, Texas. Geological Society America, Abstracts with Programs, v. 7, 1975, p. 1154.

Keyword(s): fluid extraction
Location(s): Texas, United States

Kreitler, C. W. Faulting and Land Subsidence from Ground-Water and Hydrocarbon Production, Houston-Galveston, Texas. IN: Proceedings, 2nd International Symposium on Land Subsidence, Anaheim, CA, December 13-17, 1976, International Association of Hydrological Sciences Publication No. 127, Washington D.C., 1977, p. 435-446.
Keyword(s): hydrology, subsurface water, oil extraction, fluid extraction
Location(s): Texas, United States

Kreitler, C. W. Fault Control of Subsidence, Houston, Texas. Ground Water, 15, 1977, p. 203-214.
Keyword(s): geologic features, hydrology
Location(s): Texas, United States

Krey, T. C. In-Seam Seismic Exploration Techniques. IN: Coal Exploration, Proceedings 1st International Symposium, Miller Freeman, San Francisco, CA, 1976, p. 227-235.
Keyword(s): roof stability, seismic, coal mining

Kripakov, N. P. Numerical Modeling Applied to Simulating Cutter Roof Failure in Underground Coal Mines. IN: Proceedings, 3rd Conference on Ground Control Problems in the Illinois Coal Basin, Mt. Vernon, IL, August 8-10, 1990, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 143-154.
This paper presents an overview of the application by the USBM of three unique numerical modeling techniques to analyze cutter roof problems in underground coal mines. Cutter roof failures are common in coal mines where the immediate roof is often composed of thin shale laminae exposed to high regional tectonic stress fields.
Keyword(s): roof stability, coal mining, modeling, roof support, finite element, roof bolting, geologic features, boundary element
Location(s): Pennsylvania, West Virginia, Illinois Coal Basin, Appalachian Coal Region, Rocky Mountain Coal Region, United States

Krishna, R., B. N. Whittaker. Floor Lift in Mine Roadways--Recent Investigations and Modern Methods of Control. Colliery Guardian, November, 1973, p. 396-402.
Keyword(s): mine operation, floor stability

Krishna, R. Progress in Ground Control Instrumentation. IN: Proceedings, International Symposium on Underground Engineering, New Delhi, India, B. Singh, ed., April 14-17, 1988, Balkema, Rotterdam, p. 83-89.
The author studied the mechanics of subsurface deformation caused by caving of the extracted area in a mine in the Ranigunj Coalfield. The earlier research findings indicate that the surface subsidence takes place as a result of deformation in underground and intervening strata. The paper describes some of the instruments being used in this project for study of the above phenomena, along with a few of the latest ones that are currently being developed to provide basic data for designing safe and economical underground structures.
Keyword(s): coal mining, monitoring design, monitoring equipment, overburden, instrumentation, remote sensing, seismic
Location(s): India

Kulhawy, F. H. Geomechanical Model for Rock Foundation Settlement. IN: Proceedings, ASCE, Journal of the Geotechnical Engineering Division, v. 104, GT2, February 1978, p. 211-227.
Keyword(s): foundations, geotechnical, engineering, modeling
Location(s): United States

Kumar, R., N. C. Saxena, B. Singh. Measurement of Horizontal and Vertical Movements on the Surface Caused by Mining Excavations. Journal of Engineering Geology, v. 7, no. 1, 1975, p. 429-436.
Keyword(s): monitoring equipment, modeling, horizontal displacement, vertical displacement, monitoring methods

Kumar, R., N. C. Saxena, B. Singh. A New Hypothesis for Subsidence Prediction. Journal of Mines, Metals and Fuels, 1983, p. 459.
Keyword(s): prediction

Kumar, S. R., B. Singh. Investigations on Surface Subsidence in Mine No. 1. Central Mining Research Station, Dhanbad, Bihar, India, Research Paper 34, May, 1967, 17 p.
Keyword(s): coal mining
Location(s): India

Kumar, S. R. Mine Subsidence Investigations Over a Longwall Working and the Prediction of Subsidence Parameters for Indian Mines. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 10, 1973, p. 151-172.

Results of subsidence investigations over the workings of a longwall panel, above which two old workings were present are described in this paper. These results provide a typical example of subsidence behavior in Indian mines. The comparison of observed and calculated subsidence parameters and their conformity with the authors' equations are discussed for this particular case in detail. Three other case histories are also briefly described to demonstrate the suitability of the authors' approach for the prediction of subsidence effects in Indian mines.

Keyword(s): active mines, abandoned mines, longwall, prediction, multiple-seam extraction

Location(s): India

Kumar, S. R., B. Singh, K. N. Sinha. Subsidence Investigations in Indian Mines. IN: Proceedings, 4th Annual Symposium on Subsidence in Mines, Wollongong, Australia, February 20-22, 1973, A.J. Hargraves, ed., Australasian Institute Mining & Metallurgy, Illawarra Branch, Paper 6, p. 6-1 - 6-8.

The subsidence behavior in Indian coal mines indicates smaller values of the angle of draw, small values of maximum subsidence and the distribution of subsidence over smaller surface area over the worked out area. The reasons for these special effects may be the hard nature of overlying strata and small areas of working in individual panels. Mines were worked on the bord-and-pillar system, the longwall system, the French method of working thick seams, the knife edge system of extraction pillars on a longwall basis (Russian method) and by a partial extraction system. Some workings were stowed with sand and some were caved.

Keyword(s): coal mining, stowing, room-and-pillar, longwall, pillar extraction, angle of draw, overburden, geologic features, vertical displacement, horizontal displacement

Location(s): India

Kusznir, N. J., D. Ashwin, A. Bradley. Mining Induced Seismicity in the North Staffordshire Coalfield, England. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 17, no. 1, February, 1980, p. 45-55.

Mining induced seismicity associated with longwall coal extraction in North Staffordshire, England, was investigated in order to establish the cause and mechanism of the seismicity. The study shows that seismicity is directly caused by active mining with earth tremor hypocentres moving in unison and in advance of the face. The seismicity does not appear to be directly associated with any of the major faults bounding the mined area.

Keyword(s): seismic, coal mining, rock mechanics, longwall, geologic features, monitoring methods

Location(s): England

Kusznir, N. J., K. R. Whitworth. Use of Synthetic Fracture Logs Derived from Borehole Geophysics to Assess Mine Roof and Floor Quality. International Journal Mining Engineering, October, 1983, p. 253-260.

Keyword(s): roof stability, floor stability, geophysical

Kusznir, N. J., K. R. Whitworth, K. Atkinson, R. Brassington. Experience in the Application of RocTec, a New Method of Obtaining Rock Quality Data from Borehole Geophysical Logs. IN: Extractive Industry Geology Conference, Warwick, England, March 1983, Institution of Geologists, London, p. 69-95.

This paper describes a method to aid prospecting for and evaluation of non-metallic rocks and minerals.

Keyword(s): overburden, geophysical, rock mechanics, geotechnical, non-metal mining

Location(s): England

Kuti, J. Mining Engineering Aspects of Longwall System Parameters in North America. Coal Mining Institute of America, December 11, 1969.

The development of longwall systems designs in the U.S. is compared to the European experience.

Keyword(s): coal mining, longwall, mine design

Location(s): United States, Europe

Kuti, J. Engineering Approaches to Rock Mechanics Problems in Longwall Mining. AIME Preprint No. 71-F-340, 1971.

Problems with longwall mining in the United States are discussed, including the effects of shallow workings and roof control.

Keyword(s): coal mining, roof stability, roof support, longwall, mine design, geologic features

Location(s): United States

Kuti, J. Longwall vs. Shortwall Systems. American Mining Congress Journal, August 1975, p. 24-33.

Keyword(s): longwall, shortwall, mine design, ground control, roof support, coal mining

Kuti, J. Longwall Mining in America. Society of Mining Engineers Preprint 78AU336, September, 1978.

Keyword(s): longwall

Location(s): United States

Kuti, J. Longwall Mining in America. Mining Engineering, November 1979, p. 1593-1602.

This article covers the historical background of longwall mining, general statistics for the United States and other countries, state of the art, development trends, and forecasts longwall systems of the future. The author states that immediate development will be determined by the need to comply with health and safety regulations without sacrificing production.

Keyword(s): longwall, coal mining, mine operation

Location(s): United States

Laage, L. W. The Development of Guidelines for Closing Eastern Underground Coal Mines. M.S. Mining Engineering thesis, Michigan Technological University, Houghton, 1982, 132 p.

Coal production from underground mines has been important to the development of the industrial economy of the United States. Environmental problems including subsidence have developed from some abandoned operations. The undesirable present-day situations could have been avoided or at least minimized by varying certain mining practices or mine closure procedures.

Keyword(s): coal mining, abandoned mines, active mines, mine waste, mine fires, mine operation, law, government, surface structural damage, surface water, reclamation

Location(s): Ohio, Illinois, United States

Lacey, R. M. Damage Resulting from Coal Mine Subsidence. Citizen Participation and Attitudes as a Guide to Governmental Action. M.S. Thesis, Southern Illinois University at Edwardsville, February, 1978.

The purpose of this paper is to provide some information and guidance for those decision-makers and the public who may at some point in the future be faced with subsidence problems. An incident is recounted where subsidence was occurring and adjustments to the problem were sought.

Keyword(s): surface structural damage, coal mining, abandoned mines, literature search, government, historical, foundations, construction, land-use planning, law, insurance, hydraulic backfilling

Location(s): Illinois, Illinois Coal Basin, United States

Lacey, W. D., H. T. Swain. Design for Mining Subsidence. Architecture Journal, October 10, 1957, v. 126, no. 3287, p. 557-570.

Keyword(s): architecture, coal mining, construction, engineering, foundations

Location(s): England

Lacey, W. D., H. T. Swain. The Development of the Notts System of Construction. Architecture Journal, October 24, 1957, v. 126, no. 3288, p. 631-636.

Keyword(s): construction, architecture, engineering, foundations

Location(s): England

Lacey, W. D., H. T. Swain. Three Nottinghamshire Schools. Architecture Journal, v. 129, no. 3348, 1960, p. 651-668.

Keyword(s): architecture, coal mining, foundations

Lackington, D. W., B. Robinson. Articulated Service Reservoirs in Mining Subsidence Areas. Journal of the Institution of Water Engineers, v. 27, 1973, p. 197-215.

Keyword(s): surface water

Laird, R. B., A. L. Amundson, G. J. Colaizzi, L. M. Bithell. Geologic Conditions Affecting Coal Mine Ground Control in the Western United States. U.S. Bureau of Mines OFR 63-86, Goodson and Associates, Inc., Denver, CO, December, 1985, 200 p. (NTIS PB86-217171/WNR)

An investigation was conducted into geologic features affecting coal mine ground control in western underground coal mines. The study involved a literature search. Data on mining operations were collected by interviewing mining and research personnel. Selected mines were toured within 10 coalfields in Utah and Colorado.

Keyword(s): literature search, ground control, roof stability, geologic features, coal mining

Location(s): Utah, Colorado, Rocky Mountain Coal Region, United States

Lama, R. D., P. Moxon, D. M. Shu. Prediction of Subsidence Due to Longwall Mining at West Cliff Colliery. IN: Proceedings, Symposium on Ground Movement and Control Related to Coal Mining, Illawarra, Australia, August, 1986, N.I. Aziz, ed., Australasian Institute of Mining and Metallurgy, p. 311-323.

Subsidence profiles at West Cliff colliery, in the Illawarra coal measures, Australia, have been predicted by three methods, the NCB empirical method, Salustowicz's profile functions, and the method of superposition of critical subsidence profiles. A method of predicting maximum subsidence using local data is also presented. Results are also compared with field measurements for the first four longwall panels. Strata movements above the extracted longwalls are also discussed.

Keyword(s): coal mining, longwall, prediction, prediction theories, National Coal Board, empirical model, profile function, survey data processing, overburden, active mines

Location(s): Australia

LaMoreaux, P. E., J. G. Newton. Catastrophic Subsidence: An Environmental Hazard, Shelby County, Alabama. Environmental Geology Water Science 8, 1986, p. 25-40.

Keyword(s): geologic features, hydrology
Location(s): Alabama, United States

LaMoreux, P. E. Catastrophic Subsidence, Shelby County, Alabama. IN: Sinkholes: Their Geology, Engineering and Environmental Impact, Proceedings 1st Multidisciplinary Conference on Sinkholes, Orlando, October 15-17, B.F. Beck, ed., 1984, Balkema, Rotterdam, p. 131-136.
Recent subsidence and collapse of the land surface in at least three areas underlain by carbonate rocks in Alabama have dramatically demonstrated the need for greater understanding of the causative mechanisms involved. Buildings, highways, utility lines, oil and gas pipelines, and constructions of all types are threatened by these collapses. This paper describes some of the remote sensing methods used to investigate this problem.
Keyword(s): geologic features, remote sensing, photography, hydrology
Location(s): Alabama, United States

Land, L. F., C. A. Armstrong. A Preliminary Assessment of Land-Surface Subsidence in the El Paso Area, Texas. Water-Resources Investigations Report No. WRI 85-4155, 1985, U.S. Geological Survey, Denver, CO, 96 p.
Keyword(s): surface subsidence damage, fluid extraction
Location(s): Texas, United States

Landes, K. K., T. B. Piper. Effect Upon Environment of Brine Cavity Subsidence at Grosse Isle, Michigan. Solution Mining Research Institute Report SMRI 72-0003, 1971, 55 p.
Keyword(s): non-metal mining, environment
Location(s): Michigan, United States

Landes, K. K. Recent Subsidence Hamilton County, Kansas. Association Petroleum Geologists Bulletin, v. 15, no. 6, 1978, p. 708.
Keyword(s): Kansas, United States

Landsberg, H. Recording of Roof Subsidence. Transactions, AIME, v. 119, 1936, p. 139-149.
Keyword(s): instrumentation, roof stability

Lane, W. T., J. H. Roberts. The Principles of Subsidence and the Law of Support. Alfred A. Knopf, Ltd., London, 1929, 311 p.
This book gives the English mining officials' and technicians' viewpoints at the time (1929) of legal questions regarding subsidence.
Keyword(s): ground control, descriptive theories, law
Location(s): England

Lang, T. A. Rock Mechanics Considerations in Design and Construction. IN: Proceedings 6th Symposium on Rock Mechanics, University of Missouri-Rolla, October, 1964, E.M. Spokes and C.R. Christiansen, eds., p. 561-605.
This paper emphasizes general considerations and fundamental principles rather than detailed procedures. In most cases, the latter must be developed to meet the needs and requirements of each job and site.
Keyword(s): rock mechanics, mine design, geologic features, lab testing, in situ testing, geotechnical

Langland, R., D. Fletcher. Predicting Subsidence Over Coal Gasification Sites. UCID-17326, Lawrence Livermore Laboratory, 1976, Livermore, CA.
Keyword(s): prediction, coal gasification

Lansdown, R. F. The Development of Pneumatic Stowing in the South Wales Coalfield. Transactions, Institute of Mining Engineers, v. 108, 1948, p.512.
Keyword(s): pneumatic backfilling, coal mining
Location(s): Wales

Larson, M. K., T. L. Pewe. Origin of Land Subsidence and Earth Fissuring, Northeast Phoenix, Arizona. Bulletin Association of Engineering Geologists, 23, 1986, p. 139-165.
Keyword(s): geologic features, engineering
Location(s): Arizona, United States

LaScola, J. Aerial Measurement of Mining Subsidence. MinTech '90: The Annual Review of International Mining Technology and Development, 1990, T.L. Carr, ed., Sterling, p. 67-70.
Keyword(s): remote sensing, surface subsidence damage, monitoring methods
Location(s): United States

LaScola, J. C. Comparison of Aerial and Ground Surveying of Subsidence Over an Active Longwall. U.S. Bureau of Mines RI 9214, 1988, 12 p.
The USBM repeatedly surveyed a grid of monuments over an active longwall mine panel in southwestern Pennsylvania during a 1-year period. Both conventional ground surveying techniques and photogrammetry were used. The objective of this investigation was to compare elevation measurements of subsidence obtained from aerial and

ground survey methods under dynamic ground conditions. The results of a statistical analysis of the survey data show that the mean of the differences between 372 matched pairs of elevation measurements was 0.20 foot (61 mm) with a 95% confidence interval of 0.05 foot (15 mm). The mean of the absolute values of the differences was 0.38 foot (116 mm) with a 95% confidence interval of 0.04 foot (12mm). Ninety-five percent of the absolute values of the differences were less than 1.11 feet (338 mm).

Keyword(s): monitoring methods, monitoring equipment, monitoring installation, survey methods, survey equipment, survey design, remote sensing, horizontal displacement, vertical displacement, photography, longwall, active mines, coal mining

Location(s): Pennsylvania, Appalachian Coal Region, United States

Laubscher, D. H., H. W. Taylor. The Importance of Geomechanics Classification of Jointed Rock Masses in Mining Operations. IN: Proceedings Symposium on Exploration for Rock Engineering, Johannesburg, November, 1976.

Keyword(s): rock mechanics, geologic features

Location(s): South Africa

Lautsch, H. Principles of the Theoretical Prediction of Ground Movements--Comparison with Practical Results and the Task of the Mining Surveyor in the Application of These Predictions. IN: Proceedings 1st Canadian Symposium on Mining Surveying and Rock Deformation Measurements, 1969, University of New Brunswick, Fredericton, p. 293-324.

Keyword(s): prediction, survey methods

Lautsch, H. Die Erweiterte Trogtheorie Zur Deutung Bergbaulich Bedingter Bodenbewegungen (Interpretation of the Ground Subsidence, Caused by the Mining Exploitation, by Means of the Expanded Trough Theory). Glueckauf-Forschungshefte, v. 35, no. 5, October 1974, p. 167-173.

Keyword(s): prediction theories

Lawson, J., A. Winstanley. The Working of Seams in Proximity. Transactions, Institution of Mining Engineers, v. 83, 1931-32, p. 176-190; discussion, v. 84, 1932-33, p. 43-49 and 324-325.

Keyword(s): multiple-seam extraction, longwall, coal mining

Leavitt, B. R., J. F. Gibbens. Effects of Longwall Coal Mining on Rural Water Supplies and Stress Relief Fracture Flow Systems. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 228-236.

The response of 174 domestic water supplies to longwall mining of the Pittsburgh coal seam was compared to various physical parameters. Sixty-four percent of domestic water supplies returned to service without the need for intervention, while 36% required intervention to reestablish a suitable water supply. Domestic well response is strongly correlated with the topographic setting. Valley wells showed the least effect while hilltop wells showed the greatest effect.

Keyword(s): hydrology, subsurface water, longwall, coal mining, modeling

Location(s): Pennsylvania, Ohio, West Virginia, Appalachian Coal Region, United States

Ledvina, C. T., C. W. Shabica, R. V. Sachs, K. Webb. Mining Geology of Secondary Paleo-channels Affecting the Herrin (No. 6) and Springfield (No. 5) Coals of Illinois. IN: Proceedings 2nd Conference on Ground Control Problems in the Illinois Coal Basin, May 1985, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 9-18.

The deposition of the Herrin and Springfield Coals and overlying strata was closely tied to primary (major), easily mappable paleo-channel systems such as the Walshville Channel and fill, herein named the Walshville Sandstone, and the Galatia Channel and fill, herein named the Galatia Sandstone. Because of this genetic relationship, primary channels have profound effects on the geology of coal, roof, and floor. Primary paleo-channel systems have been extensively mapped, and mines can be planned and operated to avoid them. Less obvious and predictable, however, are secondary paleo-channels. Secondary channels may be related to primary systems as tributaries or distributaries and occur frequently where mines operate or are contemplated. These channels almost always adversely affect mining by disrupting the continuity of coal, roof, or floor.

Keyword(s): coal mining, geologic features, mine design, ground control

Location(s): Illinois, Illinois Coal Basin, United States

Lee, A. J. The Effect of Faulting on Mining Subsidence. The Mining Engineer, v. 125, no. 71, August, 1966, p. 735-745.

This paper is a record of a preliminary investigation of the effects of faulting on mine subsidence. A summary is given of the results obtained from a detailed survey of a selected area. These results indicate that faults are more important than generally thought. An analysis of the results is made and tentative rules are advanced for the prediction of movement in simplified cases.

Keyword(s): overburden, geologic features, prediction, survey methods

Lee, F. T., J. F. Abel, Jr. Subsidence from Underground Mining: Environmental Analysis and Planning Considerations. U.S. Geological Survey Circular 876, 1983, 28 p.

Subsidence is potentially severe in damage to surface utilities and structures, changes in water conditions, and effects on vegetation and animals. To develop prediction methods and models for the United States, more information is needed on magnitude and timing of ground movements and geologic properties.

Keyword(s): environment, land-use planning, hydrology, time factor, prediction, modeling, utilities, surface water, subsurface water, geologic features, wildlife

Location(s): New Mexico, Wyoming, Rocky Mountain Coal Region, Pennsylvania, West Virginia, Appalachian Coal Region, United States

Lee, K. L., M. E. Strauss. Prediction of Horizontal Movements Due to Subsidence Over Mined Areas. IN: Land Subsidence, Proceedings International Symposium, September 14-18, 1969, Tokyo, IAHS Publication 89, v. 2, 1969, p. 512-522.

This paper reviews qualitative and quantitative interrelations among vertical subsidence, geological conditions, and resulting horizontal movements. It includes a case history of horizontal movements occurring over a sulfur mining area.

Keyword(s): vertical displacement, horizontal displacement, prediction, finite element, non-metal mining, geologic features

Lee, K. L., C. K. Shen. Horizontal Movements Related to Subsidence. ASCE Journal Soil Mechanics & Foundations Division, v. 69, no. SM1, 1969, p. 139-166; v. 96, no. SM4, 1970, p. 1464-1466.

This paper reviews cases involving compressible foundations to illustrate the extent of subsidence. Analytical methods and experimental studies are used to investigate mechanisms of horizontal movement. An earth dam constructed on a compressible foundation is used as an example of predicted horizontal movements.

Keyword(s): horizontal displacement, soil mechanics, prediction, foundations

Lee, P. A., W. F. Kane, E. C. Drumm, R. M. Bennett. Investigation and Modeling of Soil-Structure Interface Parameters. IN: Proceedings Congress on Foundation Engineering, Evanston, IL, June 25-29, 1989, F.H. Kulhawy, ed., ASCE, p. 580-587.

Keyword(s): foundations, soils, modeling, engineering

Location(s): United States

Lee, P. H. Interface Parameters for Earth-Structure Interaction During Mining-Induced Subsidence. M.S. Thesis, University of Tennessee, Knoxville, December, 1989, 111 p.

This investigation examines the technique of placing various materials under foundations to reduce friction. A hyperbolic model, in order to allow future numerical analyses, is presented to characterize this type of interface behavior. A series of direct shear tests were performed on various interface combinations of soil and construction materials. The interfaces were tested over a range of normal stresses, which includes the typical stresses to which a residential or light commercial facility foundation might be subjected. For each interface combination, shear strength, shear stiffness, and hyperbolic model parameters were determined.

Keyword(s): surface structural damage, structural mitigation, foundations, modeling, soils, coal mining, active mines, lab testing

Location(s): Illinois, Illinois Coal Basin, United States

Lee, R. D. Testing Mine Floors. Colliery Engineering, v. 38, no. 448, 1961.

Keyword(s): floor stability, in situ testing

Leeman, E. R. The Measurement of Stresses in Rock. (a) Part I: The Principle of Rock Stress Measurements; (b) Part II: Borehole Rock Stress Measuring Instruments; (c) Part III: The Results of Some Rock Stress Investigations. Journal South African Institute Mining & Metallurgy (a) September 1964, p. 45-81; (b) September 1964, p. 82-114; (c) November 1964, p. 254-284.

Keyword(s): ground control, instrumentation, rock mechanics, in situ testing

Location(s): South Africa

Leeman, E. R., W. L. Van Heerden. Stress Measurements in Coal Pillars. Colliery Engineering, pt. 1, December 1963; pt. 2, January 1964.

These articles present data obtained from borehole stress measurements in coal pillars.

Keyword(s): coal mining, instrumentation, monitoring methods, pillar strength, in situ testing

Legget, R. F. Duisberg Harbor Lowered by Controlled Coal Mining. Canadian Geotechnical Journal, v. 9, no. 4, 1972, p. 374-383.

Mining operations led to the successful lowering of the Duisberg Harbor and associated industrial facilities. Subsurface geological conditions, planning, and mining operations are outlined, and results described in detail.

Keyword(s): hydrology, surface water, subsurface water, coal mining

Lehr, J. What's All the Fuss About Longwall Mining? Water Well Journal, February 1989, p. 4-5.

Found on the Editor's Page, this article describes the longwall mining process and its effects on surface and subsurface hydrology. According to the author, in most cases, the net hydrogeological result of longwall mining is increased permeability, transmissibility, and specific capacities of wells as a result of the increases in secondary fracturing. Surface hydrology is less commonly affected, though local springs may experience moderate decreases or increases in flow. With few exceptions, what amounts to massive hydrofracturing of the shallow formations yields an improved groundwater system. For the most part, negative impacts are easy to remedy.

Keyword(s): surface water, subsurface water, hydrology, coal mining, longwall, overburden, geologic features, mine safety, surface structural damage

Location(s): United States

Leighton, M. W. Coal Research at the Illinois State Geological Survey. IN: Proceedings Illinois Mining Institute, 1986, p. 20-45.

This paper discusses coal research program at the ISGS in terms of present and future needs.

Keyword(s): coal mining, environment, geologic features

Location(s): Illinois, Illinois Coal Basin, United States

Lenge, A. Inspection and Correction of Damage to Railways Caused by Mining in the Saar. IN: Proceedings, European Congress on Ground Movement, Leeds, England, April 9-12, 1957, London Harrison, p. 106-114.

This paper describes the subsidence damage to railroads in the Saar mining region; repair methods used are also detailed.

Keyword(s): surface structural damage, railroads

Location(s): Europe

Leonhardt, J. Bessere Standfestigkeit Von Grubenbauen Durch Markscheiderische Messungen (Improved Stability of Workings by Measurements by Mine Surveyors). Glueckauf-Forschungshefte, v. 110, no. 24, December 1974, p. 1027-1029.

Keyword(s): survey methods

Lepper, C. M., F. Ruskey. High Resolution Seismic Reflection Techniques for Mapping Coal Seams from the Surface. U.S. Bureau of Mines, Coal Mine Health and Safety Program, TPR 101, 1976, 17 p.

Keyword(s): roof stability, ground control, seismic, coal mining, geologic features, mine safety

Location(s): United States

Leshendok, T. V. Geologic Factors Related to Surface Subsidence Due to Underground Coal Mining. IN: Proceedings, 41st Annual Meeting American Society of Photogrammetry, Boulder, CO, March 6-8, 1975, p. 21-22.

Keyword(s): geologic features, coal mining, surface subsidence damage

Location(s): United States

Leshendok, T. V., R. V. Amato, O. R. Russell. Remote Sensing Applied to Mine Subsidence: Experience in Pennsylvania and the Midwest. IN: Proceedings 41st Annual Meeting of American Society of Photogrammetry, Boulder, CO, March 6-8, 1975, p. 298-307.

Keyword(s): remote sensing, coal mining

Location(s): Pennsylvania, Appalachian Coal Region, United States

Leting, H. The Law Governing Dynamic Subsidence, Tilts and Curvatures Over a Working Face During Mining. IN: Ground Movements and Structures, Proceedings 4th International Conference, University of Wales College of Cardiff, July 8-11, 1991, J.D. Geddes, ed., Pentech Press, London, 1992, p. 209-222.

This paper discusses the laws governing dynamic subsidence, tilt, and curvature during mining, as opposed to the final, fully developed subsidence trough. A series of problems such as

the distribution of ground movements and their derivatives, their maximum values, and the laws covering the locations of these maxima, still await resolution. Based on data from stations set up for ground movement observations at Zijuang mine, a preliminary analysis and discussion are presented of the laws governing the subsidence, tilts, and curvatures of a half subsidence trough directly over the face, before it is subjected to the dynamic effect brought about by a critical or a supercritical area of extraction.

Keyword(s): horizontal displacement, vertical displacement, survey data processing

Location(s): China

Leung, A., J. W. Mahar, S. S. Huang, M. D. Boscardin. Mine Subsidence at the Northland Drive - Southland Court Area, Belleville, Illinois; Progress Report, June 30 to 1981 to May 31, 1982. Illinois Abandoned Mined Lands Reclamation Council, 1983, 41 p.

Keyword(s): surface structural damage, coal mining, abandoned mines

Location(s): Illinois, Illinois Coal Basin, United States

Levy, E. Rock Filling at Rio Tinto. Engineering and Mining Journal, v. 89, 1910, p. 363.

This article describes hand stowing in a Spanish copper mine for roof control, due to the limited availability of timber.

Keyword(s): stowing, historical, metal mining, roof support

Location(s): Spain

Lewis, B. C. Longwall Mining: Future Concerns That Must Be Addressed. Mining Engineering, October, 1990, p. 1170-1171.

This article lists present trends in the coal mining industry. Also, responses to an industry questionnaire regarding technological needs are given, with the number one category being subsidence-groundwater issues.

Keyword(s): longwall, hydrology, mine operation, coal mining, law

Location(s): Illinois, Illinois Coal Basin, United States

Lewis, R., A. Clark. Elements of Coal Mining. 3rd Edition, McGraw-Hill, New York, 1966.

This text is designed to acquaint mining students with the entire spectrum of mine-related activities, both coal and metal. Several chapters deal with the support of mining excavations, coal mining methods, and rock mechanics.

Keyword(s): coal mining, metal mining, rock mechanics, mine design, mine operation

Liebenburg, A. C. Building on Undermined Ground. South African Mining Engineering Journal, v. 81, no. 4038, June 26, 1970, p. 179, 181-183.

Keyword(s): construction, engineering, land-use planning

Location(s): South Africa

Lin, P. M., S. M. Hsiung, S. S. Peng. Investigation of Subsidence of AML: A Case Study. IN: Proceedings 6th International Conference on Ground Control in Mining, June 9-11, 1987, S.S. Peng, ed., West Virginia University, Morgantown, p. 249-257.

This paper describes the approach employed for the determination of abandoned mine subsidence. A site investigation was made first. According to the information obtained from the site investigation, a hypothesis was set up. Then instrumentation was used to prove the hypothesis. By going through the procedures for several cases, a guideline which can be used by the inspectors to inspect abandoned mine subsidence will be established.

Keyword(s): abandoned mines, coal mining, roof stability, floor stability, surface structural damage, bituminous, instrumentation

Location(s): Pennsylvania, Appalachian Coal Region, United States

Lin, P. M., S. S. Peng. Surface Damage Due to Longwall Mining--A Case Study. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 519-526.

A subsidence monitoring program over a longwall panel was established to explore the impacts of dynamic subsidence on the ground surface and structures and to correlate the movements between the structures and their corresponding points on the ground. The program consisted of a transverse line survey and a series of survey points around the structures on the ground surface and their corresponding survey points on the exterior walls of the structures.

Keyword(s): longwall, monitoring methods, surface structural damage, survey methods, vertical displacement, coal mining

Location(s): West Virginia, Appalachian Coal Region, United States

Lin, P. M., S. S. Peng, P. Tsang. Abatement Optimization of Abandoned Mine Land Subsidence. SME Preprint No. 90-165, for presentation at the SME Annual Meeting, Las Vegas, NV, February 26-March 1, 1990, 5 p.

This paper presents an overall stabilization method to eliminate the potential of reoccurrence of subsidence over abandoned mine lands. The method considers column grouting at the specific locations inside the subsidence influence areas including the destressed and stress concentration zones instead of grouting around and beneath the damaged structures. The conditions of stress distribution in the strata before and after grouting can be calculated using the finite element method.

Keyword(s): abandoned mines, grouting, finite element, land-use planning, surface structural damage

Location(s): Pennsylvania, Appalachian Coal Region, United States

Lin, P. M., S. S. Peng, P. Tsang. Dealing with Subsidence on Abandoned Mine Lands. Mining Engineering, November 1990, p. 1245.

Column grouting is a common method being applied to remedy a small-scale abandoned mine subsidence. The advantages are that it is a simple operation and only a small amount of grouting material is used. However, this method may not be able to solve the long-term stability problem due to stress concentration. Subsidence will develop continuously if remedial measures are not provided. However, subsidence still may reoccur if the remedial measures do not take into account the stress concentration.

Keyword(s): grouting, abandoned mines, coal mining, surface structural damage, surface subsidence damage

Location(s): United States

Lin, P. N., S. M. Hsiung, S. S. Peng. Prediction of Abandoned Mines Trough Subsidence. IN: Proceedings Symposium on Evolution of Abandoned Mine Land Technologies, Riverton, WY, June 14-16, 1989, p. 17-35.

The objectives of this study were to develop techniques to locate the surface subsidence area and the underground failure zone, and to reconstruct the subsidence profile. These techniques will help to improve the effectiveness of the remedial program. The probability (influence) function method has been used to predict the subsidence profile and ground movements caused by longwall mining. The results show a fairly good agreement with the field data, especially for flat terrain. In this paper the method is extended to predict abandoned mine trough subsidence only. Sinkhole subsidence is not discussed.

Keyword(s): prediction, abandoned mines, structural mitigation, backfilling, influence function, modeling, surface structural damage, horizontal displacement, coal mining, room-and-pillar, longwall

Location(s): Illinois, Illinois Coal Basin, Pennsylvania, Appalachian Coal Region, United States

Lin, S., B. N. Whittaker, D. J. Reddish. Application of Asymmetrical Influence Functions for Subsidence Prediction of Gently Inclined Seam Extractions. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 29, no. 5, 1992, p. 479-490.

The principle of the asymmetrical influence function method using variable functional parameters is detailed for predicting subsidence induced by the extraction of gently inclined seams. Also dealt with are the fundamental parameters necessary for accurate subsidence prediction and their relations with the seam dip. Carefully calibrated with respect to the Subsidence Engineers' Handbook, the model is applied for subsidence analysis of some cases of coal fields from the United Kingdom in comparison with the measured data.

Keyword(s): influence function, prediction, coal mining, modeling, longwall, active mines, geologic features, National Coal Board

Location(s): United Kingdom

Lindstrom, P. Longwall Mining Results at the Radon Mine. Transactions SME-AIME, December, 1964, p. 397-400.

This article is in reference to longwall mining in a uranium mine in Utah. Surface surveys indicate an increase in surface elevation outside the margins of the extraction area. The author theorizes that a thick (135 to 220 feet) sandstone layer cantilevers.

Keyword(s): metal mining, longwall, survey data processing, survey methods, overburden

Location(s): Utah, United States

Listak, J. M., J. L. Hill III, J. C. Zelanko. Direct Measurement of Longwall Strata Behavior: A Case Study. U.S. Bureau of Mines RI 9040, 1986, 19 p.

This report describes a rock mechanics study conducted to monitor deformation of near-seam strata above a longwall panel in the Pittsburgh coalbed. The primary goal was to determine the

height of caving immediately behind advancing longwall face supports.

Keyword(s): rock mechanics, longwall, overburden, monitoring methods, coal mining

Location(s): Pennsylvania, Appalachian Coal Region, United States

Listak, J. M., J. L. Hill III, J. C. Zelanko. Characterization and Measurement of Longwall Rock Mass Movement. IN: U.S. Bureau of Mines IC 9137, Eastern Coal Mine Geomechanics, Proceedings Bureau of Mines Technology Transfer Seminar, Pittsburgh, PA, November 19, 1986, p. 12-26.

The USBM conducted a rock mechanics study to monitor deformation of near-seam strata above a longwall panel in the Pittsburgh Coalbed. The primary goal of this research was to determine the height of caving immediately behind advancing longwall face supports. This study, although site specific, provides information on the caving mechanism associated with longwall extractions so that strata behavior and its interaction with longwall face supports can be better understood.

Keyword(s): longwall, rock mechanics, overburden, roof support, coal mining, geologic features, geotechnical, lab testing, instrumentation, monitoring equipment, monitoring methods

Location(s): Pennsylvania, Appalachian Coal Region, United States

Listak, J. M., J. C. Zelanko. An Assessment of the Effects of Longwall Chain Pillar Configuration on Gate Road Stability. IN: Rock Mechanics, Proceedings of the 28th U.S. Symposium, June 29-July 1, 1987, I.W. Farmer, et al., eds., Tucson, AZ. Balkema, Rotterdam, p. 1083-1093.

The USBM conducted a study to assess the redistribution of mining induced stress associated with longwall panel extraction. The objective of this study was to assess the performance of various chain pillar configurations on gate road entry stability. To achieve this objective, field measurements were collected and analyzed to develop profiles of the stress redistribution occurring in the gate road chain pillars during longwall panel retreat mining.

Keyword(s): longwall, coal mining, ground control, instrumentation, pillar strength, yielding supports

Location(s): Pennsylvania, Appalachian Coal Region, United States

Littlejohn, G. S. Soil-Structure Interaction in Mining Areas with Particular Relevance to Horizontal Subgrade Restraint. Ph.D. Thesis, Department of Civil Engineering, University of Newcastle-upon-Tyne, 1966.

Keyword(s): surface structural damage, foundations, longwall

Littlejohn, G. S. Monitoring Foundation Movements in Relation to Adjacent Ground. Ground Engineering, v. 6, no. 4, 1973, p. 17-22.

Location(s): foundations, monitoring methods

Littlejohn, G. S. Observations of Brick Walls Subjected to Mining Subsidence. IN: Proceedings Conference on Settlement of Structures, Cambridge, April, 1974, John Wiley & Sons, New York, p. 384-393.

This paper describes a field experiment carried out at Peterlee New Town, County Durham. Brick walls with footings and footings without walls were built and monitored in order to make a detailed investigation of their behavior when subjected to mining subsidence.

Keyword(s): surface structural damage, construction, foundations, horizontal displacement, monitoring methods

Location(s): United Kingdom

Littlejohn, G. S. Old Coal Workings--A Cover-Up Job. Ground Engineering, v. 8, no. 1, January, 1975.

Keyword(s): abandoned mines, coal mining

Littlejohn, G. S. Consolidation of Old Coal Workings. Ground Engineering, v. 12, no. 4, May, 1979, p. 15-18, 20-21.

Bearing in mind the variety of coal mining methods and extraction patterns developed in Britain over the centuries, together with the present-day situation of these same workings in various states of deterioration or collapse, no one method of treatment can be recommended to satisfy all conditions.

Keyword(s): abandoned mines, coal mining, grouting, backfilling, National Coal Board, geologic features

Location(s): United Kingdom

Littlejohn G. S. Surface Stability in Areas Underlain by Old Coal Workings. Ground Engineering, v. 12, no. 2, 1979, p. 22-48.

Keyword(s): abandoned mines, coal mining, ground control

Littlejohn, G. S., J. M. Head. Specification for the Consolidation of Old Shallow Mine Workings. IN: Mineworkings 84: Proceedings, International Conference on Construction in Areas of Abandoned Mineworkings, Edinburgh, 1984, M.C. Forde, B.H.V. Topping, and H.W. Whittington, eds., Engineering Technics Press, p. 131-140.
Keyword(s): abandoned mines, coal mining, engineering

Litwiniszyn, J. The Differential Equation of Displacements of Rock Masses. Bulletin De L'Academie Polonaise Des Sciences, v. I, 1953, p. 38-40.
Keyword(s): modeling

Litwiniszyn, J. Applications of the Equations of Stochastic Processes to Mechanics of Loose Bodies. Archivum Mechanikik Stosowanej, v. 8, 1956, p. 393-411.
Keyword(s): modeling, empirical model, stochastic model

Litwiniszyn, J. The Theories and Model Research of Movement of Ground Masses. IN: Proceedings European Congress on Ground Movement, University of Leeds, England, April, 1957, p. 202-209.
This paper presents a series of differential equations to describe subsidence phenomena using the stochastic media approach. Mathematical and laboratory subsidence models are described and summarized.
Keyword(s): prediction, modeling, empirical model, stochastic model, mathematical model

Litwiniszyn, J. Fundamental Principles of the Mechanics of Stochastic Media. IN: Proceedings 3rd Congress on Theoretical and Applied Mechanics, Bangalore, 1957, p. 93-110.
Keyword(s): modeling, empirical model, stochastic model

Litwiniszyn, J. Time-Space Processes in Stochastic Media II. Bulletin de L'Academie Polonaise des Sciences, v. 7, 1959, p. 319-326.
Keyword(s): modeling, empirical model, stochastic model

Litwiniszyn, J. On a Certain Problem of Stochastic Bodies with Discontinuously Non-Homogeneous Properties. Bulletin de L'Academie Polonaise des Sciences, v. 7, 1959, p. 673-678.
Keyword(s): modeling, empirical model, stochastic model

Litwiniszyn, J., A. Z. Smolarski. On a Certain Solution of the Equation and its Application to the Problems of Mechanics of Loose Media. Bulletin de L'Academie Polonaise des Sciences, v. 10, 1962, p. 115-121.
Keyword(s): modeling, empirical model, stochastic model

Litwiniszyn, J. On Certain Linear and Non-Linear Strata Theoretical Models. IN: Proceedings 4th International Conference on Strata Control and Rock Mechanics, May 4-8, 1964, Henry Krumb School of Mines, Columbia University, New York, 1965.
The author reviews theoretical and experimental investigations conducted in the field of discontinuous media and their application to rock mechanics.
Keyword(s): modeling, rock mechanics, empirical model, stochastic model

Litwiniszyn, J. Remark Concerning the So Called "Point of the Attraction Centre" and its Connection with the Formation of the Subsidence Trough. Archiwum Gornictwa, v. 19, no. 3, 1974, p. 231-236.
Keyword(s): modeling, empirical model

Litwinowicz, L., K. Kazimierz. Effect of Mining Subsidence on Near Surface Underground Structures. IN: Strata Mechanics, Proceedings of the Symposium, University of Newcastle-upon-Tyne, April, 1982, I.W. Farmer, ed., Elsevier, New York, p. 220-222.
The effect on communication tunnels of horizontal tensile deformations perpendicular to the tunnel axis was examined, and a generalized hypothesis for vertical and horizontal pressures was developed.
Keyword(s): surface structural damage, vertical displacement, horizontal displacement, subsurface structural damage, utilities
Location(s): Poland

Litwinowicz, L. The Influence of Horizontal Expansion on Soil Strength in Mining Areas. IN: Ground Movements and Structures, Proceedings 3rd International Conference, University of Wales Institute of Science and Technology, Cardiff, 1984, J.D. Geddes, ed., Pentech, London, 1985, p. 397-403.

Extensional soil deformations are developed in the outer zone of mining depressions. When a mining face advances, soil near the surface first expands and then passes into a compression strain zone, adversely affecting foundation conditions and causing building damage in mining areas. One less recognized aspect of the problem is the extent of change in soil strength occuring in the outer zone.
Keyword(s): soils, soil mechanics, foundations, surface structural damage, active mines

Liv, B. S. Motion of Rock Masses Due to Advancing Exploitation But in Light of Theory of Stochastic Media. Bulletin, Academie Polonaise des Sciences, Serie des Sciences Techniques, v. 10, no. 4, 1962, p. 243-252.
Keyword(s): modeling, empirical model, stochastic model

Lizak, J. B., J. E. Semborski. Horizontal Stresses and Their Impact on Roof Stability at the Nelms No. 2 Mine. IN: Proceedings 4th Conference on Ground Control in Mining, West Virginia University, Morgantown, July 22-24, 1985, 7 p.
Keyword(s): roof stability, ground control, horizontal displacement

Lloyd, W. D. The Effect of Coal Mining On the Overlying Rocks and On the Surface. Transactions Institute of Mining Engineers, London, v. 57, 1918-19, p. 74-100.
Keyword(s): coal mining, subsurface subsidence damage, overburden, surface subsidence damage
Location(s): England

Lofgren, B. E. Near-Surface Land Subsidence in Western San Joaquin Valley, California. Journal Geophysical Research, v. 65, 1960, p. 1053-1062.
Keyword(s): fluid extraction
Location(s): California, United States

Lofgren, B. E. Measurement of Compaction of Aquifer Systems in Areas of Land Subsidence. U.S. Geological Survey Professional Paper 424-B, 1961, p. B49-B52.
Keyword(s): hydrology, subsurface water, fluid extraction
Location(s): United States

Lofgren, B. E. Land Subsidence in the Arvin-Maricopa Area, San Joaquin Valley, California. Geological Survey Research 1963, Professional Paper 475-B, U.S. Department of the Interior, p. B171-B175.
Keyword(s): fluid extraction
Location(s): California, United States

Lofgren, B. E. Land Subsidence Due to Artesian-Head Decline in the San Joaquin Valley, California. IN: Guidebook for Field Conference I, Northern Great Basin and California--International Association of Quaternary Research, 7th Congress, U.S.A., Nebraska Academy of Science, Lincoln, 1965, p. 140-142.
Keyword(s): fluid extraction, subsurface water
Location(s): California, United States

Lofgren, B. E. Subsidence Related to Ground Water Withdrawal. IN: Proceedings, 2nd Geologic Conference on Landslides and Subsidence, Los Angeles, CA, California Resources Agency, Sacramento, 1966, p. 97-104.
Keyword(s): fluid extraction
Location(s): California, United States

Lofgren, B. E. Analysis of Stresses Causing Land Subsidence. U.S. Geological Survey Professional Paper 600-B, 1968, p. B219-B225.
Keyword(s): fluid extraction, surface subsidence damage
Location(s): United States

Lofgren, B. E. Parameters Relating Subsidence to Water-Level Decline. Geological Society of America, Special Paper 101, (abstract), 1968, p. 125-126.
Keyword(s): fluid extraction
Location(s): United States

Lofgren, B. E., R. L. Klausing. Land Subsidence Due to Ground-Water Withdrawal, Tulare-Wasco Area, California. U.S. Department of the Interior, Geological Survey, Professional Paper 437-B, 1969, p. B1-B103.
Keyword(s): fluid extraction, subsurface water
Location(s): California, United States

Lofgren, B. E. Land Subsidence Caused by Water-Level Decline in Intermontane Basins. IN: Geological Society of America, Abstracts with Programs, pt. 5, 1969, p. 45-46.
Keyword(s): fluid extraction
Location(s): United States

Lofgren, B. E. Parameters for Estimating Future Subsidence. Geological Society of America, Special Paper 121, (abstract), 1969, p. 178-179.
Keyword(s): fluid extraction, prediction

Lofgren, B. E. Monitoring Ground Movement in Geothermal Areas. IN: Proceedings American Society Civil Engineers, Hydraulics Division Annual Special Conference, no. 21, 1973, p. 437-447.
Keyword(s): fluid extraction, monitoring methods

Lofgren, B. E. Land Subsidence and Fissuring Caused by Pumping Ground Water, Raft River Valley, Idaho. IN: Association Engineering Geologists, Annual Meeting, Program Abstracts, 1975, no. 18, p. 34.
Keyword(s): fluid extraction, subsurface water, hydrology
Location(s): Idaho, United States

Lofgren, B. E. Land Subsidence Due to Ground-Water Withdrawal, Arvin-Maricopa Area, California. U.S. Department of the Interior, Geological Survey Professional Paper 437-D, 1975, 55 p.
Keyword(s): fluid extraction, subsurface water
Location(s): California, United States

Lofgren, B. E. Land Subsidence and Aquifer-System Compaction in San Jacinto Valley, Riverside County, California; a Progress Report. U.S. Department Interior, Geological Survey Journal of Research, v. 4, 1976, p. 9-18.
Keyword(s): fluid extraction, hydrology
Location(s): California, United States

Lofgren, B. E. Hydrogeologic Effects of Subsidence, San Joaquin Valley, California. IN: Proceedings 2nd International Symposium on Land Subsidence, Anaheim, CA, IAHS-AIHS Publication No. 121, December, 1976, p. 113-123.
Keyword(s): hydrology
Location(s): California, United States

Logan, W. E. On the Character of the Beds of Clay Immediately Below the Coal Seams of South Wales; and On the Occurrence of Coal Boulders in the Pennant Grit of that District. IN: Proceedings Geological Society of London, v. 3, 1842, p. 275-277; also Transactions Geological Society London, v. 6, p. 491-498.
Keyword(s): floor stability
Location(s): United Kingdom

Lojas, J., A. Kidybinski, Z. Hladyysz. Working the Lower Lift of a Thick Seam Under the Caved Debris Reconsolidated with Waters from Drainage of Overburden Strata. IN: 6th International Strata Control Conference, Banff, Canada, September, 1977, p. 1-10.
Keyword(s): hydrology, subsurface water, overburden, ground control

Londong, D. Principles for the Planning and Design of Drainage Pumping Stations in Areas of Mining Subsidence. IN: Proceedings International Symposium on Fossil Fuel Production and Water Resources, 1976, 20 p.
Keyword(s): engineering, hydrology

Lonergan, M. J., R. P. Terry. Local and State Regulatory Powers Dealing with Land Use and Construction in Subsidence Prone Areas for the Commonwealth of Pennsylvania. Appalachian Regional Commission Report ARC-73-163-2557, 1975, 159 p. (NTIS PB 272 513)
Keyword(s): government, law, land-use planning
Location(s): Pennsylvania, United States, Appalachian Coal Region

Long, A. E., L. Obert. Block Caving in Limestone at the Crestmore Mine, Riverside Cement Company, Riverside, California. U.S. Bureau of Mines IC 7838, 1958, 21 p.
Keyword(s): non-metal mining
Location(s): California, United States

Longwall Forum. Industry Prevails in Recent Flannery Decision on Recharge Capacity. American Mining Congress Subsidence Network, v. 2, no. 2, October 1990.
A decision by Judge Thomas Flannery in the first round of litigation over regulations issued by OSM to implement the permanent regulatory program produced largely favorable results for the coal industry.
Keyword(s): law, government, active mines, subsurface water, longwall
Location(s): United States

Longwall Forum. Industry Blasts ELI Study on Subsidence. American Mining Congress Subsidence Network, v. 2, no. 2, October 1990.
This article reviews a study published in April 1990 by the Environmental Law Institute (ELI) called, "Environmental Regulation of Coal Mining--SMCRA's Second Decade."
Keyword(s): law, coal mining, active mines, longwall
Location(s): United States

Longwall Forum. Industry Succeeds in Limiting Accommodation Act. American Mining Congress Subsidence Network, v. 2, no. 2, October 1990.

As originally drafted, the Accomodation Act threatened to disrupt existing and future mining operations by requiring mineral developers to alter their operations to accommodate surface uses, regardless of cost.

Keyword(s): law, coal mining, active mines, longwall

Location(s): United States

Longwall Forum. Southern Ohio Coal Company--Winner of Reclamation Award. American Mining Congress Subsidence Network, v. 2, no. 2, 1990.

The Southern Ohio Coal Company earned an excellence in Surface Coal Mining and Reclamation Award for 1989 from OSM.

Keyword(s): coal mining, active mines, structural mitigation, reclamation, longwall

Location(s): Appalachian Coal Region, United States

Longwall Forum. Industry Panel Testifies at Hearings on Subsidence. American Mining Congress Subsidence Network, v. 2, no. 2, 1990.

The Mining and Natural Resources Subcommittee of the House Interior and Insular Affairs Committee held an oversight hearing on active mine subsidence June 28, 1990. From all indications, it appears that subsidence will be among the most significant issues of the 1990s.

Keyword(s): law, government, coal mining, active mines, longwall

Location(s): United States

Longwall Forum. Valid Existing Rights Rule on Separate Track. American Mining Congress Subsidence Network, v. 2, no. 2, 1990.

While the OSM apparently has shifted its focus on the subsidence rulemaking, a companion proposal to define the "valid existing rights" (VER) exception to the SMCRA Section 522(e) prohibitions appears to be proceeding on a separate, but parallel track.

Keyword(s): law, government, active mines, coal mining, longwall

Location(s): United States

Longwall Forum. OSM Shelves 522(e) Proposal; Commences Outreach on Subsidence. American Mining Congress Subsidence Network, v. 2, no. 2, 1990.

In the face of strong opposition from coal industry leaders and members of Congress, the OSM has shelved a proposal to apply the prohibitions in Section 522(e) of the Surface Mining Control and Reclamation Act of 1977 (SMCRA) to subsidence.

Keyword(s): law, government, subsurface water, surface structural damage, structural mitigation

Location(s): United States

Loos, W. The Occurrence of the Subsidence Trough in the Saar Coalfield. Mitteilungen aus dem Markscheidewesen, no. 5, v. 67, 1960, p. 264-265 (in German).

Keyword(s): coal mining

Lorig, L. J., R. D. Hart, M. P. Board, G. Swan. Influence of Discontinuity Orientations and Strength on Cavability in a Confined Environment. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., 1989, Balkema, Rotterdam, p. 167-174.

This paper presents the results of two- and three-dimensional distinct element analyses that show different conclusions than those reported from finite element studies. The distinct element method is selected for analysis of cavability because this method treats the rock mass as an assemblage of rock blocks that may interact individually. The results of the analyses are compared to a documented case history.

Keyword(s): rock mechanics, finite element, modeling, metal mining

Location(s): Canada

Louis, H. Compensation for Subsidence. Transactions Institute Mining Engineering, London, v. 59, 1920, p. 292-310; v. 60, 1920, p. 240-241.

Keyword(s): mine operation, surface subsidence damage

Louis, H. A Contribution to the Theory of Subsidences. Transactions Institute of Mining Engineers, London, v. 64, 1922, p. 257-273.

The article details the derivation of a subsidence prediction theory based upon Coulomb's theory of earth pressure.

Keyword(s): vertical displacement, prediction theories

Louis, H. The Theory of Subsidences. Colliery Guardian, January 5, 1923, p. 1215-1216.

The author says it is remarkable that subsidence, a subject of great importance to the mining industry, should have received such scanty attention in the literature. He propounds a general theory of subsidence, in hopes of helping mining companies deal with subsidence damage claims against them.

Keyword(s): coal mining, surface structural damage, surface subsidence damage, prediction, angle of draw

Location(s): United Kingdom

Louis, H. Subsidence From Mining. Mining and Metallurgy, v. 10, 1929, p. 130-131.

Louis, H. The Royal Commission on Mining Subsidence. Transactions AIME, v. 88, 1929, p. 135-143.

Keyword(s): government

Location(s): England

Lu, P. H. In-Situ Determination of Rock Properties and Strata Pressures. IN: Ground Control Aspects of Coal Mine Design, Proceedings, Bureau of Mines Technology Transfer Seminar, Lexington, KY, March 6, 1973, U.S. Bureau of Mines IC 8630, 1974, p. 28-34.

This paper presents several practical ways of determining geomechanical properties of coal measure strata and of determining strata pressures from in situ measurements. Emphasis is given to the basic concepts of measurement techniques and to the impact of measured results on safer and rational mine design and ground control.

Keyword(s): coal mining, overburden, mine design, ground control, in situ testing, active mines

Location(s): United States

Lu, P. H. Rock Mechanics Instrumentation and Monitoring for Ground Control Around Longwall Panels. IN: State-of-the-Art of Ground Control in Longwall and Mining Subsidence, September, 1982, Y.P. Chugh and M. Karmis, eds., SME-AIME, p. 159-166.

This report presents several practical and inexpensive types of rock mechanics instrumentation for ground control around longwall panels. Application of these critical parameters, determined by this instrumentation, to the design and modification of rational longwall-mining systems is also discussed.

Keyword(s): coal mining, rock mechanics, monitoring methods, ground control, longwall, instrumentation, mine design, monitoring equipment

Location(s): Utah, New Mexico, Rocky Mountain Coal Region, West Virginia, Appalachian Coal Region, Oklahoma, United States

Lu, P. H. Stability Evaluation of Retreating Longwall Chain Pillars with Regressive Integrity Factors. IN: Rock Mechanics for Resource Development, Mining and Civil Engineering, Proceedings 5th Congress International Society for Rock Mechanics, Melbourne, Australia, 1983, Balkema, Rotterdam, p. E 37-E 40.

Profiles of mining-induced loading and residual strength across a pillar vary with the position of the longwall face. The residual pillar-strength profile can be constructed on the basis of laboratory-determined triaxial compressive strength, in which the in situ measured horizontal pressure is considered as the constraint. The vertical-loading profile can be established with the measured vertical pressures. Vertical and horizontal pillar pressures can be measured with hydraulic borehole pressure cells. Defined as the ratio of the integrated total strength to the integrated total load under the profiles, the integrity factor is proposed here as a rational parameter for evaluating chain-pillar stability.

Keyword(s): longwall, coal mining, pillar strength, rock mechanics, geotechnical, lab testing, in situ testing, mine design, monitoring methods, monitoring equipment

Lubina, T. Praktyczny Sposob Wyznaczania Parametrow Teorii T. Kochmanskiego (Simplified Method for Determining the Parameters of the T. Kochmanski Theory). Przeglad Gorniczy, v. 29, no. 5, 1973, p. 196-200.

Keyword(s): prediction theories, modeling, empirical model, influence function

Lucas, J. R. Design Optimization in Underground Coal Systems. Interim Report, July-September 1977. Report on U.S. DOE Contract/Grant EX-76-C-01-1231, Virginia Polytechnic Institute and State University, Blacksburg, VA, December, 1977, 53 p. (NTIS FE-1231-10)

Continued work on the dependence of measured mechanical properties on sample size and shape and loading rate was described. Computer programs to simulate longwall mining, support loads, ground subsidence, etc., and to aid in longwall planning and equipment selection were developed. Body-loaded plastic longwall models were examined by photoelastic methods to validate computer programs. Roof truss supports were evaluated by a literature search, model studies, and the behavior of instrumented roof trusses installed in an Alabama coal mine.

Keyword(s): coal mining, active mines, longwall, computer, modeling, roof support, rock mechanics

Location(s): Alabama, United States

Lucas, J. R. Design Optimization in Underground Coal Systems. Interim Report, April--June 1978. Report on DOE Contract/Grant EX-76-C-01-1231, September, 1978, by Virginia Polytechnic Institute and State University, Blacksburg, 58 p. (NTIS FE-1231-13)

The mechanical properties of coal are reviewed with respect to sampling, size, and shape of samples, loading rate, etc. Longwall mining was investigated with respect to panel width, economic analysis, and ground subsidence. Roof truss supports were investigated by literature search and photoelastic models. All of these efforts included the development of extensive computer programs and field studies.

Keyword(s): coal mining, active mines, longwall, rock mechanics, economics, roof support, literature search, computer, modeling, backfilling, mathematical model, elastic model, roof bolting

Location(s): United States

Lucero, R. F. Use of Foaming Mud Cement to Terminate Underground Coal Fires and to Control Subsidence of Burn Cavities. Final Report to Office of Surface Mining, September 29, 1988, Colloidal Concrete Corporation, Golden, CO, 149 p. (NTIS PB89-223853)

Foaming mud cement (FMC) was developed at the Colorado School of Mines Research Institute for the purpose of addressing abandoned mine land problems. During a program sponsored by the OSM, the following significant developments were made: (1) the ability to effectively isolate buring coal from the available air by penetrating burning coal rubble with heat resistive FMC; and (2) the ability to encapsulate and isolate a wide range of coal particle sizes, resulting in permanent coal fire termination by air exclusion. The materials developed were specifically designed to terminate underground coal fires and prevent further subsidence.

Keyword(s): mine fires, abandoned mines, coal mining, reclamation, soils

Location(s): Wyoming, Colorado, Rocky Mountain Coal Region, Arizona, United States

Luckie, P. T., T. S. Spicer. Methods Employed for Underground Stowing (A Resume of a Literature Survey). Pennsylvania State University, College of Earth and Mineral Science Experiment Station, Coal Research Section, Special Report SR-55, February 28, 1966, 55 p.

Principles of backfilling as applied to underground mines are covered. This report discusses hand, mechanical, and pneumatic backfilling, and includes compressibility data for materials.

Keyword(s): pneumatic backfilling, stowing, literature search, lab testing

Location(s): Pennsylvania, Appalachian Coal Region, United States, Europe, England

Lundin, T. K., G. G. Marino, E. G. Wildanger, J. W. Mahar, A. L. Leung. Procedures for Responding to Hazardous Subsidence Induced Structural Damage Events. Subsidence Response Team Final Report, July 1980-June 1981, Illinois Abandoned Mined Lands Reclamation Council, Springfield, 128 p.

Keyword(s): surface structural damage, abandoned mines, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Luo, Y., S. S. Peng. CISPM--A Subsidence Prediction Model. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 853-860.

A PC-based computer model was developed by the authors for predicting surface subsidence due to underground coal mining. Its reliability, comprehensiveness and user friendliness demonstrate that it is a good tool for the mine operators, government agencies and scientific researchers alike.

Keyword(s): prediction, modeling, coal mining, geologic features, mathematical model, influence function, longwall, active mines, survey data processing

Luo, Y., S. S. Peng. A Mathematical Model for Predicting Subsidence Over Chain Pillars Between Mined-Out Longwall Panels. IN: Mine Subsidence - Prediction and Control, National Symposium, 33rd Annual Meeting, Association of Engineering Geologists, October 2-3, 1990, C.D. Elifrits, ed., Pittsburgh, PA, p. 247-257.

A model was developed for predicting subsidence over the chain pillars between two adjacent longwall panels. The development and application of the model are presented in this paper.

Keyword(s): prediction, longwall, modeling, pillar strength, overburden, mathematical model, coal mining

Location(s): Appalachian Coal Region, United States

Luo, Y., S. S. Peng. Mathematical Model for Predicting Final Subsidence Basin in Hilly Regions. IN: Mine Subsidence - Prediction and Control, National Symposium, 33rd Annual Meeting Association of Engineering Geologists, October 2-3, 1990, C.D. Elifrits, ed., Pittsburgh, PA, p. 223-231.

In this paper, a mathematical model is proposed for predicting surface movement and deformation induced by underground longwall mining in hilly regions. The development of this model is based on the principles of the influence function method.

Keyword(s): coal mining, longwall, mathematical model, influence function, horizontal displacement, vertical displacement

Luo, Y., S. S. Peng. Protecting a Subsidence Affected House: a Case Study. IN: Proceedings VIII Congress International Society for Mine Surveying, September 22-27, 1991, University of Kentucky, Lexington, UKY BU154, p. 297-300.

In this paper, a case of applying the CISPM code (a subsidence prediction model developed by the authors) in design and implementation of some mitigation techniques for protecting an old residence over a shallow longwall panel is illustrated.

Keyword(s): surface structural damage, structural mitigation, active mines, longwall, coal mining, modeling, prediction, foundations, horizontal displacement, vertical displacement

Location(s): United States

Luo, Y., S. S. Peng. Some New Findings from Surface Subsidence Monitoring Over Longwall Panels. Mining Engineering, October 1991, v. 43, no. 10, p. 1261-1264; also SME Annual Meeting preprint 91-150. Discussion by E. Arioglu, Mining Engineering v. 44, no. 8, August 1992, p. 1042-1044.

Several issues deserve further attention to improve subsidence prediction accuracy. These include subsidence initiation and development over a setup area; subsidence development after face stop; and subsidence over chain pillars. An intensive subsidence monitoring program has been carried out over several longwall panels. A large amount of subsidence data has been collected and analyzed, and solution techniques have been developed. In this paper, some of the measured data, data analysis techniques and the developed prediction models are presented.

Keyword(s): longwall, coal mining, modeling, mathematical model, prediction, survey data processing

Location(s): Appalachian Coal Region, Illinois, Illinois Coal Basin, Alabama

Luo, Y., S. S. Peng, D. Dutta. Some Mitigative Measures for Protection of Surface Structures Affected by Ground Subsidence. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 129-138.

Theoretical and analytical analyses of three mitigative measures (the plane fitting method, trenching, and tension cable) led to the development of a total protection plan to eliminate or reduce damages to residential structures subjected to surface movements caused by underground longwall mining. The protection plan was successfully applied to 12 residential houses and 2 external garages. This paper describes the methods employed for protection and results of those case studies.

Keyword(s): structural mitigation, surface structural damage, coal mining, longwall, active mines

Location(s): United States

Luxbacher, G. W. Subsidence Planning and Risk Assessment. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 100-105.

The inclusion of a new term "planned subsidence" in the Surface Mining and Reclamation Act of 1977 has led the coal mining industry into a new aspect of engineering: subsidence planning. Subsidence planning has necessitated the integration of geotechnical, civil, and mining engineering. This paper discusses the application of subsidence planning in several brief case studies (a high voltage transmission tower, a sewage treatment plant, and a slurry impoundment), emphasizing the risk assessment aspects necessary to account for some of the uncertainties that may exist.

Keyword(s): law, engineering, mine design, coal mining, utilities, prediction, surface structural damage, structural mitigation, longwall, active mines

Location(s): Virginia, West Virginia, Appalachian Coal Region, United States

Luza, K. V. Stability Problems Associated with Abandoned Underground Mines in the Picher Field, Northeastern Oklahoma. Oklahoma Geological Survey Circular 88, University of Oklahoma, Norman, 1986, 114 p.

Approximately 2,540 acres are underlain by underground lead-zinc mines in northeastern Oklahoma. Subsidence problems associated with these mines either existed during mining or have developed since cessation of mining in the Picher Field.

Keyword(s): abandoned mines, metal mining, structural mitigation, land mitigation, historical, surface subsidence damage

Location(s): Oklahoma, Kansas, Missouri, United States

Ma, W. M., W. Y. Zhu. Effect of Multi-Seam Mining on Subsidence. International Journal of Mining Engineering, v. 2, no. 2, 1984, p. 171-173.

Model studies and case histories show that vertical settlement and surface subsidence above multiple seam coal mining, where the upper seam is worked first, is greater than would be expected from the sum of equivalent single seam mining operations. This can be attributed to three factors: (1) strata disturbed by the mining of the upper seam has reduced bending resistance and bed separation does not occur, (2) where the seams are closely spaced, dilation during caving is reduced, and (3) pressure over the goaf or caved area increases with depth leading to increased compaction of the caved area, and reduced ribside abutment pressures.

Keyword(s): multiple-seam extraction, coal mining, overburden, vertical displacement

Location(s): China

Mabry, R. E. An Evaluation of Mine Subsidence Potential. IN: New Horizons in Rock Mechanics: Underground Design and Instrumentation, Proceedings, 14th Symposium on Rock Mechanics, SME/AIME, New York, 1973, p. 263-297.

Keyword(s): prediction, mine design, rock mechanics, instrumentation

Mac Court, L., B. J. Madden, E.H.R. Schumann. Case Studies of Surface Subsidence Over Collapsed Bord and Pillar Workings in South Africa. IN: Proceedings, SANGORM Symposium, October 21, 1986, Sandton, South Africa, International Society for Rock Mechanics, South African National Group, p. 25-32.

Ground elevations above collapsed bord-and-pillar workings have been measured at 17 sites. A review of bord-and-pillar design is followed by a general geological characterization of the superincumbent strata.

Keyword(s): room-and-pillar, coal mining, longwall, surface structural damage, pillar extraction, survey methods, vertical displacement, overburden

Location(s): South Africa

MacLennan, F. W. Subsidence from Block Caving at Miami Mine, Arizona. Transactions, AIME, v. 85, 1929, 1929 Yearbook, p. 167-178.

Keyword(s): metal mining, surface subsidence damage

Location(s): Arizona, United States

Madden, B. J., D. R. Hardman. Long Term Stability of Bord and Pillar Workings. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May 1992, South African Institution of Civil Engineers, Republic of South Africa, p. 37-51.

This paper examines the factors to be considered when structures are placed over old bord-and-pillar areas or mining is done beneath existing surface structures. The probability of pillar collapse is discussed as well as the possible surface effects and remedial measures that may be undertaken to reduce the effects on the surface.

Keyword(s): pillar strength, land-use planning, room-and-pillar, coal mining, mine safety, surface structural damage, backfilling, mine fires

Location(s): South Africa

Madhav, M. R., P. Basak. Ground Subsidence Due to Nonlinear Flow Through Deformable Porous Media. Journal of Hydrology, v. 34, 1977, p. 211-213.

Keyword(s): fluid extraction, hydrology

Magers, J. A. Surface Subsidence Over a Room-and-Pillar Mine in the Western United States. U.S. Bureau of Mines IC 9347, 1993, 15 p.

This report summarizes the results of subsidence research conducted at the Roadside Mine, Powderhorn Coal Company, Palisade, Colorado. This research was conducted from February 1981 to August 1985; additional data were obtained during July 1991 to evaluate residual subsidence. Subsidence was studied at three distinct room-and-pillar sections at separate locations over the mine, and the maximum subsidence values and surface subsidence profiles for each section were determined. Maximum subsidence of 3.0 feet occurred over the room-and-pillar sections, with overburden depths ranging from 50 to 600 feet. Surface tension cracks occurred and were still evident during the residual subsidence survey.

Keyword(s): room-and-pillar, vertical displacement, coal mining, geologic features, overburden, surface water, monitoring methods, survey methods, survey design, monitoring equipment, survey data processing

Location(s): Colorado, Rocky Mountain Coal Region, United States

Magnuson, M. O., W. T. Malenka. Utilization of Fly Ash for Remote Filling of Mine Voids. IN: Ash Utilization, Proceedings 2nd Ash Utilization Symposium, March 10-11, 1970, Pittsburgh, PA, U.S. Bureau of Mines IC 8488, p. 83-96.

Dry fly ash injection and fly ash-water injection are economical, yet effective methods for remote filling of mine voids to prevent mine subsidence. These methods also control or extinguish abandoned mine fires.

Keyword(s): pneumatic backfilling, hydraulic backfilling, abandoned mines, mine fires, mine waste, coal mining

Location(s): United States

Magnuson, M. O., R. Cox. Environmental Protection of Surface Areas Near Underground Mining Sites. Coal Age, v. 80, no. 7, 1975, p. 135-138.

Keyword(s): environment, land-use planning, coal mining

Mahar, J. W., E. J. Cording, S. R. Hunt, G. G. Marino. Phase I Subsidence Study, O'Fallon, Illinois. Illinois Abandoned Mined Land Reclamation Council, Springfield, 1979, 42 p.

Subsidence was located over an abandoned mine, from which coal was excavated using the room-and-pillar method. The cause of the ground movement was probably related to the collapse of the mine pillars with possible floor heave. In the weeks preceding the main subsidence, water lines broke and pavement bumps were noted. Most of the subsidence occurred over a 36-hour period. The area that resulted is a slightly elliptical, bowl-shaped depression approximately 400 feet in diameter. The initial movement resulted in a maximum surface settlement of 2.9 feet.

Keyword(s): abandoned mines, coal mining, surface structural damage, room-and-pillar, utilities, monitoring methods, geologic features

Location(s): Illinois, Illinois Coal Basin, United States

Mahar, J. W., E. G. Wildanger, R. D. Gibson. Subsidence Rapid Response Team Quarterly Progress Report, July 1--September 30, 1980. Illinois Abandoned Mined Lands Reclamation Council, Springfield, October, 1980, 34 p.

The Subsidence Rapid Resonse Team investigated 16 subsidence reports during the quarter. Thirteen cases did not involve mine subsidence Of the three that did, only one required federal emergency funds.

Keyword(s): abandoned mines, coal mining, structural mitigation

Location(s): Illinois, Illinois Coal Basin, United States

Mahar, J. W., E. G. Wildanger, R. D. Gibson. Mine Subsidence at the District 11 State Police Headquarters in Maryville, Illinois. Illinois Abandoned Mined Lands Reclamation Council, Springfield, Progress Report: September 10, 1980 to March 31, 1981, 45 p.

Subsidence beneath the police headquarters building was first noticed on May 12, 1980, and appeared to have been caused by collapse of abandoned coal mine workings located about 230 feet below the ground surface.

Keyword(s): surface structural damage, abandoned mines, coal mining, vertical displacement, horizontal displacement, utilities, monitoring methods, subsurface water, hydrology, geologic features

Location(s): Illinois, Illinois Coal Basin, United States

Mahar, J. W., E. G. Wildanger, R. D. Gibson. Subsidence Rapid Response Team Quarterly Progress Report, October 1 through December 31, 1980. Illinois Abandoned Mined Lands Reclamation Council, Springfield, January, 1981.

During this time period, there were 10 requests for investigations of possible subsidence. Only three were found to be subsidence related, none constituting emergency conditions.

Keyword(s): abandoned mines, coal mining, surface structural damage

Location(s): Illinois, Illinois Coal Basin, United States

Mahar, J. W., E. G. Wildanger, R. A. Bauer, R. D. Gibson. Mine Subsidence, Powell Residence, Danville, Illinois. Illinois Abandoned Mined Lands Reclamation Council, July 1981, Springfield, 14 p.

This report describes the pit-type subsidence that developed in a residential area and the remedial measures used to abate the problem.

Keyword(s): abandoned mines, coal mining, land mitigation, reclamation

Location(s): Illinois, Illinois Coal Basin, United States

Mahar, J. W., G. G. Marino. Building Response and Mitigation Measures for Building Damages in Illinois. IN: Proceedings, Workshop on Surface Subsidence Due to Underground Mining, Morgantown, WV, November 30-December 2, 1981, S.S. Peng and M. Harthill, eds., Department of Mining Engineering, West Virginia University, 1982, p. 238-252.

This paper summarizes observations made on building response to mine subsidence and discusses techniques for mitigating building damage. It describes typical Illinois geologic and mining conditions.
Keyword(s): surface structural damage, engineering, construction, structural mitigation, geologic features, coal mining, abandoned mines
Location(s): Illinois, Illinois Coal Basin, United States

Mahtab, M. A. Influence of Natural Jointing on Coal Mine Stability and on the Preferred Direction of Mine Layout. IN: Ground Control Aspects of Coal Mine Design, Proceedings Bureau of Mines Technology Transfer Seminar, Lexington, KY, March 6, 1973, U.S. Bureau of Mines IC 8630, 1974, p. 70-78.
In a preliminary study on this topic, the USBM found that 3 out of 18 mines showed distinct roof jointing patterns as well as trends of roof failure. These observations highlight the importance of the effect of jointing in determining mine stability and preferred direction of mine layout. Before assessing the effect of jointing on coal mine stability, the geometric as well as the mechanical characteristics of joints must be measured.
Keyword(s): coal mining, geologic features, roof stability, modeling
Location(s): United States

Mainil, P. Contribution to the Study of Ground Movement Under the Influence of Mining Operations. International Journal of Rock Mechanics and Mining Science & Geomechanics Abstracts, v. 2, no. 2, 1965, p. 225-243.
Coal measures strata become displaced under the influence of mining operations and exert forces on the roof support, the waste, the coal pillars, and the coal faces. These forces deform, crack, or break them, since they cannot completely resist the rock movements. The influence of coal extraction reaches as far as the surface and brings about vertical subsidence and horizontal displacement of the ground in that locality.
Keyword(s): mine design, surface subsidence damage, subsurface subsidence damage, mine operation, vertical displacement, horizontal displacement, overburden, roof support, coal mining
Location(s): United Kingdom

Maize, E. R., H. P. Greenwald. Studies of Roof Movement in Coal Mines, 2. Crucible Mine of the Crucible Fuel Company. U.S. Bureau of Mines RI 3452, 1939, 19 p.
Subsidence data and roof and timber studies were taken from a mine in Pennsylvania.
Keyword(s): coal mining, roof stability, floor stability
Location(s): Pennsylvania, Appalachian Coal Region, United States

Maize, E. R., E. Thomas, H. P. Greenwald. Studies of Roof Movement in Coal Mines, 3. Gibson Mine of the Hillman Coal and Coke Company. U.S. Bureau of Mines RI 3506, 1940, 9 p.
Keyword(s): coal mining, roof stability, room-and-pillar, utilities, surface subsidence damage, overburden, floor stability
Location(s): Pennsylvania, Appalachian Coal Region, United States

Maize, E. R., E. Thomas, H. P. Greenwald. Studies of Roof Movement in Coal Mines. 4. Study of Subsidence of a Highway Caused by Mining Beneath. U.S. Bureau of Mines RI 3562, 1941, 11 p.
This paper summarizes data obtained along a Pennsylvania highway as it passed over two active mines. Mining was conducted in two stages with ultimate pillar removal. The roadbed was extensively cracked and suffered a small change in grade. The authors note that the value of the coal that would have been required for protection of the road was far in excess of the cost of repairing the road. The authors recommend total, rather than partial, extraction whenever surface displacements can be tolerated or the resulting damage is minimal.
Keyword(s): roads, roof stability, coal mining, pillar extraction, surface subsidence damage, partial extraction, longwall
Location(s): Pennsylvania, Appalachian Coal Region, United States

Maleki, H. Ground Response to Longwall Mining: A Case Study of Two-entry Yield Pillar Evolution in Weak Rock. Colorado School of Mines Quarterly, v. 83, no. 3, Fall, 1988, 52 p.
This material was prepared in response to a need of coal mine engineers and the scientific community for better understanding of practical aspects of ground control during longwall mining. Ground control experience and geotechnical investigations during and after mining a seven-panel longwall block are integrated to develop snapshots-in-time models for cave progress and load transfer to the gate pillars. A new criterion for coal mine stability evaluation is proposed based on rates of ground movement.

Keyword(s): coal mining, longwall, yielding supports, ground control, geotechnical, pillar strength, geologic features, roof stability, instrumentation, mine design, modeling

Location(s): Utah, Rocky Mountain Coal Region, United States

Maleki, H. N., M. P. Hardy, R. D. Tifft III. Geotechnical Mine Design of the Foidel Creek Mine. IN: Proceedings, 7th International Conference on Ground Control in Mining, August 3-5, 1988, S.S. Peng, ed., Department of Mining Engineering, West Virginia University, Morgantown, p. 137-148.

The results of 5 years of geotechnical investigations are presented to develop productive and stable longwall layouts for the Foidel Creek Mine. The program was initiated during the premining stage, and has continuously provided the data required for mine design. From several stress determinations at the mine, the relationship between geologic structure and the stress field/depth was established. The results were used for orienting the entries for improved stability. Cave conditions and load transfer to panel boundaries were evaluated from closely monitored full extraction mining and computer analysis. Back-analyses of ground movements, as compared with the actual measurements, indicated that cave conditions were favorable in spite of the presence of competent, thick-bedded sandstones in the main roof. Gate pillar design using a yield-rigid concept was developed through computer analyses and underground instrumentation.

Keyword(s): geotechnical, mine design, instrumentation, geologic features, computer, roof stability, pillar strength, longwall, geophysical, lab testing, in situ testing, coal mining, survey methods, monitoring methods, monitoring equipment, monitoring installation, pillar extraction, finite element, modeling, yielding supports

Location(s): Colorado, Rocky Mountain Coal Region, United States

Maleki, H. N., J. F. T. Agapito, M. Moon. In-Situ Pillar Strength Determination for Two-Entry Longwall Gates. IN: Proceedings, 7th International Conference on Ground Control in Mining, August 3-5, 1988, S.S. Peng, ed., Department of Mining Engineering, West Virginia University, Morgantown, p. 10-19.

Extensive measurements and underground observations in three coal mines in the western United States are integrated in this paper to determine in situ pillar load-deformation characteristics for narrow pillars on two-entry gate road systems. The pillar peak strength, post-failure behavior, and failure mechanism were shown to be significantly different despite similarities in the regional geology, coal pillar laboratory mechanical properties, and gate pillar geometries. Pillar peak strength was shown to be dependent on depth at one site, approaching burst-prone stress levels of 4,000 psi. At another site, the pillar peak stress was lower because of lower confinement; this was related to the higher frequency of cleats and the lower frictional properties of the roof/floor and coal contact. Two failure mechanisms were identified: one in the pillar and the other in the mine floor. The roof stability was good at all three sites because of the thick-bedded nature of the roof strata and limited total gate span in a two-entry system. Existing pillar design techniques were shown to be inadequate for design, requiring adjustments for depth of cover, cleat frequency, and roof/floor frictional properties.

Keyword(s): pillar strength, yielding supports, coal mining, floor stability, longwall, instrumentation, geologic features, lab testing, monitoring methods, rock mechanics

Location(s): Utah, Rocky Mountain Coal Region, United States

Maleki, H. N. Detecting Stability Problems by Monitoring Rate of Roof Movement. Coal, December, 1988, p. 34-38.

Roof falls have long been a factor in coal mine safety and productivity. Five different investigators have successfully demonstrated that monitoring the rate of roof movement can detect impending roof falls in a copper mine and two coal mines in the western United States.

Keyword(s): roof stability, roof support, coal mining, metal mining, monitoring methods

Location(s): Utah, Rocky Mountain Coal Region, United States

Maleki, H. N., R. Colombo, J. F. T. Agapito. Geotechnical Evaluation of Caving Mining Systems. IN: Proceedings, 3rd Conference on Ground Control Problems in the Illinois Coal Basin, Mt. Vernon, IL, August 8-10, 1990, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 249-256.

Geotechnical advantages of short-wall mining systems have been identified for shallow Illinois mines. These include (1) a reduction of surface tensile strains and improvements in hydrologic control, (2) an improvement in underclay stability, and (3) a reduction of face support capacity requirements.

Keyword(s): geotechnical, shortwall, floor stability, room-and-pillar, coal mining, active mines, longwall, overburden, hydrology, subsurface water, geologic features, in situ testing, high-extraction retreat
Location(s): Illinois, Illinois Coal Basin, United States

Maleki, H. N. Development of Modeling Procedures for Coal Mine Stability Evaluation. IN: Rock Mechanics Contributions and Challenges, Proceedings of the 31st U.S. Rock Mechanics Symposium, June 18-20, 1990, W.A. Hustrulid and G.A. Johnson, eds., Golden, CO, Balkema, Rotterdam, p. 85-92.
Procedures were developed for coal mine stability evaluation using long-term instrumentation, extensive numerical modeling, and underground observations. In view of the lack of a coherent design methodology for jointed coal measure strata, such procedures should enhance coal mine design efforts toward increasing mine stability and productivity. In this paper, an integrated approach for coal mine stability evaluation is developed, using both planned geotechnical monitoring and numerical modeling. General monitoring and modeling procedures are developed by analyzing a comprehensive case study at a coal mine in the western United States.
Keyword(s): coal mining, modeling, instrumentation, monitoring methods, geologic features
Location(s): Utah, Rocky Mountain Coal Region, United States

Malgot, J., F. Baliak, T. Mahr. Prediction of the Influence of Underground Coal Mining on Slope Stability in the Vtacnik Mountains. Bulletin of the International Association of Engineering Geology, Paris, no. 33, April, 1986, p. 57-65.
Coal mining in the Handlova deposit in middle Slovakia takes place under complicated engineering geological conditions at the foot of the volcanic Vtacnik mountains, which have slopes affected by deep gravitational deformations. A prediction, based on a detailed engineering geological investigation after undermining, was made of the influence of coal mining on the surface of the mountains. Results will serve to protect four villages.
Keyword(s): prediction, active mines, surface structural damage, engineering, coal mining, geologic features
Location(s): Czechoslovakia

Malkin, A. B., J. C. Wood. Subsidence Problems in Route Design and Construction. Quarterly Journal of Engineering Geology, Great Britain, v. 5, 1972, p. 179-194.
Keyword(s): surface structural damage, engineering, roads
Location(s): England

Maneval, D. R., H. B. Charmbury, R. A. Lambert. Underground Stowing of Anthracite Refuse for Surface Support. AIME Preprint No. 66F61, 1966.
This paper describes mine flushing using coal mine refuse. A description and cost of one project is included.
Keyword(s): hydraulic backfilling, economics, mine waste, anthracite, coal mining
Location(s): United States

Mansur, C. I., M. C. Skouby. Mine Grouting to Control Building Settlement. ASCE Journal Soil Mechanics and Foundations Division, v. 96, no. SM2, 1970, p. 511-522.
Further subsidence of a partially constructed building above an abandoned coal mine is prevented by filling the mine with portland cement grout.
Keyword(s): grouting, surface structural damage, abandoned mines, coal mining
Location(s): United States

Manula, C. B., B. Mozumdar, D. K. Jeng. A Master Environmental Control and Mine System Design Simulator for Underground Coal Mining. Volume V. Subsidence Subsystems, Grant GO111808, Pennsylvania State University, U.S Bureau of Mines OFR 84(5)-76, 1974, 199 p. (NTIS PB 255 425)
Keyword(s): coal mining, mine design, modeling
Location(s): United States

Manula, C. B., R. A. Rivell, R. V. Ramani. A Master Environmental Control and Mine System Design Simulator for Underground Coal Mining. Volume XI. Total Systems Application, Grant GO111808, Pennsylvania State University, U.S. Bureau of Mines OFR 84(11)-76, 1975, 620 p. (NTIS PB 255 431)
Keyword(s): coal mining, mine design, modeling
Location(s): United States

Manula, C. B., A. S. C. Owili-Eger. A Master Environmental Control and Mine System Design Simulator for Underground Coal Mining, v. IX: Water Generator. U.S. Bureau of Mines Open File Report 84(9)-76, 1975.
Keyword(s): subsurface water, coal mining

Marino, G. G., J. W. Mahar, E. J. Cording, J. E. Shively, T. K. Lundin. Mine Subsidence and Related Damages in O'Fallon, Illinois, Phase 2 Report. Illinois Abandoned Mined Lands Reclamation Council, Springfield, 1980, 100 p.

This document presents the detailed findings of the Phase II mine subsidence study at O'Fallon, Illinois. The document is the product of 2 years of research and monitoring that followed the mine subsidence episode in August 1978. Two homes were severely damaged by the mine subsidence, as were several utilities.

Keyword(s): surface subsidence damage, surface structural damage, utilities, abandoned mines, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Marino, G. G., J. W. Mahar, T. K. Lundin. Mine Subsidence and Related Structural Damage, Hegeler, Illinois. Phase I Report to the U.S. Bureau of Mines, 1981, 62 p.

Keyword(s): surface structural damage, abandoned mines, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Marino, G. G., J. W. Mahar, D. J. Dobbels, D. R. Kiesling. Mine Subsidence and Related Structural Damage, Hegeler, Illinois. Report to U. S. Bureau of Mines, Twin Cities Research Center, Minneapolis, MN, June, 1982, 120 p.

The purpose of this study was to augment the characterization and understanding of mine subsidence and related damage occurring over abandoned room-and-pillar mines. The project objective was to summarize and evaluate three adjacent subsidence cases in Hegeler, Illinois. Phase I of the research primarily considered the surface effects and related damage to surface structures. Phase II concentrated on the mechanisms of mine collapse. This report summarizes both phases.

Keyword(s): abandoned mines, surface structural damage, subsurface structural damage, coal mining, geologic features

Location(s): Illinois, Illinois Coal Basin, United States

Marino, G. G., J. W. Mahar. Response of Homes to Sag Subsidence Over Illinois Abandoned Coal Mines. Presented at Society of Mining Engineers of AIME Annual Meeting, Los Angeles, CA, February 26-March 1, 1984, SME-AIME preprint 84-181, 18 p.

This paper summarizes and evaluates data on mine subsidence ground movements and associated damages for houses in Illinois. The response of these homes is expressed in terms of repair costs.

Keyword(s): abandoned mines, surface structural damage, economics, coal mining, structural mitigation

Location(s): Illinois, Illinois Coal Basin, United States

Marino, G. G., J. W. Mahar. Subsidence Damaged Homes over Room and Pillar Mines in Illinois. Illinois Abandoned Mined Lands Reclamation Council Report, Springfield, 1984, 450 p.

Keyword(s): surface structural damage, abandoned mines, room-and-pillar, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Marino, G. G., J. W. Mahar. House Damage Criteria for Sag-Subsidence Over Illinois Room and Pillar Coal Mines. Transactions, SME-AIME, December, 1984, v. 278, p. 1818-1825.

This paper provides an understanding of the behavior and potential damage of homes resulting from sag-type mine subsidence. Extensive and numerous case histories in Illinois were collected. The house response to subsidence-induced ground displacements is summarized and evaluated.

Keyword(s): surface structural damage, foundations, room-and-pillar, abandoned mines, coal mining

Location(s): Illinois, United States

Marino, G. G., E. J. Cording. Geotechnical Aspects of Subsidence Over Room and Pillar Mines in Illinois. IN: Proceedings, 4th Conference on Ground Control in Underground Mining, July 22-24, 1985, Morgantown, WV, 9 p.

Site conditions at several shallow room-and-pillar mines in Illinois are described and compared with the characteristics of the subsidence profiles at the ground surface. The shape and magnitude of the subsidence profiles were found to be closely related to the thickness of the soil and rock overburden, the percent extraction of the coal, and the shape of the mine pillars. The room-and-pillar mines were located at a shallow depth beneath flat to gently rolling terrain. Thickness of the coal seams ranged from 6 to 9 feet and was underlain by underclays at all sites. This information was developed to improve techniques for evaluating the subsidence potential at sites within the Illinois Coal Basin.

Keyword(s): geotechnical, room-and-pillar, ground control, pillar strength, coal mining
Location(s): Illinois, Illinois Coal Basin, United States

Marino, G. G. Subsidence Damaged Houses over Illinois Room and Pillar Mines. Ph.D. Thesis, University of Illinois at Urbana-Champaign, Urbana, IL, 1985, 435 p.

A relationship is established between residential damage and ground movements over Illinois room-and-pillar mines. House damage can be estimated using this ground movement damage criterion and knowing the expected level of ground displacement. Subsidence characteristics observed at the ground surface are presented for estimating ground movement for damage prediction.

Keyword(s): surface structural damage, room-and-pillar, coal mining, abandoned mines, structural mitigation, vertical displacement, foundations
Location(s): Illinois, Illinois Coal Basin, United States

Marino, G. G., A. G. Devine. Mine Subsidence and Related Structural Damage, Hegeler, Illinois from July 1981 to February 1985. Report to U.S. Bureau of Mines-Twin Cities Research Center, May, 1985, Civil Engineering Department, University of Illinois at Urbana-Champaign, 45 p.

The objectives of this research program were to (1) monitor mine subsidence effects on the surface, the near-surface groundwater, and the surface structures; and (2) assess subsurface conditions and evaluate mechanisms of long-term mine collapse or yield. This work was conducted over an area of abandoned workings in Hegeler, Illinois, where subsidence has resulted and is expected to continue.

Keyword(s): surface structural damage, coal mining, abandoned mines, subsurface water, monitoring methods, time factor, vertical displacement, horizontal displacement
Location(s): Illinois, Illinois Coal Basin, United States

Marino, G. G., J. W. Mahar, L. R. Powell, R. E. Thill. Ground Subsidence and Structural Damage Over an Abandoned Room-and-Pillar Coal Mine at Hegeler, IL. U.S. Bureau of Mines IC 9072, 1986, 24 p.

The USBM and the University of Illinois investigated surface characteristics and damage to structures from mine subsidence over a room-and-pillar coal mine in Hegeler, Illinois. Data on three adjacent subsidence sags and associated structural damage were collected, summarized, and evaluated. The subsidence sags developed over a 10-year period and took place above a modified room-and-pillar operation mining the Herrin coal at a depth of 130 to 135 feet. Surface vertical displacements of 3.0 to 3.5 feet resulted from extracting 6.1 to 6.4 feet of coal.

Keyword(s): room-and-pillar, abandoned mines, surface structural damage, coal mining, utilities
Location(s): Illinois, Illinois Coal Basin, United States

Marino, G. G. Interactions Between Building and Subsidence Movements. IN: Proceedings, 2nd Workshop on Surface Subsidence due to Underground Mining, Morgantown, WV, June 9-11, 1986, S.S. Peng, ed., West Virginia University Department of Mining Engineering, p. 163-180.

The main subsidence-ground-structure interactions are presented, with an overview of the response of surface structures to subsidence ground movements. Data presented generally apply to structures up to two or three stories high and no more than several hundred feet in length.

Keyword(s): surface structural damage, construction, foundations, coal mining

Marino, G. G. Long-Term Stability of Overburden Above Room and Pillar Mines. IN: Mine Subsidence, M.M. Singh, ed., Society of Mining Engineers Fall Meeting, St. Louis, MO, September, 1986, SME, Littleton, CO, p. 73-82.

Vast improvement in methods of design and analysis of the long-term stability of overburden above room-and-pillar mines is needed. Improved methods are vital for planning and land development and for prediction above existing, presently stable, room-and-pillar mines.

Keyword(s): overburden, room-and-pillar, roof stability, floor stability, pillar strength, mine design, agriculture, coal mining
Location(s): Illinois, Illinois Coal Basin, United States

Marino, G. G., M. R. Funkhouser. Mine Subsidence of the District 11 State Police Headquarters, Maryville, Illinois. Final report for Illinois Abandoned Mined Lands Reclamation Council, Springfield, 1986, 81 p.

Keyword(s): surface structural damage, abandoned mines, coal mining
Location(s): Illinois, Illinois Coal Basin, United States

Marino, G. G., W. L. Gamble. Mine Subsidence Damage from Room and Pillar Mining in Illinois. International Journal of Mining and Geological Engineering, v. 4, 1986, p. 129-150.

This paper presents case histories of subsidence damage occurring over abandoned room-and-pillar mines in Illinois. Major modes of behavior and damage in houses from sag-subsidence are summarized. The houses rested on concrete and masonry foundations. The prevalent mode of failure of bearing walls was inward bending. Failure is analyzed. Conventional design procedures are used to evaluate foundation failure.

Keyword(s): foundations, surface structural damage, room-and-pillar, coal mining, abandoned mines

Location(s): Illinois, Illinois Coal Basin, United States

Marino, G. G. Analysis of the Initial Collapse of the Overburden Over Longwall Panels Using Subsidence Data. IN: Proceedings, 7th International Conference on Ground Control in Mining, Morgantown, WV, August, 1988.

Documented case histories of surface ground movements from mine subsidence were used to help determine when the initial collapse of the overburden occurred above longwall panels.

Keyword(s): longwall, coal mining, overburden, vertical displacement, engineering, geotechnical, roof stability, monitoring methods

Location(s): Illinois, Illinois Coal Basin, Appalachian Coal Region, Colorado, New Mexico, United States

Marino, G. G., J. W. Mahar, E. W. Murphy. Advanced Reconstruction for Subsidence-Damaged Homes. IN: Mine Induced Subsidence: Effects on Engineered Structures, Proceedings of the Symposium, American Society of Civil Engineers, Nashville, TN, May 1988, p. 87-106.

Significant repair costs have resulted from homes damaged by subsidence from underground coal mining. A research and development project was undertaken in Illinois to address many of the residential damage and reconstruction problems from mine subsidence. Phase I of this project is complete and has resulted in a draft handbook of advanced abatement and reconstruction methods.

Keyword(s): insurance, surface structural damage, coal mining, foundations, structural mitigation

Location(s): Illinois, Illinois Coal Basin, United States

Marino, G. G. Progressive Failure of the V-Day Mine and a Comparison with Other Similar Features in Illinois. IN: Proceedings 9th International Conference on Ground Control in Mining, June 4-6, 1990, S.S. Peng, ed., West Virginia University, Morgantown, p. 183-192.

The performance of the V-Day Mine near Danville, Illinois, has been evaluated from data extending about 20 years. The area included in this study involves more than 16 acres. This entire area has progressively subsided. Extensive data has been collected on the geologic and mining conditions, the subsidence movements, and on the response of the surface structures to the subsidence.

Keyword(s): abandoned mines, coal mining, surface structural damage, room-and-pillar, geologic features, floor stability

Location(s): Illinois, Illinois Coal Basin, United States

Marino, G. G. Subsidence Damage and Remedies. IN: Mine Subsidence - Prediction and Control, National Symposium, 33rd Annual Meeting, Association of Engineering Geologists, C.D. Elifrits, ed., October 2-3, 1990, Pittsburgh, PA, p. 153-164.

