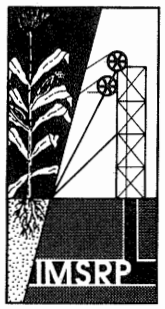
Bibliography of Selected References Related to Subsidence: An Update



B. A. Trent, R. A. Bauer, and P. B. DuMontelle
Illinois State Geological Survey

Illinois Mine Subsidence Research Program

cooperating agencies

ILLINOIS STATE GEOLOGICAL SURVEY
Department of Energy and Natural Resources

BUREAU OF MINES
United States Department of the Interior

The **Illinois Mine Subsidence Research Program** (IMSRP) was established in 1985 to investigate methods and develop guidelines for underground mining operations that aim to maximize coal extraction yet preserve the productivity of prime farmland. The research program was initiated by the Illinois Coal Association and the Illinois Farm Bureau.

The Illinois State Geological Survey, a division of the Illinois Department of Energy and Natural Resources, directed the IMSRP. Participating research institutions included Southern Illinois University at Carbondale, the University of Illinois at Urbana-Champaign, Northern Illinois University, and the Illinois State Geological Survey. A five-year Memorandum of Agreement, signed by the State of Illinois and the Bureau of Mines, U. S. Department of the Interior, ensured collaboration, cooperation, and financial support through 1991. Major funding was also provided by the Illinois Coal Development Board.

This publication is one in a series printed and distributed by the Illinois State Geological Survey as a service to the IMSRP. In the interest of making this information available to the public as quickly as possible, this bibliography has been reviewed for technical accuracy only.

Trent, B.A.

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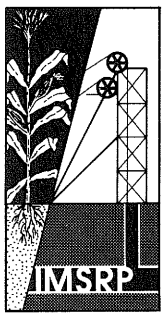
Bibliography of Selected References Related to Subsidence: An Update



B. A. Trent, R. A. Bauer, and P. B. DuMontelle
Illinois State Geological Survey

Illinois Mine Subsidence Research Program

ILLINOIS STATE GEOLOGICAL SURVEY
Morris W. Leighton, Chief

Natural Resources Building
615 East Peabody Drive
Champaign, IL 61820-6964
(217) 333-4747

Introduction and Background

The Illinois Mine Subsidence Research Program (IMSRP) compiled this bibliography to aid mine subsidence researchers, mining company technical personnel, and persons involved with agriculture in coal-resource areas in Illinois. Entries were collected from journals, proceedings, bibliographies, and library catalogs. The references were compiled using a computer database management system at the Illinois State Geological Survey (ISGS). The bibliography was printed in 1988 as IMSRP Technical Series Volume V; it contained about 2,200 references. For the present publication, the original set of references was updated, corrected, and expanded; almost 1,000 new references were added.

This bibliography emphasizes mine subsidence. References on other types of subsidence are included, however, such as that caused by groundwater withdrawal. In general, the following broad topics are covered: general information, background, and synthesis; regulations and law; monitoring and instrumentation; case studies; modeling and prediction; structural damage; backfilling and other subsidence control measures; mitigation of both land and structures; and active and abandoned mines. The references cover worldwide problems; however, the greatest number concern the United States, the United Kingdom, Australia, Europe, South Africa, and India. For the United States, many of the references are tagged by state and, if related to coal mine subsidence, they may be noted as specific to the Appalachian Coal Region, the Illinois Coal Basin, or the Rocky Mountain Coal Region.

The references are listed alphabetically by first author and year of publication. Short abstracts or descriptions of the works are included with many of the entries. Key subjects and locations are included for most entries. The database was originally designed for computer access using a combination of more than one keyword. During an on-line search, a second, third, or fourth keyword could be entered to better fit the researcher's interest. While we recognize the limitations of a printed bibliography compared with on-line searching, we printed the bibliography as a reference list.

Publication dates of the references run through the first half of 1993. If the reference is from a conference, symposium, or workshop, its date of publication is the same as the year of the conference unless otherwise stated. The availability of subsidence information varies. The best sources of subsidence-related references are university and college libraries, especially those with strong mining, geology, or engineering departments. Some references may be found at federal and state agencies, such as the U.S. Bureau of Mines or state geological surveys. Many reports on federally sponsored research contracts are available through the National Technical Information Service (NTIS).

Abbreviations

Following is a list of abbreviations used in this bibliography:

AIHS	Association Internationale d'Hydrologie Scientifique
AIME	American Institute of Mining, Metallurgical and Petroleum Engineers
ASCE	American Society of Civil Engineers
B	Bulletin
DOE	Department of Energy
EPA	Environmental Protection Agency
IAHS	International Association of Hydrological Sciences
IC	Information Circular
ISGS	Illinois State Geological Survey
NCB	National Coal Board
NTIS	National Technical Information Service
OFR	Open file report
OSM	Office of Surface Mining
RI	Report of Investigations
SMCRA	Surface Mining Control and Reclamation Act of 1977
SME	Society for Mining, Metallurgy, and Exploration
UNESCO	United Nations Educational, Scientific, and Cultural Organization
USBM	United States Bureau of Mines
USGS	United States Geological Survey

Acknowledgments

This bibliography was constructed using INMAGIC, a database management system developed for library use by Inmagic, Incorporated, Cambridge, Massachusetts. The original 741 references came from U.S. Bureau of Mines Information Circular 9007, *Subsidence Information for Underground Mines--Literature Assessment and Annotated Bibliography*. We thank the IMSRP Technical Committee who helped to select entries and keywords. The ISGS library staff provided helpful reviews. This research was supported by the IMSRP, which was funded by the U.S. Bureau of Mines and the Illinois Coal Development Board of the Illinois Department of Energy and Natural Resources. The IMSRP was administered by the ISGS.

Abel, J. F., D. W. Gentry. A Longwall Subsidence Prediction Model. American Society of Civil Engineers National Spring and Continuing Education Convention, Pittsburgh, PA, April 24-28, 1978, session 71, ASCE preprint 3293, p. 56-76.

This paper presents a preliminary subsidence prediction model. Data were obtained from an instrumentation program implemented at the York Canyon Mine, near Raton, New Mexico.

Keyword(s): vertical displacement, prediction, longwall, modeling

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

Abel, J. F., F. T. Lee. Lithologic Controls On Subsidence. Society of Mining Engineers of AIME Fall Meeting, Minneapolis, MN, October 22-24, 1980, SME-AIME Preprint 80-314, 16 p.

Keyword(s): geologic features

Location(s): United States

Abel, J. F., F. T. Lee. Subsidence Potential in Shale and Crystalline Rocks. U.S. Geological Survey OFR 80-1072, May, 1980, 99 p.

This report presents a statistical summary of worldwide subsidence experience in shale and crystalline rocks. It includes an expanded bibliography of the most significant references on mining-induced subsidence in these rocks. No measurements have been reported in the literature of subsidence in "massive" shale and crystalline rocks (potential host rocks for radioactive-waste repositories). Predictions of the subsidence response of massive rock made on the basis of information gained from less uniform rocks will be subject to unknown but possibly large error.

Keyword(s): literature search, geologic features, backfilling, prediction

Location(s): United States

Abel, J. F. Surface Subsidence Monitoring Guidelines. U.S. Geological Survey contract 14-08-0001-18822, Colorado School of Mines, June 30, 1982, 11 p. (Available for consultation at the Denver USBM Research Center.)

The author suggests guidelines for monitoring subsidence over longwall and room-and-pillar retreat mines. Included are details on monument-layout patterns, monument construction and installation, monument spacing, survey timing, and strain-measurement techniques. A rationale is provided for these guidelines. This paper should be useful for those planning a subsidence-monitoring program.

Keyword(s): monitoring design, monitoring installation, monitoring equipment, longwall, room-and-pillar, high-extraction retreat, horizontal displacement, vertical displacement, instrumentation

Location(s): United States

Ackenheil, A. C., M. T. Dougherty. Recent Development in Grouting for Deep Mines. American Society of Civil Engineers Annual Meeting and National Meeting on Structural Engineering, Sept., 1968, preprint 727.

Keyword(s): engineering, grouting

Location(s): United States

Ackenheil, A. C., M. T. Dougherty. Recent Developments in Grouting for Deep Mines. IN: Proceedings of Journal of the Soil Mechanics and Foundations Division, American Society of Civil Engineers, v. 96, no. SM 1, 1970.

This paper describes the use of grout columns for support of sites over abandoned mines; it also discusses borehole photography.

Keyword(s): foundations, photography, abandoned mines, grouting

Location(s): United States

Adamek, R., J. Lojas. Eksploatacja Instalacji Poksadzkowych Glebockich Kopaln (Operation of Hydraulic Stowage Installations in Deep Mines). Przeglad Gorniczy, v. 24, no. 6, 1968, p. 262-275.

Keyword(s): hydraulic backfilling

Adamek, V., P. W. Jeran. Evaluation of Existing Predictive Methods for Mine Subsidence in the U.S. IN: Proceedings 1st Annual Conference on Ground Control in Mining, West Virginia University, July 27-29, 1981, S.S. Peng, ed., Morgantown, WV, p. 209-219.

Two existing predictive methods were chosen for evaluation: an influence function (Bals Theory) and a profile function (hyperbolic). These were applied to seven field-measured subsidence profiles in two major coal basins in the United States. The effect of homogenous versus non-homogenous overburden on surface subsidence is demonstrated and the use of Bals Theory as a subsidence predictive method for both types of overburden is examined. The major factor affecting subsidence profile characteristics is the migration of the inflection point toward the centerline of the longwall panel.

Keyword(s): prediction, prediction theories, influence function, profile function, coal mining, overburden, longwall

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

Adamek, V., P. W. Jeran. Evaluation of Existing Predictive Methods for Mine Subsidence in the U.S. IN: Proceedings, Workshop on Surface Subsidence Due to Underground Mining, Morgantown, WV, November 30-December 3, 1981, S.S. Peng and M. Harthill, eds., Department of Mining Engineering, West Virginia University, 1982, p. 88-89.

Two existing prediction methods are evaluated for use over United States coal mines: an influence function and a profile function. These methods were applied to several field-measured subsidence profiles.

Keyword(s): vertical displacement, prediction, prediction theories, empirical model, profile function, influence function, coal mining

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

Adamek, V., P. W. Jeran. Evaluation of Surface Deformation Characteristics Over Longwall Panels in the Northern Appalachian Coalfield. IN: State-of-the-Art of Ground Control in Longwall Mining and Mining Subsidence, SME-AIME, Y.P. Chugh and M. Karmis, eds., Sept., 1982, p. 183-197.

This paper details the characteristics of surface deformations, including subsidence, inclination, curvature, and horizontal strain based on information obtained by direct field measurements over three longwall panels in the Northern Appalachian Coalfield. The authors apply two European prediction theories to Appalachian geologic conditions.

Keyword(s): prediction theories, vertical displacement, horizontal displacement, coal mining, longwall, prediction, ground control, survey methods

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

Adamek, V., P. W. Jeran. Precalculation of Subsidence Over Longwall Panels in the Northern Appalachian Coal Region. IN: Mine Subsidence Control, Proceedings Bureau of Mines Technology Transfer Seminar, Pittsburgh, PA, September 19, 1985, U.S. Bureau of Mines IC 9042, p. 34-56.

Specific lithological conditions over the Pittsburgh Coalbed prevent the use of European predictive methods. This paper describes the development of a prediction methodology suitable to the mining and geological conditions in the northern Appalachian Coal Region. Owing to lithological conditions over the Pittsburgh Coalbed, the subsidence coefficient varies within the area of the subsidence trough. This is different from the European conditions, where the subsidence coefficient is considered to be a constant.

Keyword(s): prediction theories, geologic features, angle of draw, longwall, coal mining

Location(s): Appalachian Coal Region, United States

Adamek, V., P. W. Jeran, M. A. Trevits. Evaluation of Influence Function-Based Subsidence Prediction Models. IN: Proceedings, 3rd Conference on Ground Control Problems in the Illinois Coal Basin, Aug. 8-10, 1990, Mt. Vernon, IL, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 268-275.

Recently, several computer algorithms have been published using the Budryk-Knothe influence function for subsidence prediction. This influence function was developed from Knothe's profile function in a two-dimensional coordinate system. It is the opinion of the authors that, because the two functions are conceptually incompatible, the use of a profile function in an influence function technique for underground geometries not satisfying the limitations for the use of the profile function lacks justification. Although a conception, in general, cannot be proven or disproven mathematically, a properly chosen comparative study can give insight into its soundness.

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

Location(s): United States

Adamek, V., P. W. Jeran, M. A. Trevits. Development of Dynamic Subsidence Over Longwall Panels in the Northern Appalachian Coal Region. IN: Rock Mechanics, Proceedings 33rd U.S. Symposium, Sweeney Convention Center, Santa Fe, NM, June 3-5, 1992, J.R. Tillerson and W.R. Wawersik, eds., A.A. Balkema, Rotterdam, p. 243-251.

It is a common perception that an increased rate of longwall face advance will result in a flatter dynamic subsidence trough above the panel, thus diminishing the magnitude of surface deformations, including inclination, curvature, and horizontal strain. A thorough analysis of centerline field data from 14 USBM longwall panel studies revealed, however, the only effect of the differing rates of

face advance on dynamic subsidence was the duration of its development. There was no effect on either the magnitude or the distribution of the surface deformations. Because the rate of face advance does not play a role in dynamic subsidence development, it has been determined that the prediction of dynamic subsidence can be approached using a methodology developed for static subsidence prediction.

Keyword(s): longwall, prediction, vertical displacement, horizontal displacement

Location(s): Appalachian Coal Region, United States

Adamek, V., P. W. Jeran, M. A. Trevits. Static and Dynamic Subsidence Prediction in the Northern Appalachian Based on the Use of a Variable Subsidence Coefficient. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 10-21.

Due to the variability of subsidence characteristics across coalfields in the United States, it was concluded that it would be practically impossible to develop a universal predictive model for mining-induced subsidence based on theoretical assumptions. Therefore, an effort was made to find a procedure to develop an empirical predictive model based on a sufficient amount of field data from one mining area. If successful, this procedure could be used as the template for developing predictive capabilities for other coalfields with different subsidence characteristics, given a reasonable amount of field data. This paper presents the theory, development, and application of the static and dynamic subsidence prediction models.

Keyword(s): modeling, prediction, prediction theories, empirical model, longwall, geologic features, vertical displacement, horizontal displacement, computer, angle of draw

Location(s): Appalachian Coal Region, United States

Adams, S., P. A. Hart, P. W. McDowell. Ground Conditions at Lion Salt Works Site, Marston, Cheshire. 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. 443-458.

The unused buildings at Lion Salt Works have been visibly affected by various mining activities extracting halite from beneath the site since the late 19th century. As the works are of special industrial archaeological value, prior to the commencement of preservation operations, an investigation of ground conditions, analysis of findings, and assessment of the ramifications for site preservation were performed. Two economic halite beds had been simultaneously exploited by relatively deep room-and-pillar workings and by brine well pumping at shallower depths. Overlying strata were anticipated to contain many voids, these being responsible for numerous irregularly shaped depressions on the surface.

Keyword(s): non-metal mining, abandoned mines, land-use planning, surface subsidence damage, surface structural damage, monitoring methods, geologic features, foundations, geophysical, structural mitigation

Location(s): United Kingdom

Adler, L. The Mechanics of Longwall Caving. Transactions, AIME, v. 217, 1960, p. 190-193.

Keyword(s): longwall

Location(s): United States

Adler, L., M. C. Sun. Ground Control in Bedded Formations. Research Division, Virginia Polytechnic Institute, Blacksburg, Bulletin 28, December, 1968, 266 p.

The important phases of ground control have been divided into three basic elements: roof, pillar, and floor. For each element, the significant literature dealing with the application of its respective concepts and with the available field evidence has been studied. A special application of roof control concepts to longwall mining methods has also been reviewed.

Keyword(s): ground control, literature search, longwall, roof support, pillar strength, floor stability, ground control, bumps, roof stability

Adler, L. A. Coordinated Approach--Preliminary and Integrated Analyses. IN: SME Mining Engineering Handbook, v. 1, A.B. Cummins and I.A. Givens, eds., 1973, SME-AIME, New York, p. 13-9--13-36.

This chapter discusses the design and control of underground structures in terms of preliminary analyses of individual elements such as the roof and pillars, and in terms of an integrated analysis of a synthesis of these components.

Keyword(s): mine design, roof stability, geologic features, ground control

Advani, S. H., Y. T. Lin. Subsidence and Roof Response Studies Related to Underground Coal

Gasification. IN: Proceedings 3rd Annual Underground Coal Conversion Symposium, Fallen Leaf Lake, CA, June 6-9, 1977, L.Z. Shuck and J.D. Spencer, eds., Morgantown Energy Technology Center, DOE, Morgantown, WV, p. 422-429.

Keyword(s): coal gasification, roof stability

Location(s): United States

Advani, S. H., O. K. Min, J. K. Lee. Stress and Failure Evaluations Associated with Selected Coal Mine Pillar Geometries. Ohio State University, SAND80-7098, Sandia National Laboratories, Albuquerque, NM, June, 1980, 41 p.

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

Location(s): United States

Adyalkar, P. C., K. R. Srinivasan. Role of Hydrogeology in Coal Mining Near Chandrapur in Maharashtra, India. IN: Symposium on Water in Mining and Underground Works, SIAMOS--78, Granada, Spain, 1978, p. 1-16.

The Barakar Series of the Lower Gondwanas of Central India are stratigraphically important for the occurrence of rich deposits of coal of economic significance. Coal India Ltd. plans to adopt the depillaring program in advanced coal mines in this formation to achieve maximum production based on the cost-benefit ratio. The problem of heavy seepage may occur however. Hydrogeological studies were undertaken by the Central Ground Water Board with the construction of a test wellfield near the Mahakali Colliery of Chandrapur in India. These studies have illuminated the precise status of the groundwater regime of the overlying Kamthis and the Barakars, and established the basic aquifer parameters for quantification of seepage flows during the depillaring program. These studies are of great significance for planning and designing the pumping program to prevent sudden flooding in the coal mines.

Keyword(s): hydrology, coal mining, subsurface water, pillar extraction, geologic features, mine design

Location(s): India

Afrouz, A. Floor Behavior Along Longwall Roadways. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 12, 1975, p. 229-240.

Keyword(s): longwall, floor stability

Afrouz, A. Yield and Bearing Capacity of Coal Mine Floors. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 12, 1975.

Keyword(s): coal mining, floor stability

Afrouz, A., F. P. Hassani, M. J. Scoble. Geotechnical Assessment of the Bearing Capacity of Coal Mine Floors. International Journal of Mining and Geological Engineering, 1988, v. 6, no. 4, p. 297-312.

This investigation concerns three longwall faces having variable strata and mining conditions. Bearing capacity tests along the faces were conducted to evaluate the factors influencing floor deformation and failure. The effect of size, shape, and perimeter of the base plates; thickness of the floor layer; time; and moisture on the ultimate bearing capacity of the floor was measured and discussed. The application of this work is the prediction of stability and support performance of face ends, as well as the design of support systems and ground control on production faces.

Keyword(s): floor stability, coal mining, longwall, in situ testing, instrumentation, geotechnical

Agapito, J.F.T., J. R. Aggson, S. J. Mitchell, M. P. Hardy, W. N. Hoskins. A Study of Ground Control Problems in Coal Mines with High Horizontal Stresses. 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. 820-828.

This study developed in two stages: (1) the determination of horizontal stresses in the roof by overcoring to verify the regional existence of high stresses, and (2) numerical analyses based on these stress determinations to investigate alternate mine geometries that might reduce ground control problems.

Keyword(s): rock mechanics, ground control, coal mining, roof stability, geologic features, modeling, overburden, bituminous, yielding supports, mine design

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

Agapito, J.F.T., S. J. Mitchell, M. P. Hardy, W. N. Hoskins. Determination of Insitu Horizontal Rock Stress in Both a Mine-Wide and District-Wide Basis. Report to U.S. Bureau of Mines by Tosco Research Inc., and Agapito & Associates, 1980, p. 1-173. (NTIS PB 81-139735)

Keyword(s): rock mechanics, in situ testing
Location(s): United States

Aggson, J. R. Coal Mine Floor Heave in the Beckley Coalbed, An Analysis. U.S. Bureau of Mines RI 8274, 1978, 32 p.
Keyword(s): floor stability, coal mining
Location(s): United States

Aggson, J. R. Insitu Stress Fields and Associated Mine Roof Stability. IN: Proceedings, Mini Symposium on Application of Geotechnical Data to Underground Mine Design, SME-AIME Fall Meeting, Mini Symposium Series no. 78-1, 1978, p. 16-20.
Keyword(s): roof stability, geotechnical, mine design
Location(s): United States

Aggson, J. R. Stress-Induced Failures in Mine Roof. U.S. Bureau of Mines RI 8338, 1979, 16 p.
This report presents a finite element analysis of roof stresses associated with an underground coal mine entry 4 feet high by 18 feet wide. This analysis starts with known loading conditions determined in an underground coal mine in West Virginia and is extended to other possible underground loading conditions. The roof failures predicted by the finite element analysis under known loading conditions correlate well with the roof failures observed underground. The most probable failure modes are identified for the various loading conditions considered. Various failure preventive measures are discussed.
Keyword(s): roof stability, finite element, ground control, rock mechanics, geologic features, coal mining
Location(s): West Virginia, Appalachian Coal Region, United States

Aggson, J. R. Design of Room and Pillar Mining Systems. IN: Proceedings, 1st Conference on Ground Control Problems in the Illinois Coal Basin, Aug. 22-24, 1979, Southern Illinois University, Carbondale, June, 1980, p. 44-52.
Recent investigations into ground control problems in underground coal mines have shown a strong correlation between the results of theoretical structural analyses of coal mine openings and observed failures in operating mines. This paper presents a general overview of the various loading conditions that can be expected underground and the response of the mine roof to those loading conditions. Potential ground control problems and recommended solutions are discussed for several roof types under various loading conditions.
Keyword(s): room-and-pillar, ground control, coal mining, roof stability, geologic features, mine design
Location(s): United States

Agioutantis, Z., G. Goodman, A. Jarosz, M. Karmis, P. Schilizzi. Prediction of Ground Movements Due to Underground Mining in the Eastern United States Coalfields Volume 1. Development of Prediction Methods. Report on Office of Surface Mining Contract J5140137, Virginia Polytechnic Institute and State University, Department of Mining and Minerals Engineering, Blacksburg, December, 1987, 205 p. (NTIS PB90-148594)
This report presents basic concepts of prediction methods and monitoring programs, analysis and refinement of prediction methods applicable to the eastern United States coalfield, subsidence control, and socio-economic considerations and conclusions.
Keyword(s): coal mining, prediction, mathematical model, economics, longwall, high-extraction retreat, room-and-pillar, empirical model, profile function, influence function, zone area, prediction theories, instrumentation, monitoring methods, monitoring equipment, survey data processing, angle of draw, yielding supports
Location(s): Appalachian Coal Region, United States

Agioutantis, Z., M. Karmis, A. Jarosz. Prediction of Surface Subsidence and Strain in the Appalachian Coalfields Using Numerical Methods. IN: Proceedings of 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. 95-100.
This paper presents a two-dimensional numerical procedure that incorporates concepts related to the mechanics of strata deformation as well as empirical indices associated with subsidence engineering. Regional deformation data were employed to establish overburden deformation zones, while material properties were kept constant. Scaling of final displacement was based on empirically predicted values for subsidence and strain for the Appalachian coalfield. The model was validated with a number of regional case studies and predicted subsidence and strain curves were compared with those obtained using a semi-empirical influence function formulation.

Keyword(s): prediction, modeling, overburden, influence function, empirical model, computer, coal mining

Location(s): Appalachian Coal Region, United States

Ahola, M. Application of the Discrete Element Method Toward Roof Stability Problems in Underground Coal Mines. IN: Proceedings 1st U.S. Conference on Discrete Element Methods, Golden, CO, October 19-20, 1989, Colorado School of Mines, 9 p.

Keyword(s): modeling, roof stability, coal mining

Ahola, M. P. Geomechanical Evaluation of Escarpments Subjected to Mining Induced Subsidence. 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. 129-136.

This paper presents preliminary results of numerical modeling conducted by the Bureau of Mines to illustrate the capabilities of the boundary-element method in predicting, comparing, and assessing the effects of mining beneath massive sandstone escarpments. This is rapidly becoming a major environmental concern in the Western United States. As an escarpment is undermined, the resulting subsidence induced by the mining has the potential to cause blocks of material to fail along existing joint planes and slide or topple down the talus slope below. This failure has the potential to impact wildlife habitat, raptor nesting sites, vegetation, and other land uses. A two-dimensional boundary-element analysis was conducted along a vertical cross section through a mine in Utah.

Keyword(s): modeling, boundary element, prediction, environment, longwall, coal mining, geologic features, wildlife

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

AIME. Report of Sub-Committee on Coal Mining to Committee on Ground Movement and Subsidence. Transactions, AIME, v. 74, 1926, p. 734-809.

At the time (1926), this report was considered to be the most complete collection of subsidence data. In addition to cases already in the literature, questionnaires were sent out to all the large operating bituminous coal companies and to many engineers. The effects of subsidence were discussed under the four main categories of squeezes, multiple-seam extraction, room-and-pillar mining, and longwall mining. Contains a bibliography of subsidence literature from 1913-1924.

Keyword(s): pillar extraction, multiple-seam extraction, mine operation, historical, room-and-pillar, longwall, literature search, coal mining

Location(s): Illinois, England, Appalachian Coal Region, Oklahoma, United States

AIME-SME, Coal Division. Elements of Practical Coal Mining. Port City Press, Inc., Baltimore, Maryland, 1973, 614 p.

This book presents basics of mine design and operation, including mining methods and roof support.

Keyword(s): roof support, mine design, mine operation, coal mining

Location(s): United States

Akagi, T. Some Land Subsidence Experiences in Japan and Their Relevance to Subsidence in Bangkok, Thailand. Geotechnical Engineering, v. 10, 1979, p. 1-48.

Location(s): Japan, Thailand

Akimov, A. G. On Methods of Precalculating Ground Surface Movements. Ugol, v. 2, 1958, p. 20-23.

Keyword(s): prediction

Albert, E. K., R. L. Flegal. Developing an Information System to Choose Abandoned Mine Sites for Reclamation. Mining Engineering, November, 1990, p. 1246.

A management information system that combines scientific selection procedures is being developed to provide for a flexible and customized selection procedure for AML projects.

Keyword(s): abandoned mines, reclamation, computer, coal mining

Location(s): United States

Albright, J. N., P. M. Halleck, C. Pearson, M. Fehler. Subsurface Subsidence Damage Monitoring: Seismic Tomography and Microgravimetry. 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, Morgantown, March, 1982, p. 198-205.

Both microgravimetry and crosshole seismic tomography are means by which subsurface

collapse and rock failure may be observed. The authors show results of calculations that predict changes in gravity and gravity gradient that result from void migration, bulking, and hydrology disruption due to room-and-pillar mining.

Keyword(s): monitoring design, monitoring equipment, monitoring installation, seismic, subsurface water, hydrology, overburden

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

Albright, M. B. Subsidence Related to Oil Field Activity. IN: Proceedings, 2nd Geologic Hazards Conference, Landslides and Subsidence, Los Angeles, CA, 1966, California Resources Agency, Sacramento, p. 130-134.

Keyword(s): oil extraction

Alder, H., A. Walker, L. Walker. Subsidence and Its Bearing on Mining Methods. Transactions, Institute of Mining Engineers, London, v. 107, no. 2, May, 1942, p. 302-326 and 421-424.

This paper discusses the effects of subsidence from underground mining on the surface and intermediate strata. Various mining methods are recommended that provide for maximum economical coal extraction along with minimum subsidence.

Keyword(s): mine design, overburden, partial extraction, room-and-pillar, longwall

Location(s): England

Alder, H., A. Walker, L. Walker. Subsidence and Its Bearing on Mining Methods. Colliery Guardian, v. 166, 1943, p. 569-572, 600-604, and 628-632.

Total extraction of coal over a sufficiently large area is inevitably followed by subsidence of the surface regardless of the depth of working, the method of mining, or the thickness of the seam.

Keyword(s): angle of draw, geologic features, coal mining, mine design, mine operation, partial extraction, pillar strength

Location(s): United Kingdom

Alder, H., E. L. Potts, A. Walker. Research on Strata Control in the Northern Coal Field of Great Britain. IN: Proceedings, International Conference About Rock Pressure and Support in the Workings, April 24-28, 1951, Liege, Belgium, Institut National de l'Industrie Charbonniere, p. 104-113.

Keyword(s): ground control, coal mining

Location(s): England

Aljoe, W. W., J. W. Hawkins. Investigation and Characterization of Groundwater Flow Systems in Abandoned Underground Coal Mines. IN: Reclamation 2000: Technologies for Success, Proceedings National Meeting American Society of Surface Mining and Reclamation, 1991, W. Oaks and J. Bowden, eds., p. 241-260.

Keyword(s): abandoned mines, coal mining, hydrology, subsurface water

Alke, R. B., B. L. Thompson. A Case History of the Effect of Mine Subsidence on a Concrete Arch Bridge in Northern West Virginia. 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. 907-913.

A reinforced portland concrete arch filled bridge was undermined by an active longwall in West Virginia. After the subsidence, the bridge retained its structural integrity and adequately carried the required live loads. Normal traffic was maintained continuously during and after the subsidence period. The only repair to the structure required as a result of mining was epoxy injection of the cracks. Although the bridge settled differentially, it was never out of service. Temporary supports were installed, but they never became functional nor was public safety ever in question.

Keyword(s): surface structural damage, longwall, coal mining, active mines, engineering, geologic features

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

Allen, A. S. Review of the Causes of Subsidence. U.S. Department of the Interior, Geological Survey Professional Paper 400-B, 1960, p. B147-B148.

Keyword(s): fluid extraction

Location(s): United States

Allen, A. S. Geologic Settings of Subsidence. Reviews in Engineering Geology, v. 2, D.J. Varnes and G. Kiersch, eds. Geological Society of America, Boulder, CO, 1969, p. 305-342.

Keyword(s): geologic features, engineering

Location(s): United States

Allen, A. S., C. W. Anderson. Recent Developments in the Use of Mine Waste for Subsidence Control. IN: Proceedings, 4th Mineral Waste Utilization Symposium, cosponsored by U.S. Bureau of Mines

and Illinois Institute of Technology Research Institute, Chicago, IL, May 7-8, 1974, p. 213-221.

This paper provides information on pumped-slurry backfilling procedures as well as the use of mine waste as fill for controlling subsidence in abandoned room-and-pillar mines that have become flooded or are otherwise inaccessible.

Keyword(s): hydraulic backfilling, mine waste, abandoned mines, room-and-pillar

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

Allen, A. S. Basic Questions Concerning Coal Mine Subsidence in the United States. Bulletin of the Association of Engineering Geologists, v. 15, no. 2, 1978, p. 147-161.

Keyword(s): coal mining

Location(s): United States

Allen, C.A. Coal Losses in Illinois. Illinois State Geological Survey, Mining Investigation Bulletin 30, 1925, Urbana, 34 p.

This report discusses extraction percentages in 27 counties in Illinois. Pillars and roof coal were two of the reasons for coal being left behind. Other unavoidable coal losses were left to support railroads and streams.

Keyword(s): coal mining, historical

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

Allen, C. A. Coal Losses in Illinois. Illinois State Geological Survey, Mining Investigation Bulletin 30, 1925, Urbana, 36 p.

This report discusses the amount of coal in Illinois that was left unmined as pillars and for other reasons. The author showed how extraction ratios could be increased in many cases from 50% to 80%. In some counties, coal was left to protect railroads, roads, water supplies, and/or surface agricultural land from subsidence.

Keyword(s): historical, coal mining, partial extraction, economics, agriculture, land values

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

Allen, C. W. Subsidence Resulting from the Athens System of Mining at Neganee, Michigan. Transactions, AIME, v. 109, 1934, p. 195-202.

Location(s): Michigan, United States

Allen, D. R. Physical Changes of Reservoir Properties Caused by Subsidence and Pressuring Operations. Journal of Petroleum Technology, v. 20, no. 1, 1968, p. 23-29.

Keyword(s): oil extraction, hydrology, subsurface water

Allen, D. R. Collar and Radioactive Bullet Logging for Subsidence Monitoring. IN: Proceedings, 10th Annual Society of Professional Well Log Analysts Logging Symposium, Houston, 1969, p. G.1-G.19.

Keyword(s): fluid extraction, monitoring methods, oil extraction

Allen, D. R., M. N. Mayuga. The Mechanics of Compaction and Rebound, Wilmington Oil Field, Long Beach, California, International Association Hydrological Sciences Publication 89, 1970, p. 410-423.

Keyword(s): oil extraction, fluid extraction

Location(s): California, United States

Allett, E. J. Environmental Aspects of New Mine Planning. Colliery Guardian, v. 231, no. 8, 1983, p. 434-435, 437-439, and 441.

Keyword(s): environment, mine design, land-use planning

Allgaier, F. K. Subsidence Monitoring Over Western Coal Mines. IN: Proceedings, Workshop on Surface Subsidence Due to Underground Mining, November 30-December 2, 1981, S.S. Peng and M. Harthill, eds., West Virginia University, Morgantown, March, 1982, p. 156-161.

This paper describes subsidence monitoring equipment and procedures used at five coal mines in Colorado and Utah with substantially different mine plans, mining methods, depths of cover, and topography. The monitoring procedures used at each site were similar and included designing the monitoring network layout, installing the subsidence monuments, initial and periodic surveying, and processing the survey data. Data from the monitoring program are supplied to cooperating mining companies and used by the Bureau to accomplish the long-term objective of developing and validating subsidence prediction techniques applicable to mines in the West.

Keyword(s): monitoring installation, monitoring equipment, monitoring design, survey methods, survey equipment, survey data processing, coal mining, prediction

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

Allgaier, F. K. Surface Subsidence Over Longwall Panels in the Western United States. IN: State-of-the-Art of Ground Control in Longwall Mining and Mining Subsidence, SME-AIME, Y.P. Chugh and M. Karmis, eds., Sept., 1982, p. 199-209.

The geology, mine plan, and survey network are outlined for three study sites as part of an ongoing subsidence prediction research program conducted in central Utah. Measured values from study sites are compared with two prediction methods: the NCB method and the Donets profile function.

Keyword(s): prediction, prediction theories, empirical model, vertical displacement, monitoring design, monitoring equipment, survey methods, longwall, National Coal Board, profile function

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

Allgaier, F. K. Surface Subsidence Over Longwall Panels in the Western United States: Monitoring Program and Preliminary Results at the Deer Creek Mine, Utah. U.S. Bureau of Mines IC 8896, 1982, 24 p.

Preliminary site information, subsidence results, and a report of the instrumentation are given for a study performed over four adjacent longwall panels in central Utah. Information is given to estimate labor and time needed for such a project.

Keyword(s): monitoring design, monitoring installation, monitoring equipment, survey methods, longwall, economics, survey equipment, survey data processing

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

Amato, R. B., T. V. Leshendok. Geologic Factors Related to Surface Subsidence Due to Underground Coal Mining. Geological Society of America Northeastern Section, 10th Annual Meeting, 1975, Abstracts with Programs, v. 7, p. 21-22.

Keyword(s): geologic features, coal mining

Location(s): United States

Amuedo, A. S., J. B. Ivey. Ground Subsidence and Land Use Considerations Over Coal Mines in the Boulder-Weld Coal Field, Colorado. Colorado Geological Survey Environmental Geology Series no. 9, 1975.

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

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

Andromalos, K. B., C. R. Ryan. Subsidence Control by High Volume Grouting. 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. 53-68.

Grouting techniques have been used for years to stabilize existing structures and new construction over abandoned coal mines. The purpose of mine grouting programs is to provide additional support at mine level to control future mine subsidence.

Keyword(s): grouting, abandoned mines, coal mining, mine waste

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

Andros, S. O. Coal Mining Practice in District VIII. Illinois State Geological Survey, Mining Investigation Bulletin 2, 1914, 47 p.

Keyword(s): historical, coal mining

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

Andros, S. O. Coal Mining Practice in District VII. Illinois State Geological Survey, Mining Investigation Bulletin 4, 1914, 53 p.

Keyword(s): historical, coal mining

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

Andros, S. O. Coal Mining Practice in District V. Illinois State Geological Survey, Mining Investigation Bulletin 6, 1914, 34 p.

Keyword(s): historical, coal mining

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

Andros, S. O. Coal Mining Practice in District II. Illinois State Geological Survey, Mining Investigation Bulletin 7, 1914, 22 p.

Keyword(s): coal mining, historical

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

Andros, S. O. Coal Mining Practice in District I (Longwall). Illinois State Geological Survey, Mining Investigation Bulletin 5, 1914, 42 p.

Keyword(s): longwall, coal mining, historical

Location(s): Illinois, Illinois Coal Basin

Andros, S. O. Coal Mining Practice in District VI (Mines in Bed 6 in Franklin, Jackson, Perry and Williamson Counties). Illinois State Geological Survey, Mining Investigation Bulletin 8, 1914, 49 p.

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

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

Andros, S. O. Coal Mining in Illinois. Illinois State Geological Survey, Mining Investigation Bulletin 13, 1915, 250 p.

This bulletin summarizes earlier district reports so as to compare mining practice and to make generalizations about the state as a whole. A historical chapter on the economic development of Illinois is included, as well as an appended bibliography of the geology, chemistry, and exploration of the different seams.

Keyword(s): historical, coal mining

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

Andros, S. O. Coal Mining Practice in District III. Illinois State Geological Survey, Mining Investigation Bulletin 9, 1915, 30 p.

Keyword(s): coal mining, historical

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

Andros, S. O. Coal Mining Practice in District IV. Illinois State Geological Survey, Mining Investigation Bulletin 12, 1915, 57 p.

Keyword(s): coal mining, historical

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

Ang, C. Y. A Study of Subsidence Caused by Underground Mining with Special Emphasis on Angle of Break. Thesis, Colorado School of Mines, Golden, CO, 1947.

This is a study of problems related to the angle of break in subsidence. In laboratory experiments, subsidence was observed to reach the surface unless a strong, natural arch was formed. Angle of break is a function of bed inclination, the minimum angle being 62 degrees.

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

Location(s): United States

Aoki, S. Land Subsidence in Niigata. IN: Proceedings, 2nd International Symposium on Land Subsidence, Anaheim, CA, 1977. International Association of Hydrological Sciences Publication no. 121, Washington, D.C., 1977, p. 105-112.

Keyword(s): hydrology

Arcamone, J., P. Schroeter, M.J.P. Dejean. State of the Art of Mining Subsidence in France. IN: Proceedings, 88th Annual General Meeting of Canada Institute of Mining, Montreal, May, Paper no. 84, 1986, 17 p.

Location(s): France

Archibald, G. I., A. M. Weir. A Field Study of Subsidence. Chartered Surveyor, v. 102, no. 4, 1969, p. 177-186.

Keyword(s): survey methods

Arndt, E. Zur Anwendung der Methode der Endlichen Elemente in der Bergschadenkunde (Application of Finite Element Method in Mining Subsidence Assessment). Glueckauf-Forschungshefte, v. 38, no. 2, 1977, p. 82-85.

Keyword(s): finite element, modeling

Location(s): Germany

Arnould, M. Problems of Underground Cavities in the Paris Area. IN: Proceedings, Symposium on Geological and Geographical Problems of Areas of High Population Density, Association of Engineering Geologists Annual meeting, Washington, D.C., October 23, 1970.

The author discusses approaches to subsidence problems resulting from abandoned limestone mines and solution cavities in limestone.

Keyword(s): abandoned mines, non-metal mining, backfilling

Location(s): France, Europe

Arup, O. N., R. S. Jenkins. The Design of a Reinforced-Concrete Factory at Brynmawr, South Wales. IN: Proceedings, Institution of Civil Engineers, v. 2, pt. 3, no. 3, December, 1953, p. 345-397.

The authors describe construction of a factory over abandoned room-and-pillar and longwall coal workings.

Keyword(s): ground control, abandoned mines, room-and-pillar, longwall, foundations, architecture, engineering, coal mining

Location(s): Wales

Ash, N. F., D.-W. Park. 3-D Finite Element Modeling of Longwall Mining Using Progressive Failure Concept. 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, 1987, p. 725-734.

This study uses the three-dimensional finite element method and integrates the technique of progressive failure to simulate stress redistribution at a longwall mining section. The two selected sites for which the simulation is performed are located in the Black Warrior Coal Basin of Alabama.

Keyword(s): modeling, finite element, longwall, pillar strength, overburden, roof stability, coal mining, active mines, yielding supports

Location(s): Alabama, United States

Ash, S. H., J. Westfield. Backfilling Problem in the Anthracite Region as it Relates to Conservation of Anthracite and Prevention of Subsidence. U.S. Bureau of Mines IC 7342, 1946, 18 p.

This circular describes the history of subsidence in Pennsylvania; it also discusses areas suitable for backfilling. The authors argue for federal and state involvement in subsidence-prevention research.

Keyword(s): backfilling, anthracite, coal mining, historical, subsidence research

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

Ashmead, D. C. How the Kingston Coal Company Reduces Subsidence and Conserves Coal by Rock Filling and Silting. Coal Age, v. 20, August, 1921, p. 167-171.

This paper describes the investigation of backfilling methods using mine waste in Pennsylvania.

Keyword(s): backfilling, mine waste, coal mining

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

Ashworth, E., ed. Research and 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, Balkema, Boston, 1985, v. 1 and 2, 1292 p.

Keyword(s): rock mechanics, modeling, prediction, overburden, room-and-pillar, longwall, finite element, roof support, ground control, mine design, boundary element, continuum mechanics, computer, pillar strength, seismic, instrumentation

Location(s): Canada, Illinois, United States, Appalachian Coal Region, Utah, Brazil, France, Nevada

Astin, J. A Viscoelastic Analysis of Ground Movement Due to an Advancing Coal Face. Journal of Engineering Mathematics, v. 2, 1968, p. 9-22.

Keyword(s): coal mining, modeling, viscoelastic model, phenomenological model

Aston, R. L. Subsidence Waiver Upheld in Virginia. Coal, April 1990, v. 95, no. 4, p. 77.

A Virginia federal court granted summary judgment for a coal company, holding that the company could not be held liable to a surface owner's property as a result of breaking strata that was caused by the miner's use of the longwall method of mining where there had been an express waiver.

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

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

Aston, R. L. SMCRA Rules Reviewed and Remanded by D.C. Coal, September, 1990, p. 81-83.

The U.S. District Court for the District of Columbia reviewed rules under the federal Surface Mining Control and Reclamation Act (SMCRA) of 1977 for the fourth time since it became law. The court was called in by the National Wildlife Federation to decide five separate challenges to SMCRA regulations. Three issues dealt with subsidence of land over underground coal mines, and two with when the act should begin to apply to certain types of coal mine operations.

Keyword(s): law, coal mining, active mines, surface structural damage, environment, reclamation

Location(s): United States

Aston, T.R.C. Discussion Paper: Subsidence Research in the Sydney Coalfield. CANMET, Canadian Centre for Mineral and Energy Technology Division Report ERP/CRL 83-10(R), April, 1983, Energy Research Program, Coal Research Laboratories, Sydney, Nova Scotia, 23 p.

The applicability to the Sydney Coalfield of existing guidelines for the safe working of undersea coal reserves is uncertain. Land-truthed data has been extrapolated to undersea conditions, rather than empirically derived from seabed-truthed data. It is therefore proposed to initiate a major research effort to monitor subsidence development over these undersea workings.

Keyword(s): surface water, subsurface water, coal mining, multiple-seam extraction, longwall, monitoring design, modeling, instrumentation, prediction, subsidence research, inflow

Location(s): Canada

Aston, T.R.C., R. N. Singh. A Reappraisal of Investigations into Strata Permeability Changes Associated with Longwall Mining. International Journal of Mine Water, v.2 , no. 1, 1983, p. 1-14.

Keyword(s): longwall, overburden, hydrology, subsurface water

Aston, T.R.C., B. N. Whittaker. Undersea Longwall Mining Subsidence with Special Reference to Geological and Water Occurrence Criteria in the North-East of England Coalfield. Mining Science and Technology, v. 2, 1985, p. 105-130.

To date, the use of classical statistical techniques for the identification and analysis of parameters that control the occurrence of water on longwall panels has proved inconclusive. An alternative and potentially more meaningful approach is to examine the interaction between the tensile strain induced by mining and the geological and hydrogeological environment surrounding the workings.

Keyword(s): subsurface water, hydrology, longwall, coal mining, geologic features, inflow

Location(s): England

Aston, T.R.C., H. Y. Tammemagi, A. W. Poon. A Review and Evaluation of Empirical and Analytical Subsidence Prediction Techniques. Mining Science and Technology, v. 5, 1987, p. 59-69.

A review and evaluation of a number of different empirical and analytical subsidence prediction techniques were undertaken as part of a long-term research program into seafloor subsidence in the Sydney Coalfield, Nova Scotia. After an initial review of these methods, as well as the available computer programs for subsidence prediction, a comparison is made between the results obtained from six specific prediction methods applied to a hypothetical case history.

Keyword(s): prediction theories, empirical model, prediction, coal mining, modeling, National Coal Board, profile function, influence function, stochastic model, finite element, boundary element, mathematical model, computer, surface water, vertical displacement, active mines

Location(s): Canada

Aston, T.R.C. Longwall Seafloor Subsidence Monitoring: Why and How. Mining Engineering, December, 1989, p. 1210-1212.

Extensive undersea coal reserves, identified in the offshore portion of the Sydney coalfield, Nova Scotia, have resulted in the implementation of a multi-year research program to develop site specific guidelines for the undersea longwall mining operations. Preliminary studies have revealed four potential schemes for monitoring seafloor longwall subsidence profiles: seasurface, subsea, geophysics, and direct monitoring. Further work has indicated, however, that the use of marine geophysical techniques may be the most effective method of identifying and evaluating seafloor subsidence profiles by comparing pre- and post-mining seafloor topographies.

Keyword(s): coal mining, longwall, monitoring methods, geophysical, active mines

Location(s): Canada

Aston, T.R.C. That Sinking Feeling: Scientists Monitor Seafloor Subsidence in Nova Scotia's Sydney Coalfield. Geos, v. 4, 1989, p. 18-21.

Researchers are monitoring the seafloor and measuring water depth to see whether the ocean bottom is sinking above undersea mines. Although artificial structures are rarely built on the seafloor, scientists still want to know how the rock mass behaves on the seafloor in the zone of tensile strain. Essentially, the rock mass is being pulled apart, creating a potential fracture-fissure network, which could result in a direct hydraulic connection between the mine workings and the seafloor. Although a catastrophic inrush of water to the mine workings is extremely unlikely, researchers worry about the slow but cumulative increase in water, which significantly raises production costs because of increased pumping and dewatering measures.

Keyword(s): coal mining, monitoring methods, seismic, surface water, inflow

Location(s): Canada

Atchison, T. C., Chairman. Coal Mining, Including Ground Control and Gas Outbursts. IN: Discussion C3, Rock Mechanics for Resource Development, Mining and Civil Engineering, Proceedings 5th Congress of International Society for Rock Mechanics, Melbourne, Australia, 1983. A.A. Balkema, Rotterdam, p. G219-G222.

This paper contains questions and answers from authors of papers in this section.

Keyword(s): coal mining, ground control, rock mechanics, prediction, longwall

Atkinson, J. H., D. M. Potts. Subsidence Above Shallow Circular Tunnels in Soft Ground. Department of Engineering, University of Cambridge, England, Report CUED/C-SOILS/T. R. 27, 1976.

Keyword(s): engineering, tunnelling, soils

Attewell, P. B. Ground Movements Caused by Tunnelling in Soil. 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. 812-948.

This paper briefly reviews some theoretical, laboratory, and in situ methods of predicting, measuring, and analyzing the ground movements caused by tunnelling in soil. The character of the ground losses at the tunnel with respect to the type of soil is investigated, together with the manner in which these losses are transferred to the ground surface. Practical examples of deformation distribution, as derived from field measurement programs, are given. The paper incorporates collations of case history data with particular attention being paid to surface settlement parameters. A concluding section is devoted to a brief appraisal of the type of structural damage that might be caused by tunnelling settlements.

Keyword(s): surface structural damage, tunnelling, soils, monitoring methods, lab testing, in situ testing, modeling

Location(s): United Kingdom

Attewell, P. B. Large Ground Movements and Structural Damage Caused by Tunnelling Below the Water Table in a Silty Alluvial Clay. 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. 307-356.

Ground movements were measured both inside and outside of a factory under which a tunnel was being constructed below the water table in a silty alluvial clay.

Keyword(s): surface structural damage, tunnelling, soils, monitoring methods

Location(s): United Kingdom

Attewell, P. B. Settlement Development Caused by Tunnelling in Soil. Ground Engineering, v. 18, no. 8, November, 1985, p. 17-20.

Keyword(s): tunnelling, soils

Attewell, P. B., J. Yeates, A. R. Selby. Soil Movements Induced by Tunnelling and Their Effects on Pipelines and Structures. Blackie, Glasgow, 1986.

Keyword(s): tunnelling, pipelines, soils, surface structural damage

Auchmuty, R. L. Subsidence and Ground Movement in a Limestone Mine Caused by Longwall Mining in a Coal Bed Below. Transactions, AIME, Coal Division, v. 94, 1931, p. 27-50.

A cement company in Illinois successfully stopped a coal company from mining underneath its property. The cement company was mining limestone and shale about 125 feet under the surface, by the room-and-pillar method. The coal company was mining by longwall advance methods in a seam about 450 feet below the limestone bed. Survey data were collected for over 3 years and used as evidence in the suit.

Keyword(s): longwall, law, non-metal mining, room-and-pillar, multiple-seam extraction, utilities, coal mining

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

Aughenbaugh, N. B. The Time Factor on Subsidence. IN: Proceedings, 1st Conference on Ground Control Problems in the Illinois Coal Basin, Aug. 22-24, 1979, Southern Illinois University, Carbondale, 1980, p. 260-267.

In recent years, subsidence due to underground coal mining has been receiving much attention mostly because residential and commercial developments placed over old, abandoned mines have sustained damage due to differential settlement. With renewed activity in coal mining and the continued development of the surface to urban-type use, conflicts continue to arise between development of coal reserves and surface land use. Very little information is available about the time factor on subsidence. The data that have been published relate only to longwall mining. This paper discusses only the time factor on room-and-pillar mining of coal.

Keyword(s): time factor, room-and-pillar, ground control, coal mining, modeling, land-use planning, active mines, abandoned mines

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

Aughenbaugh, N. B., C. D. Elifrits. Subsidence and Time. SME-AIME preprint no. 83-388, SME-AIME Fall Meeting and Exhibit, Salt Lake City, UT, October 19-21, 1983, 9 p.

Subsidence due to abandoned coal mines has received copious attention recently. This is a result of many factors such as the enactment of new mining laws and the effect subsidence has on land use over the mines. Prediction of subsidence features and the time aspects over supercritical

extraction (i.e., longwall and high extraction ratio pillaring) is relatively accurate. However, predicting when subsidence will occur and the surface features' size and shape above subcritical extraction of room-and-pillar mining is not yet possible. This paper discusses the factors that influence the time aspects of subsidence in room-and-pillar mining.

Keyword(s): time factor, room-and-pillar, abandoned mines, prediction, law, overburden, coal mining, pillar extraction

Location(s): United States

Australasian Institute of Mining and Metallurgy. Proceedings of the Jubilee Symposium on Mine Filling, Mount Isa, Australia, Aug. 19-22, 1973, 282 p.

This symposium details research on fill properties and filling techniques.

Keyword(s): backfilling

Location(s): Australia

Awasthi, R., L. R. Powell, E. C. Drumm. Measurement of Structural Deformation and Tilt During Subsidence. IN: Proceedings 10th International Conference on Ground Control in Mining, June 10-12, 1991, S.S. Peng, ed., West Virginia University, Morgantown, p. 233-242.

The application of a horizontal inclinometer and a tiltmeter to measure tilt, curvature, and deformations of shallow footings during mine subsidence is described. The measurements were taken during mining of a longwall panel in Southern Illinois and were supplemented with precision level survey data. Six different footings were constructed and instrumented at two sites; one above the panel centerline, and the second inside the edge of the panel in the anticipated zone of maximum tension.

Keyword(s): active mines, coal mining, longwall, vertical displacement, horizontal displacement, foundations, surface structural damage, monitoring methods, monitoring equipment, monitoring installation, survey methods

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

Ayala, C. F. J., H. R. Lain, H. L. Lain, V. E. Perianes. Subsidence Control (Determination of Movements at the Surface; Consequences of the Subsidence at the Surface.) IN: Introduccion a los Usos Industriales y Urbanos del Espacio Subterraneo y Su Tecnologia (Introduction to the Industrial and Urban Uses of the Underground Space, and Their Technology.), Instituto Geologico y Minero de Espana, Madrid, 1986, Ch. 3.7, p. 191-194 (English version).

Keyword(s): ground control, surface subsidence damage

Ayala, C. F. J., H. R. Lain, H. L. Lain, V. E. Perianes. Introduccion a los Usos Industriales y Urbanos del Espacio Subterraneo y Su Tecnologia (Introduction to the Industrial and Urban Uses of the Underground Space, and Their Technology.) Instituo Geologico y Minero de Espana, Madrid, 1986, 351 p.

Keyword(s): land-use planning, historical, tunnelling, non-metal mining, abandoned mines, utilities, railroads, roads, architecture, subsurface water, modeling, roof stability, pillar strength, phenomenological model, elastic model, roof bolting, rock mechanics

Aynsley, W. J., G. Hewitt. Subsidence Observations Over Shallow Workings, Including Pneumatic Stowing and Rapidly-Advancing Faces. The Mining Engineer, London, v. 120, no. 7, April, 1961, p. 552-569.

This paper discusses the effects of different backfilling systems on surface subsidence and resulting surface damage in shallow workings; it compares subsidence recorded where both a full and partial area of influence have been worked. The authors also compare rapidly advancing faces versus conventional machine mine workings. The slope of the subsidence profile is shown as a measure of strain.

Keyword(s): pneumatic backfilling, stowing, mine design

Location(s): England

Aynsley, W. J., G. Hewitt. Subsidence Observations Over Shallow Workings. Colliery Guardian, v. 202, May 18, 1961, p. 577-583.