This paper describes the development of advanced procedures on abatement and reconstruction of homes damaged by mine subsidence. The objectives of the project are for more economical and effective abatement measures, correct evaluation of damage, and education of contractors with abatement and reconstruction technology.

Keyword(s): insurance, room-and-pillar, abandoned mines, surface structural damage, engineering

Location(s): Illinois, Illinois Coal Basin, United States

Marino, G. G., W. L. Gamble. Repair and Strengthening of Subsidence Damaged Concrete Block Foundation Walls. IN: Proceedings, 5th North American Masonry Conference, June 3-6, 1990, Urbana, IL, 12 p.

This paper describes ongoing research and development of improved methods for repair of concrete block foundations.

Keyword(s): structural mitigation, surface structural damage, foundations, engineering, vertical displacement, horizontal displacement, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Marino, G. G. Innovative Repair of Subsidence Damage. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 139-145.

To improve handling of subsidence damages, the Illinois Mine Subsidence Insurance Fund supported the development of novel cost-effective methods of repair. The research in developing the repairs was directed towards the most common and costly damages observed. As a result, repair techniques were designed for structurally cracked foundations in the tension and compression zones, and for damaged or undamaged tilted foundations. All the postulated repair methods were laboratory and/or field tested.

Keyword(s): structural mitigation, surface structural damage, insurance, coal mining, foundations, engineering, construction, lab testing

Location(s): Illinois, Illinois Coal Basin, United States

Mark, C., Z. T. Bieniawski. A New Method for Sizing Longwall Pillars Based on Field Measurements. IN: Proceedings, 6th International Conference on Ground Control in Mining, June 9-11, 1987, S.S. Peng, ed., West Virginia University, Morgantown, p. 157-171.

A new method for the design of longwall pillars, called "Analysis of Longwall Pillar Stability" (ALPS) is described. The method is the final result of a research program that included two major field studies, extensive reanalysis of data from other in situ measurements, and detailed evaluations of available pillar design methods. The key problem addressed by ALPS is estimation of the abutment loads applied to longwall pillars.

Keyword(s): pillar strength, longwall, computer, mine design, prediction, coal mining

Location(s): West Virginia, Kentucky, Appalachian Coal Region, United States

Mark, C., T. Barton. Field Evaluation of Yield Pillar Systems at a Kentucky Longwall Headgate. IN: Proceedings, 7th International Conference on Ground Control in Mining, August 3-5, 1988, S.S. Peng, ed., Department of Mining Engineering, West Virginia University, Morgantown, p. 1-9.

The USBM is conducting research to assess the effectiveness of different chain pillar designs in maintaining gate entry stability. The study described in this paper was performed in an experimental headgate section which was 1,200 feet long and contained three pillar designs: (1) a three-entry, yield-abutment pillar system, (2) a four-entry, yield-abutment pillar system, and (3) a five-entry, all-yield pillar system. Engineers monitored entry convergence, roof sag, and changes in roof quality. The results of the study indicate that the all-yield system performed at least as well as, and probably better than, the two abutment pillar systems.

Keyword(s): pillar strength, yielding supports, longwall, mine design, roof stability, roof support, geologic features

Location(s): Kentucky, United States

Mark, C., J. Listak, Z. T. Bieniawski. Yielding Coal Pillars--Field Measurements and Analysis of Design. IN: Key Questions in Rock Mechanics, Proceedings of the 29th U.S. Symposium, Minneapolis, MN, June 13-15, 1988, P.A. Cundall, R.L. Sterling, and A.M. Starfield, eds., Balkema, Rotterdam, p. 261-270.

Yielding pillars are gaining increasing acceptance as a technique for improving ground control in coal mines The field studies described in this paper provide insights into the failure mechanics of yielding pillars that may prove helpful in improving yielding pillar design. Analysis includes the derivation of expressions for the stress distribution within a yielding pillar implied by several well known empirical pillar design formulas.

Keyword(s): yielding supports, coal mining, longwall, instrumentation, modeling, empirical model

Mark, C. Longwall Pillar Design--Some Recent Developments. SME Preprint 98-103, for presentation at SME Annual Meeting, Las Vegas, NV, February 27-March 2, 1989, 9 p.

Effective ground control in gate entries, particularly in the tailgate travelways, is essential for safe longwall mining. Longwall pillars maintain gate entry stability and carry abutment loads. To answer the need for effective longwall pillar design, an empirical method called Analysis of Longwall Pillar Stability (ALPS) was proposed. The ALPS was originally developed from field studies in which multiple stressmeters were installed in longwall pillars and monitored during mining. Several new field studies have been used to verify formulas for predicting abutment strength and pillar loads, and to develop an expression for the distribution of the abutment load. Since its development, ALPS has been applied to nearly 100 mining case histories throughout the eastern United States.

Keyword(s): longwall, mine design, pillar strength, coal mining, ground control, yielding supports, computer
Location(s): Appalachian Coal Region, United States

Mark, C. Pillar Design Methods for Longwall Mining. U.S. Bureau of Mines IC 9247, 1990, 53 p.
Effective ground control in the gate entries is essential for safe and productive longwall mining. Longwall pillars protect the gate entries from the severe abutment loads that develop as the longwall retreats. This report focuses on the Analysis of Longwall Pillar Stability (ALPS) design method. With ALPS, mining engineers can estimate the strength of longwall pillar systems and the load that will be applied to them. Several other methods that can be directly used to size longwall pillars are also described, using a data bank of more than 100 case histories.
Keyword(s): pillar strength, mine design, longwall, coal mining, ground control, yielding supports, multiple-seam extraction, floor stability
Location(s): United States

Mark, C. Horizontal Stress and its Effects on Longwall Ground Control. Mining Engineering, November 1991, p. 1356-1360.
This paper discusses measurements of in situ horizontal stress fields in the eastern United States, experience with horizontal stress in longwall mines, and methods for predicting and controlling horizontal stresses. The data were collected through site investigations at 45 longwall mines in the United States and a review of international literature.
Keyword(s): longwall, coal mining, ground control, roof stability, mine design, literature search
Location(s): West Virginia, Pennsylvania, Appalachian Coal Region, Illinois, Illinois Coal Basin, Alabama, United States

Marr, J. E. Horizontal and Vertical Movements of the Surface in Longwall Mining. Transactions, Institute of Mining Engineers, London, 1950, p. 106-118.
Keyword(s): horizontal displacement, vertical displacement, longwall, surface subsidence damage
Location(s): England

Marr, J. E., J. F. Ward. Some Practical Aspects of Precise Subsidence Surveying. Transactions, Institute Mining Surveyors, 1952, 17 pp; available upon request from A.J. Fejes, U.S. Bureau of Mines, Denver, CO.
This paper evaluates survey techniques and details the design and construction of survey monuments used to monitor ground movements over longwall mining operations.
Keyword(s): monitoring design, monitoring installation, monitoring equipment, survey methods, survey data processing, longwall, instrumentation
Location(s): United States

Marr, J. E. A New Approach to the Estimation of Mining Subsidence. Transactions, Institute Mining Engineers, London, v. 118, 1958-59, p. 692-706.
From the study of the shapes of a number of subsidence profiles, a general mathematical equation to define various subsidence parameters has been deduced. The application of this equation to two examples is illustrated. The relationship between the angle of draw and the width/depth ratios for several strata are considered, plus the relationship between angle of draw and inclined strata. The effect of variations in local geological conditions and the quality of packing systems are discussed, along with the accuracy to which subsidence estimations can be carried out.
Keyword(s): vertical displacement, prediction, angle of draw, backfilling, geologic features

Marr, J. E. The Estimation of Mining Subsidence. Colliery Guardian, v. 198, no. 5116, March, 1959, p. 345-352.
This article discusses general aspects of subsidence prediction. Included are data later improved and summarized in the form of the National Coal Board's Subsidence Engineers' Handbook.
Keyword(s): prediction, longwall, surface structural damage, vertical displacement, horizontal displacement, National Coal Board, coal mining
Location(s): England, Europe

Marr, J. E. Subsidence Observations in the South Lancashire Coalfield. Sheffield University Mining Magazine, 1961, p. 24-35.
Keyword(s): surface subsidence damage, coal mining
Location(s): England

Marr, J. E. The Effects on Surface Property By a Modified Mining Method. Chartered Surveyor, v. 97, January, 1965.
Keyword(s): surface structural damage, mine design

Marr, J. E. The Application of the Zone Area System to the Prediction of Mining Subsidence. The Mining Engineer, London, v. 176, no. 135, October, 1975, p. 53-62.

This article outlines the introduction and initial development of the zone area system in Europe and the difficulties experienced in applying the system to British mining circumstances.

Keyword(s): zone area, vertical displacement, horizontal displacement, prediction

Location(s): England, Europe

Marsden, S. S., Jr., S. N. Davis. Geologic Subsidence. Scientific American, v. 216, 1967, p. 93-100.

Keyword(s): fluid extraction

Location(s): United States

Marshall, G. J. A Viscoelastic Treatment of the Deformation of the Ground Caused by Mining Operations. Journal Mechanics Physics Solids, v. 17, no. 3, 1969, p. 151-162.

Keyword(s): modeling, viscoelastic model, phenomenological model

Martin, A.W. & Associates, Inc. Relationship Between Underground Mine Water Pools and Subsidence in the Northeastern Pennsylvanian Anthracite Floods. Department of Environmental Resources, Commonwealth of PA, Harrisburg, 1975.

Keyword(s): subsurface water, hydrology, anthracite, coal mining, environment

Location(s): Pennsylvania, Appalachian Coal Region, United States

Martin, A. W. & Associates, Inc. Development of a Comprehensive Program of Insurance Protection Against Mining Subsidence and Associated Hazardous Location Risks. Appalachian Regional Commission Report ARC-73-163-2558, June 1975, 108 p. (NTIS PB 272 515)

Keyword(s): insurance

Location(s): Pennsylvania, Appalachian Coal Region, United States

Martin, C. H., A. J. Hargraves. Shortwall Mining with Power Supports in the Broken Hill Proprietary Co., Ltd. Mines in Australia. IN: Proceedings, 5th International Strata Control Conference, London, 1972, National Coal Board, p. 13.1-13.13.

Keyword(s): shortwall, National Coal Board, roof support, coal mining

Location(s): Australia

Martin, J. C., S. Serdengecti. Subsidence Over Oil and Gas Fields. IN: Man-Induced Land Subsidence, Reviews in Engineering Geology VI, The Geological Society of America, 1984, T.L. Holzer, ed., p. 23-34.

Most oil and gas reservoirs experience only small amounts of compaction and surface subsidence. Significant subsidence due to production of hydrocarbons has been observed over some oil and gas fields. This paper presents a review of the fundamentals of reservoir compaction and surface subsidence over oil and gas fields and explains why large-scale subsidence is rare. A new method of estimating maximum potential subsidence is presented and used to analyze the subsidence over oil and gas fields in Louisiana. Large-scale compaction and subsidence are evidently associated with inelastic behavior of the reservoir rock and in some cases of the surrounding rock. No reliable methods have been established for predicting either the transition from elastic to inelastic reservoir rock behavior or large-scale reservoir compaction and subsidence.

Keyword(s): oil extraction, fluid extraction, prediction, geologic features

Location(s): Louisiana, Texas, California, United States

Martos, F. Concerning An Approximate Equation of the Subsidence Trough and Its Time Factor. IN: Proceedings, International Strata Control Congress, Leipzig, October 14-16, 1958, p. 191-205 and LXXXIII-XC.

It is well known that above seams in horizontal or almost horizontal formation at the end of movements caused by underground excavations there is a trough which in its vertical section resembles the profile of a bell. In this paper a model shows the schematic stratification of the subsidence trough in the Oroszlany coal district, after having worked two seams. The author expresses the various subsidence troughs and profile curves as analytical functions.

Keyword(s): time factor, modeling, coal mining, multiple-seam extraction, vertical displacement

Location(s): Hungary

Martos, F. Protection of Buildings from Damage Caused by Rock Movement. Hungarian Mining Research Institute, no. 2, 1958, p. 11-22.

Keyword(s): architecture, surface structural damage, engineering

Marvin, M. H., G. S. Knoke, W. R. Archibald. Backfilling of Cavities Produced in Borehole Mining Operations. Contract JO285037, Flow Industries, Inc., U.S. Bureau of Mines OFR 4-81, 1979, 85 p. (NTIS PB 81-171308)
Keyword(s): backfilling
Location(s): United States

Mates, R. R., A. M. Richardson, N. R. Roberts, M. J. Superfesky. Rock Anchor Systems for Reducing Subsidence Damage. IN: Proceedings, 2nd Workshop on Surface Subsidence due to Underground Mining, Morgantown, WV, June 9-11, 1986, S.S. Peng, ed., West Virginia University, p. 134-141.
This paper describes the use of post-tensioned rock anchors to reduce the risk of future damage to a residential structure as a result of coal mine subsidence.
Keyword(s): surface structural damage, coal mining, grouting, abandoned mines, instrumentation
Location(s): West Virginia, Appalachian Coal Region, United States

Matetic, R. J., G. J. Chekan, J. A. Galek. Design Considerations for Multiple-Seam Mining with Case Studies of Subsidence and Pillar Load Transfer. IN: Rock Mechanics: Proceedings of the 28th U.S. Symposium, University of Arizona, Tucson, June 29-July 1, 1987, I.W. Farmer, et al., eds., Balkema, Rotterdam, p. 1095-1106.
The USBM, as part of a program to improve mine planning and development, is currently investigating interactions associated with multiple-seam mining. Two common interactions that occur between adjacent coalbeds are subsidence and pillar load transfer. This study involves underground observations and measurements at two mines affected by these interactions.
Keyword(s): multiple-seam extraction, coal mining, pillar strength, instrumentation, roof support, roof bolting, mine design
Location(s): United States

Matetic, R. J., G. J. Chekan, J. A. Galek. Room-and-Pillar Mine Design in Multiple Seams. Coal Mining, December, 1987, p. 36-40.
There are two basic interactions that occur between seams: pillar load transfer and subsidence. Pillar load transfer is an interaction resulting from load transfer through pillars in overlying or underlying mining operations. This interaction occurs particularly when coalbeds are in close proximity, less than 110 feet apart. When an underlying bed is extracted first, strata interactions from subsidence will result. To further understand these interactions and their influence on mine ground stability, the USBM conducts geological and geotechnical investigations in the field. This knowledge will lead to improvements in mine design and conservation of resources that might otherwise be lost.
Keyword(s): room-and-pillar, mine design, multiple-seam extraction, pillar strength, coal mining, roof stability, roof support, roof bolting, geologic features, instrumentation, time factor
Location(s): Appalachian Coal Region, United States

Matetic, R. J., G. J. Chekan. Assessment of Pillar Load Transfer at Two Multiple-Seam Mine Sites. SME Preprint 89-94, for presentation at SME Annual Meeting, Las Vegas, NV, February 27-March 2, 1989, 13 p.
The USBM, as part of a program to improve mine planning and development, is currently investigating the effects of pillar load transfer, which can impact mining operations within a multiple-seam configuration. A comparative study was performed at two separate mine sites to determine the effects of this load transfer mechanism. The Bureau installed and monitored instrumentation at both sites to gather pertinent data on rock mechanics.
Keyword(s): mine design, pillar strength, multiple-seam extraction, instrumentation, rock mechanics, coal mining, overburden
Location(s): West Virginia, Appalachian Coal Region, Illinois, Illinois Coal Basin, United States

Matetic, R. J., M. A. Trevits. Longwall Mining Impact on Near-Surface Water. IN: Mine Subsidence - Prediction and Control, National Symposium 33rd Annual Meeting, Association of Engineering Geologists, October 2-3, 1990, C.D. Elifrits, ed., Pittsburgh, PA, p. 131-139.
A total of eight shallow observation wells were spaced across two longwall panels in Pennsylvania. Various hydrological parameters such as specific capacity, transmissivity and well yield were determined before and after mining, along with water level fluctuation data.
Keyword(s): active mines, hydrology, subsurface water, overburden, longwall, coal mining
Location(s): Pennsylvania, Appalachian Coal Region, United States

Matetic, R. J., M. A. Trevits. Hydrologic Variations Due to Longwall Mining. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 204-213.

A field case study was conducted in Cambria County, Pennsylvania, where five observation water wells were drilled above two adjacent longwall panels. The study showed that the observed changes in chemistry did not affect the potability of the water, short-term major water level fluctuations occur at the approximate time of undermining, and water level recovery begins before the process of subsidence is complete.

Keyword(s): longwall, subsurface water, hydrology, monitoring methods, coal mining

Location(s): Pennsylvania, Appalachian Coal Region, United States

Mather, J. D., D. A. Gray, D. G. Jenkins. The Use of Tracers to Investigate the Relationship Between Mining Subsidence and Ground Water Occurrence at Aberfan, South Wales. Journal of Hydrology, Amsterdam, v. 9, 1969, p. 136-154.

Keyword(s): hydrology, monitoring methods, subsurface water

Location(s): Wales, United Kingdom

Matheson, G. M., A. E. Clift. Characteristics of Chimney Subsidence Sinkhole Development from Abandoned Underground Coal Mines Along the Colorado Front Range. IN: Proceedings 2nd Workshop on Surface Subsidence due to Underground Mining, Morgantown, WV, June 9-11, 1986, S.S. Peng, ed., West Virginia University, p. 204-214.

The factors that control chimney subsidence sinkhole development in weak rock were assessed by analyzing the characteristics of approximately 3,000 chimney subsidence features along the Colorado Front Range. Data were collected for sinkholes occurring over both room-and-pillar and retreat mining areas in coal seams with a wide range of dips.

Keyword(s): abandoned mines, coal mining, geologic features

Location(s): Colorado, Rocky Mountain Coal Region, United States

Matheson, G. M., Z. F. Bliss. Observations on the Location of Chimney Subsidence Sinkhole Development Along the Colorado Front Range. IN: Proceedings, Conference on Coal Mine Subsidence in the Rocky Mountain Region, Colorado Springs, October 28-30, 1985, J.L. Hynes, ed., Colorado Geological Survey Special Publication 31, Department of Natural Resources, Denver, 1986, p. 169-189.

This paper reviews the mechanism of chimney subsidence sinkhole development in soft rocks and presents empirical data on the maximum height chimney subsidence may develop over horizontal and dipping coal seams. Generalizations are drawn that can be useful in the prediction of potential chimney subsidence sinkhole development throughout the Front Range.

Keyword(s): abandoned mines, surface subsidence damage, horizontal displacement, historical, soils, roof stability, floor stability, pillar strength, coal mining

Location(s): Colorado, Rocky Mountain Coal Region, United States

Matheson, G. M. Subsidence Above Abandoned Underground Coal Mines-Weak Rock Overburden. IN: Association of Engineering Geologists Symposium Series No. 4, Building Over Underground Mines--Subsidence Considerations, October 1987, p. 63-81.

The study of more than 85 mines of various ages, mined thicknesses, depths, and geohydrologic conditions in Colorado has shown that (1) there is a period in which active widespread subsidence occurs, and it begins with mining and ends some 20 to 30 years after mining; (2) subsidence after this period is at a much lower frequency and appears to occur from the collapse of relatively limited areas of mining; (3) a probabilistic relationship between depth to mining and chimney subsidence sinkhole development can be developed; and (4) over deeper mining areas, calibrated numerical modeling analyses indicate limits of potentially damaging surface strains for the collapse of typical sized mine openings.

Keyword(s): coal mining, abandoned mines, modeling, room-and-pillar, time factor, overburden, lab testing, multiple-seam extraction, land-use planning

Location(s): Colorado, Wyoming, Rocky Mountain Coal Region, United States

Matheson, G. M. A Probabilistic Function for Prediction of Chimney Subsidence Sinkhole Development. IN: Mine Subsidence - Prediction and Control, National Symposium, 33rd Annual Meeting Association of Engineering Geologists, October 2-3, 1990, C.D. Elifrits, ed., Pittsburgh, PA, p. 233-246.

The prediction of chimney subsidence sinkholes above abandoned underground mines has depended largely on rules of thumb and semiquantitative relations developed by assuming various caving geometries. A study of more than 2,000 chimney subsidence sinkhole features over abandoned coal mines in Colorado has resulted in the development of a probabilistic function that describes the potential for sinkholes to develop above collapsing mine openings.

Keyword(s): abandoned mines, modeling, coal mining, prediction, empirical model

Location(s): Colorado, Rocky Mountain Coal Region, United States

Mathur, S. K., M. R. Mikkilineni. Preliminary Predictive Model of Subsidence Process Over Room and Pillar Workings. Phase I. Definition of Factors. Open File Report January 81-April 82. U.S. Bureau of Mines OFR 68-83, MRM Engineers, Pittsburgh, PA, April 1982, 113 p. (NTIS PC A06/MF A01)

This report identifies all the possible activities, variables, and factors that contribute to surface subsidence over room-and-pillar workings. The subsidence failure mechanism is initiated by the failure of the mine floor bed and/or the failure of the pillars or the failure of the roof after second mining, which eventually brings down the roof. The individual responses of these components cannot be attributable to any single factor. Because of the lack of field data, no attempt was made to quantify the significance of each of these factors and relate it to the ground subsidence.

Keyword(s): prediction, room-and-pillar, modeling, floor stability, roof stability, pillar strength, pillar extraction

Location(s): United States

Maung, H. M., S. P. Banerjee. Investigation into Strata Behavior Around an Experimental Longwall Caving Face in Jharia Coalfield. Journal of Mines, Metals, and Fuels, v. 24, no. 9, September, 1976, p. 283-289.

Keyword(s): longwall

Location(s): India

Maury, V. Effondrements Spontanes (Spontaneous Subsidence). Industrie Minerale, St. Etienne, France, v. 61, no. 10, 1979, p. 511-522.

Keyword(s): surface subsidence damage

Location(s): France

Mautner, K. W. Structures in Areas Subjected to Mining Subsidence. IN: Proceedings, 2nd International Conference on Soil Mechanics and Foundation Engineering, Rotterdam, June 21-30, 1948, v. 2, p. 167-177.

This paper covers the mechanics of mining subsidence, the design of structures with regard to subsidence, and some examples of structures constructed and kept under observation for long periods.

Keyword(s): surface structural damage, engineering, foundations

Mautner, K. W. Structures in Areas Subjected to Mining Subsidence. Structural Engineering, v. 26, no. 1, 1948, p. 35-69.

Keyword(s): surface structural damage, engineering

Mavrolas, P., M. Schechtmann. Coal Mine Subsidence: Proceedings From a Citizen's Conference. The Illinois South Project, Inc., Herrin, IL, 1981, 45 p.

This report is based upon a citizen education conference on coal mine subsidence held in Illinois on October 13, 1979. The goal was to prepare a readable and useful report for people concerned about mine subsidence.

Keyword(s): active mines, abandoned mines, economics, surface structural damage, agriculture, structural mitigation, land mitigation, insurance, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Maxwell, B., G. Zink, F. D. Wang. Improving Coal Mine Roof Stability by Pillar Softening. U.S. Bureau of Mines OFR 7-78, 1977, 105 p. (NTIS PB 276-474)

Keyword(s): roof stability, room-and-pillar, roof support, pillar strength, yielding supports, coal mining

Location(s): United States

Maxwell, G. M. Some Observations on the Limitations of Geophysical Surveying in Locating Anomalies from Buried Cavities Associated with Mining in Scotland. The Mining Engineer, March, 1975, v. 134, no. 170, p. 277-285.

Keyword(s): abandoned mines, survey methods, geophysical

Location(s): Scotland

Mayer, L. W. The Advantage of Flushing in Coal Mining. Engineering and Mining Journal, v. 86, 1908, p. 1.

This article discusses advantages of hydraulic flushing over hand stowing, and gives a brief history and comparison of backfilling practices in the United States and Europe.
Keyword(s): hydraulic backfilling, coal mining, historical
Location(s): United States, Europe

Mayer, L. W. Sand Filling in the Iron Mines of Peine, Germany. Transactions, AIME, v. 39, 1908, p. 355.
Hydraulic backfilling is used in conjunction with room-and-pillar mining.
Keyword(s): hydraulic backfilling, room-and-pillar, metal mining, multiple-seam extraction
Location(s): Germany

Mayer, L. W. Subsidence with Hydraulic Filling Hardly Noticeable at Carmaux, France. Mining Methods in Europe, New York, 1909, p. 154.
This article covers the application of hydraulic backfilling to French mining methods.
Keyword(s): hydraulic backfilling
Location(s): Europe, France

Mayuga, M. N. How Subsidence Affects the City of Long Beach. IN: Proceedings, 2nd Geologic Conference on Landslides and Subsidence, Los Angeles, California Resources Agency, Sacramento, 1966, p. 122-129.
Keyword(s): fluid extraction
Location(s): California, United States

Mayuga, M. N., D. R. Allen. Long Beach Subsidence. Engineering Geology in Southern California, Association of Engineering Geologists, Los Angeles Section Special Publication, 1966, Glendale, CA, p. 280-285.
Keyword(s): oil extraction, fluid extraction
Location(s): California, United States

McCallum, T. Mineral Subsidence and Local Authority Services. Institute Municipal and County Engineers Journal, v. 70, no. 11, 1944, p. 441-422.
Keyword(s): government
Location(s): United Kingdom

McCallum, T. The Maintenance of Roads in a Mining Area. Journal of Inter Highway Engineers, v. 2, January, 1952, p. 369-376.
Keyword(s): roads

McCann, G. D., C. H. Wilts. Mathematical Analysis of the Subsidence in the Long Beach-San Pedro Area. California Institute Technical Report 117, November, 1951.
Keyword(s): modeling, mathematical model, fluid extraction
Location(s): California, United States

McCauley, C. A., R. L. Gum. Subsidence Damage in Southern Arizona. Hydrology and Water Resources in Arizona and the Southwest, v. 2, 1972, p. 87-94.
Keyword(s): fluid extraction
Location(s): Arizona, United States

McCauley, C. A. Management of Subsiding Lands: An Economic Evaluation. Ph.D. Thesis, University of Arizona, Tucson, 1973, 84 p. (NTIS 240 305)
Keyword(s): economics, land-use planning
Location(s): United States

McClain, W. C. Time-Dependent Behavior of Pillars in the Alsace Potash Mines. IN: Proceedings 6th Symposium on Rock Mechanics, University of Missouri at Rolla, 1964, E.M. Spokes and C.R. Christiansen, eds., p. 489-500.
This paper describes part of a rock mechanics investigation carried out in the potash mines of the Alsace district, France. One of the basic objectives was the understanding and description of the behavior of long pillars of potash with respect to time and the manner in which they perform their task of supporting the overlying strata.
Keyword(s): pillar strength, non-metal mining, time factor, rock mechanics
Location(s): France

McClain, W. C. Surface Subsidence Associated with Longwall Mining. Transactions, AIME, v. 235, 1966, p. 231-235.
This paper examines characteristics of subsidence due to longwall mining and resulting damages to surface structures. A general review of subsidence mechanics and protective measures used to minimize damage to surface structures is included.
Keyword(s): vertical displacement, horizontal displacement, surface structural damage, longwall
Location(s): United States

McColloch, J. S., R. F. Fonner, C. P. Messina. BOM Mine Subsidence Study, Fairmont, West Virginia, Core Drilling Report. West Virginia Geological and Economic Survey Open File Report OF8012, September, 1980, for U.S. Bureau of Mines, 54 p.

The evaluation of information obtained from core drilling was undertaken by the West Virginia Geological and Economic Survey to assist the USBM in their study of mine subsidence. The drilling program was initiated to determine the effect of deep mining on the integrity of the overburden above the extensively mined Pittsburgh coal seam.

Keyword(s): overburden, coal mining, rock mechanics, geologic features, pillar strength, floor stability

Location(s): West Virginia, Appalachian Coal Region, United States

McCoy, A. E. R. Longwall Mining at Appin Colliery. IN: Annual Conference, Australasian Institute of Mining & Metallurgy, May, 1976, p. 195-207.

Keyword(s): longwall, coal mining

Location(s): Australia

McCreedy, J., W. J. Taylor. The Use of Hydraulic Fill Underground at the Mines of the International Nickle Company of Canada, Limited. Canadian Mining Journal, v. 81, no. 9, September, 1960, p. 95-103.

This detailed article discusses complete hydraulic filling operations in three mines.

Keyword(s): hydraulic backfilling, metal mining

Location(s): Canada

McCulloch, C. M., M. Deul. Geological Factors Causing Roof Instability and Methane Emission Problems. U.S. Bureau of Mines RI 7769, 1973, 25 p.

Keyword(s): roof stability, ground control, geologic features, coal mining

Location(s): United States

McCulloch, C. M., P. W. Jeran, C. D. Sullivan. Geological Investigations of Underground Coal Mining Problems. U.S. Bureau of Mines RI 8022, 1975, 30 p.

Keyword(s): roof stability, ground control, geologic features, coal mining

Location(s): United States

McCulloch, C. M., W. P. Diamond, B. M. Bench, M. Deul. Selected Geologic Factors Affecting Mining of the Pittsburgh Coalbed. U.S. Bureau of Mines RI 8116, 1976, 19 p.

Keyword(s): roof stability, ground control

Location(s): Pennsylvania, Appalachian Coal Region, United States

McDougall, J. J. Longwall Operations, Sydney Mines, N.S. Transactions of the Candian Institute of Mining and Metallurgy and the Mining Society of Nova Scotia, 1925, Montreal, Quebec.

The object of this paper is to point out the reason for the adoption of longwall methods in the mines discussed and to give a true account of results that attended the efforts of those concerned.

Keyword(s): longwall, coal mining

Location(s): Canada

McKim, M. J., A. Shakoor. An Investigation of Mine Subsidence Incidents in Selected Areas of Madisonville, Kentucky. IN: Mine Subsidence - Prediction and Control, National Symposium, 33rd Annual Meeting Association of Engineering Geologists, October 2-3, 1990, C.D. Elifrits, ed., Pittsburgh, PA, p. 271-286.

During the past several decades, numerous houses and commercial buildings in and around Madisonville, Kentucky, have experienced extensive structural damage due to mine subsidence. Surface and subsurface investigations were conducted at four selected sites to evaluate possible subsidence mechanisms.

Keyword(s): surface structural damage, coal mining, overburden, rock mechanics, geologic features, abandoned mines, pillar strength, roof stability, geotechnical, lab testing, engineering

Location(s): Kentucky, Illinois Coal Basin, United States

McLellan, A. G. The Lining with Rubber of a Large Service Reservoir Damaged by Mining Subsidence. Journal Institute Water Engineers, v. 9, no. 1, 1955, p. 19-50.

Keyword(s): surface structural damage, surface water, structural mitigation

Location(s): United Kingdom

McMahan, T. J., W. G. Pariseau. A Comparison Between Two- and Three-Dimensional Numerical Models of a Coeur d'Alene District Mine. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium,1989, A.W. Khair, ed., Balkema, Rotterdam, p. 963-970.

This USBM study describes the development of a large-scale, three-dimensional, finite-element model of a deep-vein Coeur d'Alene District Mine. The three-dimensional model was prepared from combined digitized mine maps and generated levels that may also be analyzed as independent two-dimensional models. A comparison of the stress changes and displacements was made following a simulated vein excavation in both the three-dimensional and two-dimensional models. A one-cut excavation was simulated with the two-dimensional model and a multiple-cut excavation was simulated with the three-dimensional model. The results from the two analyses are dicussed in terms of the inherent differences between the models.

Keyword(s): modeling, finite element, metal mining

Location(s): Idaho, United States

McMillan, A. A., M. A. E. Browne. The Use or Abuse of Thematic Mining Information Maps. IN: Planning and Engineering Geology, Proceedings 22nd Annual Conference, Engineering Group of the Geological Society, Plymouth Polytechnic, September 8-12, 1986, M.G. Culshaw, et al., eds., The Geological Society, London, 1987, p. 237-245.

Thematic and environmental geology mapping has been applied in recent years by the British Geological Survey. Experience in Scotland indicates that the separate portrayal of particular aspects of the drift and solid geology, former underground mining, and geotechnical properties are of greatest benefit to planners and civil engineers concerned with land use and ground stability.

Keyword(s): coal mining, abandoned mines, land-use planning, engineering, geologic features

Location(s): Scotland, United Kingdom

McNabb, K. E. Three-Dimensional Numerical Modelling of Surface Subsidence Induced by Underground Mining. Commonwealth Scientific and Industrial Research Organization, Australia, Technical Report No. 146, July 1987, 20 p.

This report presents three-dimensional numerical analyses of the surface subsidence induced by the total extraction of a longwall panel. The finite element and displacement continuity stress analysis methods were used to obtain linear elastic solutions for an idealized subsidence problem. Subsidence profiles are presented for a number of panel length to width ratios and for a range of anisotropic material values. Model predictions show that for the geometry modeled, a 5:1 (length to width) aspect ratio produces results equivalent to a two-dimensional idealization. The aspect ratio comparison was made using a linear elastic isotropic material model. The results also show that anisotropic are better than isotropic material models in producing a closer fit to observed subsidence profiles.

Keyword(s): modeling, longwall, finite element, geologic features, mine design, computer, subsurface water, hydrology, coal mining, overburden

Location(s): Australia

McTrusty, J. W. Control of Mining Subsidence. Colliery Engineering, v. 36, no. 421, March, 1959, p. 122-125.

Keyword(s): ground control

McVey, J. R. Mechanical and Ultrasonic Closure-Rate Measurements. IN: Proceedings, 2nd Conference on Ground Control Problems in the Illinois Coal Basin, May 1985, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 91-97.

The USBM constructed two intrinsically safe closure rate measurement instruments that provide an aid for predicting an imminent local roof caving during pillar robbing. This improves operator and machine safety and reduces the incidence of getting equipment caught in the caved area. One instrument system consists of two rugged retrievable extensometers connected by long electrical cables to a digital readout unit for reading closure and closure rate. The Bureau is also evaluating a small ultrasonic unit to make these measurements. The new instrument provides an unobstructing technique to obtain measurements up to 35 feet. The ultrasonic transducer can be attached to a roof bolt, tossed into an unsupported area, or handheld.

Keyword(s): roof stability, high-extraction retreat, room-and-pillar, pillar extraction, mine safety, ground control

Location(s): Utah, United States

Meade, R. H. Compaction of Sediments Underlying Areas of Land Subsidence in Central California. U.S. Department of the Interior, Geological Survey, Professional Paper 497-D, 1968, 39 p.

Keyword(s): fluid extraction, geologic features

Location(s): California, United States

Meador, S. Regulation of Surface Subsidence in West Virginia. IN: Proceedings, 2nd Workshop on Surface Subsidence Due to Underground Mining, Morgantown, WV, June 9-11, 1986, S.S. Peng, ed., West Virginia University Department of Mining Engineering, p. 6-8.

West Virginia's coal mining regulatory programs are not unique when compared to federally approved programs implemented by other coal producing states. In fact, the language in the West Virginia Energy Act governing subsidence mirrors

that written in the Federal Surface Mining Control and Reclamation Act and other state statutes. Certain legal and administrative issues, however, combine to make West Virginia's regulation of surface subsidence a singular approach.

Keyword(s): coal mining, law, government, multiple-seam extraction, active mines, longwall, room-and-pillar

Location(s): West Virginia, Appalachian Coal Region, United States

Mehnert, B. B., D. J. Van Roosendaal, R. A. Bauer, D. F. Brutcher. Effects of Longwall Coal Mine Subsidence on Overburden Fracturing and Hydrology in Illinois. IN: Mine Subsidence - Prediction and Control, National Symposium, 33rd Annual Meeting, Association of Engineering Geologists, October 2-3, 1990, C.D. Elifrits, ed., Pittsburgh, PA, p. 105-110.

Sites over two longwall panels in southern Illinois were instrumented and characterized before and after subsidence to study the effects of coal-mine subsidence on the overburden. Geotechnical instrumentation included survey monuments, piezometers, time domain reflectometry cables, and a pump test well.

Keyword(s): longwall, coal mining, active mines, overburden, geologic features, geotechnical, instrumentation, monitoring methods, monitoring equipment, survey methods, survey data processing, subsurface water, hydrology, geophysical, rock mechanics

Location(s): Illinois, Illinois Coal Basin, United States

Mehnert, B. B., D. J. Van Roosendaal, R. A. Bauer. Long-term Subsidence Monitoring Over a Longwall Coal Mine in Southern Illinois. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 311-316.

Long-term monitoring is necessary to successfully develop predictive subsidence models. Thus, the Illinois Mine Subsidence Research Program has documented subsidence over a longwall mine in south-central Illinois throughout a 3-year period. No monitoring results of this duration have been previously published for longwall mining in Illinois.

Keyword(s): monitoring methods, longwall, coal mining, active mines, overburden, vertical displacement, survey methods, prediction, instrumentation

Location(s): Illinois, Illinois Coal Basin, United States

Mehnert, B. B., D. J. Van Roosendaal, R. A. Bauer, D. Barkley, E. Gefell. Final Report of Subsidence Investigations Over a High-Extraction Retreat Mine in Williamson County. Final Report to U.S. Bureau of Mines-Twin Cities Research Center on Contract CO267001, by Illinois State Geological Survey, Champaign, IL, January 1993, 91 p.

To investigate the effects of high-extraction retreat (HER) mining on the overburden, two instrument clusters were placed over an HER panel in Williamson County, Illinois. The effects investigated included the amount, extent, and location of fracturing in the bedrock. The effects on the local hydrogeology were also evaluated. The instruments included surface monuments, piezometers, extensometers, and two time-domain reflectometry cables. The panel was monitored before, during and after subsidence by the ISGS. This was the first time such information was collected over an HER operation in Illinois. This is one of three sites investigated under the Illinois Mine Subsidence Research Program to study the effects of mining on the overburden.

Keyword(s): high-extraction retreat, active mines, instrumentation, monitoring methods, overburden, subsurface water, monitoring equipment, geotechnical, lab testing

Location(s): Illinois, Illinois Coal Basin, United States

Meier, D. G. The Galatia Paleochannel and Ground Stability at the Wabash Mine. IN: Proceedings, 2nd Conference on Ground Control Problems in the Illinois Coal Basin, May 1985, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 19-27.

Mining near the ancient Galatia paleochannel at the Wabash Mine has exposed a variety of mining conditions. In this paper, the physical characteristics of the accompanying features and their influence on ground stability are described. The procedures that have been successful in alleviating the mining problems are discussed.

Keyword(s): coal mining, geologic features, mine design, roof support, roof bolting, ground control

Location(s): Illinois, Illinois Coal Basin, United States

Meikle, P. G., C. T. Holland. The Effect of Friction on the Strength of Model Coal Pillars. Transactions, SME-AIME, December, 1965, p. 322-327.

Laboratory experiments were performed on model coal pillars in which the pillars were lubricated at the plate-specimen interface prior to compression tests. The purpose of lubrication was to determine the effect on the ultimate unit compressive strength of coal pillars in relation to frictional forces.
Keyword(s): lab testing, coal mining, pillar strength
Location(s): United States

Merrill, R. H., T. A. Morgan. Method of Determining the Strength of a Mine Roof. U.S. Bureau of Mines RI 5406, 1958.
The strength of a mine roof was tested by injecting air between the roof rock and the overlying layers, and measuring the strain and deflection of the roof until failure.
Keyword(s): roof support, roof stability, in situ testing
Location(s): United States

Michael Baker, Jr., Inc. Architectural Measures to Minimize Subsidence Damage. Appalachian Regional Commission Report ARC-73-111-2551, December, 1974, 130 p. (NTIS PB 242 466)
The purpose of this publication is to provide guidelines, principles, and criteria to enable the architectural and engineering professions to design and construct buildings, structures, and underground utilities to minimize subsidence damage.
Keyword(s): architecture, engineering, surface structural damage, coal mining, pipelines, literature search, utilities, foundations
Location(s): Pennsylvania, Appalachian Coal Region, United States

Michael Baker Jr., Inc. A Comprehensive Program for Dealing with Mine Subsidence. Appalachian Regional Commission Report ARC-73-163-2559, 1976.
Keyword(s): surface structural damage, land-use planning, coal mining
Location(s): Appalachian Coal Region, United States

Michael Baker, Jr., Inc. Subsidence and Mining Related Problems, Summary of Research Program. Appalachian Regional Commission Report ARC-73163-2259-S, April 1977, 46 p. (NTIS PB 272 724)
Keyword(s): subsidence research, coal mining
Location(s): Pennsylvania, Appalachian Coal Region, United States

Michael, P. R. Subsidence Over Abandoned Bituminous Coal Mines in the Appalachian Coal Basin; An Analysis of Subsidence Parameters and Three Case Studies. M.S. Thesis, State University of New York, Binghamton, 1984.
Keyword(s): abandoned mines, coal mining, bituminous
Location(s): Appalachian Coal Region

Michael, P. R., A. S. Lees, T. M. Crandall, J. L. Craft. Controlled Grout Columns: A Point-Support Technique for Subsidence Abatement. IN: Association of Engineering Geologists Symposium Series No. 4, Building Over Underground Mines--Subsidence Considerations, October 1987, p. 111-125.
Mixtures of fly ash, sand, gravel, and cement are commonly used to fill abandoned room-and-pillar coal mines to prevent or abate surface subsidence due to mine void closure. However, the large volume of material required to provide support to the mine pillars, overlying strata, and surface facilities is extremely costly. Controlled placement of the material and sufficient roof contact are often difficult to achieve. To maximize control of the implaced material and improve roof contact, a method for the remote construction of cylindrical columns within the mine void has been developed.
Keyword(s): grouting, reclamation, abandoned mines, room-and-pillar, coal mining
Location(s): Ohio, United States

Michalski, S. R., L. J. Winschel, R. E. Gray. Fires in Abandoned Coal Mines. Bulletin of the Association of Engineering Geologists, November 1990, p. 479-495.
Case histories of mine fire projects in Pennsylvania's anthracite and bituminous coal fields demonstrate successful extinguishment by utilizing a combination of mitigation technologies.
Keyword(s): mine fires, abandoned mines, coal mining
Location(s): Pennsylvania, Appalachian Coal Region, United States

Mickle, D. G., H. L. Hartman. Permeability and Compressibility Tests Aid in Selecting Suitable Hydraulic Fill Materials. Mining Engineering, v. 13, no. 11, November, 1961, p. 1246.
This article describes the procedure for determining the particle size distribution and composition necessary for maximum support of rock strata overlying mined-out areas.

Keyword(s): hydraulic backfilling, geotechnical, lab testing
Location(s): Pennsylvania, Appalachian Coal Region, United States

Mickle, D. G., Jr. The Permeability of Hydraulic Fill Materials. M.S. Thesis, Department of Mining, The Pennsylvania State University, 1961.
Keyword(s): hydraulic backfilling
Location(s): United States

Mieville, A. Ground Engineering and the Support of Unstable Ground. Civil Engineering and Public Works Review, v. 66, no. 782, September, 1971, p. 953, 956-957.
Keyword(s): engineering, ground control

Mikula, P. A., G. E. Holt. Prediction of Mine Subsidence in Eastern Australia by Mathematical Modeling. IN: Proceedings, 5th International Congress on Rock Mechanics, Melbourne, Australia, 1983, p. E119-E125.
Finite element modeling of subsidence due to coal extraction in Eastern Australia is described under certain limiting conditions. A systematic means of data acquisition and handling was developed to provide realistic input for the geotechnical model. The constant strain finite element program requires large, carefully designed meshes and empirical reduction of laboratory strength properties. Anisotropy needs to be considered for coal measures strata. The inclusion of joint elements improves subsidence simulation but is not essential for generalized prediction. Examples of successful modeling at shallow depths are discussed.
Keyword(s): prediction, mathematical model, rock mechanics, finite element, coal mining, modeling, geotechnical, computer, lab testing
Location(s): Australia

Milford, K. S. Survey Techniques for the Analysis of Movement. IN: Proceedings, SANGORM Symposium, October 21, 1986, Sandton, South Africa, International Society for Rock Mechanics, South African National Group, p. 7-11.
The requirements for survey networks relating to monitoring projects are outlined. A review is given of some methods currently applied internationally. The problems of invariant quantities and biased estimates are detailed for free net adjustments and the selection of stable points from the geometric stability of the networks as characterized by angles and length ratios is discussed.
Keyword(s): survey design, survey methods, survey data processing, monitoring methods, instrumentation, modeling, empirical model, mathematical model, stochastic model, geotechnical, computer
Location(s): South Africa

Miller, C. H. Geophysical Studies to Detect the Acme Underground Coal Mine, Wyoming. U.S. Geological Survey Bulletin 1677, 1988, 27 p.
Adequate location maps are not available for some of the older underground coal mines in the Powder River Basin, Wyoming, nor for mines in other parts of the United States. These mines may subside and cause damage at the ground surface, or they may spontaneously ignite and consume coal deposits, polluting air and water. Consequently, techniques are needed for locating those potentially hazardous coal mines.
Keyword(s): geophysical, coal mining, abandoned mines, mine fires, seismic, land-use planning, subsurface water, historical, geologic features
Location(s): Wyoming, Rocky Mountain Coal Region, United States

Miller, E. H., F. L. Pierson. Underground Movement and Subsidence over United States Potash Company Mine. SME-AIME Preprint 5819P9, 1958, 3 p.
Keyword(s): non-metal mining, subsurface subsidence damage, surface subsidence damage
Location(s): United States

Miller, H. D. S., M. A. Stoakes. Subsidence Associated with Louisiana Salt Domes. IN: Proceedings, Canada Institute of Mining Conference on Subsidence in Soft Rock Mining, Saskatoon, Saskatchewan, 1985, 20 p.
Keyword(s): non-metal mining
Location(s): Louisiana, United States

Miller, M. J., R. E. Panton, J. R. Steiding. A Comprehensive Program for Dealing with Mine Subsidence Emphasizing Local Government Options. Appalachian Regional Commission Report ARC-73-163-2559, 1976, 156 p.
This report defines and evaluates potential subsidence risk and mitigation measures within the four anthracite coalfields of northeastern Pennsylvania with an emphasis on an evaluation of surface (e.g., land use) and subsurface (subsidence potential) conditions.

Keyword(s): insurance, surface structural damage, mine design, land-use planning, law, structural mitigation, land mitigation, anthracite, coal mining, government
Location(s): Pennsylvania, Appalachian Coal Region, United States

Miller, R. E. Compaction of An Aquifer System Computed from Consolidation Tests and Decline in Artesian Head. U.S. Department Interior, Geological Survey Professional Paper 424-B, Geological Survey Research 1961, p. B54-B58.
Keyword(s): fluid extraction, hydrology
Location(s): United States

Miller, R. E. Land Subsidence in Southern California. Engineering Geology in Southern California, Association Engineering Geologists, Los Angeles Section Special Publication, Glendale, CA, 1966, p. 272-279.
Keyword(s): fluid extraction
Location(s): California, United States

Miller, R. E., J. H. Green, G. H. Davis. Geology of the Compacting Deposits in the Los Banos-Kettleman City Subsidence Area, California. U.S. Department Interior, Geological Survey Professional Paper 497-E, 1971, 46 p.
Keyword(s): fluid extraction, geologic features
Location(s): California, United States

Milliken, B. E. Coal Mine Subsidence Surveys, Illawarra Encampment, New South Wales Australia. IN: Proceedings 3rd Canadian Symposium on Mining Surveying and Rock Deformation Measurements, Sudbury, Ontario, October 10-12, 1979, Canadian Institute Surveyors, p. 87-124.
This paper details the survey work performed for a subsidence monitoring project.
Keyword(s): monitoring design, monitoring installation, monitoring equipment, survey methods, survey equipment, survey data processing, computer, coal mining
Location(s): Australia

Mills, C. E. Ground Movement and Subsidence at the United Verde Mine. Transactions, AIME, v. 109, 1934, p. 153-172; also AIME Technical Publication No. 551, 1934, 21 p.
Keyword(s): surface subsidence damage
Location(s): United States

Mindling, A. L. A Summary of Data Relating to Land Subsidence in Las Vegas Valley. University of Nevada, Desert Research Institute, Center Water Resources Research, Reno, 1971, 55 p.
Keyword(s): fluid extraction
Location(s): Nevada, United States

Mines and Minerals. Method of Supporting Mine Roofs. v. 32, 1912, p. 279-281, 402-403.
This is a discussion of the patent of William Griffith covering the method of making waste to fill in the gob by blasting down the roof and/or blasting up the floor.
Keyword(s): roof support

Mines and Minerals. Flushing or Silting of Mine Workings. v. 32, 1912, p. 321-385.
This article discusses hydraulic injection of culm in 1886 to prevent subsidence of anthracite workings under the city of Shenandoah, Pennsylvania.
Keyword(s): hydraulic backfilling, anthracite, coal mining, mine waste
Location(s): Pennsylvania, Appalachian Coal Region, United States

Ming-Gao, C. A Study of the Behaviour of Overlying Strata in Longwall Mining and its Application to Strata Control. IN: Strata Mechanics, Proceedings of the Symposium, University of Newcastle-upon-Tyne, April, 1982, I.W. Farmer, ed., Elsevier, New York, p. 13-17.
The objective of this investigation was to describe the behavior of strata above a longwall face through a study of the movement of inter-strata plugs in a longwall working area. The investigations were conducted in the Dai-Tun coal mine, Province Jiangsu, China. By analyzing the subsidence curves of the overlying strata, a structural model was constructed to examine the behavior of the strata. Some of the phenomena of ground subsidence and roof pressure in the longwall mining can be explained using this model.
Keyword(s): longwall, overburden, modeling, roof stability, multiple-seam extraction, floor stability, vertical displacement, horizontal displacement
Location(s): China

Mining Magazine. Slope Filling on Rand. v. 10, May, 1914, p. 376.
This article describes hydraulic backfilling of a gold mine in South Africa to allow pillar removal.
Keyword(s): hydraulic backfilling, metal mining, pillar extraction
Location(s): South Africa

Mishra, G., R. L. Grayson. An Engineering Analysis of "Squeeze" Failure of Pillars in the Pittsburgh Coal Bed. IN: Proceedings 1st Annual Conference on Ground Control in Mining, July 27-29, 1981, S.S. Peng, ed., West Virginia University, Morgantown, p. 144-153.

In mid-1979, J&L Steel Corporation experienced rapid failure of pillars after only 2 weeks of operation with a combination of full retreat and partial mining. This paper describes the development of the squeeze, presenting the results of analyses of the condition and illustrating its progression over time through the use of maps. A general discussion of future mining plans near the squeeze area are also analyzed.

Keyword(s): coal mining, engineering, pillar strength, ground control, mine design, partial extraction, high-extraction retreat

Location(s): Pennsylvania, Appalachian Coal Region, United States

Misich, I., A. Evans, O. Jones. Groundwater Control and Strata Investigations to Allow Total Extraction of Coal by Underground Methods in the Collie Basin (Western Australia). IN: Proceedings 4th International Mineral Water Association Congress, Ljubljana (Slovenia)-Portschach (Austria), September 1991, p. 131-147.

A research program has been undertaken to evaluate the effect of total extraction of coal by underground methods on superimposed aquifer systems in the Collie Basin sediments, Western Australia. The research program has incorporated comprehensive field monitoring of surface and subsurface subsidence and groundwater levels along with empirical modeling techniques. Results have identified that ground curvature can be used to predict--ahead of mining--the likely impact on the Permian sediments and potential water inflow into the mine. Research is continuing on development of this approach using more sophisticated modeling techniques, including displacement discontinuity boundary element mathematical models and centrifuge modeling. Early results indicate both methods have good application to the subsidence processes noted in the Collie Basin.

Keyword(s): subsurface water, hydrology, coal mining, modeling, monitoring methods, boundary element, empirical model, mathematical model, physical model, inflow

Location(s): Australia

Missavage, R. J., Y. P. Chugh, T. Roscetti. Subsidence Prediction in Shallow Room-and-Pillar Mines. IN: Proceedings 2nd Conference on Ground Control Problems in the Illinois Coal Basin, May 1985, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 146-150.

A mathematical model was developed using the relative flexural strength of the strata overlying a coal seam to predict the vulnerability of shallow room-and-pillar mined areas to subsidence. The model assumes the failure of the immediate roof as the precursor of a subsidence event in shallow room-and-pillar mines. After the roof fails, either a sink hole subsidence event develops if the unconsolidated material is thin and dry; or a subsidence trough forms if the unconsolidated material is thick and wet.

Keyword(s): coal mining, prediction, room-and-pillar, mathematical model, modeling, land-use planning, abandoned mines, active mines, mine design, overburden, geologic features

Location(s): Illinois, Illinois Coal Basin, United States

Missavage, R. J., Y. P. Chugh, T. Roscetti. Subsidence Prediction in Shallow Room and Pillar Mines. International Journal of Mining and Geological Engineering, v. 4, 1986, p. 39-46.

A mathematical model uses the relative flexural strength of the strata overlying a coal seam to predict the vulnerability of shallow room-and-pillar mined areas to subsidence. The model assumes the failure of the immediate roof as the precursor of a subsidence event. The developed and validated model was subjected to a blind test in a mine in the Illinois Coal Basin; the model predicted 10 out of 12 subsidence events in the blind half of the study area and two of three additional subsidence events in the known half of the study area.

Keyword(s): coal mining, room-and-pillar, prediction, modeling, mathematical model, roof stability, abandoned mines

Location(s): Illinois, Illinois Coal Basin, United States

Mitchell, S. J., J. F. T. Agapito, L. A. Weakly. Reinforcement of Large Pillars by Bolting. IN: Rock Mechanics in Productivity and Protection, Proceedings 25th Symposium on Rock Mechanics, Northwestern University, Evanston, IL, June 25-27, 1984, C.H. Dowding and M.M. Singh, eds., SME-AIME, New York, p. 523-532.

An analysis of bolting reinforcement of several large pillars was performed. The many overcoring

stress profiles in pillars at the mine were used to produce generalized stress distributions at various stages in pre- and post-failure. A complete stress-deformation curve was estimated from this data. The effect of pillar bolting on the load-deformation behavior was extrapolated from the observed unbolted behavior. Bolting can increase pillar strength by up to 10%.
Keyword(s): pillar strength, modeling, computer
Location(s): Colorado, Rocky Mountain Coal Region, United States

Mitre Corporation. Environmental Action Programs for Northeastern Pennsylvania: Refuse Bank Removal--Subsidence Monitoring. U.S. Bureau of Mines Open File Report OFR 3-73, 1972.
Refuse removal and subsidence monitoring are the two topics of discussion.
Keyword(s): instrumentation, economics, mine waste, monitoring equipment, monitoring design, coal mining
Location(s): Pennsylvania, Appalachian Coal Region, United States

Mock, R. G., L. F. Marrs. Hazard Reduction Techniques Used for Pit Subsidence Near Hanna, Wyoming. IN: Proceedings Conference on Coal Mine Subsidence in the Rocky Mountain Region, Colorado Springs, October 28-30, 1985, J.L. Hynes, ed., Colorado Geological Survey Special Publication 31, Department of Natural Resources, Denver, 1986, p. 223-233.
Three different backfill techniques were used to reduce immediate hazards associated with pit subsidence over shallow abandoned coal mines near Hanna, Wyoming. The three techniques included the following: granular soil backfilling, a grouted boulder wedge, and open boulder backfilling.
Keyword(s): local backfilling, grouting, abandoned mines, reclamation, historical, land mitigation, coal mining
Location(s): Wyoming, Rocky Mountain Coal Region, United States

Mock, R. G., L. F. Marrs. Hazard Reduction Techniques Used for Pit Subsidence Near Hanna, Wyoming. IN: Proceedings 8th Annual National Abandoned Mine Lands Conference, August 10-15, 1986, Billings, MT, p. 151-160.
Three different backfill techniques were used to reduce immediate hazards associated with pit subsidence over shallow abandoned coal mines near Hanna, Wyoming.
Keyword(s): backfilling, abandoned mines, coal mining, local backfilling
Location(s): Wyoming, Rocky Mountain Coal Region, United States

Moebs, N. N. Geologic Guidelines in Coal Mine Design. IN: Ground Control Aspects of Coal Mine Design, Proceedings, Bureau of Mines Technology Transfer Seminar, Lexington, KY, March 6, 1973, U.S. Bureau of Mines IC 8630, 1974, p. 63-69.
Geologic techniques have been developed by which coal mine roof competency can be evaluated in advance of mining. The data for evaluation are derived from exploratory core drilling. Isopach maps of selected beds in the immediate roof are constructed from detailed logs of the core and standard physical properties of roof rock obtained from testing core samples.
Keyword(s): mine design, coal mining, geologic features, roof stability
Location(s): United States

Moebs, N. N., E. A. Curth. Geologic and Ground-Control Aspects of an Experimental Shortwall Operation in the Upper Ohio Valley. U.S. Bureau of Mines RI 8112, 1976, 30 p.
Keyword(s): roof stability, ground control, shortwall, coal mining, geologic features
Location(s): Ohio, United States

Moebs, N. N. Roof Rock Structures and Related Roof Support Problems in the Pittsburgh Coalbed of Southwestern Pennsylvania. U.S. Bureau of Mines RI 8230, 1977, 30 p.
Keyword(s): roof support, roof stability, coal mining, geologic features
Location(s): Pennsylvania, Appalachian Coal Region, United States

Moebs, N. N. Subsidence Over Four Room-and-Pillar Sections in Southwestern Pennsylvania. U.S. Bureau of Mines RI 8645, 1982, 23 p.
Keyword(s): room-and-pillar, coal mining
Location(s): Pennsylvania, Appalachian Coal Region, United States

Moebs, N. N. Subsidence Over Four Room and Pillar Sections in Southwestern Pennsylvania. U.S. Bureau of Mines, Pittsburgh Mining Technology Center, 1984.
Keyword(s): room-and-pillar, coal mining
Location(s): Pennsylvania, Appalachian Coal Region, United States

Moebs, N. N., R. M. Stateham. Geologic Factors in Coal Mine Roof Stability--A Progress Report. U.S. Bureau of Mines IC 8976, 1984, 27 p.

Keyword(s): roof stability, geologic features, coal mining

Location(s): United States

Moebs, N. N., T. M. Barton. Short-Term Effects of Longwall Mining on Shallow Water Sources. IN: Mine Subsidence Control, Proceedings Bureau of Mines Technology Transfer Seminar, Pittsburgh, September 19, 1985, U.S. Bureau of Mines IC 9042, p. 13-24.

The USBM monitored surface subsidence, water table levels, and stream flow above a longwall panel in southwestern Pennsylvania for about 6 months prior to mining and 12 months afterward. Only water levels within the boundary of the longwall showed a precipitous decline as a result of mining.

Keyword(s): longwall, hydrology, subsurface water, room-and-pillar, environment, surface water, coal mining

Location(s): Pennsylvania, Appalachian Coal Region, United States

Moebs, N. N., R. M. Stateham. The Diagnosis and Reduction of Mine Roof Failure. Coal Mining, v. 22, 1985, pt. 1, no. 2, 1985, p. 52-55; pt. 2, no. 3, 1985, p. 42-48.

Keyword(s): roof stability, coal mining

Moebs, N. N., R. M. Stateham. Coal Mine Roof Instability: Categories and Causes. U.S. Bureau of Mines IC 9076, 1986, 15 p.

Coal mine roof failure is categorized according to character, trend, or pattern of occurrence. Two principal categories of failure are proposed: geology related and stress related. Each of several subcategories reflects the probable cause of failure and thereby provides a basis for the selection of appropriate techniques for reducing the incidence of failure.

Keyword(s): roof stability, mine safety, ground control, overburden, roof support, coal mining, geologic features

Location(s): United States

Moebs, N. N., G. P. Sames. Geotechnical Aspects of Roof and Pillar Stability in a Georgia Talc Mine. U.S. Bureau of Mines RI 9404, 1992, 29 p.

This report summarizes a study on the application of geotechnology to identify and minimize ground control hazards in talc mining operations in northwestern Georgia. The major ground control hazard is pillar sloughing attributed to the steeply dipping orientation of a pronounced foliation in the talc ore body. A boundary element model confirmed the advantages of using a uniform pillar design to avoid excessive loads on portions of irregular pillars.

Keyword(s): geotechnical, non-metal mining, ground control, pillar strength, boundary element, modeling, instrumentation, roof stability, mine safety, rock mechanics, in situ testing

Location(s): Georgia, United States

Mohr, F. Observations in Shafts on Rock Movements Due to Mining. IN: Proceedings, International Strata Control Congress, Leipzig, October 14-16, 1958, p. 112-123 and IL-LVIII.

Rock movements at the surface above a mining area are of great interest in connection with the costly alterations to buildings and the drainage in the upper formations caused by such rock movements. The behaviour of the rock in the direct vicinity of the mining cavity has been frequently the subject of recent rock mechanics research. It is true that the movements occurring between these two zones have often been observed in horizontal cavities, for example, roadways.

Keyword(s): overburden, surface subsidence damage, rock mechanics

Location(s): Germany

Mohr, H. F. Influence of Mining on Strata. Mine and Quarry Engineering, April, 1956, v. 22, no. 4, 1956, p. 140-152.

This paper discusses the effects of mining on the rock strata between the surface and the extraction zone. Particular reference is made to influences on vertical shafts.

Keyword(s): overburden, subsurface subsidence damage

Molinda, G. M., K. A. Heasley, D. C. Oyler, J. R. Jones. Effects of Horizontal Stress Related to Stream Valleys on the Stability of Coal Mine Openings. U.S. Bureau of Mines RI 9413, 1992, 26 p.

This investigation was conducted to determine the nature and frequency of coal mine roof failure beneath valleys. A mechanism for this failure and suggestions for controlling this problem are presented. Hazardous roof conditions identified in some mines were positively correlated with mining activities beneath stream valleys. Mine maps with overlays of unstable roof and locations of stream valleys show that 52% of the instances of unstable roof in the surveyed mines occurred directly beneath the bottom-most part of the valley. The survey also showed that broad, flat-bottomed valleys were more likely to be sites of hazardous roof than narrow-bottomed valleys.

Keyword(s): roof stability, geologic features, coal mining, modeling

Location(s): Pennsylvania, West Virginia, Appalachian Coal Region, United States

Montz, H. W. Subsidence from Anthracite Mining. Transactions, AIME, v. 88, 1930, p. 98-134.

The author discusses three case studies involving pillar extraction.

Keyword(s): anthracite, coal mining, pillar extraction, surface structural damage

Location(s): United States

Monz, H. W. A Study of Surface Subsidence Accompanying Mining Operations in the Northern Anthracite Mining Fields of Pennsylvania. Thesis, The Pennsylvania State University, 1933.

Keyword(s): surface subsidence damage, anthracite, coal mining, active mines

Pennsylvania, Appalachian Coal Region, United States

Moore, R. C., M. A. Nawrocki. Effects of Subsidence from Thick Seam Coal Mining on Hydrology. Contract JO295012, Hittman Associates, Inc. U.S. Bureau of Mines OFR 93-80, 1980, 245 p. (NTIS PB 80-219280)

The USBM contracted a study to estimate what effects the underground mining of thick coal seams in the western United States would have on surrounding water resources. Potential coal fields where this type of mining might occur were identified. The international literature was searched for studies of effects on hydrology from thick seam underground coal mining. Estimates of the effects of this type of mining on the ground and surface water in the western states were made based on the limited information obtained from the foreign literature. No field work was performed.

Keyword(s): vertical displacement, horizontal displacement, surface water, subsurface water, hydrology, longwall, coal mining, literature search

Location(s): Montana, Wyoming, Colorado, New Mexico, Idaho, Utah, Arizona, Rocky Mountain Coal Region, United States

Morgan, R. C. Causes of Subsidences and the Best Safeguards for Their Protection. Colliery Guardian, v. 121, 1921, p. 795-797, 868, 869.

Keyword(s): backfilling, pillar strength

Location(s): Germany, England

Morgan, T. A. Coal Mine Roof Problems. IN: Ground Control Aspects of Coal Mine Design, Proceedings, Bureau of Mines Technology Transfer Seminar, Lexington, KY, March, 6, 1973, U.S. Bureau of Mines IC 8630, 1974, p. 56-62.

The factors that contribute to coal mine roof problems are so numerous and work in so many combinations that the greatest difficulty in solving these problems lies in identifying the chief cause of the problem. The staffs of coal mining companies can often identify the cause without the help of ground control specialists by using practical and inexpensive monitoring devices in their mines. These measurements may lead directly to a solution or may show the problem to be similar to the problem in another mine for which a solution has already been found.

Keyword(s): roof stability, roof support, mine design, ground control, coal mining, geologic features

Location(s): United States

Morgan, T. A., J. C. Still. The Effect of Mining and Subsidence Rates on Transfer of Overburden Weight. IN: Ground Control Aspects of Coal Mine Design, Proceedings, Bureau of Mines Technology Transfer Seminar, Lexington, KY, March 6, 1973, U.S. Bureau of Mines IC 8630, 1974, p. 35-43.

This paper suggests a relationship between the rate of subsidence and the dynamic transfer of weight within low dip, bedded deposit mines. This information can be useful in the design of mine layouts and extraction sequences.

Keyword(s): mine design, overburden, ground control, active mines

Location(s): United States

Morgando, F. P. Engineering Geological Investigation of a Subsided Area, "D" Street--Connecticut Avenue, Rock Springs, Wyoming. Wyoming Highway Department Project ARS 1435, March 28, 1969, 7 p. (Available for consultation at the USBM Denver Research Center.)

Keyword(s): backfilling, surface structural damage

Location(s): Wyoming, Rocky Mountain Coal Region, United States

Morgando, F. P. Rock Springs Backfill Project, Rock Springs, Wyoming. Wyoming Highway Department Project ARS 1523, January 21, 1971, 2 p. (Available for consultation at the USBM Denver Research Center.)
Keyword(s): backfilling, surface structural damage, abandoned mines
Location(s): Wyoming, Rocky Mountain Coal Region, United States

Morgando, F. P. Surface Subsidence Due to Coal Mining, Rock Springs, Wyoming. IN: Proceedings, 9th Engineering Geology and Soils Engineering Symposium, Idaho Department of Highways, Boise, 1971, p. 189. (NTIS Accession No. 72-00498)
Keyword(s): coal mining, abandoned mines
Location(s): Wyoming, Rocky Mountain Coal Region, United States

Morita, N., D. L. Whitfill, O. Nygaard, A. Bale. A Quick Method to Determine Subsidence, Reservoir Compaction, and In Situ Stress Induced by Reservoir Depletion. IN: Rock Mechanics Contributions and Challenges, Proceedings of the 31st U.S. Rock Mechanics Symposium, Golden, CO, June 18-20, 1990, W.A. Hustrulid and G.A. Johnson, eds., Balkema, Rotterdam, p. 5-6.
This paper provides a quick method to determine subsidence, compaction, and in situ stress conditions resulting from pore pressure changes. The method is useful for formations showing large Young's modulus contrasts compared to the surrounding rocks.
Keyword(s): rock mechanics, fluid extraction, oil extraction

Morrison, C. S., D. V. Holmquist. Analysis of Subsidence Potential Using Complimentary Influence Functions. IN: Proceedings Symposium on Evolution of Abandoned Mine Land Technologies, Riverton, WY, June 14-16, 1989, p. 299-305.
Complimentary influence functions analysis was used to predict potential subsidence and the effect of subsidence abatement procedures for undermined parts of Rock Springs, Wyoming. This analysis technique was chosen because it is easily applied to complex room-and-pillar mine geometries.
Keyword(s): influence function, prediction, room-and-pillar, computer, National Coal Board, backfilling, surface structural damage
Location(s): Wyoming, Rocky Mountain Coal Region, United States

Morrison, W. C. Stabilization of a Deep, Submerged and Abandoned Mine. Presented at Annual Meeting, Association of Engineering Geologists, September 11, 1987, 24 p.
In 1980, a mine subsidence event, which affected homes, shopping centers, churches, and service stations, was reported in the CIty of Graysville, Alabama. Beneath the affected subsidence area are two abandoned coal mines. The USBM investigated the severity and extent of this event and made appropriate recommendations for stabilization.
Keyword(s): abandoned mines, coal mining, surface structural damage, utilities, foundations, roads, subsurface water, grouting, overburden
Location(s): Alabama, United States

Morrison, W. C. Grouting in Deep Flooded Mines. IN: Association of Engineering Geologists Symposium Series No. 4, Building Over Underground Mines--Subsidence Considerations, October 1987, p. 127 (abstract only).
Grouting in the Mary Lee coalbed in Graysville, Alabama created difficulties regarding the development of massive grout columns in a flooded mine situated approximately 700 feet below the ground surface. Several difficulties had to be overcome to inject the grout into the mine.
Keyword(s): grouting, abandoned mines
Location(s): Alabama, United States

Morse, C. F. R. Some Mining Problems Encountered During the Construction of a Section of the M6 Motorway Adjacent to Walsall in Staffordshire. The Chartered Surveyor, 100, 1967, p. 236-243.
Keyword(s): roads
Location(s): United Kingdom

Mort, T., P. G. D. Pretorius. Extraction of No. 6 Shaft Pillar Area, Durban, Roodepoort Deep, Ltd. Association Mine Managers Transvaal, Papers and Discussions, 1946/47, p. 67-109.
Keyword(s): room-and-pillar, pillar extraction
Location(s): South Africa

Morton, D. M. Surface Deformation in Part of the San Jacinto Valley, Southern California. U.S. Department of the Interior, Geological Survey Journal of Research, v. 5, 1977, p. 117-124.
Keyword(s): fluid extraction
Location(s): California, United States

Moscnyi, E. Influence of Ground Subsidence Due to Mining on River Regime and Scale Model Experiments. IN: Proceedings, International Symposium of Fossil Fuel Production and Water Resources, Paper 18, 1976.

Keyword(s): surface water, surface subsidence damage, modeling

Mozumdar, B. K. A Mathematical Model of Ground Movement Due to Underground Mining. Ph.D. Thesis, The Pennsylvania State University, State College, 1974, 130 p.

Keyword(s): modeling, mathematical model

Mozumdar, B. K., C. B. Manula. Prediction of Ground Movement Due to An Advance Face. IN: Proceedings, 14th Symposium on Application of Computer Methods in the Mineral Industry, Pennsylvania State University, October 4-8, 1976, R.V. Ramani, ed., SME-AIME, New York, NY, 1977, p. 494-504.

Keyword(s): prediction, computer

Location(s): United States

Mraz, D. Z., D. Gendzwill. Evaluation of Subsidence Over a Deep Saskatchewan Potash Mine. IN: Proceedings, 2nd Workshop on Surface Subsidence due to Underground Mining, Morgantown, WV, June 9-11, 1986, S.S. Peng, ed., West Virginia University, p. 91-103.

Subsidence profiles over Saskatchewan potash mines exhibit forms that cannot be explained by existing subsidence models. The subsidence is affected by bridging of competent rocks. A modification of the theory can explain the observed displacement of subsidence profiles due to bridging. An unusual shallow secondary subsidence trough has been observed extending 2 to 3 kilometers outside the primary subsidence. The secondary subsidence is explained as an elastic compression in response to a drop in pore water pressure in the vicinity of the caving zone. The concept of pore water pressure may lead to a safe extraction limit for Saskatchewan mines.

Keyword(s): non-metal mining, modeling, empirical model, profile function, influence function, prediction, rock mechanics, geologic features, overburden

Location(s): Canada

Mraz, D. Z., R. S. Jones. A Case History of Convergence and Subsidence Over a Deep Saskatchewan Potash Mine. IN: Mine Subsidence, Society of Mining Engineers Fall meeting, St. Louis, MO, September, 1986, M.M. Singh, ed. SME, Littleton, CO, p. 117-127.

Unlike in coal mines where caving methods are used, the subsidence over potash mines in Saskatchewan, Canada, is a function of gradual mining convergence. Because of the presence of high pressure water aquifers over the evaporite salt formations, the mines have to be designed as regionally stable and no caving is allowed. The extracted area converges gradually and the convergence is mainly a function of the extraction and mining method employed. Consequently, the subsidence rate is very slow and the bridging of the overlying strata is a considerably more important phenomenon than elsewhere. The paper evaluates a case history of convergence and subsidence in a deep potash mine in Saskatchewan.

Keyword(s): non-metal mining, subsurface water, overburden, geologic features, survey methods, survey data processing, angle of draw

Location(s): Canada

Mroz, Z., P. Nawrocki. Deformation and Stability of an Elasto-Plastic Softening Pillar. Rock Mechanics and Rock Engineering, v. 22, no. 2, April-June, 1989, p. 69-108.

A model of rock pillar or coal seam is considered assuming linear elastic behaviour before reaching the maximum strength and post-peak behaviour characterized by the residual strength. Deformation and stress across pillar height are assumed to be uniform. The interaction with overlying rock strata is treated assuming a beam model of the strata. The elasto-plastic stress distribution within the pillar and the onset of instability occurring for the critical opening span are determined. Comparison with a solution for a simplified "spring" model of a pillar is also presented.

Keyword(s): pillar strength, modeling, coal mining

Mrugala, M. J., R. M. Belesky. Pillar Sizing. IN: Rock Mechanics as a Guide to Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, A.W. Khair, ed., 1989, Balkema, Rotterdam, p. 395-402.

Coal strength, based on scaled uniaxial compressive strength from the laboratory and back-calculations from in-mine observations of pillar stability, indicates that material strength scaling rules are open to debate. Analyses presented indicate that the application of scaling factors lower than 0.5 provide a better correlation with field observations of pillar stability.

Keyword(s): coal mining, pillar strength, lab testing, rock mechanics, mine design, room-and-pillar, pillar extraction
Location(s): Pennsylvania, Appalachian Coal Region, United States

Mrugala, M. J., W. Bishop. Performance of a Two-Cavern Storage System Using Finite Element Method. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium,1989, A.W. Khair, ed., Balkema, Rotterdam, p. 689-696.

Finite element method was employed to assess the performance of a two-cavern system over a 20-year period of operation. Of primary importance was evaluation of the stability of the pillar separating the two caverns. Results of these analyses are discussed along with practical implications relevant to cavern operation.

Keyword(s): finite element, pillar strength, nonmetal mining, modeling, computer
Location(s): United States

Mueller, W. Die Berechnung Der Bewegungen Und Spannungen Des Gebirges Vom Abbau Bis Zur Tagesoberflaeche Nach Der Methode Der Endlichen Elemente (Calculation of Displacements and Stress in Rock Strata Between the Mining Exploitation and the Surface by Means of Finite Element Method). Glueckauf-Forschungshefte, v. 34, no. 6, December 1973, p. 228-236.

Keyword(s): finite element, modeling, overburden

Muller, R. A., A. I. Juskin, J. I. Karavaev (eds.) Manual to Calculation of Buildings and Constructions Designed on Mining Areas. Publication of Construction Literature, Leningrad, U.S.S.R., 1968, 278 p. (in Russian).

Keyword(s): architecture, construction, surface structural damage

Munson, D. E., S. E. Benzley. Analytical Subsidence Model Using Void-Volume Distribution Functions. IN: Rock Mechanics: A State of the Art, Proceedings 21st U.S. Symposium on Rock Mechanics, University of Missouri at Rolla, May 28-30, 1980, D.A. Summers, ed., p. 299-307.

This paper presents an analytic theory of subsidence that acts as a framework describing both the time-dependent and time-independent aspects of the subsidence process. Also included is a description of the numerical tests performed on this proposed model using a finite element computer program.

Keyword(s): vertical displacement, horizontal displacement, computer, rock mechanics, time factor, finite element, modeling
Location(s): United States

Munson, D. E., W. F. Eichfeld. Evaluation of European Empirical Methods for Subsidence in U.S. Coal Fields. U.S. Department Energy contract SAND 80-0537, Sandia National Laboratory, 1980, 27 p. (NTIS SAND-79-2355 C)

This report analyzes the applicability of European subsidence prediction methods (including graphical methods, profile functions, and influence functions) for U.S. longwall mining conditions where the subsidence process has been documented.

Keyword(s): vertical displacement, horizontal displacement, prediction theories, longwall, profile function, influence function, coal mining, empirical model
Location(s): Europe, United States

Munson, D. E., W. F. Eichfeld. European Empirical Methods Applied to Subsidence in U.S. Coal Fields. SAND80-1920, Sandia National Laboratories, Albuquerque, NM, October, 1980, 20 p.

Keyword(s): prediction theories, coal mining, empirical model
Location(s): United States, Europe

Munson, D. E., H. J. Sutherland. Empirical and Analytic Approaches to Subsidence Prediction. IN: Proceedings, Conference on Ground Control in Room-and-Pillar Mining, Southern Illinois University, Carbondale, August 6-8, 1980, Y. P. Chugh, ed., SME-AIME, New York, 1982, p. 139-149.

Empirical methods for describing the shape of the subsidence trough over coal mines in Europe are tested against field measurements of subsidence over longwall panels in the United States. The graphical methods developed by the National Coal Board in the United Kingdom do not correlate well with measurements from the United States; however, the profile functions typically used on in Europe give quite acceptable fits to the data.

Keyword(s): prediction, modeling, ground control, empirical model, room-and-pillar, profile function, coal mining, National Coal Board
Location(s): Illinois, New Mexico, United States, Europe, United Kingdom

Munson, R. D. Subsidence Monitoring Using Seismic Activity. U.S. Bureau of Mines Denver Research Center, Mining Research Contract Final Report J5160064 to Office of Surface Mining, November, 1987, 69 p. (NTIS PB90-162496)

The occurrence of seismic events caused by developing zones of subsurface subsidence was monitored using a near-surface geophone array. The active subsidence site was located in a residential area of northeast Colorado Springs, Colorado. Although a considerable number of events were observed during the 10-month monitoring interval, the source of only a few could be located. Despite the problems inherent of subsidence sites, results indicate that this geophysical method has the potential to detect activity that is indicative of initial subsurface subsidence (i.e., failure of the abandoned mine roof).

Keyword(s): geophysical, abandoned mines, coal mining, roof stability, seismic, ground control

Location(s): Colorado, Rocky Mountain Coal Region, United States

Murphy, E. M., M. O. Magnuson, P. Sader Jr., J. Nagy. Use of Fly Ash for Remote Filling of Underground Cavities and Passageways. U.S. Bureau of Mines RI 7214, 1968, 27 p.

Extensive tests of materials, methods, and possible problems were made at the Bruceton Experimental Mine, an operating mine, and an abandoned mine.

Keyword(s): backfilling, abandoned mines, active mines

Location(s): United States

Murphy, E. W., R. E. Yarbrough, S. C. Bradford. A Review of Claims Data--Illinois Mine Subsidence Insurance Fund, October 1979 to October 1985. IN: Proceedings 2nd Workshop on Surface Subsidence due to Underground Mining, Morgantown, WV, June 9-11, 1986, S.S. Peng, ed., West Virginia University, p. 13-18.

This paper presents subsidence insurance claims and structural monitoring data; it describes changes that have occurred in the Illinois Insurance Code during the first 6 years the Illinois Mine Subsidence Insurance Fund has been in existence.

Keyword(s): surface structural damage, insurance, coal mining, historical, abandoned mines, monitoring methods, monitoring equipment

Location(s): Illinois, Illinois Coal Basin, United States

Murphy, E. W., R. E. Yarbrough. Reconstruction of Homes Damaged by Coal Mine Subsidence -- Progress Report. IN: Proceedings, 2nd International Conference on Construction in Areas of Abandoned Mineworkings, Edinburgh, 1988, p. 185-190.

Keyword(s): coal mining, abandoned mines, foundations, structural mitigation, surface structural damage

Location(s): Illinois, Illinois Coal Basin, United States

Murray, M. J. Baillieston Interchange Bridges (with Particular Reference to the Design for Mining Subsidence). IN: Mineworkings 84: Proceedings International Conference on Construction in Areas of Abandoned Mineworkings, Edinburgh, 1984, M.C. Forde, B.H.V. Topping, and H.W. Whittington, eds., Engineering Technics Press, p. 151-161.

Keyword(s): engineering, roads

Murria, J. Subsidence in Western Venezuela Oil Fields Monitoring and Prediction. IN: Proceedings VIII Congress International Society for Mine Surveying, September 22-27, 1991, University of Kentucky, Lexington, UKY BU154, p. 439-443.

The paper presents a brief historical summary of oil production and subsidence monitoring in western Venezuela, followed by a general review of the latest developments in subsidence monitoring, and a brief description of four subsidence models developed.

Keyword(s): oil extraction, monitoring methods, survey methods, modeling, prediction, geologic features, vertical displacement, empirical model, fluid extraction, finite element

Location(s): Venezuela

Musulin, M. Making a Case for Longwalls. Coal, August, 1989, p. 52-54.

The coal industry is at a critical juncture in regard to longwall mining. The public's acceptance and tolerance of longwall mining will determine the ultimate success or failure of this mining method. In order to be successful, the industry must educate the public prior to any longwall mining. The industry must make its case logically and with all the communication skills it can muster. At the same time, the industry must be sincere in what it says. The cardinal rule for success is communication.

Keyword(s): longwall, coal mining, land-use planning, active mines

Location(s): Kentucky, West Virginia, Ohio, United States

Myers, A. R., J. B. Hansen, R. A. Lindvall, J. B. Ivey, J. L. Hynes. Coal Mine Subsidence and Land Use in the Boulder-Weld Coalfield, Colorado. Grant GO244001, Colorado Geological Survey, U.S. Bureau of Mines OFR 64-77, 1975, 92 p.

Keyword(s): land-use planning, coal mining, abandoned mines

Location(s): Colorado, Rocky Mountain Coal Region, United States

Myers, K. L., C. C. Rehn. Multi-Phased Subsidence Study and Use of Progressive Failure Model for Subsidence Prediction Above Room and Pillar Mines. IN: Proceedings, Conference on Coal Mine Subsidence in the Rocky Mountain Region, Colorado Springs, October 28-30, 1985, J.L. Hynes, ed., Colorado Geological Survey Special Publication 31, Department of Natural Resources, Denver, 1986, p. 143-167.

This paper describes a study performed for a site in Colorado Springs, Colorado. The site is located above abandoned room-and-pillar coal mines last worked in the 1920s and 1940s. The three phases of the study involved a review of published data on the mines, a limited subsurface investigation, and a very detailed evaluation of the eastern portion of the site, resulting in a prediction of final subsidence profile and ground strains.

Keyword(s): abandoned mines, room-and-pillar, prediction, modeling, pillar strength, roof stability, floor stability, overburden, subsurface water, land-use planning, structural mitigation, hydraulic backfilling, grouting, utilities, literature search, coal mining

Location(s): Colorado, Rocky Mountain Coal Region, United States

Nair, O. B. Roof and Floor Bearing Capacity Tests. IN: Proceedings, Bureau of Mines Technology Transfer Seminar, Lexington, KY, March 6, 1973, Ground Control Aspects of Coal Mine Design, U.S. Bureau of Mines IC 8630, 1974, p. 114-120.

One of the factors causing problems in longwall operations is when the size of the supports is such that the bearing pressures exerted cause failure of the floor or roof. RI 7406 describes the development and test results of a simple, inexpensive, and effective method of testing the bearing capacity of mine roof and floor. The equipment and testing procedure is described and the results of tests in nine mines in the United States are discussed. The test may be used to determine the allowable bearing pressures that can be exerted on mine roof/floor by longwall support equipment.

Keyword(s): roof stability, floor stability, in situ testing, longwall, roof support, coal mining, active mines, bituminous

Location(s): United States

Najjar, Y., M. Zaman, J. Ahern. Prediction of Surface Subsidence Caused by Underground Mining Using a Nonlinear Finite Element Procedure. IN: Proceedings 3rd International Symposium on Numerical Models in Geomechanics, Niagara Falls, May 8-11, 1989, Elsevier, p. 557-565.

Subsidence and collapse due to underground mining are examined using nonlinear finite element analysis. An elastoplastic constitutive model represents the nonlinearity of the rock strata and an accurate algorithm simulates the extraction. The analysis is applied to the Blue Goose Lease in northern Oklahoma. Stress distribution before and after extraction is examined. The effect of dumping mine waste on the surface above the workings is also studied.

Keyword(s): finite element, modeling, elastic model, mine waste

Location(s): Oklahoma, United States

Narasimham, T. N., P. A. Witherspoon. Numerical Model for Land Subsidence in Shallow Groundwater Systems. IN: Proceedings 2nd International Symposium on Land Subsidence, Anaheim, CA, IAHS-AIHS Publication No. 121, December, 1976, p. 133-143.

Keyword(s): modeling, subsurface water, hydrology

Narasimhan, T. N., K. P. Goyal. Subsidence Due to Geothermal Fluid Withdrawal. IN: Man-Induced Land Subsidence, Reviews in Engineering Geology VI, The Geological Society of America, T.L. Holzer, ed., 1984, p. 35-66.

Single-phase and two-phase geothermal reservoirs are currently being exploited for power production in Italy, Mexico, New Zealand, the United States, and elsewhere. Vertical ground displacements have been observed in California as well as in New Zealand (where horizontal displacements were also measured). No significant ground displacements attributable to large-scale fluid production have been observed in Italy or Mexico. Observations show that subsidence due to geothermal fluid production is characterized by an offset of the subsidence bowl from the main area of production, time-lag between production and subsidence, and nonlinear stress-strain relationships. Several plausible conceptual models have been proposed to explain the observed features.

Keyword(s): fluid extraction, vertical displacement, horizontal displacement, modeling

Location(s): Italy, Mexico, New Zealand, United States

National Academy of Sciences, National Research Council, Commission on Engineering and Technical Systems, Division of Natural Hazard Mitigation, Committee on Ground Failure Hazards Mitigation Research, Panel on Land Subsidence. Mitigating Losses from Land Subsidence in the United States. National Academy Press, 1991, Washington, D.C., 58 p.

More than 44,000 square kilometers of land in 45 states have been lowered by underground coal mining, groundwater withdrawal, and the drainage of organic soils. With annual costs exceeding $125 million because of the resultant structural damage and flooding, awareness and reduction of the subsidence hazard is an increasing concern in at-risk regions. This report reviews the land subsidence problem in the United States and assesses the effectiveness of current research, as well as the engineering, technical, and nonstructural solutions that have been utilized to reduce losses. Land use management, mandatory insurance, and construction codes are among the measures discussed.

Keyword(s): mitigation, coal mining, fluid extraction, land mitigation, oil extraction, soils, surface structural damage, structural mitigation, land-use planning, abandoned mines, active mines, longwall, partial extraction, economics, insurance, prediction

Location(s): United States

National Building Studies. Mining Subsidence Effects on Small Houses. Special Report No. 12, London, 1951, p. 24.
Keyword(s): surface structural damage, construction
Location(s): England

National Building Studies. Simplified Tables of External Loads on Buried Pipelines. Ministry of Works, no. 32, London, 1962.
Keyword(s): utilities, pipelines, subsurface structural damage
Location(s): England

National Coal Board. Investigation of Mining Subsidence Phenomena. Information Bulletin 52/78, 1952, 25 p.
The mechanics of surveying subsidence effects as observed at the ground surface are described.
Keyword(s): survey methods, National Coal Board, coal mining
Location(s): England

National Coal Board. Partial Extraction as a Means of Reducing Subsidence Damage. Information Bulletin 61/231, 1961, 16 p.
This bulletin is a factual record of experience in partial extraction and is intended to acquaint management with the technique and to serve as a reference for specialists. No attempt is made to discuss the theory of ground movement or to explain the phenomena recorded.
Keyword(s): partial extraction, ground control, National Coal Board, coal mining, active mines
Location(s): England

National Coal Board. Principles of Subsidence Engineering. Information Bulletin 63/240, 1963, 27 p.
Keyword(s): horizontal displacement, ground control, backfilling, descriptive theories, coal mining, National Coal Board
Location(s): England

National Coal Board. Design of Mine Layout, with Reference to Geological and Geometrical Factors. Mining Department of Working Party Report, 1972, 52 p.
Keyword(s): mine design, longwall, ground control, prediction, monitoring methods, geologic features, coal mining, National Coal Board
Location(s): England

National Coal Board. The Treatment of Disused Mine Shafts and Adits. National Coal Board, Mining Department, 1982.
Keyword(s): National Coal Board, abandoned mines, reclamation, coal mining
Location(s): England

National Coal Board, Divisional Strata Control Research Committee, Durham and Northern (N and C) Divisions. Memorandum on the Design of Mine Workings to Secure Effective Strata Control. Transactions Institution of Mining Engineers, v. 110, 1950-51, p. 252-271 and 273-278.
Keyword(s): ground control, mine design, coal mining, National Coal Board
Location(s): England

National Coal Board, Divisional Strata Control Research Committee, Durham and Northern (N and C) Divisions. Report on the Effects of Workings in Adjacent Seams Upon New Developments. Transactions Institution of Mining Engineers, v. 113, 1953-54, p. 389-403.
Keyword(s): multiple seam extraction, ground control, active mines, National Coal Board, coal mining
Location(s): England

National Coal Board, Mining Research Establishment. Strata Control on Longwall Faces. Bulletin 10, 1965, 11 p.
Keyword(s): coal mining, National Coal Board, active mines, longwall
Location(s): England

National Coal Board, Production Department. Subsidence Engineers' Handbook. 1966, 118 p.
This handbook presents a systematic discussion of subsidence and subsidence parameters derived from empirical data. It includes a scheme for using these parameters for subsidence prediction in Great Britain.
Keyword(s): engineering, prediction, time factor, survey methods, ground control, National Coal Board, coal mining
Location(s): England

National Coal Board, Production Department. Subsidence Engineers' Handbook. 1975, 111 p.
Various aspects of subsidence engineering are detailed, including prediction methods, subsidence mechanics, and structural precautions against subsidence damage.

Keyword(s): prediction, surface structural damage, horizontal displacement, structural mitigation, land mitigation, engineering, vertical displacement, subsurface structural damage, surface water, ground control, descriptive theories, angle of draw, longwall, time factor, National Coal Board, coal mining
Location(s): England

National Coal Board, Regional Subsidence Engineering Services. Subsidence Engineers' Report on Eastwood Hall. Nottingham, England, 1970.
Keyword(s): National Coal Board, coal mining, surface structural damage
Location(s): England

National Coal Board, Regional Subsidence Engineering Services. Subsidence Engineers' Report on Ransom Hospital. Nottingham, England, 1970.
Keyword(s): National Coal Board, coal mining, surface structural damage
Location(s): England

National Coal Board, Regional Subsidence Engineering Services. Subsidence Engineers' Report on the Vedonis Knitwear Factory at Watnall Road, Hucknall. Nottingham, England, 1972.
Keyword(s): surface structural damage, National Coal Board, coal mining
Location(s): England

National Research Council. Coal Mining and Ground-Water Resources in the United States. National Academy Press, Washington, D.C., 1981, 193 p.
This report examines the expansion and geographical redirection of coal mining now occurring in the United States, its effects on ground water, and the environmental and socioeconomic impacts of those effects. The term "effect" is used in reference to the changes in groundwater resources that result directly from a mining activity. The term "impact" refers to the ensuing environmental and socioeconomic consequences of the groundwater changes. Coal mining is examined as one of many competing uses for the nations's groundwater resources. The report addresses groundwater use, groundwater supplies and availability, principles that govern the functioning of hydrogeologic systems, and the institutional framework for groundwater allocation.
Keyword(s): coal mining, subsurface water, hydrology, environment, active mines, abandoned mines, inflow
Location(s): United States

Nawar, G. Quality Assurance for Buildings in Ground Movement Areas. IN: Proceedings, International Association of Bridge and Structural Engineers, Symposium on Safety and Quality Assurance of Civil Engineering Structures, Tokyo, 1986, p. 197-205.
Identification and quantification of the risk of damage to surface structures in areas liable to mining subsidence are studied. Risk is quantified with a probabilistic component, which is related to previous mining practice, and a deterministic component, which considers the relation between subsidence and consequent damage. Acceptable risk, risk management, and risk reduction to achieve an acceptable level of performance are considered.
Keyword(s): surface structural damage, coal mining, non-metal mining, multiple-seam extraction, foundations, construction
Location(s): Australia

Nawrot, J. R., R. J. Haynes, P. L. Pursell, J. R. D'Antuono, R. L. Sullivan, W. D. Klimstra. Illinois Lands Affected by Underground Mining for Coal. Cooperative Wildlife Research Laboratory, Southern Illinois University, Carbondale, 1977.
This report includes a county-by-county inventory of abandoned underground mine sites in Illinois and an assessment of environmental problems associated with each. Mine locations are shown in the appendices.
Keyword(s): abandoned mines, environment, reclamation, coal mining
Location(s): Illinois, Illinois Coal Basin, United States

Neate, C. J., B. N. Whittaker. Influence of Proximity of Longwall Mining on Strata Permeability and Ground Water. IN: Proceedings, 20th U.S. Symposium on Rock Mechanics, Austin, TX, June 4-6, 1979, University of Texas, p. 217-224.
Mining subsidence arising from longwall extractions produces appreciable ground strain in the overlying strata. The ground strains caused by mining produce changes in in situ permeability that are of special importance when working under aquifers and surface bodies of water. The paper describes the design and installation of test equipment to investigate changes in in situ permeability and groundwater conditions. Results are presented and discussed on the changes produced by the approach of a longwall coalface.
Keyword(s): longwall, subsurface water, surface water, hydrology, rock mechanics, coal mining, instrumentation, geologic features,

monitoring equipment, monitoring design, monitoring methods, inflow
Location(s): United Kingdom

Neighbors, R. J., R. E. Thompson. Subsidence in the Houston-Galveston Area of Texas. IN: Land Subsidence, Proceedings 3rd International Symposium, Venice, Italy, March 19-25, 1984, A.I. Johnson, L. Carbognin, and L. Ubertini, eds., International Association of Hydrological Sciences Publication No. 151, 1986, p. 785-793.
The withdrawal of large quantities of ground-water in the Houston-Galveston area of Texas has resulted in declines in excess of 75 meters in the potentiometric surface in the Chicot aquifer and 100 meters in the Evangeline aquifer from 1943 to 1977. These declines have caused subsidence in excess of 3.0 meters to occur in the area.
Keyword(s): fluid extraction, hydrology
Location(s): Texas, United States

Nelson, A. Mining Subsidence and Surface Damage. Iron and Coal Trades Review, v. 154, March 28, 1947, p. 517-519.
Keyword(s): coal mining, surface subsidence damage

Nelson, A. Floor Movements and Their Control. Iron and Coal Trades Review, v. 154, no. 4136, 1947, p. 1211-1214.
Keyword(s): floor stability, coal mining

Nelson, A. Ground Movements due to Mining. Canadian Mining Journal, v. 85, no. 6, June, 1964, p. 69-73.
This paper discusses factors affecting subsidence such as mining methods, type of overburden, and the influence of faults. Damage to surface structures is described, and foundation construction to limit subsidence damage is briefly covered.
Keyword(s): surface subsidence damage, overburden, surface structural damage, foundations, geologic features
Location(s): Canada

Nelson, W., K. C. Fahrni. Caving and Subsidence at the Copper Mountain Mine. Canadian Institute of Mining and Metallurgy Transactions Bulletin, v. 43, 1950, p. 2-10.
Keyword(s): metal mining
Location(s): Canada

Neubert, K. The Effects of Disturbance of the Equilibrium of the Rock Mass Occasioned by Mining in the Saxony Coalfield. IN: Proceedings, European Congress on Ground Movements, Leeds, England, April 9-12, 1957, London Harrison, p. 167-175.
Keyword(s): overburden, surface subsidence damage, coal mining
Location(s): England

New South Wales Coal Association. Mine Subsidence: A Community Information Booklet. Jointly published by New South Wales Coal Association, Department of Minerals and Energy, and the Mine Subsidence Board of Australia, September 1989, 32 p.
Preparation of this booklet was undertaken to increase community awareness and discussion concerning underground mining and surface subsidence, thereby allowing better informed decisions concerning the management of valuable coal resources and the land surface above them.
Keyword(s): coal mining, vertical displacement, horizontal displacement, land-use planning, surface structural damage, longwall, room-and-pillar, shortwall, overburden
Location(s): Australia

Newhall, F. W., L. N. Plein. Subsidence at Merrittstown Air Shaft Near Brownsville, Pennsylvania. Transactions, AIME, v. 119, 1936, p. 58-94.
Effects of subsidence on a concrete-lined air shaft were monitored by surface survey. The factors of geologic conditions, mining methods, and survey techniques are discussed.
Keyword(s): subsurface subsidence damage, subsurface structural damage, survey methods, geologic features
Location(s): Pennsylvania, Appalachian Coal Region, United States

Newman, D. A. Coal Mine Ground Control: The Effect of Geology. American Association of Petroleum Geologists Bulletin, v. 67, no. 9, 1983.
Keyword(s): ground control, coal mining, geologic features
Location(s): United States

Newman, D. A. A Modified Version of the Geomechanics Classification for Use in Underground Coal Mines. IN: Proceedings 2nd Conference on Ground Control Problems in the Illinois Coal Basin, May 1985, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 64-71.