Keyword(s): backfilling

Babcock, C. O., V. E. Hooker. Results of Research to Develop Guidelines for Mining Near Surface and Underground Bodies of Water. U.S. Bureau of Mines IC 8741, 1977, 17 p.

This publication presents guidelines for mining near surface and underground bodies of water. The guidelines were based on information developed under contract in three phases of study, as follows: (1) collection and documentation of data from worldwide sources; (2) application of existing guidelines (foreign, federal, and state) to case histories of previous inundations; and (3) development of recommended guidelines for underground coal mining near bodies of water aimed at maximum efficient use of underground coal resources consistent with minimizing inundation hazards. Tables are given for the determination of the size of coal pillars needed.

Keyword(s): surface water, subsurface water, hydrology, mine operation, coal mining, mine design, engineering, longwall, high-extraction retreat, partial extraction, inflow

Location(s): United States

Babcock, S. D. Undermining as an Element in Land Use Planning. M.S. Thesis, Southern Illinois University, Edwardsville, IL, 1973, 84 p.

Undermining, the result of underground mineral extraction, is one limiting physical characteristic of both urban and rural development. Subsidence of the surface, resulting from the failure of the underground void created by mining, is often the consequence of undermining.

Keyword(s): coal mining, metal mining, non-metal mining, abandoned mines, land-use planning, foundations, surface structural damage, engineering

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

Badenhorst, G. P. Legal Aspects on the Undermining of Structures and the Use of Undermined Ground. IN: Proceedings, SANGORM Symposium, October 21, 1986, International Society for Rock Mechanics, South African National Group, Sandton, South Africa, p. 1-6.

In almost all the cases where minerals are mined, a dual relationship, in legal terms, is to be found. First, there is a relationship between the owner of the land and the holder of the mineral rights, regulated mainly by principles of private law. Second, the State exercises control over the mining of minerals to a greater or lesser extent, depending on the nature of the minerals, and its relationship with the mineral right holder is regulated by public law.

Keyword(s): surface structural damage, law, government, historical, metal mining, engineering

Location(s): South Africa, Australia, California

Baeckstrom, L., L. Carlsson, A. Carlstedt, A. Hornsten. Influence on the Groundwater Conditions in a Multilayered Aquifer System by Alum-Shale Mining. IN: Symposium on Water in Mining and Underground Works, SIAMOS--78, Granada, Spain, 1978, p. 17-26.

Keyword(s): subsurface water, non-metal mining, hydrology

Bahuguna, P. P., B. Singh, A. M. C. Srivastava. An Empirical Method for Calculation of Maximum Subsidence. 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., A.A. Balkema, Rotterdam, p. 801-809.

Most of the empirical methods are based on the prior knowledge of quantity Smax, the maximum possible subsidence or S, the maximum subsidence that normally occurs at or near the center of the mined-out area. The subsidence profile and other associated parameters along any line in the subsidence trough are predicted, in most cases, as a function of either of these quantities (Smax or S) and the distance of the point at which subsidence is to be calculated either from a point vertically above the center of the excavation or from the point of half subsidence that is near the ribside. This paper describes a method of calculating the value of Smax due to critical or super-critical area, the value of S, occurring at or near the center of a sub-critical area. The method uses an empirical formula developed for Indian coal mines.

Keyword(s): empirical model, vertical displacement, coal mining, overburden, geologic features, room-and-pillar, longwall

Location(s): India

Bai, M., D. Elsworth. Prediction of the Fracture Zone Over Mine Workings--An Analytical Model. 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. 519-527.

A method is presented for evaluating stresses and displacements in multiply layered media based on the Fourier complex variation principle. Basic solutions are specifically presented for a three layer

model of seam extraction from which surface slopes, curvatures, and body strains may be recovered. Subject to the initial assumptions of linear elasticity, zones of potential fracture are predicted based on empirical strain based failure criteria.

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

Bai, M., D. Elsworth, L. W. Saperstein. Prediction of Surface Movement with Emphasis on Horizontal Deformation Due to 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. 731-738.

In predicting the integrity of undermined structures, surface horizontal displacements and curvatures are frequently of greater importance than the more homogeneous vertical displacements. Accurate evaluation of mining induced subsidence and horizontal displacement further requires that the predictive model adequately represents the subsurface geology, mining geometry, and extraction sequencing. The paper documents an extension of the SPASID method of evaluation of horizontal strains. Comparisons are made between predictions from SPASID and two other empirical methods against measured data from a case study. The system identification method is illustrated to predict horizontal displacements and strains most consistently with the in situ data.

Keyword(s): prediction, horizontal displacement, surface structural damage, vertical displacement, prediction, geologic features, modeling, empirical model, coal mining, profile function, influence function, longwall

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

Bai, M., D. Elsworth. Some Aspects of Mining Under Aquifers in China. Mining Science and Technology, v. 10, no. 1, January, 1990, p. 81-91.

A number of case studies of mining-induced permeability enhancement are documented. The extent of strata failure around active underground mines is determined through use of a borehole discharge test. The test delimits zones and the severity of extraction induced fracturing. From these data, empirical relationships are developed to determine the vertical and horizontal extents of the caving and fracture zones induced by mining. These relationships are developed for a variety of strata types and strengths and give quantitative recommendations applicable to similar mining conditions elsewhere.

Keyword(s): overburden, coal mining, hydrology, longwall

Location(s): China

Bailey, C. H. The Reports of the Royal Commission on Mining Subsidence. Colliery Guardian, v. 136, 1928, p. 431-433, 530-552.

Keyword(s): mine design, construction, engineering, law

Location(s): England

Bakker, D. The Undermining of Surface Structures. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May 1992. South African Institution of Civil Engineers, Republic of South Africa, p. 249-260.

At present uniform rules are applied, based on percentage extraction, to protect surface structures when mining operations are taking place underneath them. Guidelines are proposed for application in the Central Witwatersrand and Bushveld Igneous Complex Regions which are based on geotechnical detail in these regions. Safe mining spans and pillar design criteria form the essence of the proposals.

Keyword(s): surface structural damage, geotechnical, mine design, law, angle of draw, pillar strength

Location(s): South Africa

Bakker, D. The Undermining of Surface Structures and Construction/Erection Over Undermined Ground: 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. 262-270.

The undermining of surface structures and the construction of structures on undermined land by mining is restricted by the terms of the Minerals Act. The restrictions for various mining methods in the coalfields as applied by the Department of Mineral and Energy Affairs is described.

Keyword(s): coal mining, surface structural damage, construction, law, room-and-pillar, pillar strength, longwall, utilities, pillar extraction, prediction, roads

Location(s): South Africa

Balia, R., P. P. Manca, G. Massacci, M. Congiu, E. Fioravanti, S. Lai, D. Lipari, R. Sarritzu. Progressive Hangingwall Caving and Subsidence Prediction at the San Giovannie Mine, Italy. IN: Proceedings 9th

International Conference on Ground Control in Mining, June 4-6, 1990, S.S. Peng, ed., West Virginia University, Morgantown, p. 303-311.

The upper part of the "Contatto Ovest" orebody, at the San Giovanni Pb-Zn sulphur mine (Sardinia, Italy), is mined by a sublevel caving method. With increasing depth, a progressive caving of the hanging wall and discontinuous subsidence occurs.

Keyword(s): metal mining, prediction, modeling
Location(s): Italy

Bals, R. Beitrag zur Frage der Vorausberechnung Bergbaulicher Senkungen. (Contribution to the Problem of Precalculating Mining Subsidence.) Mitteilungen aus dem Markscheidewesen, v. 42/43, 1931-32, p. 98-111 (in German).

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

Bamberger, K. F., E. Bauer, D. Hartmann, F. Hollman, H. O. Luetgendorf, K. Pflaeging, G. Schoene-Warnefeld, R. Teschers. Early Detection of Mining Damages. Bundesministerium fuer Forschung und Technologie, Bonn-Bad Godesborg, Federal Republic of Germany, August, 1980, (in German) 259 p. (NTIS BMFT-FB-T-80-039)

At present, 17 different German and 10 foreign methods are available for the advanced calculation of mining subsidences. The stress behavior of pipelines as well as the behavior of construction soils under the influence of mining operations have not been investigated as yet. In view of the strong surface impact of intensified coal extraction, losses in coal deposits are to be avoided by optimized advanced calculation for the Ruhr and Saar coalfields, along with an improved protection of pipelines and buildings. Existing processes are to be improved by mathematical methods as well as checked by measurements and, partly, by geodetical methods. The theoretically calculated subsidence syncline can be adjusted to the subsidence syncline measured by aerophoto-grammetry by means of suitable functions of superposition (Ruhr district). Predictions on ground movements are possible (Saar district) using the proper geological and operational parameters. The stresses on straight and deflected pipes with all relevant parameters can be determined. Fields of movement and not planes of break develop in the building ground. Results have to be quantified further. These are generally valid processes, which may be purposefully applied in any coalfield with intensive surface building activities (e.g., also in France, Great Britain, Poland, and the USSR), to avoid losses in deposits.

Keyword(s): surface subsidence damage, coal mining, prediction, pipelines, surface structural damage, active mines
Location(s): Germany, France, United Kingdom, Poland, Soviet Union

Bao-Szen, L. Application of Theory of Stochastic Media to Determination of Profile of Subsidence Trough on Ground Surface Due to Exploitation of Inclined Deposit. Bulletin Academie Polonaise des Sciences, Serie des Sciences Techniques, v. 9, no. 9, 1961, p. 541-546.

Keyword(s): prediction, modeling, empirical model, stochastic model

Barczak, T. M. The History and Future of Longwall Mining in the United States. U.S. Bureau of Mines IC 9316, 1992, 26 p.

This report chronicles the historical development of longwall mining in the United States and speculates on future developments to the turn of the century. The involvement and contributions made by the USBM during these developments are also discussed.

Keyword(s): longwall, coal mining, roof support
Location(s): United States

Barker, O. B. A Phased Approach to the Optimal Utilisation of Undermined Ground in the Central Rand - Wits Basin. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May 1992. South African Institution of Civil Engineers, Republic of South Africa, p. 201-220.

Regulations controlling the surface use of undermined ground have created a strip of derelict land running east and west of central Johannesburg. The basis of the argument is that marginally economic mining operations have been holding up the development of prime industrial land. This paper presents an approach to the resolution of the problem. Recognizing the surface and subsurface engineering geological and rock mechanics problems, it provides a method of approach to resolve them and to reinstate the land in a progressive manner which reflects the growth in value of the surface.

Keyword(s): land-use planning, land values, engineering, geologic features, law, metal mining, rock mechanics, soils
Location(s): South Africa

Barla, G., P. Jarre. Subsidence Over an Abandoned Dissolving Salt Mine. 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., A.A. Balkema, Rotterdam, p. 871-880.

The viscoelastic closure of the underground cavities and the dissolution of the mine structures through fresh water flooding caused subsidence above the deep kainite San Cataldo mine, Sicily (Italy), opened in the early 1960s. The present paper describes the instruments installed and measurements taken to observe the phenomena. The systems used include automatic deep wire extensometers in the rock mass above the mine, measurements by surveying methods on the area above the cavities and in the neighborhood, inclinometers in the slope above the mine, piezometer sensors in the mine; microseismic monitoring, and remote sensing. A simple model has been taken to interpret all the various data collected and to compute the time for the fresh water to fill all the underground cavities.

Keyword(s): non-metal mining, instrumentation, monitoring methods, monitoring equipment, remote sensing, modeling

Location(s): Italy

Barla, G. B., S. Boshkov. Investigations of Differential Strata Movements and Water Table Fluctuations During Longwall Operations at the Somerset Mine No. 60. Department of Energy contract ET-76-C-01-9041, Columbia University, 1978, 49 p. (NTIS FE-9041-1)

This paper gives the results of research done near Washington, PA. The research involved the instrumentation and monitoring of water table fluctuations and differential strata movements over a longwall mine.

Keyword(s): subsurface water, monitoring design, monitoring installation, monitoring equipment, coal mining, longwall

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

Barnard, S. Key Administrative Aspects of Subsidence Abatement Projects. 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. 271-280.

The Wyoming Abandoned Mined Lands program is structured such that the investigation, design, and construction management is done by consulting engineers. During the administration of these projects, it became apparent that not only is the design of vital importance, but many "non-engineering" items also play a key role in the overall success of the projects.

Keyword(s): abandoned mines, reclamation, hydraulic backfilling, grouting, engineering, historical, land-use planning, land values, coal mining, subsidence research

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

Barnes, D. Subsidence Awareness and Planning in the City of Colorado Springs. 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. 267-270.

The author discusses land-use planning and development in the Colorado Springs area related to mine subsidence and the City's Planning Department Geology Section report, "Guide for Future Land Use."

Keyword(s): abandoned mines, land-use planning, surface structural damage, soils, reclamation, land values, utilities, coal mining

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

Barr, B.I.G., R. Delpak. Prediction of Ground Movement in Areas of Mining Subsidence. Highway Engineering, v. 21, June, 1974, p. 18-22, 36.

This paper deals with the estimation of surface strains and deflections caused as a result of longwall methods. The Sims-Bridle method of prediction is discussed, and displacement-calculation procedures are detailed.

Keyword(s): horizontal displacement, prediction, prediction theories, computer, longwall

Location(s): England

Barraclough, L. J. Roof Breaks in Longwall Workings. Colliery Guardian, v. 145, 1932, p. 572-577, 662-664, 845.

Properties of roof materials from longwall mines in Wales were studied in the laboratory.

Keyword(s): backfilling, roof stability, longwall, lab testing, coal mining

Location(s): Wales

Barron, K. An Analytical Approach to the Design of Coal Pillars. Canadian Institute of Mining Bulletin, v. 868, no. 77, 1984, p. 37-44.

Keyword(s): coal mining, pillar strength, mine design

Barron, K. A New Method for Coal Pillar Design. 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. 118-124.

A failure criterion for coal is proposed in which a distinction is made between brittle and "pseudo-ductile" failure. This criterion is then used in the development of new equations for coal pillar strength, including a transition from brittle fracture to pseudo-ductile yielding. In addition, equations are obtained that allow the critical minimum pillar dimensions to be calculated to avoid "catastrophic" and "ultimate failure." The use of these formulae is then demonstrated by comparing the results with pillar case histories derived from the literature.

Keyword(s): pillar strength, coal mining

Barron, L. R. Longwall Stability Analysis of a Deep, Bump-Prone Western Coal Mine - Case Study. IN: Proceedings, 9th International Conference on Ground Control in Mining, 1990, Department of Mining Engineering, West Virginia University, Morgantown, p. 142-149.

Keyword(s): longwall, bumps, coal mining

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

Barry, A. J., J. J. Wojciechowski. Roof Movement Study of Mechanized Retreating Longwall Operation, Lancashire No. 15 Mine, Bakerton, Cambria County, PA. U.S. Bureau of Mines RI 5028, January, 1954.

This report details an instrumented study of roof behavior on a longwall operation. An investigation was conducted at a mechanized longwall operation in the Lancashire No. 15 mine, Barnes & Tucker Co., Cambria County, Bakerton, PA, to study the factors that affect roof control. The objective was to measure strata movement, correlate these movements with mining operations, and determine their effect on roof control.

Keyword(s): coal mining, longwall, active mines, roof stability, instrumentation

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

Barry, A. J., O. B. Nair. In-Situ Tests of Bearing Capacity of Roof and Floor in Selected Bituminous Coal Mines. A Progress Report--Longwall Mining. U.S. Bureau of Mines RI 7406, 1970, 20 p.

The authors discuss the development and field testing of a method for estimation of the bearing capacity of mine roofs and floors. The relationship between penetration of the strata and imposed loads is determined by in situ tests to define bearing plate dimensions for hydraulic roof support jacks at longwall extraction faces.

Keyword(s): pillar strength, roof stability, floor stability, longwall, in situ testing, roof support, coal mining, bituminous

Location(s): United States

Barry, A. J. Ground Control with Longwall Mining. Mining Congress Journal, June, 1970, p. 53-55.

The author describes surface and underground instrumentation used by the USBM at an Illinois mine to gather information to determine the significance of various parameters involved in full caving longwall mining.

Keyword(s): longwall, ground control, mine design, coal mining, instrumentation

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

Barton, T. M., C. Mark. Field Evaluation of Three Longwall Pillar Systems in a Kentucky Coal Mine. U.S. Bureau of Mines RI 9283, 1989, 13 p.

The USBM is conducting research to assess the effectiveness of different chain pillar designs in maintaining gate entry stability. A particular concern is ground control for deep-cover longwalls located at depths in excess of 1,000 feet. The study was performed in two experimental sections in one longwall headgate section that contained three different pillar designs. Two of the designs used conventional abutment pillars; the third was a total-yielding pillar system. Entry convergence, roof sag, and changes in roof quality were monitored.

Keyword(s): longwall, active mines, coal mining, yielding supports, monitoring methods, mine design, pillar strength, roof stability, floor stability

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

Basham, K. D., B. A. Suprenant, M. G. Karfakis, W. L. Johnson. Suggested Guidelines and Recommendations for Residential Construction to Minimize Subsidence Related Damage. IN: Proceedings, Symposium on Evolution of

Abandoned Mine Land Technologies, Riverton, WY, June 14-16, 1989, 14 p. (supplement).

The development of criteria for construction requirements to minimize subsidence-related damage in Wyoming are discussed.

Keyword(s): structural mitigation, construction, land-use planning, abandoned mines, surface structural damage, insurance, utilities, economics, coal mining, foundations

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

Batchelor, A. S. Correlation of Roadway Displacement With Stress Redistribution and Strata Movement Caused by Longwall Mining. Ph.D. Thesis, Department of Mining Engineering, University of Nottingham, England, 1968.

Keyword(s): longwall, overburden

Bateman, A. M., H. G. Moulton. Ground Movement and Subsidence. IN: Mining Engineers Handbook, v. 1, Sec. 10,. Art. 112, 1941, R. Peale, ed., John Wiley & Sons, Inc., New York.

This article reviews theories of ground movement due to mining, including opposing opinions concerning the extent and mechanics of surface subsidence.

Keyword(s): prediction, surface subsidence damage

Bauer, E. R., G. J. Chekan, J. L. Hill III. A Borehole Instrument for Measuring Mining-Induced Pressure Changes in Underground Coal 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, p. 1075-1084.

Current ground control research at the USBM indicates the need for a simple and inexpensive instrument for measuring mining-induced pressure changes in coal pillars and mine roofs. The Borehole Platened Flatjack (BPF) is an adaptation of existing such instrumentation.

Keyword(s): instrumentation, monitoring equipment, pillar strength, roof stability, ground control, coal mining

Location(s): United States

Bauer, E. R., G. J. Chekan, G. P. Sames. Influence of Subjacent Gob on Longwall Development Mining in the Upper Kittanning Coalbed of South-Central Pennsylvania. U.S. Bureau of Mines RI 9403, 1992, 13 p.

The USBM is investigating strata interactions associated with mining of multiple coalbeds to provide the mining industry with improved methods of planning and developing multiple coalbeds, conserving resources, and increasing the safety of underground coal mining. This study involves analytical predictions and underground observations of longwall development ground control problems at a south-central Pennsylvania coal mine, which was affected by subsidence induced by multiple-seam mining. As predicted, strata interactions were found in upper mine areas mined over lower mine gob.

Keyword(s): longwall, multiple-seam extraction, coal mining, ground control, mine waste, mine safety, geologic features, prediction, roof stability

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

Bauer, R. A., P. J. DeMaris. Geologic Conditions of a Longwall Mining Demonstration at the Old Ben No. 24 Mine. SME-AIME Preprint No. 77-I-349, for presentation at the 1977 SME Fall Meeting and Exhibit, St. Louis, MO, October 19-21, 1977, 12 p.

A longwall mining demonstration in the Herrin (No. 6) Coal Member near Benton, IL, involved the extraction of three adjacent panels by the longwall method. The first panel was completed in May 1977. The ISGS was involved in this project for two reasons: (1) to detail the geology of the roof and relate the geologic features to the behavior of the roof during mining operations, and (2) to study the nature and occurrence of coal balls encountered during this demonstration.

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

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

Bauer, R. A. The Loss of Natural Moisture Content and its Effect on the Mechanical Properties of Some Pennsylvanian Shales from 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. 89-94.

Preservation of the natural moisture content of shale cores should be a primary concern to companies that are engaged in exploration and want to know the physical properties of rocks associated with coal seams. Testing should be conducted on cores that represent the natural conditions of the rock in order to properly evaluate pre-mining roof and floor conditions of coal seams;

therefore, the moisture content of these rock cores should resemble that of the rock mass being tested.

Keyword(s): rock mechanics, coal mining, geotechnical

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

Bauer, R. A., S. Hunt. Profile, Strain, and Time Characteristics of Subsidence from Coal Mining 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., West Virginia University, 1982, p. 207-217.

This paper documents subsidence in Illinois, discusses its characteristic parameters, and reports on an investigation to determine whether a time factor (based on the time interval from abandonment of the mine to occurrence of subsidence) exists in Illinois. The data used to characterize subsidence in Illinois were gathered from many sources. To characterize the subsidence completely, these data were combined with mine plan information and other sources at the ISGS.

Keyword(s): time factor, coal mining, overburden, angle of draw, rock mechanics, geologic features, room-and-pillar, active mines, abandoned mines

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

Bauer, R. A., P. J. DeMaris. Geologic Investigation of Roof and Floor Strata: Longwall Demonstration, Old Ben Mine No. 24. Illinois State Geological Survey, Contract/Grant Report 1982-2, Champaign, IL, 49 p.

In-mine mapping of three longwall panels at the Old Ben No. 24 Mine has revealed both major and minor roof-stability problems and multiple areas of concentrated coal balls within the Herrin (No. 6) Coal Member. The roof-stability problems are related to three interacting factors: variations in roof lithology, various structural features, and mining plan. Major roof-stability problems are rare at the longwall face but more common in the longwall support entries. Several major falls have occurred in areas where potential problems were identified previously during mapping. Lesser roof-stability problems are associated with "rolls" containing compaction faults and with a tectonic fault zone running perpendicular to the face of the second panel.

Keyword(s): coal mining, longwall, roof stability, geologic features, lab testing

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

Bauer, R. A., P. B. DuMontelle. Disturbance of Overburden Bedrock by Coal Mine Subsidence in Illinois. Geological Society of America Annual Meeting, Abstracts with Programs, v. 15, no. 6, 1983, p. 523.

Keyword(s): overburden, subsurface subsidence damage, coal mining

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

Bauer, R. A. Damage That May be Mistaken for Coal-Mine Subsidence. ISGS Reprint 1983-E, 1983. Reprinted from Proceedings of Illinois Mining Institute 90th Annual Meeting, Springfield, IL, October 7-8, 1982, p. 66-72.

In Illinois we tend to think of subsidence primarily in association with the failure of coal mines. Subsidence can, however, result from other conditions. Consequently, if the geologic and environmental factors of an area are not properly evaluated, damage to a home can be falsely attributed to coal-mine subsidence. Correct identification of the cause of the damage is sometimes useful in choosing a method to alleviate the problem.

Keyword(s): surface structural damage, coal mining, soils, foundations, subsurface water

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

Bauer, R. A. Subsidence of Bedrock Above Abandoned Coal Mines in Illinois Produces Few Fractures. Presented at Society of Mining Engineers of AIME Fall Meeting, Denver, CO, October 24-26, 1984, SME-AIME preprint 84-400, 1984, 8 p.

This paper documents the investigation of possible fracturing of bedrock within subsided areas over abandoned mines through exploration drilling and closed circuit television.

Keyword(s): abandoned mines, coal mining, longwall, room-and-pillar, geologic features

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

Bauer, R. A. Longwall Coal Mining in Illinois. Field Trip Guidebook for 25th U.S. Symposium on Rock Mechanics, June 27-28, 1984, Illinois State Geological Survey, Champaign, IL, 57 p.

This field trip guidebook covers the modern longwall coal mining being performed in Illinois in 1984. Old Ben Coal Company had three active

underground coal mines in Franklin County, all or which were operating in the Herrin Coal.

Keyword(s): longwall, coal mining, active mines, geologic features, rock mechanics

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

Bauer, R. A. Application of Time Domain Reflectometry to Subsidence Monitoring. IN: Proceedings 8th Annual National Abandoned Mine Lands Conference, August 10-15, 1986, Billings, MT, p. 47-53.

Time Domain Reflectometry (TDR) is an electrical pulse testing technique originally developed to locate breaks in power transmission lines. In the past decade, this technique has been adapted to monitor the movement of rock masses during mining. The long-term objectives of this project were to evaluate the use of TDR as an inexpensive technique for monitoring subsidence over abandoned and active mines.

Keyword(s): monitoring design, monitoring equipment, monitoring installation, monitoring methods, high-extraction retreat, coal mining, active mines, instrumentation

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

Bauer, R. A., E. M. Gefell, D. W. Barkley. Characterization of Coal Mine Subsidence and Impacts on Bedrock and Near Surface Hydrology Over a Shallow High-Extraction Retreat Mining Operation in Illinois. IN: Proceedings, National Symposium on Mining, Hydrology, Sedimentology, and Reclamation, December 7-11, 1987, Springfield, IL, Office of Engineering Services, University of Kentucky, Lexington, p. 197-202.

This study, conducted under the Illinois Mine Subsidence Research Program, investigated the effects of coal mine subsidence on the overburden above a shallow high-extraction retreat mine (250 feet deep) in southern Illinois. The site was instrumented to monitor movements on the surface, strain in the overburden, and changes in piezometric levels in the bedrock and overlying drift.

Keyword(s): active mines, coal mining, high-extraction retreat, hydrology, subsurface water, overburden, monitoring methods, survey methods, subsidence research

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

Bauer, R. A. The Effects of Valleys on the Strength of Rock Materials at Depth. 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. 345-349.

Most investigations of the effects valleys have on rock properties have been performed where surface excavations occurred in a valley. The impact valleys have at depth into the bedrock has been limited to borehole measurements of hydrologic conductivity, various models of stress distribution, and empirical relationships with roof instability of underground coal mines. This investigation used core from borings extending below and adjacent to bedrock valleys. Laboratory measurements of strength, slake durability, and P-wave velocities were compared between the cores. Test results show that the strength of samples from bedrock below valleys ranges from 10% to 26% less than adjacent or shallower areas of the valley. This work also shows that the deeper parts of the valleys have a greater effect on the bedrock strength.

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

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

Bauer, R. A., P. B. DuMontelle. Illinois Mine Subsidence Research Program: What Have We Learned in Five Years? IN: Proceedings, Illinois Mining Institute 98th Annual Meeting, September 27-28, 1990, p. 35-40.

This paper briefly describes the four basic study areas of the Illinois Mine Subsidence Research Program: (1) coal mine floor stability, (2) coal pillar stability, (3) overburden deformation during subsidence, and (4) impacts on crop production.

Keyword(s): subsidence research, coal mining, active mines, agriculture, hydrology, floor stability, overburden

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

Bauer, R. A., C. H. Dowding, D. J. Van Roosendaal, B. B. Mehnert, M. B. Su, K. O'Connor. Application of Time Domain Reflectometry to Subsidence Monitoring. U.S. Department of the Interior, Office of Surface Mining, Assistance Agreement No. HQ51-CT6-01537, Final Report, Illinois State Geological Survey, Champaign, IL, 1991, 48 p. (NTIS PB91-228411)

The report describes how reflected voltage pulses from coaxial antenna cable grouted in rock masses can be used to quantify type and magnitude of rock mass deformation (movements) during

abandoned mine subsidence events. Rock mass movements locally deform the grouted cable, which changes cable capacitance and thereby the reflected wave form of induced voltage pulse. By monitoring changes in these reflected signatures, it is possible to monitor rock mass deformation.

Keyword(s): lab testing, in situ testing, active mines, abandoned mines, monitoring methods, monitoring equipment, monitoring installation, longwall, surface structural damage, instrumentation, coal mining

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

Bauer, R. A., D. J. Van Roosendaal. Monitoring Problems: Are We Really Measuring Coal Mine Subsidence? IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 332-338.

Geology and weather effects produce natural ground movements that may be misinterpreted as mine subsidence. Common practices of monument and benchmark design and placement do not address the problem of natural ground movements. Monuments can be designed to minimize some natural ground movements. Differential displacements can be reduced by competent placement of benchmarks and monuments of similar design and construction. Multiple baseline surveys of an entire monitoring system should be conducted before the onset of subsidence to establish subsidence detection limits.

Keyword(s): monitoring methods, monitoring design, monitoring equipment, monitoring installation, survey design, survey equipment, survey methods, coal mining, vertical displacement, geologic features, soils

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

Bauer, R. A., D. J. Van Roosendaal. Monitoring Problems: Are We Really Measuring Coal Mine Subsidence? IN: Proceedings, Illinois Mining Institute, Centennial Year, 1992, p. 39-52.

Geology and weather effects produce natural ground movements that may be misinterpreted as mine subsidence. Weather, local geology, and vegetation clearly influence the elevation of the ground surface through frost action, changes in groundwater levels, and soil moisture content. Monuments can be designed to minimize some natural ground movements. Differential displacements can be reduced by competent placement of benchmarks and monuments of similar design and construction. Multiple baseline surveys of the entire monitoring system, conducted before the onset of subsidence, should be used to establish subsidence detection limits.

Keyword(s): monitoring methods, survey methods, surface structural damage, survey equipment, monitoring equipment, instrumentation, survey design

Bauer, R. A., B. A. Trent, P. B. DuMontelle. Mine Subsidence in Illinois: Facts for Homeowners. Illinois State Geological Survey, Environmental Geology 144, 1993, Champaign, IL,16 p.

The ISGS prepared this publication to explain the causes and nature of subsidence and to discuss ways of minimizing the damage caused by subsidence. With this information, homeowners will be able to decide whether they live in subsidence-prone areas, understand some common effects of mine subsidence, and recognize problems that can be mistaken for mine subsidence.

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

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

Baumgardner, R. W., A. D. Hoadley. Geology and Hydrology of the Wink Sink, Texas. Bureau of Economic Geology, University of Texas, Austin, October, 1980, 12 p.

Keyword(s): hydrology, geologic features

Location(s): Texas, United States

Bawden, W. F., P. Mottahed. Comparison of Three Subsidence Prediction Techniques Applied to Saskatchewan Potash Mining. IN: Proceedings 88th Annual General Meeting of Canada Institute of Mining, Montreal, Paper no. 89, 1986, 34 p.

Keyword(s): prediction, prediction theories, non-metal mining

Location(s): Canada

Beard, J. T. The Action Influence and Control of Roof in Long Workings. Transactions, Institute of Mining Engineers, London, v. 28, 1904-05, p. 341-347.

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

Location(s): England

Beck, B. F., ed. Sinkholes: Their Geology, Engineering and Environmental Impact. Proceedings, 1st Multidisciplinary Conference on Sinkholes, Orlando, FL, October 15-17, 1984, Florida Sinkhole Research Institute, University of Central Florida, Balkema, Rotterdam, 429 p.

The editor states that the term sinkhole (or doline) should refer only to localized land surface depressions arising from karst processes. Solution sinkholes form from the slow dissolution of bedrock and are not generally an engineering problem although they may be an avenue for groundwater pollution. Collapse sinkholes arise when the roof of a bedrock cavern collapses; such incidents are rare. Subsidence sinkholes (geology) or ravelling sinks (engineering) form by the piping of unconsolidated overburden into karstic openings in the underlying soluble bedrock, usually limestone. Localized land surface subsidence, rapid or slow, may also arise from numerous non-karstic causes, particularly mining and soil piping. It is suggested that these features be referred to collectively as subsidence pits to distinguish them from true sinkholes.

Keyword(s): environment, engineering, geologic features, fluid extraction

Beck, R. E., S. Sigwerth. Illinois Coal Mine Subsidence Law. DePaul Law Review, v. 29, no. 2, Chicago, IL, 1980.

This paper provides an historical overview of the development of subsidence law in Illinois; it reviews the principles of liability and legal problems established by cases.

Keyword(s): law, coal mining

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

Beck, R. E. Illinois Coal Mine Subsidence Law Updated. Southern Illinois University Law Journal, v. 1985, no. 3, 1986, The Board of Trustees of Southern Illinois University, Carbondale, IL.

A considerable number of important developments in the Illinois coal mine subsidence law have taken place since 1980.

Keyword(s): law, government, economics, coal mining, longwall, insurance

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

Beck, R. E. Recent Illinois Court Decisions on Coal Mine Subsidence. Mineral Matters, v. 8, no. 5, October, 1986, Southern Illinois University, Carbondale, IL.

During 1985 both the federal district court for the Southern District of Illinois and the Illinois Circuit Court for the Second Judicial Circuit announced decisions relating to two coal mine subsidence cases. While neither case has been concluded, the decisions to date contain several interesting points. Both cases involved subsidence resulting from longwall mining, and several questions were raised.

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

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

Beck, W. W., A. L. Russnow, G. H. Emrich. Relationship Between Underground Mine Water Pools and Subsidence in the Northeastern Pennsylvania Anthracite Fields. Appalachian Regional Commission Report ARC-73-111-2553, April, 1975, 411 p. (NTIS PB 242 467)

This study is part of a comprehensive program related to the land subsidence that occurred in the anthracite region of northeastern Pennsylvania in response to Tropical Storm Agnes. The objectives of the study were to (1) determine the mine pool factors that contribute to or influence subsidence, (2) define and document present mine pool conditions in the anthracite fields of Northeastern Pennsylvania, and (3) recommend the most effective and feasible methods of controlling the mine pools to reduce or prevent future subsidences. The findings of this investigation were as follows: (1) peak precipitation precedes subsidence 87% of the time; (2) subsidence occurs in areas where roof rock conditions are poor or where abnormally high hydrostatic pressure occurs in structurally weak areas; (3) subsidence occurs along outcrop areas and where a high percentage of coal has been removed; and (4) subsidence occurred during Tropical Storm Agnes where high hydrostatic pressure developed.

Keyword(s): subsurface water, anthracite, coal mining, geologic features

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

Beck, W. W., G. H. Emrich. Coal Mine Subsidence and Mine Pools--Northern Anthracite Field, Pennsylvania. American Society of Civil Engineers National Spring Convention and Continuing Education, Pittsburgh, PA, April 24-28, 1978, ASCE Preprint 3293, p. 1-25.

Subsidence has been a problem almost since the inception of deep mining in the anthracite region

of northeastern Pennsylvania. It appears to have been a more acute problem during active mining than after mining. This paper explores causes of subsidence in the area, including rock failure, flow of water, high precipitation periods, and attributes of the overburden (especially sandstone).

Keyword(s): subsurface water, anthracite, coal mining, geologic features, hydrology, historical, abandoned mines

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

Bee, R. W. Environmental Action Programs for Northeastern Pennsylvania Refuse Bank Removal/Subsidence. U.S. Bureau of Mines OFR 3-73, Mitre Corporation, Contract SO111414, 1972, 529 p. (NTIS PB 214 535)

Keyword(s): environment, land-use planning, mine waste

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

Beevers, C., K. Wardell. Recent Research in Mining Subsidence. Transactions, Institute of Mining Engineers, London, v. 114, 1954-55, p. 223-253.

Recent observations in the Yorkshire coalfield by precise surveying techniques are described and illustrated in this paper. Some conclusions relating to maximum possible subsidence, limiting angle, and the general angle of ground movement are discussed. The importance and influence of traveling or dynamic ground movements, particularly over comparatively shallow workings, is emphasized and examples are given.

Keyword(s): mine design, survey methods, partial extraction, stowing, survey methods, subsidence research, angle of draw, coal mining

Location(s): England

Begley, R. D., L. E. Gray, G. M. Zickefoose. Design Considerations for Structures to be Built on Subsidence Prone Land. IN: Proceedings, 2nd Workshop on Surface Subsidence Due to Underground Mining, Morgantown, WV, June 9-11, 1986, S.S. Peng, ed., West Virginia University, Morgantown, p. 181-193.

This paper presents detailed design drawings of a flexible single floor residential superstructure proposed for both longwall and room-and-pillar mining conditions. All efforts were made to provide an immediately available economical alternative for future home builders on subsidence prone land. Because of this, a basement was not included in the design because additional costs and measures would be required to minimize cracking and leakage. A cost comparison with a traditional superstructure demonstrated that this would be a cost effective alternative.

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

Begley, R. D., A. W. Khair. Development of a Mechanistic Model for Prediction of Maximum Subsidence and Subsidence Profile Due to Longwall 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. 495-502.

This paper summarizes the development of a mechanistic model to predict longwall mining induced surface subsidence. The model was originally developed from data acquired from a recent field study conducted in Northern West Virginia. Additional data have been collected from published sources and used to refine the model.

Keyword(s): modeling, prediction, longwall, angle of draw, overburden, geologic features, rock mechanics, coal mining, time factor

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

Begley, R. D. Development of a Mechanistic Model for Prediction of Subsidence Over Longwall Mines. Ph.D. Dissertation, 1989, Department of Mining Engineering, West Virginia University, Morgantown.

Keyword(s): modeling, prediction, coal mining, longwall

Location(s): United States

Bell, F. G. The Character of the Coal Measures. IN: Site Investigations in Areas of Mining Subsidence, Chapter 2, 1975, F.G. Bell, ed., Newnes-Butterworths, London, p. 25-39.

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

Location(s): England

Bell, F. G. Salt and Subsidence in Cheshire, England. Quarterly Journal of Engineering Geology, v. 9, 1975, p. 237-247.

Keyword(s): non-metal mining

Location(s): England

Bell, F. G. Ground Conditions in Mining Areas. Methods of Treatment of Unstable Ground,1975, F.G. Bell, ed., Newnes-Butterworths, London, p. 112-140. (NTIS Accession No. 77-08479)

Keyword(s): engineering, foundations, coal mining, soils, soil mechanics, geologic features, mine operation

Location(s): Europe, England

Bell, F. G. Risk of Subsidence. Building, 15 April, 1977, p. 96-99.

The need for urban redevelopment on a large scale together with the increase in the rate of construction due to increasing mechanisation and the increasing scarcity of suitable sites has meant that in recent years sites formerly regarded as unsuitable have been considered for building purposes. Furthermore, most of the large industrial centers of Britain, in all of which redevelopment is going on, are underlain by rocks of coal measures. Therefore an added redevelopment concern in such areas is concerned is the problem of past or existing mineral workings.

Keyword(s): land-use planning, active mines, abandoned mines, coal mining, surface structural damage, roads, non-metal mining, foundations, vertical displacement, horizontal displacement, National Coal Board, mitigation, structural mitigation, backfilling, angle of draw

Location(s): United Kingdom

Bell, F. G. Subsidence Due to Mining Operations. IN: Proceedings Conference on Foundation Engineering in Difficult Ground, September, 1976, Sheffield, England, 1978, F.G. Bell, ed., Newnes-Butterworths, London, p. 322-362. (NTIS Accession No. 78-47931)

Keyword(s): coal mining, foundations, backfilling, non-metal mining, engineering

Location(s): Europe

Bell, F. G. Location of Abandoned Workings in Coal Seams. Bulletin of the International Association of Engineering Geology, v. 33, April, 1986, p. 123-132.

Coal mining has gone on in many parts of Western Europe and North America, frequently for 200 years or more. Consequently, in many urban areas, there are abandoned workings at shallow depth that often are unrecorded. Investigation of abandoned coal mine workings is no easy task and requires some knowledge of past methods of mineral exploitation.

Keyword(s): coal mining, abandoned mines, geophysical

Location(s): Europe, United States

Bell, F. G. Subsidence. IN: Ground Engineer's Reference Book, Ch. 15, August, 1987, F.G. Bell, ed., Butterworths, London, 24 p.

The author states that subsidence is an inevitable consequence of mining activities, and it reflects the movements that occur in the mined out area. Unfortunately, subsidence can and does have serious effects on surface structures, services and communications; it can also be responsible for flooding and lead to the sterilization of land or make remedial measures or special constructional design in site development necessary.

Keyword(s): historical, room-and-pillar, monitoring methods, mitigation, longwall, geologic features, prediction, surface structural damage, fluid extraction, coal mining, non-metal mining

Bell, F. G. The Influence of Subsidence Due to Present Day Coal Mining on Surface Development. 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. 359-367.

Urban development and redevelopment in areas of present day coal mining faces a potential problem due to associated subsidence. Obviously the main aim of a developer is to produce a successful development with economy of design and minimization of any subsequent subsidence damage so that structures fulfill their function throughout their design life.

Keyword(s): land-use planning, active mines, coal mining, engineering, longwall, National Coal Board, surface structural damage, structural mitigation, foundations

Location(s): United Kingdom

Bell, F. G., J. C. Cripps, M. G. Culshaw, M. O'Hara. Aspects of Geology in Planning. 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. 1-38.

In this paper, the opportunity is taken to explore some of the more important geological factors that may significantly influence the planned use of land. Both natural and man-made geological hazards (including mine subsidence) are considered.

Keyword(s): land-use planning

Bell, F. G. The History and Techniques of Coal Mining and the Associated Effects and Influence on Construction. Bulletin of the Association of Engineering Geologists, v. 15, no. 4, 1988, p. 471-504.

Coal mining has gone on in many parts of western Europe and North America, frequently for 200 years or more. Consequently, in many urban areas, there are abandoned workings at shallow depth beneath the ground surface that are frequently not recorded. These may present a potential hazard when such areas are redeveloped. Subsidence from longwall mining can be regarded as more or less contemporaneous with the mining activity, and, it normally is predictable within about 10%. Obviously, measures must be taken to avoid significant damage to structures resulting from mining activity. Such measures differ according to the type of subsidence problem to be dealt with, that is, whether it is generated by the existence of old workings or by present day extraction.

Keyword(s): coal mining, historical, longwall, room-and-pillar, active mines, abandoned mines, land-use planning, surface structural damage, engineering, construction, non-metal mining, overburden, geologic features, law, foundations, pillar strength, pillar extraction, floor stability, roof stability, horizontal displacement, prediction, modeling, prediction theories, backfilling, National Coal Board

Location(s): United States, Europe, United Kingdom, Appalachian Coal Region, England, South Africa, Germany, France, Poland, Soviet Union, Illinois Coal Basin, Rocky Mountain Coal Region

Bell, F. G., J. M. Coulthard. Subsidence Prediction by the Use of Influence Functions. IN: Engineering Geology of the Underground Movements, Geological Society Engineering Geology Special Publication No. 5, F.G. Bell, et al., eds., 1988, p. 265-273.

Surface subsidence occurs as a result of extraction of a mineral resource at some depth below the surface. Most coal is mined in this way in the U.K., and such coal workings are responsible for most subsidence and the associated damage that occurs. Hence, it has become necessary to develop methods of predicting the amount of subsidence likely to develop due to coal mining. Many methods have been advanced, dating back to the latter part of the last century. However, they can be separated into three groups, namely the theoretical, the empirical, and the semi-empirical methods. A number of these methods were reviewed with the object of selecting one that lent itself to the development of a relatively simple computer program that could be used on a microcomputer. The complementary influence function method was chosen, and a program was developed to predict a complete subsidence profile for a given set of circumstances. The concept of complementary influence functions considers not only the influence of the extracted elements on a surface point but also the influence of the material remaining after extraction.

Keyword(s): prediction theories, influence function, prediction, coal mining, longwall, empirical model, computer

Location(s): United Kingdom

Bell, F. G., J. C. Cripps, M. G. Culshaw, M. A. Lovell. A Review of Ground Movements Due to Civil and Mining Engineering Operations. IN: Engineering Geology of Underground Movements, Geological Society Engineering Geology Special Publication No. 5, F.G. Bell, et al., eds., 1988, p. 3-32.

Human activity frequently causes ground movements that may later cause problems. The most notable examples of ground movements are provided by the mining industry in the form of subsidence. Mining in the broad sense includes removal of material from the ground and that material may be solid, liquid, or gas. Indeed some of the largest subsidences recorded have been in association with the abstraction of oil and groundwater, instances having occurred where the ground surface has been lowered by several meters over large areas. The construction industry is also responsible for generating ground movements, admittedly usually on a small scale. For example, deep excavation causes a reduction in the vertical and horizontal pressure in the ground and thereby can induce heave of the base of the excavation, together with inward and vertical movements, both up and down. Ground movements may develop as a result of tunnelling, particularly in soft ground, and may resemble those associated with longwall mining of coal. Induced seismicity is another example. In this case, some of the most noteworthy examples have been provided by reservoir loading and the permeation of water into the ground. Small scale seismic events also have been associated with mining activity.

Keyword(s): coal mining, tunnelling, fluid extraction, oil extraction, construction, longwall, seismic, soils, room-and-pillar

Location(s): United Kingdom

Bell, F. G., M. G. Culshaw, J. C. Cripps, M. A. Lovell, eds. Engineering Geology of Underground Movements. Geological Society Engineering Geology Special Publication No. 5, 1988, 455 p.

This book is concerned with those ground movements caused by human activity. It includes movements due to construction operation, notably deep excavations due to mining activity and the abstraction and injection of fluids, and due to induced seismicity. Prediction monitoring and control and related design measures run as a common thread throughout.

Keyword(s): engineering, tunnelling, soils, boundary element, prediction, fluid extraction, coal mining, abandoned mines, non-metal mining, influence function, roof stability, monitoring methods, shortwall, seismic, metal mining

Location(s): United Kingdom, Singapore, Poland

Bell, F. G., B. Mortimer. Subsidence Due to Abandoned Mines: Risk, Evaluation and Mitigation. IN: Proceedings 6th Australia-New Zealand Conference on Geomechanics, Christchurch, February 3-7, 1992, New Zealand Geomechanics Society, p. 215-220.

Shallow underground workings cause significant problems during redevelopment of old mining regions. Detailed information on the location of old mines is not always available. Thematic geological maps have been produced for some areas, and they can be used as an initial aid to hazard avoidance. It is still necessary to locate and ascertain the state of abandoned mines before development. This can be done using a combination of direct and indirect techniques. A site can then be zoned according to degree of risk. Stabilization by filling or special foundation structures may be used in certain cases.

Keyword(s): abandoned mines, land-use planning, coal mining, foundations, backfilling

Bell, F. G., M. G. Culshaw, B. S. P. Moorlock, J. C. Cripps. Subsidence and Ground Movements in Chalk. Bulletin of International Association of Engineering Geology, 1992, no. 45, Paris, p. 75-82.

Subsidences that occur within, or near, the outcrop of the Chalk are due to the collapse either of solution features or of old mine workings. Only the latter are considered here. Mine workings in the Chalk extend back into the distant past, the most ancient workings being those of Stone Age man in his quest for flint. The collapse of old mine workings is unpredictable and, to make the situation worse, most old workings are unrecorded and are therefore a potential hazard in areas scheduled for development.

Keyword(s): abandoned mines, non-metal mining, historical, overburden, remote sensing, photography, geophysical, backfilling, land mitigation, surface structural damage, land-use planning

Location(s): United Kingdom

Bell, F.G. Ground Subsidence: A General Review. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May 1992. South African Institution of Civil Engineers, Republic of South Africa, p. 1-20.

Mining has gone on in many parts of the world for centuries. Consequently, in many areas there are abandoned workings at shallow depth beneath the ground surface, which are frequently not recorded. This is especially the case in western Europe and North America where old room-and-pillar workings in coal may present a potential hazard when areas are developed or redeveloped. Subsidence consequent upon longwall mining can be regarded as more or less contemporaneous with the mining activity. Obviously, measures must be taken to avoid significant damage to structures due to mining activity. Such measures differ according to the type of subsidence problem, that is, whether it is generated by the existence of old workings or by present day extraction.

Keyword(s): abandoned mines, active mines, surface structural damage, longwall, room-and-pillar, pillar strength, remote sensing, geophysical, seismic, land-use planning, foundations, backfilling, grouting, coal mining, geologic features, prediction, modeling, influence function, zone area, National Coal Board, structural mitigation

Location(s): Europe, United States

Bell, F. G., ed. Methods of Treatment of Unstable Ground. Newnes-Butterworths, London, 1975.

Keyword(s): ground control

Bell, F. G., ed. Site Investigations in Areas of Mining Subsidence. Newnes-Butterworths, London, 1975, 168 p.

Keyword(s): coal mining

Bell, F. G., ed. Foundation Engineering in Difficult Ground. Newnes-Butterworth, 1978.

Keyword(s): foundations, engineering

Bell, S. E. Successful Design for 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. 562-578.

The CLASP system of building is designed to withstand the effects of mining subsidence. The author inquires as to how CLASP-designed buildings have withstood mining subsidence over a 16-year period.

Keyword(s): mine design, surface structural damage, land-use planning, engineering, coal mining

Location(s): United Kingdom

Belous, Y. I. Effect of Transverse Walls on Total Rigidity of Undermined Buildings. Soil Mechanics and Foundation Engineering, v. 18, no. 1, January-February, 1981 (translated from Russian).

This paper describes investigations to establish the effect of transverse walls and their foundations on the preservation of buildings undermined in the territory of the Lvov-Volyn coal basin.

Keyword(s): surface structural damage, subsurface structural damage, construction, soil mechanics, foundations, coal mining, architecture

Location(s): Soviet Union

Ben-Hassine, J., E. C. Drumm, J. D. Hoskins III, R. M. Bennett. Mechanistic Approach for the Prediction of Structural Response Due to Subsidence. 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. 373-390.

In the past, the satisfactory prediction of structural damage due to subsidence has been limited, and has been primarily empirical. Mechanistic analysis methods such as the finite element method allow the representation of the soil-structure system by the respective mechanical properties and geometries. Such a representation provides a rational means for the prediction of not only structural damage, but the complete structural response during a specified subsidence event. These methods also permit the economical evaluation of different types of construction, and various damage mitigation measures.

Keyword(s): structural mitigation, modeling, finite element, prediction, surface structural damage, foundations, construction, longwall

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

Bennett, H. B., H. E. Sanford, R. W. Stahl. Continuous Mining with Solid Pneumatic Stowing at Dornisthrope Colliery. Transactions, Institute of Mining Engineers, v. 114, 1954, p. 625; also Colliery Guardian, v. 189, no. 4896, December, 1954, p. 811.

Keyword(s): pneumatic backfilling, stowing

Location(s): United Kingdom

Bennett, R. M., E. C. Drumm, D. C. Johnson. Behavior of Linear Foundations Subjected to Longwall Subsidence. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 121-128.

Twelve linear test foundations were constructed over an advancing longwall panel in southern Illinois. Various mitigation techniques were incorporated into the footings. From the results of the study, preliminary recommendations are made regarding construction of footings and foundations over mining areas.

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

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

Benson, J. B., H. E. Sanford, R. W. Stahl. Conditions and Practices of Coal Mines in the Ruhr District of Western Germany. U.S. Bureau of Mines IC 7549, 1950, 48 p.

Following World War II, a 1-year investigation was made of safety conditions and operating practices in German mines.

Keyword(s): backfilling, mine safety, coal mining

Location(s): Germany

Benson, R. C. Assessment of Localized Subsidence (Before the Fact). IN: Proceedings, International Conference on Evaluation and Prediction of Subsidence, Pensacola Beach, FL, January, 1978, S.K. Saxena, ed., American Society of Civil Engineers, New York, 1979, p. 47-57.

Keyword(s): prediction

Location(s): United States

Benson, R. C., L. B. Yuhr. Assessment and Long Term Monitoring of Localized Subsidence Using Ground Penetrating Radar. IN: Karst Hydrogeology: Engineering and Environmental Applications, Proceedings, 2nd Multidisciplinary Conference on

Sinkholes and the Environmental Impacts of Karst, Orlando, FL, 1987, B.F. Beck and W.L. Wilson, eds., p. 161-169.
Keyword(s): monitoring methods, monitoring equipment

Benzley, E., R. D. Krieg. A Continuum Finite Element Approach for Rock Failure and RUBBLE Formation. SAND8O-227, Sandia National Laboratories, Albuquerque, New Mexico, August, 1980, 23 p.
Keyword(s): modeling, finite element
Location(s): United States

Benzley, S. E., R. D. Krieg. A Continuum Finite Element Approach for Rock Failure and RUBBLE Formation. International Journal for Numerical and Analytical Methods in Geomechanics, v. 6, 1983, p. 277-286.
Keyword(s): finite element, modeling

Benzley, S. E. SCRUBS.BYU, A Finite Element Formulation for Underground Resource Removal. College of Engineering Sciences and Technology, Brigham Young University, Provo, UT, December, 1983, 101 p.
Keyword(s): finite element, modeling
Location(s): United States

Benzley, S. E., D. W. Basinger. SCRUBS.BYU, Application of Combined Jointed Media and Discrete Media Plane Characteristics to Subsidence Prediction. College of Engineering Sciences and Technology, Brigham Young University, Provo, UT, December, 1984, 218 p.
Keyword(s): modeling, finite element, prediction
Location(s): United States

Berbower, R. F. Subsidence Problem in the Long Beach Harbor District. ASCE Journal of the Waterways, Harbors, and Coastal Engineering Division, v. 85, no. WW2, June, 1959, p. 43-80.
The author discusses subsidence of the ground surface due to oil extraction and salt water injection to repressure depleted formations.
Keyword(s): surface water, oil extraction, fluid extraction
Location(s): United States

Berbower, R. F. Effects of Ground Surface Subsidence in the Long Beach Harbor District. IN: American Society Testing and Materials Proceedings, v. 64, 1965, p. 903-921.
Keyword(s): fluid extraction
Location(s): California, United States

Bergstrom, R. E., K. Piskin, L. R. Follmer. Geology for Planning in the Springfield-Decatur Region. Illinois State Geological Survey, Circular 497, 1976, Champaign, IL, 76 p.
Keyword(s): land-use planning, coal mining, historical, abandoned mines, geologic features, surface structural damage
Location(s): Illinois, Illinois Coal Basin, United States

Berry, D. S. Theoretical Investigations of Ground Movement Due to Mining Operations. Annual Report for the National Coal Board, Department of Mining Engineering, University of Nottingham, 1961.
Keyword(s): coal mining, modeling, National Coal Board, phenomenological model, elastic model, prediction
Location(s): United Kingdom

Berry, D. S. Ground Movement Considered as an Elastic Phenomena. The Mining Engineer, v. 37, 1963, p. 28-39.
Keyword(s): phenomenological model, elastic model, modeling

Berry, D. S., T. W. Sales. An Elastic Treatment of Ground Movement Due to Mining. Journal of Mechanics and Physics of Solids, pt. 1, v. 8, 1960, p. 280-292; pt. 2, v. 9, 1961, p. 52-62; pt. 3, v. 10, 1962, p. 73-83; pt. 4, v. 11, 1963, p. 373-375.
Keyword(s): modeling, phenomenological model, elastic model

Berry, D. S. The Ground Considered as a Transversely Isotropic Material. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 1, 1964, p. 159-167.
Keyword(s): continuum mechanics, rock mechanics, modeling, phenomenological model, elastic model

Berry, D. S. Ground Movement Considered as an Elastic Phenomenon. The Mining Engineer, London, v. 123, no. 41, 1964, p. 28-41.
Keyword(s): continuum mechanics, modeling, phenomenological model, elastic model

Berry, D. S. A Theoretical Elastic Model of the Complete Region Affected by a Mining Seam. IN:

Proceedings 6th U.S. Symposium on Rock Mechanics, 1964, E.M. Spokes and C.R. Christiansen, eds., University of Missouri at Rolla, p. 310-329.