The Geomechanics Classification (Bieniawski 1979) was modified for use in underground room-and-pillar coal mines through the introduction of adjustment multipliers for strata weatherability, high horizontal stresses, and the roof support reinforcement factor. Sixty-two case histories of standing and fallen mine roof were collected from two mines. Each case history consisted of thirty-two engineering and geological parameters. Partial correlation analysis was conducted on the cases to determine which parameters have a significant impact upon the supported stand-up time of coal mine roof.

Keyword(s): ground control, coal mining, room-and-pillar, mine safety, prediction, geologic features

Location(s): Appalachian Coal Region, United States

Newman, D. A. Automated Data Acquisition System for Remote Monitoring of Pillar and Roof Deformation on a Longwall Panel. SME Preprint 88-64, for presentation at the SME Annual Meeting, Phoenix, AZ, January 25-28, 1988, 5 p.

The purpose of this research is to examine the post-failure behavior of coal as a mass and examine the relationship between the results of this study and prior laboratory investigations of the post-failure behavior of coal as a material. Instrumentation to measure changes in stress and deformation was placed in a headgate yield pillar and will be monitored as the face passes the area. A battery powered, automated data acquisition system, capable of recording up to 9,000 data points, is currently used to remotely monitor changes in vertical and horizontal pillar stress.

Keyword(s): coal mining, longwall, instrumentation, pillar strength, roof stability, monitoring equipment, monitoring installation, monitoring methods, yielding supports, lab testing, in situ testing

Location(s): United States

Newton, J. G., L. W. Hyde. Sinkhole Problem in and Near Roberts Industrial Subdivision, Birmingham, Alabama. Geological Survey of Alabama Circular 68, 1971, 42 p.

Keyword(s): geologic features

Location(s): Alabama, United States

Newton, J. G. Induced Sinkholes--A Continuing Problem Along Alabama Highways. IN: Proceedings 2nd International Symposium on Land Subsidence, Anaheim, CA, IAHS-AIHS Publication No. 121, December, 1976, p. 453-463.

Keyword(s): surface subsidence damage, roads

Location(s): Alabama, United States

Newton, J. G. Sinkholes Resulting from Ground-Water Withdrawals in Carbonate Terranes--An Overview. IN: Man-Induced Land Subsidence, Reviews in Engineering Geology VI, Geological Society of America, 1984, T.L. Holzer, ed., p. 195-202.

Numerous sinkholes resulting from declines in the water table due to groundwater withdrawals in carbonate terranes have occurred in the eastern United States and elsewhere. In Alabama alone, it is estimated that more than 4,000 of these sinkholes, areas of subsidence, or related features have formed since 1900. Almost all occur where cavities develop in residual or other unconsolidated deposits overlying openings in carbonate rocks.

Keyword(s): fluid extraction

Location(s): Alabama, United States

Newton, J. G. Review of Induced Sinkhole Development. IN: Sinkholes: Their Geology, Engineering, and Environmental Impact, Proceedings 1st Multidisciplinary Conference on Sinkholes, Orlando, 1984, B.F. Beck, ed., Balkema, Rotterdam, p. 3-9.

Induced sinkholes are those caused or accelerated by human activity. They are divided into two types: those resulting from a decline of water level due to pumpage and those resulting from construction. Almost all occur where cavities develop in unconsolidated deposits overlying openings in carbonate rocks. Triggering mechanisms resulting from water level declines are loss of buoyant support, increase in water velocity, water-level fluctuations, and induced recharge. Those resulting from construction include piping, saturation, and loading.

Keyword(s): geologic features, fluid extraction

Location(s): United States

Newton, J. G. Natural and Induced Sinkhole Development in the Eastern United States. IN: Land Subsidence, Proceedings 3rd International Symposium, Venice, Italy, March 19-25, 1984, A.I. Johnson, L. Carbognin, and L. Ubertini, eds., International Association Hydrological Sciences Publication No. 151, 1986, p. 549-564.

Detailed investigations of sinkhole occurrence have been previously limited to Alabama and Missouri. A reconnaissance-type investigation of this occurrence in the eastern United States was made in 1981 to regionalize previous findings.

About 850 sites, at which an estimated 6,000 sinkholes have occurred, were identified in 19 states.
Keyword(s): geologic features, fluid extraction
Location(s): United States

Newton, J. G. Development of Sinkholes Resulting from Man's Activities in the Eastern United States. U.S. Geological Survey Circular 968, 1987, 54 p.
Keyword(s): geologic features
Appalachian Coal Region, United States

Neyman, B. Z., Z. Szecowka, W. Zuberek. Effective Methods for Fighting Rock Bursts in Polish Collieries. IN: Proceedings 5th International Strata Control Conference, 1972, Paper No. 23, 9 p.
Keyword(s): ground control, room-and-pillar, bumps, longwall
Location(s): Poland

Nicholls, B. Pillar Extraction on the Advance at Oakdale Colliery. IN: Proceedings 1st International Conference on Stability in Coal Mining, Miller Freeman Publishers, 1978, p. 182-196.
Keyword(s): room-and-pillar, pillar extraction, coal mining

Nieto, A. S. Evaluation of Damage Potential to Earth Dam by Subsurface Coal Mining at Rend Lake, Illinois. IN: Proceedings 10th Ohio River Valley Soils Seminar on Geotechnics of Mining, Lexington, KY, 1979, p. 9-18.
Presented are results of a study undertaken to evaluate probable effects of past, impending, and future coal-mining activity at Rend Lake Dam and Reservoir, near Benton, Illinois.
Keyword(s): surface structural damage, engineering, geotechnical, coal mining, surface water, inflow
Location(s): Illinois, Illinois Coal Basin, United States

Nieto, A. S., D. G. Russell. Sinkhole Development in Windsor-Detroit Solution Mines and the Role of Downward Mass Transfer in Subsidence. In Situ, 8, 1984, p. 293-327.
Keyword(s): non-metal mining
Location(s): United States

Nishida, R., T. Esaki, K. Aoki. Evaluation and Prediction of Subsidence in Old Working Areas and Practical Preventive Measures Against Mining Damage to New Structures. IN: Land Subsidence, Proceedings 3rd International Symposium, Venice, Italy, March 19-25, 1984, A.I. Johnson, L. Carbognin, L. Ubertini, eds., IAHS Publication No. 151, 1986, p. 717-725.
The shortage of adequate construction sites has compelled many engineering structures to be planned in old mining areas in Japan. This paper shows the characteristic of the excavated underground environment and necessary measures for the safety of surface structures. Where the depth of a mined out area is relatively shallow, there is a tendency of cave-in consequent to surface loadings. The effect of surface loading is inversely proportional to the depth of working. In the case of heavy structures with limited allowable deformation, special preventive measures against differential subsidence must be taken into consideration. A power plant project is studied as an example.
Keyword(s): prediction, surface structural damage, construction, abandoned mines, subsurface water, finite element, modeling
Location(s): Japan

Nishida, T., K. Goto. On the Relationship Between the Geological Disturbance and Surface Movement Due to Mining Excavation. Research Institute of Science and Industry, Report 27, 1960, Kyshu University, Japan, p. 66-72.
Keyword(s): surface subsidence damage
Location(s): Japan

Nishida, T. Mining Subsidence. Research Institute of Science and Industry, Kyushu University, Japan, Report 32 , 1962, p. 1-74 (in Japanese).
Location(s): Japan

Nishida, T., K. Gotto. Damage to Irrigation Pond due to Mining Subsidence. IN: Land Subsidence, Proceedings International Symposium, September 14-18, 1969, Tokyo, IAHS Publication 89, v. 2, p. 496-501.
Keyword(s): surface water

Nishida, T., N. Kameda. On the Mechanism of Caving-In Due to Mining at a Shallow Depth. Journal Mining & Metallurgy Institute, Japan, v. 88, no. 1018, 1972, p. 863-868 (in Japanese).
Keyword(s): surface subsidence damage

Nishida, T., T. Esaka, N. Kameda. A Development of the Base Friction Technique and its Application to Subsidence Engineering. IN: Proceedings International Symposium on Engineering in Complex Rock Formations, November 3-7, 1986, Beijing, China, Pergamon Press.

The base friction apparatus, which is capable of supplying compressed air on the surface of the model, can provide an application of the similarity between in situ and model behavior of practical rock structures. This paper describes a new base friction apparatus, which has a stiff metal plate with urethane rubber instead of an endless belt and a lateral loading system. The phenomena of cave-in and surface subsidence in shallow coal mining are studied for a continuous and a discontinuous model.
Keyword(s): modeling, coal mining
Location(s): Japan

Nix, J. P. Unusual Disturbances in Belleville, Illinois. Report to Most Rev. Albert Zuroweste, D.D., Bishop of Belleville, IL, November 1960, John P. Nix Structural Engineers, St. Louis, MO.
Evidence is quite positive that sifts, fractures, subsidence, and other unusual disturbances have occurred and probably will continue to occur in the Belleville area. Many of the disturbances involve subsidence of the bedrock strata and are probably associated with subsidence of the coal mines that underlie a large part of the area.
Keyword(s): surface structural damage, abandoned mines, coal mining, foundations, architecture, construction, geologic features
Location(s): Illinois, Illinois Coal Basin, United States

Nogushi, T., R. Takahashi, U. Tokumitsu. Small Sinking Holes in Limestone Area with Special Reference to Drainage of Coal Mines. IN: Land Subsidence, Proceedings International Symposium, September 14-18, 1969, Tokyo, IAHS Publication 89, v. 2, p. 512-522.
Keyword(s): hydrology, coal mining

Norman, J. W. The Photogeological Detection of Unstable Ground. Journal Institute Highway Engineers, February, 1970, p. 19-22.
Keyword(s): photography, remote sensing, instrumentation

Norman, J. W., I. Watson. Detection of Subsidence Conditions by Photogeology. Engineering Geology, v. 9, no. 4, 1975, p. 359-381.
Keyword(s): fluid extraction, photography, instrumentation, remote sensing

Norris, R. V. Surface Support. Transactions, AIME, v. 88, 1930, p. 98-101.
This paper is an introduction to the article entitled, "Subsidence from Anthracite Mining," by H. W. Montz. The author discusses three problems of surface support and suggests methods that would limit surface subsidence.
Keyword(s): backfilling, mine design, anthracite, coal mining
Location(s): United States

North, C. Surface Subsidence Occasioned by Mine-Workings. Transactions Institute Mine Surveyors, v. 14, October, 1937, 18 p.
Keyword(s): surface subsidence damage

North, F. J. Some Geological Aspects of Subsidence Not Due to Mining. IN: Proceedings South Wales Institute Engineers, v. 75, no. 3, 1952, p. 127-158.
Keyword(s): geologic features

North of England Safety in Mines Research Committee. 7th Progress Report of an Investigation into the Cause of Falls and Accidents Due to Falls. Transactions Institute of Mining Engineers, v. 108, 1949, p. 489-510.
Keyword(s): roof stability, roof support, mine safety
Location(s): England

North, P. G., R. P. Callagahan. Subsidence Associated with Mining at Mt. Lyell. IN: Proceedings, New Zealand Conference, Australasian Institute of Mining Metallurgy, University of Auckland, May 19-23, 1980, p. 193-203.
Keyword(s): surface subsidence damage

Nottram, C. Some Notes on Roof Subsidence. Colliery Guardian, v. 148, 1934, p. 901-903.
The author discusses bending and fracturing of roof strata, including the influence of the rate of face advance upon the shape and failure of the roof.
Keyword(s): roof stability

Nunez, O., D. Escojido. Subsidence in the Bolivar Coast. International Association Hydrological Sciences Publication 121, 1977, p. 257-266.
Keyword(s): hydrology

O'Beirne, T. J., J. Shepherd. The Failure of Coal Pillar Ribs and Possible Methods of Control. IN: Australia/New Zealand Conference on Geomechanics, Perth, Australia, May 1984, Institute of Engineers, Barton, p. 661-667.
Keyword(s): mine design, ground control, pillar strength, coal mining
Location(s): Australia

O'Connor, K. M., J. E. O'Rourke, J. Carr. Influence of Rock Discontinuities on Coal Mine Subsidence. U.S. Bureau of Mines Mining Research Contract Report, Contract No. JO100087, September, 1983, 111 p. plus appendices.
This report documents the process of literature review, site selection, instrument installation, data acquisition, and preliminary data reduction performed to evaluate the influence of rock mass discontinuities on coal mine subsidence. A system of surface, subsurface, and mine level instrumentation was installed at a mine in West Virginia, where the overburden varied in thickness from 630 to 1,040 feet.
Keyword(s): coal mining, instrumentation, monitoring methods, monitoring equipment, geologic features, overburden, survey methods, survey equipment, survey data processing, in situ testing, longwall, active mines
Location(s): West Virginia, Appalachian Coal Region, United States

O'Connor, K. M., C. H. Dowding. Application of Time Domain Reflectometry to Mining. IN: Rock Mechanics in Productivity and Protection, Proceedings 25th Symposium on Rock Mechanics, Northwestern University, Evanston, IL, June 25-27, 1984, C.H. Dowding and M.M. Singh, eds., SME-AIME, New York, p. 737-746.
Examples are presented in which Time Domain Reflectometry (TDR) was employed to locate deformation in rock masses induced by mining. The first example involved monitoring the propagation of overburden fractures above a longwall coal panel and the second example involved the use of TDR to monitor rock mass deformation in the vicinity of a strip mine highwall. Rock mass deformation, strata separation and large block movement generated strains and failure along coaxial cables which were installed in drill holes and the TDR reflections generated by these strains and failures were monitored. Analysis of field data and a preliminary laboratory test indicate that it may be possible not only to locate rock mass movements but also to quantify these movements with TDR data.
Keyword(s): monitoring methods, monitoring equipment, instrumentation, longwall, coal mining, overburden

O'Connor, K. M. Distinct Element Modeling and Analysis of Mining-Induced Subsidence. Ph.D. Dissertation, Northwestern University, Evanston, IL, 1988, 175 p.
A hybrid two-dimensional distinct element model has been developed by combining the Northwestern University Rigid Block Model with the Rigid Block Model developed by Peter Cundall. A specific case of subsidence induced by longwall mining in West Virginia was simulated with this model as an example application.
Keyword(s): coal mining, modeling, computer, longwall, rock mechanics, engineering, geologic features, geotechnical, instrumentation, monitoring methods, vertical displacement, horizontal displacement
Location(s): West Virginia, Appalachian Coal Region, United States

O'Connor, K. M., C. H. Dowding. Hybrid Discrete Element Code for Simulation of Mining-Induced Strata Movements. IN: Proceedings 1st U.S. Conference on Discrete Element Methods, G.G.W. Mustoe, M. Henriksen, and H.P. Huttelmaier, eds., Colorado School of Mines Press, 1989, 10 p.
Keyword(s): modeling, overburden
Location(s): United States

O'Connor, K. M., C. H. Dowding, M. B. Su. Monitoring Rock Mass Deformation Using Time Domain Reflectometry. IN: Proceedings International Conference, Surface Crown Pillar Evaluation for Active and Abandoned Metal Mines, Timmins, Ontario, Canada, November 15-17, 1989, M.C. Betournay, ed., p. 123-132.
Keyword(s): monitoring methods, monitoring equipment, overburden

O'Connor, K. M. Comparison of Mining-Induced Displacement of the Ground Surface and Residential Structures. IN: Proceedings, 3rd Conference on Ground Control Problems in the Illinois Coal Basin, Mt. Vernon, IL, August 8-10, 1990, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 301-310.
Residential structures located over chain pillars of two longwall panels as well as prototype structures constructed over the center line of a high extraction retreat mine were monitored in conjunction with ground surface displacements.

Plots have been developed to illustrate the dynamic displacement fields induced by high extraction mining and the spatial variation of computed slope and curvature profiles provides some explanation for conflicting published results relative to ground curvature and structure curvature. Computed values of angular distortion and deflection ratio for the ground and structures are compared with published criteria for cracking of unreinforced masonry walls. It was found that the angular distortions for all cases were consistent with the superstructure cracks observed or reported, while the deflection ratios were consistent with the foundation cracks observed or reported.

Keyword(s): surface structural damage, coal mining, active mines, high-extraction retreat, longwall, foundations, monitoring methods, monitoring design, survey design, survey data processing

Location(s): Illinois, Illinois Coal Basin, United States

O'Connor, K. M., C. H. Dowding. Distinct Element Modeling and Analysis of Mining-Induced Subsidence. Rock Mechanics and Rock Engineering, v. 25, no. 1, January-March 1992, p. 1-24.

The influence of rock discontinuities on mining-induced subsidence is addressed in this paper. A two-dimensional rigid block computer model was used to simulate discontinuities within strata overlying a longwall coal mine.

Keyword(s): longwall, coal mining, modeling, computer, horizontal displacement, vertical displacement, instrumentation, overburden, geologic features

Location(s): West Virginia, Appalachian Coal Region, United States

O' Donahue, T. A. Subsidence Caused by Coal Mining. Colliery Guardian, v. 139, 1929, p. 1771-1773, p. 1872-1875.

This paper includes observations of subsidence over steeply sloping seams.

Keyword(s): angle of draw, surface structural damage, coal mining, geologic features

O'Riordan, N. J., K. W. Cole, D. J. Henkel. Collapses of Abandoned Limestone Mines in the West Midlands of England. IN: Proceedings, International Society for Rock Mechanics Symposium on Design and Performance of Underground Excavations, Cambridge, England, September, 1984, E.T. Brown and J.A. Hudson, eds., British Geotechnical Society, London, p. 401-408.

Keyword(s): abandoned mines, non-metal mining

Location(s): England

O'Rourke, J. E., R. M. Mabry, B. B. Ranson, K. O'Connor. Subsidence Monitoring Systems for Undermined Areas. Department of Energy contract ET-76-C-01-9123, Woodward-Clyde Consultants, 1977, 304 p. (NTIS FE/9123-1)

Major applications and specifications of subsidence monitoring systems are reviewed, and the relevant data measurements for a cost-effective monitoring program are identified for each. Seven sets of measurements are formalized as individual measurement systems. Availability, cost, and ease of use are listed for more than 100 potentially useful instruments.

Keyword(s): monitoring design, monitoring installation, monitoring equipment, survey methods, survey equipment, economics, instrumentation

Location(s): United States

O'Rourke, J. E. Design and Demonstration of Subsidence Monitoring Systems. Report on U.S. DOE Contract/Grant no. ET-78-C-01-3436, Woodward-Clyde Consultants, San Francisco, CA, October 1978, 4 p. (NTIS TID-29016)

Design and demonstration of a subsidence monitoring system is briefly outlined, and the results expected are tabulated.

Keyword(s): instrumentation, monitoring methods, monitoring design

Location(s): United States

O'Rourke, J. E., B. B. Ranson, K. O'Connor, R. M. Mabry. Instrumentation Systems for Mining Subsidence. IN: Evaluation and Prediction of Subsidence, Proceedings International Conference, Pensacola Beach, FL, January 15-20, 1978, S.K. Saxena, ed., ASCE, New York, 1979, p. 154-168.

This paper is based on a research project carried out by Woodward-Clyde and sponsored by the USBM. Its purpose is to facilitate subsidence monitoring for mine operators, surface users, and regulatory agencies by providing guidelines to help them select appropriate, low-cost accurate instrumentation suited to their individual subsidence problems. Because no single instrumentation program will satisfy all subsidence problems, seven monitoring programs were developed. Each consists of one or more measurements with specifications and detailed descriptions of the suitable instrumentation.

Keyword(s): instrumentation, prediction, monitoring equipment, monitoring design, monitoring methods, law, surface structural damage
Location(s): United States

O'Rourke, J. E. Instrumentation Plan for Characterization of Subsidence Over Longwall Mining Panels at Allen Mine, Weston, Colorado. 1980, 42 p. (NTIS DOE/PC/30117-T2)
Keyword(s): instrumentation, longwall, monitoring design, monitoring methods, monitoring equipment, active mines, coal mining
Location(s): Colorado, Rocky Mountain Coal Region, United States

O'Rourke, J. E., P. H. Rey, K. O'Connor. Characterization of Subsidence Over Longwall Mining Panel. Final Report to U.S. Department of Energy, Contract DE-AC22-80PC30117, 9/19/80-9/19/82, September, 1982, Woodward-Clyde Consultants, San Francisco, 180 p.
This report documents the process of site selection, instrument installation, data acquisition, and preliminary data analysis followed to characterize the physical response of overlying strata to longwall mining. A system of surface, subsurface and mine level instrumentation was installed in Colorado where the overburden thickness varied from 600 to 900 feet. Survey monuments, automatic-recording strain-meters, multi-point rod extensometers, inclinometer-extensometers, stressmeters, and tape extensometer convergence stations were installed to monitor displacements and stress changes. A preliminary analysis of the data acquired up until project termination has shown the system to be operative and strata response to be similar to that reported for other subsidence monitoring case histories. Recommendations for continued monitoring of the systems are presented.
Keyword(s): overburden, instrumentation, monitoring methods, monitoring equipment, horizontal displacement, vertical displacement, survey methods, longwall, coal mining, active mines
Location(s): Colorado, Rocky Mountain Coal Region, United States

O'Rourke, J. E. Monitoring Subsidence in the West: Problems and Analysis. IN: Proceedings, Workshop on Surface Subsidence Due to Underground Mining, Morgantown, WV, November 30-December 2, 1981, S.S. Peng and M. Harthill, eds., Department of Mining Engineering, West Virginia University, 1982, p. 164-179.
This paper describes results of a project for the design and demonstration of subsidence monitoring systems, including descriptions of the instrumentation systems, site conditions, problems of installation, resulting recommendations, and subsidence data.
Keyword(s): monitoring design, monitoring installation, monitoring equipment, monitoring methods, survey methods, survey equipment
Location(s): Utah, Rocky Mountain Coal Region, United States

O'Rourke, J. E., K. M. O'Connor, P. H. Rey. Instrumentation Systems for Subsidence Monitoring of Longwall Panels. IN: State-of-the-Art of Ground Control in Longwall Mining and Mining Subsidence, SME-AIME, September, 1982, Y.P. Chugh and M. Karmis, eds., p. 235-244.
This paper evaluates construction and monitoring techniques for specific geotechnical instrumentation used to provide overburden and surface-subsidence data. Instrumentation for monitoring ground and subsurface deformations and mine-level stresses are discussed.
Keyword(s): monitoring equipment, monitoring methods, monitoring design, survey equipment, geotechnical, longwall, overburden, monitoring installation, instrumentation, vertical displacement, horizontal displacement
Location(s): Utah, Colorado, Rocky Mountain Coal Region, West Virginia, Appalachian Coal Region, United States

O'Rourke, J. E. Monitoring Subsidence in the West. IN: Surface Mining Environmental Monitoring and Reclamation Handbook, L.V.A. Sendlein, et al., eds., Coal Extraction and Utilization Research Center, Southern Illinois University, Carbondale, U.S. Department of Energy Contract No. DE AC22 80ET 14146, Elsevier, New York, 1983, p. 717-733.
Instrumentation systems of demonstrated capabilities are available for monitoring subsidence over underground coal mines, and guidelines for specific programs and cost elements of the programs are given. Many of the objectives of acquiring data that will aid in subsidence prediction modeling are being met. A certain amount of ground control data that will be found useful to optimize mine design will result from subsidence monitoring programs and can thus aid mining production, as well as help to minimize surface damage through improved mine planning relative to subsidence effects.

Keyword(s): monitoring methods, monitoring equipment, monitoring installation, monitoring design, instrumentation, vertical displacement, horizontal displacement, overburden
Location(s): Rocky Mountain Coal Region, United States

O'Rourke, J. E., K. O'Connor. Core Recovery of Soft or Poorly Consolidated Materials. IN: Proceedings Conference on Coal Mine Subsidence in the Rocky Mountain Region, Colorado Springs, October 28-30, 1985, J.L. Hynes, ed., Colorado Geological Survey Special Publication 31, Department of Natural Resources, Denver, 1986, p. 97-111.
The problems of core recovery in soft or poorly consolidated material are broad and encompass numerous varieties of conditions and materials.
Keyword(s): monitoring installation, overburden, geologic features
Location(s): United States

O'Rourke, T. D., S. M. Turner. Longwall Subsidence Patterns: A Review of Observed Movements, Controlling Parameters and Empirical Relationships. U.S. Bureau of Mines, Geotechnical Engineering Report 79-6, 1979, School of Civil and Environmental Engineering, Cornell University, 82 p.
Keyword(s): longwall, geotechnical
Location(s): United States

O'Rourke, T. D., S. M. Turner. A Critical Evaluation of Coal Mining Subsidence Patterns. IN: Proceedings, AIME Annual Meeting, New Orleans, 1979.
Keyword(s): coal mining, prediction
Location(s): United States

O'Rourke, T. D., S. M. Turner. A Critical Evaluation of Coal Mining Subsidence Patterns. IN: Proceedings, Geotechnics of Mining, Ohio River Valley Soils Seminar, Lexington, KY, October 5, 1979, p. 1-8.
This paper examines subsidence patterns caused by longwall mining in both the United States and the United Kingdom. Special attention is directed to the subsidence prediction charts that have been developed for mining conditions in the United Kingdom. The regional geologies in several coal producing areas are surveyed and compared. Case histories of mining subsidence are summarized with special emphasis on lateral ground strains and surface curvatures. Consideration is extended to subsidence associated with retreat pillar mining.
Keyword(s): longwall, prediction, coal mining, geologic features, high-extraction retreat, pillar extraction
Location(s): United Kingdom, United States, Pennsylvania, West Virginia, Virginia, Appalachian Coal Region, Illinois, Illinois Coal Basin

O'Rourke, T. D., S. M. Turner. Empirical Methods for Investigating Subsidence in U.S. Coal Fields. IN: Proceedings, 22nd U.S. Symposium on Rock Mechanics, Massachusetts Institute of Technology, Cambridge, June 28-July 2, 1981, p. 322-327.
Keyword(s): coal mining, monitoring methods, subsidence research, empirical model
Location(s): United States

Oberhausen, J. The Compression of Stope Fillings. School of Mines Quarterly, v. 26, April, 1905, p. 271-276.
This paper describes compressibility of fill using data from a study at the Kaiser mine in Germany.
Keyword(s): backfilling
Location(s): Germany

Obert, L. Measurement of Pressures on Rock Pillars in Underground Mines, Part I. U.S. Bureau of Mines RI 3444, 1939-40.
This report presents a laboratory method that uses sound waves to determine pressure-velocity relationships for small rock columns. Measurements are given for 22 samples of varying materials.
Keyword(s): pillar strength, lab testing
Location(s): United States

Obert, L. Measurement of Pressures on Rock Pillars in Underground Mines. U.S. Bureau of Mines RI 3521, 1939-40.
This report presents an in situ method of measuring velocity of sound in rock mine pillars, which was tested in a lead mine. Results indicate that, due to the formation of a pressure arch, the pillars were not under great enough pressure to be measurable. Other testing was performed on concrete pillars.
Keyword(s): in situ testing, pillar strength, metal mining
Location(s): United States

Obert, L., S. L. Windes, W. I. Duvall. Standardized Tests for Determining the Physical Properties of Mine Rock. U.S. Bureau of Mines RI 3891, 1946, 67 p.
Keyword(s): rock mechanics, lab testing
Location(s): United States

Obert, L., W. I. Duvall. Microseismic Methods of Determining Stability of Underground Workings. U.S. Bureau of Mines B 573, 1957.

The rate of production of microseisms is related to the magnitude of stress and is an indicator of instability. Geophones in drill holes to monitor microseisms may detect accumulating stress conditions.

Keyword(s): seismic, in situ testing, monitoring methods, monitoring equipment, pillar strength

Location(s): United States

Obert, L., W. I Duvall, R. H. Merrill. Design of Underground Openings in Competent Rock. U.S. Bureau of Mines Bulletin, v. 587, 1960, 36 p.

This study considered both massive formations mined with an arched roof and bedded formations with flat roofs. Designs pertain to efficient mineral extraction rather than the prevention of surface subsidence.

Keyword(s): mine design, roof stability, tunnelling

Location(s): United States

Obert, L., W. I. Duvall. Seismic Methods of Detecting and Delineating Subsurface Subsidence. U.S. Bureau of Mines RI 5882, 1961, 28 p.

This report discusses traveltime, microseismic, traveltime difference, and seismic reflection methods of detecting subsurface subsidence.

Keyword(s): seismic, subsurface subsidence damage, monitoring methods

Location(s): United States

Obert, L. An Inexpensive Triaxial Apparatus for Testing Mine Rock. U.S. Bureau of Mines RI 6332, 1963.

Keyword(s): rock mechanics, lab testing

Location(s): United States

Obert, L. Deformation Behavior of Model Pillars Made from Salt, Trona, and Potash Ore. IN: Proceedings, 6th Symposium on Rock Mechanics, University of Missouri-Rolla, October, 1964, E.M. Spokes and C.R. Christiansen, eds., p. 539-560.

This investigation considered the deformational behavior of model pillars made from salt, trona, and potash ore tested under a constant applied load. Although load on the mine pillars is not constant at the time it is being formed, it is virtually constant over the larger part of its effective lifetime. As the load in the pillar prior to reaching this constant value is less than that after the pillar has assumed its maximum load, any design based on constant load conditions would be on the conservative side.

Keyword(s): modeling, pillar strength, non-metal mining, rock mechanics, lab testing

Obert, L., W. I. Duvall. Rock Mechanics and the Design of Structures in Rock. John Wiley & Sons, New York, 1967.

Keyword(s): rock mechanics, roof bolting, mine design, ground control, pillar strength, instrumentation

Location(s): United States

Ochab, Z. Rules Concerning New Instructions for the Determination of Safety Pillars in the Collieries of Upper-Silesian Coal Fields. Polish Ministry for Mining and Power, Report No. 271, 1961.

Keyword(s): mine design, pillar strength, coal mining

Location(s): Poland

Ogden, H. The Law Of Support. Transactions, Institute of Mining Engineers, London, v. 84, 1932, p. 1-8, 61-63.

Keyword(s): mine design

Ogden, H., R. J. Orchard. Ground Movements in North Staffordshire. Transactions, Institute of Mining Engineers, London, v. 119, 1959-60, p. 259-272.

Surface surveys were carried out over a 10-year period. The article describes the problems of surveying when the mine underlies buildings.

Keyword(s): surface structural damage, survey data processing, survey methods, survey design

Location(s): England

Oitto, R. H. Three Potential Longwall Mining Methods for Thick Coal Seams in the Western United States. U.S. Bureau of Mines IC 8792, 1979, 34 p.

Keyword(s): longwall, mine design, coal mining

Location(s): Rocky Mountain Coal Region, United States

Okonkwo, I. O., W. R. Judd, A. G. Altschaeffl. A Review of Some Aspects of Grouting for Mine Subsidence Control. IN: Mine Induced Subsidence: Effects on Engineered Structures, Proceedings of the Symposium, Nashville, TN, May 11, 1988, ASCE Geotechnical Special Publication No. 19, p. 127-145.

This paper presents an overview of the state-of-the-art of grouting as a technique for mine subsidence control. A review of some aspects of grouting theory is presented, and illustrative case histories are discussed. Limitations and factors underlying the successful application of grouting as a technique for controlling mine subsidence are presented.

Keyword(s): grouting, abandoned mines, active mines, coal mining, geologic features

Location(s): Wyoming, Rocky Mountain Coal Region, Indiana, Pennsylvania, Appalachian Coal Region, United States

Okonkwo, P. C. Ground Movements and Subsidence in Nigeria's Coal and Metal Mines. IN: Land Subsidence, Proceedings, 3rd International Symposium, Venice, Italy, March 19-25, 1984, A.I. Johnson, L. Carbognin, L. Ubertini, eds., IAHS Publication No. 151, 1986, p. 687-697.

Ground movements and subsidence result from uncontrollable tectonic forces to controllable human activities. Mining and quarrying industries have been identified as the contributory human activities, hence the scientific and technological research programs by nations to combat the adverse environmental effects and residual hazards to public health. Nigeria with its coal and metalliferous mines is facing two major hazards of surface subsidence from underground coal operations and ground movements and from erosion generated by unrehabilitated metalliferous mines.

Keyword(s): coal mining, metal mining, reclamation, geologic features, historical, government, subsidence research

Location(s): Nigeria

Oldroyd, D. C. Stooping Under An Overland Conveyer, Transvaal Navigation Collieries. IN: Proceedings, SANGORM Symposium, October 21, 1986, Sandton, South Africa, International Society for Rock Mechanics, South African National Group, p. 89-96.

This paper describes the undermining of an overland conveyer belt, measurements of surface subsidence taken, and results obtained. It also describes the effect of subsidence on the conveyor and the preventative measures that could have been taken to prevent the relatively minor damage caused. Although the magnitude of the strains that occurred were very high, the conveyor remained functional and carried coal throughout the undermining.

Keyword(s): coal mining, pillar extraction, surface structural damage, monitoring methods, structural mitigation

Location(s): South Africa

Oravecz, K. I. Analogue Modeling of Stresses and Displacements in Bord and Pillar Workings of Coal Mines. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 14, 1977, p. 7-23.

Keyword(s): room-and-pillar, modeling, coal mining

Oravecz, K. I. Measurement of Surface Displacements Caused by Extraction of Coal Pillars. IN: Large Ground Movements and Structures, Proceedings International Conference, Univ. of Wales Institute of Science and Technology, Cardiff, 1977, J.D. Geddes, ed., John Wiley, 1978, p. 60-85.

This paper summarizes the procedures used in a subsidence study conducted over a bord-and-pillar operation. Details are given on instrumentation used to determine surface subsidence, lateral displacements, and development and extent of the cave in relation to the mining geometry.

Keyword(s): monitoring design, monitoring installation, monitoring equipment, survey methods, survey equipment, survey data processing, instrumentation, room-and-pillar, pillar extraction, coal mining

Location(s): South Africa

Oravecz, K. I. Improved Prediction of Surface Subsidence Using the Influence Function Approach. IN: Proceedings, SANGORM Symposium, October 21, 1986, Sandton, South Africa, International Society for Rock Mechanics, South African National Group, p. 73-80.

A shortcoming in the prediction of surface displacements resulting from caved tabular excavations at shallow and moderate depths stems from the lack of ability to estimate precisely the convergence or closure distribution. The development of a variety of numerical methods assist in the improved modeling of the complex mechanism of caving and the global response of the rock mass.

Keyword(s): prediction, empirical model, influence function, modeling, computer, finite element, boundary element

Orchard, R. J. Recent Developments in Predicting the Amplitude of Mining Subsidence. Journal Royal Institute Chartered Surveyor, no. 33, May, 1954, p. 864-876.

This paper evaluates the amplitude of mine subsidence through the examination of method of mining, geological conditions, rate of face advance, time factors, and differing mining conditions. The author refers to the partial subsidence curve, and how this curve can be used for practical applications.

Keyword(s): vertical displacement, horizontal displacement, prediction, time factor, geologic features

Orchard, R. J. Surface Effects of Mining--The Main Factors. Colliery Guardian, v. 193, 1956.

Keyword(s): surface subsidence damage

Orchard, R. J. Prediction of the Magnitude of the Surface Movement. IN: Proceedings, European Congress on Ground Movement, Leeds, April, 1957.

Keyword(s): prediction

Orchard, R. J. Prediction of the Magnitude of Surface Movements. Colliery Engineering, v. 34, 1957, p. 455-462.

The author examines various aspects of mine subsidence: the effects of backfilling on ground movements, geologic conditions, and an analysis of the relationship among subsidence, seam depth, and horizontal strain. Tensile strain, compressive strain, and the relationship of strain to slope are also evaluated.

Keyword(s): vertical displacement, horizontal displacement, prediction, backfilling, geologic features

Orchard, R. J. Surface Effects of Mining--The Main Factors. Transactions, Institute of Mining Engineers, London, v. 116, 1956-57, p. 941-958.

The various factors affecting surface movements are summarized, and the manner in which they influence the shape of the subsidence trough is described. The importance of the width-depth ratio in determining the maximum amplitude of subsidence is discussed. Also included is a brief discussion of surface damage and methods for reducing this damage.

Keyword(s): surface structural damage, mine design, backfilling, survey data processing

Orchard, R. J. The Effect of Mining Subsidence Upon Public Health Engineering Works. Journal Institute Public Health Engineering, v. 56, 1957, p. 188-204.

Keyword(s): utilities

Orchard, R. J. Underground Stowing. Colliery Guardian, v. 203, August 1961, p. 258-263.

The article discusses requirements for maximum subsidence and briefly compares pneumatic and hydraulic backfilling methods. Cost of solid back-filling methods are compared with damage produced by uncontrolled subsidence.

Keyword(s): pneumatic backfilling, hydraulic backfilling, economics

Orchard, R. J. Surface Subsidence Resulting from Alternative Treatment of Colliery Goaf. Colliery Engineering, v. 41, October, 1964, p. 428-435.

This paper compares surface subsidence caused by total and partial extraction methods when caving is allowed rather than backfilling. Roadways and packs and their effects upon convergence are discussed in relation to "effective" panel width and maximum subsidence.

Keyword(s): surface structural damage, mine design, pneumatic backfilling, stowing, mine waste, partial extraction, longwall

Orchard, R. J. Partial Extraction and Subsidence. The Mining Engineer, London, v. 123, no. 43, April, 1964, p. 417-430.

Subsidence and roof control are shown to be dependent upon the size of pillars in relation to the seam depth. With room-and-pillar workings, both safety and higher extraction can be obtained simultaneously only in shallow seams. With deeper seams, longwall partial extraction layouts are shown to produce greater mine safety and economical utilization of coal reserves.

Keyword(s): partial extraction, roof stability, room-and-pillar, longwall, National Coal Board, mine safety, mine design, coal mining

Location(s): England

Orchard, R. J., W. S. Allen. Ground Curvature Due to Coal Mining. Chartered Surveyor, v. 97, no. 11, 1965, p. 622-631.

Keyword(s): surface subsidence damage, survey methods, coal mining

Orchard, R. J. The Control of Ground Movements in Undersea Workings. The Mining Engineer, London, v. 128, no. 101, February, 1969, p. 259-273.

Laws governing coal extraction under bodies of water were revised in an attempt by the National Coal Board to standardize coal extraction legislation and to promote maximum use of reserves.

Keyword(s): surface water, ground control, National Coal Board, law, coal mining
Location(s): England

Orchard, R. J., J. Knecht, G. A. Voytko. State of Predictive Art in Subsidence Engineering--Discussion. IN: ASCE Proceedings, Journal Soil Mechanics and Foundations Division, v. 96, no. SM6, 1970, p. 2162-2163.
Keyword(s): prediction

Orchard, R. J., W. S. Allen. Longwall Partial Extraction Systems. The Mining Engineer, London, v. 129, no. 117, June, 1970, p. 523-535.
The author suggests an improved method for calculation of maximum subsidence, taking width and depth into account separately instead of combining them into a width/depth ratio. The mechanics of harmonious extraction are examined.
Keyword(s): longwall, partial extraction, prediction

Orchard, R. J. Vitrified Clay Pipes in Areas of Mining Subsidence. Clay Pipe Development Association, 1972.
Keyword(s): pipelines, utilities

Orchard, R. J. Some Aspects of Subsidence in the United Kingdom. IN: Proceedings 4th Annual Symposium, A.J. Hargraves, ed., Wollongong, Australia, February 20-22, 1973, Australasian Institute of Mining and Metallurgy, Illawarra Branch, Paper 3, p. 3-1--3-11.
This article represents a discussion of National Coal Board guidelines for undersea coal extraction in relation to the type of working, minimum depth of extraction, and monitoring of subsidence effects.
Keyword(s): surface water, monitoring design, mine design, National Coal Board, coal mining, inflow
Location(s): United Kingdom

Orchard, R. J. Working Under Bodies of Water. The Mining Engineer, London, v. 134, no. 170, March, 1975, p. 261-270.
This article discusses the consequences of extracting coal reserves located under bodies of water. Specific examples detail the results of mining beneath rivers, reservoirs, triassic sandstones, and aquifers.
Keyword(s): surface water, subsurface water, mine design, hydrology, coal mining

Orchard, R. J., W. S. Allen. Time Dependence in Mining Subsidence. IN: Proceedings, Symposium on Minerals and the Environment, London, June 4-7, 1974, Institute Mining and Metallurgy, London, 1975, p. 643-659.
An attempt is made to define the nature and size of post-mining subsidence having regard to the depth of mining, layout, nature of the strata, and sequence of mining. Examples show the measured residual effects under differing circumstances. Normal residual mining subsidence can be estimated to an acceptable degree of precision by analysis of the time-dependent effects shown during the period when coal faces are being worked. The phase relationship between the developing subsidence and the advance of the coal face can be compared, provided that a component of the surface subsidence can be measured with a high degree of accuracy. The use of one component is described and its sensitivity to the working cycle for underground extraction is shown.
Keyword(s): time factor, coal mining, prediction, National Coal Board, active mines
Location(s): United Kingdom

Orchard, R. J. Discussion of Kapp, W. A., "A Study of Mine Subsidence at Two Collieries in the Southern Coalfield, New South Wales." IN: Proceedings, Australasian Institute Mining and Metallurgy, no. 277, 1981, p. 53.
Keyword(s): coal mining
Location(s): Australia

Orlowski, A. C., W. F. Kane, R. M. Holbrook. Prediction of Subsidence-Induced Ground Movement and its Effects on a Coal Refuse Dam. IN: Mine Subsidence - Prediction and Control, National Symposium, 33rd Annual Meeting Association of Engineering Geologists, October 2-3, 1990, C.D. Elifrits, ed., Pittsburgh, PA, p. 61-68.
The stability of a coal refuse dam is as important as that of a water impoundment from a safety standpoint. Refuse dams exposed to potential mining-induced subsidence must be analyzed for such an occurrence. This paper presents some of the methods used in the evaluation of subsidence effects on a coal refuse dam and conclusions reached concerning the stability of the structure.
Keyword(s): surface structural damage, engineering, coal mining, mine waste, active mines, geologic features, prediction, pillar strength
Location(s): Virginia, Appalachian Coal Region, United States

Osterwald, F. W. Deformation and Stress Distribution Around Coal Mine Workings in Sunnyside No. 1 Mine, Utah. U.S. Geological Survey Professional Paper 424-C, 1961, p. C349-C353.

Keyword(s): rock mechanics, coal mining

Location(s): Utah, United States

Osterwald, F. W. USGS Relates Geologic Structures to Bumps and Deformation in Coal Mine Workings. Mining Engineering, v. 14, no. 4, 1962, p. 63-68.

Keyword(s): bumps, geologic features

Osterwald, F. W., C. R. Dunrud. Geology Applied to the Study of Coal Mine Bumps at Sunnyside, Utah. SME-AIME Preprint 65I27, AIME Annual Meeting, Chicago, IL, February 14-18, 1965.

Coal mine bumps, which are violent spontaneous failures of coal or other rocks in mine faces, ribs, roofs, and floors, are a serious hazard to life and property in the mines of east-central Utah. In seeking a better understanding of the factors causing bumps, the USGS studied relationships between geologic features and coal mine bumps at Sunnyside, Utah, for about 5 years.

Keyword(s): bumps, coal mining, active mines, geologic features

Location(s): Utah, Rocky Mountain Coal Region, United States

Osthof, H., J. C. Swain. European Underground Coal Mining Technology. Battelle Energy Program Report, Columbus, OH, June, 1975, 25 p. (NTIS PB 249 052)

This report is a review of the current technology of longwall mining in Europe.

Keyword(s): mine operation, mine design, coal mining, longwall, multiple-seam extraction

Location(s): Europe, France, West Germany

Otto, J. B. The Effect of Total Extraction Coal Mining on Transmission Towers. IN: Proceedings, SANGORM Symposium, October 21, 1986, Sandton, South Africa, International Society for Rock Mechanics, South African National Group, p. 59-72.

Transmission towers, like many other surface structures, are a serious obstruction to total extraction coal mining and to longwall mining in particular. A 132-kV self-supporting suspension tower was monitored during undermining. The displacements were then used as the input to a computer model of the tower, in an attempt to simulate the effect of differential displacement of its foundation.

Keyword(s): modeling, prediction, computer, surface structural damage, foundations, longwall, coal mining, monitoring methods

Location(s): South Africa

Overbey, W. K. Jr., C. A. Komar, J. Pasini III. Predicting Probable Roof Fall Areas in Advance of Mining by Geological Analysis. U.S. Bureau of Mines, Health and Safety Research Program TPR 70, May, 1973, 17 p.

Surface fracture trace density, changes in roof rock type, and topographic unloading due to drainage were mapped for mining areas located in the Blacksville-Osage, West Virginia, quadrangles to investigate their influence on mine roof falls. A technique was developed, using these factors, to predict probable roof fall areas ahead of projected mining operations.

Keyword(s): roof stability, geologic features

Location(s): West Virginia, Appalachian Coal Region, United States

Owili-Eger, A. S. C. Geohydrologic and Hydrogeochemical Impacts of Longwall Coal Mining on Local Aquifers. SME-AIME preprint no. 83-376, for presentation at the SME-AIME Fall Meeting and Exhibit, Salt Lake City, UT, October 19-21, 1983, 16 p.

The author describes an investigation undertaken in the Appalachian coal basin in response to problems of impaired well yields and water quality deterioration.

Keyword(s): coal mining, subsurface water, hydrology, longwall, subsurface subsidence damage

Location(s): Appalachian Coal Region, United States

Owili-Eger, A. S. C. Predicting the Impacts of a Logical Mining Unit System on the Water Resources of an Area. IN: Proceedings 23rd Annual American Water Resources Association Symposium, November 1987.

Keyword(s): hydrology, subsurface water, prediction, overburden

Owili-Eger, A. S. C. Dynamic Fractured Flow Simulation Model. Mining Engineering, February 1989, v. 41, no. 2, p. 110-114.

An efficient state-of-the-art dynamic model to simulate and predict the rate of water production in longwall coal mining operations was developed as a tool for mine planning purposes. The model can also provide an estimate of any potential resultant hydrogeological impacts of an operation via an array of element-specific, single-valued parameters referred to as the field-rating indices. The computational procedure was designed to exploit the benefits of hydrogeotechnology and use a combination of conceptual, physical, empirical, and numerical approaches to define, characterize, analyze, and evaluate flow-controlling properties of fractured rock systems.

Keyword(s): longwall, coal mining, modeling, hydrology, subsurface water, prediction, mine design, overburden, geologic features, surface water, computer, mathematical model, active mines

Location(s): Appalachian Coal Region, Pennsylvania, West Virginia, Wyoming, North Dakota, United States

Oyanguren, P. R. Simultaneous Extraction of Two Potash Beds in Close Proximity. IN: 5th International Strata Control Conference, London, 1973, Paper 32, 5 p.

Keyword(s): non-metal mining, multiple-seam extraction

Ozbay, M. U. The Stability and Design of Yield Pillars Located at Shallow and Moderate Depths. Journal of the South African Institute of Mining and Metallurgy, March 1989, p. 73-79.

The stability of pillars is analyzed on the assumption that pillars shed load in a stable manner if the slope of the strata load-deformation relation is steeper than that of pillars in the post-peak regime. Concepts of local stiffness, mine structural stiffness, and critical stiffness are discussed. Procedures are described for the determination of strata stiffness for various pillar layouts by use of the available boundary-element computer programs. The post-peak stiffness of pillars is assessed from the available data relating to the post-peak load-deformation relationship and width-height ratio.

Keyword(s): yielding supports, pillar strength, rock mechanics, boundary element

Location(s): South Africa

Ozkal, K. Practice of Hydraulic Sandstowing in Armutcuk Coalfield. Symposium on Coal, Zonguldak, Turkey, December, 1961.

This paper describes the hydraulic sandstowing process, practiced in active mines.

Keyword(s): hydraulic backfilling, coal mining, active mines, stowing

Location(s): Turkey

Padgett, M. F. Statistical Analysis of Residential Damage in an Area of Underground Coal Mining Boulder County, Colorado. IN: Association of Engineering Geologists Symposium Series No. 4, Building Over Underground Mines--Subsidence Considerations, October, 1987, p. 95-97 (expanded abstract).

An engineering assessment of damage that has occurred to structures and property in the past 30 years was completed in order to examine the relationship between mine subsidence and residential damage, either to the structure or to the property. This study evaluated the effects of underground coal mines on residential damage using statistical tests. The database for this study was developed through field surveys of 230 randomly selected residences and the evaluation of mine maps and drill hole boring logs.

Keyword(s): abandoned mines, coal mining, surface structural damage

Location(s): Colorado, Rocky Mountain Coal Region, United States

Padgett, M. F. Residential Damage in an Area of Underground Coal Mining. IN: Mine Induced Subsidence: Effects on Engineered Structures, Proceedings of the Symposium, Nashville, TN, May 11, 1988, ASCE Geotechnical Special Publication No. 19, p. 1-17.

A statistical analysis of past residential damage in the Boulder-Weld, Colorado, coal field was performed to estimate the potential for future subsidence-related residential damage. The objectives of this study were to assess the difference in damage severity and frequency between undermined and non-undermined areas, and to determine, where applicable, which mining factors significantly influence the severity and frequency of residential damage.

Keyword(s): surface structural damage, abandoned mines, coal mining, geologic features

Location(s): Colorado, Rocky Mountain Coal Region, United States

Palarski, J. Przyczynek Do Wyjanienia Zjawiska Nieciaglych Deformacji Powierzchni I Znacznych Obnizen Nad Podsadzonymi Wyrobiskami (Contribution to the Explanation of Discontinuous Surface Deformations and Large Subsidences Over Stowed Workings). Przeglad Gorniczy, v. 34, no. 3, 1978, p. 120-125.

Keyword(s): stowing, surface subsidence damage

Palmer, R. E. Observation on Ground Movement and Subsidence at Rio Tinto Mines, Spain. Transactions, AIME, v. 91, 1930, p. 168-185.

Keyword(s): surface subsidence damage

Location(s): Spain

Palowitch, E. R. Shortwall Mining Applications in the United States. SME Fall Meeting and Exhibit, October, 1972, Birmingham, AL, Preprint No. 72-AM-356, 12 p.

This paper describes the shortwall mining method, reviews its history, and discusses the current status of shortwall mining in the United States.

Keyword(s): mine design, ground control, shortwall, roof stability, mine operation

Location(s): United States

Pam, E. Water-Borne Packing for Stope Filling. Mining Magazine, v. 5, 1911, p. 295.

Hydraulic sand backfilling of metal mines in South Africa is used for strata control and increased extraction.

Keyword(s): hydraulic backfilling, metal mining, ground control

Location(s): South Africa

Pampeyan, E. H., T. L. Holzer. Earth Fissures and Localized Differential Subsidence. U.S. Geological Survey Open-File Report 79-51, 1979.

Location(s): United States

Panek, L. Estimating Mine Pillar Strength from Compression Tests. Transactions, SME-AIME, v. 268, 1980, p. 1749-1761.

Keyword(s): coal mining, pillar strength, lab testing

Location(s): United States

Panek, L.A. Centrifugal Testing Apparatus for Mine Structure Stress Analysis. U.S. Bureau of Mines RI 4883, 1952.

Keyword(s): lab testing

Location(s): United States

Panek, L. A. Methods and Equipment for Measuring Subsidence. IN: Proceedings 3rd Symposium on Salt, J.L. Rau and L.F. Dellwig, eds., April 22-24, 1969, Cleveland, OH, Northern Ohio Geological Society, Inc., v. 2, 1970, p. 321-338.

This paper describes measurement techniques and equipment appropriate for determining the horizontal and vertical components of displacement and strain, tilt, and curvature. Particular attention is given to the principal characteristics and uses of monuments, extensometers, tapes, electronic distance-measuring instruments, theodolite, alignment telescope, spirit level, tilt meter, and borehole inclinometer probe.

Keyword(s): monitoring design, monitoring installation, monitoring equipment, monitoring methods, survey methods, survey equipment, ground control, horizontal displacement

Panek, L. A. Solutions of Mine Structure Problems Through Field Measurements and Theoretical Analysis. IN: Rock Mechanics Instrumentation for Mine Design, U.S. Bureau of Mines IC 8585, 1973, p. 23-24.

Keyword(s): mine design, instrumentation, rock mechanics, ground control

Location(s): United States

Panek, L. A. Longwall Problems. IN: Ground Control Aspects of Coal Mine Design, Proceedings Bureau of Mines Technology Transfer Seminar, Lexington, KY, March 6, 1973, U.S. Bureau of Mines IC 8630, 1974, p. 97-100.

Longwall strata control depends on the transfer of overburden weight to the perimeter of the mined area through bridging of the main roof strata. Cutting and transport of coal along the face is done under this strata bridge, where the roof support requirement is relatively small, compared to normal overburden pressure. For effective strata control, however, the support system must be able to yield while at the same time maintaining a high resistance to settling of the roof. The proper support characteristics depend on the relative strengths and stiffnesses of the roof strata, coal, and floor.

Keyword(s): longwall, ground control, overburden, coal mining, active mines, geologic features, roof support, roof stability

Location(s): United States

Panek, L. A. Evaluation of Roof Stability from Measurements of Horizontal Roof Strain. IN: Ground Control Aspects of Coal Mine Design, Proceedings Bureau of Mines Technology Transfer Seminar, Lexington, KY, March 6, 1973, U.S. Bureau of Mines IC 8630, 1974, p. 92-96.

The author discusses a field measurement technique intended for evaluating roof stability. It is a roof monitoring system based on the structural behavior concept that the horizontal roof strain necessarily increases as the roof sags, and increasing roof sag leads ultimately to a fall. The approach is particularly oriented toward evaluating the stability of a bolted roof.

Keyword(s): roof bolting, roof support, in situ testing

Location(s): United States

Panow, A. D., K. W. Ruppeneit. Problems Concerning Strata Control. IN: Proceedings, International Strata Control Congress, Leipzig, October 14-16, 1958, p. 97-111 and XLVII-XLVIII.

Research activities were directed to the following: (1) study of the mechanical properties of rocks, their deformability and strength, (2) investigations into stress distribution and displacements, (3) examination of rock pressure phenomena on models of equivalent and optically active material, and (4) strata control research in the pit using special instruments and equipment. C. Mohr's theory of strength was found to be the best suited for the description of rock strength characteristics.

Keyword(s): ground control, rock mechanics, modeling

Location(s): Russia

Paone, J., R. H. Cox, A. S. Allen. Subsidence-Control Project in the Belleville-Maryville Area, Illinois. Presented at the 1977 SME Fall Meeting and Exhibit, St. Louis, MO, October 19-21, 1977, Preprint No. 77-F-339, 21 p.

Subsidence movements have damaged houses, schools, streets, and public utility lines in some undermined sections of Belleville and Maryville, Illinois. In cooperation with local officials and the State of Illinois, the USBM is sharing experience in backfilling abandoned coal mines to demonstrate that bituminous mine workings in southwestern Illinois can be successfully backfilled and subsidence-prone areas stabilized. Subsurface investigations revealed that mine workings are dry and underlain by underclay deposits susceptible to instability upon wetting. Backfilling will be accomplished by pneumatic injection instead of the hydraulic methods used in previous subsidence-control projects.

Keyword(s): surface structural damage, ground control, pneumatic backfilling, abandoned mines, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Parate, N. S. A Study of Ground Movement in Relation to Buildings and Surface Features. Masters Engineering Thesis, 1965, University of Sheffield, United Kingdom.

Keyword(s): surface structural damage
Location(s): England

Parate, N. S. Reducing the Effects of Mining Subsidence on Surface Structures. Colliery Engineering, v. 44, May 1967, p. 190-195.

This paper investigates the mechanics of subsidence and methods of reducing surface subsidence damage. It includes discussions on the nature and amplitude of subsidence, subsidence profiles, area of influence, amplitude of strain, time factor, and design of new structures.

Keyword(s): vertical displacement, horizontal displacement, surface structural damage, time factor, ground control, architecture

Parate, N. S. Short Note on Subsidence Damage Problems. Journal Mines, Metals & Fuels, v. 18, August, 1970, p. 287-291.

Keyword(s): surface subsidence damage

Parate, N. S. Earth Movement Due to Mining; Subsidence and Deformation (Movimento de Terreno Devido Mineracao; Abaizamento e Deformacao). Abstract from Congreso Latinoamericano de Geologia, Resumenes, no. 3, 1976, p. 104 (in Portuguese and French). (NTIS Accession no. 77-02604)

Keyword(s): engineering, surface structural damage, coal mining

Parate, N. S. Sinkhole and Subsidence Damage and Protective Measures. IN: Sinkholes: Their Geology, Engineering and Environmental Impact, Proceedings 1st Multidisciplinary Conference on Sinkholes, Orlando, October 15-17, 1984, B.F. Beck, ed. Balkema, Rotterdam, p. 379-383.

Ground subsidence has long been recognized as a major problem in both middle and eastern Tennessee. This subsidence consists of downward and lateral movement of the ground surface and is a result of loss of support within the low level subsurface materials. This loss of support can result from extraction of solids or liquids from beneath the surface (particularly in the coal mining regions of eastern Tennessee), or may result from a subsurface erosion of overlying soil into either caverns or slots within the underlying limestone bedrock. Of prime importance to the engineer or geologists is reducing subsidence damage to man-made structures. The methods for reducing damage will vary according to the subsidence causes and mechanisms.

Keyword(s): coal mining, surface structural damage, engineering
Location(s): Tennessee, United States

Pariseau, W. G., H. D. Dahl. Mine Subsidence and Model Analysis. Transactions, AIME, v. 241, December, 1968, p. 488-494.

This paper summarizes approaches to subsidence studies, examines the possibility of duplicating subsidence phenomena in laboratory models, and analyzes a particular model using sand as the media. The results of the sand model application are discussed.

Keyword(s): modeling, phenomenological model, plastic model, physical model
Location(s): United States

Pariseau, W. G. Plasticity Theory for Anisotropic Rocks and Soil. IN: Proceedings, 10th U.S. Symposium on Rock Mechanics, University of Texas at Austin, 1972, p. 267-296.

Keyword(s): modeling, phenomenological model, plastic model, rock mechanics

Pariseau, W. G. Limit Design of Mine Pillars Under Uncertainty. IN: Design Methods in Rock Mechanics, Proceedings 16th U.S. Symposium on Rock Mechanics, Minneapolis, MN, September 22-24, 1975, C. Fairhurst and S.L. Crouch, eds., ASCE, New York, 1977, p. 287-301.

Limits to mine pillar stability are computed on the basis of flow and fracture mechanisms of local inelastic deformation following a review of the traditional approaches to mine pillar design. Emphasis is on pillars in flat-lying ore deposits. The advent of computers and finite element techniques has eliminated the historic necessity for one-dimensional pillar design thinking. Detailed analyses of stress as well as progressive failure are now possible on a routine basis. A return to fundamentals is explicit in the updated design approach advocated here. Ten examples are presented that simultaneously illustrate the oversimplification of the one-dimensional view and the improvement in design discrimination between stable and unstable pillar states obtained through application of existing rock mechanics technology.

Keyword(s): lab testing, modeling, phenomenological model, pillar strength, rock mechanics, finite element, mine design
Location(s): United States

Pariseau, W. G. Elastic-Plastic and Elastic-Brittle Finite Element Analysis of Cave Zone Growth in

Response to Longwall Face Advance. IN: Proceedings 20th U.S. Symposium on Rock Mechanics, June 4-6, 1979, University of Texas, Austin, p. 541-553.

Comparisons of finite element analyses of "cave" zone growth with longwall face advance using elastic-plastic and elastic-brittle material descriptions show some differences in cave zone extent, but the differences are not large relative to the loads on wood cribs used for support in the "bleeder" entry adjacent to the longwall starting room. The elastic-plastic description is based on pressure dependent yield and associated flow rules; the elastic-brittle description is based on a discontinuing strain softening concept appropriate to diffuse fracturing accompanied by an abrupt change in rock properties.

Keyword(s): finite element, modeling, longwall, mine design, roof support

Location(s): Utah, Rocky Mountain Coal Region, United States

Pariseau, W. G., A. C. Walkup, W. W. Carlson, K. K. Wu. Ropes Mine Crown Pillar Rock Mechanics. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 909-918.

A crown pillar cave occurred at the Ropes Mine in December 1987, resulting in closure of the mine. Production was resumed soon afterwards with the formulation of a rock mechanics plan designed to address several issues of safety and stability. The plan proved to be successful and shows what can be accomplished in the realm of applied rock mechanics where a cooperative atmosphere exists.

Keyword(s): rock mechanics, metal mining, instrumentation

Location(s): Michigan, United States

Park, D-W., D. A. Summers, N. B. Aughenbaugh. Model Studies of Subsidence and Ground Movement Using Laser Holographic Interferometry. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 14, no. 6, November, 1977, p. 235-245.

Keyword(s): instrumentation, modeling

Park, D-W. Model Studies of Subsidence Over Room-and-Pillar Coal Mines Using Holographic Interferometry. IN: Rock Mechanics: A State of the Art, Proceedings 21st Symposium, University of Missouri-Rolla, May 28-30, 1980, D.A. Summers, ed., p. 265-274.

The technique of holographic interferometry has been successfully applied to a self-loading, simple-cavity model simulating subsidence resulting from longwall mining. Holographic interferometry has the capability of detecting full-field movement on the surface of any material. A similar method was adopted for analyzing subsidence above room-and-pillar mines. This paper presents the modeling method and analysis of the results taken from that model.

Keyword(s): room-and-pillar, coal mining, modeling

Park, D-W., D. C. Kicker. Physical Model Study of a Longwall Mine. IN: Research & Engineering Applications in Rock Masses, Proceedings 26th U.S. Symposium on Rock Mechanics, South Dakota School of Mines & Technology, Rapid City, June 26-28, 1985, E. Ashworth, ed., Balkema, Rotterdam, p. 1261-1272.

A new physical longwall mine model was developed to study stress distributions around a longwall face in both the chain pillars and panel. State-of-the-art stress detection devices combined with a new excavation technique and model material have provided reproducible results on the manner of stress redistributions caused by longwall mining. The model has successfully simulated the mode of stress changes in the chain pillars and has measured the development of the panel front abutment.

Keyword(s): modeling, longwall, coal mining, physical model

Location(s): Alabama, United States

Park, D-W, N. F. Ash. Subsidence Study of Alabama Coal Fields. IN: Proceedings, 4th Annual Workshop Generic Mineral Technology Center Mine Systems Design and Ground Control, Moscow, ID, October 21-26, 1986, Department of Mining and Minerals Engineering, Virginia Polytechnic Institute and State University, p. 81-92

Underground coal mining has been a serious cause of subsidence problems in the Warrior Coal Field of Alabama, where few subsidence data are available. A thorough monitoring program at two sites has been ongoing for the past 3 years to study factors that contribute to subsidence. A variation in depth of mining between the two sites from deep to shallow has demonstrated striking differences in subsidence behavior. A numerical simulation of the subsidence was carried out using the finite element method. The modeling of the two case studies has been successfully completed. Also

included in this study has been the effect of mining subsidence on the groundwater hydrology. The results show that subsidence influences groundwater hydrology when mining activity is nearby, but that when mining is completed, the groundwater level returns to normal.

Keyword(s): coal mining, subsidence research, monitoring design, monitoring methods, hydrology, subsurface water, modeling, finite element, longwall, overburden, mine design

Location(s): Alabama, United States

Park, D-W. Effect of Mine Subsidence on Ground Water Hydrology. SME-AIME Preprint 87-98, for presentation at the SME-AIME Annual Meeting, Denver, CO, February 24-27, 1987, 8 p.

Underground mining alters ground condition, producing a disturbance in the groundwater regime. The level of disturbance is dependent on the local hydrology, geology, and type of mining. The primary objective of this study was to investigate the effects of mine subsidence on the groundwater hydrology in the Warrior Coal Basin in Alabama.

Keyword(s): hydrology, subsurface water, coal mining, metal mining, abandoned mines, multiple-seam extraction, geologic features

Location(s): Alabama, United States

Park, D.-W. Two Case Histories of Subsidence in the Warrior Coalfield. Mining Engineering, March 1988, p. 185-191.

Underground openings resulting from coal mining activities have been a serious cause of subsidence problems in the Warrior Coalfield of Alabama. The problem will be even more serious in the future because most of Alabama's coal reserves are classified as an underground resource.

Keyword(s): coal mining, geologic features, longwall, survey data processing, monitoring methods, monitoring equipment, National Coal Board

Location(s): Alabama, United States

Park, D-W., V. Gall. Supercomputer Assisted Three-Dimensional Finite Element Analysis of a Longwall Panel. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 133-140.

The failure criterion that considers rock mass properties applied in three-dimensional finite element modeling of a longwall panel has shown encouraging results. The availability of a supercomputer enables large scale modeling. An automated procedure for progressive failure simulation provides the tool for easy data processing. The combination of a three-dimensional model with the technique of progressive failure simulation produces a realistic simulation of the mining of a longwall panel. The model allows detailed study not only of sections near the face location, as presented in this study, but also analysis of the pressure arch and surface and subsurface subsidence.

Keyword(s): computer, modeling, finite element, longwall, coal mining, yielding supports, rock mechanics

Location(s): Alabama, United States

Park, D-W. Yield Pillar Analysis in a Deep Coal Mine. IN: Proceedings, 3rd Conference on Ground Control Problems in the Illinois Coal Basin, Mt. Vernon, IL, August 8-10, 1990, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 257-267.

In longwall coal mines, the size of chain pillars has a great influence on the stability of entries. When applied to deep coal mines in the Warrior Coalfield, conventional pillar systems consisting of equally sized pillars have created problems, such as floor heaves and roof failures due to the high stress concentrations in the area adjacent to the longwall panel. A mine has adopted a yield pillar system as a solution for the instability and has proven the yield pillar system to be an effective alternative. This paper presents the results of a study that analyzed the behavior of the yield pillar system in comparison to conventional pillar systems.

Keyword(s): pillar strength, yielding supports, coal mining, longwall, active mines, mine design, instrumentation, modeling, finite element, ground control

Location(s): Alabama, United States

Park, D. W., Y. M. Jiang, L. A. Morley, W. Keeton. Stability Analysis of a Room-and-Pillar Mine with Thinly-Laminated Roof, Strong Pillars and Weak Floor. Mining Engineering, v. 44, no. 11, November 1992, p. 1355-1360.

Underground room-and-pillar mining operations in the Warrior Coalfield in Alabama frequently suffer instability due to soft floors and thinly-laminated immediate roofs. This investigation concerns a mine that was experiencing ground-control problems with weak floor conditions. Several roof falls occurred locally, and floor heaves as great as 2 feet have been experienced. The paper presents the results of comprehensive analyses conducted on floor heave, roof sagging, pillar penetration, and floor-bearing capacity using instrumentation and numerical modeling.

Keyword(s): room-and-pillar, floor stability, geologic features, ground control, roof stability, pillar strength, instrumentation, modeling

Location(s): Alabama, United States

Parker, J. What Can Be Learned from Surface Subsidence? Part 2: Practical Rock Mechanics for the Miner. Engineering & Mining Journal, v. 174, July, 1973, p. 70-73.

Keyword(s): rock mechanics

Parker, J. M. Salt Solution and Subsidence Structures, Wyoming, North Dakota, and Montana. Bulletin American Association of Petroleum and Geology, v. 51, no. 10, 1967, p. 1929-1947.

Keyword(s): non-metal mining

Location(s): Wyoming, North Dakota, Montana, United States

Parry-Davies, R. Consolidation of Old Mine Workings. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May 1992, South African Institution of Civil Engineers, Republic of South Africa, p. 223-227.

This paper describes case histories of the applications of consolidation of old coal mine workings, both in the United Kingdom and in South Africa. Different techniques are included for old coal mine workings and for steeply dipping gold mine workings.

Keyword(s): coal mining, metal mining, backfilling, grouting

Location(s): United Kingdom, South Africa

Pasamehmetoglu, A. G. An Investigation into Time-Dependent Aspects of Mining Subsidence. Ph.D. Thesis, University of Nottingham, 1972.

Keyword(s): time factor

Patey, D. R. Grouting Old Mine Workings at Merthyr Tydfil. Ground Engineering, November, 1977, v. 10, no. 8, p. 24-27.

Keyword(s): abandoned mines, grouting

Pathak, B. D. Investigation of the Hydrogeological Problems in Some Mines in India. IN: Mine Water, Proceedings 2nd International Congress, Granada, Spain, September 1985, R. Fernandez-Rubio, ed., v. 1, p. 181-189.

An accurate knowledge of groundwater flow into the mine working is essential to plan for safe mining operations. The salient features and results of investigations on different groundwater problems in three selected collieries and mines in India have been presented in this paper. In a copper ore mine, the studies indicated that due to slow movement of groundwater in the mine area, conditions do not exist for sudden inundation of mines through the fracture systems, but caving of water stored solution cavities in the dolomites and old slopes may cause inundation depending upon the size and extent of caverns. The problem of groundwater inrush in a few selected colliery areas have also been investigated.

Keyword(s): coal mining, metal mining, hydrology, subsurface water, mine safety

Location(s): India

Pattee, C. T., C. J. Booth. Long-Term Hydraulic Changes in a Shallow Confined Aquifer Induced by Longwall Coal-Mine Subsidence, Illinois. Geological Society of America North-Central Section meeting, Iowa City, April 30, 1992, Abstracts with Programs, v. 24, no. 4, p. 59.

Keyword(s): hydrology, subsurface water, coal mining, longwall, monitoring methods, geologic features

Location(s): Illinois, Illinois Coal Basin, United States

Patton, J. D. Hydraulic Stowing. Transactions, Institution of Mining Engineers, v. 47, part 4, 1914, p. 468.

The author discusses reasons for development of hydraulic backfilling in Britain and indicates major objections and solutions.

Keyword(s): economics, hydraulic backfilling

Location(s): England

Paul, J. W., J. N. Geyer. A Study of Falls of Roof and Coal in Mines of Harrison County, West Virginia. U.S. Bureau of Mines RI 3110, 1931.

Keyword(s): roof stability, coal mining

Location(s): West Virginia, Appalachian Coal Region, United States

Paul, J. W., J. N. Geyer. Caving Chambers in Bituminous Mines. Transactions, AIME, v. 108, 1934, p. 79-87.

Keyword(s): coal mining, roof stability, roof support, bituminous

Location(s): Pennsylvania, Appalachian Coal Region, United States

Paul W. J., L. N. Plein. Methods of Development and Pillar Extraction in Mining the Pittsburgh Coalbed in Pennsylvania, West Virginia and Ohio. U.S. Bureau of Mines IC 6872, 1935.

Keyword(s): coal mining, pillar extraction, active mines, mine design

Location(s): Pennsylvania, West Virginia, Ohio, Appalachian Coal Region, United States

Pauvlik, C. M. The Effects of Longwall Mining Subsidence on the Ground Water Conditions of a Shallow, Unconfined Aquitard Proximate to Old Ben Mine 25, West Frankfort, Illinois. M.S. Thesis, Southern Illinois University, 1986, 149 p.

This study presents the results of monitoring a shallow, unconfined, unconsolidated aquitard during the course of undermining and subsidence.

Keyword(s): subsurface water, longwall, monitoring methods, hydrology, geologic features

Location(s): Illinois, Illinois Coal Basin, United States

Pauvlik, C. M., S. P. Esling. The Effects of Longwall Mining Subsidence on the Groundwater Conditions of a Shallow, Unconfined Aquitard in Southern Illinois. IN: Proceedings, National Symposium on Mining, Hydrology, Sedimentology, and Reclamation, December 7-11, 1987, Springfield, IL, University of Kentucky, Lexington, UKY BU145, p. 189-195.

This study investigated the effect of subsidence associated with longwall mining on a shallow surficial aquitard composed of glacially related sediments. A coal seam 2.4 meters thick and 150 meters deep was mined from a panel 150 meters wide. Three monitoring wells, two installed over the panel and one over nearby chain pillars to serve as a control, were drilled to bedrock. They ranged in depth from 10 to 14 meters. Monthly monitoring of hydraulic conductivity, head, and groundwater chemistry began 2 months before undermining and continued for 10 months. In addition, hydraulic conductivity and head were measured every few days as mining progressed. The possible effects of subsidence on groundwater chemistry were complicated by the application of fertilizer to the agricultural field. Water table elevations fell as a function of subsidence, and groundwater flow shifted from a northerly direction toward a stream to a northwesterly direction. Flow returned to the original configuration by the end of the study, but the gradient remained elevated by 63%.

Keyword(s): coal mining, subsurface water, hydrology, monitoring methods, active mines, longwall, geologic features

Location(s): Illinois, Illinois Coal Basin, United States

Payne, A. R., A. K. Isaac. The Application of Numerical Models in Coal Rib Pillar Design at Longwall Panels. IN: Research & Engineering Applications in Rock Masses, Proceedings 26th U.S. Symposium on Rock Mechanics, South Dakota School of Mines & Technology, Rapid City, June 26-28, 1985, E. Ashworth, ed., Balkema, Rotterdam, p. 685-692.

The rib pillars left between adjacent longwall panels are intended to protect the gateroads from harmful stress abutments, with a reduction in pillar width generally requiring an increase in strength of the gateroad support system. Numerical model simulation provides one method of investigating the effect of separate support elements to be evaluated together.

Keyword(s): modeling, mine design, longwall, coal mining, pillar strength

Location(s): United Kingdom

Payne, H. M. European Practice of Filling Abandoned Workings With Sand. Engineering and Mining Journal, v. 89, 1910, p. 522.

This article describes hydraulic sand backfilling at a mine in Poland, including methods, costs, and materials used.

Keyword(s): hydraulic backfilling, abandoned mines, economics

Location(s): Europe, Germany, Poland

Payne, H. R. Opportunities and Responsibilities. IN: Planning and Engineering Geology, Proceedings 22nd Annual Conference of the Engineering Group of the Geological Society, Plymouth Polytechnic, September 8-12, 1986, M.G. Culshaw, et al., eds., The Geological Society, London, 1987, p. 617-621.

Some of the administrative and social responsibilities facing local authorities in dealing with hazardous events such as landslides, rock falls, mining subsidence, and coastal erosion are considered. These are illustrated by examples drawn from Wales.

Keyword(s): land-use planning, engineering, geologic features, government

Location(s): Wales, United Kingdom

Payne, H. R., ed. Mining Subsidence: South Wales Desk Study: Summary of Research and Description of the Mapping Techniques Developed. Department of the Environment/Welsh Office, Cardiff, 1986, 39 p.

Keyword(s): coal mining, literature search

Location(s): Wales

Payne, V. E. Coal Mining Subsidence and Golden Eagle Habitat. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 167-172.

Issues between resource utilization and resource preservation often develop in connection with coal mining. One such conflict exists in eastern Utah where PacifiCorp and Energy West Mining Company are working with state and federal agencies to address the resource recovery/resource preservation dispute. The effects of underground longwall coal mining on golden eagle cliff nesting sites have been studied at the Cottonwood Mine since 1986. Subsidence, escarpment spalling, and nesting activities of the local eagle population were monitored.

Keyword(s): environment, longwall, coal mining, active mines, wildlife

Location(s): Utah, Rocky Mountain Coal Region, United States

Peabody Coal Company. Ground Control and Slope Stability. Information Circular No. 138, 5/75, 1975, 14 p.

The main object of the study of slope stability and rock mechanics is to learn to predict rock behavior in and around excavations with increased confidence and to develop ground control. This paper presents attempts to study what happens and when and where slopes fail to possibly determine why the slope failed and to develop ground control by determining how to prevent future failures.

Keyword(s): ground control, rock mechanics, coal mining

Peabody Coal Company. Impact of Subsidence Regulations on Peabody Coal Company. Prepared by Peabody Coal Company, Illinois Division, Industrial Engineering Department, August 20, 1982.

This report was prepared to determine the potential effect of the proposed subsidence regulations on Peabody Coal Company's mines and reserve areas. Studies were made of key areas, and the results were applied to present operations and those in the most probable case for the next 10 years. The studies were conducted in the states of Kentucky, Illinois, and Ohio. The following information was evaluated: tonnage within the reserve, projected extraction ratio as presently mined, preventive factors affecting extraction ratio, projected extraction ratio to prevent subsidence under the proposed regulations, tonnage loss, topography of the area, and the potential percentage of recoverable reserves lost.

Keyword(s): law, coal mining, active mines, geologic features, room-and-pillar, high-extraction retreat, roof stability

Location(s): Kentucky, Illinois, Indiana, Ohio, Illinois Coal Basin, United States

Peck, R. B. Deep Excavation and Tunnelling in Soft Ground. IN: 7th International Conference on Soil Mechanics and Foundation Engineering, Mexico City, 1969.

Keyword(s): tunnelling, soil mechanics, engineering

Peele, R. Mining Engineers' Handbook. v. 1, 3rd edition, John Wiley & Sons, New York, 1944.

This handbook was written in 1929 and revised in 1941. It is useful as a historical and developmental reference for mining procedures, but it is not current enough for modern subsidence control techniques.

Keyword(s): historical

Location(s): United States

Pellissier, J. P., A. A. B. Williams, B. G. Lunt. Predicting and Assessing Undermining-Induced Distress in Typical South African Buildings. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May 1992. South African Institution of Civil Engineers, Republic of South Africa, p. 117-123.

High-extraction coal-mining has the advantage that a high percentage of the available coal can be extracted, but a disadvantage in that it causes surface subsidence. Buildings on the surface may show distress if undermined and a method of predicting this distress and of assessing the potential damage is required to help mine authorities make decisions about the economics of undermining.

Keyword(s): surface structural damage, active mines, prediction, geologic features, foundations, horizontal displacement, structural mitigation

Location(s): South Africa

Pellissier, J. P., A. A. B. Williams. The Cellular Raft Foundation for Buildings Over Mined Areas. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May, 1992, South African Institution of Civil Engineers, Republic of South Africa, p. 125-130.

This paper discusses design of new buildings to resist or accommodate soil deformation due to high-extraction coal mining. Also included is information on foundation design for structures in the gold fields of South Africa. The most appropriate methods of construction for South African conditions are reviewed.

Keyword(s): coal mining, metal mining, active mines, foundations, engineering, structural mitigation, vertical displacement, horizontal displacement, lab testing, in situ testing, geologic features, pillar extraction, longwall

Location(s): South Africa

Pells, P. J. N., J. C. Braybrooke, J. Mong, G. P. Kotze. Cliff Line Collapse Associated with Mining Activities. IN: Proceedings, Extension Course on Soil Slope Instability and Stabilisation, Sydney, Australia, November 30-December 2, 1987, B.F. Walker and R. Fell, eds., Balkema, Rotterdam, p. 359-385.

This paper gives information on rockfalls and landslides within eight areas in the Sydney Basin where coal or oil shale mining has occurred beneath, or adjacent to, sandstone escarpments. The failures have occurred between about 1914 and the present day and have varied from minor rockfalls to approximately 30 million ton rocks at Nattai North.

Keyword(s): geologic features, coal mining, longwall, surface subsidence damage

Location(s): Australia

Pendleton, J. A. The Regulation of Coal Mine Subsidence in Colorado. IN: Mine Subsidence, M.M. Singh, ed., Society of Mining Engineers Fall Meeting, September, 1986, St. Louis, MO, SME, Littleton, CO, p. 101-108.

In response to Public Law 95-87 (SMCRA), Colorado promulgated regulations governing the mining of coal. These regulations require the prediction, monitoring, and mitigation of "material damage" caused by subsidence. All permitted underground coal mines within Colorado have approved subsidence programs. Preliminary monitoring results indicate the subsidence mechanical predictions have been sufficiently accurate to preclude material subsidence damage. The State of Colorado has developed a practical approach to regulating subsidence. It stresses monitoring verification of predicted subsidence phenomena. However, shortcomings exist in our ability to predict precisely the secondary consequences of subsidence, including effects to structures, the hydrologic balance, and the environment. Lack of accuracy in predicting these secondary consequences results in uncertainty, necessitating conservatism in permitting. Future research should emphasize the secondary consequences of subsidence to avoid increasingly stringent permit restrictions.

Keyword(s): coal mining, law, mitigation, monitoring methods, prediction, hydrology, surface structural damage, partial extraction, longwall, angle of draw, land-use planning, mine design, mine operation

Location(s): Colorado, Rocky Mountain Coal Region, United States

Peng, S. S. How Five Different Mines Apply Shortwall Methods to Mine Coal. Coal Age, March, 1976, p. 82-88.

Keyword(s): roof support, ground control, shortwall, coal mining, mine design, active mines

Peng, S. S. Roof Control Study of Low Coal Area, Olga No. 1 Mine, Coalwood, WV. Final report, U.S. Bureau of Mines Contract JO155125, July, 1976, 22 p.

Keyword(s): longwall, roof stability, ground control, pillar strength, mine design, coal mining

Location(s): West Virginia, Appalachian Coal Region, United States

Peng, S. S., D. W. Park. A Review of Shortwall Mining in the United States. Coal Mining & Processing, December, 1977, p. 54-59.

Keyword(s): roof support, shortwall, coal mining

Location(s): United States

Peng, S. S., D. W. Park. Rock Mechanics Study for the Shortwall Mining at the Valley Camp No. 3 Mine, Triadelphia, WV. Final report, U.S. Bureau of Mines Contract JO155125, December, 1977.

Keyword(s): mine design, ground control, shortwall, rock mechanics, roof stability, coal mining

Location(s): West Virginia, Appalachian Coal Region, United States

Peng, S. S. Roof Control Studies at Olga No. 1 Coal Mine, Coalwood, WV. IN: Energy Resources and Excavation Technology, Proceedings 18th U.S. Symposium on Rock Mechanics, Keystone, CO, June 22-24, 1977, F.-D. Wang and G.B. Clark, eds., Colorado School of Mines Press, Golden, p. 1C3-1--1C3-6.

Two factors appeared to control the fall of roof in the Low Coal Area of the Olga No. 1 Mine: one is related to coal extraction; the other is independent of coal extraction and has to do with local geological features.

Keyword(s): geologic features, roof stability, coal mining, active mines

Location(s): West Virginia, Appalachian Coal Region, United States

Peng, S. S., M. H. Maung. Formula for Shape and Size Effects of U.S. Coal Pillar Strength, A Comprehensive Review. College of Mineral and Energy Resources, West Virginia University, Morgantown, December, 1978.

Keyword(s): pillar strength, coal mining

Location(s): United States

Peng, S. S. Surface Subsidence. IN: Coal Mine Ground Control, Chapter 9, John Wiley & Sons, New York, 1978, p. 281-342.

This chapter classifies and discusses two ground movement theories: descriptive theories and continuum mechanics theories. The author analyzes subsidence trough determination including descriptions of profiles, strains, profile slopes, and profile curvatures. Subsidence measurement techniques, surface damage, and prevention of damage to surface facilities are also covered.

Keyword(s): vertical displacement, horizontal displacement, surface structural damage, mine design, monitoring design, survey methods, survey equipment, prediction, descriptive theories, continuum mechanics, coal mining, prediction theories, ground control

Peng, S. S., K. K. Kohli, S. L. Cheng. Surface Subsidence and Structural Damages Due to Underground Longwall Coal Mining--A Case Study. IN: Rock Mechanics: A State of the Art, Proceedings 21st U.S. Symposium on Rock Mechanics, University of Missouri at Rolla, May 28-30, 1980, D.A. Summers, ed., p. 275-284.

This paper presents a case history of surface subsidence over a longwall section at an eastern Ohio mine, including surface monitoring plans, measured results, and subsequent surface structural damages.

Keyword(s): surface structural damage, monitoring design, survey design, mine operation, longwall, coal mining

Location(s): Ohio, United States, Appalachian Coal Region

Peng, S. S., S. L. Cheng. Evaluation of Surface Subsidence Potential Due to Underground Coal Mining at Upper Shavers Fork, Monongahela National Forest, Randolph/Pocahontas County, WV. Report on Office of Surface Mining PO P5211006, West Virginia University, 1980, 62 p.

Keyword(s): surface subsidence damage, environment, coal mining, land-use planning

Location(s): West Virginia, Appalachian Coal Region, United States

Peng, S. S., U. Chandra. Getting the Most from Multiple Seam Reserves. Coal Mining & Processing, v. 17, no. 11, 1980, p. 87-84.

Keyword(s): multiple-seam extraction, coal mining

Peng, S. S., K. Matsuki, W. H. Su. 3-D Structural Analysis of Longwall Panels. IN: Rock Mechanics: A State of the Art, Proceedings, 21st U.S. Symposium on Rock Mechanics, University of Missouri at Rolla, May 28-30, 1980, D.A. Summers, ed., p. 44-56.

Three-dimensional finite element analyses were performed to determine the major controlling factors in the design of an advancing longwall panel and its support systems. Comparisons of stress redistribution between advancing and retreating longwall systems and between rigid and soft support systems are presented along with the evaluations of the importance of those parameters, such as panel size, caved area, packwall material, packwall width and state of in situ stress. The analyses show that the most influential factors in the design evaluation are face width, Young's modulus of the packwall material, packwall width, and in situ lateral stresses. An example is presented to illustrate how these influential factors can be incorporated into the selection of design alternatives.

Keyword(s): longwall, coal mining, rock mechanics, modeling, finite element

Location(s): United States

Peng, S. S., S. L. Cheng. Predicting Surface Subsidence for Damage Prevention. Coal Mining & Processing, v. 18, no. 5, 1981, p. 84-95.

This paper contains background information on subsidence engineering, with reference to subsidence-related structural damage, and damage prevention techniques. An empirical subsidence prediction method is discussed.

Keyword(s): vertical displacement, surface structural damage, prediction, coal mining

Peng, S. S., S. L. Cheng. House Damages Due to Room and Pillar Mining. IN: Proceedings, 22nd U.S. Rock Mechanics Symposium, Cambridge, MA, June 1981, p. 335-340.

Keyword(s): surface structural damage, room-and-pillar

Peng, S. S., D. Y. Geng. Surface Subsidence, Overburden Behavior and Structural Damages Due to Longwall Mining--Two Case Studies. IN: Proceedings, 2nd International Conference on Stability in Underground Mining, 1982, University of Kentucky, p. 497-523.

Keyword(s): longwall, overburden, surface structural damage, coal mining

Peng, S. S., C. T. Chyan. Surface Subsidence, Surface Structural Damages and Subsidence Predictions and Modeling in the Northern Appalachian Coalfield. IN: Proceedings, Workshop on Surface Subsidence Due to Underground Mining, Morgantown, WV, November 30-December 2, 1981, S.S. Peng and M. Harthill, eds., Department of Mining Engineering, West Virginia University, 1982, p. 73-84.

This paper is a summary document of five previously published papers on subsidence over 24 longwall panels and 5 room-and-pillar sections in the northern Appalachian coalfield; it includes the physical characteristics of 54 surface subsidence profiles collected for longwall and room-and-pillar mining. Empirical and analytical methods of prediction and modeling are discussed in detail.

Keyword(s): vertical displacement, surface structural damage, longwall, room-and-pillar, prediction, modeling

Location(s): Appalachian Coal Region, United States

Peng, S. S., D. Y. Geng. Methods of Predicting the Subsidence Factor, Angle of Draw and Angle of Critical Deformation. IN: State-of-the-Art of Ground Control in Longwall Mining and Mining Subsidence, SME-AIME, Y.P. Chugh and M. Karmis, eds., September, 1982, p. 211-221.

This report analyzes the effects of geology and mining methods on subsidence factor, angle of draw, and angle of critical deformation based on the results of 40 longwall subsidence profiles in the northern Appalachian coalfield.

Keyword(s): vertical displacement, horizontal displacement, longwall, prediction, ground control, angle of draw, geologic features, coal mining

Location(s): Appalachian Coal Region, United States

Peng, S. S., H. S. Chiang. Roof Stability in Longwall Coal Faces. IN: Proceedings, 1st International Conference on Stability in Underground Mining, Vancouver, British Columbia, August, 1982, p. 295-335.

Keyword(s): coal mining, roof stability, longwall, ground control

Peng, S. S., S. M. Hsiung. Development of Roof Control Criteria for Longwall Mining--Parametric Modeling I. IN: Strata Mechanics, Proceedings of the Symposium, University of Newcastle-upon-Tyne, April, 1982, I.W. Farmer, ed., Elsevier, New York, p. 51-58.

Keyword(s): coal mining, roof stability, longwall, modeling

Peng, S. S., H. S. Chiang. Longwall Ground Control--U.S. Experiences Journal of Mines, Metals, and Fuels, September, 1983, Special Number on Update on Longwall Mining--Evolving Trends, p. 397-415.

For over a decade, longwall mining in the United States has been demonstrated to be safe and easily in compliance with current laws. It is highly productive provided it is properly designed and operated.

Keyword(s): longwall, roof support, roof stability, mine design

Location(s): United States

Peng, S. S., D. Y. Geng. The Appalachian Field: General Characteristics of Surface Subsidence and Monitoring Methods. IN: Surface Mining Environmental Monitoring and Reclamation Handbook, L.V.A. Sendlein, et al., eds., Coal Extraction and Utilization Research Center, Southern Illinois University, Carbondale, U.S. Department of Energy Contract No. DE AC22 80ET 14146, Elsevier, New York, 1983, p. 627-646.

This paper discusses the zones of caving and deformation found from just above the mined-out coal seam up to the surface. In addition, many terms and concepts are defined.

Keyword(s): vertical displacement, horizontal displacement, angle of draw, coal mining, overburden, prediction, longwall, monitoring methods, survey methods

Location(s): United States

Peng, S. S., H. S. Chiang. Longwall Mining. John Wiley & Sons, New York, 1984, 708 p.

Keyword(s): longwall, mine design, surface structural damage , active mines, coal mining, monitoring methods, survey data processing, overburden, vertical displacement, horizontal displacement

Peng, S. S. Longwall Mining in the US: Where Do We Go From Here? Mining Engineering, March, 1985, p. 232-234.

Modern longwall mining, introduced to the United States coal industry in the mid-1960s, is the latest coal mining technique. Today, longwall mining produces more than 15% of all underground coal production. The growth of longwall mining in the United States is slow. Nearly two decades of longwall mining have demonstrated that its benefits outweigh the disadvantages.

Keyword(s): longwall, coal mining, mine safety, economics, active mines, mine design

Location(s): United States

Peng, S. S., W. H. Su. Socio-Economic, Subsidence, Transportation and Legal Ramifications of Potential Liquefaction Plant Sitings. Task: Prediction of Subsidence Potential Over Abandoned Mine Land. Final Report to Pittsburgh Energy Technology Center, U.S. DOE, Grant No. DE-FG22-83PC60053, 1986, West Virginia University, Morgantown, 32 p.

The purpose of this study is to investigate the causative factors for subsidence over abandoned coal mines. Roof caving, pillar failure, and pillars punching into soft mine floor are discussed in detail. Aging and creep are considered two of the most important processes controlling the causative factors. Creep tests of coal measure rocks were conducted in the laboratory to better define the time-dependent behavior of coal pillars and the rocks surrounding them. Procedures for predicting subsidence potential over an abandoned coal mine were proposed using a combined statistical and material strength approach.

Keyword(s): coal mining, abandoned mines, roof stability, pillar strength, floor stability, lab testing, prediction

Location(s): United States

Peng, S. S. Case Studies Illustrate the Need for a New Concept of Coal Pillar Design. Mining Engineering, v. 38, no. 11, November, 1986, p. 1033-1035.

The most commonly used ground control design in coal mining is the determination of pillar size by various pillar strength formulas for mine layout. However, there have been few documented case histories concerning the validity of those strength formulas.

Keyword(s): pillar strength, room-and-pillar, mine design, roof support, finite element, coal mining, ground control

Location(s): United States

Peng, S. S., W. M. Ma, W. L. Zhong. Longwall Mining Under Linear Structures--A Case Study. IN: Mine Subsidence, M.M. Singh, ed., Society of Mining Engineers Fall Meeting, St. Louis, MO, September, 1986, SME, Littleton, CO, p. 51-64.

Across a longwall section that consisted of seven panels, there were two high pressure gas transmission pipelines buried from 3 to 10 feet below the surface. Strain gages were mounted on the pipelines above three of the panels to investigate the stress conditions sustained by the pipelines during underground longwall mining. Survey monuments were also installed along, but near, the pipelines. This paper presents a subsidence prediction method and the preliminary results of pipeline stress conditions as affected by underground longwall mining.

Keyword(s): longwall, pipelines, survey methods, monitoring methods, prediction, survey data processing, horizontal displacement, influence function

Peng, S. S., A. W. Khair, Y. Luo. Topographical Effects of Surface Subsidence--A Case Study. IN: Proceedings, National Symposium on Mining, Hydrology, Sedimentology, and Reclamation, Springfield, IL, December 7-11, 1987, University of Kentucky, Lexington, p. 223-228.

Surface movement, including vertical subsidence and horizontal displacement due to longwall mining, was measured for a panel located in a steep terrain. The measured vertical subsidence matched fairly well with that predicted by the probability integration function method while the measured horizontal displacement differed considerably from that predicted by the focal point method for flat surfaces. In most cases the horizontal displacement moved downward along the true dip direction regardless of face location and panel geometry. It was hypothesized that top soil moved separately from the bedrock and contributed to the excessive horizontal displacement.

Keyword(s): vertical displacement, horizontal displacement, longwall, geologic features, overburden, computer, modeling, coal mining, survey design, survey methods, survey data processing

Location(s): West Virginia, Appalachian Coal Region, United States

Peng, S. S., P. M. Lin, S. M. Hsiung. Subsidence Over AML and Its Causes--A Case Study. IN: Mine Induced Subsidence: Effects on Engineered Structures, Proceedings of the Symposium, Nashville, TN, May 11, 1988, ASCE Geotechnical Special Publication No. 19, p. 147-167.

Subsidence over abandoned mined lands can be attributed to several causes. For purposes of compensation, liability, and development of remedial measures, it is essential to identify the real causes. Detailed procedures for a subsidence investigation are given in this paper. The keys to identification and determination of the causes and severity of damages are illustrated and discussed through a case study in this paper.

Keyword(s): abandoned mines, surface structural damage, monitoring methods, instrumentation, monitoring equipment

Location(s): Pennsylvania, Appalachian Coal Region, United States

Peng, S. S. Development of an Improved Longwall Mining Technique--An Integrated Multidisciplinary Approach. SME Preprint 89-188, for presentation at SME Annual Meeting, Las Vegas, NV, February 27-March 2, 1989, 18 p.