The author proposes an elastic model theory to describe subsidence resulting from longwall mining with complete or nearly complete caving. This model is considered applicable to the final deformed state when movement has ceased, even though previous movement is considered to be viscoelastic. The ground is treated as a transversely isotropic medium.

Keyword(s): rock mechanics, longwall, phenomenological model, elastic model, modeling

Berry, D. S. A Discussion of the Stochastic Theory of Ground Movement. Felsmechanik und Ingenieurgeologie (Rock Mechanics and Engineering Geology) II/3-4, 1964, p. 213-227.

Keyword(s): modeling, empirical model, stochastic model

Berry, D. S., G. J. Marshall. Calculation of the Stress Around an Advancing Longwall Face in Viscoelastic Ground. IN: First Congress, International Society of Rock Mechanics, v. 2, 1966, p. 379-384.

The large scale behavior of the ground is assumed to be transversely isotropic and viscoelastic. The seam is supposed to be deep and sufficiently thin, in comparison with other significant measurements, that it can be considered to be of infinitesimal thickness, and the face advances at a constant rate. The resulting stress distribution and displacement field in the surrounding rock mass are computed with the aid of a computer for a number of viscoelastic materials.

Keyword(s): prediction, longwall, modeling, phenomenological model, elastic model, viscoelastic model, rock mechanics

Berry, D. S. Progress in the Analysis of Ground Movements due to Mining. 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. 781-811.

This paper is intended as a historical review as well as an account of current ideas on analytical methods of estimating ground movements resulting from mining

Keyword(s): modeling, phenomenological model, elastic model, historical, prediction, angle of draw, empirical model, prediction theories, National Coal Board, coal mining, profile function, influence function, stochastic model, continuum mechanics, finite element, time factor

Location(s): United Kingdom

Beshai, J. Subsidence Monitoring. Geos (Canada), v. 14, no. 3, 1985, p. 22-25.

CANMET developed a system to monitor ground movement and provide a means of predicting when ground failures would occur. The integrated monitoring system incorporates tiltmeters, photogrammetry, and geodetic survey techniques. The tiltmeter system uses computerized radiotelemetry to determine the time required for caving to migrate to the surface, aerial photogrammetry delineates the extent of the subsidence area, and electro-optical distance techniques provide accurate measurements in easily accessible areas.

Keyword(s): monitoring methods, monitoring design, monitoring equipment, coal mining, geologic features, photography, survey methods, active mines

Location(s): Canada

Beyer, F. On Predicting Ground Deformations Due to Mining Flat Seams. Thesis presented to the Technical University of Berlin, 1945 (in German).

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

Beyer, L. Bergschadenssicherung von Gasleitungen (Protecting Gas Pipelines from Damage by Mining). Gas-Wasserfach, Gas-Erdgas, v. 122, no. 4, 1981, p. 181-186.

Keyword(s): pipelines, utilities

Bezuidenhout, C. A., J. F. Enslin. Surface Subsidence and Sinkholes in the Dolomitic Areas of the Far West Rand, Transvaal, Republic of South Africa. International Association Hydrological Sciences Publication 89, 1970, p. 482-495.

Keyword(s): geologic features

Location(s): South Africa

Bhattacharya, S., M. M. Singh, C. Y. Chen. Proposed Criteria for Subsidence Damage to Buildings. IN: Rock Mechanics in Productivity and Protection, Proceedings 25th Symposium on Rock Mechanics, June, 1984, C.H. Dowding and M.M. Singh, eds., Northwestern University, Evanston, IL, p. 747-755.

United States federal and state regulatory authorities require underground mine operators to adopt adequate measures to minimize material damage to the surface caused by mine subsidence. This paper presents an approach to define and determine the extent of material damage due to subsidence from underground coal mining. The basic steps involved in the development of adequate criteria have been enumerated together with the approaches and methodologies used.

Keyword(s): surface structural damage, engineering, rock mechanics, literature search

Location(s): United States

Bhattacharya, S., M. M. Singh, N. N. Moebs. Mine Subsidence Hazard Detection Technique for Pennsylvania's Anthracite Coalfields. 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. 977-984.

This paper presents a methodology to screen potential sites in the anthracite coalfields to determine which sites would be most appropriate to monitor for impending subsidence activity. It provides an integrated monitoring plan for subsidence detection using surface geophysical techniques.

Keyword(s): abandoned mines, anthracite, coal mining, land mitigation, monitoring design, monitoring equipment, instrumentation, geophysical, room-and-pillar, land-use planning

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

Bhattacharya, S., M. M. Singh. Development of Subsidence Damage Criteria. Report on U.S. Office of Surface Mining Contract J5120129, Engineers International, Inc., Westmont, IL, October 1985, 226 p. (NTIS PB90-147356)

Federal and State regulatory authorities require underground mine operators to adopt adequate measures to minimize material damage (MD) to the surface caused by mine subsidence. However, what constitutes MD to surface structures and renewable resource lands has not been clearly defined. The report proposes criteria for determining MD to a wide range of surface structures and renewable resources based on observed trends of selected data on surface effects of underground coal mining from major coal-producing regions in the United States and abroad. Guidelines are provided to determine time span for post-mining subsidence damage.

Keyword(s): coal mining, surface subsidence damage, government, land mitigation, structural mitigation, rock mechanics, soil mechanics, engineering, prediction, soils, surface structural damage, roads, railroads, pipelines, room-and-pillar, longwall, profile function, National Coal Board

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

Bhattacharyya, A. K., D. M. Shu. Mathematical Modelling of Surface Subsidence in the Coal-Fields of New South Wales Using a Back Analysis Technique. IN: Proceedings International Symposium on Land Subsidence, Dhanbad, 1989, p. 20-29.

Keyword(s): modeling, mathematical model, coal mining

Location(s): Australia

Bhattacharyya, A. K., M. A. Pattinaja. Mathematical Modelling of the Convergence and Vertical Stress Patterns Around a Longwall Panel in 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. 175-181.

Mathematical modeling was carried out to determine the probable convergence and vertical stress patterns around a retreating longwall panel in an underground coal mine in New South Wales. An "Electrical Resistance Analogue" and a program called "THREED" based on the displacement of discontinuity method were used for the modeling. Parts of the obtained results are presented here and compared with some measurements of convergence at the site. The modelled and measured data agree better qualitatively than quantitatively.

Keyword(s): modeling, mathematical model, longwall, coal mining, vertical displacement

Location(s): Australia

Bickley, D., T. Keptner, E. Eisenbise, F. Carlson, R. Springman. The Development of Environmental Guidelines for Land Use Policy, Applicable to Floodprone and Mine-Subsidence-Prone Areas in Pennsylvania. Department of Environmental Resources, Harrisburg, PA, June 1975, 229 p. (NTIS PB 249 532)

Keyword(s): surface water, land-use planning, environment

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

Bieniawski, Z. T. In-Situ Strength and Deformation Characteristics of Coal. Engineering Geology, v. 2, no. 5, 1968, p. 325-340.

Keyword(s): pillar strength, ground control, in situ testing, coal mining

Bieniawski, Z. T. Note on In Situ Testing of the Strength of Coal Pillars. Journal of the South African Institute of Mining and Metallurgy, v. 68, May, 1968, p. 454-464.

The uniform load and uniform deformation methods are discussed and compared as two possible methods of in situ testing of large coal specimens. Current in situ tests using the uniform load method are described and a pillar strength formula is proposed for design purposes in South Africa. Complete load-deformation characteristics of coal are also discussed.

Keyword(s): pillar strength, in situ testing, coal mining, mine design, rock mechanics, geotechnical

Location(s): South Africa

Bieniawski, Z. T. The Effect of Specimen Size on Compressive Strength of Coal. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 6, no. 4, 1968.

Keyword(s): coal mining, lab testing, pillar strength

Bieniawski, Z. T. In Situ Large Scale Testing of Coal. IN: Proceedings Conference on In Situ Investigations in Soils and Rocks, British Geotechnical Society, 1969, p. 67-74.

Keyword(s): pillar strength, ground control, geotechnical, in situ testing, coal mining

Location(s): England

Bieniawski, Z. T., W. L. Van Heerden. The Significance of In-Situ Tests on Large Rock Specimens. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 12, no. 4, 1975, p. 101-114.

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

Bieniawski, Z. T., F. Rafia, D. A. Newman. Ground Control Investigations for Assessment of Roof Conditions in Coal Mines. 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. 691-700.

This paper presents the results of geotechnical investigations aimed at assessing roof conditions in coal mines. The study included diamond core drilling, borescope observations, borehole and core logging, and engineering geological mapping in two coal mines. The field investigations were accompanied by regional geology studies involving aerial photography and lineament analysis as well as by laboratory testing of rock and coal samples. A bibliography on roof control in coal mines is provided.

Keyword(s): roof stability, coal mining, ground control, in situ testing, lab testing, rock mechanics, geotechnical, photography, remote sensing, modeling

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

Bieniawski, Z. T. Improved Design of Coal Pillars for U.S. Mining Conditions. IN: Proceedings 1st Annual Conference on Ground Control in Mining, West Virginia University, July 27-29, 1981, S.S. Peng, ed., Morgantown,WV, p. 13-22.

This paper presents the results of a survey of room-and-pillar dimensions and design practice in U.S. coal mines aimed at improving the design procedures in room-and-pillar mining. A review is given of the current pillar strength formulas, and suggestions are made for better use of research results in engineering practice.

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

Location(s): United States

Bieniawski, Z. T. An Overview of Ground Support Considerations in Room and Pillar Coal Mining. IN: Proceedings, Conference on Ground Control in Room and Pillar Mining, Southern Illinois University at Carbondale, August 6-8, 1980, Y.P. Chugh, ed., SME-AIME, New York, 1982, p. 95-104.

Ground support requirements for safe and economical design of room-and-pillar coal mining layouts are reviewed. The design methods for mine roof and mine pillars are discussed, and the role of the geotechnical aspects are considered. It is shown that current support design procedures in the United States do not fully use the latest research findings, and the need for more effective technology transfer in coal mine ground control is emphasized. Promising new developments in ground support are identified, and possible research areas are suggested.

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

Location(s): United States

Bieniawski, Z. T. Improved Design of Room-and-Pillar Mining Systems. Final Report to U.S. Department of Energy, June, 1982, 1983.

Keyword(s): mine design, room-and-pillar

Location(s): United States

Bieniawski, Z. T. New Design Approach for Room-and-Pillar Coal Mines in the U.S.A. IN: Proceedings, International Congress on Rock Mechanics, Melbourne, Australia, 1983, p. E27 - E36.

A detailed study has been made of the United States practice and design needs for room-and-pillar coal mining. Although some 90% of underground coal mining in the United States is by the room-and-pillar method, no comprehensive design procedure is available for this purpose. A survey of more than 200 coal mines was conducted and typical mining conditions and room-and-pillar configurations were analyzed during a 3-year research project. Specific investigations were conducted to improve the methods of span selection, roof support and pillar design in the coal mines. In particular, pillar strength formulae for coal mining were studied. An improved procedure for room-and-pillar coal mining in the United States was proposed.

Keyword(s): coal mining, mine design, room-and-pillar, rock mechanics, roof stability, pillar strength

Location(s): United States

Bieniawski, Z. T. Rock Mechanics Design in Mining and Tunneling. 1984, Balkema, 272 p.

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

Bieniawski, Z. T. Strata Control in Mineral Engineering. John Wiley & Sons, New York, 1986, 240 p.

This book covers the state-of-the-art of strata control practice in the United States and abroad, including rock bolting, longwall mining technology, and energy development. The stability of rock pillars, rockbursts, shaft design, and rock engineering are described. Mineral and energy needs in the United States are also detailed.

Keyword(s): ground control, longwall, roof stability, roof support, pillar strength

Location(s): United States

Bieniawski, Z. T. Towards A Creative Design Process in Mining. Mining Engineering, November 1988, v. 40, no. 11, p. 1040-1043.

After many significant advances in mining, including development of sophisticated methods for strata characterization and numerical modeling analyses, the engineering design process in mining strata control is as primitive as it was two decades ago. Yet, major advances in design methodologies have occurred in other branches of engineering. Is creative design in mining a myth only? Are we deluding ourselves when we talk about innovative mining design of today? Did you know that most design experts are often unaware of their own decision-making processes? This paper explores the methodology of creative engineering design as a newly recognized discipline.

Keyword(s): ground control, mine design, engineering, geotechnical, rock mechanics, mine waste

Bischke, R. E., P. S. Getty. A Method for Assessing the Potential of Mine Subsidence at Abandoned Mine Sites Through the Assistance of Finite Element Modeling. 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. 722-726.

The analysis of subsidence prone sites reveals the importance of understanding and applying all of the parameters influencing mine subsidence Finite element modeling is capable of incorporating the parameters specific to each site, which is an important shortcoming of empirical methods. The finite element model's usefulness in interpreting the in situ stresses within mines and the surface subsidence anticipated over mined regions is exemplified in the increased efficiency and effectiveness of subsidence prevention programs.

Keyword(s): modeling, finite element, coal mining, prediction, abandoned mines, bituminous, anthracite, multiple-seam extraction

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

Bise, C. J. Pennsylvania's Subsidence-Control Guidelines: Should They Be Adopted by Other States? Mining Engineering, v. 33, November, 1981, p. 1623-1628.

This paper analyzes the Pennsylvania Bituminous Mine Subsidence Act of 1966--the only comprehensive subsidence act passed by any state. The applicability of this law to other states is also discussed.

Keyword(s): ground control, law

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

Black, R. A., A. N. Brown. The Measurement and Analysis of Strata Movements Connected with the Extraction of a Shaft Pillar at Depth. Association of Mine Managers of South Africa, Papers and Discussion, 1960-61, p. 231-313.

Keyword(s): pillar extraction, monitoring methods

Location(s): South Africa

Blair, B. E. Physical Properties of Mine Rock. Part 3. U.S. Bureau of Mines RI 5130, 1955, 69 p.

Keyword(s): rock mechanics, lab testing

Location(s): United States

Blair, B. E. Physical Properties of Mine Rock. Part 4. U.S. Bureau of Mines RI 5244, 1956, 69 p.

Keyword(s): rock mechanics, lab testing

Location(s): United States

Blevins, C. T. Horizontal Stress Problems in Illinois Basin Coal Mines. IN: Proceedings, 3rd Conference on Ground Control Problems in the Illinois Coal Basin, August 8-10, 1990, Mt. Vernon, IL, Y.P. Chugh, ed., Southern Illinois University, Carbondale, 1990, p. 92-97.

In situ directional horizontal stresses are evident in underground mines throughout the Illinois Coal Basin. Evidence of these stresses exists in mines in Indiana, Western Kentucky and Illinois. These stresses normally cause ground control problems in north-south headings, ranging from minor inconveniences to extremely serious problems that become the primary reason for mine closures. This paper covers the following areas relating to horizontal stresses: geological features, mining methods to minimize horizontal stress problems during development of entries and cross cuts, and mining methods to minimize horizontal stress problems during pillar recovery.

Keyword(s): coal mining, roof stability, ground control, geologic features, mine operation, roof support, roof bolting

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

Bloemsma, J. P., E. Shackley, W. D. Claeys. The Effects of Total Extraction Mining Methods on the Stability of Roads at New Denmark Colliery. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May 1992. South African Institution of Civil Engineers, Republic of South Africa, p. 145-155.

The results of extensive research at New Denmark Colliery into the caving characteristics of the overburden strata and the development of surface subsidence above longwall and shortwall panels are presented. The results are compared with other, industry-wide research; empirical methods for predicting future subsidence are highlighted. On a number of occasions public roads were undermined and the resulting minor damage correlated to the influencing subsidence parameters, such as induced ground strains and tilts. This paper describes how confident predictions can be made by relating the extent of anticipated damage to road alignments and surfaces to expected subsidence and planned total extraction mining layouts.

Keyword(s): coal mining, longwall, shortwall, prediction, roads, law, surface structural damage, vertical displacement, horizontal displacement, geologic features

Location(s): South Africa

Bodus, T. M. Relationship Between the Clay Fabric of Roof Shales and Roof Collapse in Mines of the Herrin Coal, Southern Illinois. 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. 605-612.

The strength of roof shales is, in part, a function of the preferred orientation of clay minerals within them. Therefore, analysis of clay fabric under both air-dried and hydrated conditions should be helpful in understanding roof shale failure. Core samples were collected from the Energy, Anna, and Lawson shales, which are locally present as roof shales of the Herrin No. 6 coal of southern Illinois. The Clay Fabric Index (CFI) was measured for 30 core samples, using X-ray diffractometry, to investigate the relationship between clay fabric and roof collapse in coal mines. Greater CFI values indicate a weaker preferred orientation among clay minerals, which generally results in a weaker inter-grain bond.

Keyword(s): roof stability, coal mining, geologic features, lab testing

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

Bodziony, J., J. Litwiniszyn, A. Smolarski. New Research Into Rock Masses Treated as Media Characterized by Stochastic Equations. IN: Proceedings, International Conference on Strata Control, Paris, 1960, p. 137-150.

Keyword(s): modeling, empirical model, stochastic model

Bojarski, Z., A. Szczurowski. Report Prepared for the Coal Committee, U.N. Economic Commission for Europe on "The Exchange of Experiences in the Field of Coal Working Under Buildings and Industrial Plants." Central Mining Institute, Research Center for the Deposit and Surface Protection, Katowice, Poland, December 1978, 27 p.

This report contains detailed information on the mining of safety pillars.

Keyword(s): vertical displacement, horizontal displacement, mine design, prediction, pillar extraction, surface structural damage, coal mining

Location(s): Poland, Europe

Bonell, R. A. UK Longwalls, A Review of Strata Control Experience and Current Trends. IN: Proceedings, 6th International Strata Control Conference, Paper 25, Banff, Canada, 1977.

Keyword(s): longwall, ground control, coal mining

Location(s): United Kingdom

Bonte, A. Mining Subsidence and Geology. Industrie Minerale, St. Etienne, France, v. 61, no. 10, 1979, p. 531-541.

Keyword(s): geologic features

Booth, C. J. The Hydrogeological Impact of Deep Longwall Mining, Appalachian Plateau, Pennsylvania. IN: Proceedings, National Water Well Association Conference on the Impact of Mining on Ground Water, Denver, CO, 1984, p. 360-379.

An investigation of the Barnes and Tucker Company's Lancashire No. 20 Mine, Cambria County, Pennsylvania, was conducted to provide a conceptual model and calibration data for the development of a numerical model of groundwater flow associated with underground coal mining in the Appalachian Plateau. This paper presents some hydrologic results and conclusions relating to the groundwater inflow to the mine and the impact of the mine on overlying aquifers.

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

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

Booth, C. J. A Numerical Model of Groundwater Flow Associated with an Underground Coal Mine in the Appalachian Plateau, Pennsylvania. Ph.D. Dissertation, 1984, The Pennsylvania State University, University Park, 458 p.

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

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

Booth, C. J. Strata-Movement Concepts and the Hydrogeological Impact of Underground Coal Mining. Ground Water, v. 24, no. 4, 1986, p. 507-515.

A review of mining-engineering concepts and studies in mine hydrology suggests a conceptual model linking the strata-deformation, hydraulic property changes, and groundwater impacts due to underground coal mining. A study of a deep coal mine in the Appalachian Plateau, Pennsylvania, indicated (1) probable hydraulic connections between the mine and shallow aquifers in a principal valley area; (2) no obvious response of water levels in shallow aquifers to undermining by supported headings; and (3) rapid, considerable declines in such water levels in response to nearby longwall mining. These results are consistent with the conceptual model.

Keyword(s): subsurface water, hydrology, coal mining, modeling, overburden, geologic features, inflow

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

Booth, C. J., J. A. Saric. The Effects of Abandoned Underground Mines on Ground Water, Saline County, Illinois. IN: Proceedings, National Symposium on Mining, Hydrology, Sedimentology, and Reclamation, Springfield, IL, December 7-11, 1987, University of Kentucky, Lexington, UKY BU145, p. 243-248.

The hydrogeological effects of abandoned underground coal mines were studied at the town of Muddy, Saline County, Illinois. Muddy is underlain by two abandoned mines at depths of 300 and 400 feet, and exhibits subsidence features. Water levels were measured in glacial and bedrock aquifer wells in 1985-1986. The water table follows the nearly flat topography. The bedrock piezometric surface exhibits anomalies interpreted as being due to leakage of water from glacial to bedrock aquifers, possibly through well casings and from shallow bedrock aquifers to the mine because of subsidence-induced fracturing. The bedrock heads over the mine itself are anomalously low, indicating that the mine is absorbing the upward regional groundwater discharge. No effects of subsidence were noted on the transmissivities determined from simple pumping tests of wells. The

groundwater in the glacial aquifer is of intermediate hydrochemical facies. In the bedrock, it is dominated by Na and HCO3, consistent with a regional-upwelling ground-ater provenance. The chemistry also indicates some mixing between glacial and bedrock waters. The impacts at Muddy are minor but indicate that abandoned underground mines interfere with groundwater flow patterns, and they have the potential for significant impacts on local groundwater resources and the migration of poor quality water into aquifers.

Keyword(s): hydrology, subsurface water, abandoned mines, coal mining, overburden, geologic features, inflow

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

Booth, C. J., E. D. Spande, D. F. Brutcher, B. B. Mehnert. Hydrogeological Response to Longwall Coal Mining in Illinois. Geological Society of America Abstracts with Programs, 1989, p. A230.

Underground coal mining in the Illinois Basin has been mainly dry, with little impact on the minor aquifers present. Longwall mining, however, which causes rapid subsidence and strata fracturing and is known (in Appalachia) to affect aquifer properties and groundwater flow, has been introduced recently to the area. This study, under the Illinois Mine Subsidence Research Program, is of the aquifer response to longwall mining in this new hydrogeological setting.

Keyword(s): hydrology, subsurface water, coal mining, longwall, overburden, active mines

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

Booth, C. J., E. D. Spande, D. F. Brutcher, B. B. Mehnert. Effects of Longwall-Induced Subsidence on Groundwater Hydrology in Southern Illinois. An Industry Under Siege: Some Facts About Subsidence, American Mining Congress and Illinois Coal Association Seminar, February 15-16, 1990, Mt. Vernon, IL.

Historically, underground coal mining in Illinois has been dry and had little effect on the minor aquifers present. However, high-extraction mining, which has been observed in Appalachia to considerably affect aquifer properties and groundwater flow, is being increasingly used in the area. This study, under the Illinois Mine Subsidence Research Program, is examining aquifer response to longwall mining in Illinois.

Keyword(s): longwall, hydrology, subsurface water, coal mining, active mines, geologic features

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

Booth, C. J., E. D. Spande. Piezometric and Aquifer Property Changes Above Subsiding Longwall Panels, Southern Illinois. IN: EOS, Transactions of American Geophysical Union Spring Meeting, Baltimore, MD, May 30, 1990, v. 71, no. 17, 1990, p. 506 (abstract of poster session).

Longwall mining, a recent feature in Illinois, creates rapid ground subsidence over the rectangular panels of coal extracted; the associated fracturing changes the aquifer properties and piezometric levels in the overlying strata. In this Illinois Mine Subsidence Research Program study (1988-1990), wells and piezometers were monitored and aquifer properties determined before and after subsidence over a longwall mine 700 feet deep.

Keyword(s): hydrology, subsurface water, longwall, geologic features, monitoring methods, coal mining

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

Booth, C. J., E. D. Spande. Response of Groundwater Hydrology to Subsidence Above a Longwall Mine in Illinois. 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. 113-118.

This study examined the effects of longwall-related subsidence and fracturing on aquifer properties and potentiometric levels above an active, 725-foot-deep longwall mine in southern Illinois.

Keyword(s): hydrology, overburden, longwall, subsurface water, active mines, coal mining

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

Booth, C. J., E. D. Spande. Changes in Hydraulic Properties of Strata Over Active Longwall Mining, Illinois, USA. IN: Proceedings, 4th International Mine Water Congress, Portschach, Austria, September, 1991, p. 163-174.

This study examined potentiometric and hydraulic property changes caused by active longwall mining at two sites in Illinois.

Keyword(s): coal mining, active mines, longwall, hydrology, subsurface water, overburden, monitoring methods, geologic features

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

Booth, C. J., P. J. Carpenter, E. D. Spande, J. T. Kelleher, B. B. Mehnert, D. J. Van Roosendaal. Geological Control of the Hydrogeological Effects of Longwall Mining: New Interpretations from Recent IMSRP Studies in Illinois. IN: Geological Society of America, Abstracts with Programs, No. 17783, October, 1991, p. A39.

Illinois Mine Subsidence Research Program studies show that the hydrogeological impact of longwall coal mining is principally mediated by subsidence-induced changes in hydraulic properties, and thus differs with lithologic variations, from unit to unit and between sites. This model is supported by IMSRP results from potentiometric monitoring, pre- and post-subsidence determination of hydraulic properties, and surface and subsurface strain characterization over two active longwall mines.

Keyword(s): hydrology, geologic features, longwall, coal mining, monitoring methods, active mines, vertical displacement, horizontal displacement

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

Booth, C. J. Hydrogeologic Impacts of Underground (Longwall) Mining in the Illinois Basin. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 222-227.

Hydrogeological impacts of active longwall mining were studied at two sites in Illinois. At the site with the more transmissive sandstone aquifer, aquifer permeabilities increased an order of magnitude due to subsidence. Piezometric levels declined with subsidence due to increased porosity, and ahead of mining due to a transmitted drawdown. Levels recovered rapidly at first and fully over 2 years. At the site with the less transmissive aquifer, impacts were similar except that recovery has been limited. Local aquifer enhancement through increased yield can occur, but only where the aquifer is transmissive enough for recovery.

Keyword(s): longwall, hydrology, subsurface water, geologic features, active mines, coal mining, monitoring methods

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

Booth, C. J., E. D. Spande. Potentiometric and Aquifer Property Changes Above Subsiding Longwall Mine Panels, Illinois Basin Coalfield. Ground Water Journal, v. 30, No. 3, May-June 1992, p. 362-368.

This study examined the response of potentiometric levels and hydraulic properties to subsidence caused by a 725-foot-deep active longwall mine in southern Illinois.

Keyword(s): hydrology, subsurface water, overburden, coal mining, longwall, active mines, geologic features

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

Boreck, D. L. Increasing the Recovery of Thick and Closely Spaced Coal Seams in the Western US--Some Geologic and Longwall Considerations. Mining Engineering, March 1988, p. 168-173.

This paper examines some of the geologic factors that would affect development of thick or closely spaced seams in the western United States. In an effort to increase future recovery from such deposits, the USBM analyzed the potential for incorporating three thick-seam mining methods into western coal mines. These methods are high-face longwall, multi-slice longwall, and longwall caving.

Keyword(s): geologic features, coal mining, longwall, multiple-seam extraction, roof stability, mine safety

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

Borecki, M., A. Kidyibinski. Coal Strength and Bearing Capacity of Coal Pillars. IN: Proceedings, 2nd International Congress on Rock Mechanics, 1970, v. 2, Paper No. 3-21, p. 145-152.

Keyword(s): pillar strength, rock mechanics, coal mining

Born, D. D. Longwall Mining Near An Impoundment Embankment--A Case Study. 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. 231-233.

This paper describes conditions of cover and strata in the Pittsburgh seam where a body of impounded water was safely undermined.

Keyword(s): longwall, surface water, coal mining, inflow

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

Boscardin, M. D., E. J. Cording, T. D. O'Rourke. Case Studies of Building Behavior in Response to Adjacent Excavation. Report No. UMTA-

IL06-0043-78-2, U.S. Department of Transportation, Washington, DC, 1978.

Keyword(s): engineering, surface structural damage

Location(s): United States

Boscardin, M. D. Building Response to Excavation-Induced Ground Movements. Ph.D. Thesis, University of Illinois, Urbana-Champaign, 1980, 279 p.

The study showed that the most useful relationships between building damage and distortions could be established when both lateral strains and angular distortions were measured. However, some estimate of the lateral ground strains affecting a structure could be made based upon the settlement slopes if the settlement profile shape and the size and position of the structure with respect to the settlement profile were known. Once a reasonable estimate of the ground movements caused by an excavation was made, the figures and tables presented in this report could be used to estimate the response of a structure and the resulting damage.

Keyword(s): surface structural damage, tunnelling, instrumentation, engineering, architecture, modeling, horizontal displacement, construction

Location(s): United States, District of Columbia, Illinois

Boscardin, M. D., I. Ahmed. Subsidence Effects on Buildings and Buried Pipelines. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 106-112.

This paper reviews subsidence-induced ground movements, how these ground movements are transmitted to and accommodated by buildings and buried pipelines, and how these structures may alter ground movements relative to free field, subsidence-induced ground movements.

Keyword(s): pipelines, surface structural damage, utilities, prediction, structural mitigation, soils, active mines, abandoned mines

Bosworth, R. G. What Duty to Support the Surface Does a Subsidence Owner Owe? AIME Technical Publication No. 116, May, 1928, 44 p.

Keyword(s): surface structural damage, land-use planning, mine operation

Location(s): United States

Boukharov, G. N., M. W. Chanda. A Theoretical Study Into Damage to Pillars Caused by Blasting. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May 1992. South African Institution of Civil Engineers, Republic of South Africa, p. 53-57.

Surface subsidence when mining is dependent on the behaviour of the pillars supporting the overlying strata. Different factors influence pillar strength; one of them is the damage caused to the pillars from cracks induced or propagated in the rock by blasting. This paper presents an attempt to estimate the thickness of a damage zone to the pillar caused by blasting.

Keyword(s): modeling, pillar strength, engineering, mathematical model

Bowders, J., M. Gabr, G. Pigott. Analysis of a Landfill Over a Deep Mined Area: A Case Study. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 146-157.

A case study describing the expansion of a landfill over a deep mined area is described. Finite element analyses were used to predict the surface subsidence and associated tensile strains on the landfill liner of the expansion site. A synthetically reinforced liner system is recommended to minimize the impact of subsurface movements on the integrity of the liner system.

Keyword(s): finite element, prediction, geologic features, coal mining, abandoned mines, overburden, rock mechanics

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

Bowders, J. J., Jr., S. C. Lee. Effect of Longwall Mining Subsidence on the Stability of Surface Slopes. IN: Proceedings, 7th International Conference on Ground Control in Mining, August 3-5, 1988, S.S. Peng, ed., Morgantown, WV, p. 314-320.

The stability of surface slopes undergoing subsidence due to longwall mining was investigated to examine the effect of subsidence on the stability of the slopes. Stability analyses were performed on all slopes along both longitudinal and transverse sections of the longwall panel before and after subsidence. Both finite- and infinite-slope analyses were performed with both drained and undrained cases. The results indicated that the changes in the stability of slopes due to subsidence were insignificant for the cases analyzed. Although significant lateral ground movements were

recorded, these were not attributed to slope failure. Explanations for these movements are presented.

Keyword(s): longwall, geologic features, coal mining, active mines, instrumentation, survey methods, soils

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

Bowman, C. H., M. G. Karfakis, E. Topuz, C. Haycocks. Backfilling in Coal Mining - A State-of-the-Art Review. 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. 193-205.

The effect of subsidence can be mitigated by the placement of the correct fill during and/or after the mining operation. Fills, if properly selected and placed for the prevailing geologic and mining conditions, have the potential, during the mining operation, of functioning as alternative ground control measures, increasing coal recovery, and enhancing ventilation control. During post-abandonment, they serve the purpose of minimizing subsidence, preserving the hydrologic regime, minimizing underground fires, and enhancing post-mining surface land use and value.

Keyword(s): coal mining, mine fires, partial extraction, room-and-pillar, longwall, backfilling, active mines, hydraulic backfilling, pneumatic backfilling, stowing, mine waste

Location(s): United States

Boyum, B. H. Subsidence Case Histories in Michigan Mines. IN: Proceedings, 4th Symposium on Rock Mechanics, State College, PA, March 30-April 1, 1961. Bulletin Mineral Industry Experiment Station, v. 76, November, 1961, p. 19-57.

This report covers the cumulative studies on mine subsidence in Michigan underground iron mines, with particular emphasis on the investigations by the Cleveland-Cliffs Iron Company. Most of the information and effort have been related to the Marquette Iron Range, the oldest in the Lake Superior region. A historical summary is presented with a brief description of the geology of Range. Sketches of some early subsidence case histories are related.

Keyword(s): rock mechanics, seismic, metal mining, pillar strength, monitoring methods, monitoring equipment, subsidence research

Location(s): Michigan, United States

Brackley, I. J. A., P. N. Rosewarne, L. A. Grady. A Prediction of Surface Subsidence Caused by Lowering the Water-Table in Dolomite. IN: Proceedings, 3rd International Symposium on Ground Subsidence, Venice, Italy, 1984.

Keyword(s): prediction, subsurface water, geologic features, fluid extraction

Brackley, I. J. A. Numerical Prediction of Dolomitic Subsidence Caused by Mine Dewatering. IN: Proceedings, SANGORM Symposium, October 21, 1986, International Society for Rock Mechanics, South African National Group, Sandton p. 115-121.

The dewatering of hydrological compartments by deep gold mines has resulted in dolomitic sink-holes and subsidence. Great difficulty has been experienced in locating areas of high risk, but certain empirical criteria have been developed.

Keyword(s): subsurface water, prediction, metal mining, surface structural damage

Location(s): South Africa

Brady, B. H. Rock Mechanics and Ground Control for Underground Mining and Construction. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings of the 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 5-17.

Recent improvements are described in several techniques for ground control in underground mining. Promising methods for analysis and mitigation of rockbursts are discussed. Methods of assessing damage to underground excavations from repetitive seismic loading are reviewed. Analysis of mining-induced surface subsidence is discussed.

Keyword(s): rock mechanics, ground control, engineering, longwall, overburden, grouting, geologic features, coal mining, prediction, metal mining, modeling

Location(s): Australia, Finland

Brady, B. T., F. G. Horino, W. I. Duvall. The Use of Rock Belts or Wire Rope to Increase the Strength of Fractured Model Pillars. U.S. Bureau of Mines RI 7568, 1971, 24 p.

Keyword(s): pillar strength

Location(s): United States

Brady, S. D. Subsidence in the Sewickley Bed of Bituminous Coal Caused by Removing the Pittsburgh Bed in Monongalia County, West Virginia. Transactions, AIME, Coal Division, Fairmont Meeting, March 26-27, 1931.

The author concludes that coordination of mine designs and pillar pulling can protect overlying and underlying seams. The upper seam must be developed simultaneously with the lower, but retreat pillaring of the lower should be after pillaring of the upper seam.

Keyword(s): mine design, pillar extraction, multiple-seam extraction, room-and-pillar, pillar strength, coal mining, bituminous

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

Branham, K. L. Cavity Detection Using High-Resolution Seismic Reflection Methods. M.S. Thesis, 1984, Southwest Missouri State University, Springfield, 75 p. (NTIS PB90-264565)

Surface collapses due to abandoned coal mines are a problem of great concern in southwest Kansas. A reliable and cost-efficient method for detecting mined cavities is needed to evaluate prospective construction sites. High-resolution reflection was used successfully to detect mined cavities in a 3-foot-thick coal seam at depths of 29 and 43 feet. A dominant frequency of 275 Hz was attained and reflections from the top and bottom of the coal seam were resolved. The reflected event from the top of the coal seam exhibited reduced amplitudes over water and coal ash slurry-filled cavities. The reflected event from the bottom of the coal seam exhibited a velocity pull-up beneath water and slurry-filled cavities.

Keyword(s): seismic, abandoned mines, coal mining, land-use planning

Location(s): Kansas, United States

Branthoover and Richards, Inc. Final Report Mine Subsidence Control Project SL452-102.2, Marion Elementary and Bellmar Junior High Schools, Belle Vernon Area School District, Washington Township, Fayette County, Pennsylvania. Prepared for Commonwealth of Pennsylvania. Department of Environmental Resources, Harrisburg, PA, 1979.

Keyword(s): surface structural damage

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

Branthoover, G. L., J. W. Richards. Mine Subsidence Control Using Foundation Grouting, Southwestern Pennsylvania. IN: Proceedings 18th Annual Engineering Geology Soils Engineering Symposium, Boise, ID, April 2-4, 1980, Pennsylvania Department of Environmental Resources, p. 323-337.

This paper overviews a subsidence investigation program that includes core borings, borehole television, and rock mechanics. It also describes instrumentation and stabilization of structures.

Keyword(s): surface structural damage, rock mechanics, foundations, structural mitigation, architecture, instrumentation

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

Brass, J. F. First Modern Longwall in Alabama. Mining Congress Journal, October, 1980, p. 25-30.

At the time of this article, there were around 85 longwall installations operating in this country, so a new one was hardly headline news. However, Jim Walter Resources planned to install 11 longwalls in a part of the country better known for cotton growing than advanced technology mining. Indeed, when the first of these longwall units started up, the next nearest working longwall was about 400 miles away. Described here are some of the considerations involved in introducing the new system, as well as the early operating experience.

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

Location(s): Alabama, United States

Brauner, G. Critical Review of Present-Day Theory and Practices in the Prediction of Surface Deformation Caused by Mining. U.S. Bureau of Mines Grant GO100749 MIN-28, Michigan Technological University, December, 1969, 57 p.

The author reviews subsidence prediction methods with an emphasis on European methods; these are divided into two groups, on the basis of mathematical expressions either for the trough profile or for the influence of infinitesimal extraction elements.

Keyword(s): vertical displacement, horizontal displacement, prediction, prediction theories, mathematical model

Brauner, G. Subsidence Due to Underground Mining (In Two Parts). 1. Theory and Practices in Predicting Surface Deformation. U.S. Bureau of Mines IC 8571, 1973, 56 p.

The author details two fundamental methods of predicting mine subsidence: the trough profile and the influence of infinitesimal extraction elements. Also included are analyses of horizontal displacements and deformations, surface displacements over inclined seams, time effects, and physical and abstract models.

Keyword(s): empirical model, vertical displacement, horizontal displacement, prediction, prediction theories, surface structural damage, ground control, profile function, influence function, horizontal displacement, time factor

Location(s): Europe, Soviet Union

Brauner, G. Subsidence Due to Underground Mining (In Two Parts). 2. Ground Movements and Mining Damage. U.S. Bureau of Mines IC 8572, 1973, 53 p.

The author discusses the practical implications of ground movements involving surface structures and shafts, including structural and underground precautions against mining damage.

Keyword(s): surface structural damage, mine design, stowing, room-and-pillar, vertical displacement, horizontal displacement, time factor, ground control, descriptive theories, surface subsidence damage, surface water

Location(s): Soviet Union

Brauner, G. Calculation of Ground Movements in European Coalfields. IN: Proceedings 4th Annual Symposium on Subsidence in Mines, Wollongong, Australia, February 20-22, 1973, A.J. Hargraves, ed., Australasian Institute of Mining and Metallurgy, Illawarra Branch, Paper 10, p. 10-1 - 10-8.

The precalculation methods preferred in European coal-mining are classified in three groups, namely direct formulas, the profile function method, and the superposition method. The fundamentals are empirical relationships and theoretical approaches. The calculation parameters that characterize the strata conditions must be found from measured ground movements. The horizontal displacements and strains can be determined from the derivatives of the subsidence curves. The direct formulas can be applied to distinct surface points only, the profile function method to entire trough profiles in cases of simple mining geometries, and the superposition method to any surface point and arbitrary mining geometries. A more general influence function may be employed for the superposition method when the agreement with observed movements appears to be insufficient.

Keyword(s): coal mining, prediction, prediction theories, profile function, horizontal displacement, vertical displacement, influence function

Location(s): Europe

Breeds, C. D. A Study of Mining Subsidence Effects on Surface Structures With Special Reference to Geological Factors. Ph.D. Thesis, University of Nottingham, England, 1976, 250 p.

This is a comprehensive reference on protecting existing surface structures from severe subsidence damage. It includes history and appraisal of early prediction methods and a description of the prediction methods used at the time in England.

Keyword(s): vertical displacement, horizontal displacement, surface structural damage, subsurface structural damage, structural mitigation, mine design, ground control, monitoring design, monitoring installation, monitoring equipment, survey methods, survey equipment, foundations, prediction, prediction theories, historical, geologic features

Location(s): England

Breeds, C. D., C. Haycocks, M. Karmis, E. Topuz. Design Optimization in Underground Coal Systems Sections 1, 2, 3, and 4. Virginia Polytechnic Institute, Department of Mining and Mineral Engineering, November, 1979, 66 p. (NTIS FE-1231-18)

Keyword(s): mine design, coal mining

Location(s): United States

Breeds, C. D., M. Karmis, C. Haycocks. Subsidence - Prevention or Control. IN: Proceedings, 1st Conference on Ground Control Problems in the Illinois Coal Basin, Southern Illinois University, August 22-24, 1979, Carbondale, IL, 1980, p. 283-296.

This paper examines a solution for subsidence damage that is readily accepted in other foreign coalfields. That is the concept of control, or accommodation of subsidence movements. Both underground and surface methods of lessening the effects of mining subsidence are discussed. In addition, two case studies are presented to illustrate the success of one surface and one underground method.

Keyword(s): ground control, surface subsidence damage, surface structural damage, stowing, structural mitigation, geologic features, shortwall, room-and-pillar, longwall, mine design

Location(s): United States, United Kingdom

Briggs, H., J. Morrow. An Attempt at the Rationale of Faulting and Subsidence. Transactions, Institute of Mining Engineering, London, v. 73, 1926-27, p. 465-505.

Keyword(s): geologic features

Location(s): England

Briggs, H. Mining Subsidence. Edward Arnold & Co., London, 1929, 215 p.

This book provides a comprehensive study of mine subsidence, with information on British laws, historical theories, partial extraction mining and backfilling. It contains observations from England, India, and the United States.

Keyword(s): surface structural damage, law, historical, backfilling, partial extraction

Location(s): England, India, United States

Briggs, H. Flexure of Undermined Strata. Colliery Engineering, v. 9, 1932, p. 247-251.

Keyword(s): overburden, time factor, rock mechanics

Briggs, H., W. Ferguson. Investigation of Mining Subsidence at Barbauchlaw Mine, West Lothian. Transactions, Institute of Mining Engineering, London, v. 85, 1932-33, p. 303-334.

Location(s): England

Brink, D., F. von M. Wagener. The Construction of Tailings Dams on Areas Mined by High Extraction Mining Methods. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May, 1992. South African Institution of Civil Engineers, Republic of South Africa, p. 243-247.

High extraction mining methods result in surface subsidence. Ultimately, a point of equilibrium is reached where the resistance of the compressed rubble that fills the mining void equals the weight of the overburden strata. At this point no further surface subsidence should occur. If a tailings dam is constructed on a subsided area, the overburden pressure increases and secondary subsidence will occur. This paper covers the aspect of the prediction of secondary settlement induced by additional loading of a mined area and gives practical recommendations for the design and operation of tailings dams on subsided areas.

Keyword(s): coal mining, longwall, pillar extraction, prediction

Location(s): South Africa

British Geotechnical Society. Settlement of Structures. Halsted Press, New York, 1975, 811 p.

Keyword(s): geotechnical, surface structural damage

Location(s): England

Broms, B. B., A. Frederickson. Land Subsidence in Sweden Due to Water Leakage into Deep-Lying Tunnels and its Effects on Pile Supported Structures. IN: Proceedings, 2nd International Symposium on Land Subsidence, Anaheim, CA, IAHS-AIHS Publication No. 121, December, 1976.

Keyword(s): subsurface water, tunnelling

Location(s): Sweden

Brook, D., K. W. Cole. Subsidence of Abandoned Limestone Mines of West Midlands of England. IN: Land Subsidence, Proceedings, 3rd International Symposium on Land Subsidence, 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. 675-685.

Abandoned limestone mines in the West Midlands of England present potential problems of subsidence under urban areas. A study was made to (1) discover the extent of information that remains, (2) investigate the extent of the mines and physical characteristics of the mines and the rocks surrounding them, (3) establish the degree of risk, if any, of ground movement occasioned by the collapse of the mines, and (4) consider and recommend remedial and other works for dealing with the assessed risk.

Keyword(s): abandoned mines, non-metal mining, coal mining, surface structural damage, literature search, geologic features, backfilling, land-use planning

Location(s): United Kingdom

Brook, G. A., T. L. Allison. Fracture Mapping and Ground Subsidence Susceptibility Modeling in Covered Karst Terrain: The Example of Dougherty County, Georgia. 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. 595-606.

Subsidence susceptibility maps of a covered karst terrain in southwest Georgia have been developed using a geographic information system. Five variables were used in the model: sinkhole density, sinkhole area, fracture density, fracture length, and fracture intersection density. Broadly similar subsidence susceptibility models were developed from the data.

Keyword(s): geologic features, modeling

Location(s): Georgia, United States

Brown, A., F. L. Casey. An Investigation Into Surface Subsidence Associated With the Extraction

of Coal Seams. Canada Department of Energy, Mines, and Resources, Mining Research Centre International Report MR 71/88-10, 1971, 39 p.

Keyword(s): surface subsidence damage, coal mining

Location(s): Canada

Brown, A., J. Murphy, H. Bartell. Slurry Backfilling of an Underground Coal Mine. IN: Conference on Hydraulic Fill Structures, Colorado State University, Fort Collins, August 15-18, 1988, D.J.A. Van Zyl and S.G. Vick, eds., ASCE Geotechnical Special Publication No. 21.

The Wyoming Abandoned Mine Lands program is remediating the impacts resulting from mining conducted over the last century. An important part of that program calls for the control of subsidence over abandoned underground coal mines. This paper describes the planning, performance, and effectiveness of a subsidence control project conducted in Hanna, Wyoming, in which 800,000 tons of remotely placed hydraulic backfill was used as a supporting medium for part of an underground coal mine that underlies the main part of the town. This project is the first fully successful application of this technology in the western United States.

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

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

Brown, D. F., D. S. Buist. Mine Workings and Their Treatment on the Unstone-Dronfield By-Pass. Department of the Environment Construction, v. 17, 1976, p. 23-25.

Keyword(s): roads, land-use planning

Brown, E. O. F. Packing Excavations in Coal Seams by Means of Water. Transactions, Institution of Mining Engineers, v. 28, 1905,.

This article discusses hydraulic sand backfilling in Poland.

Keyword(s): hydraulic backfilling, mine fires, coal mining

Location(s): Poland, Europe

Brown, E. T., E. Hoek. Trends in Relationship Between Measured In-Situ Stresses and Depth. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 15, 1978, p. 211-215.

Keyword(s): rock mechanics, in situ testing

Brown, R. E. A Multi-Layered Finite Element Model for Predicting Mine Subsidence. Ph.D. Thesis, Carnegie-Mellon University, Pittsburgh, PA, 1968.

Results of a finite element model of subsidence movements were compared with British field data, and showed good agreement for the cases studied.

Keyword(s): modeling, prediction, finite element, phenomenological model, elastic model

Location(s): England

Brown, R. L., R. R. Parizek. Shallow Ground-Water Flow Systems Beneath Strip and Deep Coal Mines At Two Sites, Clearfield County, Pennsylvania. The Pennsylvania State University Special Research Report SR-84, May 1, 1971, Contract No. CR-66.

The objective of this study was to describe the groundwater flow systems in rock units associated with coals so that acid mine drainage could be more effectively prevented, treated, isolated, or diluted as conditions require. The physical groundwater flow systems for two sites near Kylertown, Pennsylvania, were approximated by flow net construction. The flow nets cannot give a unique solution to the flow problem because all of the parameters were not completely defined. In particular, the influence of joints on horizontal and vertical permeabilities could not be specifically measured.

Keyword(s): hydrology, subsurface water, coal mining, geologic features, monitoring methods, abandoned mines

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

Bruhn, R. E. The Tolerance of Structures to Ground Movements - Some Considerations. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 83-93.

This paper considers several cases where structural behavior and site specific details had to be taken into account in assessing the relationship between damage and ground movements.

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

Bruhn, R. W., M. O. Magnuson, R. E. Gray. Subsidence Over the Mined-Out Pittsburgh Coal. American Society of Civil Engineers National Spring Convention and Continuing Education, Pittsburgh, PA, April 24-28, 1978, ASCE Preprint 3253, 1978, p. 26-55.

This paper discusses subsidence as it occurs above abandoned mines in the Pittsburgh Coal of western Pennsylvania. In particular, it dentifies two principal types of subsidence of subsidence features (sinkholes and troughs), presents data from 354 incidents of subsidence, and discusses the costs of subsidence to the public.

Keyword(s): economics, room-and-pillar, prediction, abandoned mines, coal mining

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

Bruhn, R. W. Mine Subsidence in the Pittsburgh Area. IN: 45th Annual Field Conference of Pennsylvania Geologists, Pittsburgh, October 3-4, 1980, Pittsburgh Geological Society, p. 25-35.

Keyword(s): surface subsidence damage

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

Bruhn, R. W., M. O. Magnuson, R. E. Gray. Subsidence Over Abandoned Mines in the Pittsburgh Coalfield. 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. 142-156.

This paper discusses subsidence above abandoned mines in the Pittsburgh Coal based on data from 354 documented incidents that took place in western Pennsylvania and West Virginia in the period of 1955 to 1976. Past mining practice is related to subsidence and available information regarding the geometry of subsidence features, and their time of occurrence is summarized. Practical inferences are drawn, and several cases are cited where human activities have apparently hastened the onset of subsidence above abandoned mines.

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

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

Bruhn, R. W., W. S. McCann, R. C. Speck, R. E. Gray. Damage to Structures Above Active Underground Coal Mines in the Northern Appalachian Coal Field. IN: Proceedings 1st Conference on Stability in Underground Mines, Vancouver, British Columbia, Canada, August 16-18, 1982, AIME, 21 p.

This paper presents the results of a characterization study of subsidence damage to 134 homes. It proposes a uniform subsidence-damage classification system for structural damage.

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

Location(s): Appalachian Coal Region, United States

Bruhn, R. W., R. C. Speck, W. S. McCann, O. S. Cecil. Survey of Ground Surface Conditions Affecting Structural Response to Subsidence. Final Report to U.S. Bureau of Mines, OFR 12-84, Contract JO295014, June, 1983, by GAI Consultants, Inc., Monroeville, PA, 601 p. (NTIS PB 84-155860)

The objective of the study is to examine the apparent influence of soil and near-surface rock strata on the severity of damage experienced by surface structures subjected to mine subsidence. The report discusses (1) modes of ground movement that might complicate or be confused with mine subsidence; (2) prevailing concepts concerning mine subsidence in the Northern Appalachian Coal Field and Illinois Basin; (3) apparent influences of soil and near-surface rock strata on the character of subsidence-related ground movements; (4) classifications and criteria for characterizing damage due to ground movements; and (5) types of subsidence damage experienced by homes above active mines in western Pennsylvania. Presented is a damage classification system incorporating a severity index for characterizing subsidence damage to homes with basements above active mines. A series of case histories illustrate subsidence damage to structures above active and abandoned mines.

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

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

Bruhn, R. W., R. C. Speck, R. E. Thill. The Appalachian Field: Damage to Structures Above Active Underground Mines. IN: Surface Mining Environmental Monitoring and Reclamation Handbook, L.V.A. Sendlein, et al., eds., Coal Extraction and Utilization Research Center, Southern Illinois University at Carbondale, U.S. Department of Energy Contract No. DE AC22 80ET 14146, Elsevier, New York, 1983, p. 657-670.

This paper reviews four major topics concerning subsidence over active mines: the character of subsidence damage experienced by conventional homes, including typical repair costs, methods of

predicting subsidence damage, the frequency of occurrence of subsidence damage, and techniques of mitigating subsidence damage.

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

Location(s): Appalachian Coal Region, United States

Bruhn, R. W., R. C. Speck. Ground Movements Associated with Pillar Extraction Coal Mining in Northern West Virginia. 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. 727-736.

An investigation was made of ground response to pillar retreat mining in a 1.7-meter-thick seam at a depth of 108 meters at a site in northern West Virginia. This paper describes mining-related stress changes and movements at mine level, displacements within the overburden, ground surface subsidence and groundwater level variations. Subsidence approached 40% of the mine height and continued for more than a year after mining. Water levels declined in some of the deep-lying strata.

Keyword(s): pillar extraction, coal mining, high-extraction retreat, overburden, subsurface water, active mines, instrumentation, monitoring methods

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

Bruhn, R. W. Case Report: Coal Mine Subsidence in Farmington, West Virginia. Underground Space, v. 9, no. 5-6, 1985, p. 261.

The town of Farmington, in Marion County, West Virginia, was visited by consulting geotechnical engineers to determine the cause of ground movements that had become prominent the preceding year.

Keyword(s): utilities, surface structural damage, geotechnical, abandoned mines, room-and-pillar, pillar strength, reclamation, backfilling, coal mining

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

Bruhn, R. W. Influence of Deep Mining on the Ground Water Regime at a Mine in Northern Appalachia. 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. 234-248.

Findings concerning groundwater effects presented in this paper indicate that total extraction mining produced significant water level declines in deep-lying strata, but had little effect on water levels at shallower depths. Post-mining values of hydraulic conductivity were typically somewhat higher than pre-mining values. Changes in water chemistry associated with mining were not sufficient to render the water unfit for human consumption.

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

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

Bruhn, R. W., G. W. Luxbacher, J. R. Ferrell, T. A. Gray. The Structural Response of a Steel Lattice Transmission Tower to Mining-Related Ground Movements. IN: Proceedings 10th International Conference on Ground Control in Mining, June 10-12, 1991, S.S. Peng, ed., West Virginia University, Morgantown, p. 301-306.