An expert team consisting of geology, civil engineering, and mining engineering professors was organized to investigate several problems of longwall mining in three mine sites. Problems included site investigation, panel layout and support selection, overburden strata movement, surface subsidence and structural damages, slope stability, well and stream dewatering, and other topics. The results include the development of a PC software package such as powered support selection, surface subsidence prediction, optimum panel dimension, and pillar design.

Keyword(s): longwall, overburden, surface structural damage, surface water, subsurface water, computer, prediction, coal mining

Location(s): United States

Peng, S. S., Y. Luo. Slope Stability Under the Influence of Ground Subsidence Due to Longwall Mining. Mining Science and Technology, v. 8, no. 2, 1989, p. 89-95.

Surface subsidence, especially horizontal displacements, induced by underground longwall mining in hilly regions is reportly different from that in level areas. The mechanisms behind this phenomenon are not clear however. Here, this problem is considered to be a slope stability problem, and a mathematical model is proposed to assess the slope stability under the influence of subsidence due to longwall mining.

Keyword(s): coal mining, longwall, horizontal displacement, mathematical model, overburden, modeling

Peng, S. S. Some Basic Problems in Coal Mine Ground Control Discussed. Mining Engineering, v. 41, no. 8, August, 1989, p. 835-838.

The biggest problem in coal mine ground control is that miners are dealing with materials of rapidly varying properties and occurrence and only the exposed surface can be identified positively. Thus, in attempting to solve ground control problems, many unknown factors are assumed. Some of the problems deriving from such assumptions are discussed here, including coal pillars, geological conditions, in situ stress, instrumentation, computer modeling, surface subsidence, and floor heave.

Keyword(s): coal mining, ground control, instrumentation, computer, modeling, floor stability, roof stability, rock mechanics, geologic features, vertical displacement, horizontal displacement, subsurface water

Location(s): United States

Peng, S. S. Comments on Surface Subsidence Prediction. Mining Science and Technology, v. 11, 1990, p. 207-211.

The problems concerning the application of various types of subsidence prediction models are discussed, including model imperfection, errors in representative coefficients or parameters and subsidence survey, and human errors. Prediction accuracy and methods of evaluating model prediction accuracy are also discussed.

Keyword(s): prediction, prediction theories, coal mining, modeling, finite element, geologic features, profile function, influence function

Peng, S. S. Surface Subsidence Engineering. Society for Mining, Metallurgy, and Exploration, Inc., Littleton, CO, 1992, 161 p.

Surface subsidence caused by underground mining is an old problem that did not receive its due attention in the United States until after the mid-1960s. The increasing use of longwall mining and further housing development into the abandoned mined lands in suburban areas further accelerated public concerns about surface subsidence resulting from underground mining. Many research programs have been initiated and completed since the passage of SMCRA in 1977. The data obtained from these intensified research programs have demonstrated that surface subsidence due to underground mining is a complicated problem resulting from the interaction between mining operation, overburden geological conditions, and time. As such, the exact process and its prediction and prevention tend to be site specific, although there are general trends and principles applicable to most subsidence problems. In this book, the general trends and principles about surface subsidence due to underground coal mining are discussed.

Keyword(s): active mines, coal mining, engineering, overburden, geologic features, vertical displacement, horizontal displacement, prediction, profile function, influence function, finite element, mathematical model, modeling, prediction theories, surface structural damage, structural mitigation, monitoring methods, room-and-pillar, longwall, abandoned mines, subsurface water, hydrology

Peng, S.S. Underground Design Models Prove Practical. Coal, v. 97, no. 5, May, 1992, p. 46-49.

Combining developmental theories and field validation, four ground control programs have been developed: PILLAR, ROOFBOLT, DEPOWS, AND CISPM. All of the programs can be used for longwall and room-and-pillar mine design.

Keyword(s): modeling, mine design, active mines, longwall, room-and-pillar, surface structural damage, coal mining, finite element, geologic features, yielding supports, prediction, pillar strength

Location(s): Kentucky, West Virginia, Appalachian Coal Region, United States

Peng, S. S., Y. Luo. Comprehensive and Integrated Subsidence Prediction Model -CISPM (V2.0). IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 22-31.

This paper presents a computer program for predicting surface movement and deformation caused by underground coal extractions. The program is capable of predicting final surface movement and deformation over underground openings, predicting dynamic surface movement and deformation process associated with underground longwall mining operations, processing subsidence data, recommending subsidence parameters for those new coal mines where no subsidence data are available, and deducing subsidence parameters from collected data.

Keyword(s): computer, prediction, coal mining, active mines, longwall, geologic features, mathematical model, influence function

Peng, S. S., Y. Luo. A New Method for Designing Support Area to Protect Surface Structures Over Underground Coal Mining Areas. Society for Mining Metallurgy and Exploration Preprint 93-265, for presentation at SME-AIME Annual Meeting, Reno, NV, February 15-18, 1993, 7 p.

The size of the support area for structures designed as stated in the Pennsylvania Underground Coal Mining Rules (1985) will be excessively large, resulting in wasteful use of the coal reserve when the overburden depth is more than 350 feet. A more scientific method is proposed for designing the support area. This method is based on a large amount of subsidence data collected throughout a number of major coal fields in the United States and the authors' experience with monitoring and protecting surface structures undermined by longwall panels. It considers the critical deformation indices that a structure can tolerate, and depth and height of underground extraction. The support area designed by this new method will not only assure the safety of the structure to be supported but also maximize the extraction of the coal reserve.

Keyword(s): coal mining, surface structural damage, active mines, longwall, partial extraction, overburden, influence function

Location(s): Pennsylvania, Appalachian Coal Region, United States

Peng, S. S. Strength of Laboratory-Sized Coal Specimens vs. Underground Coal Pillars. Mining Engineering, v. 45, no. 2, February 1993, p. 157-158.

Is the laboratory-sized coal specimen much stronger than underground coal pillars? The answer to this question has a profound implication for many coal operators. It will decide how much of the coal reserve can be recovered.
Keyword(s): pillar strength, lab testing, coal mining, rock mechanics
Location(s): United States

Peng, S. S., ed. Proceedings, 1st Conference on Ground Control in Mining. Department of Mining Engineering, College of Mineral and Energy Resources, West Virginia University, Morgantown, July 1981, 259 p.
Keyword(s): ground control, coal mining, pillar strength, roof stability, roof bolting, longwall, prediction, monitoring methods

Penman, D. Hydraulic Stowing in Thick Seams of India. Transactions, Institution of Mining Engineers, v. 80, 1930-31, p. 123.
Hydraulic backfilling in India is described, where many seams are more than 20 feet thick and range up to 90 feet thick.
Keyword(s): hydraulic backfilling, pillar extraction, room-and-pillar
Location(s): India

Pennington, D., J. G. Hill, G. J. Burgdorf, D. R. Price. Effects of Longwall Mine Subsidence on Overlying Aquifers in Western Pennsylvania. U.S. Bureau of Mines OFR 142-84, 1984, 129 p. (NTIS PB84 236710)
Groundwater levels and subsidence were monitored over a longwall panel of a deep coal mining operation located in western Pennsylvania.
Keyword(s): subsurface water, longwall, hydrology, coal mining, geophysical, overburden, inflow
Location(s): Pennsylvania, Appalachian Coal Region, United States

Pennsylvania Anthracite Subsidence Commission. Final Report. Submitted to the Legislature, March 15, 1943, 12 p.
Keyword(s): government, anthracite, coal mining, law
Location(s): Pennsylvania, Appalachian Coal Region, United States

Pennsylvania Department of Commerce, Bureau of Appalachian Development. Mine Subsidence Information Center. June, 1977, 47 p. (NTIS PB 274 108)
Keyword(s): land-use planning, coal mining
Location(s): Pennsylvania, Appalachian Coal Region, United States

Pennsylvania Department of Commerce, Bureau of Appalachian Development. Bituminous Mining Laws of Pennsylvania. 1953, 305 p.
Keyword(s): law, coal mining, government, bituminous
Location(s): Pennsylvania, Appalachian Coal Region, United States

Pennsylvania Department of Mines. Anthracite Mining Laws of Pennsylvania. 1954, 240 p. (Available for consultation at the USBM Denver Research Center.)
This document contains laws enacted in 1954 that pertain to subsidence resulting from anthracite mining in northeastern Pennsylvania.
Keyword(s): law, anthracite, coal mining, surface subsidence damage
Location(s): Pennsylvania, Appalachian Coal Region, United States

Pennsylvania Department of Mines and Minerals. Bituminous Mining Laws of Pennsylvania for Underground Mines. 1961, 231 p.
Keyword(s): law, coal mining, bituminous, government
Location(s): Pennsylvania, Appalachian Coal Region, United States

Pennsylvania Subsidence Committee. Report of the Subsidence Committee to the General Assembly of the Commonwealth of Pennsylvania. March 1, 1957, 54 p.
Keyword(s): government, law, coal mining
Location(s): Pennsylvania, Appalachian Coal Region, United States

Perin, R. J., D. G. Puglio. Bailey Mine Slurry Impoundment Longwall Subsidence Monitoring. IN: Proceedings, 7th International Conference on Ground Control in Mining, August 3-5, 1988, S.S. Peng, ed., West Virginia University, p. 83A.
Subsidence monitoring was conducted in proximity to the 1-A and 2-A longwall panels at the Bailey Mine slurry impoundment of Consol Pennsylvania Coal Company. Monitoring fulfills federal Mine Safety and Health Administration mandated requirements. Monitoring was conducted before, during, and after mining of the panels. The embankment was not deleteriously impacted by longwall mining.

Keyword(s): longwall, monitoring methods, geologic features, geotechnical, survey methods, foundations, instrumentation, vertical displacement, horizontal displacement, prediction, modeling, surface water

Location(s): Pennsylvania, Appalachian Coal Region, United States

Persche, E. P. Architectural Mitigating Measures to Control Subsidence Damage. IN: Proceedings, Conference on Coal Mine Subsidence in the Rocky Mountain Region, Colorado Springs, October 28-30, 1985, J.L. Hynes, ed., Colorado Geological Survey Special Publication 31, Department of Natural Resources, Denver, 1986, p. 215-221.

With development of the Rocky Mountain region, damage to buildings due to mine subsidence has increased. Much of the reported damage could be avoided by prudent planning and zoning. Where zoning does not keep building away from mine subsidence areas, other measures have to be employed to avert or mitigate potential subsidence damage.

Keyword(s): surface structural damage, abandoned mines, geotechnical, structural mitigation, architecture, construction, foundations, utilities, coal mining

Location(s): Rocky Mountain Coal Region, United States

Perz, F. Mathematical Relationships and Subsidence Troughs. Mine and Quarry Engineering, v. 23, June 1957, p. 256-260.

This paper describes a subsidence prediction method that uses mathematical relationships to model the formation of subsidence troughs above mine workings, taking into account the properties of overlying strata.

Keyword(s): vertical displacement, horizontal displacement, prediction, mathematical model, modeling, geologic features

Perz, F. A New Method of Expressing the Mathematical Relationships Governing the Formation of Subsidence Troughs Above Mine Workings. IN: Proceedings, European Congress on Ground Movement, Leeds, England, April 9-12, 1957, London Harrison, p. 21-26.

Keyword(s): mathematical model, modeling

Perz, W. Subsidence Observations on Workings in Austrian Tertiary Carboniferous Synclines. U.S. Bureau of Mines Translation No. 199, 1956, 6 p.

Keyword(s): coal mining

Location(s): Austria

Perz, W. Observations of Subsidence Over Underground Workings in the Tertiary Coal Basins. IN: Proceedings, European Congress on Ground Movement, Leeds, England, April 9-12, 1957, London Harrison, p. 92-98.

Keyword(s): surface subsidence damage, coal mining

Location(s): Austria

Perz, W. Subsidence Observations in Austria. Colliery Engineering, v. 35, no. 12, 1958, p. 533-535.

Keyword(s): coal mining

Location(s): Austria

Peterlee Development Corporation. The Master Plan--Report. 1952.

The development of the new town of Peterlee in northeast England provides an instance of successful coordination of surface building and underground coal mining.

Keyword(s): multiple-seam extraction, land-use planning, surface structural damage, construction, National Coal Board, coal mining, architecture

Location(s): England

Peters, D. C., R. A. Speirer, V. R. Shea. Lineament Analysis for Hazard Assessment in Advance of Coal Mining. IN: ERIM Symposium, 6th Thematic Conference on Remote Sensing and Geology, Houston, TX, 1988, p. 253.

Lineament analysis, a common remote sensing tool for petroleum and mineral exploration, can be used for coal mine properties to assess potential ground control hazards by estimating the relative degrees of risk associated with geologic structures that cause the lineaments. This assessment can be applied to unmined properties to provide a preliminary analysis for mine feasibility planning or to active mines to evaluate potential hazards in undeveloped reserves. Studies using this analysis, in-mine observation of lineament locations and ground control problems, and ancillary data have been conducted in Utah and northern Alabama.

Keyword(s): coal mining, active mines, remote sensing, geologic features

Location(s): Utah, Alabama, United States

Peters, W. R., T. M. Campbell, V. R. Sturdivant. Detection of Coal Mine Workings Using High-Resolution Earth Resistivity Techniques. Report on Contract HO292030, SW Research Institute, U.S. Bureau of Mines OFR 55-81, 1980, 80 p. (NTIS PB 81-215378)

Keyword(s): coal mining, monitoring equipment, abandoned mines, geophysical
Location(s): United States

Peterson, D. E. Problems of Basin Subsidence in the Southwest. Mining Engineering, v. 17, 1965, p. 51.
Keyword(s): fluid extraction
Location(s): United States

Petley, D. J., F. G. Bell. Settlement and Foundations. IN: Foundation Engineering in Difficult Ground, F.G. Bell, ed., Butterworth, London, 1978, p. 293-321.
Keyword(s): foundations, soils

Pflaging, K. Quantifying the Effects of Continuous Underground Mining. IN: Ground Movements and Structures, Proceedings 3rd International Conference, University of Wales Institute of Science and Technology, Cardiff, 1984, J.D. Geddes, ed., Pentech, London, 1985, p. 354-376.
The influence of continuous underground mining operations on movements was first described by Lautsch (1969). He found that the results of level measurements carried out during the period from 1950 to 1966, covering successive underground workings in one tectonic zone, showed increasing deviation from precalculated figures after every measurement interval.
Keyword(s): prediction, coal mining, horizontal displacement, remote sensing, vertical displacement
Location(s): Germany

Philbrick, S. S. Investigation and Proposed Treatment of Caved Mine Beneath a 20-Story V. A. Hospital. Geological Society of America Bulletin, v. 59, 1948, p. 1344.
This abstract describes pressure grouting of an undermined site.
Keyword(s): surface structural damage, backfilling
Location(s): Pennsylvania, Appalachian Coal Region, United States

Philbrick, S. S. Cyclic Sediments and Engineering Geology. IN: Proceedings, 21st International Geological Congress, 1960.
The concept of cyclic sedimentation is related to common problems encountered in foundation investigations in coal sequences. The author discusses remedial measures required over undermined areas.
Keyword(s): engineering, foundations, structural mitigation, coal mining, soils

Phillips, D. W. The Nature and Physical Properties of Some Coal Measure Strata. Transactions, Institute of Mining Engineers, v. 80, 1930-31, p. 212-242; v. 81, 1930-31, p. 30-33; v. 82, 1931-32, p. 432-449; v. 83, 1931-32, p. 229-237.
The results of laboratory strength tests on different types of coal measure rocks are given, including a description of the nature of fractures which form in the roof.
Keyword(s): pillar strength, angle of draw, time factor, modeling, coal mining, overburden, lab testing, geologic features

Phillips, D. W., T. J. Jones. Strata Movements Ahead of and Behind Longwall Faces. Transactions, Institute of Mining Engineers, v. 101, 1941, p. 348-351.
This paper discusses results of observations ahead of and behind a longwall face at a depth of 900 yards. A seam 250 yards above the longwall face was monitored for subsidence effects.
Keyword(s): subsurface subsidence damage, multiple-seam extraction, longwall
Location(s): England

Phillips, D. W., H. Henshaw. Underground and Surface Strata Movements. Transactions, Institute of Mining Surveyors, January, 1942, v. 21, Pt. I.
Keyword(s): surface subsidence damage, subsurface subsidence damage

Phillips, D. W. Research on Strata Control in Great Britain. Transactions, AIME, v. 168, 1946, p. 27-50.
Roof and roadway maintenance pertaining to ground control in Great Britain are described. Strain distribution near roadways and methods for measuring strain and loading are discussed.
Keyword(s): ground control, roof support, mine operation, monitoring methods, subsidence research
Location(s): United Kingdom

Phillips, D. W. American Coal Mining. Colliery Guardian, v. 175, no. 4523, 1947, p. 37-43.
Keyword(s): mine design, coal mining
Location(s): United States

Phillips, R. A., D. V. Holmquist. Backfilling of the Pikeview Mine Manway. IN: Proceedings, Conference on Coal Mine Subsidence in the Rocky Mountain Region, Colorado Springs, October 28-30, 1985, J.L. Hynes, ed., Colorado Geological Survey Special Publication 31, Department of Natural Resources, Denver, 1986, p. 255-265.

Evaluation of subsidence potential over the Pikeview Coal Mine sloping entryway in Colorado Springs, Colorado, indicated a substantial risk of future ground movements. A procedure was formulated to block the lower end of the entryway and backfill the upslope portion of the opening with cement slurry.

Keyword(s): abandoned mines, hydraulic backfilling, historical, reclamation, coal mining

Location(s): Colorado, Rocky Mountain Coal Region, United States

Phillips, R. A., D. V. Holmquist, J. S. L. Morgan. Rock Springs, Wyoming Subsidence Abatement Project--Downtown Area. IN: Proceedings, Symposium on Evolution of Abandoned Mine Land Technologies, Riverton, WY, June 14-16, 1989, p. 356-366.

Evaluation of subsidence potential over a portion of a mine that underlies the southern half of downtown Rock Springs, Wyoming, indicated a high risk of future ground movements. A procedure was formulated to isolate the portion of the mine underlying the project site with grouted gravel or zero slump grout barriers. The area would then be stabilized with grout backfill or by pressure injection of low strength grout into the mined zone where sand slurry had previously been placed. This paper details some of the findings of the subsidence evaluation and describes the methods used to stabilize the underlying mined zone.

Keyword(s): coal mining, abandoned mines, grouting, railroads

Location(s): Wyoming, Rocky Mountain Coal Region, United States

Pielok, J. Bestimmung Der Senkungen In Dynamischen Zwischenstufen Des Sendungstroges (Determining the Subsidence in the Dynamic Intermediate Stages of the Subsidence Trough). Academy of Mining & Metallurgy, Cracaw, Poland, Neue Bergbautechnik, v. 3, no. 9, 1973, p. 642-644.

Keyword(s): prediction

Pierce, R. L. Reducing Land Subsidence in the Wilmington Oil Field By Use of Saline Waters. IN: Proceedings, Saline Water Symposium, Water Resources Research, v. 6, 1970, p. 1505-1514.

Keyword(s): oil extraction

Pierson, F. L. Application of Subsidence Observations to Development of Modified Longwall Mining System for Potash. SME-AIME Annual Meeting, New York, February 14-18, 1965, SME-AIME Preprint 65-AM-22, 19 p.

Two-stage extraction room-and-pillar mining of potash was found to increase pressure on the extraction face; the solution was to reduce the extraction rate, resulting in yielding pillars, rather than caving. Increased extraction resulted since no pillars were completely abandoned as a result of unstable roof conditions.

Keyword(s): longwall, non-metal mining, room-and-pillar, pillar extraction, pillar strength, yielding supports

Location(s): United States

Piggford, J. Notes on Subsidence Caused by Coal Workings at Teversal and Pleasby Collieries. Transactions, Institute of Mining Engineers, London, 1909.

Keyword(s): surface subsidence damage, coal mining

Location(s): England

Piggott, R. J., P. Eynon. Ground Movements Arising from the Presence of Shallow Abandoned Mine Workings. IN: Large Ground Movements and Structures, Proceedings International Conference, University of Wales Institute of Science and Technology, Cardiff, 1977, J.D. Geddes, ed., John Wiley & Sons, New York, 1978, p. 749-780.

Underground mineral extraction has taken place for many centuries. Mining methods did not develop at the same rate for all minerals, either in the same or in different countries. Because of the scope of this subject, in this brief review of the historical background, only the development of coal mining practice at shallow depth in the United Kingdom is discussed.

Keyword(s): coal mining, abandoned mines, historical, surface subsidence damage

Location(s): United Kingdom

Pillar, C. L., A. D. Drummond. Importance of Geological Data in Planning Underground Ore Extraction. SME-AIME Fall Meeting and Exhibit, Pittsburgh, PA, September 19-21, 1973, Preprint No. 73-1-312.

Keyword(s): roof stability, ground control, mine design, geologic features

Location(s): United States

Pineda, L., J. Lucas. For Better or for Worse: Public Involvement in Subsidence Abatement Decisions at the Virginia Mine, Colorado. IN: Proceedings National Symposium and Workshops on Abandoned Mine

Land Reclamation, Bismarck, ND, May 21-22, 1984, L.L. Schloesser, et al., eds., North Dakota Public Service Commission and the University of North Dakota, p. 661-675.

In 1981 Colorado found itself overwhelmed by concerned citizens with a major subsidence problem in a suburban neighborhood area. Unlike previous subsidence events in Colorado, this was the first occurrence of damage that resulted in local government action to rezone an entire neighborhood using geological hazard zoning authority. The residents soon discovered that their homes were not salable, even at deeply discounted prices. They could not obtain building permits without performing detailed geotechnical evaluations, and they could not obtain loans for repairs or new construction. The affected homeowners filed a major law suit against the county and the developer.

Keyword(s): abandoned mines, surface structural damage, government, coal mining, reclamation

Location(s): Colorado, Rocky Mountain Coal Region, United States

Piper, T. B. Surveys for Detection and Measurement of Subsidence. Solution Mining Research Institute, Project Report 81-0003-SMRI, January, 1981, Woodstock, IL, 53 p.

This report was prepared for companies engaged in solution mining and is intended to serve as an outline of the technology of detecting, measuring, and reporting subsidence. It is intended for use by the industry or others faced with similar problems.

Keyword(s): survey design, monitoring design, non-metal mining, survey methods, survey data processing, survey equipment, monitoring equipment

Location(s): United States

Pittsburgh Coal Company. Subsidence...Its Cause, Effect, and Prevention. Pittsburgh Coal Company Library, Pittsburgh, PA, 1957, 6 p. (Available for consultation at the USBM Denver Research Center.)

Keyword(s): coal mining, active mines

Location(s): Pennsylvania, Appalachian Coal Region, United States

Platt, J. Underclays of South Wales Coalfields and Their Influence on Floor Penetration. Ph.D. Thesis, University of Wales, Cardiff, 1956.

Keyword(s): floor stability, coal mining

Location(s): Wales

Plewman, R. P., F. H. Deist, W. D. Ortlepp. The Development and Application of a Digital Computer Method for the Solution of Strata Control Problems. South African Institute of Mining and Metallurgy Journal, v. 70, no. 2, September, 1969, p. 33-44.

The design of a completely digital mathematical model to be used in place of previously used analog models is described in detail. The application of the model to an actual problem is included.

Keyword(s): computer, ground control, modeling, phenomenological model, elastic model, mathematical model

Location(s): South Africa

Poland, J. F., G. H. Davis. Subsidence of the Land Surface in the Tulare-Wasco (Delano) and Los Banos-Kettleman City Area, San Joaquin Valley, California. American Geophysical Union Transactions, v. 37, 1956, p. 287-296.

Keyword(s): fluid extraction

Location(s): California, United States

Poland, J. F. Land Subsidence Due to Ground Water Development. Journal of Irrigation and Drainage Division, ASCE, v. 84, no. IR3, Paper 1774, September, 1958, p. 11.

This paper describes subsidence in six areas of California caused by development of groundwater resources; mitigation or elimination procedures are suggested for the problem.

Keyword(s): subsurface water, fluid extraction

Location(s): California, United States

Poland, J. F. The Coefficient of Storage in a Region of Major Subsidence Caused by Compaction of an Aquifer System. U.S. Department Interior Geological Survey Professional Paper 424-B, Geological Survey Research 1961, p. B52-B54.

Keyword(s): fluid extraction, hydrology

Location(s): United States

Poland, J. F., J. H. Green. Subsidence in the Santa Clara Valley, California--A Progress Report. U.S. Department Interior, Geological Survey, Water-Supply Paper 1619-C, 1962, 16 p.

Keyword(s): fluid extraction

Location(s): California, United States

Poland, J. F., R. L. Ireland. Shortening and Protrusion of a Well Casing Due to Compaction of Sediments in a Subsiding Area in California. Geological Survey Research 1965, U.S. Department of the Interior, Geological Survey Professional Paper 525-B, p. B180-B183.

Keyword(s): fluid extraction
Location(s): California, United States

Poland, J. F., W. I. Gardner, M. N. Mayuga, T. Leps, P. Saint Amand. Symposium--What Studies of Land Subsidence Problems Should be Initiated or Further Implemented? IN: Proceedings, Landslides and Subsidence--2nd Geologic Conference, Los Angeles, California Resources Agency, Sacramento, 1966, p. 156-169.
Keyword(s): fluid extraction, subsidence research
Location(s): California, United States

Poland, J. F., R. E. Evenson. Hydrogeology and Land Subsidence, Great Central Valley, California. Geology of Northern California, California Division Mines and Geology Bulletin 190, 1966, p. 239-247.
Keyword(s): fluid extraction
Location(s): California, United States

Poland, J. F. Role of Pore Pressure in Subsidence Caused by Ground Water Withdrawal. Geological Society of America Paper 115, 1968, p. 179.
Keyword(s): fluid extraction, hydrology
Location(s): United States

Poland, J. F. Land Subsidence and Compaction, 1960-1964, in the Santa Clara Valley, California. Geological Society of America, Special Paper 101, (abstract), 1968, p. 167.
Keyword(s): fluid extraction
Location(s): California, United States

Poland, J. F. Status of Present Knowledge and Needs for Additional Research on Compaction of Aquifer Systems. IN: Land Subsidence, Proceedings International Symposium, September 14-18, 1969, Tokyo, IAHS Publication 88, v. 1, 1969, p. 11-21.
Keyword(s): fluid extraction, hydrology

Poland, J. F., G. H. Davis. Land Subsidence Due to Withdrawal of Fluids. IN: Reviews in Engineering Geology, v. 2, 1969, D.J. Varnes and G. Kiersch, eds., Geological Society of America, p. 187-269.
Keyword(s): fluid extraction
Location(s): United States

Poland, J. F. Subsidence and its Control. IN: Underground Waste Management and Environmental Implications, T.D. Cook, ed., Memoir No. 18, 1972, American Association Petroleum Geologists, Houston, p. 50-71.
Keyword(s): fluid extraction, ground control
Location(s): United States

Poland, J. F., B. E. Lofgren, F. S. Riley. Glossary of Selected Terms Useful in the Studies of the Mechanics of Aquifer Systems and Land Subsidence Due to Fluid Withdrawal. U.S. Department Interior, Geological Survey, Water-Supply Paper 2025, 1972, 9 p.
Keyword(s): fluid extraction
Location(s): United States

Poland, J. F., B. E. Lofgren, R. L. Ireland, R. G. Pugh. Land Subsidence in the San Joaquin Valley, California, as of 1972. Professional Paper 437-H, USGS, 1975.
Keyword(s): surface subsidence damage, fluid extraction
Location(s): California, United States

Poland, J. F. Land Subsidence Stopped by Artesian-Head Recovery, Santa Clara Valley, California. IN: Proceedings, 2nd International Symposium on Land Subsidence, Anaheim, CA, IAHS-AIHS Publication No. 121, December, 1976, p. 124-132.
Keyword(s): fluid extraction
Location(s): California, United States

Poland, J. F., ed. Guidebook to Studies of Land Subsidence Due to Groundwater Withdrawal. Studies and Reports in Hydrology, IAHS-UNESCO, 40, 1984, 323 p.
Keyword(s): fluid extraction, hydrology

Poole, G., J. T. Whetton. Stowage of the Goaf. Transactions, Institute of Mining Engineers, v. 82, 1931, p. 514 (abstract).
Keyword(s): stowing, mine waste
Location(s): England

Popovich, J. M., R. F. J. Adam, A. J. Miscoe, G. R. Desko. Returning Coal Waste Underground. IN: Proceedings, International Congress on Technology & Technology Exchange: Technology & the World Around Us, Pittsburgh, PA, October 8-10, 1984. International Technology Institute, Pittsburgh, p. 140-141.
The authors describe a backfilling system developed to hydraulically transport and dispose of preparation plant refuse into an underground mine section at a coal mine complex in southwestern Virginia. This design is adaptable to other mines with minor site-specific variations. Underground disposal will eliminate surface disposal sites with

their safety and health risks, and will reduce surface subsidence, increase pillar stability, and improve water quality. However, groundwater may still be affected, and this is a major concern. Because the drainage water is collected and recycled, no detrimental effect on groundwater is anticipated.

Keyword(s): hydraulic backfilling, mine waste, pillar strength, economics, coal mining

Location(s): Virginia, Appalachian Coal Region, United States

Popp, J. T. Surface Subsidence Due to Coal Mining in the Greater Egypt Region of Southern Illinois. Geological Society of America, North Central Section, Abstracts with Programs, v. 9, 1977, p. 642-643.

Keyword(s): surface subsidence damage, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Potash Company of America, Division of Rio Algom Ltd. The Study and Predictive Modelling of Subsidence Induced by Potash Mining. Canada/New Brunswick Mineral Development Agreement, contract number 23440-8-9083/01-SQ, July 13, 1990, 125 p. (NTIS MIC-91-00377)

The Potash Company of America mines potash and rock salt from an evaporite structure to the east of Sussex in southern New Brunswick. Mining of the potash is by a continuous cut-and-fill method, while the rock salt is mined using a room-and-pillar method. The mining operation takes place under the Trans Canada Highway as well as the low-lying Kennebecasis River valley. A preliminary finite element analysis was carried out and a high quality geodetic monitoring network was established to precisely determine ground surface movements caused by the mining activity. Surveys of various types were carried out over 2 years. This work will form the basis for a case history of surface subsidence induced by mining a complex evaporite body and will act as the first stage in the development of a predictive subsidence model.

Keyword(s): non-metal mining, finite element, monitoring methods, survey methods, instrumentation, modeling, prediction, roads, surface water

Location(s): Canada

Pothini, B. R. Finite Element Elastic Model Analyses of Mine Subsidence. M.S. Thesis, Pennsylvania State University, University Park, 1969, 119 p.

Keyword(s): finite element, modeling, elastic model

Pottgens, J. J. E. Ground Movements by Coal Mining in the Netherlands. IN: Evaluation and Prediction of Subsidence, Proceedings International Conference, Pensacola Beach, FL, January 15-20, 1978, S.K. Saxena, ed., ASCE, New York, 1979, p. 267-282.

This paper discusses the Dutch coal-mining area, ground movement components, and prediction of subsidence by the integration net method (an empirical method).

Keyword(s): surface subsidence damage, surface structural damage, angle of draw, coal mining, prediction, empirical model, time factor

Location(s): Netherlands

Pottgens, J. J. E. Ground Movements Caused by Mining Activities in the Netherlands. IN: Land Subsidence, Proceedings 3rd International Symposium, Venice, Italy, March 19-25, 1984, A.I. Johnson, L. Carbognin, L. Ubertini, eds., International Association of Hydrological Sciences Publication No. 151, 1986, p. 651-659.

The mining activities in the Netherlands consist of coal mining from the beginning of this century to the mid-1970s. Presently, oil and gas on- and off-shore production takes place, particularly from one major gas reservoir. Subsidence results from the interaction between the compacting reservoir and its visco-elastic surroundings. This displacement interaction can be calculated for a disc-shaped reservoir using the theory of poro-elasticity. An outline is given of the subsidence due to coal mining in the past.

Keyword(s): coal mining, oil extraction, subsurface water, historical, abandoned mines, prediction, modeling

Location(s): Netherlands

Potts, E.L.J. Underground and Surface Strata Movements in Mining Areas. Colliery Guardian, v. 179, October 1949, p. 425-430.

Keyword(s): subsurface subsidence damage, surface subsidence damage

Potts, E.L.J. Ground Subsidence From Mining. Engineering, London, v. 168, 1949, p. 321-324.

Keyword(s): surface subsidence damage

Potts, E.L.J. The Influence of Time-Dependent Effects on the Design of Mine Pillars. IN: Proceedings, International Bureau of Rock Mechanics 6th International Meeting, 1964.

Keyword(s): time factor, mine design, pillar strength, rock mechanics

Potts, E.L.J. Current Investigations in Rock Mechanics and Strata Control. IN: Proceedings 4th International Conference on Strata Control and Rock Mechanics, May 4-8, 1964, Henry Krumb School of Mines, Columbia University, New York, 1965, p. 29-45.

The author describes trends in ground control and rock mechanics, especially with the use of rapidly advancing faces in longwall mining. The growth of rock mechanics research is of primary importance to the mining engineer.

Keyword(s): ground control, rock mechanics, mine design, mine operation, longwall

Location(s): England

Potts, E.L.J., W. H. Potts, A. Szeki. Development of Ground Control Techniques and Mining Design Parameters in Rock-Salt Mining. IN: Proceedings, 5th International Strata Control Conference, London, 1972, Paper No. 26, 8 p.

Keyword(s): ground control, non-metal mining, mine design

Potts, E.L.J. Mining Subsidence and the Environment. IN: Proceedings, International Symposium on Mining and the Environment, London, June 4-7, 1974, Institute of Mining and Metallurgy, London, 1975, p. 661-683.

Keyword(s): environment

Powell, L., R. Yarbrough, L. Harp. Planning for Subsidence at Rend Lake, Illinois. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 158-166.

High extraction mining is approaching low-lying environmentally sensitive and high public use areas on the east edge of Rend Lake. Advanced planning is required to maximize coal extraction and minimize the potential for adverse effects from subsidence on current and future land use. Premining assessment of the potential effects of subsidence on wildlife habitats, drainage, and structures is helping to develop mining plans that meet mining and environmental regulations and ensuring the continued surface land use of the areas with minimum amount of disruption.

Keyword(s): land-use planning, active mines, coal mining, environment, surface water, mine design, government, law, longwall, subsidence research, wildlife

Location(s): Illinois, Illinois Coal Basin, United States

Powell, L. R. Longwall Subsidence Case History Number 1. Northern Appalachian Coal Region. U.S. Bureau of Mines OFR 124(1)-81, v. 1, 1981, 12 p.

Keyword(s): longwall, coal mining

Location(s): Appalachian Coal Region, United States

Powell, L. R. Longwall Subsidence Case History Number 2. Northern Appalachian Coal Region. U.S. Bureau of Mines OFR 124(2)-81, v. 2, 1981, 10 p.

Keyword(s): longwall, coal mining

Location(s): Appalachian Coal Region, United States

Powell, L. R. Longwall Subsidence Case History Numbers 3 and 4. Northern Appalachian Coal Region. U.S. Bureau of Mines OFR 145-81, 1981, 17 p.

Keyword(s): longwall, coal mining

Location(s): Appalachian Coal Region, United States

Powell, L. R. Longwall Subsidence Case History Number 1. Northern Appalachian Coal Region. Technical Progress Report, U.S. Bureau of Mines, 1985.

Keyword(s): longwall, coal mining

Location(s): Appalachian Coal Region, United States

Powell, L. R. Longwall Subsidence Case History Number 2, Northern Appalachian Coal Region. Technical Progress Report, U.S. Bureau of Mines, 1985.

Keyword(s): longwall, coal mining

Location(s): Appalachian Coal Region, United States

Powell, L. R., P. B. DuMontelle. The Illinois-Bureau of Mines Cooperative Mine Subsidence Research Program. IN: Proceedings, 2nd Conference on Ground Control Problems in the Illinois Coal Basin, May 29-31, 1985, Y.P. Chugh, ed., Southern Illinois University, Carbondale, v. 2, p. 13-17.

The USBM and the State of Illinois have periodically cooperated on mine subsidence research since 1911. In 1985 Congress provided research funds to the Bureau for a study of Illinois subsidence problems with matching funds to be provided from non-federal state sources. The Bureau and the State of Illinois are cooperating to develop guidelines for underground mining methods to maximize coal recovery, minimize the surface effects of subsidence, and maximize mine stability. This paper highlights past and present subsidence research projects within Illinois.

Keyword(s): subsidence research, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Powell, L. R., T. L. Triplett, R. E. Yarbrough. Measurement and Analysis of Foundation Tilt Resulting From Mine Subsidence in Southern Illinois. IN: Proceedings, 2nd Workshop on Surface Subsidence due to Underground Mining, Morgantown, WV, June 9-11, 1986, S.S. Peng, ed., West Virginia University, p. 142-152.

The USBM, in cooperation with the Illinois Mine Subsidence Insurance Fund, is monitoring the response of two foundations to ground movements induced by subsidence from high-extraction mining in southern Illinois. The objectives of the monitoring program are to study the interaction between the ground surface and a foundation during a subsidence event and to determine the capability of the tiltmeter to detect and monitor subsidence movements.

Keyword(s): insurance, foundations, monitoring methods, monitoring equipment, vertical displacement, survey methods, coal mining, active mines, instrumentation, high-extraction retreat

Location(s): Illinois, Illinois Coal Basin, United States

Powell, L. R., R. Yarbrough. Analysis of Level Survey Data Over Mine Subsidence Events in Illinois, USA--Abandoned and Active Mines. IN: Proceedings, International Symposium on Deformation Measurement Analysis and Prediction, June 6-9, 1988, University of New Brunswick, Fredericton, p. 430-439.

The major technique for monitoring ground movements caused by active and abandoned mines in Illinois is by level survey. This technique is used to monitor the growth and duration of mine subsidence events to determine when structural repairs can safely begin. Because surveying is costly over long periods of time, several alternative, less costly monitoring techniques are under investigation by the USBM in conjunction with the Illinois Mine Subsidence Insurance Fund (IMSIF). New survey guidelines adopted by the IMSIF and procedures for monitoring subsidence events in urban areas of Illinois are presented. Three case histories, including both abandoned and active mines, are discussed to illustrate the suggested survey guidelines and monitoring methods.

Keyword(s): insurance, monitoring equipment, survey data processing, abandoned mines, active mines, coal mining, computer, modeling, prediction, instrumentation, monitoring methods, surface structural damage, foundations, high-extraction retreat, room-and-pillar, horizontal displacement, vertical displacement

Location(s): Illinois, Illinois Coal Basin, United States

Powell, L. R., T. L. Triplett, R. E. Yarbrough. Foundation Response to High-Extraction Mining in Southern Illinois. U.S. Bureau of Mines RI 9187, 1988, 54 p.

The USBM, in cooperation with the Illinois Mine Subsidence Insurance Fund, instrumented and monitored the response of two foundations to ground movements induced by subsidence from high-extraction retreat mining in southern Illinois. The objective was to study the interaction between the ground surface and a foundation during a subsidence event to enhance the understanding of the mechanisms that produce subsidence effects in structures. This study measured the response of two differently constructed foundations to subsidence, evaluated the capability of the instrumentation and monitoring program to detect and track foundation and ground movements, and provided data for developing mitigative techniques to reduce foundation damage and formulate economic repair strategies. The instrumentation and monitoring plan successfully measured the response of the foundations to the ground movements.

Keyword(s): foundations, high-extraction retreat, instrumentation, monitoring methods, monitoring design, structural mitigation, construction, monitoring equipment, vertical displacement, horizontal displacement, insurance, partial extraction, surface structural damage

Location(s): Illinois, Illinois Coal Basin, United States

Powell, L. R., R. E. Yarbrough. Monitoring Subsidence-Induced Structural Movements Over Abandoned Coal Mines in Illinois. IN: Proceedings, Symposium on Evolution of Abandoned Mine Land Technologies, Riverton, WY, June 14-16, 1989, p. 56-78.

The USBM and the Illinois Mine Subsidence Insurance Fund (IMSIF) have cooperated since the early 1980s in instrumenting, monitoring, and analyzing subsidence-induced ground movements in Illinois. The major objective has been to understand, describe, and analyze the response of surface structures to ground movements. The coal mining industry and IMSIF are both responsible for repairing structures that have been affected by mine subsidence in Illinois. Industry is responsible for active mines and mines over which they do not own a subsidence waiver.

Keyword(s): active mines, abandoned mines, coal mining, surface structural damage, monitoring methods, monitoring equipment, monitoring design, instrumentation, foundations, insurance, survey methods, survey data processing, high-extraction retreat, vertical displacement, horizontal displacement, structural mitigation

Location(s): Illinois, Illinois Coal Basin, United States

Powell, W. J., P. E. LaMoreaux. A Problem of Subsidence in a Limestone Terrain at Columbiana, Alabama. U.S. Geological Survey, Water Resources Division, and Geological Survey of Alabama, Circular 56, 1969.

Subsidence problems in a karst area are aggravated by groundwater withdrawal from deep wells.

Keyword(s): fluid extraction, subsurface water, geologic features, land-use planning, hydrology

Location(s): Alabama, United States

Pratt, W. E., D. W. Johnson. Local Subsidence of the Goose Creek Oil Field (Texas.) Journal of Geology, v. 34, 1926, p. 577-590.

Keyword(s): oil extraction

Location(s): Texas, United States

Preece, D. S., W. R. Wawersik. Leached Salt Cavern Design Using a Fracture Criterion for Rock Salt. IN: Proceedings, 25th U.S. Symposium on Rock Mechanics, Northwestern University, June, 1984.

Keyword(s): rock mechanics, non-metal mining, mine design

Location(s): United States

Price, D. G., A. B. Malkin, J. L. Knill. Foundations of Multi-Story Blocks On the Coal Measures with Special Reference to Old Mine Workings. Quarterly Journal Engineering Geology, v. 1, no. 4, 1969, p. 271-322.

Foundation investigations for undermined apartment sites are discussed. This article considers various corrective measures that have arrested subsidence.

Keyword(s): abandoned mines, foundations, engineering, construction, surface structural damage, backfilling, overburden, coal mining

Price, N. J. The Compressive Strength of Coal Measure Rocks. Colliery Engineering, v. 37, 1960, p. 283-292.

Keyword(s): rock mechanics, lab testing, coal mining, overburden

Prickett, T. A. Geohydrologic Data Review and Pumping Test Possibilities--70th Street and Canterbury Mine Areas, Belleville, Illinois. Report to Illinois State Geological Survey, April 2, 1979, by Camp, Dresser & McKee, Champaign, IL.

This is a letter-type report on the findings and possibilities of pump testing the mines in question to determine void volumes for backfilling purposes.

Keyword(s): hydraulic backfilling, abandoned mines, coal mining, surface structural damage

Location(s): Illinois, Illinois Coal Basin, United States

Priest, A. V., R. J. Orchard. Recent Subsidence Research in the Nottinghamshire and Derbyshire Coalfield. Colliery Guardian, July 4, 1957, p. 4-10.

Routine observation of ground movement due to mining operations was begun in the area of the southwestern extremity of the North Derbyshire and Nottinghamshire coalfield. The seams are relatively shallow, especially in the south and west, where working is carried on near the outcrop to within 50 yards of the surface.

Keyword(s): coal mining, monitoring methods, monitoring equipment, survey methods, survey equipment, pipelines, surface structural damage, architecture, subsidence research

Location(s): United Kingdom

Priest, A. V., R. J. Orchard. Recent Subsidence Research in the Nottinghamshire and Derbyshire Coalfield. Transactions, Institute of Mining Engineers, London, v. 117, 1957-58, p. 499-512.

This paper describes monitoring of vertical and horizontal subsidence displacements such that steps could be taken to prevent or reduce structural damage to existing pipelines and buildings in the Nottinghamshire and Derbyshire coalfield, England.

Keyword(s): surface structural damage, subsurface structural damage, mine design,

monitoring design, utilities, monitoring methods, monitoring equipment, pipelines, survey methods, subsidence research, survey equipment, coal mining
Location(s): England

Prokopovich, N. P. Land Subsidence Along Delta-Mendota Canal, California. Rock Mechanics, v. 1/2-3, 1969, p. 134-144.

This subsidence was caused essentially by an irrigation overdraft of the confined groundwater. Due to the overdraft from 1905 to 1953, decline of piezometric levels along the alinement varied from 90 to 200 feet. With canal water delivery in 1951 to 1953, the overdraft virtually ceased. Subsidence at the time was, therefore, a progressively diminishing "lag" inherited from past overdraft. Active subsidence in neighboring areas may also have affected the canal.

Keyword(s): subsurface water, fluid extraction, hydrology, surface structural damage, engineering, agriculture, surface water
Location(s): California, United States

Prokopovich, N. P. Prediction of Future Subsidence Along Delta-Mendota and San Luis Canals, Western San Joaquin Valley, California. IN: Proceedings, Association Internationale d'Hydrologie Scientifique, Tokyo, September 1969, p. 600-610 (in English).

About 120 miles of the Delta-Mendota and San Luis Canals, constructed by the Bureau of Reclamation, have been affected by subsidence caused by overdraft of ground water. Estimates of ultimate future subsidence, varying from traces to 3.6 feet, were derived from bench mark data treated as an exponential decay function.

Keyword(s): subsurface water, fluid extraction, hydrology, surface structural damage, engineering, agriculture, surface water, prediction
Location(s): California, United States

Prokopovich, N. P. Land Subsidence and Population Growth. IN: Proceedings, 24th International Geologic Congress, 13, 1972, p. 44-54.

Keyword(s): fluid extraction, land-use planning

Prokopovich, N. P., M. J. Marriott. Cost of Subsidence to the Central Valley Project, California. Bulletin Association Engineering Geologists 20, 1983, p. 325-332.

Keyword(s): economics, fluid extraction
Location(s): California, United States

Prokopovich, N. P. Classification of Land Subsidence by Origin. IN: Land Subsidence, Proceedings 3rd International Symposium, Venice, Italy, March 19-25, 1984, A.I. Johnson, L. Carbognin, and L. Ubertini, eds., International Association Hydrological Sciences Publication No. 151, 1986, p. 281-290.

Data collected during the last decades allow classification of subsidence into two groups: endogenic, caused by processes originating within the planet; and exogenic, caused by processes originating near the surface. Exogenic subsidence can be subdivided into subsidence caused by removal or weakening of support and subsidence caused by an increase in actual or effective loading.

Keyword(s): fluid extraction, geologic features

Prokopovich, N. P. Economic Impact of Subsidence on Water Conveyance in California's San Joaquin Valley, USA. IN: Land Subsidence, Proceedings 3rd International Symposium, Venice, Italy, March 19-25, 1984, A.I. Johnson, L. Carbognin, and L. Ubertini, eds., International Association of Hydrological Sciences Publication 151, 1986, p. 795-804.

Agriculture in the arid San Joaquin Valley depends on irrigation. Depletion of aquifers prior to surface water delivery by the Central Valley Project caused subsidence, locally up to 8 to 9 meters. Subsidence-related rehabilitation of old canals and design modification of new ones cost $67 million. Surface water importation is achieved by pump lifting water from the Sacramento-San Joaquin Delta. The Delta was a tidal marsh with thick peat deposits. Oxidation of peat in the reclaimed delta caused locally more than 6.5 meters of subsidence, resulting in numerous floods and repairs.

Keyword(s): hydrology, economics, utilities, fluid extraction, agriculture
Location(s): California, United States

Propokovich, N. P. Land Subsidence Terminological Confusion. Bulletin Association of Engineering Geologists 22, 1985, p. 106-108.

Keyword(s): fluid extraction

Proust, A. Etude Sur Les Affaissements Miniers Dans Le Rassin Du Nord Et Due Pas-De-Calais (Study of Mine Subsidence in Nord and Pas-De-Calais Coal Fields). Revue de l'Industrie Minerale, v. 46, no. 6, 1964, p. 513-516; v. 46, no. 7, 1964, p. 547-581.

Keyword(s): coal mining, subsidence research
Location(s): France

Pryke, J.F.S. Eliminating the Effects of Subsidence. Colliery Engineering, December, 1954.

The author discusses methods of correcting subsidence effects on the surface in relation to structures.

Keyword(s): structural mitigation, surface structural damage

Pryke, J.F.S. Underpinning and Jacking Buildings Affected by Mining Subsidence or Other Differential Foundation Movement. Royal Institute Chartered Surveyors, 1960.

Keyword(s): structural mitigation, surface structural damage, foundations

Location(s): England

Public Record Corporation (Denver, CO) The Code of Colorado Regulations. 2 CCR 407-2, 1980, p. 91-96, 285-288.

Pertinent sections deal with the responsibilities of the mine operator in regard to subsidence due to underground mining in Colorado.

Keyword(s): law, mine operation, government

Location(s): Colorado, Rocky Mountain Coal Region, United States

Pula, O., Y. P. Chugh, W. M. Pytel. Estimation of Weak Floor Strata Properties and Related Safety Factors for Design of Coal Mine Layouts. IN: Rock Mechanics Contributions and Challenges, Proceedings of the 31st U.S. Rock Mechanics Symposium, Golden, CO, June 18-20, 1990, W.A. Hustrulid and G.A. Johnson, eds., Balkema, Rotterdam, p. 93-100.

This paper presents regression equations for the estimation of weak floor strata properties from engineering index properties that can be used for the design of coal pillars. It also illustrates the application of probability concepts for the design of single pillars. The analysis indicates that significantly higher extraction ratios may be achieved by using more reliable data in mine design. The authors plan to extend these analyses to the design of coal pillars in a panel with consideration of roof-pillar-floor interaction.

Keyword(s): coal mining, floor stability, in situ testing, lab testing, rock mechanics, geotechnical, pillar strength

Location(s): Illinois, Illinois Coal Basin, United States

Pula, O., Y. P. Chugh, W. M. Pytel. Estimation of Weak Floor Strata Properties and Related Safety Factors for Design of Coal Mine Layouts. IN: Mine Subsidence - Prediction and Control, National Symposium, 33rd Annual Meeting, Association of Engineering Geologists, October 2-3, 1990, C.D. Elifrits, ed., Pittsburgh, PA, p. 91-103.

The authors present modified statistical correlations for estimation of representative ultimate bearing capacity (UCB) and deformability modulus (DM) for weak floor strata based on data from six mines in Illinois. Based on dispersion characteristics of the data in statistical analysis, the authors also present concepts to develop appropriate safety factors based on reliability concepts developed for structural engineering.

Keyword(s): floor stability, geotechnical, mine design, partial extraction, pillar strength, geologic features, lab testing, in situ testing

Location(s): Illinois, Illinois Coal Basin, United States

Pytel, W., Y. P. Chugh, B. Zabel, R. D. Caudle. A Simplified Two-Dimensional Analysis of the Roof-Pillar-Floor Interaction Problem in Coal Mines. IN: Proceedings, 7th International Conference in Ground Control in Mining, August, 1988, S.S. Peng, ed., Morgantown, WV, p. 271-281.

A two-dimensional, time-dependent analysis of an overburden-pillar-weak floor strata interaction problem is presented as a beam model consisting of a composite roof beam resting on multiple elastic foundations (pillars) underlain by a composite rock mass representing immediate floor strata. Several different material models may be considered for the immediate floor strata. The analysis can include all openings and pillars in a panel and permits bed separations in the roof composite beam. The model has enabled identification of the relative significance of different geometric and mechanical behavior parameters governing the system. The paper presents the theoretical background for the model as well as its application to a mine in Illinois where surface and underground geotechnical observations were conducted.

Keyword(s): modeling, overburden, coal mining, floor stability, prediction, instrumentation

Location(s): Illinois, Illinois Coal Basin, United States

Pytel, W. M., Y. P. Chugh. An Analysis of Roof-Pillar-Weak Floor Interaction in Partial Extraction Room-and-Pillar Mining. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 621-628.

The applicability of the beam theory in analysis of roof-pillar-weak floor interaction in partial extraction room-and-pillar mining is presented. The mine structure is modeled as an equivalent multi-indeterminate overburden elastic beam supported by elasto-plastic pillars resting on a viscoelastic layer of immediate weak floor strata underlain by a competent rock mass. The developed analytical model was initially used to conduct sensitivity analyses of different variables affecting the mining system, such as the deformability of coal and weak floor strata, thickness of weak floor strata, number of pillars in a panel, width of pillars, and width of panel. These analyses were then extended to three overburden strata - coal pillar - floor strata lithologies typical of active coal mining areas in Illinois.

Keyword(s): partial extraction, room-and-pillar, coal mining, modeling, overburden, floor stability, pillar strength, active mines

Location(s): Illinois, Illinois Coal Basin, United States

Pytel, W. M., Y. P. Chugh, O. Pula. An Approach for Design of Coal Pillars in Partial Extraction Coal Mining Panels With a Consideration of Roof-Pillar-Floor Interaction. IN: Rock Mechanics Contributions and Challenges, Proceedings of the 31st U.S. Rock Mechanics Symposium, Golden, CO, June 18-20, 1990, W.A. Hustrulid and G.A. Johnson, eds., Balkema, Rotterdam, p. 101-108.

This paper presents an approach for design of coal pillars in a panel with a consideration of roof-pillar-floor interaction. The main goal of this analysis is to design mine layouts that would maximize coal recovery in different sections of the panel while maintaining pillar, floor, and roof stability. Overriding considerations may include factors such as equipment size and panel geometry.

Keyword(s): room-and-pillar, partial extraction, coal mining, floor stability, pillar strength, modeling, roof stability, computer

Location(s): Illinois, Illinois Coal Basin, United States

Pytel, W. M., Y. P. Chugh. Simplified Three-Dimensional Roof-Pillar-Floor Interaction Analysis Including Time Effect. IN: Rock Mechanics as a Multidisciplinary Science, Proceedings 32nd U.S. Symposium, The University of Oklahoma, Norman, July 10-12, 1992, J.-C. Roegiers, ed., Balkema, Rotterdam, p. 781-790.

A simplified three-dimensional roof-pillar-floor interaction analysis model, based on the theory of thin plates on inelastic foundations has been developed. The mine structure is modeled as an equivalent indeterminate plate resting on multiple deformable foundation elements transmitting the load to the weak floor strata. The problem solution is based on the finite difference method, which permits one to relate the actual mining progress with equivalent time-dependent overburden/floor deformability, using an incremental advance approach, including all mined-out areas, with suitable time, or time differences of extraction.

Keyword(s): modeling, floor stability, time factor, room-and-pillar, lab testing, in situ testing, overburden

Location(s): Illinois, Illinois Coal Basin, United States

Pytel, W. M., Y. P. Chugh. Subsidence Prediction in Longwall Mining Using a Beam Theory Based Simplified Analytical Model. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 66-75.

A simplified two-dimensional model to analyze time-dependent load distribution and surface subsidence associated with longwall mining geometries is described. The model is based on the theory of beams resting on inelastic foundations and includes visco-elastic behavior of coal pillars, elastic behavior of face supports, and visco-elastic behavior of the overburden strata. The relative importance of the different variables affecting the performance of longwall mining geometries from a ground control point of view is also analyzed. The model has been validated for field observations from one Illinois longwall mine.

Keyword(s): modeling, longwall, active mines, elastic model, overburden, ground control, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Pytlarz, T., K. Trojanowski. Subsidence Calculation With an Arbitrary Shape of the Exploitation Area by the Segment Network Method on Basis of S. Knothe's Theory. 1974, 52 p. (NTIS TT 74-54011)

This report details calculation of surface subsidence using Knothe's theory of the exploitation effect on the ground surface for the case of a spatial problem with an arbitrary shape of the given exploitation area.

Keyword(s): vertical displacement, horizontal displacement, prediction theories, empirical model, profile function, prediction

Qian, M-G., G-J. Zhao. The Behaviour of the Main Roof Fracture in Longwall Mining and its Effect on Roof Pressure. IN: Rock Mechanics, Proceedings of the 28th U.S. Symposium, Tucson, AZ, June 29-July 1, 1987, I.W. Farmer, et al., eds., Balkema, Rotterdam, p. 1123-1128.

This paper explains a model as a semi-infinite long beam to be clamped on a Winkler elastic foundation.

Keyword(s): modeling, roof stability, longwall, coal mining

Location(s): China

Quan, C. K. Overview of the Bureau of Mines Subsidence Research Program. SME-AIME Annual Meeting, New Orleans, LA, February 18-22, 1979, SME-AIME Preprint 79-84, 1979, 9 p.

The state of the art in subsidence prediction, control, and prevention and in subsidence-related damage abatement has not progressed in the United States to the level achieved in other countries. To bridge this gap, the USBM is pursuing a comprehensive subsidence investigation, specifically designed to address major problems on the local, regional, and national level.

Keyword(s): prediction, economics, structural mitigation, land mitigation, ground control, subsidence research

Location(s): United States

Rad, P. F. Mechanical Properties and Cutting Characteristics of Coal. U.S. Bureau of Mines IC 8584, 1973, p. 1-46.
Keyword(s): rock mechanics, coal mining, lab testing, pillar strength
Location(s): United States

Radcliffe, D. E., R. M. Stateham. Effects of Time Between Exposure and Support on Mine Roof Stability, Bear Coal Mine, Somerset, Colo. U.S. Bureau of Mines RI 8298, 1978, 13 p.
Keyword(s): roof support, roof stability, coal mining, mine operation
Location(s): Colorado, Rocky Mountain Coal Region, United States

Railway Gazette. Trackside Foundations in Subsidence Areas. April 3, 1959, p. 390-391.
This paper discusses the construction of concrete rafts to carry steel structures for overhead electrification.
Keyword(s): railroads, foundations, utilities

Ramani, R. V., C. B. Manula. A Master Environmental Control and Mine System Design Simulator for Underground Coal Mining. Volume I. Executive Summary. Grant GO111808, Pennsylvania State University, U.S. Bureau of Mines OFR 84(1)-76, 1975, 31 p. (NTIS PB 255 421)
Keyword(s): mine design, environment, modeling, coal mining
Location(s): United States

Ramani, R. V., ed. Longwall-Shortwall Mining, State-of-the-Art. AIME, New York, 1981, 296 p.
Keyword(s): longwall, environment, mine design, shortwall, surface subsidence damage, coal mining
Location(s): United States, Europe, Ohio, Appalachian Coal Region, Pennsylvania, Alabama, New Mexico, Illinois, Canada, United Kingdom

Ramsay, R. Discussion on Deep, Long-Wall Workings. Journal of the Illinois Mining Institute, v. 1. no. 3, 1892, p. 227-231.
Keyword(s): longwall, coal mining, geologic features, historical
Location(s): Illinois, Illinois Coal Basin, United States

Randolph, B. S. The Theory of the Arch in Mining. Colliery Engineering, v. 35, March, 1915, p. 427-429.
Keyword(s): roof stability
Location(s): England

Rankilor, P. R. An Approach to the Simulation of Mining Subsidence Phenomena in an Elastic Layered Model. Quarterly Journal of Engineering Geology, v. 3, December, 1970, p. 55-63.
The author comments on the background to model analysis of mining problems, and describes the use of urethane rubber in the construction of a layered model simulating strata over mine workings. In this paper, the author describes angles of draw below 35 degrees and also describes the subsidence development profile of the model in relation to those observed for some European mining. Possible future applications for this type of model work are suggested.
Keyword(s): phenomenological model, elastic model, modeling, overburden, angle of draw, prediction
Location(s): Europe

Rankilor, P. R. The Construction of a Photoelastic Model Simulating Mining Subsidence Phenomena. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 8, no. 5, September, 1971, p. 433-444.
The author has adopted the use of a soft, photoelastic polyurethane rubber to construct a two-dimensional model section through the earth's strata in to simulate mining extraction with its consequent surface subsidence phenomena. The model is used to make in initial assessment of the effect on subsidence of varying panel-to-pillar width ratios in a partial-extraction system. From photoelastic observations on the model, the author demonstrates the formation of an inverted "wedge" over the mine workings, instead of the classical "arch" so frequently postulated in mining papers.
Keyword(s): modeling, phenomenological model, elastic model, rock mechanics, pillar extraction, partial extraction

Rankilor, P. R. Engineering Geology and Mining. Ground Engineering, v. 9, no. 7, October, 1976, p. 22-26.
Keyword(s): engineering

Ratigan, J. L. User Information Manual. SUBSID: A Nonlinear, Two-Dimensional Finite Element Program for Static Evaluation of Mining Subsidence. Lawrence Berkeley Laboratory, University of California, June 1980, 74 p. (NTIS LBL-113 56)

Keyword(s): finite element, modeling, computer
Location(s): United States

Ratigan, J. L., R. E. Goodman. Modeling of Static Subsidence in a Nonlinear Medium. Lawrence Berkeley Laboratory, University of California, December 1980, 17 p. (NTIS LBL-11896)
Keyword(s): modeling
Location(s): United States

Ratigan, J. L., T. J. Vogt. Technical Note: A Note on the Use of Precision Level Surveys to Determine Subsidence Rates. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 28, no. 4, 1991, p. 337-341.
The purpose of this paper is to present an algorithm for reducing level survey data to subsidence rates. The algorithm accounts for ground movement taking place during the level surveys. Two level surveys at a specific site are analyzed with the new algorithm as well as with an algorithm that neglects the ground movement during the level surveys. The resulting subsidence rates for the two algorithms are compared and errors are discussed.
Keyword(s): survey data processing, survey methods, vertical displacement

Rau, J. L., P. Nutalaya, M. Boonsener. Subsidence and Chloride Contamination at Nong Bo Reservoir, Northeast Thailand. Geotechnical Engineering, 13, 1982, p. 51-72.
Keyword(s): surface water
Location(s): Thailand

Rauch, H. W. A Summary of Ground Water Impacts from Underground Mine Subsidence in the North Central Appalachians. IN: Proceedings Special Institute on Coal Mine Subsidence in Pittsburgh, Eastern Mineral Law Foundation, Morgantown, WV, 1989, p. 2.01-2.31.
Keyword(s): subsurface water, surface water, hydrology, coal mining, longwall
Location(s): Appalachian Coal Region, United States

Rayburn, J. M. Subsidence in Thick Freeport Coal. Transactions AIME, Coal Division, v. 88, 1930, p. 144-150.
Survey lines were established parallel and perpendicular to the line of pillar extraction in an attempt to determine the shape of the traveling subsidence trough.
Keyword(s): pillar extraction, angle of draw, survey design, survey methods, coal mining
Location(s): Pennsylvania, Appalachian Coal Region, United States

Read, T. T. Lake Superior Copper Mining: Present and Future II. Mining and Scientific Press, v. 140, 1915, p. 215.
Stamps sands were used for backfilling and for subsidence prevention.
Keyword(s): backfilling, metal mining, ground control
Location(s): United States

Reddish, D. J. Study of Ground Strain in Relation to Mining Subsidence. Ph.D. Thesis, 1984, University of Nottingham, U.K.
Keyword(s): horizontal displacement, coal mining
Location(s): United Kingdom

Reed, J. J. Mine-Opening Stabilization by Stress Redistribution. Colorado School of Mines Quarterly, v. 51, no. 3, July, 1956.
Keyword(s): rock mechanics, mine design
Location(s): United States

Reed, J. J. Case History in Pillar Recovery. Transactions, AIME (Mining Engineering), v. 11, July, 1959, p. 701-705.
Keyword(s): pillar extraction
Location(s): United States

Rees, D. W. Subsidence in Anthracite Areas. Colliery Guardian, v. 74, no. 3234, December 22, 1922.
This paper describes subsidence observations in the anthracite area, where one seam is worked at a moderate depth, the floor is hard and no heaving takes place, and the coal serves as a true boundary because of its resistant nature.
Keyword(s): anthracite, coal mining, roof support, floor stability, angle of draw

Reeves, A. Legal Aspects of Development in Coal Mining Areas: The National Coal Board Involvement. IN: Mineworkings 84: Proceedings International Conference on Construction in Areas of Abandoned Mineworkings, Edinburgh, 1984, M.C. Forde, B.H.V. Topping, and H.W. Whittington, eds., Engineering Technics Press, p. 189-195.
Keyword(s): law, coal mining, land-use planning, National Coal Board
Location(s): United Kingdom

Reifsnyder, R. H., J. F. Peters. Sodium Silicate Grouts: The Solution to Difficult Subsidence Problems. IN: Proceedings Symposium on Evolution of Abandoned Mine Land Technologies, Riverton, WY, June 14-16, 1989, p. 329-335.

A new cement grouting technique is now available for use for a wide variety of grouting applications. This process not only results in a superior grout in terms of strength, acid resistance, and angle of repose, but it also significantly reduces the costs associated with completing the job. Initially designed for subsidence abatement in flooded abandoned mines, it has been proven to be adaptable to a number of different end uses and sites.

Keyword(s): grouting, abandoned mines, structural mitigation, surface structural damage

Location(s): Ohio, United States

Reiss, I. H. Total Utilization of a Land Resource. Mining Congress Journal, v. 63, no. 10, 1977, p. 55-59.

This paper discusses coal as a legitimate crop in terms of a long-term land-use program, and describes grassland farming as a viable alternative to cornland. The author concludes that corn, coal, and cattle are still compatible.

Keyword(s): agriculture, reclamation, land-use planning, coal mining

Location(s): United States

Reitz, H. M., D. S. Eskridge. Construction Methods Which Recognize the Mechanics of Sinkhole Development. Hydrologic Problems in Karst Regions, 1977, R.R. Dilamarter and S.C. Casallany, eds., Western Kentucky University, p. 432-438.

Keyword(s): construction, land-use planning, geologic features

Location(s): United States

Rellensmann, O., E. Wagner. The Effect on Railways of the Ground Movements Due to Mining. IN: Proceedings, European Congress on Ground Movement, Leeds, England, April 9-12, 1957, London Harrison, p. 74-82.

This paper analyzes partial-extraction methods that can be used to minimize subsidence damage to railway lines, with discussions on the use of safety pillars and various mine designs. A short explanation of the mechanics of ground deformations is also given.

Keyword(s): mine design, railroads, partial extraction, room-and-pillar, pillar strength

Location(s): Europe

Rellensmann, O. Rock Mechanics in Regard to Static Loading Caused by Mining Excavation. Colorado School of Mines Quarterly, v. 52, no. 3, July 1957, p. 35-48.

This paper pertains to the behavior of strata overlying mined-out areas and the calculation of surface movements. The author briefly mentions the use of empirical data to predict subsidence.

Keyword(s): rock mechanics, overburden

Location(s): United States

Ren, G., D. J. Reddish, B. N. Whittaker. Mining Subsidence and Displacement Prediction Using Influence Function Methods. Mining Science and Technology, v. 5, 1987, p. 89-104.

A flexible influence function/zone area approach to subsidence and horizontal displacement prediction is described in detail, with particular emphasis being placed on the applicability of the method to computer prediction. The method is compared to the National Coal Board Subsidence Engineers' Handbook empirical model for ground movement prediction over a full panel. Examples of graphical output from the program, and comparisons to field cases and other models are provided.

Keyword(s): prediction, empirical model, influence function, profile function, stochastic model, zone area, computer, modeling, National Coal Board, horizontal displacement, longwall, active mines

Location(s): United Kingdom

Ren, G., D. J. Reddish, B. N. Whittaker. Computerised Subsidence and Displacement Prediction Using Influence Function Methods. IN: Proceedings 7th International Conference on Ground Control in Mining, Morgantown, WV, August 3-5, 1988, S.S. Peng, ed., Department of Mining Engineering, West Virginia University, Morgantown, p. 101-115.

A computerized influence function approach to subsidence and horizontal displacement prediction is described, with particular emphasis being placed on the applicability of the method to irregularly shaped mine workings. Based on previous work, this approach has been put forward for inclined seam situations. Examples are given of graphical output presenting surface subsidence contours, horizontal displacement vectors and principal strain vectors and their significance discussed in relation to current problems.

Keyword(s): computer, influence function, prediction, prediction theories, empirical model,

horizontal displacement, multiple-seam extraction, National Coal Board, stochastic model, modeling, coal mining
Location(s): United Kingdom

Ren, G., B. N. Whittaker, D. J. Reddish. Mining Subsidence and Displacement Prediction Using Influence Function Methods for Steep Seams. Mining Science and Technology, v. 8, no. 3, 1989, p. 235-252.
The prediction of subsidence and displacements arising from longwall mining of steep seams is examined. Various influence function methods and the National Coal Board Subsidence Engineers' Handbook empirical design technique are compared for different mining conditions. Comparisons are made between the methods reviewed. The results of predictions with these methods are compared with field observations.
Keyword(s): prediction, influence function, longwall, coal mining, empirical model, National Coal Board
Location(s): United Kingdom

Repa, J. V., J. W. McMullen, P. D. Smith. Conceptual Design for a Subsidence Simulator. February, 1980, 7 p. (NTIS LA-8239-MS)
Keyword(s): modeling

Research Committee of Midland County Institute of Mining Engineers. The Influence of Variation in the Nether Roof on the Incidence of Falls. Transactions Institute of Mining Engineers, v. 84, 1932-33, p. 93-110; v. 85, 1932-33, p. 27.
This report describes a series of studies made in a mine seam that, in different areas, has a roof composed of sandstone, stone bind, shale, clod, and coal.
Keyword(s): roof stability, coal mining, geologic features
Location(s): United Kingdom

Reynolds, J. F. First North American Longwall in Pitching Seams Proven Feasible. Mining Engineering, December 1983, p. 1615-1618.
Snowmass Coal Company, in cooperation with the U.S. Department of Energy, introduced the longwall mining method in pitching seams to North America. This venture is a coal mining research program directed toward the profitable production of coal under difficult mining conditions as found in pitching seams of the western United States.
Keyword(s): longwall, coal mining, active mines, mine operation
Location(s): Colorado, Rocky Mountain Coal Region, United States

Rhodes, G. W. Plate Bearing Tests on Coal Mine Underclays. M.S. Thesis, University of Missouri-Rolla, 1978.
Keyword(s): floor stability, coal mining, in situ testing

Rhodes, H., R. H. Horsley. Observations on the Working of a Seam of Coal Under a Railway Tunnel. Transactions, Institution of Mining Engineers, v. 87, 1933-34, p. 129-139.
A brick-lined railway tunnel was successfully undermined, by a 5-foot-thick seam of coal lying 613 to 701 feet below the tunnel floor. The tunnel required only minor repairs after mining.
Keyword(s): railroads, backfilling, coal mining

Ricca, V., M. Hemmerich. Underground Mine Drainage Quantity and Quality Generation Model. IN: Proceedings 1st World Congress on Water in Mines and Underground Works, SIAMOS--78, Granada, Spain, September 18-22, 1978, R. Fernandez-Rubio, ed., p. 863-882.
This computer model is capable of simulating underground mine makewater and its consequent discharge rates from adits. An additional feature is its ability to generate acid loads associated with the drainage. A hydrologic model using climatological data, watershed parameters, and mine operation information is used to calculate the amount of water passing to the geologic strata of the mine. As the water movement through the mine works is modeled, the acid generated is simulated by mathematical formulations describing the chemical productions and removal mechanisms. The component contributions are summed, with time preservation, and expressed as discharge rates and loads. The model is presented as a case study application to a coal mine in the United States.
Keyword(s): modeling, computer, subsurface water, hydrology, coal mining, environment, geologic features
Location(s): West Virginia, Appalachian Coal Region, United States

Rice, G. S. Mining-Wastes and Mining Costs in Illinois. Illinois Geological Survey Bulletin No. 14, Year-Book for 1908, H.F Bain, Director. University of Illinois, Urbana, 1909, p. 211-222.
In this chapter, the author discusses the range of coal extraction and the variation in yield from different parts of the state. The percentage of yield

varied from about 50% to 90%. Surface subsidence and its effect on agricultural land was cited as one of the reasons for decreased extraction in some areas. The author also discusses reasons why hydraulic backfilling would not be applicable in Illinois for subsidence prevention.

Keyword(s): historical, economics, hydraulic backfilling, mine waste, agriculture, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Rice, G. S. Some Problems in Ground Movement and Subsidence. Transactions AIME, v. 69, 1923, p. 374-405, 413-433.

The author discusses subsidence from mining, mechanics of ground movement, pillar extraction, and prediction methods.

Keyword(s): coal mining, metal mining, room-and-pillar, pillar extraction, longwall, angle of draw

Location(s): Illinois Coal Basin, Appalachian Coal Region, Rocky Mountain Coal Region, United States

Rice, G. S., C. Enzian. Tests of Strength of Roof Supports Used in Anthracite Mines of Pennsylvania. U.S. Bureau of Mines Bulletin 303, 1929, 44 p.

Tests of coal pillar strength and other roof supports were reviewed.

Keyword(s): roof support, anthracite, pillar strength, ground control, mine design, coal mining, lab testing, in situ testing

Location(s): Pennsylvania, Appalachian Coal Region, United States

Rice, G. S. The Question of the Angle-of-Draw. Mining & Metallurgy, v. 10, March, 1929, p. 132-133.

Keyword(s): angle of draw

Rice, G. S. Recent Researches on Ground Movement Effects in Coal Mines and on the Strength of Coal and Roof Supports. Transactions, AIME, v. 101, 1932, p. 269-293.

Keyword(s): roof stability, roof support, pillar strength, coal mining

Location(s): United States

Rice, G. S. Ground Movement from Mining in Brier Hill Mine, Norway, Michigan. Transactions, AIME, v. 109, 1934, p. 118-152.

Keyword(s): surface subsidence damage, metal mining

Location(s): Michigan, United States

Rice, G. S. Bumps in Coal Mines of the Cumberland Field, Kentucky and Virginia--Cause and Remedy. U.S. Bureau of Mines RI 3267, 1935, 36 p.

Keyword(s): ground control, room-and-pillar, mine design, bumps, coal mining

Location(s): Kentucky, Virginia, Appalachian Coal Region, United States

Rice, G. S. Bumps in Coal Mines--Theories of Causes and Suggested Means of Prevention or of Minimizing Effects. Transactions, AIME, Coal Division, v. 119, 1936, p. 11-39.

Keyword(s): ground control, room-and-pillar, floor stability, mine design, bumps, coal mining

Location(s): United States

Rice, G. S. Ground Movement and Subsidence Studies Aid in Solving Mining Problems. Mining and Metallurgy, v. 17, January, 1936, p. 15-16.

The author reviewed work by P. Bucky, Helmut Landsberg, and Ryojun College, on the strength and elastic recovery of rocks.

Keyword(s): mine design, pillar strength, room-and-pillar

Location(s): England

Rice, G. S. Ground Movement and Subsidence Studies in Mining Coal, Ores and Nonmetallic Minerals. Transactions, AIME, v. 139, 1937, p. 140-154.

Keyword(s): coal mining, metal mining, non-metal mining

Location(s): United States

Rice, G. S. Notable Studies in the Kolar Gold Field and at a Pittsburgh Coal Mine. Mining and Metallurgy, v. 19, January, 1938, p. 24-25.

This paper reviews subsidence studies in the gold fields of India, as well as those by the USBM at the Montour mine in Pittsburgh.

Keyword(s): metal mining, coal mining

Location(s): India, Pennsylvania, Appalachian Coal Region, United States

Rice, G. S., I. Hartmann. Coal Mining in Europe. A Study of Practices in Different Coal Formations and Under Various Environmental Regulatory Conditions Compared with Those in the United States. U.S. Bureau of Mines B 414, 1939, 369 p.

This report describes hydraulic, pneumatic, and mechanical backfilling; it also deals with many aspects of European mining including filling problems and procedures.

Keyword(s): environment, mine operation, law, hydraulic backfilling, pneumatic backfilling, geologic features
Location(s): United States, Europe

Rice, G. S. Ground Movement and Subsidence. Mining and Metallurgy, v. 21, January, 1940, p. 8-9.
This article is a review of subsidence investigations in 1939.
Keyword(s): backfilling
Location(s): Pennsylvania, Appalachian Coal Region, United States

Richardson, A. Mine Subsidence. Journal Chemical Metallurgy & Mining Society South Africa, v. 7, March, 1907, p. 279-288.
Location(s): South Africa

Richert, G. I. Filling Stopes with Mill Tailings. Engineering and Mining Journal, v. 127, 1929, p. 348; and U.S. Bureau of Mines IC 6145, 1929.
This report discusses increased efficiency and lowered cost involved using recycled mine waste as fill in a Cuban copper mine.
Keyword(s): backfilling, metal mining, mine waste, mine operation, economics
Location(s): Cuba

Richey, J. E. Surface Effects of Mining Subsidence. Elements of Engineering Geology, Pitman, London, 1964, Ch. 12, 137 p.
Keyword(s): surface subsidence damage

Riddle, J. M. Dealing With Subsidence and SMCRA. Mining Engineering, December 1980, v. 32, no. 12, p. 1702-1704.
The subsidence permitting process involves just one part of the mass of Surface Mining Control and Reclamation Act (SMCRA) regulations. But of the 18 main SMCRA sections, subsidence is critical to the permitting process for coal operators. Permitting is an area in which applicants have had problems interpreting regulations and preparing permit applications. SMCRA regulations apply to any coal operations "that exhibits surface effects." Thus they apply to surface strip mines as well as underground coal operations. This article discusses frequently asked questions in an attempt to help individuals trying to interpret subsidence regulations or prepare permit applications.
Keyword(s): law, reclamation, coal mining, subsurface water, surface water, surface structural damage, land-use planning, pillar strength, roof stability, land mitigation
Location(s): United States

Rightnor, T. A., J. P. McHale, C. H. Johnson, W. D. Shrader, M. D. Loy. Analysis of the Impact of Public Law 95-87 on Mining Performance. U.S. Department of Energy Contract ET-77-CO-1-8914, Skelly and Loy, 1979, 417 p. (NTIS FE 8914-3)
Keyword(s): law, mine operation, government, coal mining, economics
Location(s): United States

Rigsby, K. B. Mine Subsidence at the Kathleen Mine. IN: Proceedings, Illinois Mining Institute, Centennial Year, 1992, p. 53-59.
At the Kathleen Mine, coal is being mined by caving methods at depths as shallow as 100 to 145 feet. The amount of subsidence and the angle of draw at this mine have been less than expected for this type of mining. A railroad spur and a power line were also successfully undermined. There are four limestone members in the overburden that may be creating a blocking effect, reducing the amount of subsidence seen at the surface.
Keyword(s): coal mining, pillar extraction, active mines, angle of draw, overburden, land mitigation, room-and-pillar
Location(s): Illinois, Illinois Coal Basin, United States

Riley, F. S., S. N. Davis. A Tiltmeter to Measure Surface Subsidence Around a Pumping Artesian Well. Journal Geophysical Research, (abstract), v. 65, 1960, p. 1637.
Keyword(s): fluid extraction, monitoring equipment, subsurface water

Riley, F. S. Land Surface Tilting Near Wheeler Ridge, California. American Geophysical Union Transactions, v. 49, 1968, p. 664.
Keyword(s): fluid extraction
Location(s): California, United States

Riley, F. S. Land-Surface Tilting Near Wheeler Ridge, Southern San Joaquin Valley, California. U.S. Department of the Interior, Geological Survey Professional Paper 497-G, 1970, p. G1-G29.
Keyword(s): fluid extraction
Location(s): California, United States

Riley, F. S. Developments on Borehole Extensometry. IN: Land Subsidence, Proceedings 3rd International Symposium, Venice, Italy, March

19-25, 1984, A.I. Johnson, L. Carbognin, and L. Ubertini, eds., International Association of Hydrological Sciences Publication No. 151, 1986, p. 169-186.

Progressive development of the deep-well extensometer over a period of 30 years facilitated the evolution of fundamental concepts and predictive capability in studies of aquifer-system compaction and land subsidence due to fluid withdrawal.

Keyword(s): instrumentation, monitoring equipment, fluid extraction

Location(s): United States

Rimant, A. Extraction of Shaft Pillars. Freiberger Forschungshefte, A448, 1968, p. 157-179 (in German).

Keyword(s): pillar extraction

Location(s): Germany

Robeck, K. E. Potential Land Use Impacts of Coal Production: 1975-2000. Argonne National Laboratory, July, 1980, 71 p. (NTIS DE 82003264)

Keyword(s): land-use planning, environment, land values, coal mining, economics

Location(s): United States

Roberts, A. Partial Extraction in Restricted Workings. Colliery Engineering, v. 24, no. 284, 1947, p. 335-340.

The principles of surface support in areas where partial extraction of underlying minerals is made are discussed, and some examples from various coalfields are described. A short discussion of recommended pillar dimensions and the development of pressure arches is included.

Keyword(s): pillar strength, mine design, overburden, partial extraction, coal mining

Roberts, A. A. A Problem of Strata Control in Bord and Pillar Working. Colliery Guardian, v. 170, no. 4404, 1945, p. 663-668.

Keyword(s): ground control, room-and-pillar

Roberts, E. W. A History of Land Subsidence and its Consequences Caused By the Mining of Anthracite Coal in Luzerne County, Pennsylvania. Ph.D. Thesis, New York University, 1948, 230 p.

Keyword(s): historical, anthracite, coal mining

Location(s): Pennsylvania, Appalachian Coal Region, United States

Roberts, J. M., A. L. Masullo, Jr. Pneumatic Stowage Becomes Affordable. Reprinted from Coal Age, 1986, 5 p.

In recent years, the economics have changed and the equipment and technology improved to the point where pneumatic stowing of material underground may now make some money sense to coal operators.

Keyword(s): coal mining, backfilling, stowing, pneumatic backfilling, economics

Location(s): United States

Roberts, J. M., F. W. Tobias, A. L. Massulo, J. A. Holbrook. Remote Pneumatic Stowing in Abandoned Room and Pillar Mines. IN: Proceedings 8th Annual National Abandoned Mine Lands Conference, August 10-15, 1986, Billings, MT, p. 111-139.

A review and feasibility study of the state-of-the-art of remote pneumatic stowing for backfilling abandoned room-and-pillar mines was completed. Technical specifications to permit implementation of a project were prepared, and a subsurface investigation was also performed. The investigation included the use of a borehole video camera.

Keyword(s): pneumatic backfilling, room-and-pillar, abandoned mines, stowing

Location(s): Pennsylvania, Appalachian Coal Region, United States

Robertson, T. Mining Subsidence--The Geological Aspects and Their Relations to Town Planning in County Durham. Colliery Guardian, v. 179, no. 4634, 1949, p. 575-578.

This paper discusses geological aspects of town planning, with special reference to limestone solution with fluctuating water tables and surface disturbance over undermined areas.

Keyword(s): land-use planning, surface structural damage, hydrology, geologic features, subsurface water

Location(s): England

Robinson, G. L., J. C. Swain, R. P. Yantis, H. W. Ray. A Systems Approach to Underground Coal Mining: Phase I. Problem Analysis and Research Recommendations. Battelle Labs, Columbus, OH, June 1975, 293 p. (NTIS PB 249 054)

Keyword(s): mine operation, coal mining, subsidence research

Location(s): United States

Robinson, K. E., B. Stimpson. Geotechnical and Ground Control Design Parameters for a Proposed Shallow Longwall Coal Mine. IN: Geotechnical Research and its Application to Canadian Resource Development, Preprint Volume for 36th Canadian Geotechnical Conference, June 22, 1983, Vancouver, British Columbia.

The Clover Bar coal seam has been widely worked in the Edmonton area since the 19th century. A proposal to expand production of one of the few currently operating mines in this seam, by converting from a room-and-pillar system to a longwall caving operation required an investigation of the geotechnical properties of the strata, and an assessment of its behavior under a longwall system of mining. The proposed mine would remove coal ranging in thickness from 1.0 to 3.5 meters, from a depth of only 20 to 25 meters. The depth of the proposed operation would make the mine one of the shallowest longwall operations in the world.

Keyword(s): coal mining, longwall, room-and-pillar, geotechnical, active mines, mine design, rock mechanics, in situ testing, lab testing

Location(s): Canada

Rockaway, J. D., R. W. Stephenson. Investigation of the Effects of Weak Floor Conditions on the Stability of Coal Pillars. IN: Site Characterization, Proceedings 17th U.S. Symposium on Rock Mechanics, Snowbird, UT, August 25-27, 1976, W.S. Brown, S.J. Green, and W.A. Hustrulid, eds., University of Utah, Salt Lake City, p. 4A5-1 (abstract only).

This project studied the engineering properties of underclays to determine those factors which contribute to their development or loss of strength. In addition, the process by which floor failures occur is being investigated and the applicability of bearing capacity analysis to solving floor stability evaluated. The study includes an evaluation of underclay properties from all major coal fields of the United States, although the areas of extensive testing have been concentrated in the mid-continent coal field in Indiana, Illinois, and western Kentucky.

Keyword(s): floor stability, coal mining, pillar strength

Location(s): Illinois, Indiana, Kentucky, Illinois Coal Basin, United States

Rockaway, J. D., R. W. Stephenson. Investigations of the Effect of Weak Floor Conditions on the Stability of Coal Pillars. USBM Contract No. JO-155153, July, 1979, 225 p. (NTIS PB 81-181109)

Keyword(s): floor stability, pillar strength, coal mining

Location(s): United States

Rockaway, J. D., R. W. Stephenson. Investigation of the Effects of Weak Floor Conditions on the Stability of Coal Pillars. Final Report, June 27, 1975-December 31, 1978, U.S. Bureau of Mines OFR-12-81, July 15, 1979, 227 p. (NTIS PC A11/MF A01)

Keyword(s): coal mining, floor stability, pillar strength

Location(s): United States

Rockaway, J. D., C. D. Elifrits. Investigation of the Effects of Mining Subsidence I: The Vicinity of Rend Lake Dam, Illinois. Report prepared for the U.S. Army Corps of Engineers, St. Louis, MO, 1979, 51 p.

Keyword(s): coal mining, surface water, surface structural damage

Location(s): Illinois, Illinois Coal Basin, United States

Rockaway, J. D., R. W. Stephenson. Evaluation of the Effects of Weak Underclays on the Support of Coal Pillars in Illinois Basin Mines. IN: Proceedings 1st Conference on the Ground Control Problems in the Illinois Coal Basin, August 22-24, 1979, Southern Illinois University, Carbondale, 1980, p. 59-69.

Failure of the mine floor supporting coal pillars frequently occurs when the subcoal strata include "underclays" or other low strength strata. The failure process has been studied to define the response of these materials to applied coal pillar loads and also to determine the applicability of bearing capacity analysis for evaluating unsafe conditions. The study has been accomplished through an investigation of both the intact and in situ geotechnical properties of the subcoal strata, as well as through the installation of floor movement monitoring instrumentation. Results indicated that both the shear strength of the underclay and the stratigraphy of the subcoal strata must be considered in the analysis.

Keyword(s): floor stability, pillar strength, room-and-pillar, ground control, coal mining, geotechnical, lab testing, in situ testing

Location(s): Illinois, Illinois Coal Basin, United States

Rockaway, J. D., R. W. Stephenson. Influence of Moisture Content on the Bearing Capacity of Coal Mine Floors. SME-AIME Annual Meeting, Chicago, IL, 1981.
Keyword(s): floor stability, coal mining

Roenfeldt, M. A., D. V. Holmquist. Analytical Methods of Subsidence Prediction. IN: Proceedings Conference on Coal Mine Subsidence in the Rocky Mountain Region, Colorado Springs, October 28-30, 1985, J.L. Hynes, ed., Colorado Geological Survey Special Publication 31, Department of Natural Resources, Denver, 1986, p. 191-209.
This paper summarizes the history of subsidence prediction, current practices in subsidence engineering, and recent developments of predictive subsidence models. The discussions include analytical approaches for longwall and room-and-pillar mining techniques.
Keyword(s): prediction, prediction theories, empirical model, coal mining, modeling, influence function, National Coal Board, profile function, historical, room-and-pillar, longwall
Location(s): Europe, United Kingdom, United States

Roll, R. J. Effect of Subsidence on Well Fields. Journal of American Water Works Association, v. 59, no. 1, 1967, p. 80-88.
Keyword(s): fluid extraction, subsurface water, hydrology, subsurface subsidence damage
Location(s): United States

Ropski, St., R. D. Lama. Subsidence in the Near-Vicinity of a Longwall Face. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 10, 1973, p. 105-118.
Keyword(s): longwall

Roscoe, G. H. Saint Wilfrid's Church, Hickleton: Mining Subsidence and Remedial Works. IN: Engineering Geology of Underground Movements, Geological Society Engineering Geology Special Publication No. 5, F.G. Bell, et al., eds., 1988, p. 257-264.
This paper describes the new foundation required as part of the restoration of a church that had been badly damaged by mining subsidence. Damage is related to the geology and mining history of the church site in order to determine the right course of remedial action. The case history illustrates the influence that ground conditions at shallow depth can have on the surface effects of deep mining. The church has settled by more than 2 meters as a result of coal mining activity. Surface movements due to deep mining were predicted by conventional methods and are compared with the damage to the church. Most damage resulted from the horizontal ground movements caused by workings that were some distance from the site, and these movements were concentrated by fissures in the rock.
Keyword(s): coal mining, foundations, surface structural damage, horizontal displacement, vertical displacement, surface subsidence damage, geologic features, multiple-seam extraction, longwall, room-and-pillar, partial extraction, structural mitigation
Location(s): United Kingdom

Roscoe, M. S. Longwall Subsidence Over the Pittsburgh No. 8 Coal on North American Coal Corporation's Eastern Ohio Properties. IN: Longwall-Shortwall Mining, State-of-the-Art, 1981, R.V. Ramani, ed., SME-AIME, New York, p. 87-98.
In order to more accurately predict longwall surface subsidence over the Pittsburgh No. 8 Coal Mine in eastern Ohio, this company undertook or participated in several subsidence studies. Due to the changing roof geology and rapid variations in the amount of cover, two separate areas were investigated at two different mines to determine the subsidence response, if any, to these changes. Data generated were compared with data derived from the National Coal Board for accuracy and then used to predict subsidence under houses, gas lines, and other critical man-made structures.
Keyword(s): longwall, coal mining, utilities, monitoring methods, angle of draw, rock mechanics, surface structural damage, National Coal Board, prediction, geologic features, overburden
Location(s): Ohio, United States

Ross, A. J. M. Sand Filling at the Homestake Mine. Transactions, AIME, v. 141, 1940, p. 146.
The author describes hydraulic flushing techniques used in the Homestake Gold Mine, South Dakota.
Keyword(s): metal mining, hydraulic backfilling
Location(s): South Dakota, United States

Rothwell, R. J., H. J. Payne. Longwall Coal Mining Under S.M.C.R.A. 1977--The Ohio Experience. IN: Proceedings 2nd Workshop on Surface Subsidence due to Underground Mining, Morgantown, WV, June 9-11, 1986, S.S. Peng, ed., West Virginia University, p. 9-12.

Underground mining of coal by longwall mining methods has not been a predominant technique in Ohio. To date, only five mines in the state use this method; however, the technique has sparked a certain amount of controversy. As a mining technique, longwalling was introduced into southeastern Ohio in the early 1970s, but it did not attract public attention until the mines began moving into privately held surface lands. This occurred coincidentally at about the same time that the State of Ohio began to regulate the environmental impacts of underground mining.

Keyword(s): law, longwall, government, subsurface water, surface water, coal mining

Location(s): Ohio, United States

Rousset, G., B. Bazargan-Sabet, R. Lenain. Time-Dependent Behavior of Rocks: Laboratory Tests on Hollow Cylinder. IN: Rock Mechanics as a Guide to Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 385-391.

This paper presents laboratory experiments on hollow cylinder samples. The advantage of such a geometry is to approach in situ conditions around cylindrical openings, especially for borehole stability applications. Time-dependent behavior has not been well studied; for this purpose, two different tests were set up on a deep clay: a quick unloading test, and a creep and relaxation test. The experimental results were then compared with those given by a theoretical model developed in the laboratory.

Keyword(s): time factor, rock mechanics, lab testing, modeling, computer, geologic features

Location(s): France, Belgium

Royse, K. W. Daylighting of an Abandoned Underground Mine. IN: Proceedings National Symposium and Workshops on Abandoned Mine Land Reclamation, Bismarck, ND, May 21-22, 1984, L.L. Schloesser, et al., eds., North Dakota Public Service Commission and the University of North Dakota, p. 277-293.

Several hundred voids created by subsidence from past mining activity existed at this site at the start of the project. The holes measured 30 to 40 feet in diameter and 20 feet deep. The original mined level was known to be 30 to 70 feet below the surface, and drilling showed the mine to be almost completely flooded. Several tests were conducted before the reclamation method "daylighting" (overexcavation and backfill) was chosen, including drilling, dragline and scraper tests, and dynamic consolidation tests.

Keyword(s): backfilling, reclamation, surface subsidence damage, land mitigation, abandoned mines, coal mining

Location(s): North Dakota, United States

Rozier, I. T., T. J. R. Godfrey. The Acquisition and Application of Underground Mine Design Criteria Derived from a Geological Exploration Program. Canadian Institute of Mining and Metallurgy 2nd District Five Meeting, September 10-13, 1985, Hinton, Alberta, Paper/Presentation No. 12, 18 p.

To investigate the engineering geological parameters that could impact on the potential underground mining of a coal seam in Alberta, a geotechnical data collection program was integrated with overall geological exploration. A combination of geological, geotechnical, and hydrological parameters were identified that could have a significant impact on the selection of preferential areas for further exploration, planning, and development of an underground mine. The joint program proved the feasibility of deriving both geological and geotechnical mine design criteria from cored exploration drillholes without compromising the objectives of either program.

Keyword(s): geotechnical, active mines, coal mining, geologic features, hydrology

Location(s): Canada

Rudenko, D., J. S. Walker, A. M. Richardson, H. D. Ackerman, J. W. Reil. P-Wave and S-Wave Velocity Measurements Related to Subsidence Over a Longwall Mine. IN: Society of Exploration Geophysics 59th International Meeting and Exposition, October 29-November 2, 1989, Dallas, Extended Abstracts, p. 363-367.

This paper is the result of ongoing research to develop a monitoring system for detection of mine subsidence using geophysical techniques. The seismic technique was judged to be the most insensitive to human interference, and most directly related to material properties of the rock overlying the mines. An active longwall mine was used as a control site to relate changes in seismic properties with subsidence. The initial phase of the project consisted of running seismic traverse lines before, during, and after mining. The data showed significant changes in the compressional and shear wave velocities. These changes are related to induced changes in the stress regime, and fractures in the rock due to subsidence.

Keyword(s): seismic, geophysical, longwall, coal mining, overburden, monitoring methods, monitoring equipment, monitoring design

Location(s): Maryland, Appalachian Coal Region, United States

Runkle, J. R. Effects of Longwall Mining on Surface Soil Moisture and Tree Growth. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 173-182.

Studies in eastern Ohio, northern West Virginia, and southwestern Pennsylvania determined whether subsidence caused by longwall mining influences soil moisture and tree growth. Soil moisture was measured over new longwall panels and an unmined control area throughout the growing seasons of 1990, which was a wet year when the panels were excavated, and 1991, a dry year. No significant effects of mining could be detected. Tree growth was studied in two pairs of woodlots. Differences in tree growth between mined and unmined areas were neither significant (for most species) nor consistent in direction. The results imply that if mining does have impacts, they are likely to be highly site-specific and localized, such as by disruptions of springs or soil slippage.

Keyword(s): soils, environment, longwall, active mines, agriculture, subsurface water, hydrology

Location(s): Ohio, West Virginia, Pennsylvania, Appalachian Coal Region, United States

Russell, J. E. Strength of Mine Pillars. IN: Research & Engineering Applications in Rock Masses, Proceedings 26th U.S. Symposium on Rock Mechanics, South Dakota School of Mines & Technology, Rapid City, June 26-28, 1985, E. Ashworth, ed., Balkema, Rotterdam, p. 703-704 (abstract only).

Bieniawski (1984) notes that the strength of mine pillars depends on three factors: (1) the size effect, whereby the strength of the material is reduced; (2) the shape effect, generally included in the form of the width-to-height ratio; and (3) the effect of the properties of the pillar material. In this paper, the size effect is studied using an elastic-plastic material model employing the empirical strength criterion for rock masses published by Hoek and Brown (1980) as the yield criterion. A conventional finite-element code with Mohr-Coulomb material model is used for the calculations.

Keyword(s): pillar strength, mine design, rock mechanics

Russell, O. R., R. V. Amato, T. V. Leshendok. Remote Sensing and Mine Subsidence in Pennsylvania. ASCE Transportation Engineering Journal, v. 105, no. 2, March, 1979, p. 185-198.

Keyword(s): remote sensing

Location(s): Pennsylvania, Appalachian Coal Region, United States

Russnow, A. L., W. W. Beck, Jr., G. H. Emrich. Coal Mine Subsidence and Mine Pools--Northern Anthracite Field, Pennsylvania. Geological Society of America Abstracts with Programs, 1975, v. 7, p. 1331-1332.

Keyword(s): anthracite, coal mining

Location(s): Pennsylvania, Appalachian Coal Region, United States

Rutledge, J. J. Examples of Subsidence in Two Oklahoma Coal Mines. Transactions, AIME, v. 69, 1923, p. 406-433.

This paper discusses two subsidence events, including structural damage, geologic and mine features, and surface evidence of subsidence.

Keyword(s): coal mining, surface structural damage, room-and-pillar

Location(s): Oklahoma, United States

Ryan, C. R. High-Volume Grouting to Control Sinkhole Subsidence. IN: Sinkholes: Their Geology, Engineering and Environmental Impact, Proceedings 1st Multidisciplinary Conference on Sinkholes, Orlando, October 15-17, 1984, B.F. Beck, ed., Balkema, Rotterdam, p. 413-417.

Sinkhole subsidence caused by underground mining activities and natural solution cavities is a problem found in many areas of the United States. High-volume grouting techniques have been used to correct the problem by filling the underground voids on many sites, both as a preventative and as a remedial measure. Several case examples are presented, including limerock subsidence and mine subsidence.

Keyword(s): grouting, backfilling, coal mining

Location(s): Florida, Pennsylvania, Alabama, Appalachian Coal Region, United States

Ryder, J. A., N. C. Officer. An Elastic Analysis of Strata Movements Observed in the Vicinity of Inclined Excavations. South African Institute of Mining and Metallurgy Journal, v. 64, no. 6, 1964, p. 219-244.

Keyword(s): modeling, phenomenological model, elastic model

Location(s): South Africa

Rymer, T., D. Yeatts, R. Boswell, A. Donaldson. RYBAD Empirical Field Model for Prediction of Maximum Land Subsidence Associated with Longwall Coal Mining. IN: Proceedings 7th International Conference on Ground Control in Mining, August 3-5, 1988, S.S. Peng, ed., Department of Mining Engineering, West Virginia University, Morgantown, p. 174-178.

Mathematical modeling of mine subsidence measured at 21 locations in Pennsylvania and northern West Virginia allows for the refinement of current methods of predicting maximum land subsidence associated with longwall coal mining. This model predicts subsidence more accurately for a greater range of mining and geological parameters through the recognition of the following: (1) subsidence increases at a decreasing rate (curvilinear relationship) with greater overburden thickness up to a critical value beyond which subsidence decreases; (2) subsidence is strongly influenced by the stratigraphic proximity of strong rocks to the coal (size of potential caving zone); and (3) subsidence index is related to overburden thickness by a family of curves, each for incremental variations in the effective percentage of strong rock in the overburden.

Keyword(s): empirical model, modeling, prediction, prediction theories, coal mining, longwall, mathematical model, geologic features, overburden

Location(s): West Virginia, Appalachian Coal Region, United States

Ryncarz, T. Influence of Surface Load on Formation of Subsidence Trough In Light of Equation of Stochastic Processes. Bulletin, Academie Polonaise des Sciences, Serie des Sciences Techniques, v. 9, no. 9, 1961, p. 535-540.

Keyword(s): modeling, empirical model, stochastic model

Ryncarz, T. Factors Influencing the Load on Longwall Support. IN: Proceedings 1st Conference on Ground Control Problems in the Illinois Coal Basin, August 22-24, 1979, Southern Illinois University, Carbondale, 1980, p. 216-225.

It has been found through by trial and error that the required load capacity is generally greater in coal mines in the United States than the one applied in European deep coal mines. In this paper, an attempt is made to assess the interaction between the powered supports and surrounding rocks and the appropriate evaluation of required support capacity for longwall mining.

Keyword(s): longwall, coal mining

Location(s): United States, Europe

Sadykov, N. M., V. Y. Setkov. Probability, Statistical Indices of Sudden Roof Subsidences. Soviet Mining Science, v. 14, no. 2, March, 1978, p. 195-200 (English translation).

Keyword(s): roof stability

Location(s): Soviet Union

Safai, N. M., G. F. Pinder. Numerical Model of Land Subsidence Due to Pumpage from Fully and Partially Penetrating Wells. Water Resource Program Technical Report No. 78-WR-1, Princeton University, 1977.

Keyword(s): modeling, subsurface water, fluid extraction

Location(s): United States

Safai, N. M., G. F. Pinder. Vertical and Horizontal Land Deformation Due to Fluid Withdrawal. International Journal of Numerical and Analytical Methods in Geomechanics, v. 4, no. 2, 1980, p. 131-142.

A non-linear distribution of vertical displacement versus aquifer depth is calculated in the case of a partially penetrating well. For a fully penetrating well, however, a linear distribution is observed. The solution exhibits a vertically uniform horizontal displacement in the case of a fully penetrating well and, for a partially penetrating well, the maximum horizontal displacement occurs at the elevation of the well bottom.

Keyword(s): vertical displacement, horizontal displacement, subsurface water, hydrology, modeling, finite element, fluid extraction

Location(s): United States

Salamon, M.D.G. The Influence of Strata Movement and Control on Mining Development and Design. Ph.D. Thesis, University of Durham, England, 1962.

Keyword(s): mine design, ground control

Salamon, M.D.G. Elastic Analysis of Displacements and Stresses Induced by the Mining of Seam or Reef Deposits. Journal of the South African Institute of Mining and Metallurgy, Pt. 1, v. 64, November 1963, p. 128-149; Pt. 2, v. 64, January 1964, p. 197-218; Pt. 3, v. 64, March 1964, p. 468-500; Pt. 4, v. 65, December 1964, p. 319-341.

The author discusses fundamental principles and basic solutions derived from idealized models, practical methods of determining subsidence parameters from a given mining geometry, application of elastic theory, and protection of surface installations by underground pillars.

Keyword(s): phenomenological model, elastic model, continuum mechanics, modeling, pillar strength, surface structural damage, room-and-pillar

Location(s): South Africa

Salamon, M.D.G., K. I. Oravecz. Displacements and Strains Induced by Bord and Pillar Mining in South African Collieries. IN: Proceedings 1st International Congress on Rock Mechanics, Lisbon, Portugal, 1966, v. 2, p. 227-232.

Field experiments were performed in order to establish the behavior of coal measure strata, including displacement patterns, when these strata are subjected to mining conditions. The experiments were designed to obtain the displacement pattern in the zone of expected compression and tension over pillars and bords, respectively.

Keyword(s): room-and-pillar, overburden, coal mining, in situ testing

Location(s): South Africa

Salamon, M.D.G. A Method of Designing Bord and Pillar Workings. Journal of the South African Institute of Mining and Metallurgy, v. 68, September, 1967, p. 68-78.

The author formulates a procedure to determine mining dimension in bord-and-pillar workings, using a pillar strength formula devised statistically from surveys of mines in South Africa. This formula assumes that the entire weight of the overburden is carried by the pillars.

Keyword(s): room-and-pillar, pillar strength, mine design, overburden

Location(s): South Africa

Salamon, M.D.G., A. Munro. A Study of the Strength of Coal Pillars. Journal of the South African Institute of Mining and Metallurgy, v. 68-2, September, 1967, p. 55-67.

This paper uses data obtained from actual surveys of mining conditions to derive empirically a coal pillar strength formula.

Keyword(s): pillar strength, coal mining

Location(s): South Africa

Salamon, M.D.G. Two-Dimensional Treatment of Problems Arising from Mining Tabular Deposits in Isotropic or Transversely Isotropic Ground. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 5, 1968, p. 159-185.

The analysis is restricted to geometries that do not alter appreciably when moving along their long axes. It is postulated that (1) the mining takes place

in an inclined seam, (2) the depths of the excavations below surface are effectively infinite, and (3) all three components of displacement are independent of the coordinate parallel with the long axis of the mining layout. Expressions for the displacement and stress components are given in terms of a single complex potential in both models.
Keyword(s): rock mechanics, metal mining, coal mining, modeling
Location(s): South Africa

Salamon, M.D.G., K. I. Oravecz, D. R. Hardman. Rock Mechanics Problems Associated with Longwall Trials in South Africa. IN: 5th International Strata Control Conference, London, 1972, Paper 14, 8 p.
Keyword(s): rock mechanics, longwall
Location(s): South Africa

Salamon, M.D.G. Rock Mechanics of Underground Excavations. IN: Advances in Rock Mechanics, Proceedings 3rd Congress of International Society for Rock Mechanics, Denver, 1974, National Academy of Sciences, Washington, D.C., 1(B), p. 951-1099.
Keyword(s): rock mechanics

Salamon, M.D.G. Least-Squares Analysis of Ground Displacement Observations. IN: Large Ground Movements and Structures, Proceedings of International Conference, University of Wales Institute of Science and Technology, Cardiff, 1977, J.D. Geddes, ed., John Wiley & Sons, New York, 1978, p. 30-59.
The creation of surface or underground excavations is always accompanied by some deformation of the rock mass. Usually, the most easily observed and the most meaningful manifestation of this deformation is the displacement of points inside or on the surface of the rock mass. Observation of the displacement of the ground is closely akin to the work of land or mine surveyors. However, this similarity is not all-embracing. The traditional aim of surveyors is to determine the permanent location of points. The purpose of the rock mechanics field observer is to determine the change in the position of points and to follow the progress of this change by repeated observations at intervals.
Keyword(s): survey methods, survey data processing

Salamon, M.D.G. The Role of Linear Models in the Estimation of Surface Ground Movements Induced by Mining Tabular Deposits. IN: Large Ground Movements and Structures, Proceedings International Conference, University of Wales Institute of Science and Technology, Cardiff, 1977, J.D. Geddes, ed., John Wiley & Sons, New York, 1978, p. 187-208.
This paper gives a brief summary of the principles involved in treating tabular excavations as displacement discontinuities, the outlines of which coincide with the plan of the excavations. More details are given on the application of these principles to the prediction of displacements at the ground surface and to the protection of structures on the surface.
Keyword(s): vertical displacement, horizontal displacement, mine design, prediction, modeling, surface structural damage
Location(s): South Africa

Salamon, M.D.G. Linear Models for Predicting Surface Subsidence. IN: Rock Mechanics for Resource Development, Mining and Civil Engineering, Proceedings 5th Congress of International Society for Rock Mechanics, Melbourne, Australia, 1983, Balkema, Rotterdam, p. E 107-E 114.
The notion of a preliminary screening of models is introduced using critical measures of surface movement. Exact elastic media are then examined with attention focused on the modeling of stratified rock masses using an equivalent medium. The Monte Carlo technique is employed to estimate from the properties of individual layers, which are treated as independent random variables, the moduli of the equivalent transversely isotropic mass. Semi-empirical models are discussed and their application is illustrated by an example.
Keyword(s): modeling, elastic model, phenomenological model, empirical model, prediction, National Coal Board, prediction theories
Location(s): United Kingdom

Salamon, M.D.G. Subsidence Prediction Using a Laminated Linear Model. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 503-510.
If all stratifications are horizontal, the computation of surface deformation induced by coal mining involves the prediction of roof and floor convergence and then the transfer of the effects of this relative displacement to the surface through the use of the appropriate influence functions. A laminated model, in the form of a quasi-continuum,

provides a simple means of computing the approximate convergence distribution and leads to the Gaussian distribution as the influence function. This paper presents a subtle but fundamental generalization of the influence function method. It is postulated that the influence of a small area of extraction is proportional to the roof and floor convergence and not to the thickness extracted. This difference in definition removes many conceptual difficulties associated with the influence function method. The surface disturbances induced by the extraction of a parallel sided long panel are derived to demonstrate the utility of the model. Formulas giving subsidence, tilt, horizontal displacement and strain are given.

Keyword(s): prediction, modeling, coal mining, influence function, vertical displacement, horizontal displacement, elastic model, overburden

Location(s): United States

Salamon, M.D.G. Mechanism of Caving in Longwall Coal Mining. IN: Rock Mechanics Contributions and Challenges, W.A. Hustrulid and G.A. Johnson, eds., Proceedings of the 31st U.S. Rock Mechanics Symposium, June 18-20, 1990, Golden, CO, Balkema, Rotterdam, p. 161-168.

Longwall extraction, in conjunction with caving, is one of the most widely practiced underground coal mining methods. Caving and the subsequent reconsolidation of the caved rocks combine to form a mechanism that is kernel to the solution of several important problems.

Keyword(s): coal mining, longwall, overburden

Salamon, M.D.G. Displacements and Stresses Induced by Longwall Mining in Coal. IN: Proceedings International Congress on Rock Mechanics, Aachen, 1991, W. Wittke, ed., v. 2, p. 1199-1202.

A linear laminated model is employed, in conjunction with a non-linear compaction characteristic for the caved rocks, to describe the behavior of the rock mass. The model of the rock mass is characterized by two parameters (Young's modulus and an effective lamination thickness), the caved rubble by an effective "modulus," and the coal seam by an elastic modulus. These four parameters are combined in the model to yield the goaf compaction (convergence), pressure transmitted from the roof to the floor, load transmitted from the panel to surrounding ribsides, and subsidence of the surface. The convergence, pressure, and subsidence distributions illustrated appear to be realistic.

Keyword(s): modeling, longwall, coal mining

Salamon, M.D.G. Partial Extraction to Control Surface Subsidence Due to Coal Mining. IN: Rock Mechanics as a Multidisciplinary Science, Proceedings 32nd U.S. Symposium, The University of Oklahoma, Norman, July 10-12, 1991, J.-C. Roegiers, ed., Balkema, Rotterdam, p. 861-870.

The longwall partial extraction (panel and pillar) mining method has been used successfully to control subsidence in many countries. Extraction ratios up to 60% to 70% have been achieved. The fundamentals of the layout are examined using a simple linear laminated model of stratified coal measures. Cases of a narrow panel, of an infinite train of panels, and edge effects are studied. Suggestions are made concerning underground geometry, panel centre distances, and span to minimise edge effects.

Keyword(s): longwall, partial extraction, modeling, coal mining, mine design, vertical displacement, horizontal displacement

Salamon, M.D.G., G. Yang. The Seam Element Method: Prediction of Subsidence Due to Coal Mining. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 47-55.

The laminated model, in conjunction with the seam element method, is expected to be a powerful predictor of subsidence due to coal mining. The fundamental solutions for the model are presented. Numerical approaches to determine the roof-to-floor convergence and evaluation of ground movement are discussed. Numerical results and comparisons with field observations are given to illustrate the validity and the potential of the model.

Keyword(s): prediction, coal mining, modeling, boundary element

Salas, J. A. J. Two Subsidence Cases in Spain. IN: Proceedings International Society for Rock Mechanics 4th International Congress, Montreux, v. 3, 1979, p. 369-373.

Keyword(s): rock mechanics

Location(s): Spain

Sanda, A. P., S. A. Zaburunov. Is It a Short Longwall, or a Long Shortwall? Coal, December, 1988, p. 39-41.

The "go longwall" maxim is being challenged by a 25-year-old concept just now being proven to be commercially viable and operationally feasible. The shortwall machine was originated in the 1960s, but one coal company in western Pennsylvania calls it the solution to their problem.

Keyword(s): coal mining, shortwall, longwall, National Coal Board
Location(s): Pennsylvania, Appalachian Coal Region, United States

Sanderson, S. A. The Future of Longwall Mining Under SMCRA. An Industry Under Siege: Some Facts About Subsidence, Seminar sponsored by American Mining Congress and Illinois Coal Association, February 15-16, 1990, Mt. Vernon, IL, 12 p.
During the past 2 years, the coal industry has faced many nationwide regulatory initiatives to limit or curtail full-extraction underground coal mining. The increasing political scrutiny and attention to longwall mining is reflected in state legislative measures to restrict longwall mining, court decisions, and rulemaking proposals.
Keyword(s): law, longwall, coal mining, environment, surface structural damage, active mines
Location(s): Rocky Mountain Coal Region, Illinois Coal Basin, Appalachian Coal Region, United States

Sandhu, R. S., E. L. Wilson. Finite-Element Analysis of Land Subsidence. IN: Land Subsidence, Proceedings International Symposium, September 14-18, 1969, Tokyo, IAHS Publication 89, v. 2, p. 393-400.
Keyword(s): finite element, modeling

Sandhu, R. S. Modeling Land Subsidence. IN: Evaluation and Prediction of Subsidence, Proceedings International Conference, S.K. Saxena, ed., Pensacola Beach, FL, January 15-20, 1978. ASCE, New York, 1979, p. 565-579.
The author selectively and briefly reviews the development of land subsidence models in this paper. The purpose is to highlight doubts and to raise questions regarding the validity of some commonly accepted notions. First, some theoretical models are looked at and certain differences of opinion are noted in setting up constitutive relationships. Thereafter, some theoretical as well as numerical schemes are considered. An example is included to illustrate the possibility of error inherent in the use of ad hoc simplifications.
Keyword(s): prediction, modeling, mathematical model, phenomenological model, continuum mechanics

Sandia National Laboratories. A Review of Subsidence Prediction Research Conducted at Sandia National Laboratories. SAND82-0017, Sandia National Laboratories, Albuquerque, NM, April, 1982, 46 p.
Keyword(s): prediction, subsidence research
Location(s): United States

SANGORM, International Society for Rock Mechanics, South African National Group. The Effect of Underground Mining on Surface. Proceedings SANGORM Symposium, October 21, 1986, Sandton, South Africa.
The proceedings contains 18 papers related to the effects of underground mining on the surface.
Keyword(s): coal mining, metal mining, nonmetal mining, rock mechanics, law, surface structural damage, monitoring methods, survey methods, room-and-pillar, longwall, influence function, computer, modeling, empirical model, prediction, subsurface water, mine design
Location(s): South Africa

Sann, B. Considerations on Precalculating Ground Subsidences Due to Coal Mining. Bergbau-Rundschau, 1949, p. 163-168 (in German).
Keyword(s): prediction, coal mining, modeling, empirical model, influence function

Santy, W. P., W. F. Eichfeld, R. J. McKelvey. Methods of Characterization of Subsidence Due to Longwall Mining in the Illinois Coal Basin. IN: Proceedings 1st Conference on Ground Control Problems in the Illinois Coal Basin, August 22-24, 1979, Southern Illinois University, Carbondale, 1980, p. 247-259.
This paper describes the monitoring systems conducted in conjunction with the rock mechanics study undertaken with the longwall demonstration project at Old Ben No. 24 Mine from 1975 to 1979. Two subsidence monitoring systems were employed for monitoring subsidence. The reasons for using two systems were to show the feasibility of using a concentrated system for characterizing subsidence and to compare the results obtained from more traditional monitoring techniques.
Keyword(s): coal mining, longwall, monitoring methods, monitoring equipment, monitoring design, survey equipment, survey methods, vertical displacement, horizontal displacement
Location(s): Illinois, Illinois Coal Basin, United States

Sargand, S. M., G. A. Hazen. Highway Damage Due to Subsidence. IN: Mine Induced Subsidence: Effects on Engineered Structures, Proceedings of

the Symposium, Nashville, TN, May 11, 1988, ASCE Geotechnical Special Publication No. 19, 1988, p. 18-31.

In this study, subsidence profiles were obtained over three longwall panels that were mined beneath state highways in southeastern Ohio. Immediate and short-term subsidences were recorded. A video camera probe was lowered into two core holes before and after longwall mining took place, and visual inspections were performed to examine the nature of cracking. A laboratory investigation was conducted to determine the strength and elastic properties of rock strata above the mine.

Keyword(s): longwall, coal mining, roads, survey methods, lab testing, rock mechanics, profile function, horizontal displacement, prediction, structural mitigation

Location(s): Ohio, United States

Saric, J. A. The Hydrogeological Effects of Abandoned Underground Coal Mines, Muddy, Illinois. M.S. Thesis, Northern Illinois University, De Kalb, May, 1987, 106 p.

The long-term hydrogeologic effects of underground mining and mine-induced fracturing and subsidence were studied at the town of Muddy, Illinois, which is underlain by two abandoned mines. The Pennsylvanian rocks include several minor sandstone aquifers and are overlain by glacial lake deposits, some water-bearing. The Cottage Grove Fault separates the mines. It is generally thought that the strata fracturing associated with subsidence can increase permeability and create interaquifer connections. In this study, subsidence features were located and water levels in wells were measured in 1985 and 1986. Although the water table, like the topography, is almost flat, the bedrock piezometric surface shows anomalies due to the mine. Possibly, mine-induced fractures connected aquifers and allowed groundwater to enter the mine conduit. However, transmissivities estimated from pumping tests showed no relation to subsidence features. It is suggested that the mine is absorbing the regional upward discharge of groundwater, creating a depression in the piezometric surface. Mixing zones between glacial and bedrock aquifers were seen to occur as leakage occurred through mine-induced fractures and through leaky well casings. Water samples were analyzed for major ions; indirect evidence was found for the upwelling of mineralized water. Mixing is shown to occur between glacial and bedrock wells in relation to mine-induced fracturing and subsidence.

Keyword(s): subsurface water, coal mining, abandoned mines, hydrology, overburden, geologic features, inflow

Location(s): Illinois, Illinois Coal Basin, United States

Sauck, W. A. Geophysical Studies Near Subsidence Fissures in Central Arizona. Transactions American Geophysical Union, EOS, v. 56, 1975, p. 984-985.

Keyword(s): fluid extraction, geophysical

Location(s): Arizona, United States

Sauer, A. Die Einfluesse Von Durchbauungsgrad, Abbaukonzentration Und Abbaugeschwindigkeit Auf Die Vorausberechnung (Influence of Previous Workings, Concentration, and Advance Rate of Mining Exploitation on the Precalculation of Ground Deformations). Glueckauf-Forschungshefte, v. 36, no. 1, February 1975, p. 16-26.

Keyword(s): prediction, multiple-seam extraction

Saul, H. The Working of Coal Seams in Close Proximity. Transactions Institute of Mining Engineers, v. 113, no. 1089, April, 1954.

Keyword(s): backfilling, multiple-seam extraction, coal mining

Saustowicz, A. New Conceptions as to the Phenomena of Stress and Strain in Rocks Around Mining Excavations. IN: Proceedings International Strata Control Congress, Leipzig, October 14-16, 1958, p. 1-13 and III-IV.

One of the first problems studied was the determination of the magnitude of pressure effected by rocks on supports in roads and tunnels. The subject of this paper is the role played by time in strata control phenomena.

Keyword(s): ground control, time factor, rock mechanics, modeling, lab testing

Location(s): Poland

Savage, W. Z. Prediction of Vertical Displacements in a Subsiding Elastic Layer--A Model for Subsidence in Karst Terrains. U.S. Geological Survey OFR 79-1094, 1979, 13 p.

This paper details a model in which a subsiding region is modeled as an infinitely long elastic layer resting on a rigid base and deforming under its own weight into an opening at its lower edge. An approximate solution for vertical displacements on the ground surface and over the opening is found for the case when the layer thickness is much greater than the width of the opening.

Keyword(s): modeling, vertical displacement, geologic features
Location(s): United States

Savage, W. Z. Prediction of Vertical Displacements in a Subsiding Elastic Layer. Geophysical Research Letters, v. 8, no. 3, 1981, p. 195-198.

The author quantitatively discusses a method of modeling subsidence over an underground cavity. The subsiding region is assumed to be an infinitely long elastic layer that rests on a rigid base and deforms under its own weight into an opening under its lower surface. An approximate analytic solution based on Fourier transform methods is found for vertical displacements of the ground surface and the roof of the opening when the layer thickness is much greater than the width of the opening.

Keyword(s): vertical displacement, modeling, geologic features, geophysical

Savkov, L. V. Ground Movement Induced by Open Cut and Underground Mining. Soviet Mining Science, v. 2, no. 6, November/December 1966, p. 557-583.

Keyword(s): surface subsidence damage
Location(s): Soviet Union

Saxena, N. C., S. Samanta, K. P. Mukherjee, B. Singh. Strata Control Investigations at Caved Longwall Faces with Special Reference to the Faces of Moonidih Project. Journal of Mines, Metals, and Fuels, March, 1978, p. 109-130.

Keyword(s): ground control, longwall, roof stability
Location(s): India

Saxena, N. C., B. Singh. Investigations into the Safety of the Railway Line Against Ground Movement Due to Extraction of Two Thick Seams in India. IN: Rock Mechanics: A State of the Art, Proceedings 21st U.S. Rock Mechanics Symposium, University of Missouri at Rolla, May 28-30, 1980, D.A. Summers, ed., p. 345-355.

A railway line was subsided 385 mm, without affecting its normal operations.

Keyword(s): railroads, coal mining, multiple-seam extraction
Location(s): India

Saxena, N. C., B. Singh. Subsidence Behaviour of Coal Measures Above Bord and Pillar Workings. IN: Strata Mechanics, Proceedings of the Symposium, University of Newcastle-upon-Tyne, April, 1982, I.W. Farmer, ed., Elsevier, New York.

The angle of draw in Indian coalfields is positive and varies between 4 and 31 degrees. The non-effective width varies between 0.3 and 1.0 times the depth. It has not been possible to establish general relationships in the proportion of sandstone from 64% to 95% in the Coal Measures Succession, and its nature, is a contributing factor in the variation of subsidence behaviour. Safe limits of surface slope and strains for various categories of surface features and structures are proposed.

Keyword(s): prediction, surface subsidence damage, mine design, multiple-seam extraction, room-and-pillar, longwall, surface structural damage, surface water, coal mining, overburden, inflow
Location(s): India

Saxena, N. C., B. Singh. Subsidence Research in India. IN: Land Subsidence, Proceedings 3rd International Symposium, Venice, Italy, March 19-25, 1984, A.I. Johnson, L. Carbognin, and L. Ubertini, eds., IAHS Publication No. 151, 1986, p. 661-667.

Due to lack of knowledge of subsidence behavior of Indian Coal Measures, seams underneath surface properties have mostly remained unexploited. Recent research has made it possible to partially develop subsidence indices and also to extract more than 6 million tons of coal underneath surface properties.

Keyword(s): coal mining, geologic features, hydraulic backfilling, pneumatic backfilling, room-and-pillar, surface structural damage, roads, railroads, subsidence research, angle of draw, surface water
Location(s): India

Saxena, N. C., B. Singh. Subsidence in Indian Coalfields. IN: Proceedings 7th International Conference on Ground Control in Mining, August 3-5, 1988, S.S. Peng, ed., Morgantown, WV, p. 344-350.

Subsidence investigations in Indian coalfields have led to development of relationships between subsidence movement parameters and defining safe limits of subsidence movements for surface properties. The maximum subsidence over caved workings was generally not more than 60% of extraction thickness underground. In the case of hydraulically stowed sand stowed workings, it was generally not more than 5%. The relationships have been useful in extraction of more than 7 million tons of coal from underneath and in the vicinity of surface properties.

Keyword(s): coal mining, hydraulic backfilling, surface structural damage, room-and-pillar, longwall, active mines, railroads, geologic features

Location(s): India

Saxena, N. C., B. Singh. Extraction of Coal Seams Underneath a Main Railway Line at Sudamdih in Jharia Coalfield. IN: Proceedings, International Symposium on Underground Engineering, New Delhi, India, April 14-17, 1988, B. Singh, ed., Balkema, Rotterdam, p. 389-393.

About 3 million tons of coking coal have been extracted from three thick coal seams by ascending slicing with hydraulic sand stowing at depths ranging from 35 to 400 meters underneath and in the vicinity of a main railway line. The railway line has been made to gradually subside by a maximum of 621.8 mm. The railway tracks have also been subjected to a maximum strain of 3 mm/m, which was taken as the safe limit for jointed construction railway lines. It has not been necessary to adjust the railway track or stop its operation so far.

Keyword(s): hydraulic backfilling, horizontal displacement, longwall, coal mining, railroads, multiple-seam extraction

Location(s): India

Saxena, S. K. A Review of the Methods Used in Investigation of Subsidence. IN: Evaluation and Prediction of Subsidence, Proceedings International Conference, Pensacola Beach, FL, January 15-20, 1978, S.K. Saxena, ed., ASCE, New York, 1979, p. 214-244.

This paper concentrates on examining the available methods for evaluating subsidence due to fluid flow. The problem of fluid flow through a geologic media is a hydrogeomechanical problem and the solutions are based on the conservation principle of classical physics.

Keyword(s): fluid extraction, oil extraction, modeling

Saxena, S. K. A Review of the Theories Used in Investigation of Subsidence. Indian Geotechnical Journal, Delhi, v. 11, no. 1, 1981, p. 75-91.

Keyword(s): prediction theories

Location(s): India

Saxena, S. K., ed. Evaluation and Prediction of Subsidence. Proceedings International Conference, Pensacola Beach, FL, January 15-20, 1978, American Society of Civil Engineers, New York, 1979, 594 p.

Subsidence due to withdrawal of ground fluids has been observed in Venezuela, Thailand, Mexico, Italy, Netherlands, and several states in the United States. In the last decade, there has been a significant development in theory and evaluation of methods to predict subsidence. This conference brought together experts in groundwater hydrology, geotechnology, and geologists from various parts of the world. The evaluation of subsidence is a geomechanical problem and requires a synthesis of knowledge from many fields.

Keyword(s): prediction, engineering, modeling, fluid extraction, coal mining, surface structural damage

Schaffer, J. F. Roof Fall Prediction at an Illinois Underground Mine. IN: Proceedings 2nd Conference on Ground Control Problems in the Illinois Coal Basin, May 1985, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 55-63.

Roof fall prediction in coal mines is complicated by the many interacting geological factors contributing to the occurrence of a fall. Empirical methods are typically best suited to characterize the nature of conditions that result in roof falls at a given mine. In this mine in the Springfield seam, clay dikes are the primary cause of roof falls. Collection and analysis of pertinent geological data from 96 falls led to the development of the "Roof Failure Rating System" for predicting the occurrence of roof falls with a reasonable degree of accuracy.

Keyword(s): roof stability, coal mining, partial extraction, mine safety, geologic features

Location(s): Illinois, Illinois Coal Basin, United States

Schaller, S. Stability of Chain Pillars and Gate Roads at South Bulli 'B' Mine Longwalls. Australian Coal Industry Research Labs., Ltd., North Ryde, Australia, October 1983, 80 p.

Keyword(s): pillar strength, longwall, coal mining

Location(s): Australia

Schilizzi, P., M. Karmis, A. Jarosz. Development of Subsidence Prediction Technology from an Extensive Monitoring Program. IN: Proceedings 2nd Workshop on Surface Subsidence due to Underground Mining, Morgantown, WV, June 9-11, 1986, S.S. Peng, ed., West Virginia University, p. 31-43.

A detailed subsidence and strain monitoring program was initiated above a number of active mines, located in three major coal-producing counties of Virginia. The aim of this program was to enhance the database with accurate and complete measurements of surface movements and to allow, therefore, the evaluation and refinement of prediction techniques.

Keyword(s): empirical model, prediction theories, prediction, horizontal displacement, coal mining, law, government, profile function, influence function, monitoring methods, survey equipment, survey methods

Location(s): Virginia, Appalachian Coal Region, United States

Schmechel, F. W., W. F. Eichfeld, W. P. Santy. Automated Data Acquisition for Subsidence Characterization. Presented at SME-AIME Fall Meeting, New Orleans, LA, February 18-22, 1979, SME-AIME preprint 79-132, 12 p.

This paper reviews the design and installation of an automatic data-acquisition system over a coal mine in Illinois to monitor and record ground deformations associated with underground mining operations.

Keyword(s): monitoring design, monitoring installation, monitoring equipment, survey equipment, computer, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Schmidt, B. Settlements and Ground Movements Associated with Tunnelling in Soil. Ph.D. Thesis, 1969, University of Illinois, Urbana-Champaign.

Keyword(s): soils, tunnelling

Schmidt, B. State of Predictive Art in Subsidence Engineering. Discussion ASCE Journal Soil Mechanics & Foundations Division, v. 96, no. SM5, 1970, p. 1841-1843.

Keyword(s): prediction, soil mechanics

Schmidt, B. Prediction of Settlements Due to Tunneling in Soil: Three Case Histories. IN: Proceedings Rapid Excavation and Tunneling Conference, v. 2, 1974, p. 1179-1199.

Keyword(s): prediction, tunnelling

Schmidt, R. D. Fracture Zone Dewatering to Control Ground Water Inflow in Underground Coal Mines. U.S. Bureau of Mines RI 8981, 1985, 84 p.

This investigation focuses on the identification and control of groundwater inflow problems that occur in the active sections of underground Appalachian coal mines. A fracture inflow survey of eight underground mines was conducted. Three types of mine fracture intercepts typical of wet section mining conditions were identified. A mine in Preston County, West Virginia, was selected as the site for a fracture zone dewatering experiment. This investigation indicates that fracture zones are responsible for the sudden release of stored groundwater, which often occurs as mining sections advance beneath fracture valley topography. It is concluded, therefore, that dewatering operations designed to intercept the component of groundwater stored in fracture zones will be most effective in controlling infiltration to active mine sections.

Keyword(s): subsurface water, coal mining, geologic features, hydrology, inflow

Location(s): West Virginia, Appalachian Coal Region, United States

Schmidt, R. D., W. F. Ebaugh. Some Considerations Regarding the Steady-State Response of Shallow Aquifers to Underground Mining. IN: Proceedings, Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation, University of Lexington, KY, December 9-13, 1985, p. 1-7.

The effect of underground room-and-pillar mine development (first mining only) on shallow ground water aquifers is often difficult to predict. A hydrogeologic context that includes not only the underlying mine void, but also multiple aquifer-aquitard layers, and zones of rock fracturing is important to understanding the hydrologic effects of underground mining in eastern coal regions. Nested piezometers were installed at various depths above a mine void in western Pennsylvania. Piezometer measurements indicate a downward gradient in head in the rock units overlying the mine that is highly variable, depending on piezometer depth in relation to fractures and shale aquitard layers.

Keyword(s): coal mining, room-and-pillar, hydrology, subsurface water, overburden, monitoring methods

Location(s): Pennsylvania, Appalachian Coal Region, United States

Schmidt, R. D. Factors Affecting Residential Water Well Yield in the Vicinity of Room and Pillar Mines. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 244-252.

The USBM is conducting an investigation to develop remediation techniques for residential water wells whose yield has been affected in the long term by underground mining. Initial work related to this project was conducted from 1984 to 1987 at a room-and-pillar mine in Indiana County in Pennsylvania.

Keyword(s): hydrology, subsurface water, room-and-pillar, coal mining, longwall, mitigation, geologic features

Location(s): Pennsylvania, Appalachian Coal Region, United States

Schonfeldt, H. V., F. D. Wright, K. F. Unrug. Subsidence and its Effect on Longwall Mine Design. Session papers American Mining Congress, St. Louis, MO, May 20-23, 1979, v. 6, 12 p. (NTIS Accession No. 80-06126)

Keyword(s): longwall, mine design, geologic features

Location(s): United States

Schoonbeck, J. B. Land Subsidence as a Result of Natural Gas Extraction in the Province of Groningen. Society of Petroleum Engineers of AIME, SPE Paper 5751 presented to SPE--European Spring Meeting, 1976, Amsterdam, The Netherlands.

Keyword(s): fluid extraction, oil extraction

Location(s): Netherlands

Schoonbeek, J. B. Land Subsidence as a Result of Gas Extraction in Groningen, The Netherlands. International Association Hydrological Sciences Publication 212, 1977, p. 267-284.

Keyword(s): oil extraction, fluid extraction

Location(s): Netherlands

Schothorst, C. J. Subsidence of Low Moor Peat Soils in the Western Netherlands. Geoderma, v. 17, 1977, p. 265-291.

Keyword(s): fluid extraction, soils

Location(s): Netherlands

Schubert, J. P. Reducing Water Leakage into Underground Coal Mines by Aquifer Dewatering--A Computer Simulation Study. IN: Proceedings 1st World Congress on Water in Mines and Underground Work, SIAMOS, September 18-22, 1978, R. Fernandez-Rubio, ed., Granada, Spain, p. 911-932.

Stratigraphic, structural, hydrogeologic, and mining data were collected during a study in central Pennsylvania. A two-dimensional, finite-difference computer model was used to simulate groundwater flow in a sandstone unit (0.3-11 m thick) overlying an underground mine, and to evaluate the responses of the flow system and leakage rate into the mine when hypothetical dewatering wells are introduced into the system. Simulation of well dewatering, using 25 wells, showed that negligible reduction in leakage would occur if sandstone permeability was less than 0.30 m/day. When sandstone permeability equalled 3.0 m/day, 25 wells reduced leakage by 2.4%.

Keyword(s): computer, modeling, hydrology, subsurface water, coal mining, mine waste, environment, geologic features

Location(s): Pennsylvania, Appalachian Coal Region, United States

Schubert, J. P. Fracture Flow of Groundwater in Coal-Bearing Strata. IN: Proceedings Symposium on Surface Mining Hydrology, Sedimentology, and Reclamation, Lexington, KY, December 1-5, 1980, D.H. Graves and R.W. DeVore, eds., University of Kentucky, UKY BU123, p. 61-73.

Fractures are of considerable importance to groundwater flow through lithified coal-bearing strata. By studying and understanding more about the structural control of fractures in coal basins, the larger inflows possibly could be avoided. This would reduce pumping and water treatment costs and lessen the depletion of groundwater resources in surrounding areas.

Keyword(s): coal mining, subsurface water, hydrology, overburden, lab testing, in situ testing, inflow

Location(s): Appalachian Coal Region, United States

Schuler, K. W., S. E. Benzley, H. J. Sutherland. A Study of Subsidence Over Longwall Panels Using Numerical and Physical Modeling Techniques. IN: Proceedings 19th Annual Meeting, Society of Engineering Science, University of Missouri-Rolla, October 27-29, 1982, p. 189 (abstract only).

Keyword(s): longwall, modeling, physical model

Schulte, H. F. The Effects of Subsidence on the Strata Immediately Above a Working with Different Types of Packing and in Level Measures. IN: Proceedings European Congress on Ground Movement, Leeds, England, April 9-12, 1957, London Harrison, p. 188-197.

Various measurements were made to determine the effectiveness of backfilling methods, as well as to determine the effect of subsidence on roof strata.

Keyword(s): backfilling, subsurface subsidence damage, overburden, roof stability

Schumann, E.H.R. Controlled Subsidence of the Blackhill-Greenside Railway Line: Part 1. Chamber of Mines of South Africa, Research Report 8/83, 1983.

Keyword(s): railroads, active mines

Location(s): South Africa

Schumann, E.H.R. Surface Subsidence Due to the Extraction of Moderately Thick Coal Seams at Shallow Depth. IN: Ground Movements and Structures, Proceedings 3rd International Conference, University of Wales Institute of Science and Technology, Cardiff, 1984, J.D. Geddes, ed., Pentech, London, 1985, p. 248-263.

A significant proportion of the increase in South Africa's coal output comes from open cast mines and collieries employing longwall and pillar extraction methods. As a result of the change in mining technology and the scale of operations, damage to the surface and surface structures becomes a critical factor for the South African coal mining industry. For underground mining, the situation is aggravated by the thickness of the seams being extracted and their relatively shallow depth. This paper describes some results of research work carried out in connection with the undermining of surface structures.

Keyword(s): coal mining, surface structural damage, active mines, longwall, pillar extraction, monitoring methods, survey methods, survey equipment

Location(s): South Africa

Schumann, E. H. R. The Monitoring, Computation and Data Analysis of Surface Subsidence. IN: Proceedings, SANGORM Symposium, October 21, 1986, Sandton, South Africa, International Society for Rock Mechanics, South African National Group.

Surface subsidence monitoring above total extraction coal mine workings was conducted by the 'Radial Precision Survey' method, using a theodolite and an electronic distance meter. The paper concludes that this method meets all of the requirements of modern subsidence monitoring and should therefore replace precise leveling where possible.

Keyword(s): survey methods, survey equipment, survey data processing, monitoring methods, monitoring equipment, profile function, empirical model, horizontal displacement, vertical displacement, coal mining, computer

Location(s): South Africa

Schumann, E. H. R. The Control of Surface Subsidence by Width/Depth Ratio and Chain Pillar Size in the Presence of Competent Coal Measures. IN: Proceedings 7th International Conference on Ground Control in Mining, August 3-5, 1988, S.S. Peng, ed., Morgantown, WV, p. 358-368.

The local stratigraphy and composition of the coal measures, including competent dolerite sill and massive sandstone layers, is shown to have a restricting influence on the development and magnitude of surface subsidence above total extraction panels in South Africa. The critical panel width necessary to induce non-violent failure of a dolerite sill is quantified. Maximum surface subsidence, tilt and ground strain is compared to the National Coal Board model. An exponential subsidence profile curve (SPC) describes a trough half-profile. A parabolic relationship between horizontal displacement and tilt, which has been discovered to exist, can be substituted in the first derivative of the SPC to generate transverse displacement and strain profiles.

Keyword(s): coal mining, active mines, geologic features, overburden, National Coal Board, horizontal displacement, vertical displacement, room-and-pillar, multiple-seam extraction, longwall, pillar extraction

Location(s): South Africa

Schumann, E. H. R. Occurrence of Controlled Coalmining Subsidence in South Africa. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May 1992, South African Institution of Civil Engineers, Republic of South Africa, p. 87-96.

In this paper, an overview is given of results of surface subsidence monitoring above numerous total extraction panels at shallow to moderate depth in various South African coalfields. Statutory restrictions are applied on the undermining of buildings and structures in order to protect them. Modes of surface subsidence are defined in terms of the severity of differential displacements, and the mechanism of caving and the deformation of superincumbent strata is briefly explained.

Keyword(s): surface structural damage, coal mining, active mines, longwall, pillar extraction, vertical displacement, horizontal displacement, survey data processing, National Coal Board, foundations, roads, pipelines, railroads

Location(s): South Africa

Schumann, H. H., J. F. Poland. Land Subsidence, Earth Fissures, and Groundwater Withdrawal in South-Central Arizona, U.S.A. IN: Proceedings Reading Symposium on World Water Balance, Institute of Scientific Hydrology, July, 1970.

Keyword(s): hydrology, subsurface water, fluid extraction

Location(s): Arizona, United States

Schwartz, B., R. Dubois. Effects of the Treatment of the Goaf (Strip Packing or Caving) On the Rock In the Immediate Vicinity. IN: Proceedings European Congress on Ground Movement, Leeds, England, April 9-12, 1957, London Harrison, p. 152-158.

Keyword(s): backfilling, mine waste

Schwartz, B., R. Buisson, R. DuBois. Application of Statistical Methods to Characterize Support Efficiency and Floor Stability. IN: Proceedings, International Strata Control Congress, Leipzig, October 14-16, 1958, p. 137-156 and LXVI-LXV.

The purpose of these investigations was to determine the data for the strength of the surrounding rock and the behavior of the support in the various panels.

Keyword(s): rock mechanics, floor stability, pillar strength, longwall, coal mining

Location(s): France

Schwartz, B. Movements of the Roof and Floor in Roadways. IN: Proceedings 4th Symposium on Rock Mechanics, Mineral Industries Experiment Station Bulletin 76, The Pennsylvania State University, University Park, 1961, p. 1-10.

This paper includes an approximate mathematical method of forecasting long-term movements in roadways, to facilitate design of roadway supports.

Keyword(s): coal mining, floor stability, roof stability, rock mechanics, mine design, mathematical model

Location(s): United States

Schwarz, S. D., G. McLucas. Detection of Destressed Rock and Potential Collapse Above Old Mine Workings by the Seismic Refraction Method. IN: Proceedings Symposium on the Application of Geophysics to Engineering and Environmental Problems, Society of Engineering and Mineral Exploration Geophysicists, March 28-31, 1988, p. 658-665.

The delineation of existing or potential geologic hazards related to the subsidence, relaxation or weakening of rock above old mine workings is important to public safety and the mitigation of property damage. The detection of areas of destressed rock by conventional exploration methods can be extremely difficult and expensive. A number of sites in coal-mining areas of the western and northwestern United States have been explored using seismic refraction. It has been demonstrated that low velocity zones in bedrock can be diagnostic of destressed zones in bedrock above old mine workings. In areas where no detailed or reliable mine maps are available, low velocity zones in bedrock interpreted from highly detailed seismic velocity profiles can provide a basis for establishing targets for more direct methods of exploration.

Keyword(s): abandoned mines, seismic, geophysical, coal mining, overburden, geologic features

Location(s): Washington, United States

Scotese, T. R. Instrumentation and Monitoring for Pillar Extraction in a Deep, Faulted Uranium Mine. IN: Rock Mechanics in Productivity and Protection, Proceedings 25th Symposium on Rock Mechanics, Northwestern University, Evanston, IL, June 25-27, 1984, C.H. Dowding and M.M. Singh, eds., SME-AIME, New York, p. 513-522.

A rock mechanics instrumentation and monitoring program was implemented during pillar extraction at the deepest uranium mine in the United States. Three types of monitoring were employed: (1) drift convergence around stopes (using a portable tube extensometer), (2) stress changes in pillars (using vibrating wire stressmeters in horizontal boreholes), and (3) load changes in haulageways under stopes (using vibrating load cells in jack stands). The instrumentation and monitoring program provided a warning system against ground control problems and a characterization of ground behavior for future development and extraction of pillars.

Keyword(s): pillar extraction, metal mining, instrumentation, monitoring methods, monitoring equipment

Location(s): New Mexico, United States

Scott, A. C. Locating and Filling Old Mine Workings. Civil Engineering Public Works Review, v. 52, 1957, p. 1007-1011.

Keyword(s): backfilling, abandoned mines

Scott, J. J. Practical Ground Control as it Relates to Productivity, Safety and Costs. IN: 2nd Conference on Ground Control Problems in the Illinois Coal

Basin, May 1985, Southern Illinois University, Carbondale, Y.P. Chugh, ed., (keynote address), p. 1-7.

Rock mechanics theory needs to be applied to solve ground control problems but, in the final analysis, the mining method and equipment used will be those that solve problems in a practical manner. Equipment and its inherent productivity and safety as supplied by "off the shelf" items by manufacturers often dictate the size of mine openings. In this whole process, the costs of mining finally dictates what system will be employed and what equipment will be used.

Keyword(s): ground control, mine safety, rock mechanics, economics, mine operation, geologic features, instrumentation, roof bolting, coal mining, metal mining

Location(s): United States

Scott, R. F. Subsidence--A Review. IN: Evaluation and Prediction of Subsidence, Proceedings International Conference, Pensacola Beach, FL, January 15-20, 1978, S.K. Saxena, ed., ASCE, New York, 1979, p. 1-25.

In this paper, a brief review is given of surface movement mechanisms, analytical techniques, and a few case histories.

Keyword(s): horizontal displacement, vertical displacement, fluid extraction, geologic features, coal mining, modeling, oil extraction, finite element

Scurfield, R. W. Reconstruction in the North Staffordshire Coalfield. Colliery Guardian, v. 195, no. 5030, July, 1956, p. 95.

Keyword(s): backfilling, coal mining

Location(s): United Kingdom

Segatto, P., W. F. Heinz. Backfilling of Coal Mines. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May 1992, South African Institution of Civil Engineers, Republic of South Africa, p. 237-241.

This paper describes primarily the two types of backfilling operations done in the undermined coalfields in Ermelo. Particular reference has been made to filling under fiery and flooded mine conditions. This successful backfilling operation had to take into account the availability and pumpability of the backfill material in the Ermelo area, while at the same time minimizing the costs to make the exercise economically viable.

Keyword(s): backfilling, coal mining, abandoned mines, hydraulic backfilling

Location(s): South Africa

Seils, D. E., R. G. Darmody, F. W. Simmons. Water Movement on Aeric Ochragualf as Revealed by Dye Tracers. IN: Agronomy Abstracts, American Society of Agronomy/Soil Science Society of America 82nd Annual Meeting, San Antonio, TX, October 21-26, 1990, p. 303.

A solution of dye and tracer was ponded on three pedons to characterize the macroporosity and flow paths of an Aeric Ochraqualf with a weak fragipan, located over a subsiding longwall panel.

Keyword(s): agriculture, soils, longwall, active mines, coal mining, hydrology

Location(s): Illinois, Illinois Coal Basin, United States

Seils, D. E., R. G. Darmody, F. W. Simmons. The Effects of Coal Mine Induced Subsidence on Macropores and Bromide Movement. IN: Agronomy Abstracts, American Society of Agronomy/Soil Science Society of America, October 27-November 1, 1991, Denver, CO, p. 51.

Subsidence is increasing as the coal-mining industry adopts more efficient methods of underground extraction. Subsidence as deep as 2 meters and cracks as wide as 0.3 meters can develop above a mine panel. However, most noticeable cracks close after the mining front moves beyond a given point. Field studies were initiated to determine if subsidence cracks result in greater preferential flow.

Keyword(s): soils, active mines, longwall, agriculture, mitigation, subsurface water

Location(s): Illinois, Illinois Coal Basin, United States

Seils, D. E., R. G. Darmody, F. W. Simmons. The Effects of Coal Mine Subsidence on Soil Macroporosity and Water Flow. IN: Proceedings National Symposium on Prime Farmland Reclamation, 1992, R.E. Dunker, R.I. Barnhisel, and R.G. Darmody, eds., Department of Agronomy, University of Illinois, Urbana, p. 137-145.

A field study using Rhodamine B dye and bromide tracers was conducted to determine whether subsidence fractures remain in the soil and contribute to increased preferential flow. Results indicated that cracks remain in the soil along the mine panel edge 8 months after subsidence. Preferential flow was shown to be enhanced at this site following subsidence. However, evidence of this is lacking for the panel center. Further research is needed to determine if groundwater quality changes occur as a consequence of subsidence cracks along the mine panel edge.

Keyword(s): active mines, soils, longwall, coal mining, agriculture, subsurface water, hydrology
Location(s): Illinois, Illinois Coal Basin, United States

Seils, D. E. Soil-Hydrological Impacts of Coal Mine Subsidence. M.S. Thesis, University of Illinois Department of Agronomy, 1992, 93 p.
A field study was undertaken to determine whether soil cracks resulting from coal mine induced subsidence allowed greater preferential flow of water through soil and also to document the effects of subsidence on near-surface groundwater elevations. A solution of Rhodamine B dye and bromide were applied to characterize changes in soil structure and water movement. Cracks were found to remain in the soil at the mine panel edge eight months after subsidence as revealed by the dye. Dye patterns at the panel center line revealed no subsidence cracks. Groundwater elevations at the site a year after subsidence were approximately the same as before subsidence.
Keyword(s): agriculture, soils, hydrology, coal mining, active mines, longwall, monitoring methods
Location(s): Illinois, Illinois Coal Basin, United States

Seldrenrath, R. Can Coal Measures be Considered as Masses of Loose Structures to Which the Laws of Soil Mechanics May be Applied? IN: International Conference on Rock Pressure and Support in the Workings, Liege, 1951, p. 79-83.
Keyword(s): coal mining, overburden, soil mechanics

Selman, P. H. Coal Mining and Agriculture: A Study in Environmental Impact Assessment. Journal of Environmental Management, 22, 1986, p. 157-186.
Coal mining activities in the United Kingdom are extending into areas of comparatively unspoilt countryside. Despite reductions in the National Coal Board's program of future expansion, it is considered that the scale of impact of new mining activities on agriculture is still likely to be significant. The major impact will be associated with land alienation, but a wide range of other adverse effects will also be encountered. In view of the controversy likely to accompany new mining proposals, it is recommended that methods of environmental impact assessment (EIA) should be adopted. The nature and components of EIA are reviewed, and a framework appropriate to mining-agriculture conflicts is advanced.
Keyword(s): coal mining, agriculture, environment, reclamation, active mines, mine waste, soils, vertical displacement, horizontal displacement
Location(s): United Kingdom

Sendlein, L. V. A., H. Yazicigil, C. L. Carlson, H. K. Russell, eds. Surface Mining, Environmental Monitoring and Reclamation Handbook. Coal Extraction and Utilization Research Center, Southern Illinois University, Carbondale, U.S. Department of Energy Contract No. DE AC22 80ET 14146. Elsevier, New York, 1983, 750 p.
The process for constructing this handbook was based on the philosophy that experts working in the field could best describe the state of the art of monitoring and planning to meet the requirements of the SMCRA (1977). The book has eight chapters on geology, hydrology, reclamation, air quality, blasting, fish and wildlife, archaeological resources, and subsidence. Each chapter has sections written by various experts on the subject.
Keyword(s): monitoring methods, reclamation, environment, geologic features, hydrology, surface structural damage, wildlife
Location(s): Illinois Coal Basin, Appalachian Coal Region, Rocky Mountain Coal Region, United States

Sendlein, L. V. A., J. S. Dinger, T. D. Fickel. Impact of Underground Coal Mining on the Anvil Rock Aquifer. IN: Proceedings 4th Conference on Ground Control for Midwestern U.S. Coal Mines, Mt. Vernon, Illinois, November 2-4, 1992, Y.P. Chugh and G. Beasley, eds., Southern Illinois University, Carbondale, p. 15-50.
This paper describes the data collection and analysis performed to assess the impact of underground coal mining on groundwater. The coal mine under study is located in western Kentucky in a region that has been mined for the last 50 years. A major aquifer is present in the area and is a stratigraphic unit that occurs in both sheet and channel phases.
Keyword(s): active mines, abandoned mines, room-and-pillar, subsurface water, hydrology, geologic features, coal mining
Location(s): Kentucky, Illinois Coal Basin, United States

Serata, S., B. H. Gardner. Prediction and Design Control of Surface Subsidence by Global Simulation of Mine Behavior Using Finite Element Model. IN: Proceedings 2nd Workshop on Surface Subsidence due to Underground Mining, Morgantown, WV, June 9-11, 1986, S.S. Peng, ed., West Virginia University, p. 44-53.

The Stress Control Method of mine design provides enhanced engineering control over the behavior of underground structures in comparison to conventional mine design methods. A field example is given in this paper to illustrate the application of this method.

Keyword(s): finite element, mine design, computer, modeling, prediction

Serata, S., F. Carr. Stress Control Method Applied to Stabilization of Underground Coal Mine Openings. IN: Rock Mechanics in Productivity and Protection, Proceedings 25th Symposium on Rock Mechanics, Northwestern University, Evanston, IL, June 25-27, 1984, C.H. Dowding and M.M. Singh, eds., SME-AIME, New York, p. 583-590.

Serious floor heave of as much as 2.4 meters in a 2.4-meter-high mine entry was eliminated by applying the stress control method of mining in the Black Warrior coal basin near Birmingham, Alabama. Underground observation of the first three-room entry created using the stress control method is discussed here. The behavior of the test entry, which eliminated the heave problem, is analyzed in relation to studies conducted in a salt mine underground conditions by using finite element analysis.

Keyword(s): finite element, floor stability, coal mining, non-metal mining

Location(s): Alabama, United States

Serata, S., B. Das, K. Shrinivasan, V. J. Hucka. Application of the Stress-Property-Deformation Relation (SPDR) Technology to Underground Mine Design Optimization. IN: Proceedings, International Symposium on Underground Engineering, New Delhi, India, April 14-17, 1988, B. Singh, ed., Balkema, Rotterdam, p. 157-163.

The behavior of complex ground commonly involves a number of behavioral components, including elasticity, viscoelasticity, viscoplasticity, strength deterioration, strain hardening, and brittle ductile movement. A quantitative approach for analyzing and designing earth structures in such complex ground has been synthesized from in situ stress measurement, in situ property measurement, field deformation measurement, and development of an REM (Rheological Element Method) finite element computer program.

Keyword(s): yielding supports, in situ testing, ground control, instrumentation, finite element, computer

Location(s): Pennsylvania, Appalachian Coal Region, United States

Sgambat, J. P., E. A. LaBella, S. Roebuck. Effects of Underground Coal Mining on Ground Water in the Eastern United States. Geraghty & Miller, Annapolis, MD, US EPA-600/7-80-120, Contract No. 68-03-2467, June, 1980, Industrial Environmental Research Laboratory, Office of Research and Development, US EPA, Cinncinnati, 183 p.

This report addresses the past effects and the possible future effects of underground coal mining activities on groundwater resources in the region east of the 100th meridian. Such effects are highly dependent on the location of the mine with respect to natural flow system. Recharge-discharge relationships in the vicinity of active mines may be altered, and lowered groundwater levels may not recover to pre-mining conditions after closure. Studies indicate that contamination of groundwater exists in many places in the immediate vicinity of coal mines. Many refuse piles and impoundments probably affect the quality of streams and shallow groundwater. However, on a regional basis, there is little evidence from the scanty data on hand of gross groundwater contamination in heavily mined areas.

Keyword(s): coal mining, subsurface water, hydrology, mine waste, inflow, surface water, active mines, bituminous, anthracite, abandoned mines

Location(s): Alabama, Illinois, Indiana, Kentucky, Maryland, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia, Illinois Coal Basin, Appalachian Coal Region, United States

Shadbolt, C. H., W. J. Mabe. Subsidence Aspects of Mining Development in Some Northern Coalfields. IN: Geological Aspects of Development and Planning in Northern England, P.T. Warren, ed., Yorkshire Geological Society, Leeds, England, 1970, p. 108-123.

This paper discusses three factors pertaining to surface development and exploitation in undermined areas: orthodox ground movements related to the dimensions of mineral extraction, geotechnical conditions, and the tolerance of surface structures to ground movements.

Keyword(s): mine design, mine operation, surface structural damage, structural mitigation, coal mining, land-use planning, geologic features

Location(s): England

Shadbolt, C. H., B. N. Whittaker, D. J. Forrester. Recent Developments in Mining Subsidence Engineering. IN: 64th General Meeting of the Midland County Mineral Division of the Royal Institute of Chartered Surveyors, Nottingham, October 19, 1973.

This paper examines methods of subsidence prediction and engineering and their influence by local geological site conditions. Subsidence aspects of both deep mining and surface mining are dealt with in detail and attention is focused on structural aspects of mining subsidence. The authors describe current forms of instrumentation and field measurement techniques.

Keyword(s): prediction, survey methods, instrumentation, geologic features, surface structural damage

Location(s): United Kingdom

Shadbolt, C. H. Mining Subsidence. IN: Site Investigations in Areas of Mining Subsidence, F.G. Bell, ed. Newnes-Butterworths, 1975, p. 109-124.

Shadbolt, C. H. Mining Subsidence and Protective Measures for Surface Structures. Chartered Surveyor Land Hydrology & Mineral Quarterly, v. 3, no. 2, 1975-76, p. 29-32.

Keyword(s): surface structural damage, engineering

Shadbolt, C. H. Mining Subsidence--Historical Review and State of the Art. IN: Large Ground Movements and Structures, Proceedings International Conference, University of Wales Institute of Science and Technology, Cardiff, 1977, J.D. Geddes, ed., John Wiley & Sons, New York, 1978, p. 705-748.

The author discusses various subsidence parameters and their effects as they relate to mine extraction dimensions, and explains various means of reducing subsidence damage. Also included is a historical review of the theories and work by early subsidence investigators.

Keyword(s): vertical displacement, horizontal displacement, surface structural damage, subsurface structural damage, survey data processing, engineering, historical, prediction theories

Shadbolt, C. H. A Study of the Effects of Geology on Mining Subsidence in the East Pennine Coalfield. Ph.D. Thesis, University of Nottingham, UK, 1987.

Keyword(s): geologic features, coal mining

Shadrin, A. G. Trajectory of a Point at the Surface Near An Advancing Extraction Face. Soviet Mining Science, v. 9, no. 1, January/February 1973, p. 7-10.

Keyword(s): surface subsidence damage

Location(s): Soviet Union

Shadrin, A. G., A. S. Yagunov. Raschet Maksimal Nykh Velichin Sdvizhenii Zemnoi Poverkhnosti Pri Podzemndi Razrabotke Ugol'Nykh Mestorozhdenii (Calculation of Maximum Shifts of the Ground Surface Due to Underground Working of Coal Deposits). Permskii Politehniceskii Institut, U.S.S.R., Izvestiya Vysshikh Uchebnykh Zavedenij, Gornyj Zhurnal, no. 11, 1973, p. 53-58.

Keyword(s): prediction, coal mining

Location(s): Soviet Union

Shea-Albin, V. R. Effects of Longwall Subsidence on Escarpment Stability. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 272-279.

Because sandstone escarpments are an environmental issue, millions of tons of coal reserves that underlie these escarpments risk being classified as unminable by regulatory agencies. At this time, the effect of subsidence on escarpments has not been well documented or characterized. The USBM is using numerical modeling techniques to analyze escarpment response to longwall mining. Two- and three-dimensional models have been constructed for a study area near Price, Utah, where longwall panels were mined near an escarpment.

Keyword(s): coal mining, longwall, geologic features, active mines, environment, wildlife, modeling, finite element, boundary element

Location(s): Utah, Rocky Mountain Coal Region, United States

Shelton, J. W. Role of Contemporaneous Faulting During Basinal Subsidence. Bulletin American Association of Petroleum and Geology, v. 52, no. 3, 1968, p. 399-413.

Keyword(s): fluid extraction, geologic features

Sheng, X. L., S. Y. Jing. The Research on the Mechanical Properties of Hard Roof in Underground Coal Mining. IN: Rock Mechanics as a Guide to Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 579-586.

During the course of mining, when the roof above coal seams is constituted by thick and hard sandstone, sudden roof movements often take place with great force and destruction, which is the biggest danger to safety and production. Such severe movements of the roof directly relate to rock mechanical properties, which are the main factors that influence the regularity of hard roof movement and its destruction form. A significant way to apply rock mechanics into mining engineering is to study the properties of the hard roof; parameters can then be altered that will help to more efficiently control the movement of the hard roof.

Keyword(s): coal mining, roof stability, overburden, rock mechanics, engineering, active mines

Location(s): China

Sheorey, P. R., B. Singh. Strength of Rectangular Pillars in Partial Extraction. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 11, no. 1, January, 1974, p. 41-44.

Model sandstone pillars were used in laboratory compression tests. The concluding theory was that average width rather than least width is important in determining pillar strength.

Keyword(s): room-and-pillar, pillar extraction, pillar strength, rock mechanics, partial extraction, lab testing

Sheorey, P. R., T. N. Singh, B. Singh. Considerations for the Stability of Longwall Chain Pillars and Adjacent Roadway. IN: Strata Mechanics, Proceedings of the Symposium, University of Newcastle-upon-Tyne, April, 1982, Elsevier, New York, I.W. Farmer, ed., p. 129-133.

The old subject of stability of chain pillars and a roadway protected by them is dealt with using a new approach. The simple method of the theory of beams on elastic support is used to estimate the one-sided pressure distribution over the chain pillars when the goaf is only on one side. It is shown how the mechanical properties involved in the method can be determined measuring roof-seam contact displacements in situ. Even if the pillars per se are stable, the roadway they protect may still show signs of distress, as shown in a case study. A modern rock mass classification has been applied to assess roadway stability.

Keyword(s): longwall, mine design, pillar strength, in situ testing, modeling, coal mining, roof support, rock mechanics

Location(s): India

Sheorey, P. R., M. N. Das, D. Barat, R. K. Prasad, B. Singh. Coal Pillar Strength Estimation from Failed and Stable Cases. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 24, no. 6, December, 1987, p. 347-355.

A new pillar strength equation is proposed for all practical values of width-height ratio based on 23 unstable and 20 stable pillar cases. Strength data of a number of coal seams are used to show that the in situ large-scale strength is more likely to be affected by depth of cover than the laboratory small-specimen strength. The latter is therefore incorporated in the new equation. Performance of some of the better known pillar strength formulas is compared with the new equation against the case studies. It is proposed that the safety factor should be changed with depth of cover and width-height ratio of pillars. Safety factor values are accordingly recommended for stowed and unstowed pillar arrays and chain pillars. An alternative simpler equation is also proposed for slender pillars.

Keyword(s): pillar strength, coal mining, lab testing, in situ testing

Location(s): India

Sheorey, P. R., B. Singh. Case Studies of Depillaring Under Special Strata and Mining Conditions. IN: Proceedings 7th International Conference on Ground Control in Mining, August 3-5, 1988, S.S. Peng, ed., Morgantown, WV, p. 351-357.

Four case studies of special geomining conditions from Indian coalfields are discussed. These cases relate to pillar extraction in two seams simultaneously under a difficult roof, depillaring in an inclined seam resulting in rib instability, depillaring resulting in floor lift and side spalling, and contiguous pillar extraction under hard incavable strata. Solutions to these problems are given based on rock mechanics principles involving stress analysis, classification techniques, past experiences, and engineering judgement.

Keyword(s): pillar extraction, coal mining, multiple-seam extraction, rock mechanics, active mines, floor stability, overburden, geologic features

Location(s): India

Sherman, G. D. Assessment of Subsidence Related Damage to Structures in Louisville and Lafayette, Colorado. IN: Proceedings Conference on Coal Mine Subsidence in the Rocky Mountain Region, Colorado Springs, October 28-30, 1985, J.L. Hynes, ed., Colorado Geological Survey Special

Publication 31, Department of Natural Resources, Denver, 1986, p. 87-95.
Many theoretical methods are available to estimate subsidence induced horizontal ground strains. However, no evidence exists as to the magnitude of ground strains developed from collapse or the type and amount of structural damage that can be expected. To quantify the above questions, the author conducted an investigation of structures that are underlain by mine workings but were built prior to mining.
Keyword(s): abandoned mines, surface structural damage, horizontal displacement, foundations, prediction, empirical model, influence function, coal mining, architecture
Location(s): Colorado, Rocky Mountain Coal Region, United States

Sherrey, P., R. Dunham. An Approximate Analysis of Floor Heave Occurring in Roadways Behind Advancing Longwall Faces. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 15, 1978, p. 277-288.
Keyword(s): floor stability, longwall

Shih, S. F., J. W. Mishoe, J. W. Jones, D. L. Myhre. Subsidence Related to Land Use in Everglades Agricultural Area. Transactions, American Society Agricultural Engineers, 22, 1979, 560-568.
Keyword(s): land-use planning, agriculture
Location(s): Florida, United States

Shilang, L. Rational Layout of Roadways in Floor Strata Affected by Longwall Extraction. IN: Strata Mechanics, Proceedings of the Symposium, University of Newcastle-upon-Tyne, April, 1982, I.W. Farmer, ed., Elsevier, New York, p. 201-206.
Keyword(s): mine design, mine operation, longwall

Shippam, G.K. Numerical Investigation of Elastic Behaviour Around Longwall Excavations. Ph.D. Dissertation, University of Nottingham, 1970.
Keyword(s): longwall, modeling
Location(s): England

Shoemaker, F. D. How and Why Backfill Anthracite Mines. Coal Age, v. 44, May, 1939, p. 68.
A 4.5-foot. seam was successfully extracted beneath an industrial and residential district.
Keyword(s): anthracite, backfilling, room-and-pillar, coal mining, economics
Location(s): Pennsylvania, Appalachian Coal Region, United States

Shoemaker, H. D., S. H. Advani, F. D. Gmeindl, Y. T. Lin. Studies of Thermo-Mechanical Subsidence Associated with Underground Coal Gasification. IN: Evaluation and Prediction of Subsidence, International Conference, Pensacola Beach, FL, ASCE, 1979.
Keyword(s): coal gasification
Location(s): United States

Shoemaker, R. P. A Review of Rock Pressure Problems. American Institute Mining and Metallurgy Engineers Technical Publication 2495, 1948, 14 p.
Keyword(s): mine operation, rock mechanics
Location(s): United States

Shoemaker, R. P., T. J. Thorley. Problems of Ground Subsidence. Journal of the American Water Works Association, v. 47, April, 1955, p. 412-418.
This paper describes subsidence problems associated with oil extraction from the Wilmington oil field in Long Beach, California. Repressurization using gas or water as a means of arresting subsidence is briefly mentioned.
Keyword(s): oil extraction
Location(s): California, United States

Shoemaker, R. R. Protection of Subsiding Waterfront Properties. Journal of the Waterways Division, ASCE, v. 81, Proceedings Paper 805, p. 805-1--805-24, September, 1955.
Subsidence resulted from a reduction of fluid pressure in the Wilmington oil field.
Keyword(s): oil extraction, surface structural damage
Location(s): United States, California

Shoham, D., L. Levin. Subsidence on the Reclaimed Hula Swamp Area of Israel. Israel Journal of Agricultural Research, 18, 1968, p. 15-18.
Keyword(s): fluid extraction, agriculture
Location(s): Israel

Shultz, R. A. Ground-Water Hydrology of Marshall County, West Virginia, with Emphasis on the Effects of Longwall Coal Mining. U.S. Geological Survey Water-Resources Investigations Report 88-4006, in cooperation with Marshall County Commission, Charleston, WV, 1988, 147 p.
This report describes the groundwater hydrology of Marshall County, West Virginia, with emphasis on the effects of longwall coal mining.

Two hundred and eighteen wells and 59 springs were inventoried. A groundwater monitoring network was established whereby water levels in 62 wells and discharges of 13 springs were measured at least monthly. Single-well aquifer tests were made at three sites. The following geophysical logs were run on selected wells: gamma ray--15 wells, caliper--14 wells, and electric resistivity--2 wells. Two observation wells were drilled in July 1985 ahead of an advancing longwall panel to obtain pre- and post-mining data. Water samples from 56 wells and 16 springs were analyzed for major chemical constituents. Additional ground-water data obtained during previous studies by the USGS also are available.

Keyword(s): subsurface water, surface water, hydrology, geologic features, coal mining, longwall, overburden, geophysical, monitoring methods

Location(s): West Virginia, Appalachian Coal Region, United States

Siddle, H. J., M. E. Oliver, P. Ansell. The Effect of Mining Subsidence on Spoil Heap Stability: A Case History. IN: Ground Movements and Structures, Proceedings 3rd International Conference, University of Wales Institute of Science and Technology, Cardiff, 1984, J.D. Geddes, ed., Pentech, London, 1985, p. 264-278.

This paper describes the methods used to assess the possible effects of mining shallow panels of coal by rapid retreat beneath the a tip complex. Critical areas of the tip included tailings lagoons, some of which were capped, and a 45-meter-high face overlooking a road and cottages. The measures recommended to enable completion of the tip are described, together with the results of the monitoring performed during the mining.

Keyword(s): coal mining, active mines, mine waste, geotechnical, monitoring methods, vertical displacement, horizontal displacement

Location(s): United Kingdom

Siekmeier, J. A., K. M. O'Connor, L. R. Powell. Rock Mass Classification Applied to Subsidence Over High Extraction Coal Mines. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 317-325.

The USBM uses a commercially available computer spreadsheet program in combination with a modified version of Bieniawski's Rock Mass Rating system to characterize the geology overlying high extraction coal mines. The results presented in this paper focus on the relationship between the bridging potential of individual beds and the deformation measured using Time Domain Reflectometry. Subsurface displacements measured over seven high-extraction coal mines in southern Illinois were correlated with the bed stiffness and bridging potential profiles.

Keyword(s): instrumentation, monitoring methods, geologic features, coal mining, active mines, monitoring equipment, computer, modeling, rock mechanics, overburden, longwall, high-extraction retreat

Location(s): Illinois, Illinois Coal Basin, United States

Simes, D. J., F. E. Jaggar. Strata Control in Mining Operations in a New Mine at South Bulli Colliery. IN: 5th International Strata Control Conference, London, 1972, Paper 3, 9 p.

Keyword(s): ground control, active mines

Sims, F. A., R. J. Bridle. Bridge Design in Areas of Mining Subsidence. Journal Institute Highway Engineers, v. 13, 1966, p. 19-38.

Keyword(s): surface structural damage, engineering

Sinclair, D., P. B. Bucky. Photoelasticity and its Applications to Mine Pillar and Tunnel Problems. Transactions, AIME, v. 139, 1940, p. 224-252.

Isotropic transparent material was stressed and viewed with polarized light, obtaining an image indicating the magnitude of the stress in color bands of light. This method studies the principal points of maximum stresses in loaded model pillars; it includes the effects of cutting the tops of the pillars or of tunnelling underneath them.

Keyword(s): pillar strength, modeling, tunnelling

Location(s): United States

Sinclair, J. Mining Subsidence in the South Yorkshire Coalfield. Transactions, Institute Mining Engineers, London, v. 110, 1951, p. 365-387.

This paper deals with a method of setting out lines of stations to observe subsidence and accompanying lateral movements; observation techniques and results are described in detail.

Keyword(s): survey design, survey methods, coal mining, vertical displacement, horizontal displacement

Location(s): England

Sinclair, J. Ground Movement and Control at Collieries. Sir Isaac Pitman & Sons Ltd., London, England, 1966, 93 p.

The author discusses methods of roof support for safe and economical extraction of coal. One chapter is devoted to methods of reducing subsidence damage. These methods include measures taken underground in the layout and workings, such as packing and stowing, and precautions to be taken on the surface during construction.

Keyword(s): ground control, roof support, economics, construction, engineering, mine design, stowing, coal mining

Singh, L. N., M. A. Rafigui, B. Singh. Angle of Fracture in Mine Subsidence. Journal of Mines Metals & Fuels, v. 24, 1976, p. 375-385.

Singh, M. M., W. J. Courtney. Application of Pneumatic Stowing in United States Coal Mines. AIME Annual Meeting, Dallas, Texas, February 24-28, 1974.

This paper gives details of methods and equipment used in pneumatic filling and describes various problems involved; it also mentions potential explosion hazards.

Keyword(s): pneumatic backfilling, coal mining

Location(s): United States

Singh, M. M. Experience With Subsidence Due to Mining. IN: Evaluation and Prediction of Subsidence, Proceedings International Conference, Pensacola, Beach, FL, January 15-20, 1978, S.K. Saxena, ed., ASCE, New York, 1979, p. 92-112.

This paper lists states in the United States with subsidence damage and suggests a dual approach to attack the problem.

Keyword(s): surface subsidence damage, subsurface subsidence damage, environment, prediction

Location(s): United States

Singh, M. M., F. S. Kendorski. Strata Disturbance Prediction for Mining Beneath Surface Water and Waste Impoundments. IN: Proceedings 1st Annual Conference on Ground Control in Mining, July 27-29, 1981, S.S. Peng, ed., West Virginia University, Morgantown, p. 76-89.

The scope of this paper is limited to the exploitation of stratified mineral deposits with overlying surface bodies of water.

Keyword(s): surface water, coal mining, prediction, inflow

Location(s): United States

Singh, M. M. Review of Subsidence Control Measures--Past, Present, and Future. SME-AIME preprint #84-182, SME-AIME Annual Meeting, Los Angeles, CA, February 26-March 1, 1984, 6 p.; also Transactions, AIME, v. 276, 1985, p. 1988-1992.

The author reviews subsidence control measures to meet new regulations, including basic techniques and specific procedures to implement those measures.

Keyword(s): land-use planning, partial extraction, backfilling, room-and-pillar, surface structural damage, law, ground control

Location(s): United States

Singh, M. M., S. Bhattacharya. Proposed Criteria for Assessing Subsidence Damage to Renewable Resource Lands. Preprint No. 84-341, SME-AIME Fall Meeting, 1984, Denver, CO.

This paper attempts to establish relationships of various levels of subsidence damage for aquifers, agricultural lands, and other renewable resource areas.

Keyword(s): hydrology, agriculture, environment, land-use planning, surface subsidence damage, subsurface water, surface water, coal mining

Location(s): United States

Singh, M. M., S. Bhattacharya. Proposed Criteria for Assessing Subsidence Damage to Renewable Resource Lands. Mining Engineering, March, 1987, p. 189-194.

The Surface Mining Control and Reclamation Act of 1977 (SMCRA) requires underground coal mine operations to prevent "material damage" to renewable resource lands caused by subsidence. However, what constitutes material damage is not defined. This paper discusses the applicable criteria for agricultural lands, forests and grazing lands, surface water bodies, and aquifers. Although data on the subject are limited, an attempt is made to present quantitative guidelines to distinguish between moderate and severe damage due to subsidence.

Keyword(s): law, surface subsidence damage, surface water, subsurface water, hydrology, agriculture, environment, land-use planning, coal mining, inflow

Location(s): United States

Singh, M. M., ed. Mine Subsidence. Proceedings of Society of Mining Engineers Fall Meeting, September, 1986, St. Louis, MO, SME, Littleton, CO, 143 p.

This volume contains chapters on the following subjects: modeling and prediction, case histories, regulatory aspects, and subsidence in hardrock mining.

Keyword(s): coal mining, metal mining, non-metal mining, modeling, prediction, law

Singh, R. N., S. Hibberd, R. J. Fawcett. Numerical Calculation of Groundwater Inflow to Longwall Coal Faces. IN: Mine Water, Proceedings 2nd International Congress, Granada, Spain, September 1985, R. Fernandez-Rubio, ed., v. 1, p. 541-552.

The paper describes numerical calculations of groundwater inflow to longwall coal faces through heterogeneous anisotropic rock strata using the boundary element method. The influence of mining induced changes in conductivity is investigated. The effect of a protective layer of intact rock between damaged strata and water bearing strata is examined. Results are supported by diagrams of Darcy seepage velocities.

Keyword(s): longwall, coal mining, hydrology, subsurface water, modeling, boundary element

Singh, S. P. Ground Control Aspects of Longwall Design. IN: Strata Mechanics, Proceedings of the Symposium, University of Newcastle-upon-Tyne, April, 1982, I.W. Farmer, ed., Elsevier, New York, p. 123-128.

Recognizing the important role to be played by longwall mining in achieving the projected doubling of coal production in the United States, the author endeavours to outline the basic considerations for longwall design with a special focus on ground control measures. The influence of the geological features, geotechnical considerations, seam characteristics and support system on the longwall design is discussed. The importance of design and stability of gate roadways are considered. Special emphasis is given to the significance of ground control measures in the success of a longwall design.

Keyword(s): longwall, mine design, ground control, coal mining, geologic features, geotechnical, roof stability

Location(s): United States

Singh, T. N., B. Singh. Partial Extraction to Minimize Surface Subsidence. Journal of Mines, Metals, Fuels, v. 12, December 1964, p. 369-379.

Keyword(s): partial extraction, surface subsidence damage

Singh, T. N., R. N. Gupta. Influence of Parameters of Packing on Surface Protection. Journal of Mines, Metals, Fuels, v. 16, February, 1968, p. 37-52.

Subsidence mechanics are briefly outlined, followed by a discussion on the economic aspects of packing. Various packing parameters are defined, including compressibility, consolidation, cementation, packing efficiency, and pack density. The results of previous research are summarized for each parameter; useful information on the angle of draw is included.

Keyword(s): backfilling, economics, angle of draw

Singh, T. N., B. Singh. Angle of Draw in Mine Subsidence. Journal of Mines, Metals, Fuels, v. 16, July 1968, p. 253-258.

This paper analyzes the effect of different natural and operational factors on the magnitude of the angle of draw in mine subsidence with reference to the mechanism of draw. It also discusses the importance of angle of draw in measuring methods.

Keyword(s): vertical displacement, horizontal displacement, backfilling, angle of draw

Singh, T. N., B. Singh. Load and Convergence Measurements in Worked Out Areas in Mines--A Critical Review. Journal of Mines, Metals, and Fuels, January, 1971, p. 7-21.

Singh, T. N., B. Singh. Strata Movement Around Workings in a Massive Formation--Equivalent Material Model Investigation. Journal of Mines, Metals, and Fuels, v. 20, no. 9, September, 1972, p. 267-274.

Keyword(s): modeling

Singh, T. N., B. Singh. Model Studies of Strata Movement Around a Longwall Face. Journal of Mines, Metals, and Fuels, v. 25, no. 2, February, 1977, p. 39-43.

Keyword(s): modeling, longwall

Singh, T. N., B. Singh. Caving of a Coal Seam Under Kamptee Aquifers of India. IN: Symposium on Water in Mining and Underground Works, SIAMOS--78, Granada, Spain, September 18-22, 1978, p. 657-673.

A coal seam of the Chanda-Wardha Valley of Maharashtra is overlain by the Kamptee formation, which is reported to be highly aquiferous. This seam developed on the bord-and-pillar system has rarely been depillared in conjunction with hydraulic stowing with a view of avoiding water hazards. It is proposed to try caving under this condition, which needs anticipation of pumping load at different stages of caving. In the absence of any field experience, the indirect technique of Equivalent Mine Modeling was used. On the basis of the model findings and the available hydrological information, the likely pumping problem during caving is described in this paper.

Keyword(s): subsurface water, hydrology, coal mining, room-and-pillar, pillar extraction, modeling, geologic features

Location(s): India

Sinha, K. M. Hydraulic Stowing--A Solution for Subsidence Due to Underground Mining in the USA. IN: Rock Mechanics as a Guide to Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 827-834.

Hydraulic stowing, which is being practiced in several major coal producing countries to deal with adverse mining conditions, usually permits almost 100% coal recovery from underground mines with minimal and controlled surface subsidence. It can be implemented in coal mines in the United States to reduce the severe effect of land subsidence and at the same time improve the cost of coal production, both of which are major setbacks for the coal industry in the United States.

Keyword(s): coal mining, economics, environment, land-use planning, reclamation, mine waste, hydraulic backfilling, stowing

Location(s): Illinois, Illinois Coal Basin, United States

Siriwardane, H. J., J. Amanat. Prediction of Subsidence in Hilly Ground Terrain Using Finite Element Method. IN: Proceedings 2nd International Conference on Stability in Underground Mining, A.B. Szwilski and C.O. Brawner, eds., 1984, SME-AIME, New York, p. 554-575.

Keyword(s): prediction, finite element, geologic features

Siriwardane, H. J., J. Amanat. Analysis of Subsidence Caused by Underground Mining. International Journal of Mining Engineering, v. 2, no. 4, 1984, p. 271-290.

Some aspects of subsidence caused by longwall coal mining are analysed using the finite element method. Results of the analysis are compared with a true mine panel, where measurements on subsidence were available. Rock deformations in the overburden were modeled using an elasto-plastic constitutive model. The study indicates that the shape of the subsidence profile can be predicted reasonably well using nonlinear finite element analysis.

Keyword(s): coal mining, longwall, modeling, finite element, overburden, elastic model, prediction, empirical model, phenomenological model

Location(s): United States

Siriwardane, H. J. A Numerical Procedure for Prediction of Subsidence Caused by Longwall Mining. IN: Proceedings 5th International Conference on Numerical Methods in Geomechanics, Nagoya, Japan, April 1-5, 1985.

A numerical procedure, based on the nonlinear finite element analysis, was developed for the prediction of subsidence profiles over longwall mine panels. The behavior of the overburden rock was modeled using an elasto-plastic constitutive model.

Keyword(s): finite element, modeling, prediction, longwall, phenomenological model, elastic model, overburden

Location(s): United States

Siriwardane, H. J. Some Aspects of Analysis and Prediction of Subsidence. IN: Rock Masses: Modeling of Underground Openings/Probability of Slope Failure/Fracture of Intact Rock, Proceedings, Symposium sponsored by Geotechnical Engineering Division of ASCE, in conjunction with ASCE Convention, Denver, CO, April 29-30, 1985, p. 2-13.

A procedure, based on the nonlinear finite element analysis, was investigated for the prediction of subsidence caused by longwall mining. This paper presents a case study involving predictions of subsidence at a coal mine panel for which a considerable amount of data was available in the literature. Aspects of the selection of material properties and shape of the subsidence profile are discussed.

Keyword(s): finite element, prediction, longwall, modeling, coal mining

Location(s): United States

Siriwardane, H. J. Numerical Modelling of the Behavior of Overburden Rock Masses Associated with Longwall Mining. IN: Research & Engineering Applications in Rock Masses, Proceedings 26th U.S. Symposium on Rock Mechanics, South Dakota School of Mines & Technology, Rapid City, June 26-28, 1985, E. Ashworth, ed., Balkema, Rotterdam, 1985, p. 171-177.

This paper presents two approaches based on the finite element method for modeling the behavior of overburden rock masses over longwall mine panels for predicting surface subsidence. Results obtained from a case study are presented.

Keyword(s): modeling, prediction, finite element, continuum mechanics, longwall, computer, overburden

Location(s): West Virginia, Appalachian Coal Region, United States

Siriwardane, H. J., H. Ramli, J. Amanat. Comparison of Predictions and Measurements of Subsidence Caused by Underground Mining in Northern Appalachia. IN: Proceedings 7th International Conference on Ground Control in Mining, Morgantown, WV, August 3-5, 1988, S.S. Peng, ed., Department of Mining Engineering, West Virginia University, p. 163-173.

This paper presents results from three case studies involving longwall mine panels at which the measured ground movements were compared with the numerical model predictions based on the finite element method. A new approach called the "displacement approach" was used in this study. The general concept of this method is based on the assumption that total roof collapse occurs behind the mine face as it advances. This assumption appears to be true for almost all longwall mining conditions. The prediction based on the numerical model appears to compare well with the measurements.

Keyword(s): longwall, prediction, empirical model, finite element, roof stability, modeling, coal mining, surface subsidence damage, surface structural damage, bituminous, mathematical model, continuum mechanics, National Coal Board, profile function, computer, geologic features

Location(s): West Virginia, Appalachian Coal Region, United States

Siriwardane, H. J., J. Amanat. Displacement Based Approach for the Prediction of Subsidence Caused by Longwall Mining Using Numerical Methods. IN: Computer Methods and Advances in Geomechanics, Proceedings 7th International Conference, Cairns QLD Australia, May 6-10, 1991, G. Beer, J.R. Booker, and J.P. Carter, eds., v. 2, Balkema, Rotterdam, p. 1387-1392.

An improved procedure, called the "displacement approach" for predicting the magnitude of subsidence over longwall mine panels was developed. This approach is based on history matching concept using finite element and displacement discontinuity methods. Here, measured ground movements at a number of mine panels were used in developing and verifying the model. The general concept of the method is based on the assumption that roof collapse occurs behind the mine face as it advances. Based on the results of a typical case presented in the paper, as well as the results for a number of other cases, the authors conclude that the predictive capability of maximum subsidence has been significantly improved. However, the predictive capability of the shape of the subsidence profile needs further improvements.

Keyword(s): prediction, computer, longwall, coal mining, finite element, modeling, rock mechanics

Location(s): West Virginia, Appalachian Coal Region, United States

Siska, L. Problems Relating to Coal Extraction in Seams Containing Strong Sandstones in the Overlying Strata. IN: 5th International Strata Control Conference, London, 1972, Paper 24, 12 p.

This paper analyzes specific problems related to mining discontinuous seams with variations in seam height. It indicates that low density supports are needed to operate under thick sandstone roofs.

Keyword(s): mine operation, ground control, overburden, roof support, coal mining

Skelly and Loy, Inc. Guidelines for Mining Near Surface Water. Report to U.S. Bureau of Mines, Contract No. HO252083, 1977, 190 p. (NTIS PB 264728/AS)

Keyword(s): surface water, mine design, mine operation

Location(s): United States

Skelly, W. A., J. Wolgamott, F-D. Wang. Coal Mine Pillar Strength and Deformation Prediction Through Laboratory Sample Testing. IN: Energy Resources and Excavation Technology, Proceedings 18th U.S. Rock Mechanics Symposium, Keystone, CO, June 22-24, 1977, F-D. Wang and G.B. Clark, eds., Colorado School of Mines Press, Golden, p. 2B5-1--2B5-5.

This paper presents results of a study that includes measurement of pillar strength and deformation in situ, as well as laboratory compression tests of small specimens. Field and laboratory data are compared with predictions of pillar strength calculated from several empirical equations suggested for use in pillar design. Field research was conducted in an underground mine in southern West Virginia.

Keyword(s): pillar strength, ground control, prediction, coal mining, lab testing, in situ testing, rock mechanics, instrumentation
Location(s): West Virginia, Appalachian Coal Region, United States

Skempton, A. W., D. H. MacDonald. Allowable Settlements of Buildings. IN: Proceedings, Institution of Civil Engineers, Part III, 1965, v. 5, p. 727.
Keyword(s): surface structural damage, engineering

Skinderowicz, B. Zasady Wyznaczania Filarow Ochronnych Dla Pokladow Nachylonych (Principles of Determination of Surface Protecting Pillars in Exploitation of Steeply Dipping Coal Seams). Przeglad Gorniczy, v. 25, no. 6, 1969, p. 294-297.
Keyword(s): coal mining, pillar strength

Skinderowicz, B. Rownanie Pelnej Nie Ustalonej Niecki Osiadania (Equation of a Full Nonstabilized Subsidence Trough). Przeglad Gorniczy, v. 33, no. 2, 1977, p. 75-79.
Keyword(s): modeling

Skinderowicz, B. Description of Mining Methods for Minimizing the Effect of Mining Work on the Surface. Phase I, Task No. 4. Subsidence Prediction and Control Project No. 14-01-0001-1451, Central Mining Institute, Katowice, Poland, March, 1978, 20 p. Translation, Joint Research Project through the Maria Sklodowska-Curie Joint Fund.
Keyword(s): mine design, mine operation, ground control
Location(s): Poland

Skinderowicz, B. Subsidence Prediction and Control, Phase 1: The State of Knowledge in Poland Concerning the Influence of Mining Exploitation on the Surface. U.S. Department Energy Contract DOE/TIC-11481, Central Mining Institute, Katowice, Poland, Final Report, Phase 1, 1978, 39 p. (NTIS DOE/TIC-11481)
This report examines the geologic and mining conditions and subsidence problems of 12 coal mines located in the Appalachian Region, Illinois Basin, and Rocky Mountain Region. Remarks and suggestions are made on subsidence prediction and control on the basis of the mines inspected.
Keyword(s): vertical displacement, horizontal displacement, subsurface water, mine design, prediction, ground control, coal mining, geologic features
Location(s): Poland, Appalachian Coal Region, Illinois Coal Basin, Rocky Mountain Coal Region, United States

Sladen, J. A., C. S. Bodimeade, V. R. Jobling. Site Investigation and Urban Development Guidelines with Respect to Mining Subsidence Hazards--Two Examples from Alberta, Canada. IN: Mineworkings 84: Proceedings International Conference on Construction in Areas of Abandoned Mineworkings, Edinburgh, 1984, M.C. Forde, B.H.V. Topping, H.W. Whittington, eds., Engineering Technics Press, p. 196-220.
Keyword(s): land-use planning, abandoned mines
Location(s): Canada

Slagel, G. E. Key Regulatory Issues--Planned and Controlled Subsidence. IN: Mine Subsidence, Society of Mining Engineers Fall Meeting, St. Louis, MO, September, 1986, M.M. Singh, ed., SME, Littleton, CO, p. 93-96.
The 1974 surface mining law showed that Congress considered removing all the coal from an area and causing subsidence in a predictable and uniform manner to be equal to or better than leaving support coal and causing no subsidence. While the actual provision in the bills talked of preventing subsidence, a subsequent exception made it clear that the real intent was to control it. The author feels that the original intent of Congress has been changed from one of controlling subsidence to one of minimizing damage. This paper reviews the surface mining law, subsidence aspects, differences between state and federal regulations, and offers suggestions on possible ways for the coal industry to deal with these issues.
Keyword(s): law, environment, coal mining, government, partial extraction, hydrology, subsurface water, longwall, active mines, mine design, mine operation
Location(s): Illinois, Illinois Coal Basin, Pennsylvania, Appalachian Coal Region, United States

Sloan, P., R. C. Warner. A Case Study of Groundwater Impact Caused by Underground Mining. IN: Proceedings, Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation, University of Kentucky, Lexington, December 2-7, 1984, p. 113-120.
An investigative methodology is presented to assist mining and regulatory personnel in determining the effect underground mining can have on

local aquifers in the Appalachian coal region. The impact of underground mining on groundwater may be more extensive than first realized. The primary reason for this possible underassessment of deep mining's influence on groundwater is the methods used to calculate groundwater movement. In many cases, groundwater flow times and the corresponding areas of influence are much greater than those assumed because water is rapidly moved through fractured zones that commonly occur throughout Appalachia.

Keyword(s): subsurface water, hydrology, coal mining

Location(s): Kentucky, United States

Small, J. B. Settlement Investigations in the Vicinity of Galveston-Houston, Texas, and San Joaquin Valley, California. Journal of Geophysical Research, v. 64, 1959, p. 1124-1125.

Keyword(s): fluid extraction

Location(s): Texas, California, United States

Smart, B. G. D., A. K. Isaac, P. A. Carr. The Elimination of Rib Pillars Between Adjacent Longwall Coalfaces. IN: Rock Mechanics: A State of the Art, Proceedings 21st Symposium on Rock Mechanics, May 28-30, 1980, D.A. Summers, ed., University of Missouri at Rolla, p. 319-355.

British longwall coal mining has traditionally used a pair of single gateroads to serve each panel, rib pillars being left between adjacent panels. The widths of these pillars are determined with stability as the design criterion either by empirical formula, or local experience, and range from a few meters to tens of meters. Consideration is being given, however, to the elimination of these pillars for reasons of maximizing extraction of reserves, cost savings, and development time saving.

Keyword(s): coal mining, longwall, mine design, economics, instrumentation

Location(s): United Kingdom

Smedley, N. Subsidence Management in the North Derbyshire Area. Mining Engineering, London, v. 136, no. 188, December 1976-January 1977, p. 185-192.

Keyword(s): ground control

Location(s): United Kingdom

Smelser, R. E., O. Richmond, F. C. Schwerer. Interaction of Compaction Near Mine Openings and Drainage of Pore Fluids from Coal Seams. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 21, no. 1, February, 1984, p. 13-20.

The long range transport of gas and water through coal seams is generally thought to occur through a natural fracture network, called cleats, existing in the coal seam. During mining, the overburden load formerly supported by the excavated coal is transferred to the nearby pillars and abutments. This added loading will cause the coal seam to yield, or deform plastically, close to the mine openings. In addition, the stresses acting to deform the coal seam--and consequently, the size of the yield zone--are also influenced by changes in the fluid pressure in the natural fracture network. In the present work, a model of the yielded region is developed that follows the ideas proposed by Dugdale for yielding in metal sheets. The Dugdale model is generalized to include the effects of changes in the pressure (drainage) of fluids in the natural fracture network. Changes in porosity and permeability resulting from additional microfracturing in the yielded zone are calculated based on this model.

Keyword(s): coal mining, hydrology, subsurface water, overburden, modeling, overburden

Smith, A., R. E. Collins. The Extraction of Barrier Pillars Between Adjacent Longwall Panels at the Durban Navigation Collieries (Pty) Ltd. Journal of South African Institute of Mining and Metallurgy, v. 85, no. 4, April, 1985, p. 125-130.

The practice of leaving barrier pillars between adjacent longwall panels at the Durban Navigation Collieries (Durnacol) has resulted in a considerable loss of coal reserves. Durnacol has now modified the layout of its longwall panels to allow the concurrent mining of barrier pillars and the extraction of the longwalls. The implementation of the new panel layout has increased the percentage extraction of reserves and will result in an extension of the life of the mine. The method of extracting barrier pillars between adjacent longwall panels is described in this paper.