A 125-foot-high steel lattice frame tower supporting a 500-kV EHV transmission line and located over the gateroads of a longwall mining operation was subjected to ground movements from the mining of adjacent longwall panels.

Keyword(s): surface structural damage, longwall, finite element, prediction, horizontal displacement, utilities, coal mining, active mines, instrumentation

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

Brummer, R. K. A Simplified Modelling Strategy for Describing Rockmass Behaviour Around Stope Faces in Deep Hard-Rock Gold 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, p. 113-120.

Gold mines in South Africa working at depths of up to 3,600 m have mining layout designed on the basis of numerical models that assume elastic behavior of the rockmass.

Keyword(s): rock mechanics, mine design, metal mining, modeling, elastic model, boundary element

Location(s):S outh Africa

Brutcher, D. F., B. B. Mehnert, D. J. Van Roosendaal, R. A. Bauer. Rock Strength and Overburden Changes Due to Subsidence Over a

Longwall Coal Mining Operation in Illinois. 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. 563-570.

The overburden above an active underground longwall coal mining operation was characterized before and after subsidence using core drilling, geotechnical instrumentation, and in situ testing. The analysis of mining-induced changes in the overburden provides a better understanding of the mechanisms leading to the surface expression of subsidence and hydrologic changes.

Keyword(s): longwall, coal mining, overburden, rock mechanics, instrumentation, monitoring methods, active mines, lab testing, in situ testing, subsurface water, hydrology, monitoring equipment

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

Bryan, A., J. G. Bryan, J. Fouche. Some Problems of Strata Control in Pillar Workings. The Mining Engineer, London, v. 123, no. 41, 1964, p. 238-266.

This paper discusses possible causes for a mine collapse in South Africa in which 437 people were killed; the collapse covered at least 75 acres. Topics covered include geologic conditions, failure mechanisms, and coal pillar strength.

Keyword(s): room-and-pillar, ground control, mine safety, pillar strength

Location(s): South Africa

Bucherer, L. Hydraulic Filling in European Mines. Mines and Minerals, v. 32, 1912, p. 715.

Early mining of multiple coal levels used hydraulic backfilling. Difficulties concerning pipe abrasion, fluid mixtures, sorting of fill, and relative cost are discussed.

Keyword(s): hydraulic backfilling, multiple-seam extraction, coal mining, historical

Location(s): Europe

Buck, W. A. Geological Environment in Relation to Longwall Operation in the U.S.A. The Mining Engineer, London, v. 137, no. 199, 1978, p. 363-371.

Keyword(s): longwall, geologic features

Location(s): United States

Bucky, P. B. Use of Models for the Study of Mining Problems. AIME Technical Publication No. 425, 1931, p. 3-28.

This paper discusses and compares modeling methods.

Keyword(s): prediction, modeling, mathematical model

Location(s): United States

Bucky, P. B., A. L. Fortress. Applications of Principles of Similitude to Design of Mine Workings. Transactions, American Institute of Mining and Metallurgical Engineers, v. 109, 1934, p. 25-50.

Samples from natural mine arches were tested for strength according to their size and shape.

Keyword(s): mine design, roof stability, rock mechanics, lab testing

Location(s): United States

Bucky, P. B., A. J. Toering. Mine Roof and Support Design as Applied to Flat-Lying Beds Stressed Within the Elastic Limit. Engineering and Mining Journal, v. 106, 1935, p. 178-181.

Formulas based on laws of mechanics are derived for calculating the safe span allowable between pillar center lines, pillar size, and percent extraction.

Keyword(s): mine design, pillar strength, roof stability

Bucky, P. B. Roof Control Problems in High Speed Mechanization Answered by Barodynamics. Coal Age, v. 43, January, 1938, p. 61-66.

Barodynamics deals with the behavior of weighty structures and applies laws of mechanics to determine the behavior of the structure and/or the application of similitude to the behavior of small-scale models to determine how the prototype will behave.

Keyword(s): roof support, modeling

Bucky, P. B., R. V. Taborelli. Effects of Immediate Roof Thickness in Longwall Mining as Determined by Barodynamic Experiments. Transactions, AIME, v. 130, Coal Division, 1938, p. 314-332.

There is available an accumulation of experience regarding longwall mining but coordination of experience is lacking and this series of experiments was undertaken to help serve this purpose. Model experiments were used for reasons of safety, cost, and time, and because it has been previously shown that a scalar model built of the same material as the prototype will behave in a manner similar to that of the prototype, with time effects the same, if the effective weight of the model is increased in the same proportion as its linear dimensions are decreased.

Keyword(s): longwall, coal mining, lab testing, modeling

Budavari, S., E. L. J. Potts. Rock Deformation Measurements for Evaluating Mine Stability. Transactions, Institution of Mining and Metallurgy, Section A, Mining Industry, v. 79, 1970, p. A37-A42.

Keyword(s): rock mechanics, mine design

Building. NHBC Plans to Reduce £3.5m Annual Claims, 29 April, 1977, p. 41.

Faced with claims of £3.5 million a year on its 10-year new house guarantee insurance, the National House-Building Council is introducing a five-point plan to ensure that houses built in 1977 are the best yet. The article shows two pictures of structures damaged by mine subsidence.

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

Location(s): United Kingdom

Buist, D. S., P. F. Jones. Potential Instability of Permian Strata in the Pleasley By-Pass Area, Derbyshire. 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. 427-448.

Excavations for a new highway scheme encountered intensive fracturing of the Magnesian Limestone. Further problems were posed by a "hidden" fault at the site of a proposed bridge. The possibility of reactivation of the fault by future coal mining subsidence, and the consequent deleterious effect that this would have on the stability of the bridge necessitated a very careful reassessment of the proposed structure. Eventually the design of the bridge was radically altered. This paper investigates the origin and engineering implications of fracturing in the Magnesian Limestone. The paper also describes methods undertaken to calculate the magnitude of future subsidence and to ensure that resultant structural damage is kept to a minimum.

Keyword(s): surface structural damage, roads, coal mining, engineering, geologic features, lab testing, in situ testing

Location(s): United Kingdom

Bull, W. B. Causes and Mechanics of Near-Surface Subsidence in Western Fresno County, California. Short Papers in the Geologic and Hydrologic Sciences, U.S. Department of the Interior, Geological Survey Professional Paper 424-B, 1961, p. B187-B189.

Keyword(s): fluid extraction

Location(s): California, United States

Bull, W. B. Prehistoric Near-Surface Subsidence Cracks in Western Fresno County, California. Geological Society of America, Special Paper 115, 1968, p. 314-315.

Keyword(s): fluid extraction, historical

Location(s): California, United States

Bull, W. B. Subsidence Due to Artesian-Head Decline in the Los Banos-Kettleman City Area, California. Geological Society of America, Special Paper 101, (abstract), 1968, p. 29-30.

Keyword(s): fluid extraction, subsurface water

Location(s): California, United States

Bull, W. B. Prehistoric Near-Surface Subsidence Cracks in Western Fresno County, California. USGS Professional Paper 437-C, 1972, 85 p.

The thousands of clay-filled tension cracks found in the alluvial fans of the San Joaquin Valley, California, during the excavation of the California Aqueduct raised the possibility of postconstruction tensional rupture of the canal. In western Fresno County, the cracks were the result of subsidence caused by compaction due to wetting.

Keyword(s): surface water, subsurface water, engineering

Location(s): California, United States

Bull, W. B. Geologic Factors Affecting Compaction of Deposits in a Land Subsidence Area. Bulletin of the Geological Society of America, 84, 1973, p. 3783-3802.

Keyword(s): geologic features

Bull, W. B. Land Subsidence Due to Ground-Water Withdrawal in the Los Banos-Kettleman City Area, California; Part 2, Subsidence and Compaction of Deposits. U.S. Department of the Interior, Geological Survey Professional Paper 437-F, 1975, 90 p.

Keyword(s): fluid extraction

Location(s): California, United States

Bull, W. B., J. F. Poland. Land Subsidence Due to Ground-Water Withdrawal in the Los Banos-Kettleman City Area, California; Part 3, Interrelations of Water-Level Change, Change in Aquifer-System Thickness and Subsidence. U.S.

Department of the Interior, Geological Survey Professional Paper 437-G, 1975, 62 p.

Keyword(s): fluid extraction, hydrology
Location(s): California, United States

Bull, W. B., R. E. Miller. Land Subsidence Due to Ground-Water Withdrawal in the Los Banos-Kettleman City Area, California, Part 1, Changes in the Hydrologic Environment Conducive to Subsidence. Geological Survey Professional Paper 437-E, 1975, U.S. Government Printing Office, Washington, D.C.

Keyword(s): fluid extraction, subsurface water, surface subsidence damage
Location(s): California, United States

Bullock, K. P. The Measurement of Coal Mining Subsidence--An Example. Mining Magazine, April, 1984, p. 379-385.

The equipment and methods used in measuring the subsidence over a particular longwall coal mining face are described in this article, together with details of the results obtained. The Electronic Distance Measurement system employed allows accurate results to be obtained with a minimum of time spent in field observation.

Keyword(s): monitoring methods, monitoring equipment, survey methods, survey design, coal mining, longwall, vertical displacement, horizontal displacement
Location(s): United Kingdom

Bullock, W. D., R. L. Brittain, G. A. Place. Mining and the Environment. Exploration Update '75, Calgary, Alberta, May, 1975.

The requirements of recent environmental legislation enacted in Canada and the United States have made mining operations increasingly complex. This paper briefly reviews the extent of mining activity in both countries and lists its major environmental impact. Pending legislation of concern to mine operation is reviewed.

Keyword(s): environment, law, mine operation
Location(s): United States, Canada

Bumm, H., G. Schweden, G. Finke. The Mining Subsidences in the Harbours of Duisburg-Ruhrort. Bulletin of the Permanent International Association of Navigation Congress, Brussels, v. 3, no. 21, 1966, p. 3-29.

This paper discusses mining-extraction methods used to control subsidence effects on the Rhine River in the Federal Republic of Germany; valuable coal deposits under the River had not been mined previously because of possible damage to shipping channels.

Keyword(s): surface structural damage, surface water, mine design, economics, coal mining
Location(s): Germany

Buntain, M. E. Longwall Growth in the U.S. May Depend on How Well Subsidence is Controlled. Coal Mining and Processing, v. 12, no. 12, 1976, p. 71-74, 88-89.

This paper discusses factors affecting subsidence resulting from longwall mining, including angle of draw, geology, width of extraction, and rate of advance; it also contains information on subsidence-control techniques.

Keyword(s): mine design, backfilling, law, longwall, partial extraction, coal mining, angle of draw, geologic features
Location(s): United States

Bur, T. R., B. Berson. A Review of Foreign Subsidence Laws and a Presentation of Mining Laws Within the U.S. that are Applicable to Subsidence. U.S. Bureau of Mines Twin Cities Research Center Project Report, 29 p. (date unknown).

This USBM report presents laws pertinent to subsidence related to underground mining. Included are a brief history of the development of subsidence laws in Europe and the United States, recent regulation of the U.S. Department of the Interior, and laws of the 21 states comprising the major part of the deep coal reserve for underground mining.

Keyword(s): law, coal mining, active mines, abandoned mines
Location(s): United States, Europe

Bur, T. R., A. A. Allen. Preliminary Investigation of Subsidence in the Cleveland Street Area, Eveleth, Minnesota. U.S. Bureau of Mines, Division of Minerals Environmental Technology, Branch of Applied Technology and Demonstration, January, 1980.

This report concerns subsidence and settlement problems in a residential area covering about 2 acres in Eveleth, Minnesota. The area was mined for iron ore by surface or a combination of surface and underground methods. The pit was backfilled, and construction began in the mid-1920s.

Keyword(s): abandoned mines, metal mining, surface structural damage, soils, land-use planning, structural mitigation
Location(s): Minnesota, United States

Burdick, R. G., L. E. Snyder. Use of Automated Resistivity System to Locate Potential Subsidence Areas Over Old Mines. IN: Proceedings, 2nd Conference on Ground Control in Mining, Morgantown, WV, July 19-21, 1982, S.S. Peng and J.H. Kelly, eds., West Virginia University, 1982, p. 214-221.

This paper describes the automated resistivity method and discusses sites in Colorado, Wyoming, and Illinois where the SBM has used this method to locate abandoned mines and potential subsidence areas.

Keyword(s): abandoned mines, computer, surface structural damage, surface subsidence damage

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

Burdick, R. G., L. E. Snyder, W. F. Kimbrough. A Method for Locating Abandoned Mines. U.S. Bureau of Mines RI 9050, 1986, 27 p.

Problems presented by old mine workings affect both present-day mining and land development. This report describes six mining areas in the United States that were investigated with the Bureau's automated resistivity method; results showed a high rate of success in detecting old mines. Field measurement techniques and data analysis procedures are described.

Keyword(s): abandoned mines, coal mining, land-use planning, land values, monitoring methods, survey methods, survey data processing

Location(s): United States

Burley, J. D., A. H. Drowin. Solution to Ground Subsidence Problems in Casing Strings and Wellheads. Journal of Petroleum Technology, v. 23, June 1971, p. 654-660.

Keyword(s): subsurface water, fluid extraction

Burns, K. Prediction of Delayed Subsidence. 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, March, 1982, p. 220-223.

In planning insurance or restitution measures, a predictive model is of value in estimating the magnitude of the problem and the size of long-term budgetary commitments. Only one model is known, and it was developed for the USBM by GAI Consultants of Monroeville. The GAI model is presented in qualitative terms. This report develops a formal basis for the model and tests a numerical implementation on one of the best-described study areas, Allegheny County in Pennsylvania.

Keyword(s): prediction, modeling, abandoned mines, survey data processing, stochastic model

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

Burton, A. N., P. I. Maton. Geophysical Methods in Site Investigations in Areas of Mining Subsidence. IN: Site Investigations in Areas of Mining Subsidence, 1975, F.G. Bell, ed., Newnes-Butterworths, London, p. 75-102.

Keyword(s): geophysical

Burton, D. A Three Dimensional System for the Prediction of Surface Movements Due to Mining. 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. 209-228.

This text is concerned with an understanding of surface movement above mine workings, with particular reference to the type of three-dimensional system that the observer can create and use in connection with the subsidence of important surface structures and installations.

Keyword(s): prediction, vertical displacement, horizontal displacement

Burton, D. The Introduction of Mathematical Models for the Purpose of Predicting Surface Movements Due to 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. 50-64.

Although an observer could begin with the assumption that a mathematical model will prevent anyone from keeping a sensible balance between the general description of mining subsidence and the peculiarities of each case, the actual effect of introducing such a model is quite different. By taking advantage of the memory and the speed of the computer, the investigator gains control over predictions in particular situations. For practical purposes, the process of subsidence prediction is divided into two parts: the construction of a suitable model required to generate the numbers for prediction, and the subsequent control of the predictions with a feedback of information.

Keyword(s): mathematical model, prediction, modeling, railroads

Location(s): United Kingdom

Burton, D. Ground Deformation Above Longwall Panels Geometry of the Three Dimensional System. IN: Strata Mechanics, Proceedings of the Symposium, University of Newcastle-upon-Tyne, April, 1982, I.W. Farmer, ed., Elsevier, New York, p. 30-35.

The paper describes the purpose of a three-dimensional variable geometry beginning with an illustration involving the strains measured in a vertical section across a longwall face, and showing certain features of rock movement that could be related to geology, and the particular case, are features of geometry. The paper continues with a description of the general application of the variable geometry.

Keyword(s): longwall, geologic features, computer, modeling

Location(s): United Kingdom

Burton, D. A Program in BASIC for the Analysis and Prediction of Ground Movement Above Longwall Panels. 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. 338-353.

This paper contains a program (using BASIC as the formal language) that will calculate the displacement of any surface point in the x, y, z dimensions of space at any time, whether the face of the panel is static or moving.

Keyword(s): computer, prediction, longwall, coal mining

Bushnell, K., J. R. Peak. Map of the Upper Freeport Coal Bed: its Outcrop, Overburden, mining Activity and Related Surface Subsidence, Allegheny, Washington, and Westmoreland Counties, Pennsylvania. U.S. Geological Survey Miscellaneous Field Studies Map MF-693B, 1975.

Keyword(s): surface subsidence damage, overburden, coal mining

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

Bushnell, K. O. Map Showing Areas That Correlate With Subsidence Events Due to Underground Mining of the Pittsburgh and Upper Freeport Coalbeds; Allegheny, Washington and Westmoreland Counties, Pennsylvania. U.S. Geological Survey, MF-693C, 1975.

Keyword(s): surface subsidence damage

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

Bushnell, K. O. Map Showing: Depths to the Pittsburgh Coalbed, Mining Activity, and Related Surface Subsidence; Allegheny, Washington, and Westmoreland Counties, Pennsylvania. U.S. Geological Survey, MF-693A, 1975.

Keyword(s): surface subsidence damage

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

Bushnell, K. O. Mine Subsidence. "Lots" of Danger: Property Buyer's Guide to Land Hazards of Southwestern Pennsylvania, J.L. Freedman, ed. Pittsburgh Geological Society, Inc., Pittsburgh, 1977, p. 9-16. (NTIS Accession No. 78-15992)

Surface subsidence because of underground mines abandoned decades ago is one of the most vexing problems faced by home owners in western Pennsylvania. This chapter covers the laws affecting surface subsidence and reviews the steps a land owner can take to appraise his own situation. The geology and mining practices of the region are discussed in relation to surface subsidence. The work and services of various government agencies on behalf of the property owner are described.

Keyword(s): surface structural damage, coal mining, abandoned mines, foundations, law, overburden, geologic features, land-use planning, engineering, government, backfilling, grouting

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

Butler, D. Detection of Abandoned Coal Mine Workings and Underground Voids by Microgravity. Mining Engineering, April, 1989, v. 41, no. 4, p. 245-247.

Subsurface density changes can be detected by very precise surface gravity measurements. A feasibility study, combined with field experience using modern instruments, will indicate the probability of success. In addition to projected anomaly parameters, surface conditions that affect the survey precision must be evaluated. Examples with excavated zones at a depth of 9 meters (30 ft) and plus or minus 22 microgal error are compared with the same model at 30 meters (98 ft). The figures illustrate anomaly detectability. The survey

error is a function of surface topography and lateral density variation in the very near surface.

Keyword(s): abandoned mines, coal mining, modeling, geologic features

Butler, P. E. Utilization of Coal Mine Refuse in Highway Embankment Construction. SME-AIME Preprint No. 75-F-81, SME-AIME Annual Meeting, New York, NY, February 16-20, 1975, 32 p.

Since early 1973, the Pennsylvania Department of Transportation has been actively engaged in the utilization of coal mine refuse in the design and construction of highway embankments. The program includes field investigations, laboratory testing, engineering evaluation, planning, coordination, implementation, construction control, and review of construction performance.

Keyword(s): mine waste, coal mining, roads, land-use planning, engineering, anthracite, bituminous, lab testing

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

Butler, R. A., D. Hampton. Subsidence Over Soft Ground Tunnel. ASCE Journal of Geotechnical Engineering Division, v. 101, 1975, p. 35-49.

Keyword(s): tunnelling

Cady, G. H. Coal Resources of District I (Longwall). Illinois State Geological Survey, Mining Investigation Bulletin 10, 1915, 149 p.

This report discusses the geology and economics of coal mining in the "longwall district" in north-central Illinois.

Keyword(s): coal mining, historical

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

Cady, G. H. Coal Resources of District VI. Illinois State Geological Survey, Mining Investigation Bulletin 15, 1915, 94 p.

This report discusses geology and economics of coal mining in Jefferson, Franklin, and part of Williamson Counties in Illinois.

Keyword(s): coal mining, historical

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

Cady, G. H. Coal Resources of District II (Jackson County). Illinois State Geological Survey, Mining Investigation Bulletin 16, 1917, 55 p.

Keyword(s): coal mining, historical

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

Cady, G. H. Coal Resources of District V (Saline and Gallatin Counties). Illinois State Geological Survey, Mining Investigation Bulletin 19, 1919, 135 p.

Keyword(s): coal mining, historical

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

Cady, G. H. Coal Resources of District IV. Illinois State Geological Survey, Mining Investigation Bulletin 26, 1921, 247 p.

Keyword(s): coal mining, historical

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

Cambefort, H. The Principles and Applications of Grouting. Quarterly Journal of Engineering Geology, 1977, v. 10, p. 57-95.

Keyword(s): grouting

Cameron-Clarke, I. S. The Distribution and Nature of Surface Features Related to Shallow Undermining on the East Rand. IN: Proceedings, SANGORM Symposium, October 21, 1986, International Society for Rock Mechanics, South African National Group, Sandton, South Africa, p. 33-38.

Developments over areas undermined at shallow depths are severely restricted because of the potential for subsidence or sudden collapse of the ground surface. To facilitate planning, it is advantageous to have some idea of the location of the undermined areas as well as a general understanding of the actual conditions underground.

Keyword(s): abandoned mines, coal mining, metal mining, land-use planning, photography, historical, surface subsidence damage

Location(s): South Africa

Cameron-Clarke, I. S., A. J. Barrett, G. E. Blight. Support of Areas Undermined by Shallow Coal Workings for Road Corridors. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May 1992, South African Institution of Civil Engineers, Republic of South Africa, p. 193-198.

Developments over areas of shallow undermining are restricted because of the potential for surface subsidence. There are several different ways of protecting surface structures. One, which is particularly applicable to the protection of roads, is to incorporate a layer of welded steel mesh into the road structure.

Keyword(s): surface structural damage, coal mining, metal mining, roads, structural mitigation, geologic features, engineering, abandoned mines

Location(s): South Africa

Cameron, D. W. G. Menace of Present Day Subsidence Due to Ancient Mineral Operations. Journal of Royal Institution of Chartered Surveyors, (Scottish Supplement), 1956, v. 19, Part 3, p. 159-171.

Keyword(s): abandoned mines

Location(s): United Kingdom

Camp, C. L. Filling Mine Workings Under Railway Bridges with Concrete at Scranton. Engineering News, January 11, 1912, p. 60.

Subsurface reinforcement of bridge footings was achieved by constructing concrete columns within abandoned mines.

Keyword(s): abandoned mines, grouting, multiple-seam extraction, railroads

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

Campbell, J. A. L., L. J. Petrovic, W. J. Mallio, C. W. Shulties. How to Predict Coal Mine Roof Conditions Before Mining. Mining Engineering, October 1975, p. 37-40.

Keyword(s): roof stability, coal mining

Campoli, A., T. Barton, F. Van Dyke, M. Gauna, M. DeMarco. Gate Design Key to Bump Control. Coal, September, 1990, p. 54-58.

Full extraction retreat mining, during both longwall and room-and-pillar operations, leads to the concentration of stresses in nearby support pillars. When this occurs at great depth and between unyielding roof and floor strata, portions of these highly stressed pillars often fail rapidly and violently. Such failures, commonly called bumps, vary from minor vibrations without significant strata movement, to notable earth tremors that may eject thousands of tons of coal and rock into the workings.

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

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

Canace, R., R. Dalton. A Geological Survey's Cooperative Approach to Analyzing and Remedying a Sinkhole Related Disaster in an Urban Environment. 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. 343-348.

A sinkhole resulting from the break of an underground water main severely undermined the foundation of a private residence in densely populated Phillipsburg, New Jersey. Subsurface borings revealed the presence of a deeply dissected dolomitic bedrock surface and, more importantly, significant voids in the stiff, silty to gravelly clay overbruden; some voids were in excess of 10 feet in height.

Keyword(s): surface structural damage, geologic features

Location(s): New Jersey, United States

Canadian Institute of Mining and Metallurgy. Mining with Backfill. Proceedings, 12th Canadian Rock Mechanics Symposium, Sudbury, Ontario, May 23-25, 1978 Canada Institute of Mining Special v. 19, 150 p.

Keyword(s): stowing, backfilling

Location(s): Canada

Candeub, Fleissig, and Associates (Newark, NJ) Demonstration of a Technique for Limiting the Subsidence of Land Over Abandoned Mines. Department of Housing and Urban Development Report HUD-WYO D-I, June 1971, 92 p. (NTIS PB 212 708)

This report presents the findings and conclusions of a demonstration project carried out by the city of Rock Springs, WY, in 1970 using the Dowell Process.

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

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

Candeub, Fleissig, and Associates (Newark, NJ) Demonstration of a Technique for Limiting the Subsidence of Land Over Abandoned Mines. Department of Housing and Urban Development Report HUD-WYO D-I, November, 1973, 34 p. (NTIS PB 233 089)

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

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

Cappleman, H. L. Horizontal Movements Related to Subsidence. Discussion, ASCE Journal Soil Mechanics Foundations Division, v. 96, no. SM1, 1970, p. 310-317.

Keyword(s): horizontal displacement

Location(s): United States

Carbognin, L., P. Gatto, G. Mozzi, G. Gambolati, G. Ricceri. New Trend on the Subsidence of Venice. International Association of Hydrological Sciences Publication 121, 1977, p. 65-81.

Keyword(s): surface subsidence damage, surface water, fluid extraction

Location(s): Italy

Carbognin, L. Land Subsidence: A Worldwide Environmental Hazard. Nature and Resources, UNESCO, v. 21, no. 1, 1983, p. 2-12.

Keyword(s): surface subsidence damage, environment

Carbognin, L., P. Gatto. An Overview of the Subsidence of Venice. 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. 321-328.

A general view of the aspects of the Venice subsidence situation, as studied by the CNR in Venice since 1969, is supplied. A look at the cause and effect relationship is given, along with an illustration of the three factors making up the land elevation loss during the 20th century (namely, natural subsidence, man-induced subsidence, and eustacy).

Keyword(s): surface water, fluid extraction, surface subsidence damage

Location(s): Italy

Carey, S. Cave-ins of Abandoned Coal Mines Present Growing Threat to Life, Land in 30 States. Wall Street Journal, August 21, 1984.

Keyword(s): abandoned mines, coal mining

Location(s): United States

Carlson, E. J. Hydraulic Model Studies for Backfilling Mine Cavities. Bureau of Reclamation Report REC-ERC-73-19, October 1973, 36 p. (NTIS PB 225 613)

This report presents test results from investigation of effects of various backfilling parameters (including slurry concentration, injection velocity, and floor slope) on deposition patterns.

Keyword(s): hydraulic backfilling, modeling

Carlson, E. J. Hydraulic Model Studies for Backfilling Mine Cavities (Second Series of Tests). Bureau of Reclamation Report REC-ERC-75-3, March 1975, 38 p. (NTIS PB 241 510)

This report presents test results from investigation of effects of various backfilling parameters on deposition patterns for five specific mine patterns.

Keyword(s): hydraulic backfilling, modeling

Location(s): United States

Carlson, M. J., L. W. Saperstein. Efficient Use of Additives to Improve Pneumatically Emplaced Backfill Strength. Mining Engineering, June 1989, v. 41, no. 6, p. 462-466.

With the goal of improving the strength characteristics of pneumatically emplaced material used for localized subsidence control, the binding additives fly ash, bentonite, and portland cement were examined for their effect on the support capabilities of coal refuse. It was found that, within certain concentration ranges, all three offered some increase in the ultimate strength of the backfilling mixture; portland cement gave the greatest percentage increases. Selection of the appropriate backfilling mixture will allow for the most economical and efficient subsidence control when pnuematic stowing is employed.