Keyword(s): longwall, coal mining, pillar extraction

Location(s): South Africa

Smith, M. Coal Mine Subsidence in Washington State; Inventory of a Geologic Hazard. IN: Geological Society of America Abstracts with Programs, Cordilleran Section, 71st Annual Meeting, Los Angeles, CA, March 25-27, 1975, p. 377. (NTIS Accession No. 77-45431)

Keyword(s): engineering, coal mining, land-use planning
Location(s): Washington, United States

Smith, P. A National Mine Subsidence Engineering Research Program. U.S. Department of Energy Contract W-7405-ENG36, Los Alamos Scientific Laboratory LA-8907-MS, July, 1981, 47 p. (NTIS LA8907-MS)
This report suggests a logical approach to choosing and sequencing research activities to attain a suitable set of techniques for predicting the damaging consequences of mine subsidence. The detail required for damage predictions varies from customers who conduct regional impact assessments to subsidence hazard engineers who are concerned with a particular structure to be undermined. High priority research needs include the following: a National Mine Subsidence Information Management Center, empirical surface and subsurface subsidence damage correlations for practice in the United States, a comprehensive study of influence function subsidence prediction techniques, finite element computer code refinements for full-extraction subsidence prediction and engineering geology approach to assessing the timing of room-and-pillar subsidence, and well-designed field observations in support of all research needs.
Keyword(s): subsidence research, prediction, land-use planning, surface structural damage, influence function, finite element, computer, room-and-pillar, longwall, engineering
Location(s): United States

Smith, R. M. Update on Overburden Characteristics. IN: American Mining Congress Coal Convention Session Papers Set No. 3, Pittsburgh, PA, May 1-4, 1977, 17 p.
The author outlines methods of sampling and characterizing coal mine overburden to aid mining and reclamation plans.
Keyword(s): reclamation, overburden, coal mining, monitoring installation, mine design
Location(s): United States

Smith, W. C. Evaluation of Progressive Rib Failure in Thick Coal Seams. SME Preprint 89-174, for presentation at SME Annual Meeting, Las Vegas, NV, February 27-March 2, 1989, 7 p.
Even with the most conservative mine plan, rib instability can occur unexpectedly and, if not adequately dealt with, can progress from a nuisance to a major safety hazard. This USBM paper examines the mechanisms of progressive rib failure in high mine openings and discusses techniques to control rib slabbing. A field test site in a longwall mine was instrumented to investigate rib behavior during mining. Although data analysis showed minor pillar dilation, sporadic zones of progressive rib instability were detected, which culminated in eventual rib failure. The failure occurred despite conservative pillar dimensions and shallow depth. Physical and computer models were used to demonstrate the mechanisms of rib failure and then evaluate the influence of support and other mine-related parameters on rib behavior.
Keyword(s): coal mining, mine design, longwall, instrumentation, pillar strength, modeling, computer, mine safety
Location(s): Rocky Mountain Coal Region, United States

Smith, W. C. Rib Stability: Practical Considerations to Optimize Rib Design. U.S. Bureau of Mines IC 9323, 1992, 16 p.
The USBM examined previous research on rib stability to develop a practical approach to understanding, characterizing, and controlling weak rib conditions in underground coal mines. Because success in stabilizing ribs depends on a basic knowledge of how weak ribs behave, the report reviews the mechanics of rib failure and the relationship of coal mine geology and pillar constraint to rib instability. Strategies for choosing an effective method of rib support are considered, and various rib support methods are discussed. Finally, the report documents techniques for monitoring ribs and use of models to assess rib stability; such monitoring and modeling can also help determine the most effective method for roof support.
Keyword(s): roof support, coal mining, geologic features, mine safety
Location(s): United States

Sneed, L. A., R. Sumner. Longwall Mining Beneath A State Highway - Case History. IN: Mine Subsidence - Prediction and Control, National Symposium, 33rd Annual Meeting Association of Engineering Geologists, October 2-3, 1990, Pittsburgh, PA, C.D. Elifrits, ed., p. 269-270.
In July 1988, Old Ben Coal Company undermined and subsided Illinois State Highway 149 by use of the longwall mining method. This was the first time in the State of Illinois that such planned subsidence mining was done beneath a state highway. This paper outlines the steps followed in planning, monitoring and effecting repairs.

Keyword(s): roads, active mines, coal mining, longwall, monitoring methods, mitigation
Location(s): Illinois, Illinois Coal Basin, United States

Snodgrass, J. J., D. A. Newman. An In Situ Technique for the Assessment of Failure in Coal Pillars. IN: Research & Engineering Applications in Rock Masses, Proceedings 26th U.S. Symposium on Rock Mechanics, South Dakota School of Mines & Technology, Rapid City, June 26-28, 1985, E. Ashworth, ed., Balkema, Rotterdam, p. 1181-1188.

A coal pillar comprises two distinct zones, a solid elastic core enclosed and confined by an exterior of failed or yielded coal. Initially the elastic core-yield zone boundary is located immediately adjacent to the pillar edge. As the pillar load increases, the boundary migrates towards the center of the pillar, ultimately culminating in pillar failure. The ability to delineate the elastic core-yield zone boundary in the field is therefore of fundamental importance. A dry-hole sonic velocity logging probe was used to define the boundary on the basis of sonic velocity profiles.
Keyword(s): pillar strength, monitoring equipment, monitoring methods, room-and-pillar, longwall, in situ testing
Location(s): Utah, Rocky Mountain Coal Region, West Virginia, Appalachian Coal Region, United States

Snow, R. E. Estimation and Control of Ground Water Inflow and Discharge from Underground Mines. SME Preprint 90-117, for presentation at SME Annual Meeting, Salt Lake City, February 26-March 1, 1990, 9 p.

The objective of this paper is to discuss the practical applications of mine inflow and discharge analysis, describe the typical flow components, outline the procedures necessary to perform the analysis, and illustrate the modeling procedures and potential results of mine inflow and discharge predictions.
Keyword(s): subsurface water, hydrology, modeling, environment, coal mining, inflow
Location(s): United States

Snowden, J. O., W. B. Simmons, E. B. Traughber, R. W. Stephens. Differential Subsidence of Marshland Peat as a Geologic Hazard in the Greater New Orleans Area, Louisiana. Transactions, Gulf Coast Association Geological Society, 27, 1977, p. 169-179.
Keyword(s): fluid extraction, geologic features, soils
Location(s): Louisiana, United States

Snowden, J. O. Drainage-Induced Land Subsidence in Metropolitan New Orleans, Louisiana, USA. IN: Land Subsidence, Proceedings 3rd International Symposium, Venice, Italy, March 19-25, 1984, A.I. Johnson, L. Carbognin, and L. Ubertini, eds., International Association Hydrological Sciences Publication No. 151, 1986, p. 507-527.

Now that the relationship between drainage and land subsidence is relatively well understood in the New Orleans region, it is possible to predict areas that have the potential for future hazardous subsidence. Present drainage systems should be modified and future systems designed to keep subsidence-prone sediments and soils as wet as possible. Water table levels should be kept as high as possible. Thorough geological and geotechnical surveys should be done prior to further drainage projects within the Mississippi River delta plain.
Keyword(s): fluid extraction, soils
Location(s): Louisiana, United States

Soil Testing Services, Inc. HUD - Mine Subsidence Evaluation Manual. June 30, 1976, 45 p.

Under ordinary circumstances, the intent of the design of foundations has the primary goals of providing a reasonable factor of safety against failure and of limiting or minimizing damage movements. However, many well located sites on which intense mining activity has occurred in the past, and in which time-related mechanisms of subsurface deformation and deterioration are now operating, are expected to exhibit future subsidence and horizontal displacements. Housing development on such sites should be done with the realization that the potential for damaging movements definitely exists.
Keyword(s): coal mining, time factor, horizontal displacement, pillar strength, foundations, construction, land-use planning, surface structural damage
Location(s): United States

Sopworth, A. Discussions of Subsidence Due to Coal Workings. Institution of Civil Engineers, Minutes of Proceedings, v. 135, 1898, p. 165-167.
Keyword(s): historical, coal mining
Location(s): England

Sorenson, W. K., W. G. Pariseau. Statistical Analysis of Laboratory Compressive Strength and Young's Modulus Data for the Design of Production

Pillars in Coal Mines. IN: Proceedings 19th U.S. Symposium on Rock Mechanics, Stateline, NV, May 1-3, 1978, Y.S. Kim, ed., University of Nevada-Reno, p. 30-37.

Sample statistics (mean, standard deviation, coefficient of variation, regression line slope and intercept, correlation coefficient) obtained from statistical analyses of a total of 371 tests for unconfined compressive strength and Young's modulus performed on test cylinders having nominal diameters of 1, 2, 4, 6, 8, and 12 inches, and height-to-diameter ratios of 1/2, 1, 1-1/2, and 2 are presented. The paper discusses some of the possible implications of such data for "size effects" and the design of production pillars in coal mines.

Keyword(s): rock mechanics, pillar strength, mine design, lab testing, coal mining

Location(s): United States

Sossong, A. T. Subsidence Experience of Bethlehem Mines Corporation in Central Pennsylvania. IN: Proceedings, 4th Annual Symposium on Subsidence in Mines, Wollongong, Australia, February 20-22, 1973, A.J. Hargraves, ed., Paper 5, Australasian Institute of Mining and Metallurgy, Illawarra Branch, p. 5-1--5-5.

Although mining was conducted in the Cambria County area of Central Pennsylvania for more than 75 years, surface subsidence was not given serious consideration until 1966. At that time, the state drafted legislation making the coal operators responsible for any damage caused as a result of mining to any private dwelling or public building. At about the same time, Bethlehem Mines Corporation was introducing the first successful longwall mining system in Pennsylvania. With conventional mining, the pillar line was from 300 to 400 feet. With longwall, this figure became 600 feet wide. Subsidence surveys of third order were conducted over both longwall and conventional sections. Minimal pillar design changes have been attempted to control subsidence because poor roof conditions and thick overburden mandate wide pillar lines to mine economically. Support pillars are necessary in heavily populated areas, under wide concrete interstate highways, and under breasts of water reservoirs.

Keyword(s): mine operation, coal mining, active mines, longwall, surface water, roads, law, survey methods, bituminous, mine design

Location(s): Pennsylvania, Appalachian Coal Region, United States

Souder, W. E., E. R. Palowitch. The Growth of Longwall Technologies in the United States. IN: SME-AIME Mini Symposium Series 79-05, 1979, p. 7-16.

Keyword(s): mine design, mine operation, longwall

Location(s): United States

South African Mining and Engineering Journal. Problems Associated with Building on Undermined Ground. v. 82, no. 4048, 1970, p. 769-741.

Keyword(s): engineering, construction, surface structural damage, abandoned mines

Location(s): South Africa

South Wales Institute of Engineering. The Pneumatic Stowing of Longwall Faces in South Wales. IN: Proceedings, v. 63, no. 2, 1947, p. 30.

This paper describes the use of pneumatic backfilling as an alternative to hand packing for roof control in longwall coal mines.

Keyword(s): pneumatic backfilling, longwall, coal mining, roof support

Location(s): Wales

Southwestern Illinois Metropolitan and Regional Planning Commission. Mine Subsidence: A Guidebook for Local Officials. Illinois Department of Mines and Minerals, and Abandoned Mined Lands Reclamation Council, June 1983, R.S. Pocreva and R.K. Thompson, assistants, 148 p.

This booklet was designed for Illinois community officials to detail the characteristics of subsidence. It examines a series of options available to local government to deal with subsidence, including the Illinois Mine Subsidence Insurance Fund, a subsidence preparedness plan, public facility construction policies, land development ordinances, and underground mine permit processes.

Keyword(s): vertical displacement, horizontal displacement, law, land-use planning, government, insurance, construction, mine operation, land values, surface structural damage, abandoned mines, roads, utilities, bituminous, coal mining, metal mining, non-metal mining

Location(s): Illinois, Illinois Coal Basin, United States

Sovinc, I., N. Hass, M. Ribicic. Prediction and Evaluation of Subsidence Above a Thick Coal Seam. IN: Proceedings International Symposium on Numerical Models in Geomechanics, Zurich, September 1982, p. 814-819.

Keyword(s): prediction, coal mining

Sowers, G. F. Mechanisms of Subsidence Due to Underground Openings. IN: Subsidence Over Mines and Caverns, Moisture and Frost Actions, and Classification, Transportation Research Record 612, Part 1, Transportation Research Board, Washington, D.C., 1976, p. 2-8. (NTIS PB 272 844)

Subsidence from underground defects is an increasing problem, and effective preventive or corrective measures depend on knowing the mechanism causing the failure. Too often, however, the mechanism is ignored or diagnosed from the appearance of the ground surface, leading to routine indiscriminate treatment such as filling the depression or draining any water, which can be successful, ineffective, or harmful, depending on the mechanism involved. This paper briefly discusses subsidence caused by several types of mechanisms.

Keyword(s): roads, surface structural damage, geologic features, utilities, structural mitigation, reclamation, coal mining, non-metal mining, metal mining, tunnelling, subsurface water, hydrology, railroads

Location(s): Florida, United States

Sowry, C. G., K. Tubb. The Investigation of Strata Movements When Mining Three Thick Coal Seams in One Area. South African Institute of Mining and Metallurgy Journal, v. 65, 1964, p. 143-170.

This paper describes instruments and methods used to measure strata movements and pillar contraction when mining superimposed coal seams 60 to 170 feet below the surface.

Keyword(s): monitoring equipment, monitoring methods, multiple-seam extraction, coal mining, pillar strength

Location(s): South Africa

Spalding, J. Theory and Practice of Ground Control (the Kolar Gold Field). Transactions, Institution of Mining and Metallurgy, v. 47, 1937-38, p. 71-110.

Keyword(s): ground control, metal mining

Spande, E. D. Effects of Longwall-Induced Subsidence on Hydraulic Properties at a Site in Jefferson County, Illinois. M.S. Thesis, Department of Geology, Northern Illinois University, 1990, 245 p.

Longwall mine subsidence potentially alters aquifer and aquitard hydraulic properties, potentiometric surfaces, and pore-water geochemistries as a result of subsidence-induced fracturing. Changes in these three areas were measured through monitoring the water levels in domestic wells and drift and bedrock piezometers, conducting hydraulic tests, and analyzing water chemistry.

Keyword(s): hydrology, subsurface water, longwall, active mines, coal mining, monitoring methods, overburden, geologic features

Location(s): Illinois, Illinois Coal Basin, United States

Spanovich, M. Construction Over Shallow Mines: Two Case Histories. ASCE Structural Engineering Division Meeting, Pittsburgh, PA, September 30-Oct. 4, 1968. ASCE Preprint 703, New York, 10 p.

This paper describes groutcase and caissons to support structures over subsidence-prone areas; it includes costs for methods employed.

Keyword(s): engineering, construction, economics, roof support

Location(s): United States

Spark, H. G. Subsidence in Coal Mines. B.E. Thesis, University of Sydney, Australia, 1968, 90 p.

Keyword(s): coal mining

Speck, R. C. A Comparative Analysis of Geologic Factors Influencing Floor Stability in Two Illinois Coal Mines. Thesis, University of Missouri-Rolla, 1979, 265 p.

Keyword(s): floor stability, geologic features, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Speck, R. C. The Influence of Certain Geologic and Geotechnical Factors on Coal Mine Floor Stability--A Case Study. IN: Proceedings 1st Annual Conference on Ground Control in Mining, July 27-29, 1981, S.S. Peng, ed., West Virginia University, Morgantown, p. 44-49.

This paper describes the floor heave problem as it was manifested at two room-and-pillar coal mines in Illinois. The objective of the study was to develop one or more simple procedures to allow detection of a potential floor heave problem during the exploration phase of mine design--before initiation of production mining.

Keyword(s): floor stability, ground control, geotechnical, coal mining, geologic features, in situ testing, lab testing

Location(s): Illinois, Illinois Coal Basin, United States

Speck, R. C., R. W. Bruhn, R. E. Gray. Instrumentation Plan for Monitoring Ground Movements Associated With Pillar Extraction Mining

at the Kitt No. 1 Mine in Northern West Virginia. IN: Proceedings, Workshop on Surface Subsidence Due to Underground Mining, Morgantown, WV, November 30-December 2, 1981, S.S. Peng and M. Harthill, eds., Department of Mining Engineering, West Virginia University, 1982, p. 231-236.

This paper discusses the design and installation of surface, subsurface, and mine-level instrumentation to monitor ground movements associated with pillar-extraction mining.

Keyword(s): monitoring design, monitoring installation, monitoring equipment, instrumentation, room-and-pillar, pillar extraction

Location(s): West Virginia, Appalachian Coal Region, United States

Speck, R. C., R. W. Bruhn. The Appalachian Field: A Surface Monitoring Program Over Pillar-Extraction Mine Panels. IN: Surface Mining Environmental Monitoring and Reclamation Handbook, L.V.A. Sendlein, et al., eds., 1983, Coal Extraction and Utilization Research Center, Southern Illinois University, Carbondale, U.S. Department of Energy Contract No. DE AC22 80ET 14146, Elsevier, New York, p. 647-656.

Pillar extraction is a mining technique whereby the coal within the mine area is almost totally removed. It is often used in areas where, for reasons of economy, geologic setting, mine space or timing, longwall total-extraction mining is not appropriate. The authors monitored the ground movements associated with pillar-extraction mining at a coal mine in northern West Virginia.

Keyword(s): monitoring methods, pillar extraction, coal mining, vertical displacement, horizontal displacement, survey methods, monitoring installation, monitoring equipment, survey equipment, geologic features

Location(s): West Virginia, Appalachian Coal Region, United States

Speck, R. C., R. W. Bruhn. Prediction of Mine Subsidence Ground Movements and Resulting Surface-Structure Damage - Complicating Factors. IN: Mine Subsidence - Prediction and Control, National Symposium, 33rd Annual Meeting, Association of Engineering Geologists, October 2-3, 1990, C.D. Elifrits, ed., Pittsburgh, PA, p. 79-88.

Empirical methods have shown some promise in improving the capability of engineers to predict ground-surface movements and damage to surface structures associated with underground mining, particularly in yielding estimates of ground movements. Departures from prediction behavior are common and can be related to mining, geology, and surface structures. Ground movements normally unassociated with mine subsidence may take place concurrently with a subsidence event.

Keyword(s): empirical model, prediction, surface structural damage, geologic features, soils, abandoned mines, active mines, longwall, room-and-pillar, overburden

Location(s): United Kingdom, United States

Spencer, L. H. Subsidence Research Carried Out in the Bestwood Area of Nottinghamshire. Transactions, Institute of Mining Engineers, London, v. 120, no. 3, December, 1960, p. 201-210.

Keyword(s): subsidence research

Location(s): England

Spickernagel, H. Der Einfluss Der Abbautechnik Auf Die Senkungsbewegungen An Der Erdoberflaeche (Influence of the Mining Method on the Subsidence Movements of the Earth's Surface). Glueckauf-Forschungshefte, v. 34, no. 5, October, 1973, p. 168-174.

Keyword(s): mine operation, mine design, surface subsidence damage

Location(s): Germany

Spickernagel, H. Hebungen Des Gebirges Als Folgen Des Bergbaus Unter Tage (Rock Lifting Caused by Underground Mining Operations). Glueckauf-Forschungshefte, v. 36, no. 4, August, 1975, p. 170-176.

Keyword(s): subsurface subsidence damage

Spokes, E. M., C. R. Christiansen, eds. Proceedings of the 6th Symposium on Rock Mechanics. University of Missouri at Rolla, October, 1964.

Keyword(s): rock mechanics, instrumentation, roof support, mine design, modeling, pillar strength, time factor, metal mining, backfilling, room-and-pillar

Spokes, E. M., J. J. Scott. Rock Mechanics in Coal Mining. Mining Congress Journal, 1967, v. 53, p. 44-48.

Keyword(s): rock mechanics, coal mining

Sprouls, M. W. Rend Lake Banks on Longwalls. Coal, April, 1989, v. 27, no. 4, p. 88-90.

Consolidation Coal successfully switches an Illinois mine from pulling pillars to developing longwall panels.

Keyword(s): longwall, coal mining, mine design, mine operation
Location(s): Illinois, Illinois Coal Basin, United States

St. John, C. M., M. P. Hardy. Geotechnical Models and Their Application in Mine Design. IN: Proceedings, Mini Symposium on Application of Geotechnical Data to Underground Mine Design, SME-AIME Fall Meeting, September, 1978, Mini Symposium Series no. 78-1.
Keyword(s): modeling, mine design, geotechnical

Stacey, T. R. Three-Dimensional Finite Element Stress Analysis Applied to Two Problems in Rock Mechanics. South African Institute of Mining and Metallurgy Journal, v. 72, 1972, p. 251-256.
Keyword(s): finite element, rock mechanics, modeling
Location(s): South Africa

Stacey, T. R. Interaction of Underground Mining and Surface Development in a Central City Environment. Transactions, Institute of Mining and Metallurgy, 95A, 1986, p. 176-180.
Keyword(s): land-use planning

Stacey, T. R., D. Bakker. The Erection or Construction of Buildings and Other Structures on Undermined Ground. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May 1992, South African Institution of Civil Engineers, Republic of South Africa, p. 282-288.
The Mines and Works Regulations stipulate that permission is required from the Government Mining Engineer when buildings or other structures are to be erected or constructed over undermined ground. These guidelines have been reviewed recently and considerations given to revising them. This paper contains some of the background to the review, and some suggestions regarding new guidelines are made.
Keyword(s): law, government, surface structural damage, roads, railroads, metal mining, geologic features, coal mining, time factor, utilities, pipelines, horizontal displacement, vertical displacement
Location(s): South Africa

Stache, J. E. Database Analysis in Mine Subsidence Research. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 326-331.
Commercial software programs are used to create and maintain a mine subsidence database in conjunction with USBM research on mine subsidence in Illinois. A 3-year survey net of monitored structures in an Illinois subdivision was incorporated into the database design.
Keyword(s): computer, survey data processing, abandoned mines, coal mining, surface structural damage, vertical displacement
Location(s): Illinois, Illinois Coal Basin, United States

Stahl, R. L. Guide to Geologic Features Affecting Coal Mine Roof. MSHA Information Report 1101, 1979, 18 p.
Keyword(s): roof stability, geologic features, coal mining
Location(s): United States

Stahl, R. W. Extracting Final Stump in Pillars and Pillar Lifts with Continuous Miners. U.S. Bureau of Mines RI 5631, 1960.
Keyword(s): room-and-pillar, pillar extraction
Location(s): United States

Stahl, R. W. Survey of Practices in Controlling Roof at Intersections and Junctions in Underground Coal Mines. U.S. Bureau of Mines IC 8113, 1962, 13 p.
Keyword(s): roof support, coal mining, ground control
Location(s): United States

Stall, F. J. The Ports of the Rhine-Herne Canal Subject to the Effects of Mining Operations. Bulletin Permanent International Associated Navigation Congress, v. 1-2, no. 19/20, 1966, p. 87-123.
Keyword(s): surface subsidence damage, surface structural damage, surface water
Location(s): Europe

Starfield, A. M., C. Fairhurst. How High-Speed Computers Advance Design of Practical Mine Pillar Systems. Engineering and Mining Journal, May, 1968, p. 78-84.
Computer programs are used to solve structural problems found in determining stress on pillars of various sizes.
Keyword(s): pillar strength, computer, mine design

Starfield, A. M., W. R. Wawersik. Pillars as Structural Components in Room and Pillar Design.

IN: Basic and Applied Rock Mechanics, Proceedings, 10th Symposium on Rock Mechanics, University of Texas, Austin, 1972, p. 793-809.

Pillar stability is presented in a computer model as the interaction between the pillars and the surrounding rock. Qualitative behavior of pillars is obtained using compression tests.

Keyword(s): pillar strength, computer, room-and-pillar, modeling, rock mechanics, lab testing

Starfield, A. M., S. L. Crouch. Elastic Analysis of Single Seam Extraction. IN: Proceedings, 14th Symposium on Rock Mechanics, Pennsylvania State University, 1972.

This paper describes a digital computer method for computing stresses and displacements due to a dislocation in an otherwise continuous linearly elastic, infinite rock mass.

Keyword(s): rock mechanics, phenomenological model, elastic model, computer, modeling

Location(s): United States

Stark, J. F. Report of the Subsidence Committee. Submitted to the Joint State Government Commission of the General Assembly of PA, Harrisburg, PA, February 20, 1957, 54 p.

Keyword(s): government, law

Location(s): Pennsylvania, Appalachian Coal Region, United States

Starkey, D. L. Removal of a Shaft Pillar at Depth, Simmer and Jack Ltd. Associated Mine Managers South Africa, Papers and Discussions, 1962/63, p. 723-745.

Keyword(s): room-and-pillar, pillar extraction

Location(s): South Africa

Stassen, P., H. Duyse. Harmful Influences of Faces on the Roadways in a Colliery Layout, and Methods of Reducing Them. IN: 5th International Strata Control Conference, London, 1972, Paper 19, 8 p.

This paper discusses the importance of planning the behavior of main roadways of a mine and shows the harmful effect of a pillar of abandoned coal in a seam on roadways situated in this pillar or immediately above or below it.

Keyword(s): mine design, pillar strength, coal mining

Stateham, R. M. Field Studies on an Unsupported Roof, York Canyon Coal Mine, Raton, New Mexico. U.S. Bureau of Mines RI 7886, 1974, 18 p. (NTIS PB 231 122)

Infrared and displacement studies were made of an unsupported roof in Kaiser Steel Corporation's York Canyon coal mine, Raton, New Mexico. Monitoring of the roof continued until the roof over the area was caved. Loose slabs in the roof were detected by means of associated thermal anomalies using remote-sensing infrared instruments. Displacement measurements taken during the study indicate that roof movement was cyclic in nature, and the cycles appear to be related to the mine work cycle (work days to idle days).

Keyword(s): roof support, roof stability, coal mining, remote sensing

Location(s): New Mexico, Rocky Mountain Coal Region, United States

Stateham, R. M., D. E. Radcliffe. Humidity: A Cyclic Effect in Coal Mine Roof Stability. U.S. Bureau of Mines RI 8291, 1978, 19 p.

Climatic conditions are compared with roof fall occurrence. These comparisons indicate that humidity has a strong influence on roof fall occurrence rates. Cubic regression techniques are used to develop best fit curves. Statistical analysis of these curves indicate that both are sinusoidal and exhibit positive correlation with each other. The sine waves have a period of 1 year with maximum and minimum inflection points in August and February.

Keyword(s): roof stability, coal mining, mine design

Location(s): United States

Statham, I., C. Golightly, G. Treharne. Thematic Mapping of the Abandoned Mining Hazard: A Pilot Study for the South Wales Coalfield. IN: Planning and Engineering Geology, Proceedings 22nd Annual Conference of the Engineering Group of the Geological Society, Plymouth Polytechnic, September 8-12, 1986, M.G. Culshaw, et al., eds., The Geological Society, London, 1987, p. 255-268.

A desk study was conducted to look into the feasibility of producing thematic maps of the mining subsidence risk for planners.

Keyword(s): abandoned mines, coal mining, land-use planning, engineering

Location(s): Wales, United Kingdom

Statham, I. C. F. Subsidence and Shaft Pillars. Colliery Guardian, v. 125, 1923, p. 325-327, 387-388, 449.

This article reviews and compares various formulas for calculating the size of a shaft pillar.

Keyword(s): bumps, overburden, angle of draw, room-and-pillar, roof stability, pillar strength

Statham, I. C. F. Coal Mining. English University Press, Ltd., 1951, 564 p.
Keyword(s): coal mining

Stearn, E. W. Can Coal Live With Subsidence Laws? Coal Mining & Processing, v. 3, no. 11, 1966, p. 31-34.
Keyword(s): law, coal mining, government, mine operation

Steart, F. A. Strength and Stability of Pillars in Coal Mines. Transactions, Chemical, Metallurgical, and Mining Society of South Africa, v. 54, 1953-54, p. 309-325.
This paper describes bord-and-pillar or pillar-and-stall method of mining as practiced in South Africa. The author discusses pressure exerted on pillars and various means of estimating this pressure and the strength of coal within the pillars. The results of laboratory tests are described in relation to actual conditions within active mines.
Keyword(s): coal mining, pillar strength, room-and-pillar, lab testing, active mines
Location(s): South Africa

Steart, F. A. Mining Subsidence with Particular Reference to the Coalfields of South Africa. Coal and Base Minerals, Part 1, December 1955, p. 42-46; Part 2, January 1956, p. 30-38; Part 3, February 1956, p. 28-56.
Keyword(s): coal mining
Location(s): South Africa

Steed, C., W. F. Bawden, A. M. Coode, P. Mottahed. Subsidence Prediction for Saskatchewan Potash Mines. IN: Research & Engineering Applications in Rock Masses, Proceedings 26th U.S. Symposium on Rock Mechanics, South Dakota School of Mines & Technology, Rapid City, June 26-28, 1985, E. Ashworth, ed., Balkema, Rotterdam, 1985, p. 163-170.
This paper describes the use of an empirical subsidence prediction method applied to Saskatchewan potash mines. Subsidence data were collected from five producing mines. A review of existing subsidence prediction methods was made and applicability of the methods was considered. The data indicate that subsidence tends to be time dependent. The plastic nature and low strength of the evaporites cause subsidence to occur in two stages.
Keyword(s): empirical model, modeling, prediction, time factor, zone area, influence function, computer, non-metal mining, active mines
Location(s): Canada, Saskatchewan

Stefanko, R. Subsidence and Ground Movement. SME Mining Engineering Handbook, v. 1, A.B. Cummins and I.A. Givens, eds., 1973, SME-AIME, New York, p. 13-2--13-9.
This treatment of subsidence and ground movement is confined to subsidence control for limiting surface damage by assessing the significant parameters affecting ground movements during mining to optimize mining techniques.
Keyword(s): coal mining, angle of draw, overburden, longwall, room-and-pillar, mine design
Location(s): United States , Europe

Stemple, D. T. A Study of Problems Encountered in Multiple Seam Coal Mining in the Eastern United States. Virginia Polytechnic Institute Bulletin, v. 49, no. 5, March, 1956, 64 p.
The author discusses several factors that have been shown to have an influence on the presence and amount of disturbance in multi-seam operations. These include proximity of the seams to each other, method of mining, and the amount of overburden above the uppermost bed.
Keyword(s): backfilling, multiple-seam extraction, pillar strength, room-and-pillar, mine design, mine operation, coal mining, overburden, roof stability
Location(s): Appalachian Coal Region, United States

Stephens, J. C. Subsidence of Organic Soils in the Florida Everglades. IN: Proceedings, Soil Science Society of America, v. 20, 1956, p. 77-80.
Keyword(s): fluid extraction, soils
Location(s): Florida, United States

Stephens, J. C. Subsidence of Organic Soils in the Florida Everglades--A Review and Update. Memoirs, Miami Geological Society, 2, 1974, p. 352-361.
Keyword(s): soils, fluid extraction
Location(s): Florida, United States

Stephens, J. C., L. H. Allen, Jr., E. Chen. Organic Soil Subsidence. IN: Man-Induced Land Subsidence, Reviews in Engineering Geology VI, T.L. Holzer, ed., The Geological Society of America, 1984, p. 107-122.
Organic soil subsidence occurs mainly with drainage and development of peat for agriculture.

Subsidence occurs either from densification or from actual loss of mass. Densification usually occurs soon after drainage is established. Slow, continuous loss of mass is due mainly to biological oxidation. Subsidence rates are determined mainly by type of peat, depth to water table, and temperature.

Keyword(s): soils, fluid extraction, modeling, remote sensing

Location(s): Florida

Stephenson, R. W., N. B. Aughenbaugh. Analysis and Prediction of Ground Subsidence Due to Coal Mine Entry Collapse. IN: Large Ground Movements and Structures, Proceedings International Conference, University of Wales Institute of Science and Technology, Cardiff, 1977, J.D. Geddes, ed., John Wiley & Sons, New York, 1978, p. 100-118.

This paper discusses the field investigation and analysis used to determine the cause of movements of an elementary school and to establish the probable magnitude of future movements of the structure.

Keyword(s): surface structural damage, coal mining, abandoned mines

Location(s): Illinois, Illinois Coal Basin, United States

Stephenson, R. W. Ground Surface Subsidence Due to Coal Mine Collapse. IN: Evaluation and Prediction of Subsidence, Proceedings International Conference, Pensacola Beach, FL, January 15-20, 1978, S.K. Saxena, ed., ASCE, New York, 1979, p. 113-128.

This paper discusses subsidence, structural damage, and monitoring at the Washington Elementary School in Johnston City, Illinois.

Keyword(s): abandoned mines, surface structural damage, surface subsidence damage, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Sterling, R.L. Roof Design for Underground Openings in Near-Surface Bedded Rock Formations. Ph.D. Thesis, University of Minnesota, 1977.

Keyword(s): roof stability, roof support, mine design

Location(s): United States

Stewart, C. L. Subsurface Rock Mechanics Instrumentation Program for Demonstration of Shield-Type Longwall Supports at York Canyon, Raton, New Mexico. IN: Energy Resources and Excavation Technology, Proceedings 18th U.S. Symposium on Rock Mechanics, Keystone, CO, June 22-24, 1977, F-D. Wang and G.B. Clark, eds., Colorado School of Mines Press, Golden, p. 1C2-1 - 1C2-13.

A rock mechanics instrumentation program, designed to determine the rock mass response due to longwall mining a thick coal seam using shield-type supports, was instituted at the York Canyon Mine near Raton, New Mexico. This report summarizes the information obtained from the subsurface instrumentation program during mining of the initial longwall panel. The data collected during this study are unique in that they represent the results from mining a super-critical longwall panel in a known geologic environment with cross- and along-panel topographic variations.

Keyword(s): geologic features, active mines, coal mining, longwall, roof support, rock mechanics, instrumentation

Location(s): New Mexico, Rocky Mountain Coal Region, United States

Stewart, C. L., J. E. Shoemaker. Subsidence Monitoring Program at Cyprus Coal's Colorado Operations. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 254-262.

This paper summarizes the results of a subsidence monitoring program above two longwall panels at the Foidel Creek Mine located in northwest Colorado. The monitoring area is characterized by overburden ranging from 1,000 to 1,100 feet in thickness. The surface slope parallels the dip of the bedding at approximately 5 degrees. Average mining height is 9 feet. Smax averaged 3.4 feet. Draw angles averaged 15 degrees for up-dip ribsides and 19 degrees for down-dip ribsides. A site-specific profile function is developed from the data.

Keyword(s): monitoring methods, survey methods, overburden, longwall, coal mining, angle of draw, profile function, vertical displacement

Location(s): Colorado, Rocky Mountain Coal Region, United States

Stewart, J. E. Mining a 100 Million Tonne Orebody Without Subsidence. IN: Proceedings, New Zealand Conference, University of Auckland, May 19-23, 1980, Australasian Institute Mining & Metallurgy, p. 111-123.

Keyword(s): mine design, ground control

Stier, K. H. Measurement of Ground Movements in Shafts With the Help of a New Method. IN: Proceedings, European Congress on Ground Movement, Leeds, England, April 9-12, 1957, London Harrison, p. 159-166.
Keyword(s): instrumentation, monitoring methods

Stimpson, B., G. Walton. Clay Mylonites in English Coal Measures: Their Significance in Open-Cast Slope Stability. IN: Proceedings, 1st International Congress Association of Engineering Geologists, Paris, 1970, v. 3, p. 1388-1393.
Keyword(s): coal mining, floor stability
Location(s): England

Stingelin, R. W., E. T. Baker, S. B. Cousin. Overview of Subsidence Potential in Pennsylvania Coal Fields. Appalachian Regional Commission Report ARC73-111-2552, June, 1975, 220 p. (NTIS PB 272 682)
This study is part of a comprehensive program on mining activities, the associated surface subsidence effects, and their correlation with post-hurricane Agnes reconstruction projects in Pennsylvania. The objective was to develop a methodology that would permit the classification of land areas within the Anthracite Region in terms of their potential for mine-incurred subsidence.
Keyword(s): coal mining, surface structural damage, land-use planning, anthracite, bituminous, prediction
Location(s): Pennsylvania, Appalachian Coal Region, United States

Stingelin, R. W., P. O. MacDonald, J. P. Sparks, E. T. Baker. The Impact of Overmining and Undermining on the Eastern Underground Coal Reserve Base. User's Manual for the Coal Loss Calculation Model Computer Program. Contract JO357129, HRB-Singer, Inc. U.S. Bureau of Mines OFR 6(2)-77, 1976, 78 p. (NTIS PB 262 519)
Keyword(s): computer, multiple-seam extraction, modeling, coal mining
Location(s): Appalachian Coal Region, United States

Stingelin, R. W., P. O. MacDonald, J. P. Sparks, E. T. Baker. The Impact of Overmining and Undermining on the Eastern Underground Coal Reserve Base. Final Report July 1975-September 1976. U.S. Bureau of Mines OFR 6-77-Vol. 1, HRB-Singer Inc., State College, PA, HRB-4967-F, September, 1976, 286 p. (NTIS PB-262 518)
This study developed and implemented of a methodology for estimating the impact of coal seam interaction on the eastern bituminous underground reserve base as published in USBM IC 8655. The effects of previous mining in multiple coal seam areas on currently mined and reserve seams are predicted as a percentage of coal loss by an engineering assessment model called the Coal Loss Calculation Model. The model was developed and tested using data from four coal mines in western Pennsylvania and southern West Virginia.
Keyword(s): coal mining, active mines, bituminous, multiple-seam extraction, modeling, mathematical model, rock mechanics
Location(s): Pennsylvania, West Virginia, Appalachian Coal Region, United States

Stone, K. J. L., R. J. Jewell. Modelling Surface and Subsurface Subsidence Over Coal Mines. IN: Proceedings 6th Australia-New Zealand Conference on Geomechanics, Christchurch, February 3-7, 1992, New Zealand Geomechanics Society, p. 269-273.
Many modern mining methods make surface subsidence unavoidable. Subsidence prediction has generally been by empirical methods. Both longwalling and Wongawilli extraction have been simulated in tests in a geotechnical centrifuge to enable greater understanding of the phenomenon. Scaling laws, the trapdoor system to replicate mining, and data acquisition are discussed. Initial results are illustrated, with crack patterns on model faces and model surfaces shown. Work suggests that centrifuge testing will prove a valuable tool in understanding and predicting subsidence.
Keyword(s): modeling, prediction, longwall, high-extraction retreat
Location(s): Australia

Stoner, J. D. Probable Hydrologic Effects of Subsurface Mining. Ground Water Monitoring Review, v. 3, no. 1, 1983, p. 128-137.
Keyword(s): hydrology, subsurface water

Stout, K. The Law of Subsidence and Support as Applied to Mines. IN: SME Mining Engineering Handbook, v. 1, 1973, A.B. Cummins and I.A. Givens, eds., SME-AIME, New York, p. 13-180 - 13-193.
This chapter discusses what a landowner can expect in terms of lateral and subjacent support. Lateral support is given by land lying adjacent; subjacent support is support by underlying land.
Keyword(s): law

Stringfield, V. T., J. R. Rapp. Land Subsidence Resulting from Withdrawal of Groundwater in Carbonate Rocks. IN: Proceedings 2nd International Symposium on Land Subsidence, Anaheim, CA, IAHS-AIHS Publication No. 121, December, 1976, p. 447-452.

Keyword(s): fluid extraction

Stritzel, D. L. Observations in Mines Which are Indicative of Ground Control Problems in the Illinois Basin. IN: Proceedings, 1st Conference on Ground Control Problems in the Illinois Coal Basin, August 22-24, 1979, Southern Illinois University, Carbondale, 1980, p. 53-58.

Actual case studies are presented that depict serious ground control problems in the Illinois Basin to understand the theoretical concepts of roof control more clearly. Many concepts of rock mechanics can be applied in the daily routine of practical observations. Complex situations often have simple solutions. If the basics of what causes ground control problems are understood, experience can be used in conjunction with theory to prevent such occurrences, thereby providing safer and more efficiently operated coal mines.

Keyword(s): coal mining, ground control, roof stability, rock mechanics, mine safety

Location(s): Illinois, Illinois Coal Basin, United States

Strzalkowski, P. Evaluation of the Parameters for Use with Statistic-Integral Theories of Predicting the Influence of Mining Extraction Based on Zych's Method. IN: Ground Movements and Structures, Proceedings 4th International Conference, University of Wales College of Cardiff, July 8-11, 1991, J.D. Geddes, ed., Pentech Press, London, 1992, p. 255-265.

The application of Zych's (1987) method (which provides a great improvement on the statistic-integral theories presented so far) considerably increases the quality of a prediction. Therefore, in this work, the discussion of the selection of proper values of parameters for carrying out calculations is presented on the basis of Zych's method.

Keyword(s): prediction, modeling, horizontal displacement, vertical displacement

Location(s): Poland

Stull, R. T., R. K. Hursh. Tests on Clay Materials Available in Illinois Coal Mines. Illinois State Geological Survey, Mining Investigation Bulletin 18, 1917, 130 p.

Keyword(s): coal mining, historical

Location(s): Illinois, Illinois Coal Basin, United States

Stump, D. E. Underground Coal Mine Subsidence Impacts on Surface Water. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 253 (abstract only).

Subsidence from underground coal mining alters surface water discharge and availability. The magnitude and areal extent of these impacts are dependent on many factors, including the amount of subsidence, topography, geology, climate, interactions between surface water and groundwater interactions, and fractures in the overburden. These alterations may have positive and/or negative impacts. One of the most significant surface water impacts occurred in July 1957 near West Pittston, Pennsylvania. Subsidence in the Knox Mine under the Coxton Yards of the Lehigh Valley Railroad allowed part of the discharge in the Susquehanna River to flow into the mine and create a crater 200 feet in diameter and 300 feet deep.

Keyword(s): surface water, coal mining

Location(s): Pennsylvania, Appalachian Coal Region, United States

Sturges, F. C., J. H. Clark. Fly Ash--The Answer to Mine Subsidence Protection? Coal Mining and Processing, v. 7, no. 4, 1970, p. 69-73, 88-89.

This paper discusses several applications and procedures for using fly ash to minimize mine subsidence damage.

Keyword(s): backfilling, abandoned mines, coal mining

Stutzer, O. Geology of Coal. The University of Chicago Press, Chicago, IL, original 1923, translation 1940, p. 416-426.

One section covers disturbances of coal beds, including subsidence. The author describes surface cracks, overburden characteristics, subsidence prediction, groundwater withdrawal, and house and bridge damages.

Keyword(s): floor stability, coal mining, geologic features, surface structural damage, hydrology, subsurface water

Location(s): Germany

Styler, A. N. Strata Deformation Above Longwall Faces. Department of Mining Engineering, University of Newcastle-Upon-Tyne, England, 1979,

11 p. (Available for consultation at the USBM Denver Research Center.)

Keyword(s): longwall, subsurface subsidence damage

Location(s): United Kingdom

Styler, A. N., R. K. Dunham. Strata Deformation Above Longwall Faces. IN: Rock Mechanics: A State of the Art, Proceedings 21st U.S. Symposium on Rock Mechanics, University of Missouri at Rolla, May 28-30, 1980, D.A. Summers, ed., p. 308-318.

The mechanics of strata deformation above longwall faces has attracted the attention of many investigators over the past 20 years. Because of access difficulties, very few of these investigations have included detailed measurement of inter-strata deformations at levels above the seam. This paper presents the final results from two investigations to monitor strata deformation above shallow undersea longwalls. Results are compared with those of similar studies and with predicted values of ground movement obtained from the National Coal Board Subsidence Engineers Handbook.

Keyword(s): longwall, coal mining, active mines, monitoring methods, overburden, instrumentation, surface water

Location(s): United Kingdom

Styler, N. Prediction of Inter-Strata Movements Above Longwall Faces. IN: Rock Mechanics in Productivity and Protection, Proceedings 25th Symposium on Rock Mechanics, Northwestern University, Evanston, IL, June 25-27, 1984, C.H. Dowding and M.M. Singh, eds., SME-AIME, New York, p. 651-658.

This paper presents an analysis of measurements of inter-burden deformations above six longwall faces. An attempt is made to demonstrate some correlation between the movements at the various sites and to examine their importance with respect to predicting caving height, disruption of overlying seams, and disruption of aquifers. This analysis demonstrates some significant differences between predicted surface subsidence and inter-burden deformation. In addition, it is shown that the caving height above a longwall face is equal to 8 to 12 times the extraction height, with a zone of fractured rock extending to approximately 50 times the extraction height above the seam.

Keyword(s): longwall, overburden, subsurface water, prediction, multiple-seam extraction, prediction

Location(s): United Kingdom, United States

Su, D. W. H., G. J. Hasenfus. Field Measurements of Overburden and Chain Pillar Response to Longwall Mining. IN: Proceedings, 6th International Conference on Ground Control in Mining, June 9-11, 1987, S.S. Peng, ed., West Virginia University, Morgantown, p. 296-311.

This paper presents the results of an extensive geomechanical testing and monitoring program conducted at a longwall panel. The field program included the monitoring of roof caving sequence and mechanism, surface subsidence, change of pillar stress, roof displacement and entry convergence, and strength characterization of the overburden rocks. The response of eight headgate pillars and the adjacent entries was monitored as the longwall face approached and passed the instrumented locations. Overburden response to longwall mining was monitored using TDR; the height of the highly fractured zone above the gob was determined by postmining drilling. Good correlation was found between the height of the highly fractured zone and the TDR, subsidence, and pillar stress data. The results provide a detailed picture of the response of overburden strata and chain pillars to longwall mining.

Keyword(s): longwall, monitoring methods, overburden, monitoring equipment, modeling, coal mining, rock mechanics, instrumentation, pillar strength, survey equipment, survey methods, survey data processing

Location(s): Appalachian Coal Region, United States

Su, D. W. H. Finite Element Modeling of Subsidence Induced by Underground Coal Mining: The Influence of Material Nonlinearity and Shearing Along Existing Planes of Weakness. IN: Proceedings 10th International Conference on Ground Control in Mining, June 10-12, 1991, S.S. Peng, ed., West Virginia University, Morgantown, p. 287-300.

Surface subsidence induced by multiple-panel coal extraction was calculated with finite element stress analysis. The use of nonlinear material behavior and GAP elements, which provide a realistic representation of shearing along existing planes of weakness, allows the finite element program to accurately reproduce observed subsidence profiles.

Keyword(s): finite element, modeling, coal mining, prediction, mathematical model

Location(s): Appalachian Coal Region, United States

Su, D. W. H. Finite Element Modeling of Surface Subsidence Induced by Underground Coal Mining. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 32-46.

The finite element model described and evaluated in this paper is based on 5 years of underground and surface observations and evolutionary development of modeling techniques and attributes. The model can be used to calculate post-mining stress and strain conditions at any horizon between the mine and the ground surface.

Keyword(s): finite element, modeling, coal mining, prediction, longwall, rock mechanics

Location(s): Appalachian Coal Region, United States

Su, W. H., S. M. Hsiung, S. S. Peng. Optimum Mining Plan for Multiple Seam Mining. IN: Rock Mechanics in Productivity and Protection, Proceedings 25th Symposium on Rock Mechanics, Northwestern University, Evanston, IL, June 25-27, 1984, C.H. Dowding and M.M. Singh, eds., SME-AIME, New York, p. 591-602.

Multiple seam mining and its associated problems are very serious in southern West Virginia where poor planning or lack of knowledge in seam interaction often results in complete loss of coal properties. Several measures have been proposed to alleviate the interaction problems under various multiple seam conditions, but few of them are specific in terms of mining plan. Two parallel approaches are adopted for this paper.

Keyword(s): coal mining, multiple-seam extraction, active mines, finite element

Location(s): West Virginia, Appalachian Coal Region, United States

Subsidence Compensation Review Committee. The Repair and Compensation System for Coal Mining Subsidence Damage. Department of Energy, London, 1984, 98 p.

Keyword(s): surface structural damage, coal mining

Location(s): United Kingdom

Sugawara, K., Y. Obara, H. Okamura. Pre-Calculation of Surface Subsidence Due to Coal Mining. IN: Proceedings 5th International Conference on Numerical Methods in Geomechanics, Nagoya, Japan, April 1-5, 1985.

A finite element procedure is applied for the prediction of surface subsidence. It features improvements, such as use of joint elements for bedding planes and considerations of the scale effect on the stiffness of discontinuity and the transverse anisotropic behavior of rock related to the tensile fracture, and permits the simulation of thin seam extraction.

Keyword(s): prediction, finite element, longwall, overburden, modeling, coal mining, geologic features

Sullivan, A. M. Satellite Photos Trace Unstable Mine Roof. Coal Age, v. 83, no. 9, 1978, p. 60-69.

Keyword(s): photography, coal mining, roof stability, remote sensing

Sullivan, P. J., C. F. Hutchinson, J. Makihara, J. Evensizer. Methodology for the Environmental Assessment of Advanced Coal Extraction Systems. Jet Propulsion Laboratory, Pasadena, CA, June 15, 1980, 205 p. (NTIS JPL-PUB-79-82)

Keyword(s): environment, coal mining, land-use planning

Location(s): United States

Summers, D. A., ed. Rock Mechanics: A State of the Art. Proceedings 21st U.S. Symposium on Rock Mechanics, May 28-30, 1980, University of Missouri at Rolla, 835 p.

Keyword(s): rock mechanics, finite element, longwall, modeling, ground control, room-and-pillar, surface structural damage, railroads, pillar extraction, mine design, lab testing

Summers, J. W., R. I. Jeffery. Numerical Prediction of Strata Deformation Associated with Longwall Mining. Transactions Institution of Mining and Metallurgy, Jan-Apr, v. 101, 1992.

Keyword(s): prediction, longwall

Sutherland, H. J., R. A. Schmidt, K. W. Schuler, E. S. Benzley. Physical Simulation of Subsidence by Centrifuge Techniques. Report on Department of Energy Contract No. DE-AC04-76DP00789, 1979, 18 p. (NTIS SAND-78-2272C)

Keyword(s): modeling, physical model

Location(s): United States

Sutherland, H. J., R. A. Schmidt, K. W. Schuler, S. E. Benzley. Physical Simulations of Subsidence by Centrifuge Techniques. IN: Proceedings, 20th U.S. Symposium on Rock Mechanics, Austin, TX, June 4-6, 1979, p. 279-286.

The subsidence of linearly elastic strata above shallow mine drifts is studied by using centrifuge simulation techniques and finite-element calculational techniques. The centrifuge simulations, conducted on a 6-foot-radius machine, examined six configurations in jointed and unjointed structures of foundry stone and ashfall tuff. Two of these configurations are analyzed numerically.

Keyword(s): finite element, modeling, physical model

Sutherland, H. J., K. W. Schuler, S. E. Benzley. Observations and Analytic Calculations of Strata Movement Above Idealized Mine Structures. IN: Proceedings, 7th Annual Underground Coal Conversion Symposium, Fallen Leaf Lake, CA, September 8-11, 1981, p. 290-302.

Keyword(s): mine design, modeling, overburden, coal mining

Sutherland, H. J., D. E. Munson. Complementary Influence Functions for Predicting Subsidence Caused by Mining. IN: Issues in Rock Mechanics, Proceedings 23rd U.S. Symposium on Rock Mechanics, R.E. Goodman and F.E. Heuze, eds., SME, New York, 1982, p. 1115-1121.

Surface subsidence caused by underground mining is described through complementary influence functions. The complementary functions developed here differ from the simple functions previously used in that the surface displacement is the result of the combined contributions of the mined and unmined zones. This eliminates computational difficulties experienced with the simple functions in determining the deflections above the rib side and in the eventual application of influence functions to complex room-and-pillar configurations. Although the analysis framework presented is intended for predicting subsidence over complex mine configurations, use of the complementary functions is illustrated adequately by application to a longwall panel of the Old Ben No. 24 coal mine.

Keyword(s): influence function, prediction, empirical model, rock mechanics, longwall, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Sutherland, H. J. Centrifuge Simulations of the Subsidence Over Coal Mines and the Stability of Tailings Dams. IN: High Gravity Simulation for Research in Rock Mechanics, G.B. Clark, ed., Colorado School of Mines, May 13-14, 1982, p. 71-98.

Keyword(s): modeling, coal mining

Location(s): United States

Sutherland, H. J., K. W. Schuler. A Review of Subsidence Prediction Research Conducted at Sandia National Laboratories. IN: Proceedings, Workshop on Surface Subsidence Due to Underground Mining, November 30-December 2, 1981, S.S. Peng and M. Harthill, eds., Department of Mining Engineering, West Virginia University, Morgantown, 1982, p. 1-14.

This paper highlights results of the subsidence research program at Sandia National Laboratories: the application of empirical methods to subsidence above longwall panels; the use of the "rubble model" to describe the behavior of broken strata as it distends when it falls to the mine floor and then is compacted by overlying strata; and the application of physical modeling techniques (centrifuge simulations) and numerical techniques to study failure mechanisms in highly structured stratigraphy.

Keyword(s): vertical displacement, longwall, prediction, modeling, geologic features, subsidence research

Location(s): Illinois, Illinois Coal Basin, West Virginia, Appalachian Coal Region, United States

Sutherland, H. J., K. W. Schuler. A Review of Subsidence Prediction Research Conducted at Sandia National Laboratories. Sandia National Laboratories, Report SAND82-0017, Albuquerque, NM, April, 1982, 46 p.

This paper reviews the results of the subsidence research program at Sandia National Laboratories. The manuscript highlights the following: the application of empirical methods (profile functions) to the subsidence above longwall panels in the United States; the use of the "rubble model" to describe the behavior of broken strata as it distends when it falls to the mine floor (or top of the rubble pile) and then is subsequently compacted as it is loaded by overlying elements of strata; and the application of physical modeling techniques (centrifuge simulations) and numerical techniques to study the failure mechanisms in highly structured stratigraphy. The capabilities of the latter two are illustrated by comparing their predictions to the results of a field case that has complicated stratigraphy.

Keyword(s): empirical model, profile function, modeling, geologic features, longwall

Location(s): United States

Sutherland, H. J., K. W. Schuler, S. E. Benzley. Numerical and Physical Simulations of Strata Movements Above Idealized Mine Structures. In Situ, v. 7, no. 1, 1983, p. 87-113.

Keyword(s): modeling, physical model

Sutherland, H. J., P. J. Hommert, L. M. Taylor, S. E. Benzley. Subsidence Prediction for the Forthcoming TONO UCG Project. IN: Proceedings 9th Annual Underground Coal Gasification Symposium, DOE/METC/84-7 (DE84003052), December, 1983, p. 99-108.
Keyword(s): prediction, coal gasification
Location(s): United States

Sutherland, H. J., P. J. Hommert, L. M. Taylor, S. E. Benzley. Subsidence Modeling. IN: Process and Technology Development Activities for In Situ Coal Gasification-FY83, R.E. Glass, ed., Sandia National Laboratories, Albuquerque, NM, SAND83-2041, October, 1983, p. 33-49.
Keyword(s): modeling, coal gasification

Sutherland, H. J., D. E. Munson. Subsidence Prediction for High Extraction Mining Using Complementary Influence Functions. Sandia National Laboratories Report, SAND82-2949, U.S. DOE contract DE-ACO4-76DP00789, Albuquerque, NM, February, 1983, 31 p. (NTIS SAND82-2949)
A new approach has been developed for the use of influence functions in the prediction of mine subsidence. In this approach, complementary influence functions are developed for the response of both mined and unmined elements. The surface displacement is then determined by integrating (appropriately summing) the response for each unit element over its area of influence. Both elements contribute significantly to the subsidence prediction. Development of complementary influence functions represents a significant advancement in the subsidence analysis of complicated room-and-pillar mines using empirical techniques. Comparisons between field data and predictions for two longwall panels and a room-and-pillar panel illustrate the capabilities of this technique.
Keyword(s): vertical displacement, prediction, influence function, empirical model, modeling, room-and-pillar, longwall, yielding supports
Location(s): Illinois, Illinois Coal Basin, West Virginia, Pennsylvania, Appalachian Coal Region, United States

Sutherland, H. J., A. A. Heckes, L. M. Taylor. Physical and Numerical Simulations of Subsidence Above High Extraction Coal Mines. Preprint, Sandia National Laboratories, Albuquerque, NM, for the U.S. Department of Energy, SAND83-1191C, March, 1984, 8 p.
Modeling the failure and settlement of strata above mine openings requires a knowledge of several different geomechanical processes such as the failure of the rock mass above the opening, the fall of this mass into the opening, the associated bulking of the rock rubble, and the recompaction of the rubble under subsequent loading. These processes are studied in this paper using physical models and analytical models. The former are based on centrifuge simulation techniques and the latter on numerical techniques.
Keyword(s): modeling, coal mining, overburden, physical model
Location(s): United States

Sutherland, H. J., D. E. Munson. Prediction of Mine Subsidence Using Complementary Influence Functions. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 21, no. 4, August, 1984, p. 195-202.
Surface subsidence caused by high-extraction underground mining is described through complementary influence functions. This concept differs from other proposed concepts in that the surface displacement is the result of the combined contributions of mined and unmined zones. The approach eliminates computational difficulties experienced with the conventional influence functions in determining the deflections above the rib side, and in the application of influence functions to complex room-and-pillar configurations. The general analytical framework for complementary influence functions is reported here. The technique is illustrated with analyses of several case histories which include both longwall and room-and-pillar mine plans.
Keyword(s): prediction, influence function, rock mechanics, empirical model, longwall, room-and-pillar
Location(s): Illinois, Illinois Coal Basin, Pennsylvania, West Virginia, Appalachian Coal Region, United States

Sutherland, H. J., P. J. Hommert, L. M. Taylor, S. E. Benzley. Subsidence Prediction for Two UCG Projects. In Situ, v. 8, no. 4, 1984, p. 347-367.
Keyword(s): prediction

Sutherland, H. J. The Use of Centrifuge Simulation Techniques in U.S. Rock Mechanics. IN: 1984 Annual Review of U.S. Progress in Rock Mechanics: Rock Dynamics, F.E. Henze, ed.
Keyword(s): rock mechanics, modeling
Location(s): United States

Sutherland, H. J., A. A. Heckes, L. M. Taylor. Physical and Numerical Simulations of Subsidence Above High Extraction Coal Mines. IN: Proceedings, International Society for Rock Mechanics Symposium on Design and Performance of Underground Excavations, Cambridge, England, September, 1984, E.T. Brown and J.A. Hudson, eds., British Geotechnical Society, London, p. 65-72.
Keyword(s): coal mining, modeling, physical model

Sutherland, H. J., L. M. Taylor, S. E. Benzley. Physical and Numerical Simulations of Subsidence in Fractured Shale Strata. IN: Proceedings, 10th Annual Underground Coal Gasification Symposium, DOE/METC-85/5 (DE85001956), December, 1984, E. Burwell, L. Docktor, and J.W. Martin, eds., p. 388-399.
Keyword(s): prediction, modeling, physical model, overburden, coal gasification, roof stability

Sutherland, H. J. Roof Stability Prediction for the TONO UCG Site. Underground Coal Gasification Program FY84 Annual Report, C.E. Tyner, ed., SAND85-0101, Sandia National Laboratories, Albuquerque, NM, March, 1985, p. 39-41.
Keyword(s): roof stability, prediction, coal gasification
Location(s): United States

Sutherland, H. J. Subsidence and Roof Stability Analyses for the Extraction and In Situ Processing of Fossil Fuels. Sandia National Laboratories, Albuquerque, NM, Report SAND85-2077, for U.S. Department of Energy, (DE86007552), December, 1985, 95 p. (NTIS 624751747 F)
In the late 1970s, a coal mine subsidence research and development program was initiated at Sandia National Laboratories for the U.S. Department of Energy. The program objective was to develop the capability to predict surface subsidence above coal mines as a function of the mine plan and the geologic setting. As this research progressed, its scope was expanded to encompass strata motions associated with in situ extraction of fossil fuels. A comprehensive bibliography of the publications produced by this program and synergistic studies at Sandia is included.
Keyword(s): prediction, coal mining, mine design, geologic features, longwall, modeling, roof stability, room-and-pillar, empirical model, influence function, finite element, literature search
Location(s): United States, England, Wyoming, Illinois, New Mexico, Washington, Pennsylvania

Suzuki, K. Stress Variation in Coal-Seam Near Longwall Workings Underground. Journal Mining & Metallurgy Institute, Japan, v. 74, 1958, p. 996-1000.
Keyword(s): longwall, coal mining

Swain, H. Successful Design for Mining Subsidence. Architecture Journal, v. 143, May, 1974, p. 1047-1054.
The author describes a building construction system (CLASP) designed for articulated structures located over undermined areas. Rather than depending on strength, the buildings are designed to depend on lightness and flexibility to withstand the effects of subsidence. The key component, diagonal spring-loaded wind brace, permits the buildings to resist wind forces but compress to allow the building frame to adjust to subsidence.
Keyword(s): surface structural damage, ground control, construction, engineering, architecture

Swallow, F. C. Caving Chambers. Colliery Guardian, v. 157, 1938, p. 1079 and 1159; v. 158, 1939, p. 392.
Caving the roof in certain areas lessened the stress and strengthened the roof over areas adjacent to the caved area.
Keyword(s): roof stability

Swart, L. The Extraction of a Shaft Pillar at Shallow Depth. Association Mine Managers Transvaal, Papers and Discussions, 1952/53, p. 93-103.
Keyword(s): pillar extraction, room-and-pillar
Location(s): South Africa

Sweet, A. L. Validity of a Stochastic Model for Predicting Subsidence. IN: ASCE Journal Engineering Mechanics Division, v. 91, no. EM6, Proceedings Paper 4573, 1965, p. 111-128.
Experiments using sand and glass spheres as media investigated the small subsidence of media between two parallel plates of glass resulting from the medium escaping through a narrow opening at the lower edges of the plates.
Keyword(s): prediction, stochastic model, modeling, empirical model
Location(s): United States

Sweet, A. L., J. L. Bogdanoff. Stochastic Model for Predicting Subsidence. ASCE Journal Engineering Mechanics Division, v. 91, no. EM2, 1965, p. 21-45.

A stochastic model for predicting subsidence of a granular medium is presented; it yields a Markov chain for which a solution is not found. Time is eliminated as a variable by examining the subsidence only after motion has ceased.

Keyword(s): prediction, stochastic model, modeling, empirical model

Symons, M. V. Sources of Information for Preliminary Site Investigation in Old Coal Mining Areas. IN: Large Ground Movements and Structures, Proceedings International Conference, University of Wales Institute of Science and Technology, Cardiff, 1977, J.D. Geddes, ed., John Wiley & Sons, New York, 1978, p. 119-135. (NTIS Accession No. 79-22617)

All known sources of information relating to past coal mining activities were consulted for an area where coal extraction from the productive Upper Coal Measures took place between the 16th and mid-20th centuries. The occurrence of shafts, adits, and shallow workings obtained from this study were compared with that obtained by the normal procedure of referring to the abandonment plans held by the National Coal Board, to Ordnance and Geological Survey plans, to Geological Memoirs, and to aerial photographs. The benefits to be gained from this more extensive form of preliminary investigation are assessed and the feasibility of adopting it as standard procedure is discussed. Recommendations are made in relation to site investigations in old coal mining areas.

Keyword(s): coal mining, abandoned mines, surface structural damage, engineering, land-use planning, National Coal Board

Location(s): United Kingdom

Symons, M. V. Preliminary Site Investigation in Old Coal Mining Areas -Problems of Correlating Coal Seam Names. IN: Ground Movements and Structures, Proceedings 2nd International Conference, University of Wales Institute of Science and Technology, Cardiff, 1980, J.D. Geddes, ed., John Wiley & Sons, New York, 1981, p. 211-237.

This paper examines the problems involved in correlating old coal seam names with present known seams in an area where coal was mined between the 16th and mid-20th centuries. The practical benefits to be gained from this correlation are assessed.

Keyword(s): coal mining, historical, land-use planning, engineering

Location(s): United Kingdom

Symons, M. V. Site Investigation in Old Coal Mining Areas--Recommended Procedure for the Desk Study. IN: Ground Movements and Structures, Proceedings 3rd International Conference, University of Wales Institute of Science and Technology, 1984, J.D. Geddes, ed., Pentech, London, 1985, p. 173-187.

Details are provided of a good practice procedure for carrying out the Desk Study for a site investigation in an old coal mining area. Step-by-step instructions are given, in both written and flow chart form, with all information sources listed and the feasibility of consulting them discussed.

Keyword(s): abandoned mines, literature search, coal mining, land-use planning, National Coal Board

Location(s): United Kingdom

Systems Planning Corporation. Evaluation of Mine Subsidence, Neighborhood Development Program, Webster-Elba and Roberts-Devilliers Project Action Areas. Report for the Urban Redevelopment Authority, Pittsburgh, PA, 1973.

This paper covers subsidence of mines operated prior to 1900 at depths of less than 100 feet. Possible subsidence prevention measures included overexcavation, deep foundations, loose filling, grout columns, and bulk grouting.

Keyword(s): grouting, historical, abandoned mines, structural mitigation, land-use planning

Location(s): Pennsylvania, Appalachian Coal Region, United States

Szpetkowski, S. Obliczanie Wielkosci Deformacji Powierzchni Na Terenachgorniczych (Calculating the Extent of Surface Deformation Resulting from Mining Exploitation). Przeglad Gorniczy, v. 27, no. 4, 1971, p. 170-174.

Keyword(s): prediction

Szpetkowski, S. Wyznaczanie Deformach Powierzchni Przy Eksploateji Prostokatnych Pol Pokladow Poziomych (Determination of Surface Deformation in Excavation of Rightangled Fields of Horizontal Seams). Archiwum Gornictwa, v. 21, no. 3, 1976, p. 205-222.

Keyword(s): prediction

Szpetkowski, S. Prognozowanie Wplywow Na Powierzchni Terenu Nie Zlozach Pokladowych (Forecasting Mining Effects on the Land Surface of Ungotten Solid Coal and Roadside Packs in Sedimentary Deposits). Przeglad Gorniczy, v. 35, no. 7-8, 1979, p. 292-294.
Keyword(s): prediction

Szpetkowski, S. Determination of Surface Subsidence While Extracting Several Coal Seams at Medium and Great Depth with Caving. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 19, no. 3, June, 1982, 8 p.
Keyword(s): surface subsidence damage, prediction, mine design, multiple-seam extraction, coal mining

Szpetkowski, S. Extended Range of Determination of the Predicted Effect of Underground Mining for the Purpose of Surface Protection. Archivum Gornictwa (Mining Archive), v. 27, 1982, no. 1-2 (in English).
Keyword(s): prediction

Szumierz, W. Wplyw Poziomych Deformacji Gorniczych Podloza Na Prace Budowli Liniowych (Influence of Horizontal Deformations on the Subsidence of Linear Structures). Archiwum Inzynierii Ladowej, v. 22, no. 4, 1976, p. 647-663.
Keyword(s): horizontal displacement, surface structural damage

Szwilski, A. B., B. N. Whittaker. Control of Strata Movement Around Face-Ends. Mining Engineering, v. 174, 1975, p. 515-525.
Keyword(s): mine design, longwall, ground control

Szwilski, A. B. Stability of Coal Seam Strata Undermined by Room and Pillar Operations. IN: Proceedings 20th U.S. Symposium on Rock Mechanics, June 4-6, 1979, University of Texas, Austin, p. 59-65.

Mining interaction in multiple seam coal mines is an ever increasing problem. Interaction is a significant mining feature that demands effective planning. Analysis of the mining situation can alleviate the risks of interaction, enhance profitability and the development of reserves. Subsequently systematic mining should be practiced. A concept of anticipating the effect of undermining coal seams by room-and-pillar operations has been developed based on an actual case study. A parallel is made to that of an advancing/retreating longwall panel. Conclusions are drawn as to the best mining method of exploiting the disturbed coal seam that has been undermined, based on the specific geological conditions.
Keyword(s): multiple-seam extraction, coal mining, mine design, room-and-pillar, geologic features
Location(s): Rocky Mountain Coal Region, United States

Szwilski, T. B. Influence of Coal Rib Pillar Width on the Stability of Strata Around the Face-End and Gateroad in Longwall Mining. IN: Rock Mechanics: A State of the Art, Proceedings 21st Symposium on Rock Mechanics, University of Missouri at Rolla, May 28-30, 1980, D.A. Summers, ed., p. 285-298.
The efficiency of operation and life of an advancing longwall coal face depends, to a great extent, on the face-end roof strata conditions and the stability of the gateroads. The factors that influence the rate of closure of gateroads are examined, in particular, the gateside pack and the coal rib (crush) pillars. The performance of mechanized packing systems is briefly discussed. Gateroad deformation surveys were carried out at two coal mines to determine the influence of the rib pillar width on the gateroad stability.
Keyword(s): coal mining, longwall, rock mechanics, ground control, mine design
Location(s): E

Tadolini, S. C., K. Y. Haramy. Gateroads with Yield Pillars for Stress Control. IN: Proceedings 4th Conference on Ground Control for Midwestern U.S. Coal Mines, Mt. Vernon, IL, November 2-4, 1992, Y.P. Chugh and G. Beasley, eds., Southern Illinois University, Carbondale, p. 179-194.

Ground control problems associated with deep coal mines have increased interest in the design of longwall gateroads using yielding pillars. This paper presents a discussion of the yield pillar theory and assesses the stability of gateroads with yield pillar configurations. Case studies were conducted in two underground longwall mines using two- and three-entry yielding chain pillar configurations.

Keyword(s): ground control, coal mining, active mines, yielding supports, longwall, pillar strength, mine design, instrumentation, geologic features

Location(s): Utah, Colorado, Rocky Mountain Coal Region, United States

Tandanand, S., L. R. Powell. Consideration of Overburden Lithology for Subsidence Prediction. IN: Proceedings Workshop on Surface Subsidence Due to Underground Mining, Morgantown, WV, November 30-December 2, 1981, S.S. Peng and M. Harthill, eds., Department of Mining Engineering, West Virginia University, 1982, p. 17-29.

Geological differences among various coalfields restrain the applicability of subsidence prediction using existing European methods. To modify these methods for domestic conditions, the USBM developed a method of assessment to evaluate the lithological effects on subsidence in the Northern Appalachian basin by examining data collected from 16 longwall panels in the coalfield. Results to date showed that the ratio of maximum subsidence to extraction thickness, known as the subsidence factor, can be expressed in terms of the width-to-depth ratio by a simple exponential equation that has a coefficient tentatively considered as the subsidence index. This index varies with the lithology of a particular site and can be expressed in terms of the percent distribution of weak and strong rocks in the overburden.

Keyword(s): prediction, overburden, prediction, longwall, coal mining, geologic features

Location(s): Appalachian Coal Region, United States

Tandanand, S., L. R. Powell. Assessment of Subsidence Data from the Northern Appalachian Basin for Subsidence Prediction. U.S. Bureau of Mines RI 8630, 1982, 14 p.

The authors investigated data collected from 16 longwall panels in the northern Appalachian basin, paying particular attention to the effects of rock lithology, excavation width, and panel depth on the subsidence factor. Based on these data, the subsidence factor is expressed in terms of the width-to-depth ratio by an exponential equation.

Keyword(s): vertical displacement, longwall, prediction, survey data processing, geologic features, coal mining

Location(s): Appalachian Coal Region, United States

Tandanand, S., L. R. Powell. Influence of Lithology on Longwall Mining Subsidence. Mining Engineering, December, 1984, p. 1666-1671.

Data were collected from 13 mines in the Northern Appalachian Coal Basin to assess the geological effects on the ratio of maximum subsidence and extraction thickness, known as the subsidence factor, to develop a simple subsidence prediction method.

Keyword(s): survey data processing, prediction, longwall, geologic features, coal mining

Location(s): Pennsylvania, Ohio, West Virginia, Maryland, Appalachian Coal Region, United States

Tandanand, S. Moisture Adsorption Rate and Strength Degradation of Illinois Shales. IN: Research & Engineering Applications in Rock Masses, Proceedings 26th U.S. Symposium on Rock Mechanics, South Dakota School of Mines & Technology, Rapid City, June 26-28, 1985, E. Ashworth, ed., Balkema, Rotterdam, p. 591-600.

This paper presents a USBM study on the time-dependent behavior of coal measure rocks. The change in weight of Illinois shales due to moisture adsorption was examined. The relationships between moisture adsorption and strength degradation under isothermal conditions were developed.

Keyword(s): roof stability, prediction, overburden, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Tandanand, S., T. Triplett. New Approach for Determining Ground Tilt and Strain Due to Subsidence. IN: Proceedings, National Symposium on Mining, Hydrology, Sedimentology, and Reclamation, Springfield, IL, December 7-11, 1987, Office of Engineering Services, College of Engineering, University of Kentucky, p. 217-222.

Tilt, horizontal displacement, and ground strain due to mining-induced subsidence create severe effects on continuous and discrete surface structures. At present, field measurement of these parameters for subsidence precautions is laborious and time consuming. Empirical implications that the horizontal displacement at a particular point is proportional to the tilt and that the strain is proportional to the curvature have been used in conjunction with subsidence predictions in Europe. As part of developing a new technique to facilitate subsidence monitoring, the USBM has examined these relationships and determined that the proportionality factor is related to the depth of the neutral stratum and has a stationary value if the ratio of maximum horizontal displacement to full subsidence is constant.

Keyword(s): prediction, active mines, coal mining, subsidence research, horizontal displacement, surface structural damage, structural mitigation

Location(s): Illinois, Illinois Coal Basin, United States

Tandanand, S., L. R. Powell. Determining Horizontal Displacement and Strains Due to Subsidence. U.S. Bureau of Mines RI 9358, 1991, 9 p.

Horizontal displacements and ground strains induced by mine subsidence are significant information needed for calculating damage and developing precautions against subsidence effects on surface structures. To devise a simple method for determining the surface horizontal displacements and strains simultaneously with the subsidence prediction, the USBM examined the significance of the tilt number, which is the proportionality constant in the relationship between the horizontal displacement and the slope of the subsidence profile. The ratio of the tilt number to the critical radius of the subsidence trough is identical to the ratio of the maximum possible horizontal displacement to the full subsidence, which is found to be constant in most European coalfields. If this ratio is known for a particular minesite in the United States, then horizontal displacement and ground strains can be readily obtained from the primary subsidence data.

Keyword(s): horizontal displacement, surface structural damage, prediction, active mines, overburden

Tang, D. H., S. S. Peng. Mine Pillar Stability Analysis Using FEM Methods--Two Case Studies. IN: Proceedings 9th International Conference on Ground Control in Mining, June 4-6, 1990, S.S. Peng, ed., West Virginia University, Morgantown, p. 88-98.

Massive pillar failures were observed at two underground coal mines. The results of stability analysis using traditional pillar design formulas did not agree with the underground observations. Finite element models were used to analyze the causes and mechanisms of the pillar failures. The results were confirmed by the underground observations. Finally, the improved mine plan for each case was derived to ensure the stability of the underground structure.

Keyword(s): finite element, coal mining, pillar strength, modeling, room-and-pillar, pillar extraction, floor stability

Location(s): West Virginia, Appalachian Coal Region, United States

Tang, D. H. Y., S. S. Peng. Structural Analysis of Mine Pillars Using Finite Element Method--A Case Study. SME-AIME Preprint 87-81, for presentation at the SME-AIME Annual Meeting, Denver, CO, February 24-27, 1987.

Three-dimensional finite element modeling was performed to analyze the safety factors of stump pillars using the Modified Drucker-Prager theory. Results showed they were safe, which was substantiated by underground observations, but the safety factors predicted by three commonly used pillar design formulas showed otherwise. This paper analyzes the differences between these pillar design methods.

Keyword(s): finite element, pillar strength, computer, coal mining, modeling, mine design

Location(s): West Virginia, Appalachian Coal Region, United States

Tang, D. H. Y., S. S. Peng. Structural Analysis of Mine Pillars Using Finite Element Method--A Case Study. Mining Engineering, September, 1988, p. 893-897.

Three-dimensional finite element modeling (3-D FEM) was performed to analyze the safety factors of stump pillars (5.5 x 5.5 m under a cover of 63 m) using the Modified Drucker-Prager theory. The results showed that they were safe. This was substantiated by underground observations, but the safety factors predicted by three commonly used pillar design formulas showed otherwise. This paper discusses the modeling details and analyzes the difference between the 3-D FEM method and traditional pillar design formulas.

Keyword(s): pillar strength, finite element, coal mining, rock mechanics, room-and-pillar, surface structural damage, subsurface water, ground control, lab testing, modeling, computer, roof stability, floor stability, mine design
Location(s): West Virginia, Appalachian Coal Region, United States

Tanious, N. S. Mining Subsidence. M.S. Thesis, University of Minnesota, Minneapolis, July, 1975, 127 p. (NTIS PB 252 455)
The author details the method of analysis and procedures used for formulating a digital computer numerical method for predicting subsidence over flat-lying, seam-type deposits. Existing approaches to subsidence prediction are reviewed.
Keyword(s): vertical displacement, computer, prediction, prediction theories

Tanious, N. S. Investigation of a Large-Scale Coal Pillar Failure. SME Preprint 89-152, for presentation at SME Annual Meeting, Las Vegas, NV, February 27-March 2, 1989, 5 p.
Keyword(s): pillar strength, coal mining, monitoring methods, monitoring equipment, mine design, mine safety
Location(s): Kentucky, United States

Taylor, R. K. Site Investigations in Coalfields: The Problem of Shallow Mine Workings. Quarterly Journal Engineering Geology, v. 1, no. 2, 1968, p. 115-133.
This article gives a general discussion of voids resulting from early mining of coal, clay, and ironstone.
Keyword(s): backfilling, historical, coal mining, non-metal mining, abandoned mines

Taylor, R. K. Characteristics of Shallow Coal-Mine Workings and Their Implications in Urban Redevelopment Areas. IN: Site Investigations in Areas of Mining Subsidence, F.G. Bell, ed., Newnes-Butterworths, 1975, p. 125-148. (Also thesis, University of Minnesota, Minneapolis, July 1975, 127 p.)
Keyword(s): land-use planning, engineering, abandoned mines, coal mining

Taylor, R. K. Development of Resources. IN: Planning and Engineering Geology, Proceedings 22nd Annual Conference of the Engineering Group of the Geological Society, Plymouth Polytechnic, September 8-12, 1986, M.G. Culshaw, et al., eds., The Geological Society, London, 1987, p. 341-346.
This review compares opencast coal mining, dolomite quarrying, and an open-pit tungsten proposal with the planning impacts that affect new underground coal mines. Mine subsidence is commonly the major detractor to underground coal mining.
Keyword(s): coal mining, land-use planning
Location(s): United Kingdom

Tennessee Department of Conservation. Tennessee Coal Surface Mining Law of 1980. Title 59, ch. 8, 1980, p. 29-32.
Section 59-8-312 details the rules and regulations pertaining to surface effects of underground coal mining operations in Tennessee.
Keyword(s): law, government, coal mining
Location(s): Tennessee, United States

Terzaghi, K. Earth Slips and Subsidence for Underground Erosion. Engineering News Record, v. 107, 1931, p. 90-92.
Keyword(s): subsurface subsidence damage

Terzaghi, R. D. Brine Field Subsidence at Windsor, Ontario. IN: Proceedings 3rd Symposium on Salt, Cleveland, OH, 1969, J.L. Rau and L.F. Dellwig, eds., v. 2, p. 298-307.
Keyword(s): non-metal mining
Location(s): Canada

Thakin, D. N. Mechanism of Floor Heaving in Underground Roadways and Measures for its Control. Rock Mechanics Theory and Practice, Mining & Metallurgy Division, Institute of Engineers, Dhanbad, India, 1972, p. 258-277.
Keyword(s): mine operation, mine design, floor stability

Thill, R. E. Acoustical Methods for Monitoring Failure in Rock. IN: Proceedings 14th Symposium on Rock Mechanics, Pennsylvania State University, June, 1972, p. 649-688.
Keyword(s): ground control, bumps, monitoring methods
Location(s): United States

Thom, W. T., Jr. Subsidence and Earth Movements Caused by Oil Extraction, or by Drilling Oil and Gas Wells. Transactions AIME, v. 75, 1927, p.734-742.
The author states that subsidence due to oil and gas removal is probably limited to oil fields in relatively young formations where the oil comes from loosely cemented sands or from oil-soaked clays.

Keyword(s): oil extraction, geologic features
Location(s): Texas, United States

Thomaes, T. L. M., C. J. Vos, J. Boerhave. Viaductbouw In Een Mijnverzakkingsgebied (Construction of a Viaduct in a Coal Mining Subsidence Area). Ingenieur, The Hague, v. 81, no. 40M, October, 1969, p. BT 73-84.
Keyword(s): engineering, construction, surface structural damage

Thomas, J. L. An Introduction to Mining--Exploration, Feasibility, Extraction, Rock Mechanics. Holstead Press, New York, 1978.
Keyword(s): rock mechanics, mine design
Location(s): United States

Thomas, L. J. The Effects of Adjacent Seams and Method of Working on Roadway Closure in the Main Bright Seam at Hucknell Colliery. NCB-MRE Report No. 2330, June, 1968.
Keyword(s): mine operation, multiple-seam extraction, National Coal Board, coal mining
Location(s): England

Thomas, L. J. Effect of Adjacent Seams and Methods of Working in the Main Bright Seam at Hucknall Colliery. Colliery Guardian, v. 218, no. 4, 1970, p. 186-195.
Keyword(s): mine operation, multiple-seam extraction, National Coal Board, coal mining
Location(s): England

Thompson, T. W., J. J. Menezes, K. E. Gray. Roof Stability and Subsidence in In Situ Gasification of Coal. IN: Energy Resources and Excavation Technology, Proceedings 18th Symposium on Rock Mechanics, Keystone, CO, June 22-24, 1977, F-D. Wang and G.B. Clark, eds., Colorado School of Mines Press, Golden, p. 2B1-1--2B1-5.
In situ gasification may well be limited by the ability to predict and control roof behavior and subsidence. This is particularly true in Texas where lignite seams are overlain by weak rock and often with overlying producing aquifers.
Keyword(s): coal gasification, roof stability, overburden, subsurface water, hydrology, geologic features, coal mining, engineering
Location(s): Texas, United States

Thorburn, S., W. M. Reid. Incipient Failure and Demolition of Two-Story Dwellings Due to Large Ground Movements. IN: Large Ground Movements and Structures, Proceedings International Conference, University of Wales Institute of Science and Technology, Cardiff, 1977, J.D. Geddes, ed., John Wiley & Sons, New York, 1978, p. 87-99.
This paper discusses the investigation and monitoring of a housing development damaged by subsidence of abandoned room-and-pillar workings. The homes were eventually destroyed because they became unsafe.
Keyword(s): surface structural damage, abandoned mines, coal mining, geologic features

Thorneycroft, W. The Effect on Buildings of Ground Movement and Subsidence Caused by Longwall Mining. Transactions AIME, v. 94, 1931, p. 51-68.
This paper deals with advancing longwall mining and its effects on a residence. A slight upward wave was indicated by the surveys ahead of the subsidence, which appeared to be due to a tilting over of the massive sandstone stratum in the roof measures near the surface, the edge of the coal face acting as the fulcrum.
Keyword(s): longwall, surface structural damage, monitoring methods, survey methods, coal mining, angle of draw
Location(s): Scotland, United Kingdom

Thurman, A. G., V. Straskraba, R. D. Ellison. Development of a Ground Water Hazard Map for an Underground Coal Mine. IN: Proceedings, Symposium on Water in Mining and Underground Works, SIAMOS--78, Granada, Spain, 1978, p. 273-291.
Groundwater conditions affecting underground coal mine planning, development, and operations at an undeveloped property were investigated. Three minable seams and adjacent sandstone members, separated by shaly confining beds, act as aquifers. As a result of formation dip, head varies from zero to more than 300 meters. Faulting probably connects the aquifers in localized areas. Field and laboratory data were used to establish a groundwater hazard map ranking the property by five levels of hydrogeologic complexity. It was possible, using the map with the mining plan, established with appropriate consideration of mining efficiency, safety, and coal recovery, to estimate the water inflow during development of entries, initial longwall mining and sustained longwall mining for the entire period of operation.
Keyword(s): subsurface water, coal mining, hydrology, geologic features, mine design, longwall, geophysical, monitoring methods, lab testing, geotechnical

Location(s): Wyoming, Rocky Mountain Coal Region, United States

Tieman, G. E. Study of Dewatering Effects at Two Underground Longwall Mine Sites in the Pittsburgh Coal Seam of the Northern Appalachian Coal Field. M.S. Thesis, Department of Geology and Geography, West Virginia University, Morgantown, 1986, 147 p.

Keyword(s): surface water, subsurface water, coal mining, longwall, active mines, hydrology

Location(s): West Virginia, Appalachian Coal Region, United States

Tieman, G. E., H. W. Rauch. Study of Dewatering Effects at an Underground Longwall Mine Site in the Pittsburgh Seam of the Northern Appalachian Coalfield. Eastern Coal Mine Geomechanics, U.S. Bureau of Mines IC 9137, 1986, p. 72-89.

Dewatering effects from longwall mining were studied for a mine site in southwestern Pennsylvania. The mine showed evidence of dewatered streams and groundwater supplies. Water sources located much above base level (major stream level) and over or adjacent to recently mined longwall panels were partly to completely dewatered, probably because of downward leakage along subsidence fractures. These lost waters did not migrate to the deep mine because of its thick overburden (at least 500 feet), but instead flowed laterally over confining strata to discharge at nearby streams. Many affected water supplies recovered partially, and all streams recovered fully within 1 to 3 years following longwall mining. Spring and well recovery occurred most frequently near local stream level where newly formed springs were also common.

Keyword(s): hydrology, subsurface water, longwall, coal mining, overburden

Location(s): Pennsylvania, West Virginia, Appalachian Coal Region, United States

Tieman, G. E., H. W. Rauch, L. S. Carver. Study of Dewatering Effects at a Longwall Mine in Northern West Virginia. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 214-221.

Hydrologic impacts of longwall mining were studied in 1986 after mining had occurred at a mine in northern West Virginia. Five springs and one dug well were reportedly dewatered by mining. All such supplies are above nearby streams in elevation, and at least 800 feet above the subsided mine. Three of these six supplies showed partial recovery within 1 year. Only supplies within 50 feet in elevation of a nearby stream showed apparent partial recovery. Measured perennial streams showed notable depletion in streamflow over mined longwall panels that were less than 2 years old. Normal stream discharge was measured over panels more than 2 years old. Most apparent hydrologic dewatering impacts appear to be temporary, and the most vulnerable areas for these impacts are hill sides.

Keyword(s): hydrology, subsurface water, longwall, coal mining, active mines, surface water, monitoring methods

Location(s): West Virginia, Appalachian Coal Region, United States

Tilton, J. G. The Effect of Subsidence on Pipelines. Presented at SME-AIME Annual Meeting, New York, NY, February 27-March 3, 1966, SME-AIME preprint 66FM41, 34 p.

This paper details the damaging effects of subsidence on pipelines and suggests remedial measures to minimize this damage. The author states that subsidence rarely causes failure of pipelines with welded joints but may disrupt other types of connections. Major disruptions occur near the edge of the extraction area except where subsidence induces significant lateral movement outside of the extraction area. The text is supplemented with both plans for subsidence-resistant pipeline designs and photographs detailing the types of damage that may be encountered in a subsidence prone area.

Keyword(s): pipelines, utilities, angle of draw

Location(s): Pennsylvania, Appalachian Coal Region, United States

Tincelin, E., P. Sinou. Observation Made in the Lorraine Iron Ore Mines. IN: Proceedings European Congress on Ground Movement, Leeds, England, April 9-12, 1957, London Harrison, p. 128-140.

Keyword(s): metal mining

Location(s): Europe

Tincelin, E., P. Sinou. Summary of the Results Obtained from Eight Years Research in Strata Control. IN: Proceedings, International Strata Control Congress, Leipzig, October 14-16, 1958, p. 282-304 and CXXVII-CXXXVI.

This paper summarized results obtained in strata control research conducted in the Lorraine iron ore mines. Direct observations and measurements were used, consisting of the following: (1) determining the rate of rock deformations either at the face or in the interior of the boreholes, (2) determining the load totally acting upon a working front by measuring the velocity of sound for long distances, (3) determining the distribution of load in the interior of a rock massif, (4) laboratory testing of mechanical properties of the rocks, (5) measuring surface subsidences, and (6) measuring the forces and stresses subjected to the roof bolts.

Keyword(s): ground control, metal mining, room-and-pillar, rock mechanics, roof bolting, lab testing, in situ testing

Location(s): France

Tincelin, R., P. Sinou. Spontaneous Collapse in the Lorraine Iron Mines. IN: 4th International Conference on Strata Control and Rock Mechanics, Paris, 1964, p. 56-60.

The subject mine used room-and-pillar methods, followed by pillar extraction, and where required, provided surface protection by leaving pillars. The resulting extraction rate was 50% to 65%. Many spontaneous multiple pillar failures resulted in surface damage and fatalities underground. The failures occurred only at depths of approximately 140 meters and appeared to be related to frequent rock bursts within the area.

Keyword(s): pillar extraction, room-and-pillar, metal mining, pillar strength, surface subsidence damage, mine safety, rock mechanics, ground control

Location(s): Europe

Toenges, A. L. Longwall Mining Methods in Some Mines of the Middle Western States. U.S. Bureau of Mines IC 6893, 1936, 62 p.

This circular deals primarily with the methods of longwall mining used in some mines in certain districts of middle western states. In some instances underground methods were considered comprehensively, and in others only the actual methods of mining and face advance were noted.

Keyword(s): longwall, coal mining, historical, mine operation

Location(s): Illinois, Illinois Coal Basin, United States

Toepfer, P. H. Filling with Unclassified Tailings in Modified Cut and Fill Stopes. U.S. Bureau of Mines IC 7649, 1952, 14 p.

This report describes the substitution of hydraulically emplaced unclassified tailings for previous dry filling techniques for more efficient stope filling.

Keyword(s): hydraulic backfilling

Location(s): United States

Tousell, J., C. Rich, Jr. Documentation and an Analysis of a Massive Rock Failure at the Bautsch Mine, Galena, Ill. U.S. Bureau of Mines RI 8453, 1980, 49 p.

A lead-zinc mine in Paleozoic dolomites experienced a massive rock failure involving 3 to 5 million tons. Analysis of the rock mechanics and mode of failure revealed that failure at the Bautsch mine was the result of the interrelationship of many factors, both internal and external to the mining environment.

Keyword(s): metal mining, rock mechanics, geologic features

Location(s): Illinois, United States

Townsend, J. M., W. C. Jennings, C. Haycocks, G. M. Neall, L. P. Johnson. A Relationship Between the Ultimate Compressive Strength of Cubes and Cylinders for Coal Specimens. IN: Energy Resources and Excavation Technology, Proceedings 18th U.S. Symposium on Rock Mechanics, Keystone, CO, June 22-24, 1977, F-D. Wang and G.B. Clark, eds., Colorado School of Mines Press, Golden, p. 4A6-1--4A6-6.

Most equations being used in the United States for determining the strength of coal pillars require the testing of cubical specimens. In a virgin coal field or the interior of a large mining property, the specimens usually available for strength determination prior to mining are obtained from exploration boreholes. The diameter of the core recovered from diamond boreholes is generally insufficient to prepare cubical specimens and, therefore, cylindrical specimens are tested. The research presented in this paper determines the validity of the assumption that specimens of equal loading area have the same ultimate compressive strength when relating the strengths of cubical and cylindrical specimens.

Keyword(s): rock mechanics, pillar strength, lab testing, coal mining

Location(s): United States

Transportation Research Board, Washington D.C. Subsidence Over Mines and Caverns, Moisture and Frost Actions, and Classification. Transportation Research Record 612, Report Nos. TRB/TRR-612 and ISBN-0-309-02588-5, 1976, 90 p. (NTIS PB-272 844)

This report contains 12 papers on the following subjects: mechanisms of subsidence due to underground openings; induced and natural sinkholes in Alabama; subsidence control for structures above abandoned coal mines; and ground subsidence associated with dewatering of a depressed highway section.

Keyword(s): roads, soils, subsurface water, hydrology, soil mechanics, coal mining, abandoned mines, surface structural damage, geologic features, monitoring methods, modeling, mathematical model

Location(s): Alabama, Missouri, Hawaii, United States

Traughber, E. B., J. O. Snowden, W. B. Simmons. Differential Subsidence on Reclaimed Marshland Peat in Metropolitan New Orleans, Louisiana. IN: Evaluation and Prediction of Subsidence, Proceedings International Conference, Pensacola Beach, FL, January 15-20, 1978, S.K. Saxena, ed., ASCE, New York, 1979, p. 479-499.

This paper is a discussion of the history, origin, and utilization of the marshland in the New Orleans area, and the difficulties and hazards that resulted from its development.

Keyword(s): land-use planning, prediction, fluid extraction, foundations

Location(s): Louisiana, United States

Trent, B. C. A Computerized Subsidence Model. Presented at SME Annual Meeting, New Orleans, LA, February 18-22, 1979, SME-AIME preprint 79-86, 11 p.

This paper details a two-dimensional computer code that couples near- and far-field response to model subsidence caused by underground openings.

Keyword(s): vertical displacement, horizontal displacement, computer, modeling

Location(s): United States

Trent, B. C. Empirical Continuum and Block Caving Computer Models for Surface Subsidence. IN: Proceedings Workshop on Surface Subsidence due to Underground Mining, Morgantown, WV, November 30-December 2, 1981, S.S. Peng and M. Harthill, eds., Department of Mining Engineering, West Virginia University, 1982, p. 142-146.

The economics of today's mining industry prohibit the costly trial-and-error approach that may have been practical at one time. What is clearly needed is an inexpensive, site-specific, general computational model that will allow an engineer to modify certain design parameters in a way that minimizes the hazard of surface subsidence.

Keyword(s): computer, empirical model, modeling, coal mining

Location(s): United States

Trent, B. C., R. T. Langland. Subsidence Modelling for Underground Coal Gasification. In Situ, 1983, v. 7, no. 1, p. 53-85.

Keyword(s): modeling, coal gasification

Trevits, M. A., R. L. King, B. V. Johnson. Overview of the USBM Subsidence Research Program. IN: Proceedings 88th Annual General Meeting Canadian Institute of Mining & Metallurgy, Montreal, Canada, May 11-15, 1986, Paper 86, 14 p.

Keyword(s): subsidence research

Location(s): United States

Trevits, M. A., R. L. King, B. V. Johnson. The Bureau of Mines Subsidence Research Program. IN: Eastern Coal Mine Geomechanics, Proceedings, Bureau of Mines Technology Transfer Seminar, November 19, 1986, U.S. Bureau of Mines IC 9137, p. 57-64.

The USBM, through its Subsidence Research Program, is focusing on providing the mine operator with the ability to predict surface movements and effects on groundwater as a function of mining method and geologic context. The program is designed for coal basins where high mining activity may impact land use requirements. In the long term, all coal basins and mining methods will be addressed. Data sets from several subsidence monitoring sites have been or are being collected. Data sets are now available from the Eastern, Interior, and Rocky Mountain Coal Provinces for full-extraction mining methods. At select sites, shallow-aquifer monitoring wells have also been installed to observe the effects of subsidence on the groundwater system. To date, an empirical model for subsidence prediction has been generated for the Northern Appalachian Coal Region.

Keyword(s): subsidence research, prediction, active mines, land-use planning, monitoring methods, survey methods, hydrology, subsurface water, coal mining, modeling, survey equipment, longwall, high-extraction retreat

Location(s): Appalachian Coal Region, Illinois Coal Basin, Rocky Mountain Coal Region, United States

Trevits, M. A., J. S. Walker. An Accurate, User-Friendly Subsidence Prediction Model for Personal Computers. IN: Proceedings National Symposium on Mining, Hydrology, Sedimentology, and

Reclamation, December 7-11, 1987, Springfield, IL, University of Kentucky, p. 229-233.

The USBM is conducting a comprehensive program of research to identify the mechanisms of mining-induced ground movement. One goal of this effort is to provide the mining industry with a tool to quantify surface movement in advance of mine development, as mine operators are required to predict the magnitude, extent, and duration of surface deformations as part of the mine permitting process. European prediction models generally yield unacceptable results because they have been developed for the conditions in Europe. A model has been developed that is tailored to geologic and mining conditions in teh United States. The basis of the model is the novel application of a variable subsidence coefficient.

Keyword(s): modeling, computer, coal mining, prediction, surface structural damage, agriculture, land-use planning, vertical displacement, horizontal displacement, overburden

Location(s): Appalachian Coal Region, United States

Trevorrow, G. C. Occurrence and Effects of Subsidence in an Operating Mine in the Sewickley Coal Bed of Green County, PA. Thesis, The Pennsylvania State University, 1936.

Keyword(s): coal mining, active mines, surface subsidence damage

Location(s): Pennsylvania, United States, Appalachian Coal Region

Treworgy, C. G., C. A. Hindman, L. Pan, J. W. Baxter. Evaluation of the Potential for Damage from Subsidence of Underground Mines in Illinois. Final Report to Illinois Mine Subsidence Insurance Fund, Contract 1-5-37891, September 1989, Illinois State Geological Survey, Champaign.

This study provides statistics on the proximity of underground-mined areas to urban development. These statistics provide the most detailed view to date of the exposure of structures to the risk of mine subsidence. Prior to this study, maps of non-coal underground mines had never been compiled into a single map database, and the proximity of underground-mined areas (both coal and non-coal) to urban development had never been examined. The project was divided into two tasks: (1) to compile a map database of non-coal underground mines, and (2) to provide data on the proximity of both coal and non-coal underground mines to urban development.

Keyword(s): coal mining, metal mining, non-metal mining, land-use planning, abandoned mines, insurance, surface structural damage, law, computer

Location(s): Illinois, Illinois Coal Basin, United States

Treworgy, C. G., C. A. Hindman. The Proximity of Underground Mines to Residential and Other Built-Up Areas in Illinois. Illinois State Geological Survey, Environmental Geology 138, 1991, 18 p.

The greatest potential for mine subsidence damage to structures occurs where active or abandoned mines lie under or adjacent to cities, towns, and rural subdivisions. In this study we calculated the acreage of four categories of undermined land in Illinois: (1) residential, (2) other urban, (3) urban buffer, and (4) non-urban. We also estimated the number of housing units close to underground mines. Because the oldest mining operations in the state were generally located in and around populated areas, urban areas often have disproportionately higher percentages of undermined land than do adjacent rural areas.

Keyword(s): surface structural damage, abandoned mines, land-use planning, land values, coal mining, metal mining, non-metal mining, insurance

Location(s): Illinois, Illinois Coal Basin, United States

Triplett, T., G. Lin, W. Kane, R. M. Bennett. The Effects of Undermining on Various Types of Linear Foundations. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May, 1992, South African Institution of Civil Engineers, Republic of South Africa, p. 99-106.

This work shows that the inclusion of a reasonable intensity function into the influence function technique can produce an accurate prediction for mining conditions in southern Illinois, and that the characteristics of the ground deformation predicted by the method can be related to structural damage. Field data from case studies in southern Illinois were used to determine the two functions employed in the prediction technique.

Keyword(s): influence function, prediction, active mines, coal mining, foundations, surface structural damage, active mines, longwall, horizontal displacement, structural mitigation

Location(s): Illinois, Illinois Coal Basin, United States

Triplett, T., G. Lin, W. Kane, R. M. Bennett. Prediction of Coal Mine Subsidence and Implications for Structural Damage. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 76-82.

Twelve linear foundations were constructed above a longwall mine to assess the value of various subsidence mitigation techniques. The structures were monitored during and after undermining and footing curvatures at the time of cracking were compared with predicted values. An unreinforced concrete footing sustained substantial damage. Other footings received varying degrees of damage, with inclusion of a sand layer significantly affecting performance. A post-tensioned concrete foundation suffered minimal cracking. A technique developed by the USBM is also presented for determining the subsidence, slope, curvature, and strain of the ground surface.

Keyword(s): foundations, longwall, structural mitigation, active mines, monitoring methods, surface structural damage, vertical displacement, horizontal displacement, influence function, prediction, coal mining, mathematical model

Location(s): Illinois, Illinois Coal Basin, United States

Triplett, T. L., A. Drescher. Analysis of Pillar Punching Into Soft Claystone in Southern Illinois. IN: Key Questions in Rock Mechanics, Proceedings of the 29th U.S. Symposium, Minneapolis, MN, June 13-15, 1988, P.A. Cundall, R.L. Sterling, and A.M. Starfield, eds., Balkema, Rotterdam, p. 59-65.

Subsidence can be caused by mine level failures that occur in the roof, pillars, or floor and that allow displacements to propagate to the surface. However, in Illinois, plastic failure of weak claystone floor dominates the failure process. The objective of this USBM research is to define the failure mechanisms and resultant upper bounds to the limit loads given by the limit analysis method for both square and rectangular pillars punching into plastically behaving floor of both finite and infinite thickness. This paper describes the assumptions, techniques and preliminary results of a laboratory program designed to define the three-dimensional failure mechanisms in an infinitely thick, frictionless, perfectly plastic material beneath a square punch.

Keyword(s): floor stability, pillar strength, lab testing, modeling, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Triplett, T. L., D. W. Yurchak. Inclusion of an Intensity Function for Subsidence Prediction in Illinois. IN: Proceedings, 3rd Conference on Ground Control Problems in the Illinois Coal Basin, Mt. Vernon, IL, August 8-10, 1990,Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 276-284.

This paper presents USBM research on modifying the influence function method to predict mining subsidence in Illinois. According to theory, this technique must incorporate an intensity function to represent the relative significance of extractions at mine level. This paper shows that the inclusion of a reasonable intensity function increases the accuracy of the technique, then introduces a method for finding the required functions for a case study in Illinois. The slopes and curvatures of the subsidence trough are also shown to be given by derivatives of the influence function.

Keyword(s): prediction, influence function, coal mining, active mines, empirical model, longwall, modeling

Location(s): Illinois, Illinois Coal Basin, United States

Triplett, T. L., D. W. Yurchak. Determination of an Intensity Function for Subsidence Prediction. IN: Rock Mechanics Contributions and Challenges, Proceedings of the 31st U.S. Rock Mechanics Symposium, Golden, CO, June 18-20, 1990, W.A. Hustrulid and G.A. Johnson, eds., Balkema, Rotterdam, p. 169-175.

The objective of this research, conducted by the USBM, is to review and modify the influence function method to predict mining subsidence in Illinois. If subsidence on the surface is considered the effect, and an extraction at mine level is considered a cause of certain intensity, this work has determined that the technique must incorporate an intensity field to represent the magnitudes of these causes. This paper shows that the inclusion of a reasonable intensity field increases the accuracy of the technique.

Keyword(s): prediction, coal mining, modeling, influence function

Location(s): Illinois, Illinois Coal Basin, United States

Triplett, T. L., D. W. Yurchak. Predicting the Effects of Subsidence from High Extraction Mining in Illinois. IN: Mine Subsidence - Prediction and Control, National Symposium, 33rd Annual Meeting Association of Engineering Geologists, October 2-3, 1990, C.D. Elifrits, ed., Pittsburgh, PA, p. 71-75.

This paper presents research on modifying the influence function method to predict mining subsidence and the resultant strain in Illinois.

Keyword(s): prediction, influence function, coal mining, horizontal displacement, active mines, modeling, vertical displacement, surface structural damage

Location(s): Illinois, Illinois Coal Basin, United States

Triplett, T. L., D. W. Yurchak. The Practical Application of Subsidence Prediction in the Illinois Coal Basin. IN: Proceedings 4th Conference on Ground Control for Midwestern U.S. Coal Mines, Mt. Vernon, IL, November 2-4, 1992, Y.P. Chugh and G. Beasley, eds., Southern Illinois University, Carbondale, p. 315-327.

This paper presents research on modifying the influence function method to predict subsidence of the ground surface. The application of the technique is then demonstrated for the prediction of pre-subsidence and post-subsidence shoreline contours around Rend Lake, Illinois, the prediction of induced slopes as it relates to crop or power line damage, and the prediction of curvature for the estimation of structural damage.

Keyword(s): prediction, influence function, coal mining, vertical displacement, horizontal displacement, longwall, surface structural damage

Location(s): Illinois, Illinois Coal Basin, United States

Triplett, T. L., D. W. Yurchak. Illustrations of the Value of Subsidence Prediction in the Illinois Coal Basin. IN: Proceedings, Illinois Mining Institute, Centennial Year, 1992, p. 26-38.

This paper presents research on modifying the influence function method to predict subsidence of the ground surface. The required functions have been determined for two case studies above longwall coal panels in Illinois. However, the goal of subsidence engineering is not to predict subsidence, but to predict and mitigate subsidence damage. Therefore, the technique has been enhanced to calculate slope and curvature, and a method has been developed to predict strain using these curvatures and a simply measured site constant. The application of the technique is then demonstrated for the prediction of pre-subsidence and post-subsidence shoreline contours around Rend Lake, Illinois, the prediction of induced slopes as it relates to crop or power line damage, and the prediction of curvature for the estimation of potential structural damage.

Keyword(s): prediction, influence function, coal mining, longwall, horizontal displacement, vertical displacement

Location(s): Illinois, Illinois Coal Basin, United States

Trischka, C. Subsidence Following Extraction of Ore from Limestone Replacement Deposits, Warren Mining District, Bisbee, Arizona. Transactions, AIME, v. 109, 1934, p. 173-180.

Keyword(s): non-metal mining

Location(s): Arizona, United States

Trojanowski, K. Analityczne Sposoby Wyznaczania Wektorow Przesuniec Poziomych Punktow Terenow Gorniczych Przy Wykorzystaniu Metod Malej Triangulacji (Vectors of Points on Undermined Surface by Application of "Small Triangulation" Technique). Przeglad Gorniczy, v. 27, no. 2, 1971, p. 65-70.

Keyword(s): modeling

Trojanowski, K. Application of the Segment Network of Even Effects for Calculation of Subsidence According to K. Kochmanski Theory. 1974, 39 p. (NTIS TT74-54015)

This paper details the application of the K. Kochmanski theory of a network nomogram to the calculation of subsidence over a horizontally extending coal seam. The text is translated from Polish to English.

Keyword(s): vertical displacement, horizontal displacement, prediction theories, prediction, modeling, empirical model, influence function, coal mining

Tsang, P., S. S. Peng, S. M. Hsiung. Yield Pillar Application Under Strong Roof and Strong Floor Condition--A Case Study. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 411-418.

The mechanisms and functions of yield pillars are analyzed by employing a finite element method that takes time dependent and plastic failure of rock into consideration. The design criteria for different geological conditions are discussed. The results provide further evidence that yield pillar design will improve floor or roof conditions, especially when the floor and/or roof strata are weaker than the coal. Based on this study, the yield pillar size is determined for one coal mine located in southern West Virginia.

Keyword(s): yielding supports, finite element, time factor, geologic features, coal mining, roof stability, floor stability, mine design, pillar strength, ground control

Location(s): West Virginia, Appalachian Coal Region, United States

Tsur-Lavie, Y., S. Denekamp. A Boundary Element Method for the Analysis of Subsidence Associated with Longwall Mining. IN: Ground Movements and Structures, Proceedings 2nd International Conference, University of Wales Institute of Science and Technology, Cardiff, 1980, J.D. Geddes, ed., John Wiley & Sons, New York, 1981, p. 65-74.

A boundary element method for the evaluation of ground subsidence associated with longwall coal mining is presented. The method is based on a fundamental solution of stresses and deformation around a single rectangular indentation at the boundary of an infinite elastic half plane.

Keyword(s): boundary element, mathematical model, modeling, longwall, coal mining, vertical displacement

Tsur-Lavie, Y., S. A. Denekamp, G. Fainstein. Geometry of Subsidence Associated with Longwall Mining. IN: Ground Movements and Structures, Proceedings 3rd International Conference, University of Wales Institute of Science and Technology, Cardiff, 1984, J.D. Geddes, ed., Pentech, London, 1985, p. 324-337.

A comparison between a theoretical boundary element model and National Coal Board data is presented. This paper discusses three aspects of the model, including maximum subsidence, surface configuration, and applicability of two-dimensional models to three-dimensional cases.

Keyword(s): boundary element, modeling, National Coal Board, longwall, coal mining

Tsur-Lavie, Y., S. A. Denekamp, G. Fainstein. Surface Subsidence Associated with Longwall Mining--Two and Three Dimensional Boundary Element Model. IN: Proceedings 23rd Annual Conference of the Engineering Group of the Geological Society, Engineering Geology of Underground Movements, University of Nottingham, September 13-17, 1987.

Measured surface displacements are compared to the predictions of the model presented, with attention paid to maximum subsidence, surface profile, and the applicability of the two-dimensional model to the three-dimensional case. For deep and shallow mines, respectively, it is necessary to adopt low and high values of Poisson's ratio to obtain close agreement between measurement and calculation because at depth most of the overlying rock is intact, while for shallow mines, the failure zone reaches the surface.

Keyword(s): modeling, boundary element, longwall, prediction, overburden

Tsur-Lavie, Y., S. A. Denekamp, G. Fainstein. Surface Subsidence Associated with Longwall Mining: Two and Three Dimensional Boundary Element Model. IN: Engineering Geology of Underground Movements, Geological Society Engineering Geology Special Publication No. 5, F.G. Bell, et al., eds., 1988, p. 225-231.

Systematic measurements of surface displacements associated with longwall mining made by British Coal are compared with National Coal Board results calculated in the present study. Three aspects of subsidence are considered: maximum subsidence, surface configuration, and applicability of two-dimensional models to three-dimensional cases. The model presented in this paper is based on elementary solution for stresses and displacements in an infinite homogeneous elastic halfplane or halfspace, subjected at its boundary by a discontinuous uniform displacement. Two- and three-dimensional models were developed using those solutions. The model was used for an analysis of ground subsidence as a function of the span and height of the mined openings, assuming various Poisson's ratios. Results of two-dimensional models, representing openings of infinite length were compared with measurements (compiled by the NCB) that correspond to longwall mines.

Keyword(s): modeling, boundary element, prediction, longwall, coal mining, National Coal Board, mathematical model

Location(s): United Kingdom

Tubby, J. E., I. W. Farmer. Stability of Undersea Workings at Lynemouth and Ellington Collieries. The Mining Engineer, London, v. 141, August, 1981, p. 87-96.

Keyword(s): surface water, coal mining

Location(s): United Kingdom

Turka, R. J., R. E. Gray, F. B. Newman. Use of Concrete for Stabilization of Abandoned Coal Mines. IN: Mine Subsidence - Prediction and Control, National Symposium, 33rd Annual Meeting Association of Engineering Geologists, October 2-3, 1990, C.D. Elifrits, ed., Pittsburgh, PA, p. 177-181.

The applicability of using concrete for stabilization of abandoned coal mines is illustrated by a case history.
Keyword(s): coal mining, abandoned mines, grouting, room-and-pillar, pillar extraction
Location(s): Appalachian Coal Region, United States

Turnbull, D., E. L. J. Potts. Surface and Underground Subsidence Correlation. Colliery Engineering, v. 35, no. 2, February, 1958, p. 65-72.
This paper describes a series of leveling stations at the surface and in five underlying coal seams, which were to be used as a framework for more detailed leveling operations.
Keyword(s): surface subsidence damage, survey design, coal mining, survey methods, multiple-seam extraction

Turney, J. E. Colorado Geological Survey's Role and Responsibility - Abandoned Mine Subsidence Hazards. IN: Proceedings Conference on Coal Mine Subsidence in the Rocky Mountain Region, Colorado Springs, October 28-30, 1985, J.L. Hynes, ed., Colorado Geological Survey Special Publication 31, Department of Natural Resources, Denver, 1986, p. 19-23.
The Colorado Geological Survey's responsibilities regarding inactive mine subsidence hazards are mandated by state statutes that created the present Survey in 1967 and Colorado land use laws enacted between 1972 and 1974. These laws set the stage for the Survey's review of subsidence investigations, the development of a subsidence information library that includes reports of subsidence investigations, extent of mining maps, and publications.
Keyword(s): law, abandoned mines, land-use planning, reclamation, literature search
Location(s): Colorado, Rocky Mountain Coal Region, United States

U.S. Army Engineer District (Baltimore, MD) Northeast Flood Study, Susquehanna River Basin Flood Control and Mine Subsidence in Wyoming Valley, Pennsylvania. 1971, 35 p. (NTIS PB 207 567-D)
Keyword(s): surface water
Location(s): Pennsylvania, Appalachian Coal Region, United States

U.S. Bureau of Mines. Rock Mechanics Instrumentation for Mine Design. U.S. Bureau of Mines IC 8585, 1973, 76 p.
Keyword(s): ground control, instrumentation, rock mechanics, mine design
Location(s): United States

U.S. Bureau of Mines. Investigation of Subsidence in Farmington, Marion County, West Virginia. U.S. Bureau of Mines Mineral Resources and Environmental Development, February, 1974.
Keyword(s): surface subsidence damage
Location(s): West Virginia, Appalachian Coal Region, United States

U.S. Bureau of Mines. Ground Control Aspects of Coal Mine Design. Proceedings, U.S. Bureau of Mines Technology Transfer Seminar, Lexington, KY, 1973, U.S. Bureau of Mines IC 8630, 1974, 138 p.
This report includes an overview of the USBM approach to mine design. It includes three papers on problems associated with the design of panels, five papers on coal mine roof problems, three papers on longwall problems, and comments by the participants on the USBM-industry panel discussion. Seminar attendance consisted of representatives from the coal-mining industry, universities, mining consultants, instrument manufacturers, and local, state, and federal government agencies.
Keyword(s): mine design, ground control, coal mining, roof stability, longwall
Location(s): United States

U.S. Bureau of Mines. Pumped-Slurry Backfilling of Inaccessible Mine Workings for Subsidence Control. U.S. Bureau of Mines IC 8667, 1975.
Keyword(s): hydraulic backfilling, abandoned mines, ground control
Location(s): United States

U.S. Bureau of Mines. Surface Subsidence Control in Mining Regions. Final Environmental Statement, FES 76-58, November 5, 1976, 90 p., appendices A and B.
The most significant environmental impact of conducting subsidence control projects is the protection provided to heavily populated surface areas that have been undermined by coal or mineral extraction.
Keyword(s): hydraulic backfilling, abandoned mines, surface structural damage, mine waste, environment, surface water, subsurface water
Location(s): Wyoming, Pennsylvania, Appalachian Coal Region, United States

U.S. Bureau of Mines. Mine Ground Control U.S. Bureau of Mines IC 8973, Proceedings, Bureau of Mines Technology Transfer Seminars, Pittsburgh PA, December 6-7, 1983, and Denver CO, December 8-9, 1983, published 1984, 155 p.
The basic goal of the USBM Ground Control research program is to provide the mining industry with technology that will lead to the reduction of accidents due to falls of ground. The problems of ground control are the inability to "see" geologic anomalies ahead of the mine workings, the difficulty in predicting ground movements induced by excavation, and the need to provide efficient ground control over the widely varying and frequently unexpected conditions encountered from one place to another.
Keyword(s): ground control, mine safety, geologic features, mine design, instrumentation, monitoring equipment, roof support
Location(s): United States

U.S. Bureau of Mines. Subsidence Prediction Model. Technology News No. 256, August, 1986, U.S. Bureau of Mines, Washington, D.C., 2 p.
The objective of this model is to provide the mining industry with an easy-to-use means of accurately predicting surface subsidence caused by longwall mining in the northern Appalachian Coal Basin.
Keyword(s): coal mining, longwall, prediction, active mines, overburden
Location(s): Appalachian Coal Region, United States

U.S. Bureau of Mines. Monitoring Foundation Response to Subsidence Using a Tiltmeter. Technology News No. 313, September 1988, Bureau of Mines, Washington D.C., 2 p.
The objective is to determine how subsidence resulting from underground coal mining affects surface structures, and evaluate the usefulness of the tiltmeter for monitoring foundation movement. The USBM is studying foundation response to mine

subsidence to determine how subsidence-induced ground movements affect foundations in place directly above the mine. A computer software package was developed to aid in the reduction and analysis of the tiltmeter data.

Keyword(s): foundations, coal mining, monitoring equipment, monitoring methods, monitoring design, surface structural damage, computer, vertical displacement, horizontal displacement

Location(s): Illinois, Illinois Coal Basin, United States

U.S. Bureau of Mines. Structural Uses and Placement Techniques for Lightweight Concrete in Underground Mining. U.S. Bureau of Mines Technology News 354, January 1990.

The objective of this project is to investigate the use and placement of lightweight concrete to improve ground control technology in deep mines where deformation occurs under heavy ground conditions and where there is danger of rock bursts.

Keyword(s): ground control, mine design

Location(s): United States

U.S. Bureau of Mines. Simple Extensometer Measures Underground Backfill Displacements. U.S. Bureau of Mines Technology News 355, February 1990.

The objective of this project is to measure settling in cemented backfill when installation of borehole extensometers is not feasible.

Keyword(s): monitoring equipment, instrumentation, backfilling

Location(s): Washington, United States

U.S. Bureau of Mines. Abandoned Mine Lands Program TN No. 1 Subsidence Abatement Investigation Laboratory (SAIL). Technology News 380, April, 1991, Office of Technology Transfer, U.S. Bureau of Mines, Washington, D.C., 2 p.

The objective of this program is to provide a full-scale test facility where the effectiveness of all types of subsidence-abatement techniques can be evaluated under controlled conditions.

Keyword(s): abandoned mines, hydraulic backfilling, pneumatic backfilling, grouting

Location(s): United States

U.S. Bureau of Mines. Computer-Assisted Ground Control Management System. Technology News 381, May 1991, Office of Technology Transfer, U.S. Bureau of Mines, Washington, D.C., 2 p.

The objective of this system is to apply state-of-the-art monitoring and computer systems technology to remotely monitor geostructural data and evaluate ground conditions in near real-time.

Keyword(s): coal mining, longwall, ground control, computer

Location(s): Rocky Mountain Coal Region, United States

U.S. Bureau of Mines. Analysis of Longwall Pillar Stability (ALPS) Method for Sizing Longwall Pillars. Technology News 382, June 1991, 2 p.

The objective of this project is to improve ground control in longwall gate entries by developing a practical method for evaluating longwall pillar designs.

Keyword(s): ground control, longwall, pillar strength, coal mining, active mines

Location(s): United States

U.S. Bureau of Mines. Abandoned Mine Lands Program TN No. 3: Foaming Mud Cement Controls Underground Coal Mine Fires and Subsidence. Technology News No. 387, July 1991, Office of Technology Transfer, U.S. Bureau of Mines, Washington, D.C., 2 p.

The objective of this project was to develop a cost-effective, flexible method for extinguishing underground coal mine fires that can be readily used in fire conditions encountered in both abandoned mines and coal outcrops. A secondary objective was to prevent subsidence by filling the voids with a material having sufficient compressive strength to minimize subsidence.

Keyword(s): mine fires, abandoned mines, coal mining, mine waste, hydraulic backfilling

Location(s): Arizona, Utah, Montana, West Virginia, Rocky Mountain Coal Region, Appalachian Coal Region, United States

U.S. Bureau of Mines. Abandoned Mine Lands Program TN No. 4: Repairing Stream Channels to Reduce Water Loss into Underground Mines. Technology News 388, July 1991, Office of Technology Transfer, U.S. Bureau of Mines, Washington, D.C., 2 p.

The objective of this project was to control stream loss by identifying and selectively sealing water loss zones in stream channels overlying underground mines.

Keyword(s): subsurface water, abandoned mines, active mines, longwall, overburden

Location(s): Maryland, West Virginia, Appalachian Coal Region, United States

U.S. Bureau of Mines. Computer Program for Unsaturated Flow Analysis. Technology News 390, September 1991, 2 p.

The objective of this project was to analyze variably saturated flow in mining and other environmentally sensitive settings through the use of software for personal computers. New and innovative computer models are necessary to assess more accurately the potential impact of mining activities on groundwater resources and the environment.

Keyword(s): subsurface water, hydrology, environment, computer, modeling, finite element

Location(s): United States

U.S. Bureau of Mines. Abandoned Mine Lands TN No. 5. Abandoned Mine Detection Using Integrated Geophysical Methods. Technology News 391, September 1991, Office of Technology Transfer, U.S. Bureau of Mines, Washington, D.C., 2 p.

The objective of this project is to detect hazards associated with abandoned mine openings through the use of integrated geophysical technology.

Keyword(s): geophysical, abandoned mines, backfilling

Location(s): Colorado, Rocky Mountain Coal Region, United States

U.S. Bureau of Mines. Abandoned Mine Lands Program TN No. 9. Subsidence Monitoring Using Seismic Activity. Technology News 404, August 1992, Office of Technology Transfer, U.S. Bureau of Mines, Washington, D.C., 2 p.

The objective of this program is to validate the premise that there is measurable seismic activity associated with abandoned mine lands and that this activity can be used to determine the stability of the abandoned mine openings, failure cycle of these openings, and susceptibility of the area to surface subsidence.

Keyword(s): seismic, abandoned mines, monitoring methods

Location(s): Colorado, Pennsylvania, Rocky Mountain Coal Region, Appalachian Coal Region, United States

U.S. Bureau of Mines. Abandoned Mine Lands TN No. 13. GIS Data Base for Colorado Springs AML Study Area. Technology News 408, October 1992, Office of Technology Transfer, Bureau of Mines, Washington, D.C., 2 p.

The objective of this project is to determine the extent to which remote-sensing techniques, particularly lineament analysis, can be used to identify geologic structures that may affect the location and migration of subsidence over abandoned underground coal mines in the Colorado Springs area. Data are compiled using a geographic information system (GIS) to allow efficient and reproducible comparisons and analyses.

Keyword(s): remote sensing, abandoned mines, coal mining, computer

Location(s): Colorado, Rocky Mountain Coal Region, United States

U.S. Bureau of Mines Staff. Mine Subsidence Control. Proceedings, U.S. Bureau of Mines Technology Transfer Seminar, Pittsburgh, PA, September 19, 1985, U.S. Bureau of Mines IC 9042, 56 p.

Four papers are included. Topics are effects of subsidence on water table levels, development of subsidence precalculation methodology suitable for use with the specific lithological conditions of the Pittsburgh coalbed, an engineering comparison of technologies used in surveying for longwall mine subsidence, and a comparison of the process of subsidence over two different longwall panels. The USBM conducted research to develop accurate techniques of subsidence prediction tailored to geologic conditions specific to the United States.

Keyword(s): prediction, engineering, longwall, monitoring equipment, monitoring design, monitoring methods, survey methods, survey equipment, survey design, subsurface water, hydrology, geologic features

Location(s): Pennsylvania, Appalachian Coal Region, United States

U.S. Code of Federal Regulations. Title 30--Mineral Resources; Chapter VII--Office of Surface Mining Reclamation and Enforcement, Department of the Interior; Subchapter K--Permanent Program Performance Standards; Part 817--Underground Mining Activities. July 1, 1984.

Keyword(s): government, law

Location(s): United States

U.S. Code of Federal Regulations. Title 30--Mineral Resources; Chapter VII--Office of Surface Mining Reclamation and Enforcement, Department of the Interior; Subchapter G--Permanent Program Performance Standards; Part 783--Underground Mining Permit Applications--Minimum Requirements for Information on Environmental Resources. July 1, 1984.

Keyword(s): mine operation, law, environment, government
Location(s): United States

U.S. Congress. Surface Mining Control and Reclamation Act of 1977. Public Law 95-87, August 3, 1977, 91 Stat. 4; 30 U.S.C. 1201, et seq.
This law authorized federal regulations for reclaiming and revegetating surface areas of underground and surface coal mines.
Keyword(s): reclamation, mine operation, law, government, coal mining
Location(s): United States

U.S. Department of the Interior. Surface Mining Citizen's Complaint. Office of Hearings and Appeals, Hearings Division, Arlington, VA, January 29, 1990.
This case concerns a Surface Mining Citizen's Complaint alleging that Clinchfield Coal Company's underground mining activities had caused a well to run dry, as well as having damaged a residence.
Keyword(s): law, surface structural damage, coal mining, subsurface water, hydrology, angle of draw, pillar extraction
Location(s): Virginia, Appalachian Coal Region, United States

U.S. Department of the Interior, Bureau of Mines. Demonstration--Hydraulic Backfilling of Mine Voids, Scranton, Pennsylvania. Final Environmental Statement, FES 72-11, U.S. Bureau of Mines, May 15, 1972, 63 p.
The USBM proposes to conduct a demonstration project to test the economic feasibility of the Dowell hydraulic slurry injection process for blind backfill of dry and flooded underground mine voids to stabilize remaining coal pillars and roof rock, thereby preventing surface subsidence. If successfully completed, the project will backfill mine voids in the Clark and New County coalbeds beneath a 20-acre section of the Green Ridge residential area of Scranton, Pennsylvania, with approximately 300,000 cubic yards of crushed coal refuse from the adjacent Eureka culm bank.
Keyword(s): hydraulic backfilling, coal mining, abandoned mines, mine waste, anthracite
Location(s): Pennsylvania, Appalachian Coal Region, United States

U.S. Department of the Interior, Office of Surface Mining Reclamation and Enforcement. Permanent Regulatory Program Implementing Section 501 (b) of the Surface Mining Control and Reclamation Act of 1977. Final Environmental Statement, OSM EIS-1, January, 1979.
For the purpose of analyzing environmental impacts, the United States was divided into three regions: the eastern coal region, consisting primarily of the Appalachian coal province; the midwestern region or Interior coal province; and the western region, composed of the Northern Great Plains and Rocky Mountain coal provinces.
Keyword(s): government, law, environment, active mines, active mines, coal mining
Location(s): United States

U.S. General Accounting Office. Alternatives to Protect Property Owners from Damages Caused by Mine Subsidence. Report CED-79-25, February 14, 1979, 50 p. (NTIS PB 290 869)
This report presents an overview of experience with subsidence and its economic and social effects in the Untied States. Legislation at the federal, state, and local levels is briefly discussed, as is the relationship between partial- and total-extraction mining methods and resulting surface subsidence. Five possible alternatives for protecting property owners from financial hardship due to mine subsidence are examined.
Keyword(s): surface structural damage, mine design, law, government, insurance, backfilling, structural mitigation, partial extraction, longwall, economics, land-use planning, abandoned mines, active mines, construction, coal mining, metal mining, non-metal mining, utilities, roads, pipelines, bituminous, anthracite, economics
Location(s): Pennsylvania, Illinois, Ohio, West Virginia, New Jersey, Kansas, Missouri, Oklahoma, Kentucky, Colorado, Wyoming, Montana, Arkansas, Indiana, Washington, Maryland, Nevada, Illinois Coal Basin, Appalachian Coal Region, Rocky Mountain Coal Region, United States

University of Illinois, Urbana, IL. Mine Subsidence and Building Damage. Energy Report, Office of Energy Research, University of Illinois at Urbana-Champaign, June, 1982, 2 p.
Analysis of mine subsidence incidents in Illinois indicates that subsidence will continue to occur as the ground over abandoned coal mines collapses or settles. Subsidence is a cause for concern in Illinois because more than 750,000 acres of land have been undermined for coal. A rapid response to emergency problems caused by mine subsidence and the use of certain building techniques can minimize damage to structures. These are among

the conclusions researchers at the University of Illinois at Urbana-Champaign have reached after a detailed investigation of mine subsidence cases.

Keyword(s): surface structural damage, abandoned mines, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

University of Wyoming, Mining Engineering. Specifications and Recommendations for Residential Construction Subject to Ground Movements Related to Mine Subsidence. Report on Contract 5/38781, Department of Environmental Quality, Land Quality Division, 1988, 68 p.

The purpose of this document is to provide specifications and recommendations to mitigate damage to buildings in areas with a potential for mine subsidence related ground movements.

Keyword(s): structural mitigation, abandoned mines, coal mining, insurance, construction, architecture, foundations, utilities, engineering

Location(s): Wyoming, Rocky Mountain Coal Region, United States

Unrug, K. F. Longwall Support Requirements. Journal of Mines, Metals & Fuels, September, 1983, Special Number on Update on Longwall Mining--Evolving Trends, p. 334-344.

Planning of the longwall operation should take into account many factors such as seam thickness, dip, depth, roof and floor conditions, fractures pattern, etc.

Keyword(s): longwall, roof stability, roof support, mine operation, geologic features, coal mining

Location(s): United States

Unrug, K. F., C. A. Johnson. Subsidence Potential in the Eastern Kentucky Coal Field. IN: Mine Subsidence, Society of Mining Engineers Fall Meeting, St. Louis, September, 1986, M.M. Singh, ed., SME, Littleton, CO, p. 41-50.

The major subsidence areas in the Eastern Kentucky Coal Field were identified to distinguish the subsidence phenomena on the basis of geographical location. Further, this identification process was based upon selected critical geological, topographical, and mining features in the coal fields. The proposed identification of the regions was derived from a comparison of the subsidence potential in a particular area. The most likely severe subsidence areas were compared to those with the probable low subsidence severity. The combination of certain geological and mining parameters involved allowed for the derivation of a classification of the subsidence potential.

Keyword(s): coal mining, geologic features, land-use planning, multiple-seam extraction

Location(s): Kentucky, United States

Unrug, K. F., S. K. Nandy. Finite Element Analysis and Comparison of Shaly Mine Roof Support Systems. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 629-636.

In the paper a numerical modeling method is used for evaluation of a roof support system, which is commonly used in the coal industry in the United States. The effectiveness of mechanical roof bolting with or without header boards and steel straps are compared. This analysis takes into account the response of a shaly roof to changing environmental conditions in mines related to the seasonal changes in temperature and humidity of the intake air.

Keyword(s): finite element, roof support, modeling, coal mining, roof bolting

Location(s): United States

Unrug, K. F., S. Nandy. Improvement in Stability of Shaly Roofs in Coal Mines. IN: Proceedings, 3rd Conference on Ground Control Problems in the Illinois Coal Basin, Mt. Vernon, IL, August 8-10, 1990, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 125-142.

Maintaining the integrity of shaly roofs in coal mines requires costly, periodic rehabilitation of the support. The design parameters of a roof structure exist only over a limited period of time after excavation. Consequently, in long-term openings like mains and sub-mains, the deterioration of the conditions alters the design parameters to a point where the roof rock becomes a completely different material. Therefore, the criteria for design of roof support in long- and short-term openings should be different.

Keyword(s): roof stability, coal mining, roof support, geologic features, roof bolting, lab testing

Location(s): United States

Urban, D. W. Damage Suits: Blasting, Subsidence, and Reclamation. Ch. 10 in Mineral Law, Sprague, Sprague & Ysursa, Belleville, IL, 1982, p. 10-1-10-76.

The purpose of this chapter is to provide the attorney engaged in civil litigation with an insight into the subject of blasting and subsidence damage litigation. Although it is rare for a law firm to receive many cases pertaining to blasting damages, virtually every law firm in Illinois could possibly be faced with litigation concerning subsidence damage. This chapter is therefore designed to provide a basic understanding of the various civil and administrative remedies available to the client. It is also designed to provide a basic understanding of the principles of physics and engineering so that the attorney can properly conduct discovery and locate expert witnesses. Finally, while the attorney engaged in general civil litigation could conduct a trial based upon Illinois common law, this chapter is designed to introduce the attorney to the maze of administrative remedies created by the Surface Mining Control and Reclamation Act of 1977 and to provide an understanding of the complex regulations which accompany the Act.

Keyword(s): law, government, coal mining, abandoned mines, active mines, surface structural damage, partial extraction, longwall, insurance

Location(s): Illinois, Illinois Coal Basin, United States

Urban Redevelopment Authority, Pittsburgh, PA. Evaluation of Mine Subsidence, Neighborhood Development Program, Webster-Elba and Roberts-Devilliers Project Action Areas. March, 1973, 23 p.

Keyword(s): surface structural damage

Location(s): Pennsylvania, Appalachian Coal Region, United States

Urbanik, W., V. J. Osborne. Monitoring and Predictive Modeling of Subsidence in the West Moreton Coalfield. IN: Proceedings, Symposium on Ground Movement and Control Related to Coal Mining, Illawarra, Australia, August, 1986, N.I. Aziz, ed., Australasian Institute of Mining and Metallurgy, p. 324-333.

A subsidence monitoring network was established at a room-and-pillar colliery in southeast Queensland, Australia. A computer model, based on the theory of Kowalczyk (1972) was developed to predict subsidence, and will be used with the field data. It is hoped to ascertain the safe distance of mining from surface structures, the possibility of controlled extraction beneath surface structures, and the time dependency of subsidence.

Keyword(s): computer, prediction, modeling, monitoring methods, room-and-pillar, coal mining, active mines, surface structural damage, angle of draw, partial extraction, time factor

Location(s): Australia

Utah Board and Division of Oil, Gas, and Mining. Coal Mining and Reclamation Permanent Program, Chapter 1. Final Rules. Revised September 20, 1982, 300 p.

This report contains information concerning the regulations pertaining to surface effects of underground coal mining activities in Utah.

Keyword(s): law, surface subsidence damage, government, reclamation, mine operation, coal mining

Location(s): Utah, Rocky Mountain Coal Region, United States

Vaclav, S. A Study of Rock Movements in Long Wall Mining in Lignite Seams. Uhli, September 9, 1955.

Keyword(s): longwall

Van Besien, A. C. Analysis of Roof Fall Accident Statistics and its Application to Roof Control Research. Preprint No. 73-F-71, AIME Annual Meeting, Chicago, IL, February 25-March 1, 1973, 11 p.

Keyword(s): roof support, roof stability, ground control, mine safety

Van Besien, A. C., J. D. Rockaway. Statistical Analysis of Subsidence Events Over Room-and-Pillar Coal Mines. IN: Proceedings, 2nd Conference on Ground Control Problems in the Illinois Coal Basin, May 1985, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 138-145.

This paper presents the results of statistical analyses of subsidence events over room-and-pillar coal mines. Data were collected on subsidence events in a number of coal fields, looking for geographic patterns in subsidence behavior and a number of site geologic parameters not known to have been examined in earlier studies. The study was primarily oriented toward identifying those site conditions, whether geologic or mining in character, that influence the delay between mining and the onset of surface distress caused by subsidence.

Keyword(s): coal mining, room-and-pillar, overburden, geologic features, literature search, abandoned mines, active mines, anthracite, bituminous, soils, roof stability

Location(s): Colorado, Wyoming, Oklahoma, Illinois, Indiana, Kentucky, Alabama, Ohio, Pennsylvania, Illinois Coal Basin, Rocky Mountain Coal Region, Appalachian Coal Region, West Virginia, United States

Van Besien, A. C., J. D. Rockaway. Influence of Overburden Materials on the Type and Time Required for Subsidence Development Over Room and Pillar Coal Mines. IN: Association of Engineering Geologists Symposium Series No. 4, Building Over Underground Mines--Subsidence Considerations, October 1987, p. 51-62.

The magnitude and extent of the subsidence that occurs over coal mines may be estimated reasonably accurately by current empirical and numerical/physical prediction modeling. There are, however, few effective procedures for predicting the duration of time that elapses between mining and the initial surficial expression of subsidence. This is particularly so with respect to subsidence over mines in which the coal was extracted by room-and-pillar mining methods.

Keyword(s): coal mining, modeling, empirical model, time factor, room-and-pillar, overburden, prediction

Location(s): Illinois Coal Basin, United States

Van Besien, A. C., N. B. Aughenbaugh. Multiple Subsidence Incidents at an Elementary School. IN: Association of Engineering Geologists Symposium Series No. 4, Building Over Underground Mines--Subsidence Considerations, October, 1987, p. 99-110.

This paper details investigations of two subsidence events at a school site in Illinois; the initial damage (to the old school) occurred in 1971. A second incident, this time to the new building, still under construction, followed in 1974. There is little doubt that both incidents were caused by mine subsidence. The occurrence of only partially collapsed mine workings in the vicinity of the school coupled with water-main ruptures, damages to private residences, surveyed displacements of the surface, and fractures of the ground surface indicated that damage to both old and new school structures was caused by episodic mine subsidence.

Keyword(s): abandoned mines, coal mining, surface structural damage, vertical displacement, utilities, room-and-pillar, angle of draw

Location(s): Illinois, Illinois Coal Basin, United States

Van Besien, A. C., J. D. Rockaway. Influence of Overburden on Subsidence Development over Room and Pillar Coal Mines. IN: Engineering Geology of Underground Movements, Geological Society Engineering Geology Special Publication No. 5, F.G. Bell, et al., eds., 1988, p. 215-219.

The magnitude and extent of the subsidence that occurs over coal mines may be estimated reasonably accurately by current empirical and numerical/physical prediction modeling. There are, however, few effective procedures for predicting the duration of time that elapses between the advent of mining and the initial surficial expression of subsidence. This is particularly so with respect to subsidence over mines in which the coal was extracted by room-and-pillar mining methods. This undefined time delay may be a critical concern in areas above old or abandoned room-and-pillar mines where the uncertainty of potential subsidence affects property values and urban development. The relationship between time and subsidence development was evaluated in this study by comparing data on mining systems, overburden and floor characteristics, physical properties of the coal seam, and the delay that occurred between coal extraction and initiation of surface deformation. The data were collected essentially from the Illinois Basin coal field with additional data from other coal-producing regions in the United States. Reasonably complete data sets from over 80 subsidence events were evaluated.

Keyword(s): coal mining, time factor, overburden, room-and-pillar, land-use planning, abandoned mines, prediction, geologic features

Location(s): Illinois, Colorado, Wyoming, Alabama, Michigan, Indiana, Ohio, West Virginia, Pennsylvania, Kentucky, Illinois Coal Basin, Appalachian Coal Region, Rocky Mountain Coal Region, United States

van der Knapp, W., A. C. van der Vlis. On the Cause of Subsidence in Oil-Producing Areas. 7th World Petroleum Congress, Mexico City, 1967, v. 3, p. 85-105.

Keyword(s): oil extraction

van der Merwe, J. N. Design Methods to Arrive at the Optimal Placing and Mining of Inter Panel Pillars to Alleviate Their Effects on Surface. IN: Proceedings, SANGORM Symposium, October 21, 1986, Sandton, South Africa, International Society for Rock Mechanics, South African National Group, p. 133-144.

Current longwall panels normally incorporate the leaving of inter-panel pillars. These pillars are sometimes the cause of water accumulations on the surface. A method is described whereby the dimensions of crush pillars can be determined which do not have the same adverse effects on the surface.

Keyword(s): pillar strength, coal mining, mine design, longwall, modeling, yielding supports, computer, multiple-seam extraction, surface structural damage, surface water, agriculture

Location(s): South Africa

van der Merwe, J. N. Analysis of Surface Subsidence Over a Longwall Panel at 50m Below Surface. IN: Proceedings, SANGORM Symposium, October 21, 1986, Sandton, South Africa, International Society for Rock Mechanics, South African National Group, p. 145-150.

Longwall coal mining in South Africa tends to occur at depths of around 100 meters below the surface. Very few shallow cases are available for analysis. The paper describes the results of an analysis of a longwall panel mined at a depth of 50 meters. It was found that the normalized surface strains did not deviate significantly from the expected values, while significantly greater tilts developed. There were also major differences between the dynamic and static profiles.

Keyword(s): active mines, longwall, surface subsidence damage, coal mining, survey methods, vertical displacement, horizontal displacement

Location(s): South Africa

van der Merwe, J. N. A Study of the Effects of Mining Relatively Shallow Overlying Longwall Panels with Staggered Inter-Panel Pillars at Sigma Colliery, South Africa. IN: Engineering Geology of Underground Movements, F.G. Bell, et al., eds., Geological Society Engineering Geology Special Publication No. 5, 1988, p. 243-255.

When two coal seams in close proximity are to be mined by longwall, a number of alternatives regarding the placing of the panels relevant to one another are possible. The main factors influencing the final choice are gate-road stability, face conditions and the extent of surface deformation. The paper describes the rationale and investigations leading up to the decision to stagger overlying longwall panels at Sigma Colliery. A two-dimensional boundary element program was used to predict the stability of gate roads, after having obtained excellent correlation between predicted and actual conditions in a test case. Observations to date also confirm the prediction of stability conditions in the staggered panels. Surface deformations were measured in detail. A computer program was written which permitted the analysis of a huge volume of data in a very short time. The results of the analysis confirm that less damaging surface disturbance is caused by staggering the panels, compared with superimposing them.

Keyword(s): coal mining, multiple-seam extraction, longwall, mine design, computer, survey data processing, boundary element, modeling, prediction, monitoring methods, geologic features, rock mechanics, vertical displacement, horizontal displacement

Location(s): South Africa

van der Merwe, J. N. Experiences with Undermining by Coal in South Africa. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 299-310.

The paper provides an overview of subsidence research conducted by the Sasol Company in South Africa over a period of more than 6 years. The magnitudes of subsidence elements in South Africa are largely similar to those in the United States and Australia, as opposed to Europe. The research resulted in a subsidence prediction method with a new approach to the prediction of ground strain. The paper also describes the effects of subsidence on various commonly occurring surface structures such as roads, overland conveyor belts, pipelines and power pylons. It is concluded that while most structures are not specifically designed to accommodate mining induced displacements, they can nonetheless be undermined safely and economically with only minor precautions.

Keyword(s): active mines, coal mining, prediction, horizontal displacement, roads, pipelines, surface structural damage, vertical displacement, agriculture, longwall, pillar extraction, utilities

Location(s): South Africa

van der Merwe, J. N. The Prediction of Subsidence in the Secunda and Sasolburg Areas. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May 1992, South African Institution of Civil Engineers, Republic of South Africa, p. 81-85.

The paper presents and empirically derived two-dimensional subsidence prediction method for the Sasolburg and Secunda areas in the Republic of South Africa. Although it is based on data obtained from an area that is small relative to the combined total coal fields of the country, more than 70% of all the underground high-extraction coal mining in the country is done there. A unique approach, taking cognizance of the noncontinuous inelastic nature of the overburden and the role of the soil cover to the prediction of strain is presented.

Keyword(s): empirical model, prediction, coal mining, active mines, geologic features, overburden

Location(s): South Africa

van der Merwe, J. N. The Effects of Subsidence on a Buried Water Pipe Line. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May 1992, South African Institution of Civil Engineers, Republic of South Africa, p. 157-162.

The paper describes the effects of subsidence of just less than 1 meter on a 1.1-m diameter main water supply pipe line. The pipe was in use during the undermining. The pipe was buried to a depth of 2 to 3 meters and was not uncovered prior to mining. Although the pipe was not functionally damaged, the bitumen insulation around the pipe suffered slight damage. It is thought that the shearing action of the ground against the pipe contributed to the damage, confirming the prudence of uncovering pipes of this nature prior to undermining.

Keyword(s): pipelines, utilities, longwall, active mines, coal mining

Location(s): South Africa

van der Merwe, J. N. The Effects of Subsidence on an Overland Conveyor Belt. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May 1992, South African Institution of Civil Engineers, Republic of South Africa, p. 165-171.

The paper describes the effects of subsidences of more than 1 meter on an overland coal-transporting conveyor belt. Apart from cutting the bolts that held the conveyor structure to its foundation blocks, no precautions were considered necessary. Freeing the structure from the ground surface allowed horizontal displacement of the ground without misaligning the belt structure. The structure had sufficient flexibility not to be damaged by vertical displacement, and yet sufficient rigidity in the transverse direction to maintain itself in a straight line. The operation of the conveyor was never disrupted by subsidence. Following the experiments, a number of routine underminings of a similar nature were done, all with positive results.

Keyword(s): coal mining, longwall, active mines, horizontal displacement, surface structural damage, structural mitigation, engineering, monitoring methods

Location(s): South Africa

van der Merwe, J. N. Handling the Effects of Subsidence on Structures: A Comparison of the Approaches Adopted in the U.S.A., Australia and South Africa. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May 1992, South African Institution of Civil Engineers, Republic of South Africa, p. 272-276.

The different needs, legislative styles, and general conditions require different methods of handling the effects of subsidence on surface structures. The paper compares the approaches in selected states of the United States and Australia to that in South Africa. The U.S. approach tends to be more commercialized than the others, while the Australian approach is more regularized. In South Africa, the emphasis is on legislation and private negotiation between individual mine and surface owners. In the light of knowledge that has recently become available in South Africa, the opportunity is now there to obtain benefit from a more orderly approach based on joint planning and cooperation.

Keyword(s): law, surface structural damage, coal mining, room-and-pillar, longwall, government, mitigation, insurance

Location(s): United States, Australia, South Africa, Illinois, Pennsylvania, Maryland

van der Merwe, J. N. The Effects of Subsidence on Structures in the USA and Australia. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May 1992, South African Institution of Civil Engineers, Republic of South Africa, p. 278-281.

As subsidence elements in Australia, the United States, and South Africa tend to be largely similar, benefit may be derived from comparing the effects of subsidence on surface structures in those countries. The paper provides a summary of some descriptions of those effects, and supplies the guidelines developed abroad for situations where none exist in South Africa yet. It is concluded that the phenomenon and magnitudes of subsidence related effects on structures are not unique to South Africa and that first order projections of those effects for first off underminings of structures in South Africa can be based on examples in the United States and Australia.

Keyword(s): surface structural damage, coal mining, pipelines, roads, utilities, structural mitigation

Location(s): South Africa, United States, Australia

Van der Molen, W. H. Subsidence of Peat Soils After Drainage. Studies and Reports in Hydrology, IAHS-UNESCO, no. 19, 1975, p. 183-186.

Keyword(s): fluid extraction, soils

Van Dillen, D. E. Three-Dimensional Finite Element Analyses of Single- and Double-Entry Portions of Sunnyside Mine No. 1. Report No. R-7638-4534 to U.S. Bureau of Mines, October, 1978, 275 p.

Keyword(s): finite element, modeling, coal mining

Location(s): United States

Van Dillen, D. E., K. C. Ko, F. M. Jenkins, W. J. Karwoski. Stability Comparisons of Longwall Panel Entries Using Finite Element Analysis. IN: Rock Mechanics: A State of the Art, Proceedings 21st U.S. Rock Mechanics Symposium, May 28-30, 1980, D.A. Summers, ed., University of Missouri at Rolla, p. 1-8.

Seven configurations for panel entries of a longwall coal mine are compared and ranked according to structural stability. These entry configurations are analyzed using three-dimensional finite element modeling. The models include large dimensions to minimize boundary effects, elasto-plastic constitutive relations, and simulated excavation and construction of support systems. The stability criteria are formulated in a quantitative manner to facilitate the ranking of the entry configurations. These criteria are based on the expected volume of caved rock in the entry openings. The stability ranking is applied to the entry excavation phase, the headgate phase, and the tailgate phase of the entry life cycle. Parametric variations are applied using two-dimensional finite element models to determine the sensitivity to changes in mining and design parameters.

Keyword(s): finite element, longwall, modeling, coal mining, mine design, rock mechanics

Location(s): United States

Van Dorpe, P. Classification of Coal Mine Subsidence in Iowa. IN: Association of Engineering Geologists Symposium Series No. 4, Building Over Underground Mines--Subsidence Considerations, October, 1987, p. 83-94.

In Iowa, subsidence above abandoned coal mines is well documented, but not well studied in terms of geologic control. Subsidence poses a significant threat to several communities, most notably, Des Moines, as well as rural areas. Subsurface geology and mining information are usually inadequate to document either causal relationships or physical conditions. Nevertheless, several subsidence incidents can be classified on the basis of surface morphology and geologic control.

Keyword(s): coal mining, abandoned mines, geologic features, room-and-pillar

Location(s): Iowa, United States

Van Dorpe, P. E., M. R. Howes, M. J. Miller, S. J. Lenker. Underground Mines and Related Subsidence Potential, What Cheer, Iowa. Iowa Geological Survey OFR 84-3, 1984, Iowa City, IA.

Numerous subsidence events above underground mines have been reported in Iowa. This report was prepared from extant coal mine information to assist in evaluation of subsidence events and to serve as a research base.

Keyword(s): historical, room-and-pillar, longwall, surface structural damage, agriculture, abandoned mines

Location(s): Iowa, United States

Van Dyke, M. Placing Fly Ash in the Ground Water Table. IN: Proceedings National Symposium and Workshops on Abandoned Mine Land Reclamation, Bismarck, ND, May 21-22, 1984, L.L. Schloesser, et al., eds., North Dakota Public Service Commission and the University of North Dakota, p. 343-375.

The possible use of fly ash, from a city-owned power plant, for subsidence control in Colorado Springs is discussed. A concern at the outset of the project was potential impact on water quality resulting from introducing this material as backfill into flooded mine voids.

Keyword(s): coal mining, backfilling, subsurface water, environment, modeling, abandoned mines

Location(s): Colorado, Rocky Mountain Coal Region, United States

Van Dyke, M. W. Gravel Bulkheads for Confining Hydraulic Backfilling of Abandoned Underground Coal Mines. Preprint 85-363, SME-AIME Fall meeting, Albuquerque, NM, October 16-18, 1985, 2 p.

Keyword(s): coal mining, abandoned mines, hydraulic backfilling

Van Eeckhout, E. M. The Mechanisms of Strength Reduction Due to Moisture in Coal Mine Shales. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 13, 1976, p. 61-67.

Keyword(s): rock mechanics, roof stability, coal mining

Van Heerden, W. L. Stress Measurements in Coal Pillars. IN: Proceedings, 2nd International Congress on Rock Mechanics, 1970, Paper No. 4-16, 5 p.

Keyword(s): pillar strength, ground control, rock mechanics, coal mining

Van Heerden, W. L. In-Situ Determination of Complete Stress-Strain Characteristics for 1.4 M Square Coal Specimens with Width to Height Ratios of Up to 3.4. South Africa Council for Scientific and Industrial Research, Research Report No. ME 1265, 1975, 30 p.

Keyword(s): pillar strength, rock mechanics, ground control, in situ testing, coal mining

Location(s): South Africa

Van Impe, W. F., P. Menge, W. Wolski. Stabilizing Canal Dikes in a Mine Subsidence Urban Area. IN: Proceedings 9th Danube-European Conference on Soil Mechanics and Foundation Engineering, Budapest, October 2-5, 1990, p. 383-389.

Mining related subsidence of up to 7meters in Eisden, Belgium, was countered by stepwise lengthening of the dikes of the canal crossing the city. There were doubts about the stability of the heterogeneous slopes. The geotechnical characteristics of the banks were examined by vane shear and CPTs, samples taken for laboratory testing, and pore pressures monitored to investigate seepage flow. Stability analysis was carried out by the Bishop method. Geometrical changes are not possible, so remedial measures of soil nailing plus gravel column drains were installed in some cross sections of the dike to reach the required safety conditions.

Keyword(s): surface water, geotechnical, lab testing, soils, surface subsidence damage, abandoned mines

Location(s): Belgium

Van Roosendaal, D. J., D. F. Brutcher, B. B. Mehnert, J. T. Kelleher, R. A. Bauer. Overburden Deformation and Hydrologic Changes Due to Longwall Mine Subsidence in Illinois. IN: Proceedings, 3rd Conference on Ground Control Problems in the Illinois Coal Basin, Mt. Vernon, IL, August 8-10, 1990, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 73-82.

Subsidence-induced deformation and hydrologic changes were studied at two active longwall coal mines in Illinois. Site 1, a 725-foot-deep longwall operation in south-central Illinois, was characterized before and after subsidence by core drilling, geophysical logging, subsidence surveying, geotechnical monitoring, and hydrological testing. Results from surveying and geotechnical monitoring during subsidence are presented. Surface subsidence characteristics measured at both sites fall into a range common to other Illinois longwall operations.

Keyword(s): overburden, hydrology, coal mining, instrumentation, monitoring methods, monitoring equipment, subsurface water, longwall,

active mines, angle of draw, geologic features, geotechnical, in situ testing, lab testing
Location(s): Illinois, Illinois Coal Basin, United States

Van Roosendaal, D. J., B. B. Mehnert, J. T. Kelleher, C. E. Ovanic. Three-Dimensional Ground Movements Associated with Longwall Mine Subsidence in Illinois. IN: Proceedings, Association of Engineering Geologists 34th Annual Meeting, Chicago, IL, September 29-October 4, 1991, p. 815-826.

This study documents the complex, transient ground displacements and strains associated with dynamic subsidence above an active longwall operation in southern Illinois. During active subsidence, the most complex surface movements take place near the side of the panel where the static tensile zone develops after the passage of a dynamic subsidence wave. At this location, the ratio of horizontal to vertical measurements is at a maximum. To document these complex movements, survey monuments were installed in a 4 by 4 grid over the tension zone and also along the centerline of a longwall panel. Horizontal and vertical movements were monitored at frequent intervals as the mine face advanced under the instruments.

Keyword(s): horizontal displacement, vertical displacement, coal mining, active mines, longwall, monitoring methods, monitoring equipment, monitoring design, survey data processing, survey methods, instrumentation, overburden
Location(s): Illinois, Illinois Coal Basin, United States

Van Roosendaal, D. J., P. J. Carpenter, B. B. Mehnert, M. A. Johnston, J. T. Kelleher. Longwall Mine Subsidence of Farmland in Southern Illinois: Near-surface Fracturing and Associated Hydrogeological Effects. IN: Proceedings National Symposium on Prime Farmland Reclamation,1992, R.E. Dunker, R.I. Barnhisel and R.G. Darmody, eds., Department of Agronomy, University of Illinois, Urbana, p. 147-158.

The Illinois Mine Subsidence Research Program coordinated a study to document near-surface fracturing and hydrogeological changes caused by subsidence above an active longwall coal mine in southern Illinois. Seismic refraction, electrical resistivity, displacement measurements, and resistivity soundings were used in the monitoring program.

Keyword(s): seismic, monitoring methods, active mines, coal mining, longwall, subsurface water, hydrology, geophysical
Location(s): Illinois, Illinois Coal Basin, United States

Van Roosendaal, D. J., B. B. Mehnert, R. A. Bauer. Three-Dimensional Ground Movements During Dynamic Subsidence of a Longwall Mine in Illinois. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 290-298.

A closely spaced grid of survey points was installed over the tensile zone of a longwall panel in southern Illinois and monitored daily during subsidence to document the complex ground-surface movements associated with dynamic subsidence. Vertical and horizontal displacements were used to calculate maximum tilts and principal strains within the grid. The dynamic nature of subsidence is made evident by changes in both the direction and magnitude of maximum tilts and principal strains.

Keyword(s): horizontal displacement, vertical displacement, longwall, instrumentation, monitoring methods, monitoring equipment, active mines, coal mining, overburden
Location(s): Illinois, Illinois Coal Basin, United States

Van Voast, W. A., R. B. Hedges. Hydrogeologic Conditions and Projections Related to Mining near Colstrip, Southeastern Montana. Montana Bureau of Mines and Geology, Billings, 1975.
Keyword(s): hydrology, coal mining
Location(s): Montana, United States

Vandale, A. E. Subsidence--A Real or Imaginary Problem? Mining Engineering, v. 19, no. 9, February, 1967, p. 86-88.

This article presents a brief history of coal mining and surface protection in the Pittsburgh, Pennsylvania, area. Some of the regulations covering surface protection are included.

Keyword(s): historical, law, coal mining
Location(s): Pennsylvania, Appalachian Coal Region, United States

Vanderwilt, J. W. Ground Movement Adjacent to a Caving Block in the Climax Molybdenum Mine. Transactions, AIME, v. 181, 1949, p. 360-370.

Varlashkin, V. M. Dopustimye Deformatsii Zemnoi Poverkhnosti Pri Razrabotke Ugol'Nykh Plastov Pod Grazhdanskimi Zdaniyami (Permissible Deformations of Land Surface During Working of Coal Seams Under Civil Buildings). Izvestiya Vysshikh Uchebnykh Zavedenij Gornyj Zhurnal, no. 8, 1975, p. 39-43.
Keyword(s): surface structural damage, government, engineering, coal mining
Location(s): Soviet Union

Varlashkin, V. M. Evaluation of the Flexural Rigidity of Buildings in the Case of Differential Settlements of Foundation Beds Above Mines. Soil Mechanics & Foundation Engineering, U.S.S.R., v. 12, no. 3, May/June, 1975, p. 171-173.
Keyword(s): surface structural damage, engineering, overburden, foundations
Location(s): Soviet Union

Vega, G. E. F. Subsidence of the City of Mexico: A Historical Review. IN: Proceedings, 2nd International Symposium on Land Subsidence, Anaheim, CA, December 13-17, 1976, International Association of Hydrological Sciences, Publication No. 121, Washington, D.C., 1977, p. 35-38.
Keyword(s): historical, surface subsidence damage

Veith, D. L. Mined Land Subsidence Impacts on Farmland With Potential Application to Illinois: A Literature Review. U.S. Bureau of Mines IC 9124, 1987, 16 p.
This report summarizes a USBM review of selected literature on the effects of subsidence due to high-extraction underground coal mining on farmland areas. The data are presented for consideration in evaluating the subsidence effects due to similar mining techniques on the prime farmland areas of Illinois.
Keyword(s): agriculture, surface subsidence damage, literature search, subsurface water, surface water, soils, land mitigation, room-and-pillar, longwall, prediction, coal mining
Location(s): Illinois, Illinois Coal Basin, Pennsylvania, Appalachian Coal Region, United States

Vervoort, A. Initial Roof Movement During the Development of Room and Pillar Sections. IN: Computer Methods and Advances in Geomechanics, Proceedings 7th International Conference, Cairns QLD Australia, May 6-10, 1991, G. Beer, J.R. Booker, and J.P. Carter, eds., v. 2, Balkema, Rotterdam, p. 1393-1398.
Keyword(s): roof stability, room-and-pillar, coal mining, active mines, computer

Vervoort, A., B. Jack. Room and Pillar Strata Behaviour Under Various Geological Conditions. IN: Proceedings International Congress on Rock Mechanics, Aachen, 1991, W. Wittke, ed., v. 2, p. 1375-1380.
Accurate underground measurements of the roof deflection were conducted in room-and-pillar panels during development and pillar extraction, improving the basic knowledge of roof behaviour in coal mines. The underground observations were simulated using linear elastic and non-elastic models. These simulations indicated the effect of changing geological conditions and enabled the extrapolation of the underground measurements.
Keyword(s): room-and-pillar, coal mining, monitoring methods, pillar extraction, roof stability, geologic features
Location(s): South Africa

Virginia Polytechnic Institute and State University. Prediction of Ground Movements Due to Underground Mining in the Eastern United States Coalfields Volume 2. Surface Deformation Prediction System. User's Manual. Department of Mining and Minerals Engineering, Blacksburg, VA, December, 1987, 112 p. (NTIS PB90-148263)
The Surface Deformation Prediction System (SDPS) is designed to provide the field engineer as well as the researcher with a detailed, in-depth analysis of ground deformations over undermined areas using three different prediction methods. For easy application, appropriate computer programs have been developed based on three different numerical formulations and a variety of ground deformation indices can be computed. Presented are the basic concepts of the SDPS, the monitoring program, subsequent analysis of the field results obtained, and the adaptation of the prediction methods for mining and geological conditions in the eastern United States. The use of the computer software developed for predicting ground deformations on the surface is discussed.
Keyword(s): coal mining, prediction, computer, influence function, profile function, zone area
Location(s): Appalachian Coal Region, United States

VNIMI (General Institute of Mining Surveying) The Movements of the Rock Masses and of the Surface in the Main Coal Fields of the Soviet Union. Ugletekhjizdat, Moscow, 1958, 250 p. (in Russian).
Keyword(s): coal mining
Location(s): Soviet Union

Voight, B., W. Pariseau. The Nature of Prediction in Subsidence Engineering. ASCE Conference, New York, October 1968, Preprint 762, 42 p.
Keyword(s): prediction, modeling, phenomenological model, elastic model, engineering

Voight, B., A. C. Samuelson. On the Application of Finite-Element Techniques to Problems Concerning Potential Distribution and Stress Analysis in the Earth Science. Pure and Applied Geophysics, v. 75, no. 4, 1969, p. 157-172.
Keyword(s): finite element, modeling, phenomenological model, elastic model

Voight, B., H. D. Dahl. A Post-Yield Phenomenological Approach to Mine Subsidence. IN: Proceedings International Scientific Symposium on Mine Surveying, Mining Geology, and the Geometry of Mineral Deposits, August 26-30, 1969, Prague, Czechoslovakia, Section III, Conference Paper III/3, 12 p.
Keyword(s): modeling, phenomenological model

Voight, B., W. Pariseau. State of Predictive Art in Subsidence Engineering. ASCE Journal Soil Mechanics & Foundations Division, v. 96, no. SM2, March, 1970, p. 721-750.
This paper gives a qualitative review of existing approaches to subsidence prediction; specific sections deal with both empirical and phenomenological methods. Also discussed are damage prediction and alleviation, with details on engineering design precautions and surface considerations.
Keyword(s): vertical displacement, horizontal displacement, surface structural damage, subsurface structural damage, mine design, prediction, modeling, empirical model, phenomenological model, elastic model, ground control, prediction theories, mitigation
Location(s): United States

Voight, B., N. Orkan, K. Young. Deformation and Failure-Time Prediction in Rock Mechanics. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 919-929.
The purposes of this paper are to (1) develop the properties of a differential equation in order to describe material behavior during creep and some cases of cyclic loading, (2) develop equations to couple rate changes of various phenomena to the time of failure, (3) discuss alternative analytical and graphical procedures and criteria for failure prediction, and (4) demonstrate use of the method in rock mechanics by practical examples.
Keyword(s): rock mechanics, prediction, roof stability, bumps, coal mining, tunnelling

Von Schonfeldt, H., F. D. Wright, K. F. Unrug. Subsidence and Its Effect on Longwall Mine Design. Mining Congress Journal, v. 66, no. 5, 1980, p. 41-45, 53; also presented at the Annual AMC Coal Convention, St. Louis, MO, 1979, May 20-23.
This paper examines the characteristics of subsidence resulting from longwall extractions. From 1969 to 1979, longwall mining in the United States expanded from about 13 faces to more than 75. The main advantage of longwall mining, which is high extraction even at great depth, also can cause significant surface movements. New regulations in the United States covering coal-mining subsidence and reclamation operations require the mine operator to take certain steps in mine design. Specific sections qualitatively discuss the caving of strata, the effect of panel width and depth on settlement, and considerations governing panel design.
Keyword(s): mine design, monitoring design, monitoring installation, monitoring equipment, longwall, economics, coal mining, modeling, prediction, roof stability, National Coal Board, survey design, law
Location(s): Europe, Soviet Union, South Africa, United States, Illinois Coal Basin, West Virginia, Virginia, Poland

Vongpaisal, S. Prediction of Subsidence Resulting from Mining Operations. Ph.D. Thesis, McGill University, Montreal, 1973.
Keyword(s): prediction

Vongpaisal, S., D. F. Coates. Analysis of Subsidence from Inclined Workings. IN: Proceedings 10th Canadian Rock Mechanics Symposium, Kingston, September 2-4, 1975, Queen's University, v. 1, p. 181-201.

The studies described in this paper indicate

that for dipping orebodies, the pattern of surface settlement is similar to that caused by mining horizontal seams with the possible exception that some heaving may occur on the rise side. Any heaving that might occur over a steeply dipping orebody will increase greatly with an increase in length down-dip or with a decrease in width of the crown pillar above the opening. Horizontal movement and strain on the surface also have patterns that are similar to those for flat-lying seams. Two mine cases indicate that initial movement and initial cracking are predictable using a relatively simple model, which should provide useful guidance for mine planning.

Keyword(s): vertical displacement, horizontal displacement, finite element, modeling, mine design, metal mining

Vormberge, G. Working-Out a Seam in the Shaft Safety Pillar of a Pit Under Exceptionally Difficult Operating Conditions. International Strata Control Congress, Essen, West Germany, 1956.

Keyword(s): mine operation, pillar extraction, room-and-pillar

Vorster, G. J. P. Contractual Aspects to be Addressed in the Application of High Extraction Underground Coal Mining Methods Resulting in Surface Ground Movement. IN: Proceedings, SANGORM Symposium, October 21, 1986, Sandton, South Africa, International Society for Rock Mechanics, South African National Group, p. 151-155.

Research into the effects of high-extraction mining on the land surface and structures is gaining momentum but considerable research is still required to bridge the information gap. Negotiating mining and other contracts related to high-extraction mining under structures and land surfaces is a sound method of preventing problems in a field where many obstacles and pitfalls prevail.

Keyword(s): law, surface structural damage, high-extraction retreat, longwall, pillar extraction, coal mining

Location(s): South Africa

Vos, G., F. A. M. Claessen, J. H. G. van Ommen. Geohydrological Compensatory Measures to Prevent Land Subsidence as a Result of the Reclamation of the Markerwaard Polder in the Netherlands. IN: Land Subsidence, Proceedings 3rd International Symposium, Venice, Italy, March 19-25, 1984, A.I. Johnson, L. Carbognin, and L. Ubertini, eds., International Association of Hydrological Sciences Publication No. 151, 1986, p. 915-928.

If the Markerwaard polder is reclaimed the water level will fall 5 to 6 meters over an area of 410 square km. This will cause a drawdown of the piezometric levels in the Pleistocene aquifers underneath the eastern part of the province of North Holland. The spatial pattern of these drawdowns is calculated by a finite element groundwater model. Without countermeasures to compensate for the depletion of the piezometric level, settlement of the compressible Holocene clay and peat deposits will occur and resultant land subsidence may cause damage to buildings and infrastructures.

Keyword(s): fluid extraction, finite element, geologic features, surface subsidence damage

Location(s): Netherlands

Wade, L. V., P. J. Conroy. Rock Mechanics Study of a Longwall Panel. SME Fall Meeting, St. Louis, MO, 1977, Preprint No. 77-I-391.

This paper summarizes the results of the rock mechanics monitoring program performed as part of Old Ben Coal Company's longwall coal-mining demonstration project conducted in cooperation with the USBM. The work described herein included installation of instruments, collection of data, and data analysis performed during mining of the first longwall panel in mine no. 24. The rock mechanics monitoring program included both surface and underground instrumentation.

Keyword(s): rock mechanics, longwall, instrumentation, coal mining, monitoring methods, mine design, active mines

Location(s): Illinois, Illinois Coal Basin, United States

Wade, L. V., P. J. Conroy. Rock Mechanics Study of Old Ben Longwall Panel No. 1. IN: Proceedings, Illinois Mining Institute Annual Meeting, Springfield, October 13-14, 1977, p. 61-79.

This paper summarizes the results of the rock mechanics monitoring program performed as part of the Old Ben Coal Company's longwall coal mining demonstration project conducted in cooperation with the USBM. The work described included installation of instruments, collection of data, and data analysis performed during mining of the first longwall panel in mine no. 24. The rock mechanics monitoring program included both surface and underground instrumentation.

Keyword(s): longwall, instrumentation, coal mining, monitoring equipment, monitoring methods, survey data processing, rock mechanics

Location(s): Illinois, Illinois Coal Basin, United States

Wade, L. V., P. J. Conroy. Rock Mechanics Study of a Longwall Panel. Mining Engineering, v. 32, no. 12, 1980, p. 1728-1734.

Old Ben Coal Company successfully completed the first longwall panel in Illinois. The panel was mined using shield supports and was part of a cooperative agreement with the USBM. This paper describes the rock mechanics studies performed to monitor the performance of the supports, the stress changes in the coal and floor, convergence in entries, and caving mechanism of the roof. From this study, maximum support loads were obtained as well as the stress distribution in the panel, floor, and adjacent pillars.

Keyword(s): rock mechanics, longwall, coal mining, monitoring methods, monitoring equipment, instrumentation, roof stability

Location(s): Illinois, Illinois Coal Basin, United States

Wagner, C. B. A Report on Subsidence Literature Survey, and the Law on Subjacent Support. West Virginia University Bulletin, Series 42, no. 1-I, July 1941, 60 p.

Keyword(s): law, literature search

Location(s): United States

Wagner, H., M.D.G. Salamon. Strata Control Techniques in Shafts and Large Excavations. Association of Mine Managers of South Africa Papers and Discussions, v. 1972-1973, 1972, p. 123-140.

Keyword(s): ground control

Location(s): South Africa

Wagner, H. Determination of the Complete Load Deformation Characteristics of Coal Pillars. IN: Proceedings, 3rd International Congress Rock Mechanics, Denver, CO, 1974, v. 11-B, p. 1076-1082.

Keyword(s): pillar strength, ground control, rock mechanics, coal mining

Wagner, H., B. J. Madden. Fifteen Years Experience with the Design of Coal Pillars in Shallow South Africa Collieries: An Evaluation of the Performance of the Design Procedures and Recent Improvements. IN: Proceedings, International Society for Rock Mechanics Symposium on Design and Performance of Underground Excavations, Cambridge, U.K., September 3-6, 1984, E.T. Brown and J.A. Hudson, eds., British Geotechnical Society, London.

The pillar design procedure employed in South African collieries is reviewed. A comparison of actual and predicted pillar collapses shows good agreement. Three areas of improvement are identified. These concern the effects of regional differences in coal seam strength and method of mining on pillar design and the strength of squat pillars. Results of recent research in the latter two areas are presented. It is shown that the use of continuous miners enhances the strength of slender pillars. The strength of squat pillars is underestimated by the pillar strength formula in use in South African collieries. Extensions to the formula, which take these differences into account, are proposed.

Keyword(s): coal mining, pillar strength, rock mechanics, mine design, room-and-pillar
Location(s): South Africa

Wagner, H., E.H.R. Schumann. The Effects of Total Coal Seam Extraction on the Surface and Surface Structures. IN: Colloquium on Recent Mining and Metallurgical Developments in the Eastern Transvaal, South Africa Institute Mining & Metallurgy, Witbank, September 1985; also Chamber of Mines of South Africa Research Report 20/85, 1985.
Keyword(s): coal mining, surface structural damage, active mines
Location(s): South Africa

Waite, B. A. Ground Water Monitoring of Underground Coal Mines. Mining Engineering, v. 34, 1982, p. 170-171.
Keyword(s): hydrology, subsurface water, monitoring design, coal mining, monitoring methods

Walbert, M. S., R. J. Sutherland. Economic Model for Evaluating the Tradeoffs Between Coal Mining and Surface Subsidence. Report to Department of Energy, Washington, D.C., by Los Alamos National Laboratory, LA-9438-MS, May, 1982, 65 p.
Keyword(s): coal mining, economics
Location(s): United States

Wald, M. L. Coal Mine Robots Lift an Industry. The New York Times, February 8, 1990, 3 p.
This article describes a longwall operation in West Virginia.
Keyword(s): coal mining, longwall, active mines, mine operation
Location(s): West Virginia, Appalachian Coal Region, United States

Walker, H. C. SPR Geotechnical Program Preliminary Long-Term Monitoring Plan. Sandia National Labs, August, 1980, 27 p. (NTIS SAND80-1750)
Keyword(s): geotechnical, instrumentation, monitoring design, monitoring methods
Location(s): United States

Walker, J. S., J. B. Green, M. A. Trevits. A Case Study of Water Level Fluctuations Over a Series of Longwall Panels in the Northern Appalachian Coal Region. IN: Proceedings, 2nd Workshop on Surface Subsidence due to Underground Mining, Morgantown, WV, June 9-11, 1986, S.S. Peng, ed., West Virginia University, p. 264-269.
The purpose of this work was to provide detailed information that could be used to predict certain hydrologic effects of longwall mining in the Northern Appalachian Coal Region. Results of this case study indicate that water level fluctuations in the local groundwater system above longwall panels are associated with subsidence and that the static water level will generally re-establish at or near the pre-mining elevation after mining is completed.
Keyword(s): subsurface water, law, coal mining, longwall, hydrology, geologic features, active mines
Location(s): Pennsylvania, Appalachian Coal Region, United States

Walker, J. S., J. C. LaScola. Foundation Response to Subsidence Induced Ground Movements: A Case Study. IN: Proceedings, National Symposium on Mining, Hydrology, Sedimentology, and Reclamation, December 7-11, 1987, Springfield, IL, University of Kentucky, p. 235-241.
The purpose of this USBM effort was to determine whether mining-induced ground movement is directly transferred to a structure and, if so, how that process takes place. A series of four concrete block walls with foundations were constructed and monitored over an active longwall panel as part of a comprehensive subsidence research program.
Keyword(s): surface structural damage, coal mining, active mines, longwall, monitoring methods, monitoring equipment, foundations, prediction
Location(s): West Virginia, Appalachian Coal Region, United States

Walker, J. S. Case Study of the Effects of Longwall Mining Induced Subsidence on Shallow Ground Water Sources in the Northern Appalachian Coalfield. U.S. Bureau of Mines RI 9198, 1988, 17 p.
The USBM monitored surface subsidence and water level fluctuations in 10 shallow observation wells above a series of four adjacent longwall panels in southwestern Pennsylvania for about 4 years. This study attempted to correlate the changes in the water levels within the observation wells to the measured vertical and horizontal ground movements associated with subsidence. Results of this study indicate that the fluctuation of the water levels appears to be a function of the well location relative to the mine layout and the proximity of mining. Wells are generally unaffected by mining of a preceding panel unless they are

located within the angle of draw for that panel. Wells located at the centerline of a longwall panel exhibit the greatest fluctuation and head loss. Nine of the ten wells investigated recovered to their premining water level after mining was completed.

Keyword(s): longwall, subsurface water, hydrology, coal mining, monitoring methods, active mines

Location(s): Pennsylvania, Appalachian Coal Region, United States

Walker, J. S., M. A. Trevits, R. D. Munson. Overview of the Bureau of Mines Research On the Detection of Subsidence. IN: Proceedings, Symposium on Evolution of Abandoned Mine Land Technologies, Riverton, WY, June 14-16, 1989, p. 36-55.

The USBM Abandoned Mine Land Subsidence Research Program addresses the problems of mine void detection, the changing condition of the mine opening, and the development of effective and efficient subsidence abatement techniques. This paper summarizes two current efforts to evaluate the changing conditions of the mine opening using geophysical techniques. The research was conducted at two field sites, in Colorado and in Pennsylvania. The objective of this work was to develop an imminent subsidence detection system applicable to abandoned mine lands in all areas of the country.

Keyword(s): subsidence research, abandoned mines, coal mining, anthracite, bituminous, overburden, subsurface water, seismic, monitoring methods, surface structural damage, geophysical

Location(s): Colorado, Rocky Mountain Coal Region, Pennsylvania, Appalachian Coal Region, United States

Walker, J. S., J. C. LaScola. Foundation Response to Subsidence-Induced Ground Movements: A Case Study. U.S. Bureau of Mines RI 9224, 1989, 12 p.

The purpose of this effort was to determine whether ground movement caused by mining-induced subsidence is directly transferred to a structure and, if so, how that transfer takes place. Four concrete block walls with foundations were constructed and monitored over an active longwall panel. Three of the walls were located perpendicular to the direction of mining in zones where maximum inclination, maximum tension, and maximum curvature were predicted to occur. The fourth wall was constructed along the centerline of the panel, parallel to the direction of mining. All of the walls and the surrounding ground surface were instrumented with conventional survey monitoring points and extensometer stations to observe the vertical and horizontal movements. The fourth wall instrumentation also included continuously recording tiltmeters. The results of this investigation indicate that these simple structures respond to subsidence in a similar manner as the ground surface. This indicates that once the transfer mechanism is more fully defined, prediction models can be developed to accurately estimate the effect of mining on surface structures.

Keyword(s): foundations, coal mining, surface structural damage, longwall, active mines, instrumentation, vertical displacement, horizontal displacement, prediction, modeling

Location(s): West Virginia, Appalachian Coal Region, United States

Walker, J. S., M. A. Trevits. Development of an Early Warning System for Detection of Subsidence Over Abandoned Coal Mines. IN: Mine Subsidence - Prediction and Control, 33rd Annual Meeting of the Association of Engineering Geologists, October 2-3, 1990, C.D. Elifrits, ed., Pittsburgh, PA, p. 39-49.

Subsidence from abandoned underground mines has become an everyday concern of many citizens living in the coal-mining regions of the United States. The problem of subsidence prediction is that it is impossible to determine the location and timing of mine opening failure. If a system could be developed that would warn of imminent failure, in advance of surface manifestation, then subsidence abatement techniques could be implemented to minimize property damage. The USBM is evaluating the components of an imminent subsidence detection system at two locations in Pennsylvania. The components under evaluation include an active and passive seismic component as well as aerial photogrammetry.

Keyword(s): coal mining, abandoned mines, monitoring methods, seismic, remote sensing, photography, anthracite

Location(s): Pennsylvania, Appalachian Coal Region, United States

Walker, J. S., M. A. Trevits. Effects of Longwall Mining on Surface Structures. IN: Mine Subsidence - Prediction and Control, National Symposium, 33rd Annual Meeting, Association of Engineering Geologists, October 2-3, 1990, C.D. Elifrits, ed., Pittsburgh, PA, p. 141-152.

Five residential structures spaced across a longwall panel were studied. Measurements were made using conventional surveying and electronic instrumentation to characterize the ground surface and the structures in advance of, during, and subsequent to undermining.

Keyword(s): surface structural damage, longwall, coal mining, monitoring methods, instrumentation, vertical displacement, horizontal displacement

Location(s): Pennsylvania, Appalachian Coal Region, United States

Walker, J. S., M. A. Trevits. New Developments in Remote Pneumatic Stowing Technology for Subsidence Abatement Over Abandoned Coal Mines. IN: Mine Subsidence - Prediction and Control, National Symposium, 33rd Annual Meeting Association of Engineering Geologists, October 2-3, 1990, C.D. Elifrits, ed., Pittsburgh, PA, p. 183-192.

The USBM initiated a program for the development and evaluation of remote pneumatic stowing technology. A dedicated laboratory was constructed to test and improve currently available and prototype remote pneumatic stowing methods.

Keyword(s): pneumatic backfilling, lab testing, abandoned mines, coal mining

Location(s): United States

Walker, W. Hydraulic Stowage at Dalzell and Broomside Colliery. Iron and Coal Trades Review, July 12, 1912, p. 51.

Efficient mining of coal overlain by saturated gravel and adjacent to the Clyde River was allowed by backfilling.

Keyword(s): hydraulic backfilling, surface water, subsurface water, coal mining, overburden

Location(s): England

Wall, C. F. A Geophysical Method of Indicating Relative Sinkhole Susceptibility. IN: Proceedings, 2nd International Symposium on Land Subsidence, Anaheim, CA, IAHS-AIHS Publication No. 121, December, 1976, p. 485-493.

Keyword(s): geophysical

Wallace, M. R. Preventive Measures to Avert Crude Line Subsidence. Pipe Line Industry, June, 1988, p. 19-24.

Longwall mining can affect cross-country pipe lines. During such mining, the extraction of an entire seam of coal allows the roof of the mine to cave in behind the mining operation, thus causing subsidence of the surface. The subsidence travels in a wave-like fashion at ground level. As the wave passes under and beyond the pipe line, special measures must be taken to control its downward movement, thereby controlling bending stresses in the unsupported areas. Recently, longwall mining has affected Capline's 40-inch crude pipeline that operates from Louisiana to Patoka, Illinois. These mining operations extract coal from the 6- to 8-foot seam and over a panel 600 feet wide. Multiple parallel panels are frequently involved, which requires repeated corrective action to the pipeline each time a panel crosses the pipeline. The effects and corrective measures taken to properly support Capline during a four panel longwall mining operation are outlined in this article.

Keyword(s): coal mining, pipelines, longwall, survey design, survey equipment, survey methods, survey data processing, National Coal Board, structural mitigation, vertical displacement

Location(s): Illinois, Illinois Coal Basin, United States

Walters, R. F. Land Subsidence in Central Kansas Related to Salt Dissolution. Kansas Geological Survey Bulletin No. 214, 1977, 82 p.

Keyword(s): non-metal mining

Location(s): Kansas, United States

Waltham, A. C. Ground Subsidence. Blackie and Son Limited,Chapman and Hall, New York, 1989, 202 p.

This book presents an overview of all aspects of ground subsidence. Each style of subsidence is considered in its own right, because the causative mechanisms vary enormously. For example, sinkholes and collapses over random natural voids clearly contrast with the widespread and inevitable human-induced subsidence of drained peat. Mining subsidence, in its various forms, is covered together with the many other ways in which humans induce subsidence in their environment.

Keyword(s): fluid extraction, subsurface water, oil extraction, coal mining, geologic features, National Coal Board, empirical model, multiple-seam extraction, overburden, non-metal mining, foundations, surface structural damage, soils, soil mechanics, engineering, abandoned mines, active mines, geophysical, longwall, vertical displacement, horizontal displacement, prediction, room-and-pillar, computer, influence function, metal mining, structural mitigation, roads, engineering, pipelines, partial extraction, pillar strength, backfilling, land mitigation, mitigation, land-use planning

Location(s): United States, Appalachian Coal Region, China, United Kingdom, Pennsylvania, Florida, Australia, Illinois, Illinois Coal Basin, Germany, Europe, Japan, Kansas, California, Italy

Walton, G., R. K. Taylor. Likely Constraints on the Stability of Excavated Slopes Due to Underground Coal Workings. IN: Proceedings, Conference on Rock Engineering, University of Newcastle upon Tyne, England, April 4-7, 1977, p. 329-349.

This paper examines potential modes of slope failure that can be induced in surface coal mines largely as a consequence of former underground mine workings.

Keyword(s): engineering, rock mechanics, abandoned mines, room-and-pillar, longwall, coal mining

Location(s): England

Walton, G., A. E. Cobb. Mining Subsidence. IN: Ground Movements and Their Effects on Structures, Surrey University Press, P.B. Attewell and R.K. Taylor, eds., 1984, Chapman and Hall, p. 216-241.

The extraction of minerals by underground mining inevitably induces a risk of surface subsidence. Different methods of mining give rise to different risks of subsidence and different styles of ground movement. This chapter considers subsidence resulting from these mining methods; mineral extraction by solution, as in salt recovery, is not considered. Because coal mining is the most extensive and most researched form of mining in many parts of the world, most of the examples come from this sector of the industry.

Keyword(s): coal mining, surface structural damage, room-and-pillar, longwall, partial extraction, roof stability, floor stability, pillar strength, prediction, zone area, empirical model, National Coal Board

Location(s): United Kingdom, Europe

Wang, F. D., D. M. Ropchan, M. C. Sun. Structural Analysis of a Coal Mine Opening in Elastic, Multilayered Material. U.S. Bureau of Mines RI 7845, 1974, 36 p.

Finite-element structural analyses were performed to determine the stress distribution and displacements around a single rectangular coal mine opening in a multilayered rock system. The effects of changes in mechanical properties of roof and coal layers, roof layer and mine opening geometry, horizontal-to-vertical load ratio, and structural geologic features on the stress distribution about the opening were studied.

Keyword(s): roof stability, mine design, ground control, coal mining, finite element

Location(s): United States

Wang, F. D., D. M. Ropchan, M. C. Sun. Proposed Technique for Improving Coal-Mine Roof Stability by Pillar Softening. SME-AIME, v. 255, 1974, p. 59-63.

Keyword(s): roof stability, yielding supports, coal mining

Location(s): United States

Wang, W., M. M. Singh. A Numerical Method for Determination of Stresses Around Underground Openings. IN: Proceedings, 1st Congress International Society of Rock Mechanics, Lisbon, Portugal, v. 2, 1966, p. 363-373.

In this analysis, the rock is considered to be elastic and homogenous in each stratum, although the physical properties of each bed may vary. The method adopted employs a plain strain discrete model for which the finite-difference equations of equilibrium and boundary conditions are formulated. Two illustrative models, in the case of bedded rock, are included.

Keyword(s): boundary element, finite element, prediction, modeling, rock mechanics

Ward, T. The Subsidences in and Around the Town of Northwich in Cheshire. Transactions, Institute of Mining Engineers, London, v. 19, 1900, p. 241-264.

Keyword(s): surface subsidence damage, historical

Location(s): England

Wardell, K. A Comparison Between British and German Experience of Mining Subsidence. Transactions, Institute Mining Surveyors, v. 30, 1950, p. 51-70.

Keyword(s): England, Germany

Wardell, K. The Surveying Observations Required for the Determination of Ground Movements Caused by Mining. Transactions, Institute of Mining Surveyors, 1952, v. 32, no. 12.

Keyword(s): survey methods, survey design

Wardell, K. Some Observations on the Relationship Between Time and Mining Subsidence. Transactions, Institute Mining Engineers, London, v. 113, 1953-54, p. 471-483, 799.

This paper discusses the importance of the time factor in the study of mining subsidence and its influence on the movements accompanying an advancing face, as well as the limitations of existing methods of analysis.

Keyword(s): vertical displacement, time factor, prediction

Wardell, K. Mining Subsidence. Transactions, Royal Institute Chartered Surveyors, v. 86, no. 8, 1954, p. 53-70.
Location(s): England

Wardell, K. The Minimisation of Surface Damage by Special Arrangement of Underground Workings. IN: Proceedings, European Congress on Ground Movement, Leeds, England, April 9-12, 1957, London Harrison, p. 13-20.

This paper contains a basic explanation of harmonic mining methods designed to negate the effects of surface strains, thereby minimizing surface damage. These stepped face methods of subsidence control are shown to be most applicable to depths of less than 400 to 500 meters. The author also analyzes ground movements that result from an advancing face.

Keyword(s): mine design, ground control
Location(s): Europe

Wardell, K., N. E. Webster. Some Surface Observations and Their Relationship to Movement Underground. IN: Proceedings, European Congress on Ground Movement, Leeds, England, April 9-12, 1957, London Harrison, p. 141-148.

The concept of maximum surface subsidence is discussed as related to the area of influence, critical width, depth, and treatment of the goaf. Strain distribution is discussed in reference to its position within the subsidence trough and the effect of partial workings adjacent to a previously mined area. The authors close with a discussion of surface subsidence and underground convergence in relation to time and rate of advance of the extraction face.

Keyword(s): partial extraction, multiple-seam extraction, time factor, mine operation, angle of draw, mine waste, mine design

Wardell, K., N. E. Webster. Surface Observations and Strata Movement Underground. Colliery Engineering, v. 34, 1957, p. 329-336.
Keyword(s): subsurface subsidence damage, overburden, surface subsidence damage

Wardell, K. The Minimisation of Surface Damage. Colliery Engineering, v. 34, no. 403, September, 1957, p. 361-367.

Although numerous attempts have been made in Great Britain to minimize damage to surface structures by adopting a specially planned layout of underground workings, little has been published about the results of such experiments.

Keyword(s): surface subsidence damage, land mitigation, mine design, multiple-seam extraction, surface structural damage
Location(s): England

Wardell, K. The Problems of Analysing and Interpreting Observed Ground Movement. IN: Proceedings, International Strata Control Congress, Leipzig, October 14-16, 1958, p. 206-221 and XCI-XCVIII.

It is now generally accepted that the practical problems of surface support and surface damage, which arise as the result of ground movement caused by underground mining, can only be solved if a reasonable forecast can be made of the ground movements to be expected in any particular case. Many detailed observations of surface ground movements have been made by mining surveyors, and analysis of these data has enabled the general pattern of surface ground movement to be defined. Many investigators have, however, also attempted to rationalize the results of observations and to devise methods of precalculating ground movement that have a wide if not universal validity.

Keyword(s): coal mining, surface subsidence damage, prediction, horizontal displacement, vertical displacement, multiple-seam extraction
Location(s): United Kingdom

Wardell, K. The Protection of Structures Against Subsidence. Chartered Surveyor, v. 90, no. 10, April, 1958, p. 573-579.

The author emphasizes the main principles of the ground deformation process, mining precautions, and structural design considerations that pertain directly to the protection of surface structures.

Keyword(s): vertical displacement, horizontal displacement, surface structural damage, mine design, ground control, construction

Wardell, K. The Problems of Analyzing and Interpreting Observed Ground Movement. Colliery Engineering, v. 36, December, 1959, p. 529-540.
Keyword(s): ground control, descriptive theories

Wardell, K. Surface Ground Movements Associated with the Total and Partial Extraction of Stratified Mineral Deposits. M.S. Thesis, University of Nottingham, England, 1965, 167 p.

Keyword(s): partial extraction, longwall, mine design, surface subsidence damage
Location(s): United Kingdom

Wardell, K. Problems Posed by Past and Future Mineral Workings in a Development Area. The Chartered Surveyor, Mineral Workings, October 1966, p. 184-188.
Keyword(s): land-use planning, active mines, abandoned mines

Wardell, K., J. C. Wood. Ground Instability Problems Arising from the Presence of Old, Shallow Mine Workings. IN: Proceedings, Midlands Soil Mechanics & Foundations Engineering Society, v. 7, Paper No. 36, 1966, p. 5-30.
This paper discusses site investigation and development in undermined areas.
Keyword(s): abandoned mines, room-and-pillar, pillar strength, backfilling, roof stability

Wardell, K. Design of Partial Extraction Systems in Mining. IN: Proceedings, 4th Annual Canadian Rock Mechanics Symposium, Ottawa, March 29-30, 1967, Department Energy, Mines, and Resources, Ottawa, Canada, p. 271-296.
This paper presents an overview of partial-extraction mining methods and the various parameters involved with each method. Also, the mechanics of panel-and-pillar and room-and-pillar extraction are discussed.
Keyword(s): mine design, partial extraction, room-and-pillar, rock mechanics

Wardell, K. Report of Joint Meeting with Institution of Mining Engineers. Structural Concept of Strata Control and Mine Design. Transactions, Institute Mining & Metallurgy, London, v. 77, no. 743, Sec. A, October, 1968, p. A125-138; also The Mining Engineer, v. 127, no. 95, August 1968, p. 633-651.
Rock mechanics principles are related to problems in ground control and mine design.
Keyword(s): ground control, mine design, rock mechanics
Location(s): England

Wardell, K., R. J. Piggott. Report on Mining Subsidence. Selection of technical reports submitted to the Aberfan Tribunal, London, 1969.
These reports describe the conditions and effects of subsurface mining on coal waste banks involved in the Aberfan mining disaster.
Keyword(s): mine waste, surface subsidence damage
Location(s): England

Wardell, K. Ground Subsidence and Control. Mining Congress Journal, v. 55, no. 1, January, 1969, p. 36-42.
The author evaluates the mechanics of subsidence and explains how the panel-and-pillar mining system can be used to minimize ground deformations. An explanation of ground deformation parameters along with mathematical formulas used for subsidence prediction are included. The author also discusses the effects of subsidence on surface structures, and a general explanation of leveling procedures used for monitoring subsidence.
Keyword(s): vertical displacement, horizontal displacement, mine design, survey methods, mathematical model, modeling, prediction, monitoring methods, surface structural damage, ground control

Wardell, K. The Effects of Mineral and Other Underground Excavation on the Overlying Ground Surface. IN: Proceedings, Symposium on Geological and Geographical Problems of Areas of High Population Density, Washington, D.C., 1970, Association of Engineering Geologists, 1971, p. 20-217.
This paper details empirical studies concerning dimensional parameters of underground excavations and their influence on the surface. The author refers to the factor of geologic condition and discusses several theoretical models.
Keyword(s): modeling, prediction, surface subsidence damage

Wardell, K. and Partners. Guidelines for Mining Under Surface Water. Phase II and Final Report. Contract H0252021, U.S. Bureau of Mines OFR 30-77, 1977, 67 p. (NTIS PB 264 729)
Keyword(s): mine operation, surface water, mine design
Location(s): United States

Wardle, L. J., K. E. McNabb. Comparison Between Predicted and Measured Stresses in an Underground Coal Mine. IN: Research & Engineering Applications in Rock Masses, Proceedings 26th U.S. Symposium on Rock Mechanics, South Dakota School of Mines & Technology, Rapid City, June 26-28, 1985, E. Ashworth, ed., Balkema, Rotterdam, p. 531-538.
Rational design of complicated layouts such

as those encountered in longwall mining is only possible by use of an accurate and economical method for predicting stresses and displacements. A novel three-dimensional numerical stress analysis method is validated by comparison with results from stressmeters monitored during panel extraction. The study shows that by choosing appropriate anisotropic rock properties, predictions of vertical stresses and surface displacements are close to observed values.

Keyword(s): prediction, modeling, instrumentation, rock mechanics, longwall, coal mining

Location(s): Australia

Wardle, L. J., K. E. McNabb. Stress Monitoring During Wongawilli Extraction in 3 North Panel, Laleham No. 1, Colliery, South Blackwater, Queensland. Commonwealth Scientific and Industrial Research Organization, Mount Waverly, Australia. Division of Applied Geomechanics, May, 1985, REPT-59, ISBN-0-643-03570-2, 40 p. (NTIS PB85-232429/WNR)

The report describes investigations at the Laleham No. 1 Colliery, South Blackwater, Queensland, involving monitoring of stresses and convergences during Wongawilli (rib pillar) extraction in 3 North Panel. The project involved the installation of 16 vibrating wire stressmeters and 10 telescopic convergence rods. The aim of the project was to monitor changes in the stress distribution during extraction.

Keyword(s): instrumentation, monitoring equipment, monitoring installation, monitoring methods, pillar extraction, coal mining

Location(s): Australia

Wardle, L. J., K. E. McNabb. Stress Monitoring During Wongawilli Extraction in 3 North Panel, Laleham No. 1 Colliery, South Blackwater, Queensland. Queensland Government Mining Journal, November, 1985, p. 454-461.

This report describes investigations at the Laleham No. 1 Colliery, South Blackwater, Queensland, involving monitoring of stresses and convergences during Wongawilli (rib pillar) extraction in 3 North Panel. The project involved the installation of 16 vibrating wire stressmeters and 10 telescopic convergence rods. The instruments were installed in the fenders (rib pillars), roadway pillars, and the solid coal surrounding the panel. Instrumentation proved to be reliable and was monitored over a 6-month period. Results indicate that the major redistribution of stress occurs when a fender is isolated from the main extraction block by the drivage of a split. As the split face advances, isolating the fender, the load from the split/fender area is transferred to the main extraction block. The isolated section of the fender undergoes a constant rate of stress relaxation independent of subsequent mining. The fender is in a stress relieved state when extracted.

Keyword(s): instrumentation, monitoring methods, monitoring equipment, monitoring design, pillar strength, coal mining, mine design, pillar extraction

Location(s): Australia

Warren, J. P., L. L. Jones, W. L. Griffin. Costs of Land Subsidence Due to Ground Water Withdrawal. Texas Water Resource Institute, Texas A & M University, Technical Report 57, 1974, 79 p.

Keyword(s): fluid extraction, economics

Location(s): Texas, United States

Watkins, R. K. Structural Design in Buried Flexible Conduits. IN: Proceedings, Symposium on Soil-Structure Interaction, University of Arizona, Tucson, 1964, p. 246-255.

Keyword(s): utilities, pipelines, subsurface subsidence damage, engineering, soil mechanics

Location(s): United States

Watson, L. H. Economics of Support for Surface Properties. Chartered Surveyor, v. 92, February, 1960, p. 376-385.

Keyword(s): surface structural damage, economics

Watters, R. J., D. Finn, J. Coulthard. Pit Slope Instability Problems Induced by Disused Underground Mine Workings. IN: Engineering Geology and Geotechnical Engineering, Proceedings of the 25th Symposium, Reno, NV, March 20-22, 1989, R.J. Watters, ed., Balkema, Rotterdam, p. 101-106.

Pit slope instability occurred due to the adverse effects of old underground mine workings being intersected by slope excavations. Investigations are presently underway to develop a mitigation which will minimize or control their effects. These investigations involve both field and laboratory studies, slope stability analyses, analytical and physical modeling.

Keyword(s): abandoned mines, land mitigation, geologic features

Location(s): United States

Wayment, W. R., D. E. Nicholson. A Proposed Modified Percolation Rate Test for Use in Physical Property Testing of Mine Backfill. U.S. Bureau of Mines RI 6562, 1964, 24 p.
Keyword(s): hydraulic backfilling
Location(s): United States

Wayment, W. R., D. E. Nicholson. Improving Effectiveness of Backfill. Mining Congress Journal, v. 31, no. 3, August, 1965, p. 28-32.
This paper discusses water percolation rate, cement, and vibratory compaction, which are critical in improving backfill.
Keyword(s): hydraulic backfilling

Weaver, P., M. M. Sheets. Active Faults, Subsidence, and Foundation Problems in the Houston, Texas, Area, Field Excursion No. 5. Geology of the Gulf Coast and Central Texas and Guidebook of Excursions, Geological Society of America Annual Meeting, Houston, TX, 1962, p. 254-265.
Keyword(s): fluid extraction
Location(s): Texas, United States

Webb, B. A Study of Longwall Subsidence in the Appalachian Coalfield. M.S. Thesis, Virginia Polytechnic Institute & State University, 1982, 191 p.
Keyword(s): longwall, coal mining
Location(s): Appalachian Coal Region, United States

Weber, G. E., S. M. Raas. Geotechnical Problems Associated with Siting Large Structures Over Solution Collapse Features in Karst Terrain, East Sports Facility, University of California, Santa Cruz, California. IN: Engineering Geology and Geotechnical Engineering, Proceedings of the 25th Symposium, Reno, NV, March 20-22, 1989, R.J. Watters, ed., Balkema, Rotterdam, p. 259-265.
Construction of the East Sports Facility at the University of California, Santa Cruz, required the pool and associated building be constructed over a solution-collapse doline formed in limestone marble. Geologic and engineering investigations were conducted to determine the size and depth of the collapse doline and the potential for development of new voids below the proposed pool and building.
Keyword(s): geologic features, land-use planning, soils, geotechnical, engineering
Location(s): California, United States

Webster, N. E. Strata Control and the Influence on Underground and Surface Damage. Transactions, Institute of Mining Engineers, 1951, v. 3, Pt. 7, p. 445-475.
This paper discusses the need for maximum coal extraction combined with protection of the surface; control of subsidence effects would increase with better determination of subsidence parameters.
Keyword(s): ground control, surface subsidence damage, subsurface subsidence damage, coal mining

Weir, A. M. An Appraisal of Subsidence Observation. Colliery Guardian, v. 209, October 16, 1964, p. 513-518.
This article evaluates the design and construction of a subsidence monitoring network, and discusses methods for observation and data interpretation. It includes a discussion of monument type and effects to be observed for different purposes, such as studies of building damage, horizontal movement, vertical movements, permanent strain and traveling strain. Also, a mathematical solution for the principal strains of a biaxial system is reviewed.
Keyword(s): monitoring design, monitoring installation, monitoring equipment, monitoring methods, survey data processing, survey methods, modeling, mathematical model, surface structural damage, vertical displacement, horizontal displacement

Weir, A. M. Subsidence--The Interpretation of Traveling Strain Observations. Colliery Guardian, v. 212, May 6, 1966, p. 576-577.
The author proposes a formula stating that observed traveling strain is a function of distance between survey stations and rate of face advance.
Keyword(s): survey methods, survey equipment, survey data processing, survey design, active mines

Weir, A. M. The Prediction of Surface Subsidence with Particular Reference to Inclined Seams. Master of Philosophy Thesis, University of Nottingham, England, 1977.
Keyword(s): prediction

Weir, W. W. Subsidence of Peat Lands of the Sacramento San Joaquin Delta, California. Hilgardia, v. 20, no. 3, 1950, p. 37-56.
Keyword(s): soils
Location(s): California, United States

Weiss, I. G. Multivariate Analysis of Levelling Networks in Subsidence Areas. IN: Proceedings VIII Congress International Society for Mine Surveying, September 22-27, 1991, University of Kentucky, Lexington, UKY BU154, p. 283-285.

The height estimates of the points of the net that are needed to control the vertical movements of a subsidence area can be advantageously obtained in a multivariate model from repeated leveling in a monitoring network. In the model, a transformed multivariate hypothesis is proposed and tested successively for each point in each of two compared epochs to detect the significant height displacements at points after single epochs and after the whole campaign of observations as well.

Keyword(s): active mines, monitoring methods, modeling, vertical displacement

Location(s): Czechoslovakia

Wenzel, R. J., W. F. Eichfeld. Premining Subsidence Control Planning. IN: Proceedings, Conference on Ground Control in Room-and-Pillar Mining, Southern Illinois University, Carbondale, August 6-8, 1980, Y.P. Chugh, ed., SME-AIME, New York, 1982, p. 17-19.

The phrase "subsidence control planning" can refer to the use of specific mining methods and specialized techniques to control subsidence events or it can refer to planning for subsidence by predicting its magnitude and timing and further planning mitigation strategies. In the first case the objective is actually subsidence prevention; in the second, it is a design procedure that seeks to maximize the use of both surface and subsurface resources.

Keyword(s): ground control, land mitigation, subsidence research, coal mining, environment, engineering, subsurface water, agriculture, surface structural damage, monitoring methods, overburden, hydrology, government

Location(s): Illinois, Illinois Coal Basin, United States

Werner, E., J. C. Hempel. Effects of Coal Mine Subsidence on Shallow Ridge-Top Aquifers in Northern West Virginia. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 237-243.

The effects on aquifers by mining-induced subsidence varies significantly depending on the position of the aquifer with respect to the hydrologic base level. Aquifers above base level, generally called perched aquifers, are very sensitive to disruption by enlargement of fractures within underlying low-permeability beds because of the steep hydraulic gradients developed in these supporting beds. The effects are most intense when aquifer rocks are all of low matrix permeability and principal hydraulic transmission is through fractures. Most affected are regions near pre-existing fractures zones. The effects on these higher aquifers caused by mine subsidence are substantially different from the effects on the base level aquifers, and different principles apply.

Keyword(s): hydrology, subsurface water, surface water, coal mining, geologic features

Location(s): West Virginia, Appalachian Coal Region, United States

West, T. R., R. B. Jackson, D. Johnson. Stabilization of Underground Coal Mines Prior to Interstate Highway Construction, Birmingham, Alabama. IN: Engineering Geology and the Natural Resources Energy Spectrum, Association of Engineering Geologists Annual Meeting Program Abstracts, no. 17, 1974, p. 37-38. (NTIS Accession No. 75-06917)

Keyword(s): roads, coal mining, surface structural damage, engineering, abandoned mines

Location(s): Alabama, United States

West Virginia Department of Natural Resources. West Virginia Surface Mining Reclamation Regulations. Ch. 20-26, Sec. 7, 1982, p. 7-19 - 7-21.

Paragraph 7C provides details on the subsidence-related responsibilities of the mine operator in West Virginia.

Keyword(s): law, mine operation

Location(s): West Virginia, Appalachian Coal Region, United States

Westfield, J. Mining Subsidence and Backfilling. U.S. Bureau of Mines RI 4109, Flood Prevention Project at Pennsylvania Anthracite Mines, Progress Report for 1945 (Paper V), 1947, p. 42-50.

Keyword(s): backfilling, anthracite, coal mining

Location(s): Pennsylvania, Appalachian Coal Region, United States

Weston, J. G. The Determination of Subsidence Profiles by Mathematical Functions. The Mining Engineer, London, v. 137, April 1978, p. 493-500.

This paper examines the similarity between the hyperbolic tangent function and a longwall subsidence profile; it describes the application of this function to single panel and multipanel partial-extraction systems. A zone area system based on the use of the function and a computer method of subsidence prediction based on the National Coal Board Subsidence Engineers' Handbook is also described.

Keyword(s): vertical displacement, horizontal displacement, National Coal Board, prediction, mathematical model, longwall, partial extraction, computer, zone area, coal mining, modeling

Location(s): United Kingdom

Whaitte, R. H., A. S. Allen. Pumped-Slurry Backfilling of Inaccessible Mine Workings for Subsidence Control. U.S. Bureau of Mines IC 8667, 1975, 83 p.

This report summarizes the results obtained in a study of a hydraulic backfilling technique. Fill material was pumped as a slurry through a closed system and widely distributed in inaccessible mine workings from a single borehole.

Keyword(s): hydraulic backfilling, abandoned mines, ground control

Location(s): United States

Whetton, J. T., K. N. Sinha. Gob Stowage. Colliery Engineering, 1943, v. 25, no. 292, p. 188-193; no. 293, p. 225-242; no. 294, p. 255-276.

The authors describe hydraulic, pneumatic, and mechanical stowing methods, and list examples of their effectiveness.

Keyword(s): hydraulic backfilling, pneumatic backfilling

Whetton, J. T., K. N. Sinha. Gob Stowage at Michael Colliery. Colliery Engineering, v. 25, no. 295, September, 1948, p. 291.

Keyword(s): mine waste, stowing

Whetton, J. T., K. N. Sinha. Mechanical Methods of Gob Stowing. Colliery Engineering, v. 26, no. 299, January, 1949, p. 4.

Keyword(s): stowing, mine waste

Whetton, J. T., K. N. Sinha. Mechanical Stowing on the Continent. Colliery Engineering, v. 26, no. 307, September, 1949.

Keyword(s): stowing

Location(s): Europe

Whetton, J. T., K. N. Sinha. Power Stowing of the Goaf: Scientific Tests and Investigations. Transactions, Institute Mining Engineers, v. 109, 1949, p. 534.

Keyword(s): stowing, mine waste

Whetton, J. T., P. H. Broadhurst. Plasticity Tests on Materials Used for Pneumatic Stowing in the Goaf. Transactions, Institute of Mining Engineers, v. 111, 1952, p. 906, and v. 112, 1952, p. 351.

Keyword(s): pneumatic backfilling, stowing

Whetton, J. T., H. J. King, M. B. Jones. The Field Measurement of Subsidence and Strain. IN: Proceedings, the European Congress on Ground Movement, Leeds, England, April 9-12, 1957, London Harrison, p. 99-105.

The authors discuss problems associated with measuring horizontal strains above extraction areas. Measurements along single lines not parallel or perpendicular to the extraction face are considered to be of little use because the actual magnitude of strain is not detected. As an alternative, two parallel lines are used and strains are resolved from triangular measurements along and between lines, so that a strain contour grid is produced. An accuracy of one part in 10,000 is considered necessary to accurately define strain distribution.

Keyword(s): survey design, instrumentation, horizontal displacement, survey methods

Whetton, J. T. A General Survey of the Ground Movement Problem. Colliery Engineering, v. 34, no. 398, April, 1957, p. 153-157.

In Great Britain, a Royal Commission was appointed in June, 1923, to report on the consequences of mining subsidence from a number of different aspects. Part 2 of the Minutes of Evidence was concerned among other things, with what was called the "basic laws of subsidence." Today most of that evidence would be very strongly contested. It is very noticeable in these Minutes of Evidence that there was no mention of lateral displacements and the derivative of surface displacement, namely the straining of the surface.

Keyword(s): angle of draw, time factor, abandoned mines, active mines, longwall, prediction, multiple-seam extraction, stowing, vertical displacement, horizontal displacement

Location(s): United Kingdom

Whetton, J. T., H. J. King. Aspects of Subsidence and Related Problems. Transactions, Institute of Mining Engineers, London, v. 118, 1958-59, p. 663-676.

An account is given of the general practice underlying an attempt to simulate the strata movement by model apparatus. Some of the results obtained from the model are presented and implications are discussed. In a two-dimensional investigation, the model indicates that, with low ratios of width and extraction to depth, the maximum amplitude of convergence grows much more rapidly with increasing width than it does with increasing depth.

Keyword(s): modeling

Whetton, J. T., H. J. King. The Time Factor in Mining Subsidence. IN: Proceedings, International Symposium on Mining Research, Rolla, MO, February, 1961, G.B. Clark, ed., Pergamon Press, v. 2, 1962, p. 521-539.

This paper discusses theories of time lags in subsidence development and presents data from field observations in Great Britain. Subsidence development curves are plotted and are similar for different cases. The author mentions the possibility of delayed violent and sudden collapse in cases of partial extraction systems.

Keyword(s): vertical displacement, horizontal displacement, time factor, partial extraction, coal mining

Location(s): England

White, H. Accurate Delineation of Shallow Subsurface Structure Using Ground Penetrating Radar. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May 1992, South African Institution of Civil Engineers, Republic of South Africa, p. 23-26.

Ground-penetrating radar uses pulsed electromagnetic waves to accurately map the subsurface. Pulses are radiated from an antenna into the subsurface. These pulses propagate through the subsurface and are reflected back from electromagnetic interfaces. The depth to the interface can be calculated by measuring the two-way travel-time of the reflected pulses. Data are presented with the emphasis on three particular applications: (1) karst environments, (2) delineation of shallow subsurface bedrock fracturing as a consequence of shallow underground mining, and (3) mapping of old-mine workings from surface on the Witwatersrand.

Keyword(s): geophysical, geologic features , abandoned mines, geotechnical

Location(s): South Africa

White, W. A. Properties of Clay as Related to Coal Mining Problems. IN: Proceedings Illinois Mining Institute, 1954.

Keyword(s): floor stability, mine operation, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

White, W. A. Underclay Squeezes in Coal Mines. Mining Engineering, v. 8, no. 10, October 1956, p. 1024-1028; also Illinois State Geological Survey Reprint 1956-R, 1956; also Transactions, AIME, v. 205, 1956.

This is a preliminary report on the mechanism of squeezes in a "dry" mine without the action of additional moisture. The likelihood of underclay squeezes based on the physical and mineral content of the clay materials is discussed.

Keyword(s): floor stability, in situ testing, lab testing, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Whitelock, G. C. H. Subsidence Due to Coal Mining. Transactions, Institute of Mine Surveyors, 1920.

Keyword(s): coal mining

Whitfield, L. M. Ground Movements from Coal Extraction in the Vicinity of Dams and Storages in New South Wales, Australia. IN: Ground Movements and Structures, Proceedings 3rd International Conference, University of Wales Institute of Science and Technology, Cardiff, 1984, J.D. Geddes, ed., Pentech, London, 1985, p. 298-313.

The New South Wales Dams Safety Committee was established as a statutory authority in 1979 to maintain a surveillance of all dams in the state above a certain size and storage capacity and to ensure their continuing safety. The Committee also makes recommendations on proposals for coal-mining operations in the vicinity of such dam structures and storages, specifying the conditions under which such mining may be carried out.

Keyword(s): surface water, coal mining, active mines, surface subsidence damage, land-use planning, multiple-seam extraction, longwall

Location(s): Australia

Whitfield, L. M. Monitoring and Investigation of Water Inflow Into a Coal Mine in New South Wales, Australia. IN: Groundwater in Engineering Geology, Proceedings 21st Annual Conference of the Engineering Group of the Geological Society, September 15-19, 1985, J.C. Cripps, et al., eds., University of Sheffield, the Geological Society Engineering Geology Special Publication No. 3, 1986, London, p. 115-126.

The Dams Safety Committee is responsible for ensuring the safety and integrity of all substantial dams and storages in New South Wales. Coal mining is currently taking place beneath the Sydney

Water Board catchment where a system of five reservoirs constitute part of the urban water supply for the cities of Sydney and Wollongong. Pillar extraction of the Wongawilli seam adjacent to Avon storage resulted in an unexpected inflow of water into the mine workings. Algal analysis indicated that a proportion of this inflow may have originated from a surface source. The paper outlines the events that occurred, the monitoring initiated, and the results of the investigations.

Keyword(s): coal mining, surface water, subsurface water, hydrology, pillar extraction, surface structural damage, room-and-pillar, inflow

Location(s): Australia

Whittaker, B. N., D. R. Hodgkinson. Design and Layout of Longwall Workings. The Mining Engineer, London, no. 134, November, 1971, p. 79-96.

The principles of strata control are reviewed with special reference to the control of underground conditions. Investigations of underground studies of working layout and its effect on interaction with other workings are described. Roadway design and subsequent deformations have been examined under a variety of conditions with special reference to deriving guidelines to assist in prediction of roadway convergence and assessing support performance. Leaving rib pillars between successive longwall faces as opposed to total extraction is discussed and examples are used to highlight the respective advantages and disadvantages. Interaction between workings in the same seam and in other seams above and below the current working horizon is examined in detail and several examples given together with a discussion on how to minimize such effects both in existing and future working layouts.

Keyword(s): mine design, longwall, multiple-seam extraction, coal mining

Location(s): United Kingdom

Whittaker, B. N. Strata Control Developments on the European Continent. The Mining Engineer, London, v. 132, no. 153, June, 1973, p. 435, 443.

Keyword(s): ground control

Location(s): Europe

Whittaker, B. N. An Appraisal of Strata Control Practices. Mining Engineering, v. 166, 1974, p. 9-24.

Keyword(s): mine design, longwall, ground control, mine waste, mine operation

Whittaker, B. N., D. J. Forrester. Measurement of Ground Strain and Tilt Arising from Mining Subsidence. IN: Proceedings, Symposium on Field Instrumentation in Geotechnical Engineering, London, May 30-June 1, 1973, Halsted Press, 1974, p. 437-447.

Mining subsidence is the mass lowering of a body of strata overlying mine workings whose extracted area is sufficiently great as to permit collapse of immediately overlying strata and subsequent propagation of the movement to the surface. In the United Kingdom, the ratio of extraction width-depth for mine workings needs to be greater than 1/10 before a discernible depression is formed at the surface.

Keyword(s): monitoring design, monitoring methods, survey methods, instrumentation, survey design, geotechnical, geologic features, overburden

Location(s): United Kingdom

Whittaker, B. N., J. H. Pye. Design and Layout Aspects of Longwall Methods of Coal Mining. IN: Design Methods in Rock Mechanics, Proceedings 16th Symposium on Rock Mechanics, University of Minnesota, Minneapolis, September 22-24, 1975, C. Fairhurst and S.L. Crouch, eds., ASCE, New York, 1977, p. 303-314.

The factors influencing the layout of longwall coal mining workings are examined on the basis of experience gained in European coalfields. An account is given of the main design aspects that need consideration when a longwall layout is planned. A selection procedure for panel layout is described. The strata mechanics of underground mining associated with the longwall method are discussed with special reference to effective strata control.

Keyword(s): mine design, longwall, ground control, coal mining, overburden

Location(s): Europe

Whittaker, B. N., C. D. Breeds. The Influence of Surface Geology on the Character of Mining Subsidence. IN: Proceedings of International Symposium on the Geotechnics of Structurally Complex Formations, Capri, Italy, 1977, Association Geotechnica Italy, Milan, v. 1, p. 459-468.

This paper describes the principles of mining subsidence associated with the working of predominantly level coal seams.

Keyword(s): surface structural damage, subsurface structural damage, geologic features, coal mining, geotechnical

Location(s): England

Whittaker, B. N., J. H. Pye. Ground Movements Associated With the Nearsurface Construction Operations of a Mine Drift in Coal Measures Strata. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 14, no. 2, March, 1977, p. 67-75.

Keyword(s): overburden, rock mechanics, subsurface subsidence damage, coal mining

Whittaker, B. N., H. I. Hazine. Simulation of Surface Subsidence Due to Longwall Mining. IN: Proceedings, 19th U.S. Rock Mechanics Symposium, Stateline, NV, May 1-3, 1978, Mackay School of Mines, Reno, p. 221-228.

This paper reviews coal-mining subsidence knowledge and related problems due to longwall extraction in England, with consideration given to findings based on modeling of surface subsidence by a finite element method. The authors present and discuss the results of isotropic and anisotropic solutions. The treatment of surface strain is discussed and the validity of deriving strain from ground curvature examined. The paper concludes with the authors' findings on the modeling of surface subsidence using a finite element method, and examples are given of its application to current mining subsidence problems in the United Kingdom.

Keyword(s): vertical displacement, horizontal displacement, longwall, prediction, modeling, finite element, coal mining

Location(s): United Kingdom

Whittaker, B. N., R. N. Singh. Design and Stability of Pillars in Longwall Mining. The Mining Engineer, July 1979, p. 59-70.

This paper briefly reviews the circumstances of the use of rib pillars in longwall mining and considers the ultimate strength approach to pillar design for use in longwall layouts. Both average pillar stress and peak stresses are examined. Attention is focused on the influence of rib pillars on gate roadway stability and the scope for reducing rib pillars is discussed. Special comments are made on the rib pillar versus no rib pillar argument for longwall layout planning. Gate roadway stability in relation to various rib pillar conditions is examined. The paper presents several field observations and discusses pillar stability with reference to subsidence and mine barrier requirements.

Keyword(s): mine design, pillar strength, coal mining, longwall

Location(s): United Kingdom

Whittaker, B. N. Investigation and Evaluation Studies of Surface and Subsurface Drainage Pattern Changes Resulting from Longwall Mining Subsidence. Presented at 1st International Mine Drainage Symposium, Denver, CO, May 20-23, 1979, 25 p.; available upon request from A.J. Fejes, U.S. Bureau of Mines, Denver, CO.

This paper gives a general review of subsidence characteristics associated with longwall mining; it describes test instruments designed to investigate the zones of increased permeability resulting from longwall extraction.

Keyword(s): surface water, subsurface water, survey equipment, longwall, hydrology

Whittaker, B. N., R. N. Singh, C. J. Neate. Effect of Longwall Mining on Ground Permeability and Subsurface Drainage. IN: Proceedings, 1st International Mine Drainage Symposium, Denver, CO, 1979, G.O. Argall and C.O. Brawner, eds., p. 161-183.

Keyword(s): longwall, hydrology, subsurface water, coal mining

Whittaker, B. N., A. G. Pasamehmetoglu. Ground Tilt in Relation to Subsidence in Longwall Mining. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 18, no. 14, August, 1981, p. 321-329.

Observations of ground tilt arising from longwall mining subsidence were made using a direct method involving trials with an electrolevel. The results are compared to tilt derived by precise levelling and by a current prediction method. The electrolevel proved to be highly successful in investigating ground tilt changes and enabled variations not hitherto appreciated to be examined. Subsidence and angle of draw were investigated, and the electrolevel was used to determine when a significant change in ground tilt condition occurred owing to the approach of mining subsidence effects towards surface structures.

Keyword(s): longwall, rock mechanics, horizontal displacement, angle of draw, surface structural damage, monitoring methods, survey methods, coal mining, vertical displacement

Location(s): United Kingdom

Whittaker, B. N., D. J. Reddish. Mining Subsidence in Longwall Mining with Special Reference to the Prediction of Surface Strains. IN: Proceedings, 2nd International Conference on Stability in Underground Mining,1984, A.B. Szwilski and C.O. Brawner, eds., SME-AIME, New York, p. 576-588.

Keyword(s): longwall, coal mining, prediction, horizontal displacement

Whittaker, B. N., D. J. Reddish, D. J. Fitzpatrick. Ground Fractures Due to Longwall Mining Subsidence. IN: Mine Water, Proceedings 2nd International Congress, Granada, Spain, September 1985, R. Fernandez-Rubio, ed., v. 2, p. 1057-1072.

This paper discusses experimental results of a large model employed to study fracture development in the ground overlying longwall mining operations. The model uses gravity loading only as the means of developing caving and fracturing of the ground above the longwall excavation. The results show fracture development and caving propagation as a longwall face develops from its starting point. The effect of rock strength in the immediately overlying roof is discussed in relation to subsidence development. Special attention is focused on subsidence development to aquifer horizons. The thickness of cover between the mine horizon and overlying bodies of surface water (e.g., rivers and the sea) is considered in relation to underground excavations. The paper concludes with a general discussion on guidelines for undermining aquifers and surface water bodies with special reference to longwall operations.

Keyword(s): subsurface water, surface water, hydrology, longwall, overburden, geologic features, modeling, vertical displacement, inflow

Location(s): United Kingdom

Whittaker, B. N. Surface Subsidence Aspects of Room and Pillar Mining. Mining Department Magazine, University of Nottingham, v. 37, 1985, p. 59-70.

This paper reviews the forms of subsidence behaviour observed with room-and-pillar mining of stratified mineral deposits. The factors governing surface subsidence behaviour are examined and design procedures are discussed. The long-term aspects of subsidence occurring above such mine workings are discussed as are instrumentation and remedial measures available to assist in monitoring and controlling subsidence development.

Keyword(s): room-and-pillar, surface subsidence damage, coal mining, geologic features, pillar strength

Location(s): United Kingdom

Whittaker, B. N., D. J. Reddish, D. Fitzpatrick. Calculation by Computer Program of Mining Subsidence Ground Strain Patterns Due to Multiple Longwall Extractions. Mining Science and Technology, v. 3, 1985, p. 21-33.

The general character of surface ground strains under conditions in the United Kingdom is discussed with particular reference to calculation of principal strains at the surface for multiple-seam longwall extractions. The program uses data from the National Coal Board Subsidence Engineers' Handbook as the basis for its calculations. The principle of superposition is then applied to extend single-panel data into multi-panel data. Examples of the graphical capability of the program and of possible applications are included in the discussion.

Keyword(s): computer, longwall, prediction, National Coal Board

Location(s): United Kingdom

Whittaker, B. N., S. F. Smith. Stability and Operational Aspects of Room and Pillar Mining in UK Sedimentary Ironore Deposits. IN: Underground Mining Methods and Technology, A.B. Szwilski and M.J. Richards, eds., 1987, Elsevier, p. 393-402.

Keyword(s): room-and-pillar, metal mining, active mines

Location(s): United Kingdom

Whittaker, B. N., R. C. Frith. Aspects of Chain Pillar Design in Relation to Longwall Mining. IN: Proceedings, 6th International Conference on Ground Control in Mining, June 9-11, 1987, S.S. Peng, ed., West Virginia University, Morgantown, p. 172-182.

The paper examines the role of chain pillars in longwall mining layouts as used in several countries. The application of chain pillars in relation to their expected design role is discussed. An important feature is the specification of the pillar design to meet strata loading conditions as imposed by the mining and geological setting. The paper relates longwall width and chain pillar configurations to pillar size to satisfy anticipated loading and strength expectations. Reference is made to laboratory work that examines criteria for pillar stability.

Keyword(s): pillar strength, mine design, longwall, coal mining

Location(s): Europe, United States, South Africa, Australia, United Kingdom

Whittaker, B. N., R. C. Frith. Design of Support Systems for Mining Tunnels in Carboniferous Rock Conditions. IN: Proceedings, 6th International Conference on Ground Control in Mining, June 9-11, 1987, S.S. Peng, ed., West Virginia University, Morgantown, p. 258-270.

The paper briefly reviews the type of support and stability problems encountered in mining tunnels in the United Kingdom. Stability prediction of mining tunnels is discussed and a computer-based model dealing with stratified rock conditions is described. Various schemes for monitoring the stability of mining tunnels are examined and the application of the results discussed. Comparisons between predicted and measured closure values are presented for a major coal-mining tunnelling project. Conclusions are drawn concerning the application of the present prediction technique together with the importance of underground monitoring.

Keyword(s): tunnelling, coal mining, computer, modeling, geologic features, prediction, roof stability, floor stability, rock mechanics, instrumentation, ground control

Location(s): United Kingdom

Whittaker, B. N., D. J. Reddish. Subsidence Occurrence, Prediction and Control. Developments in Geotechnical Engineering 56, Elsevier Science Publishers, Amsterdam, 1989, 528 p.

Surface subsidence is recognized as a problem in most countries, particularly those with significant mining and other underground resource extraction industries. This book addresses the problems relating to subsidence, whether caused naturally or by mining or other forms of underground extractive activity. Its main purpose is to bring together subsidence knowledge, experiences, and research findings in many countries and rationalize such information especially in respect to its particular field of application. Emphasis has been given to collating field data on subsidence from different countries in order to make direct comparisons. Prediction of subsidence, particularly its occurrence and general characteristics has been seen as an important area where the book can contribute significantly in terms of reviewing available knowledge, methods, scope of application, and orders of accuracy achieved. The book also examines methods of controlling subsidence and discusses the response of surface structures to and protection against subsidence.

Keyword(s): geologic features, non-metal mining, historical, prediction, longwall, engineering, prediction theories, profile function, empirical model, influence function, modeling, phenomenological model, coal mining, computer, horizontal displacement, vertical displacement, multiple-seam extraction, tunnelling, room-and-pillar, longwall, subsurface water, time factor, angle of draw, fluid extraction, oil extraction, abandoned mines, active mines, metal mining, surface structural damage, backfilling, mine waste, overburden, finite element, zone area

Location(s): United Kingdom, Australia, France, South Africa, Yugoslavia, Japan, India, United States, Pennsylvania, Illinois, Louisiana, Spain, Canada, Czechoslovakia

Whittaker, B. N., P. Gaskell, D. J. Reddish. Subsurface Ground Strain and Fracture Development Associated with Longwall Mining. Mining Science and Technology, v. 10, no. 1, January, 1990, p. 71-80.

Experiments employing physical modeling to study ground behavior above longwall faces in different geological conditions are reported. The development of subsurface fractures from longwall mining extractions, and the resulting principal strain patterns are described. The significance of the strain patterns in relation to the mining dimensions and the geological setting in terms of rock strength are discussed. The effect of faulting on subsidence behaviour is also considered.

Keyword(s): overburden, geologic features, modeling, longwall, rock mechanics, coal mining, prediction, instrumentation

Location(s): United Kingdom

Whittaker, B. N., D. J. Reddish, G. Sun. Mine Design and Planning Aspects: Undermining Aquifers and Surface Water Bodies. IN: Proceedings 4th International Mineral Water Association Congress, Ljubljana (Slovenia)-Portschach (Austria), September, 1991, p. 199-210.

The paper discusses the development of fractures associated with underground mining operations. Physical modeling test results are compared with field observations and assessed by finite element and image analysis techniques. General comments are made regarding the influence of geological factors such as lithology, rock strengths, and hydrogeology in relation to the design and planning aspects of underground mines.

Keyword(s): overburden, modeling, finite element, geologic features, rock mechanics, hydrology, subsurface water, surface water, longwall, stowing, coal mining, physical model, inflow

Location(s): United Kingdom

Whitworth, K. R. Induced Changes in Permeability of Coal Measure Strata as an Indicator of the Mechanics of Rock Deformation Above a Longwall Coal Face. IN: Strata Mechanics, Proceedings of the

Symposium, University of Newcastle-upon-Tyne, April, 1982, I.W. Farmer, ed., Elsevier, New York, p. 18-24.

In the Coal Measures of South Staffordshire below the unconformity at the base of Trias, there is a zone of increased fissure permeability and porosity in which most sandstones and coals give small makes of water. Occasionally, considerably larger flushes have occurred on longwall coal faces working in or close to this zone, even though these faces are at levels much further below the Trias unconformity than the minimum 60 m permitted. One such flush at West Cannock Colliery and the resultant investigation boreholes are described. The information gained from these boreholes demonstrated the existence of tensile zones in the form of bed separations that occur in a regular geometric pattern relating to a series of beams of uniform thickness over the edge of a worked panel.

Keyword(s): overburden, longwall, subsurface water, hydrology, rock mechanics, coal mining, geologic features, inflow

Location(s): United Kingdom

Wiborg, R., J. Jewhurst. Ekofisk Subsidence Detailed and Solutions Assessed. Oil and Gas Journal (Technology), February 17, 1986, p. 47-51.

Keyword(s): oil extraction

Wickham, G. E. Support Determination Based on Geologic Predictions. IN: Proceedings, Rapid Excavation Tunnelling Conference, AIME, 1972, p. 43-64.

Keyword(s): geologic features, tunnelling, roof support

Location(s): United States

Wier, C. E., F. J. Wobber, O. R. Russell, R. V. Amato. Study of Application of ERTS--An Imagery to Fracture Related Mine Safety Hazards in the Coal Mining Industry. Earth Satellite Corporation, Washington, D.C., May, 1973, 15 p. (NTIS E73-10681)

Keyword(s): mine operation, mine safety, survey methods, photography, coal mining, remote sensing

Location(s): United States

Wier, C. E., F. S. Wobber, O. R. Russell, R. V. Amato, T. V. Leshendok. Relationships of Roof Falls in Underground Coal Mines to Fractures Mapped on ERTS-I Imagery. IN: Proceedings, 2nd Symposium on ERTS-I Imagery, 1973, NASA Publications, NASA SP-351.

Keyword(s): roof stability, photography, coal mining, remote sensing

Location(s): United States

Wiggil, R. B. The Effects of Different Support Methods on Strata Behavior Around Sloping Excavations. Journal South African Institute Mining & Metallurgy, v. 63, April, 1963, p. 391-426.

Keyword(s): ground control

Location(s): South Africa

Wiid, B. L. The Influence of Moisture Upon the Strength Behavior of Rock. Ph.D. Thesis, University of Witwaterstrand, 1967, 184 p.

Keyword(s): rock mechanics, lab testing

Wiid, B. L. The Influence of Moisture on the Pre-Rupture Fracturing of Two Rock Types. IN: Proceedings, 2nd International Conference on Rock Mechanics, Belgrade, v. 2, 1970, p. 239-245.

Keyword(s): rock mechanics, lab testing

Wildanger, E. G., J. Mahar, A. Nieto. Mine Subsidence Report St. David, Illinois, Sinkhole Type Subsidence Over Abandoned Coal Mines in St. David, Illinois. Abandoned Mined Lands Reclamation Council, Springfield, IL, 1980, 88 p.

On June 26, 1979, the Illinois Abandoned Mined Lands Reclamation Council (AMLRC) entered into cooperative agreement with the Federal Office of Surface Mining (OSM) to perform two tasks related to mine subsidence in the Village of St. David. The first and most immediate task involved the repair of a road damaged by mine subsidence. As a second task, OSM authorized the AMLRC to conduct a study of mine subsidence cases in St. David and the surrounding area. This work has been completed and the findings are presented.

Keyword(s): abandoned mines, coal mining, surface structural damage, roads, reclamation

Location(s): Illinois, Illinois Coal Basin, United States

Wildanger, E. G., J. W. Mahar, A. Nieto. Sinkhole-Type Subsidence Over Abandoned Coal Mines in St. David, Illinois. Mine Subsidence Report, St. David, Illinois. Departments of Civil Engineering and Geology, University of Illinois at Urbana-Champaign, June, 1980, 88 p.

This report examines the geologic conditions, mining history, subsidence trends, and damage in the area. A large section is devoted to detailed analyses of sinkholes and the mechanisms of sinkhole formation.

Keyword(s): vertical displacement, horizontal displacement, surface structural damage, abandoned mines, coal mining
Location(s): Illinois, Illinois Coal Basin, United States

Wildanger, E. G., J. W. Mahar, J. Shively, R. D. Gibson. Mine Subsidence at the District 11 State Police Headquarters in Maryville, IL. Abandoned Mined Lands Reclamation Council, Springfield, IL, Progress Report: May 12 to September 9, 1980, 47 p.
Keyword(s): surface structural damage, abandoned mines, coal mining
Location(s): Illinois, Illinois Coal Basin, United States

Wildanger, E. G. Sinkhole-Type Subsidence Over Abandoned Coal Mines in St. David, Illinois. M.S. Thesis, University of Illinois at Urbana-Champaign, 1980, 88 p.
Keyword(s): coal mining, abandoned mines, surface structural damage, geologic features, lab testing, literature search, overburden, subsurface water
Location(s): Illinois, Illinois Coal Basin, United States

Wildanger, E. G., A. Leung, J. W. Mahar, R. A. Bauer. Mine Subsidence at the Northland Drive - Southland Court Area, Belleville, IL. Progress Report for February 20 to June 30, 1981, Abandoned Mined Lands Reclamation Council, Springfield, IL, 1981, 61 p.
Keyword(s): surface structural damage, abandoned mines, coal mining, structural mitigation
Location(s): Illinois, Illinois Coal Basin, United States

Wilde, P. M., J. M. Crook. The Significance of Abnormal Ground Movements Due to Deep Coal Mining and Their Effects on Large Scale Surface Development at Warrington New Town. IN: Ground Movements and Structures, Proceedings 3rd International Conference, University of Wales Institute of Science and Technology, Cardiff, 1984, J.D. Geddes, ed., Pentech, London, 1985, p. 240-247.
From the outset of development of Warrington New Town, a systematic approach to the problems of mining subsidence has been adopted and one vital component of this has been the installation and monitoring of an extensive subsidence levelling network. One objective of this work is the identification of distorted patterns of subsidence that can be further investigated and, if practical, surface development delayed or restricted.
Keyword(s): surface structural damage, land-use planning, coal mining, active mines, monitoring methods, abandoned mines, geologic features
Location(s): United Kingdom

Wilde, P. M., J. M. Crook. The Monitoring of Ground Movements and Their Effects on Surface Structures - A Series of Case Histories. IN: Ground Movements and Structures, Proceedings 4th International Conference, University of Wales College of Cardiff, July 8-11, 1991, J.D. Geddes, ed., Pentech Press, London, 1992, p. 182-189.
The aim of this paper is to present a series of case histories connected with land and its associated structures that have been subject to settlements both connected with the surface development of the land inducing net increases in ground loading pressures and/or underground coal mining operations, which have involved partial removal of ground support.
Keyword(s): surface structural damage, coal mining, geotechnical, foundations, partial extraction, active mines, soils, survey methods, monitoring methods
Location(s): United Kingdom

Williams, R. E., S. D. Vincent, G. Bloomsburg. Hydrogeologic Impacts of Mine Design in Unsaturated Rock. Mining Engineering, October, 1990, p. 1177-1183.
A modeling scheme is developed to simulate the hydrogeologic effects of mine design and development in unsaturated rock. Simulations are conducted using the UNSAT2 finite element computer program and hydrogeologic data from the site of a proposed mined-out waste repository at Yucca Mountain, Nevada.
Keyword(s): modeling, computer, mine design, hydrology, finite element, subsurface water
Location(s): Nevada, United States

Williamson, W. H. Hydrogeological Aspects of Coal Mining Under Stored Waters Near Sydney, Australia. IN: Symposium on Water in Mining and Underground Works, SIAMOS--78, Granada, Spain, 1978, p. 309-328.
Hydrogeological evidence figured importantly in a public inquiry on whether coal mining should be permitted under the stored waters of five dams providing part of Sydney's water supply. Reference is made to the natural groundwater regime, entry of

water into existing mines, and test bores showing aquifer systems to be retained over the workings. Estimates, based on water discharge from the mines, are given of vertical permeability. It is concluded it is practicable to mine under the stored waters without causing undue leakage.
Keyword(s): hydrology, subsurface water, coal mining, surface water, geologic features
Location(s): Australia

Willis, A. J. Surface Stability in Areas Underlain by Old Coal Workings. M.S. Thesis, Department of Engineering, University of Aberdeen, 1976.
Keyword(s): abandoned mines, coal mining

Willis, A. J., J.A.F. Chapman. Old Coal Workings--Client, Consultant and Contractor. Ground Engineering, v. 13, no. 10, 1980, p. 22-39.
Keyword(s): abandoned mines, coal mining

Wilson, A. A. Geological Factors in Land-Use Planning at Aldridge-Brownhills, West Midlands. IN: Planning and Engineering Geology, Proceedings 22nd Annual Conference, Engineering Group of the Geological Society, Plymouth Polytechnic, September 8-12, 1986, M.G. Culshaw, et al., eds., The Geological Society, London, 1987, p. 87-94.
This paper is a verification of the planning as it affects future land use in a study area. Pillar and stall workings are a hazard. The effects of subsidence induced by coal mining are greatest in a faulted area. Dry, abandoned coal mines and the old marl quarries overlying them are a major, controlled, chemical waste disposal facility.
Keyword(s): land-use planning, abandoned mines, geologic features
Location(s): United Kingdom

Wilson, A. H. A Laboratory Investigation of a High Modulus Borehole Plug Gage for the Measurement of Rock Stress. IN: Proceedings 4th Symposium on Rock Mechanics, March 30-April 1, 1961, H.L. Hartman, ed., Bulletin 76 of the Mineral Industries Experiment Station, The Pennsylvania State University, University Park, p. 185-195.
A solid plug of relatively high modulus will serve as a suitable borehole plug gage for measuring change in rock stress when the modulus of elasticity of the rock is not known. An estimate of the rock modulus will increase the accuracy of the measurement, even though this estimate may not be very precise.
Keyword(s): rock mechanics, in situ testing, monitoring equipment

Wilson, A. H. Conclusions from Recent Strata Control Measurements Made by the Mining Research Establishment. Mining Engineering, April, 1964, p. 367-380.
Roof to floor convergence of a normal, adequately supported longwall face is shown to depend upon several factors, including face advance, extraction height, and depth of the working. The author presents a formula for the estimation of the expected convergence in Great Britain, which is accurate to within 25%.
Keyword(s): mine design, mine waste, ground control, roof stability, floor stability, longwall, prediction
Location(s): United Kingdom, Europe

Wilson, A. H., D. P. Ashwin. Research Into the Determination of Pillar Sizes--Part I, An Hypothesis Concerning Pillar Stability; Part II, Measurements of Stresses in Two Pillars at Lea Hall Colliery. The Mining Engineer, v. 141, June, 1972, p. 409-430.
Keyword(s): room-and-pillar, ground control, mine design, pillar strength
Location(s): United Kingdom

Wilson, A. H. Pillar Stability in Longwall Mining. IN: State-of-the-Art of Ground Control in Longwall Mining and Mining Subsidence, September, 1982, Y.P. Chugh and M. Karmis, eds., SME-AIME, p. 85-95.
This paper discusses estimating the design of supporting pillars to permit the correct siting of main roadways. This is important when laying out districts for longwall extraction, particularly if the results of previous experience are not available in the area to be exploited.
Keyword(s): pillar strength, longwall, coal mining, mine design
Location(s): United Kingdom

Wilson, E. D. Progress Report (Pt. 2) of Geologic Factors Related to Block Caving at San Manuel Copper Mine, Pinal County, Arizona, April 1956-March 1958. U.S. Bureau of Mines RI 5561, 1960, 43 p.
Keyword(s): metal mining, geologic features
Location(s): Arizona, United States

Wilson, G. V. Early Differential Subsidence and Configuration of the Northern Gulf Coast Basin in Southwest Alabama and Northwest Florida. Gulf Coast Association of Geological Societies Transactions, v. 25, 1975, p. 196-206.

Keyword(s): fluid extraction
Location(s): Alabama, Florida, United States

Wilson, I. Subsidence Prediction Over Room and Pillar Mining Systems. IN: Ground Movements and Structures, Proceedings 4th International Conference, University of Wales College of Cardiff, July 8-11, 1991, J.D. Geddes, ed., Pentech Press, London, 1992, p. 223-242.

Measurements taken over room-and-pillar mining systems, where the pillars remain, are rare in the United Kingdom. Those available for consideration, however, prove conclusively that subsidence does result from such mining systems and by examination of these recorded data, a preliminary prediction model may be devised. The work described in this paper was initiated in order to provide some first steps towards a subsidence prediction model for current and potentially larger, future enterprises, perhaps in areas previously sterilized due to the sensitivity of the surface.

Keyword(s): room-and-pillar, prediction, coal mining, modeling
Location(s): United Kingdom

Wilson, R. G. Source of Groundwater Entering Collieries Beneath Reservoirs. IN: Mine Water, Proceedings 2nd International Congress, Granada, Spain, September 1985, R. Fernandez-Rubio, ed., v. 1, p. 59-68.

Some collieries in New South Wales, Australia, operate beneath reservoirs of the Sydney water supply. Special conditions are imposed upon mining beneath the reservoirs. Historically, entry of water into these collieries is minor. Dykes and faults normally have no effect. Groundwater systems are maintained even when major fractures appear on the surface over areas of full extraction. In one colliery, investigations have been undertaken to determine whether a reservoir is the source of a water inflow. Chemical analyses of the water have shown little change and are different from those of the reservoir.

Keyword(s): subsurface water, hydrology, coal mining, overburden, geologic features, monitoring methods, survey methods
Location(s): Australia

Wilson, T. H., G. He, W. F. Haslebacher. Seismic Studies Over Active Longwall Mines. IN: Proceedings 7th International Conference on Ground Control in Mining, August 3-5, 1988, S.S. Peng, ed., Morgantown, WV, p. 289-302.

Common offset and refraction seismic data have been collected over four longwall panels at two locations in West Virginia. Surveys were made prior to, during, and after mining in both areas. The velocity of seismic wave propagation in the overburden rocks is observed to decrease in response to panel emplacement. Variations in the magnitude of this reduction, apparent as an additional first arrival time delay in the after mining common offset surveys, do not appear to correlate directly to the amount of subsidence that has occurred.

Keyword(s): active mines, coal mining, longwall, seismic, overburden
Location(s): West Virginia, Appalachian Coal Region, United States

Wilson, W. E. Casing Failures in Irrigation Wells in an Area of Land Subsidence, California. Geological Society of America, Special Paper 121 (abstract), 1969, p. 323-324.

Keyword(s): fluid extraction, pipelines, utilities
Location(s): California, United States

Wilson, W. P. A Background to Mine Subsidence Legislation in the State of New South Wales and the Duties and Functions of the Mine Subsidence Board. IN: Proceedings 4th Annual Symposium on Subsidence in Mines, Wollongong, Australia, February 20-22, 1973, A.J. Hargraves, ed., Australasian Institute Mining & Metallurgy, Illawarra Branch, Paper 13, p. 13-1--13-3.

Subsidence due to mining operations has always given some cause for concern to mining operators, underground workmen, surface owners, and the public. This paper describes events leading to the passage of mine subsidence legislation, then details the mine subsidence compensation acts of 1928 and 1961. The present Mine Subsidence Board is constituted under the 1961 Act and is responsible for its administration.

Keyword(s): law, government, mitigation, surface structural damage, historical, insurance, active mines, abandoned mines, coal mining
Location(s): Australia

Windes, S. L. Physical Properties of Mine Rock. Part 1. U.S. Bureau of Mines RI 4459, 1949, 79 p.

Keyword(s): rock mechanics, lab testing
Location(s): United States

Windes, S. L. Physical Properties of Mine Rock. Part 2. U.S. Bureau of Mines RI 4727, 1950, 37 p.

Keyword(s): rock mechanics, lab testing
Location(s): United States

Winfield, P. F. Foundations for Sites Over Natural Voids and Old Mine Workings. IN: Mineworkings 84: Proceedings International Conference on Construction in Areas of Abandoned Mineworkings, M.C. Forde, B.H.V. Topping, and H.W. Whittington, eds., Edinburgh, Engineering Technics Press, 1984, p. 266-272.

Keyword(s): foundations, abandoned mines, geologic features

Winstanley, A. Longwall Roof Control. Transactions, Institute of Mining Engineers, v. 81, 1930-31, p. 373-405; v. 82, 1931-32, p. 107-109, 334-337.

This article covers convergence studies of roof control, and discusses the use of packing for roof support.

Keyword(s): longwall, roof support, backfilling

Winstanley, A. Strata Movements. Transactions, Institute of Mining Surveyors, 1938, v. 19, Pt. 1.

Keyword(s): ground control

Winters, D., C. Y. Chen. Current Status of Federal Regulations and Rulemaking Governing Subsidence Due to Underground Mining. IN: Proceedings, 2nd Workshop on Surface Subsidence due to Underground Mining, Morgantown, WV, June 9-11, 1986, S.S. Peng, ed., West Virginia University Department of Mining Engineering, p. 1-5.

This paper discusses background, current regulations, recent developments, and related issues of the Surface Mining Control and Reclamation Act (SMCRA), which was enacted on August 3, 1977.

Keyword(s): law, government, reclamation, active mines, surface structural damage, land-use planning

Location(s): United States

Wintz, W. A. Jr., R. G. Kazmann, C. G. Smith, Jr. Subsidence and Ground-Water Offtake in the Baton Rouge Area. Louisiana Water Resources Research Institute Bulletin 6, 1970, 90 p.

Keyword(s): fluid extraction, subsurface water, hydrology

Location(s): Louisiana, United States

Withers, R. J., E. Nyland. Theory for the Rapid Solution of Ground Subsidence Near Reservoirs on Layered and Porous Media. Engineering Geology, v. 10, 1976, p. 169-185.

Keyword(s): fluid extraction, surface water

Wohlrab, B. Effects of Mining Subsidences on the Ground Water and Remedial Measures. IN: Land Subsidence, Proceedings, International Symposium, September 14-18, 1969, Tokyo, IAHS Publication 89, v. 2, p. 502-512.

This paper discusses the effects of mining subsidence on groundwater.

Keyword(s): subsurface water, hydrology, land mitigation

Wold, M. B. A Blocky Physical Model of Longwall Caving Under Strong Roof Conditions. IN: Research & Engineering Applications in Rock Masses, Proceedings 26th U.S. Symposium on Rock Mechanics, South Dakota School of Mines & Technology, Rapid City, June 26-28, 1985, E. Ashworth, ed., Balkema, Rotterdam, p. 1007-1014.

A well-scaled blocky physical model was used to study the feasibility of longwall coal mining under strong and massive sandstone roof conditions. Caving spans and height, bulking factor, angle of break, support loads and their interaction with the structural geology are discussed with respect to predicted mine behavior.

Keyword(s): modeling, physical model, longwall, roof stability, instrumentation, multiple-seam extraction

Location(s): Australia

Womack, W. R. Detection of Shallow Abandoned Room and Pillar Workings Using High Resolution Earth Resistivity. IN: Proceedings National Symposium and Workshops on Abandoned Mine Land Reclamation, Bismarck, ND, May 21-22, 1984, L.L. Schloesser, et al., eds., North Dakota Public Service Commission and the University of North Dakota, p. 42-62.

High resolution earth resistivity surveys were conducted as portions of the site investigations at two abandoned coal mine sites in eastern Montana. The depth of the original workings varied from 30 to 70 feet, although the associated voids often occur at more shallow depths due to roof collapse. A proposed highway corridor was found to be undermined at four locations, resulting in abandonment of the corridor. At a residential site, excellent delineation of individual rooms and pillars was achieved. Experience at these and other sites shows that the technique is conservative, i.e., all known voids were detected, but anomalies were also detected that do not represent voids. Most of the false anomalies occurred in areas of rough terrain and could be resolved by considering site geomorphology.

Keyword(s): seismic, geophysical, abandoned mines, coal mining, surface structural damage, roads
Location(s): Montana, Rocky Mountain Coal Region, United States

Wong, I. G., J. R. Humphrey, W. J. Silva. Microseismicity and Subsidence Associated with a Potash Solution Mine, Southeastern Utah, USA. IN: Proceedings 4th Conference on Acoustic Emission/ Microseismic Activity in Geological Structures and Materials, Pennsylvania, October 22-24, 1985, Clausthal-Zellerfeld, Trans Tech Publications, 1989, p. 287-306.
Microseismic activity was monitored during a pumping-refill cycle. Several thousand events were recorded that could be classified as identical to regional tectonic microearthquakes or surface wave like events, whcih are thought to be associated with collapse of a pillar in the main shaft. Microseismic activity was thought to be associated with subsidence, but there is also evidence of contribution due to local/tectonic stress fields and pre-existing zones of weakness.
Keyword(s): non-metal mining, seismic
Location(s): Utah, United States

Wood, C. C., G. J. Renfrey. The Influence of Mining Subsidence on Urban Development of Ipswich, Queensland. IN: Proceedings, 2nd Australia and New Zealand Conference on Geomechanics, Brisbane, Institute of Engineers of Australia Publication 75/4, 1975, p. 4-9.
Keyword(s): land-use planning
Location(s): Australia

Wood, P. A. Underground Stowing of Mine Waste. International Energy Agency Coal Report I CTIS/TR23, Swiftprint of New Malden, Ltd., London, April, 1983, 67 p.
This paper evaluates the effectiveness and characteristics of types of mine waste as a backfilling material for use in active and abandoned coal mines.
Keyword(s): backfilling, mine waste, abandoned mines, active mines, coal mining

Wood, R. M., G. J. Colaizzi. Overview of Methods and Techniques for the Reclamation of Mine Subsidence, Mine Drainage, and Landslide Problems on Abandoned Mined Lands. IN: Proceedings National Symposium and Workshops on Abandoned Mine Land Reclamation, Bismarck, ND, May 21-22, 1984, L.L. Schloesser, et al., eds., North Dakota Public Service Commission and the University of North Dakota, p. 248-276.
This paper describes subsidence, mine drainage and slope stability (landslides) problems related to abandoned mines lands. Discussions of subsidence include pothole and trough-type subsidence problems.
Keyword(s): abandoned mines, coal mining, reclamation, mine waste, mine fires, land mitigation, backfilling, hydraulic backfilling, pneumatic backfilling, local backfilling, grouting

Wood, W. O. The Permian Formation in East Durham. Transactions, Institute of Mining Engineers, v. 65, 1922-23, p. 178; v. 66, 1923-24, p. 196-199.
Water-pumping stations were de-watering magnesian limestones and causing subsidence, which was often blamed on the extraction of the coal far below.
Keyword(s): subsurface water, fluid extraction, coal mining

Wright, F. D. Lateral Thrust, Bedding, and Jointing in Roof Stability Calculations. IN: Ground Control Aspects of Coal Mine Design, Proceedings Bureau of Mines Technology Transfer Seminar, Lexington, KY, March 6, 1973, U.S. Bureau of Mines IC 8630, 1974, p. 86-91.
In sedimentary formations, bedding planes are generally fairly smooth and flat, and the bond between the beds is weak. Hence, the roof rock over an underground opening can become detached from the rock above to form a slab or plate loaded by its own weight or additionally by thinner, less rigid slabs above.
Keyword(s): roof stability, geologic features

Wright, F. D., R. C. Howell, J. A. Dearinger. Rock Mechanics Study of Shortwall Mining. Final Technical Report, 30 April 1979. University of Kentucky, Lexington, Department of Energy contract, April, 1979, 288 p. (NTIS PC A13/MF A01)
Keyword(s): shortwall, rock mechanics
Location(s): United States

Wright, L. The Influence of Subsidence on Coal Conservation. IN: Proceedings 4th Annual Symposium on Subsidence in Mines, Australasian Institute of Mining & Metallurgy, A.J. Hargraves, ed., Wollongong, N.S.W., Australia, 1973, p. 15-1--15-9. (NTIS Accession No. 76-07944)

Coal is a diminishing asset that is not replaceable. Considerable reserves are overlain by stored water, and the conflicting interests of coal mining and preservation of water supplies must be reconciled. The problems of subsidence effects are becoming of increasing importance. However, accurate forecasts can be made on strata behavior, including amount and extent of subsidence of the surface and intervening strata. This will permit the maximum recovery of coal consistent with adequate safeguards to surface features.

Keyword(s): engineering, coal mining, environment, surface water, subsurface water, surface structural damage, active mines, inflow

Location(s): Australia

Wu, J., S. Zhao. System Behavior Analysis of the Ground Movement Around a Longwall. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 845-852.

In this paper, the surrounding rocks and supports in a longwall are taken as an integral system. The structural characteristics and behavior of the system are discussed based on in situ observations. A set of equations, which describe the interaction among the supports, immediate roof and main roof, are developed. These equations can be used to design longwall powered supports more reasonably and economically.

Keyword(s): longwall, roof stability, modeling, roof support

Location(s): China

Wu, W., C. Haycocks. Interaction During Overmining for Longwall Operations. IN: Proceedings 4th Annual Workshop Generic Mineral Technology Center Mine Systems Design and Ground Control, Moscow, ID, October 21-26, 1986, Department of Mining and Minerals Engineering, Virginia Polytechnic Institute and State University, p. 45-56.

To study the interaction problems during overmining by longwall methods, the photoelastic modeling method was used. Using this experimental stress analysis method, a full distribution of maximum shear stress field, as well as area of stress concentration, is easier to obtain than through use of numerical modeling methods such as finite element.

Keyword(s): longwall, modeling, multiple-seam extraction, coal mining

Location(s): Appalachian Coal Region, United States

Wu, W., C. Haycocks, Y. Zhou. Designing for Interaction in Close-Seam Multi-Seam Mining. IN: Rock Mechanics: Proceedings of the 28th U.S. Symposium, Tucson, AZ, June 29-July 1, 1987, I.W. Farmer, et al., eds., Balkema, Rotterdam, p. 1107-1114.

Research into ground control problems resulting from the mining of seams in close proximity has been carried out using finite element and body-loaded photoelastic modeling methods in conjunction with statistical and empirical analysis of numerous case studies. As a result of this research, an integrated design model has been constructed and formed the basis for a computer program (MSEAM) that can assist field engineers in dealing with interaction problems caused by multi-seam mining.

Keyword(s): multiple-seam extraction, finite element, modeling, computer, ground control, overburden, pillar strength

Location(s): Appalachian Coal Region, United States

Wuest, W. J. Controlling Coal Mine Floor Heave: An Overview. U.S. Bureau of Mines IC 9326, 1992, 17 p.

This report presents an overview of ground control considerations associated with floor heave. Factors affecting heave, such as in situ stress, floor characteristics, and mine geometry are described. Floor-displacement monitoring and data analysis methods are outlined. Finally, floor heave remediation is discussed. The remedial techniques are divided into four categories: mine maintenance, supplemental support, mine structure, and techniques for multiple-seam operations. Other subjects covered in the report include laboratory and in-place testing of floor rocks, case studies, effects of mine layout, determination of excess horizontal pressure, and types of heave failure. The emphasis of this report is on practical considerations.

Keyword(s): floor stability, coal mining, mine design, multiple-seam extraction, lab testing, in situ testing

Location(s): United States

Xiao, G. C., R. A. Irvin, I. W. Farmer. Use of Database in Ground Control to Identify Weightings and Water Inflows. IN: Proceedings, 10th International Conference on Ground Control in Mining, June 10-12, 1991, S.S. Peng, ed., West Virginia University, Morgantown, p. 177-183.

A database, incorporating historical data from British mines, to study the factors affecting inflows from proximate aquifers into longwall workings, showed that a main causal factor was the immediate roof strata lithology. When this comprised principally stronger sandstone, there was a tendency for periodic inrushes associated with face weighting. This phenomenon is explained by the collection of water in bed separation cavities, where free water connected to a high pressure head aquifer source, may be trapped.

Keyword(s): subsurface water, computer, longwall, hydrology, overburden, geologic features, roof stability, coal mining, inflow

Location(s): United Kingdom

Xu, Z., Y. Pan, D. Qi. The Numerical Simulation of Lessening the Surface Subsidence by Grout Injection. IN: Computer Methods and Advances in Geomechanics, Proceedings 7th International Conference, Cairns QLD Australia, May 6-10, 1991, G. Beer, J.R. Booker, and J.P. Carter, eds., v. 2, Balkema, Rotterdam, p. 1417-1421.

In this paper, the testing of grout injection to lessen surface subsidence is introduced, then the mechanism of the reduction of surface subsidence is expounded. On the basis of the mechanism, a mathematical model is established. Finally, a numerical simulation is carried out.

Keyword(s): modeling, computer, grouting, mathematical model, coal mining, active mines, multiple-seam extraction., longwall, surface structural damage

Location(s): China

Yang, G., Y. P. Chugh, Z. Yu. Application of a Laminated Model to Surface Subsidence Prediction: A Case Study. IN: Proceedings 4th Conference on Ground Control for Midwestern U.S. Coal Mines, Mt. Vernon, IL, November 2-4, 1992, Y. P. Chugh and G. Beasley, eds., Southern Illinois University, Carbondale, p. 329-342.

This paper presents the development of a numerical model based on a laminated linear elastic mechanics model and the results of its application to prediction of subsidence due to coal mining in a southern Illinois mine. The predicted vertical and horizontal surface displacements and associated differential movements, along with their comparison with field observations, are also included.

Keyword(s): modeling, elastic model, prediction, coal mining, vertical displacement, horizontal displacement

Location(s): Illinois, Illinois Coal Basin, United States

Yang, G., Y. P. Chugh, Z. Yu. A Numerical Approach to Subsidence Prediction and Stress Analysis in Coal Mining Using a Laminated Model. IN: Proceedings, 34th U.S. Rock Mechanics Symposium, 1993.

A three-dimensional numerical model for the computation of ground movements and stresses due to coal mining is presented. It is based on a simple stratified continuum model. Analysis techniques for longwall panels with chain pillars, room-and-pillar workings and weak floor strata are discussed. The effectiveness of the model is demonstrated with a case study for a southern Illinois coal mine.

Keyword(s): prediction, coal mining, modeling, boundary element, longwall, room-and-pillar, floor stability

Location(s): Illinois, Illinois Coal Basin, United States

Yao, J. An Approach to Damage Assessment of Existing Structures. Purdue University Report CE-STR-79-4, Lafayette, IN, October, 1979.

Keyword(s): surface structural damage

Location(s): United States

Yao, X. L., D. J. Reddish, B. N. Whittaker. Evaluation of Subsidence Parameters for Inclined Seams in UK Coalfields. IN: Proceedings 10th International Conference on Ground Control in Mining, June 10-12, 1991, S.S. Peng, ed., West Virginia University, Morgantown, p. 225-232.

This paper analyses the effects of mining extraction geometry (width/depth ratio) and dip of seam on subsidence parameters based on a large database, containing 120 longwall mining cases all within coalfields in the United Kingdom.

Keyword(s): coal mining, geologic features, computer, longwall, vertical displacement, horizontal displacement, prediction, National Coal Board

Location(s): United Kingdom

Yao, X. L., B. N. Whittaker, D. J. Reddish. Influence of Overburden Mass Behavioural Properties on Subsidence Limit Characteristics. Mining Science and Technology, v. 13, no. 12, 1991, Amsterdam, p. 167-173.

An analytical calculation model for the angle of draw is introduced in this paper on the supposition that the roof is considered as an elastic beam. This model indicates the importance of the main factors that control the extent of subsidence produced on the surface and also provides some appreciation of the influence of overburden strength on the angle of draw. A finite element model was developed for application to subsidence-related rock mechanics problems.

Keyword(s): modeling, roof stability, overburden, angle of draw, finite element, rock mechanics, coal mining, geologic features

Location(s): United Kingdom

Yarbrough, R. E. Effects of Mine Subsidence on Structures--Mine Subsidence Insurance Program in Illinois. IN: Proceedings, Workshop on Surface Subsidence Due to Underground Mining, Morgantown, WV, November 30-December 2, 1981, S.S. Peng and M. Harthill, eds., Department of Mining Engineering, West Virginia University, 1982, p. 253-258.

As a result of concern for Illinois citizens owning structures above abandoned mine workings, the Illinois State Legislature passed House Bill 158 in 1978. This bill amended the Illinois Insurance Code and created the Mine Subsidence Reinsurance Fund.

Keyword(s): surface structural damage, engineering, geotechnical, insurance, monitoring methods, survey methods, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Yarbrough, R. E. Surface Subsidence--An Overview. IN: Surface Mining Environmental Monitoring and Reclamation Handbook, L.V.A. Sendlein, et al.,

eds., Coal Extraction and Utilization Research Center, Southern Illinois University, Carbondale, U.S. Department of Energy Contract No. DE AC22 80ET 14146, Elsevier, New York, 1983, p. 603-608.

This paper gives a brief history of the systematic study of surface disturbance and describes the current legislation under SMCRA (1977). It introduces the book's subsidence chapter and the papers that follow.

Keyword(s): law, subsidence research, government, reclamation, historical

Location(s): United States, England

Yarbrough, R. E. Monitoring of Two Foundations Subsided by a High Extraction Coal Mine, Sesser, Illinois. Phase I, Preliminary Data. IN: Proceedings, 2nd Conference on Ground Control Problems in the Illinois Coal Basin, May 1985, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 151-158.

The major objective of the research project is to monitor the response of two constructed foundations to ground movement induced by subsidence from high-extraction coal mining. The Illinois Mine Subsidence Insurance Fund leased land for the project for 3 years.

Keyword(s): abandoned mines, active mines, coal mining, insurance, surface structural damage, subsurface structural damage, monitoring methods, monitoring equipment, foundations, structural mitigation, vertical displacement, horizontal displacement

Location(s): Illinois, Illinois Coal Basin, United States

Yarbrough, R. E. Digitilt Tiltmeter System Utilized to Monitor Structural Response to Ground Movements Induced by Coal Mine Subsidence. The Indicator, v. 15, no. 1, 1986, Slope Indicator Co., Seattle, WA, p. 6.

The Illinois Mine Subsidence Insurance Fund and the USBM Twin Cities Research Center have chosen the Digitilt Tiltmeter as an instrument to monitor structural response to ground movements induced by coal mine subsidence. The Fund and the Bureau sponsored a program to construct and monitor two 30 x 40 foot foundations in front of a high-extraction panel in Sesser, Illinois.

Keyword(s): foundations, monitoring equipment, computer, surface structural damage, high-extraction retreat, monitoring methods, coal mining

Location(s): Illinois, Illinois Coal Basin, United States

Yarbrough, R. E., L. R. Powell, L. A. Sneed, E. W. Murphy. Monitoring Horizontal Displacement and Tilt Over a Longwall Panel, West Frankfort, Illinois. IN: Proceedings, 3rd Conference on Ground Control Problems in the Illinois Coal Basin, Mt. Vernon, IL, August 8-10, 1990, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 377-386.

In 1988, the Illinois Mine Subsidence Insurance Fund and the USBM, in cooperation with Old Ben Coal Company, initiated a monitoring program over an 850-foot-wide longwall panel at a depth of 650 feet near West Frankfort, Illinois. This paper presents the response of the ground surface to vertical, horizontal, and tilt displacements. Measuring and understanding the importance of these displacements is necessary to develop a methodology to better determine ground strains.

Keyword(s): horizontal displacement, longwall, monitoring methods, vertical displacement, survey methods, survey equipment

Location(s): Illinois, Illinois Coal Basin, United States

Yarbrough, R. E., J. E. Feddock. Horizontal Ground Movements and Mining Damage. IN: Mine Subsidence - Prediction and Control, National Symposium, 33rd Annual Meeting Association of Engineering Geologists, October 2-3, 1990, Pittsburgh, PA, p. 165-172.

This paper gives an overview of research done in the United States and abroad to predict and monitor ground movement caused by subsidence.

Keyword(s): horizontal displacement, vertical displacement, prediction, monitoring methods, foundations, coal mining, longwall, surface structural damage

Location(s): United States, Europe, United Kingdom

Yarbrough, R. E., L. R. Powell. Longwall Mining, Pseudo-Subsidence and the Human Factor. IN: Proceedings 4th Conference on Ground Control for Midwestern U.S. Coal Mines, Mt. Vernon, IL, November 2-4, 1992, Y.P. Chugh and G. Beasley, eds., Southern Illinois University, Carbondale, p. 343-351.

This paper summarizes results of research on mine subsidence in the Illinois Coal Basin conducted by the Illinois Mine Subsidence Research Program and the USBM. It also suggests ways of dealing

with surface and structure owners who live over or near subsiding areas.

Keyword(s): subsidence research, active mines, modeling, prediction, surface structural damage, longwall, vertical displacement, horizontal displacement

Location(s): Illinois, Illinois Coal Basin, United States

Yerkes, R. F., R. O. Castle. Surface Deformation Associated With Oil and Gas Field Operations in the United States. IN: Land Subsidence, Proceedings International Symposium, September 14-18, 1969, Tokyo, IAHS Publication 88, v. 1, p. 55-66.

Keyword(s): fluid extraction, oil extraction

Location(s): United States

Yi, Y. H. Subsidence Due to Mining. Thesis, University of Pittsburgh, PA, 1925.

Keyword(s): coal mining

Location(s): United States

Yin-Huai, L., Y. Ci-Shu, Z. Bing-Wen. Mining Under Rivers in Fuxin Coal Mines. IN: Proceedings 10th International Conference on Ground Control in Mining, June 10-12, 1991, S.S. Peng, ed., West Virginia University, Morgantown, p. 167-176.

In Fuxin Coal Mines, there are more than 20 million tons of coal buried under seasonal streams. The coal seams are mostly shallow. The key to success in mining shallow, under-stream coal seams, according to the authors' analysis, is that valleys or alluvia subside gently and basically evenly with contractible tension fissures and that fissures both in valleys or alluvia and in rock seams are blocked up or sealed by cohesive deposits either from alluvia or rock.

Keyword(s): surface water, overburden, coal mining, active mines, longwall, inflow

Location(s): China

Yokel, F. Y. Guidelines for Housing Construction in Mine Subsidence Areas. IN: Evaluation and Prediction of Subsidence, Proceedings International Conference, Pensacola Beach, FL, January 15-20, 1978, S.K. Saxena, ed., ASCE, New York, 1979, p. 129-139.

The purpose of this paper is to discuss suggested approaches to the problem of construction in subsidence-prone areas. The guidelines will have to address themselves to three areas: (1) site evaluation to determine subsidence risks, (2) feasibility of construction of roads, utilities, and other improvements, and methods by which subsidence effects on these facilities can be attenuated, and (3) feasibility and methods of housing construction in subsidence areas.

Keyword(s): coal mining, room-and-pillar, surface structural damage, land-use planning, utilities, roads, construction, structural mitigation, abandoned mines, active mines, horizontal displacement, vertical displacement, engineering

Location(s): United States

Yokel, F. Y., L. A. Salomone, R. M. Chung. Construction of Housing in Mine Subsidence Areas. Geotechnical Engineering Group, Structural and Material Division Center for Building Technology, National Engineering Laboratory, National Bureau of Standards, January 1981, 24 p. (NTIS NBSIR 81-2215)

This report evaluates criteria for site exploration and development, risk assessment, and housing construction in areas of actual and potential mine subsidence. Suggested measures to mitigate damage to housing are also given. The appendix explains a mathematical model, which can be used for the prediction of subsidence profile characteristics.

Keyword(s): vertical displacement, horizontal displacement, surface structural damage, ground control, construction, mathematical model, prediction, engineering, structural mitigation, land-use planning

Yokel, F. Y., L. A. Salomone, R. E. Gray. Housing Construction in Areas of Mine Subsidence. Journal Geotechnical Engineering Division, American Society of Civil Engineers, v. 108, no. GT9, September, 1982, W.F. Marcuson III, ed., p. 1133-1149.

Many areas in the United States are underlain by abandoned mines and many more areas will be undermined in the future. As mine cavities collapse, they cause settlement and ground distortions on the surface that may damage or destroy buildings and utilities. Many of these subsidence-prone areas are presently used or will be used in the future for residential housing development. Three problems associated with the development of mine subsidence areas are addressed: site exploration and evaluation, site development, and housing construction in mine subsidence areas. This paper is derived from a study sponsored by the Department of Housing and Urban Development.

Keyword(s): engineering, construction, prediction, surface structural damage, abandoned mines, utilities, land-use planning, active mines,

coal mining, horizontal displacement, vertical displacement, pipelines, roads, foundations, National Coal Board
Location(s): United States

Young, C. M. Subsidence Around a Salt Well. Transactions, AIME, v. 74, 1926, p. 810-817.
This paper contains observations of subsidence of a salt well in Kansas, as well as a description of subsidence over a sulfur deposit.
Keyword(s): non-metal mining, surface subsidence damage
Location(s): Kansas, United States

Young, L. E. Surface Subsidence in Illinois Resulting from Coal Mining. Illinois State Geological Survey, Mining Investigation Bulletin 17, 1916, 113 p.
The author examines case studies of subsidence due to mining operations in Illinois.
Keyword(s): coal mining, surface structural damage, subsurface structural damage, mine design, historical, backfilling, room-and-pillar, ground control, descriptive theories
Location(s): Illinois, Illinois Coal Basin, United States

Young, L. E., H. H. Stoek. Subsidence Resulting from Mining. University of Illinois Engineering Experiment Station Bulletin 91, v. 13, no. 49, August 1916, 205 p.
This bulletin summarized current knowledge (1916) of mine subsidence in Illinois, Pennsylvania, and West Virginia, as well as in other states and abroad.
Keyword(s): vertical displacement, horizontal displacement, surface structural damage, subsurface structural damage, surface water, subsurface water, mine design, backfilling, law, literature search, coal mining, historical
Location(s): Illinois, Illinois Coal Basin, Pennsylvania, West Virginia, Appalachian Coal Region, United States, Europe, United Kingdom, India

Young, L. E. Influence of Rate of Advance and of Time Factor in Support of Active Workings in Bituminous Coal Mines. Transactions, AIME, v. 130, 1938, p. 270-283; also AIME Technical Paper no. 933.
Keyword(s): coal mining, roof support, time factor, active mines, bituminous
Location(s): United States

Young, S. G. Surface Effects of Underground Mining. Mining Congress Journal, v. 64, 1978, p. 37-39.
Keyword(s): surface subsidence damage

Yu, Z., Y. P. Chugh, G. Chen, G. Hunt. Determination of Floor Deformations Underneath and Around a Pillar Based on Plate Loading Test and Theoretical Analyses. IN: Proceedings 4th Conference on Ground Control for Midwestern U.S. Coal Mines, Mt. Vernon, IL, November 2-4, 1992, Y.P. Chugh and G. Beasley, eds., Southern Illinois University, Carbondale, p. 149-165.
A method for determining the floor deformation underneath and around a pillar subjected to vertical loads is presented in this paper. The method is based on results of a plate loading test conducted in the field and theoretical analyses. Plate loading tests have been used extensively in the Illinois Coal Basin for determining the ultimate bearing capacity (UBC) of the weak floor.
Keyword(s): floor stability, in situ testing, modeling, finite element, ground control, room-and-pillar, active mines
Location(s): Illinois, Illinois Coal Basin, United States

Yu, Z., Y. P. Chugh, G. Yang. Determination of Plate Size Effect on Ultimate Bearing Capacity of Weak Floor in Underground Coal Mines Using a Boundary Integral Approach. IN: Proceedings, 12th International Conference on Ground Control in Mining, S.S. Peng, ed., West Virginia University, Morgantown, 1993.
An equation was developed to characterize the relationship between ultimate bearing capacity (UBC) and plate size using a boundary integral approach. The equation was validated by the results from more than 70 plate loading tests of different sizes conducted in various underground coal mines throughout the Illinois Basin. The equation indicates that the UBC decreases as the plate size increases.
Keyword(s): coal mining, in situ testing, floor stability, instrumentation, monitoring equipment
Location(s): Illinois, Illinois Coal Basin, United States

Yu, Z., Y. P. Chugh, P. E. Miller, G. Yang. A Study of Ground Behavior in Longwall Mining Through Field Instrumentation. IN: Proceedings, 34th U.S. Symposium on Rock Mechanics, 1993.

Because they impact face and mine stability, surface and subsurface deformations as well as stresses and displacements in the vicinity of the longwall face should be considered in longwall ground control. However, in the past, most studies emphasized either surface deformations or in-mine stability studies. In this research, both surface deformations and in-mine stability studies were conducted. The objectives were to study (1) subsidence characteristics, including time effects; (2) stress and deformation changes in chain pillars as a function of time and face location; (3) roof, pillar, and floor deformations in entries as a function of time and face location; and (4) relationships between the surface subsidence and underground strata behavior.

Keyword(s): longwall, monitoring methods, instrumentation, active mines, coal mining, monitoring equipment, vertical displacement, horizontal displacement, geotechnical

Location(s): Illinois, Illinois Coal Basin, United States

Yulun, Z., C. Shu, S. Guanghan, W. Ge. Identification of the Model and Parameters of Mining Subsidence and Their Practical Use. IN: Ground Movements and Structures, Proceedings 4th International Conference, University of Wales College of Cardif,f July 8-11, 1991, J.D. Geddes, ed., Pentech Press, London, 1992, p. 266-279.

This paper analyzes the problems which exist in predicting subsidence resulting from underground mining and discusses the concepts whereby models and parameters may be identified for the prediction of mining subsidence. Based on system theory, the rock mass model has been considered as a complex system that contains various forms of failure, such as faults, fractures, and bed separations. From this, a new theory about model and parameter identification of mining subsidence has been established. The theory and method have been validated using actual examples from the Zao-Zhuang coal district.

Keyword(s): prediction, modeling, geologic features, overburden, coal mining

Location(s): China

Zaburunov, S. A. Controlling Subsidence with Stowing: A Case History. Reprinted from Coal Mining, September, 1986, 3 p.

This article details the steps taken to prevent further subsidence damage to a school in Pennsylvania. An abandoned coal mine 70 feet below the school's foundation was deteriorating. Plans were drawn up and carried out to backfill the mine by using pneumatic stowing.

Keyword(s): pneumatic backfilling, stowing, surface structural damage, abandoned mines, coal mining

Location(s): Pennsylvania, Appalachian Coal Region, United States

Zachar, F. Some Effects of Sewickley Seam Mining on Later Pittsburgh Seam Mining. Mining Engineering, v. 4, no. 7, 1952, p. 687-692.

Unmined blocks in the Sewickley seam surrounded by worked out areas had been found to transmit overburden loads through the interval strata to the Pittsburgh seam 90 feet below.

Keyword(s): multiple-seam extraction, overburden

Location(s): Pennsylvania, Appalachian Coal Region, United States

Zachar, F. Factors Influencing the Selection of Mining Systems. Mining Congress Journal, v. 55, no. 10, October, 1969, p. 32-44.

This paper evaluates the factors affecting the mine layout, mining equipment, and economics of the mining systems used in the United States at the time.

Keyword(s): mine design

Location(s): United States

Zachar, F. Shortwall: A Way to Boost Production. Coal Mining and Processing, v. 9, no. 12, December, 1972, p. 39.

The author presents a discussion of reasons for reduced coal production with conventional room-and-pillar mining. He states that ventilation, dust control, and roof control required by safety legislation has lead to lower production levels. This article presents a report of the shortwall concept and proposed methods of using it to increase production.

Keyword(s): law, mine safety, shortwall, roof support, coal mining

Zaman, M. M., J. L. Ahern, Y. M. Najjar. Stability Analysis and Characterization of Ground Subsidence of Abandoned Lead-Zinc Mines in Northeastern Oklahoma. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 707-714.

This paper presents the results of a study involving characterization of ground subsidence of abandoned lead-zinc mines in northeastern Oklahoma. Two coordinated efforts were undertaken: (1) collection and analysis of available data such as drillers' logs, geologic cross sections, structure contour maps, and stratigraphic sections, and (2) development of a numerical (finite element) technique for prediction of collapse in mine subsidence. An in-depth analysis of a major collapse in the region was conducted. The factors contributing to this collapse were identified.

Keyword(s): metal mining, abandoned mines, geologic features, prediction, finite element, modeling, subsurface water

Location(s): Oklahoma, Kansas, Missouri, United States

Zenc, M. Comparison of Bals' and Knothe's Methods of Calculating Surface Movements Due to Underground Mining. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 6, 1969, p. 159-190.

The theoretical analysis of Bals' and Knothe's methods is discussed. Preliminary calculation is made of surface movements according to both methods compared with the results of measurement in the Ostrava-Karvina Coal Basin.

Keyword(s): vertical displacement, horizontal displacement, prediction theories, prediction, empirical model, profile function, influence function

Location(s): Czechoslovakia

Zeng, R. H., S. S. Peng. Prediction of Subsidence Basin by the Weibull Distribution Function. IN: Proceedings, 2nd Workshop on Surface Subsidence due to Underground Mining, Morgantown, WV, June 9-11, 1986, S.S. Peng, ed., West Virginia University, p. 78-90.

Many subsidence researchers in the United States have developed new empirical function methods to predict subsidence, or they have attempted to validate some empirical functions developed by foreign researchers for use in the United States. An attempt is made in this paper to develop a new empirical function to predict a surface subsidence basin due to longwall mining.

Keyword(s): prediction theories, computer, longwall, coal mining

Location(s): West Virginia, Appalachian Coal Region, United States

Zhang, H. C. Problem of Subsidence Caused by Coal Cutting Under the Floodbank. IN: Proceedings 6th International Congress International Association of Engineering Geology, Amsterdam, August 6-10, 1990, v. 4, Balkema, Rotterdam, p. 2699-2707.

Coal extraction under subsidence-sensitive sites is becoming more common. The case of mining under the flood prevention embankments of Weishan Lake is considered. Predictions of subsidence using the following methods are illustrated: cut and trial, structural mechanics, and geomechanics. Results, together with those from engineering comparison and probabilistic integral methods, are compared to observed ground movements. The geomechanics method gives promising results. Recommendations are made for mining practices to minimise danger for sensitive sites.

Keyword(s): prediction, coal mining, surface water, surface subsidence damage, engineering

Zhong, W. L., W. M. Ma, S. S. Peng. Prediction of Surface Subsidence by Probability Function Integration Method. IN: Proceedings, 2nd Workshop on Surface Subsidence due to Underground Mining, Morgantown, WV, June 9-11, 1986, S.S. Peng, ed., West Virginia University, p. 104-121.

The probability function integration method is one of the influence function methods. It is widely accepted in many mining districts in China and Poland because its theory and formulas can well represent the surface subsidence basins caused by longwall mining of flat or near-flat seams. This paper introduces the basic theory of the probability function integration method and determines its four basic parameters by analyzing the measured subsidence profiles in eight longwall panels in the Northern Appalachian coal field. It also discusses the two methods for determining the four parameters. Finally the acquired parameters are used to predict the subsidence and deformation of the houses for damage assessment. Comparisons are made between the measured and the predicted subsidence.

Keyword(s): prediction theories, prediction, influence function, empirical model, surface structural damage, longwall, coal mining

Location(s): China, Poland, Appalachian Coal Region, United States

Zhou, X., S. Zhang. Stability Evaluation of Alternative Designs of Drift-and-Fill Stoping in Zhaoyuan Gold Mine, P.R. China. IN: Rock Mechanics as a Guide to Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 285-292.

Mining economics is such that being too conservative in safety will result in a considerable penalty in mining cost. Initial planning and design of a mining project often must be done, however, without complete information. The assurance of economical and safe mining is thus difficult. This study focuses on the improvement of the mine design associated with Zhaoyuan Gold Mine in China. Attention is given to the selection of backfill structures. A design, which is based on a proposed practical finite element model and thought to be not only reliable but also cost effective, is recommended for further mining operations.

Keyword(s): metal mining, mine design, finite element, modeling, economics

Location(s): China

Zhou, Y., C. Haycocks. Geologic and Spatial Factors in Multi-Seam Mining. IN: Proceedings 4th Annual Workshop, Generic Mineral Technology Center Mine Systems Design and Ground Control, Moscow, ID, October 21-26, 1986, Virginia Polytechnic Institute and State University, Blacksburg, p. 115-126.

Considerable experience has been gained regarding interactions between room-and-pillar operations when mining over a previously mined underlying seam. To ameliorate upper seam conditions, design guidelines have been proposed based on model and statistical analysis of field studies for predicting upper seam stability. Although these methods are useful for predicting when potential hazards may occur in the upper seam, the precise location and magnitude of problem areas cannot as yet be determined. Studies relating upper seam damage to strata subsidence have demonstrated considerable variation. This variability is attributable to the structural conditions and their spatial locations associated with multi-seam operations, the effects of which are not yet clearly defined.

Keyword(s): multiple-seam extraction, room-and-pillar, mine design, geologic features, overburden, roof stability, modeling, finite element, pillar strength, computer

Location(s): Appalachian Coal Region, United States

Zhou, Y., C. Haycocks. Failure Mechanisms in Ultra-Close Seam Mining. IN: Rock Mechanics as a Guide to Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 613-620.

Virtually every coal seam in Appalachia will at some time be subject to multi-seam interaction. Many such problems result from seams that lie in close proximity or have split and lie within 30 feet vertically of one another. Existing techniques for multi-seam design have concentrated on conditions where the entire innerburden is not the failing member and are unsuitable for ultra-close multi-seam design. Structural integrity of the innerburden must be maintained if two superimposed seams are to be mined separately. Understanding possible failure mechanisms of the innerburden is an essential first step in the design process.

Keyword(s): coal mining, multiple-seam extraction, mine design, pillar strength, modeling, room-and-pillar

Location(s): Appalachian Coal Region, United States

Zhou, Y., C. Haycocks. Pillar Stability in Ultra-Close Seam Mining. IN: Rock Mechanics Contributions and Challenges, Proceedings of the 31st U.S. Rock Mechanics Symposium, Golden, CO, June 18-20, 1990, W.A. Hustrulid and G.A. Johnson, eds., Balkema, Rotterdam, p. 137-144.

Sooner or later virtually every seam in the Appalachian coal region will experience ground control problems due to multi-seam interaction. Mining of ultra-close seams that lie within 25 feet vertically of each other, such as where seams have split, gives rise to many of these problems. Previous multi-seam research offers solutions to some of the problems of ultra-close mining using mechanisms involving load transfer, arching, subsidence, and innerburden failure. However, field observations show that ultra-close workings separated by less than 25 feet frequently involve unique failure mechanisms of the innerburden that can affect the structural behavior of both upper and lower seam pillars.

Keyword(s): multiple-seam extraction, pillar strength, geologic features, coal mining, yielding supports, room-and-pillar

Location(s): Appalachian Coal Region, United States

Zhou, Y., C. Haycocks, E. Topuz, M. Karfakis. Controlling Subsidence Effects Using Partial Backfilling. IN: Proceedings 9th International Conference on Ground Control in Mining, June 4-6, 1990, S.S. Peng, ed., West Virginia University, Morgantown, p. 193-198.

Partial backfilling can be used to reduce and control surface subsidence damage caused by longwall mining or pillaring operations in room-and-pillar mines. The use of partial backfill as opposed to total backfill minimizes the cost associated with such efforts.

Keyword(s): longwall, room-and-pillar, pillar extraction, coal mining, grouting, pneumatic backfilling, hydraulic backfilling

Location(s): United States

Zhou, Y. Site Characterization for Ultra-Close Multi-Seam Mining. IN: Proceedings 10th International Conference on Ground Control in Mining, June 10-12, 1991, S.S. Peng, ed., West Virginia University, Morgantown, p. 161-166.

Data from these field studies and previous case study data have been combined to define ultra-close seam mining environments and relate them to observed failure conditions. A rating system for ultra-close multi-seam design has been developed and field studies have verified the applicability of the design criteria according to geologic structures, lithology, and spatial data.

Keyword(s): multiple-seam extraction, coal mining, active mines, geologic features

Zhu, D., M. Qian. A Computer Simulation of Breakage of the Main Roof in Longwall Mining. IN: Proceedings 7th International Conference on Ground Control in Mining, August 3-5, 1988, S.S. Peng, ed., Morgantown, WV, p. 205-211.

A computer simulation method, based on the results of field observation and physical model analyses, has been developed for simulating the breakage of the main roof. By this method, various parameters of rock property, different boundary conditions of the working face, as well as the initiation, development, and results of the breaking process of the main roof with different geometric dimensions can be effectively simulated. Since the main and immediate roofs and the coal seams are treated as an integrated mechanical system, the interaction among them can be studied in detail.

Keyword(s): modeling, computer, roof stability, rock mechanics, longwall, coal mining

Location(s): China

Zhu, D., S. S. Peng. A Study of Displacement Field of Main Roof in Longwall Mining and its Application. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 149-156.

A computer simulation method, based on the results of in situ observations and physical model analysis, has been developed to predict the behavior of main roof breakage in longwall mining by considering it as a Kirchoff plate on a Winkler elastic foundation. This method is used to investigate the initiation and development of the breaking process of the main roof and its displacement field before and after its breakage. In this paper, the simulation method is introduced, characteristics of the displacement field of the main roof are discussed, and monitoring variation of the displacement field of the main roof in a Chinese longwall face is demonstrated.

Keyword(s): longwall, modeling, computer, prediction, roof stability, coal mining

Location(s): China

Zorychta, H., D. W. MacFadden, F. Smith. Strata Control Measurements in the Sydney Coalfield. Transactions, Canadian Institute of Mining and Metallurgy, v. 70, 1967, p. 38-48.

Keyword(s): coal mining, ground control, instrumentation

Location(s): Australia

Zwartendyk, J. Economic Aspects of Surface Subsidence Resulting from Underground Mineral Exploitation. Ph.D. Thesis, The Pennsylvania State University, State College, 1971, 411 p.

The author presents an extensive historical survey of theories, remedies, and laws concerning surface subsidence. The study is subdivided based upon pre-WWI, post-WWI, and post-WWII conditions. It includes a historical survey of the development of hydraulic and pneumatic stowing. Also included is an extensive bibliography.

Keyword(s): economics, historical, hydraulic backfilling, pneumatic backfilling, literature search, law, prediction theories

Zwartendyk, J. Economic Aspects of Surface Subsidence Resulting from Underground Mineral Exploitation. U.S. Bureau of Mines OFR 7-72, 1971, 412 p. (NTIS PB 207 512)

This report consists of an extensive historical survey and bibliography of theories, remedies, and laws concerning surface subsidence.

Keyword(s): economics, surface subsidence damage, historical, hydraulic backfilling, pneumatic backfilling, law, literature search

Location(s): United States

Zych, J. The Asymmetry of Movements Produced at the Ground Surface by the Mining of a Horizontal Seam. IN: Ground Movements and Structures, Proceedings 4th International Conference, University of Wales College of Cardiff, July 8-11, 1991, J.D. Geddes, ed., Pentech Press, London, 1992, p. 243-254.

Detailed investigations carried out in situ and on models prove that geometric-integral theories are characterized by systematic discrepancies between the theoretical values of the deformation indices and the results of geodetic measurements. In practice, it is only possible to achieve a limited degree of accuracy using these theories, and the accuracy cannot be increased further. For this reason, the studies conducted by the author have had as an aim the elimination of these systematic divergences and, as a result, an increase in the accuracy of estimates of the effects of mining extraction on the ground surface.

Keyword(s): modeling, prediction, horizontal displacement, vertical displacement

Location(s): Poland

INDEX

Keywords

active mines

Fedorowicz, L. (1992), Ferguson, P. A. (1971), Fernandez-Rubio, R., ed. (1978), Fernando, D. A. (1988), Finlay, J. (1935), Fisekci, M. Y. (1976) (1981), Fisher, A. E. J. (1976), Fitzpatrick, D. J. (198) (1987), Flaschentrager, H. (1958), Fleming, R. M. (1957), Flowers, A. E. (1957), Follington, I. L. (1990) (1991), Fonner, R. F. (1979) (1980), Forrester, D. J. (1974) (1987) (1991), Fowler, J. C. (1977), Frankham, B. S. (1980) (1985), Franks, C. A. M. (1985) (1985), Freitag, J. A. (1991), Frieser, A. (1895), Fruco Engineers, Inc. (1981), Fry, R. C. (1992), Gaddy, F. L. (1956), Gaffney, D. V. (1981), GAI Consultants, Inc. (1980) (1981), Gall, V. (1990), Gallant, W. D. (1991) (1991), Galvin, J. M. (1986), Gamble, J. C. (1975) (1975) (1976), Gamzon, L. (1914), Gang, Y. (1992), Ganow, H. C. (1975), Gardner, F. P. (1962), Garner, J. H. (1945), Garrard, G. F. G. (1988), Garritty, P. (1982), Gaskell, P. (1988), Geddes, J. D. (1978) (1978) (1978) (1985) (1992), Geddes, J. D., ed. 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surface water

survey data processing

vertical displacement

viscoelastic model