Keyword(s): longwall, horizontal displacement, pneumatic backfilling, room-and-pillar, ground control, coal mining, lab testing, stowing

Location(s): Appalachian Coal Region, United States

Carmen, C. O. Understanding Roof Action is Imperative in Longwall Mining. Coal Mining and Processing, March, 1965, p. 38-41.

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

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

Carpenter, G. W., J. D. Rockaway, R. W. Stephenson, R. C. Speck. Geotechnical Evaluation of Sub-Coal Strata for Coal Pillar Support. IN: Proceedings Illinois Mining Institute Annual Meeting, October 13-14, 1977, Springfield, IL, p. 92-102.

Foundation failures in underground coal mines frequently occur in mines where the strata under the coal includes underclays or clay shales with poor strength characteristics. An investigation carried out at the University of Missouri-Rolla evaluated the strength and stability parameters of strata underlying coal in the Illinois Basin.

Keyword(s): coal mining, floor stability, geotechnical, pillar strength, rock mechanics, finite element, modeling, computer, roof stability

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

Carpenter, G. W. Areas of Coal Mine Floor Heave Predicted by Bearing Capacity Analysis. M.S. Thesis, University of Missouri-Rolla, Rolla, MO, 1978.

Keyword(s): floor stability, coal mining, prediction, lab testing

Location(s): United States

Carpenter, M. C., M. D. Bradley. Legal Perspectives on Subsidence Caused by Groundwater Withdrawal in Texas, California, and Arizona, 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. 817-828.

Damages from subsidence caused by groundwater withdrawal include shoreline submergence, well-casing failures, and changes in gradients of canals, sewers, irrigation ditches, and streams.

Potential damages from subsidence-related earth fissuring include structural damage to roads, railroads, and buildings, ruptured sewers and pipelines, and aquifer contamination. This paper covers legal methods of controlling and managing subsidence in Texas, Arizona, and California.

Keyword(s): fluid extraction, law, surface subsidence damage, subsurface water, hydrology, government, surface water

Location(s): Texas, California, Arizona, United States

Carpenter, P. J., M. A. Johnston. Monitoring Fracture Development Over a Subsiding Longwall Mine Panel Using Electrical Resistivity. North-Central Section Geological Society of America 25th Annual Meeting, Toledo, OH, April 18, 1991, Abstracts with Programs, v. 23, p. 6-7.

Keyword(s): seismic, monitoring methods, geophysical, overburden, longwall, active mines, coal mining

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

Carpenter, P. J., M. A. Johnston, C. J. Booth, M. P. Matheney. Geophysical Identification of Fractures and Associated Hydrological Effects Over a Collapsing Longwall Mine Panel. IN: Geological Society of America Annual Meeting, Abstracts with Programs, San Diego, CA, October, 1991, p. A39.

Geophysical methods were employed to characterize fracturing and water level changes in the upper portion of a 120-meter bedrock and drift section overlying two collapsing longwall coal panels in Illinois. Resistivity soundings, profiles, and azimuthal surveys were made over panel centers before, during and after subsidence.

Keyword(s): geophysical, hydrology, subsurface water, active mines, longwall, coal mining, seismic, geologic features

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

Carrera, G. H., P. Vanicek. Review of Techniques for Determining Vertical Ground Movements from Levelling Data. 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. 195-202.

A review of existing mathematical models to obtain the spatial and temporal representation of vertical ground movements from relevellings is presented. Models are classified in terms of their design, spatial data distribution, and temporal data distribution.

Keyword(s): mathematical model, vertical displacement

Carter, H. W. N. A Review of Strata Control Experiences in Longwall Workings in Great Britain. IN: Proceedings 3rd International Conference on Strata Control, Paris, 1960, p. 471-485.

Keyword(s): mine design, ground control, longwall, roof stability

Location(s): England

Carter, P., D. Jarman, M. Sneddon. Mining Subsidence in Bathgate, A Town Study. 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. 101-124.

This paper deals with Bathgate's history of mining and mining subsidence; the investigations that have been carried out, and the proposals evolved for designing new structures and making existing structures safe, in the zones of potential mining subsidence.

Keyword(s): surface structural damage, coal mining, abandoned mines, surface subsidence damage, subsurface subsidence damage, land-use planning, foundations, structural mitigation, construction, backfilling

Location(s): United Kingdom

Carter, T. G., C. M. Steed. Application of Remedial Measures for Stabilization of Abandoned Mine Workings. 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. 207-221.

Various methods of remediation are applicable for use in safely stabilizing old, hazardous, thin or unstable crown pillar conditions. Examples of the application of five different remediation approaches are presented: bridge-deck style concrete capping, roller compacted concrete crown reinforcement, conventional gravity backfilling, pneumatic stowing, and hydraulic backfilling.

Keyword(s): abandoned mines, pneumatic backfilling, hydraulic backfilling, economics, surface structural damage, roads, metal mining, non-metal mining

Location(s): Canada, New York, United States

Cartwright, K., C. S. Hunt. Hydrogeology of Underground Coal Mines in Illinois. ISGS reprint 1978-N, 1978. Reprinted from Proceedings International Symposium on Water in Mining and Underground Works, Granada, Spain, September 17-22, 1978, 20 p.

Little is known about the hydrogeology of the groundwater systems around underground coal mines. Illinois mines are generally "dry," with notable exceptions, despite their location in water-saturated rocks well below the water table. Reported pumpages of water from the mines vary from occasional pumping of sumps to pumpage in excess of 5,000 cubic meters per day. Most mines, however, report pumpages of less than 100 cubic meters per day. Some mines are reported to be "dry" even many years after being abandoned. These small volumes of water reported from the mines are directly related to the extremely low hydraulic conductivity of the rock associated with the coal.

Keyword(s): subsurface water, hydrology, coal mining, geologic features, active mines, abandoned mines, inflow

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

Cartwright, K., C. S. Hunt. Hydrogeology of Underground Coal Mines in Illinois. IN: Proceedings World Congress of Water in Mining and Underground Work (SIAMOS), September 18-22, 1978, R. Fernandez-Rubio, ed., Granada, Spain, p. 61-84.

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

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

Cartwright, K., C. S. Hunt. Hydrogeologic Aspects of Coal Mining in Illinois: An Overview. Illinois State Geological Survey, Environmental Geology Note 90, January 1981, 19 p. (NTIS PB 81-190126)

Water has generally not been a significant problem in Illinois mining, although most Illinois coal mines (both surface and underground) lie partly or completely below the water table. Water-related problems in and around mines are likely to increase as it becomes economically feasible to open or expand surface mines in areas with thicker and more permeable overburden and to place underground mines at greater depths. Detailed study of the hydrogeology of mining areas before, during, and after mining can help prevent problems that may occur.

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

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

Castle, M. J., J. W. Hewitt, P. F. Suine. Mining Subsidence in Relation to Roads. IN: Collected Case Studies in Engineering Geology, Hydrogeology, and Environmental Geology, M.J. Knight, E.J. Minty, and R.B. Smith, eds., Engineering Geology Specialist Group of the Geological Society of Australia, Inc., Sydney, p. 377-397.

A subsidence bowl forms due to mining of coal seams where the thickness is small in relation to the depth of cover. Movement is gradual and the surface does not necessarily fracture or fissure. Subsidence movements can be predicted and an application of techniques developed outside Australia will provide guidance to the amount of subsidence and the design parameters of roadways and bridges.

Keyword(s): coal mining, roads, prediction, geologic features, time factor

Location(s): Australia

Castle, R. O., R. F. Yerkes. Surface Deformation Associated With Oil-Field Operations in the Baldwin Hills, Los Angeles County, California. Geological Society of America, Special Paper 121 (abstract only), 1969, p. 49-50.

Keyword(s): oil extraction

Location(s): California, United States

Castle, R. O., R. F. Yerkes, F. S. Riley. A Linear Relationship Between Liquid Production and Oil Field Subsidence. IN: Land Subsidence, Proceedings International Symposium, September 14-18, 1969, Tokyo, IAHS Publication 88, v. 1, p. 162-173.

Keyword(s): fluid extraction, oil extraction, prediction

Catron, W., C. V. Colledge. Controlling Subsidence of a Large Inverted Cone Above the Ore Body, Colorada Mine, Cananea Consolidated Copper Company. Transactions Society Mining Engineers AIME, Technical Publication 938, 1938, 7 p.

Keyword(s): metal mining, ground control

Location(s): United States

Caudle, R. D. Mine Roof Stability. IN: Proceedings Bureau of Mines Technology Transfer Seminar, Lexington, KY, March, 1973, Ground Control Aspects of Coal Mine Design, U.S. Bureau of Mines IC 8630, 1974, p. 79-85.

Structural analysis methods can be used to predict the stability of coal mine roof in entry/room-and-pillar systems and headgate/longwall/tailgate systems. The behavior of the roof reflects the interaction of roof, pillar, and floor elements. Local roof stability is strongly influenced by the proximity of other openings in the mine system (other entries and/or panels).

Keyword(s): mine design, ground control, roof stability, coal mining

Location(s): United States

Caudle, R. D. Multiple Entry Design. IN: Ground Control Aspects of Mine Design, Proceedings Bureau of Mines Technology Transfer Seminar, Lexington KY, March 6, 1973, U.S. Bureau of Mines IC 8630, 1974, p. 49-55.

The design of multiple entries makes use of parametric data from structural analyses of multiple mine openings. These data can be used to deduce the influence of layering, pillar width, and rock properties upon the behavior of rock, rib, and floor. When used in conjunction with a knowledge of the stress field, the properties of coal measure rocks, and the geologic structure, design problem areas can be identified and design changes implemented to alleviate problems.

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

Location(s): United States

Caudle, R. D. Panel Design 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. 14-21.

Panel design, from a ground control viewpoint, proceeds in a manner similar to that employed in the design of surface structures.

Keyword(s): mine design, active mines, ground control, coal mining, pillar strength

Location(s): United States

Caudle, R. D., Y. P. Chugh, H. Albarracin, K. Chandrashekhar, C. Liang. Effects of Soft Floor Interaction on Room-and-Pillar Mining - A Progress Report. IN: Proceedings Annual Mineral Technology Center, Mine Systems Design and Ground Control, University of Alabama, Tuscaloosa, 1987, p. 23-24.

Keyword(s): floor stability, room-and-pillar

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

Cavinder, M. Longwall Mining with Shield Supports at Old Ben. Mining Congress Journal, June, 1978.

Keyword(s): longwall, coal mining

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

Cervantes, J. A., Y. C. Kim, I. W. Farmer. Statistical Prediction of Subsidence Events Above Abandoned Room and Pillar Workings in Penn Hills Area. IN: Proceedings 8th Annual Workshop Generic Mineral Technology Center Mine Systems Design and Ground Control, Reno, November 5-6, 1990, E. Topuz and J.R. Lucas, eds., Virginia Polytechnic Institute and State University, Blacksburg, p. 145-156.

Many subsidence events have occurred over the Pittsburgh coal seam. A statistical technique is presented to predict risk of future subsidence. It is based on the following features: geostatistical estimates of key parameters likely to affect ground stability, multiple regression analysis to determine the most significant variables, and discriminant analysis to develop rules to classify areas as likely or unlikely to suffer subsidence. Subsidence probabilities can be used to produce risk maps. Results are consistent with those of an independent study.

Keyword(s): abandoned mines, coal mining, room-and-pillar, prediction, modeling, surface subsidence damage, land-use planning, surface structural damage, rock mechanics, geotechnical

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

Chandrashekhar, K. An Analysis of Subsidence Movements and Structural Damage Related to an Abandoned Room-and-Pillar Coal Mine. M.S. Thesis, Department of Mining Engineering, Southern Illinois University, Carbondale, May, 1985.

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

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

Chandrashekhar, K., R. Nath, S. Tandon. Design of Coal Pillars Under Weak Floor Conditions. IN: Proceedings 28th U.S. Rock Mechanics Symposium, Tucson, AZ, June 29-July 1, 1987, I.W. Farmer et al., eds., Balkema, Rotterdam, p. 1037-1081.

A coal pillar on weak floor strata may be considered as a shallow foundation on cohesive soil or rock. The theory of bearing capacity and settlement of shallow foundations may therefore be

applied for designing isolated pillars. However, design of multiple coal pillars and evaluation of mine stability requires an additional consideration of interaction among the roof, coal pillar, and floor elements.

Keyword(s): mine design, pillar strength, floor stability

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

Chang, C-Y., K. Nair. Analytical Methods for Predicting Subsidence Above Solution-Mined Cavities. IN: Proceedings 4th International Symposium on Salt, Houston, TX, April 8-12, 1973. Northern Ohio Geological Society, Cleveland, v. 2, p. 101-117.

Keyword(s): prediction, non-metal mining

Channing, J. P. Subsidence at Miami, Arizona. Transactions AIME, v. 69, 1923, p. 394-397.

This paper discusses mining methods, geologic features, and mining operations during copper mining using block caving methods.

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

Location(s): Arizona, United States

Chapman, T. Concrete Bulkheads for Pillar Extraction. Engineering and Mining Journal, v. 97, 1914, p. 1145.

To allow pillar removal, concrete columns are constructed for roof support. The columns are poured through 6-inch boreholes from the surface and timber supports are later added between columns.

Keyword(s): pillar extraction, roof support, grouting

Charman, J. H., C. E. Cooper. The Frindsbury Area, Rochester: A Review of Historical Data and Their Implication on Subsidence in an Urban Area. 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. 115-124.

A sudden subsidence under a footpath, which led to the tragic death of a pedestrian, was followed by a series of further subsidences over a period of years, all incidents apparently located within an area no more than approximately 1 km square. The probable cause of the incidents at Frindsbury has been attributed to the existence of chalk mines associated with the brickfields (from production at the turn of the century) and further investigation is now taking place to locate these. Clues to all of the features were available as open file information in public records. This paper describes how the information was acquired and assimilated and emphasizes the importance of the role of the desk study in the initial stages of any development project.

Keyword(s): land-use planning, land values, engineering, geologic features, surface subsidence damage, surface structural damage, non-metal mining

Location(s): United Kingdom

Charmbury, H. B., G. E. Smith, D. R. Maneval. Subsidence Control in the Anthracite Fields of Pennsylvania. American Society of Civil Engineers Preprint 721, Annual and National Meeting on Structural Engineering, Pittsburgh, PA, September 30-October 4, 1968, 22 p.

Hydraulic flushing projects in Scranton, PA, used mine waste as the filling material.

Keyword(s): ground control, surface structural damage, economics, hydraulic backfilling, mine waste, anthracite, coal mining

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

Chase, F. E. Clay Veins: Their Physical Characteristics, Prediction, and Support. IN: Proceedings, 4th Conference on Ground Control in Mining, West Virginia University, 1985, Morgantown, p. 212-219.

Keyword(s): floor stability, coal mining

Location(s): United States

Chekan, G. J., R. J. Matetic, J. A. Galek. Strata Interactions in Multiple-Seam Mining--Two Case Studies in Pennsylvania. U.S. Bureau of Mines RI 9056, 1986, 17 p.

The authors discuss investigations performed by the USBM to improve development in mining of multiple coalbeds. Two common interactions that occur between adjacent coalbeds are subsidence and pillar load transfer. Underground measurements obtained from both mine sites correlate with theoretical and photoelastic multiple-seam models.

Keyword(s): multiple-seam extraction, pillar strength, modeling, coal mining

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

Chekan, G. J., R. J. Matetic, J. A. Galek. Multiple-Seam Mining Problems in the Eastern United States. IN: Eastern Coal Mine Geomechanics, Proceedings, Bureau of Mines Technology Transfer Seminar, Pittsburgh, PA, November 19, 1986, U.S. Bureau of Mines IC 9137, p. 27-43.

Strata interactions between adjacent coalbeds occur frequently in the Appalachian coalfields and can have unfavorable effects on both product cost and worker safety. Two common interactions that occur between adjacent coalbeds are subsidence and pillar load transfer. At two mine sites where such ground interactions were present, the Bureau conducted geologic studies and gathered various geotechnical information on pillar and entry stability using rock mechanics instrumentation.

Keyword(s): multiple-seam extraction, coal mining, active mines, mine safety, geologic features, geotechnical, room-and-pillar, instrumentation

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

Chekan, G. J., R. J. Matetic, D. L. Dwyer. Effects of Abandoned Multiple Seam Workings on a Longwall in Virginia. U.S. Bureau of Mines RI 9247, 1989, 15 p.

To reduce waste and improve resource conservation, mine planning, and development, the USBM is investigating multiple seam interactions associated with longwall mining. Longwall gate entry and panel stability have been influenced by previous mining in coalbeds above and below a mine in Virginia that operates in the Lower Banner Coalbed. Directly superjacent, approximately 115 feet, the Upper Banner Coalbed has been partially worked by room-and-pillar mining. Directly subjacent, approximately 730 feet, the Tiller Coalbed has been worked by partial room-and-pillar retreat mining. The study mine has experienced problems during development of gate entries in areas of over- and undermining. It is anticipated that stress fields associated with adjacent mining may further affect gate entry stability and face advancement during the extraction of the longwall panel. To assess overmining and undermining effects on ground stability, the Bureau gathered geotechnical information at the site.

Keyword(s): multiple-seam extraction, longwall, coal mining, room-and-pillar, abandoned mines, active mines, geotechnical, instrumentation, monitoring equipment, pillar strength

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

Chekan, G. J. Design Aspects in Multiple-Seam Mining: 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. 12-21.

Developing a coal seam that has been influenced by previous mining in seams either above or below can result in severe ground control problems. In many instances, interactions between operations are inevitable, but improvements in ground stability can usually be achieved by predicting potential problem areas in advance and adjusting the mining plans accordingly. This report investigates four case studies involving interactions between operations that used both room-and-pillar and longwall methods.

Keyword(s): geologic features, multiple-seam extraction, coal mining, room-and-pillar, longwall, mine design, instrumentation, geotechnical

Location(s): Appalachian Coal Region, United States

Chen, C. Y., Y. N. Chen, D. V. Goffney. Architectural Measures to Minimize Subsidence Damage. Appalachian Regional Commission Report ARC-73-111-2551, 1974, 130 p. (NTIS PB 242 466)

This report evaluates proposed guidelines, rules, and suggested practices to be used in the design and construction of surface structures and underground utilities to minimize subsidence damage due to underground mining.

Keyword(s): vertical displacement, horizontal displacement, surface structural damage, subsurface structural damage, ground control, architecture, utilities, prediction, engineering, construction, coal mining, structural mitigation

Location(s): Appalachian Coal Region, United States

Chen, C. Y., D. E. Jones, D. K. Hunt. Government Regulation of Surface Subsidence Due to Underground Mining. 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. 245-252.

Following a brief discussion of the technical aspects and the effects of subsidence on man and his environment, this paper presents a historical overview of how rules and regulations are used to govern subsidence related problems. The development of the regulations of subsidence under Public Law 95-87, the Surface Mining Control and Reclamation Act of 1977 (SMCRA) are also

discussed, including the new regulations being developed under the regulatory reform program.

Keyword(s): law, government, economics

Location(s): United States

Chen, C. Y. Subsidence Control Measures. Mining Engineering, v. 35, November, 1983, p. 1547-1551.

This paper discusses the mechanics of subsidence and the effects of subsidence on ground features. It also summarizes some measures used to minimize the possibility of damage to structures as a result of subsidence due to underground coal mining.

Keyword(s): ground control, coal mining, surface structural damage, structural mitigation, longwall, room-and-pillar, overburden, pillar strength, partial extraction, backfilling, law

Location(s): United States

Chen, C. Y., S. S. Peng. Underground Coal Mining and Attendant Subsidence Control: Some History, Technology, and Research. Mining Engineering, February, 1986, p. 95-98.

Surface subsidence is a critical issue facing the coal industry today. Several states have issued regulations requiring subsidence control plans and several others are in the process of issuing their own. The industry needs to look at current technologies available for subsidence control and improve on them.

Keyword(s): historical, ground control, mine operation, surface structural damage, utilities, mine design, longwall, room-and-pillar, prediction, modeling, finite element, law, subsidence research, coal mining

Location(s): United States

Chen, G., Y. P. Chugh. Application of Short-Term Time-Dependent Plate Loading Tests for Estimation of In-Situ Elastic and Viscous Parameters of Weak Floor Strata. IN: Proceedings 9th International Conference on Ground Control in Mining, West Virginia University, June 4-6, 1990, S.S. Peng, ed., Morgantown, p. 238-249.

This paper explores the possibility of using short-term time-dependent plate loading tests to estimate the elastic and viscoelastic parameters of the weak floor strata typically associated with coal seams in Illinois. Plate loading tests with incremental loads, similar to incremental creep experiments, were conducted until the floor failure occurred.

Keyword(s): floor stability, coal mining, in situ testing, time factor, room-and-pillar, longwall

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

Chen, G., Z. Yu, Y. P. Chugh, G. Hunt. A Study of Bedrock Movements Associated with Room-and-Pillar Mining in A Central Illinois Mine. 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. 129-147.

This paper discusses the instrumentation of the bedrock at an active room-and-pillar mine in Illinois. Two boreholes were drilled into the bedrock from the surface, one on a pillar and the other over an entry. Inclinometer guide pipes and settlement anchors were installed to monitor horizontal and vertical displacements of the bedrock at different depths. Geotechnical properties of the bedrock samples were also determined in the laboratory.

Keyword(s): instrumentation, monitoring methods, monitoring equipment, room-and-pillar, coal mining, lab testing, in situ testing, geotechnical, horizontal displacement, vertical displacement

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

Chlumecky, N. A Method for Testing the Bearing Capacity of Floor Strata. Mining Engineering, v. 20, no. 3, 1968.

Keyword(s): floor stability, in situ testing

Choi, D. S., D. L. McCain. Design of Longwall Systems. IN: SME-AIME Mini Symposium Series No. 79-07, 1979, p. 15-26.

A method of estimating the chain pillar size required to support the wide working faces of longwall or shortwall coal mining is presented. The pillar size is determined through the use of coal strength, entry geometry, panel width, and overburden pressure. Design analysis is focused on a three-entry development system in the Pittsburgh Seam but can be used for other development plans and other seams by substitution of the proper geometric and strength data.

Keyword(s): longwall, mine design, coal mining, shortwall, pillar strength

Location(s): Appalachian Coal Region, United States

Choi, D. S., H. D. Dahl. Measurement and Prediction of Mine Subsidence Over Room and Pillar Workings in Three Dimensions. IN: Proceedings Workshop on Surface Subsidence Due to Underground Mining, November 30-December 2, Morgantown, WV, 1981, S.S. Peng and M. Harthill, eds., Department of Mining Engineering, West Virginia University, 1982, p. 34-47.

This paper contains a subsidence measurement taken over a room-and-pillar panel of a mine located in northern West Virginia. A total of 72 monuments were used to determine a three-dimensional view of mine subsidence. In addition, the results of measurements were used to compute ground strains with the use of a numerical model. Also included are short discussions on geology, mining method, the survey network, and observation procedures.

Keyword(s): vertical displacement, horizontal displacement, monitoring design, monitoring installation, monitoring equipment, survey methods, survey equipment, room-and-pillar, prediction, modeling, geologic features

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

Choi, D. S., H. D. Dahl, D. L. McCain. Rock Mechanics Application to Room and Pillar Mining. IN: Ground Control in Room-and-Pillar Mining, Proceedings of the Conference,Southern Illinois University at Carbondale, August 6-8, 1980, Y.P. Chugh, ed., SME-AIME, New York, 1982, p. 65-80.

This paper examines current room-and-pillar mining practice in the United States from the standpoint of rock mechanics. Consideration is given to the deformation characteristics of the roof formation and the coal seam as determined in the laboratory as well as in the field. The results can be used by the practicing mining engineer to improve current mine design practice.

Keyword(s): mine design, room-and-pillar, rock mechanics, partial extraction, pillar strength, finite element

Location(s): United States

Choi, D. S., D. L. McCain. Ground Control Aspects of Longwall Coal Mining. IN: Proceedings Rapid Excavation and Tunneling Conference, Chicago, IL, June 12-16, 1983, H. Sutcliffe and J.W. Wilson, eds., SME-AIME, New York, p. 178-190.

This paper presents some results of ground control work carried on in Consol's mines. Application of these results has improved the safety and productivity of the underground mines. In addition, some other mines in the region have also successfully implemented the longwall mining method, resulting in the same benefit. Most of the tests mentioned in the paper require repeated observations to confirm their results over long mining cycles.

Keyword(s): coal mining, longwall, ground control, mine safety, room-and-pillar, vertical displacement, horizontal displacement

Location(s): United States

Choi, D. S. Theoretical Analysis of Breaking Strength of Mine Pillars and Test Specimens. 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. 953-962.

This paper presents a theoretical analysis of the effect of shape and size on strength of geologic materials. The results indicate that the shape effect is caused by the development of confining pressure at the interfaces. The linearization of the obtained formula is of the same form determined by experiments. The size effect is attibuted to the fact that the geologic materials contain discontinuities in the form of fractures, bedding planes, and cleats. The maximum reduction factor for the size effect is the one-sixth power of the volume of a cubic test specimen. These results are useful in determining the strength of pillars in underground mines.

Keyword(s): geologic features, pillar strength, coal mining, rock mechanics, lab testing, in situ testing

Christiaens, P. Clastic Behaviour of Main Roof Beds by Deep Mining. IN: Proceedings International Congress on Rock Mechanics, Aachen, 1991, W. Wittke, ed., v. 1, p. 689-692.

Beringen Colliery is working at a depth of 800 m beneath a 630-m waterbearing overburden. Serious exploitation problems are caused by strata control failures (face breakdown). No mathematical rock pressure model has ever been able to account for water pressure or the existence of faults. A measuring campaign has proved that the behaviour of the main roof beds is not elastic. These beds do not subside according to a right line, corresponding to prestressed beams of a length of at least 23 m, and their stability is particularly influenced by the shear resistance at their support point, determined mostly by the geologic and geometric configuration.

Keyword(s): coal mining, roof stability, geologic features, subsurface water, longwall, inflow

Location(s): Belgium

Chrzanowski, A., A. Szostak Chrzanowski. A Comparison of Empirical and Deterministic Prediction of Mining 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. 137-147.

All theories for predicting ground subsidence in mining areas are based either on empirical (statistical) models obtained through fitting of selected displacement functions into observed deformations or on deterministic modeling of the load-deformation relationship. The authors have been involved in a study of surface subsidence produced by extraction of a steeply inclined coal seam in difficult geological and topographical conditions of the Canadian Rocky Mountains. Actual displacements were compared with predicted values obtained from an empirical model and from a deterministic finite element model.

Keyword(s): coal mining, modeling, empirical model, finite element, geologic features, survey methods, survey data processing, monitoring methods, computer, active mines

Location(s): Canada

Chrzanowski, A., T. Poplawski, C. Y. Qi, J. Leal. Use of the Global Positioning System in Ground Subsidence Studies. IN: Proceedings VIII Congress International Society for Mine Surveying, September 22-27, 1991, University of Kentucky, Lexington, UKY BU154, p. 203-209.

Since 1985, the Engineering Surveys Research Group at the University of New Brunswick in Canada have used the Global Positioning System in several deformation measurement projects including ground deformation studies in oil fields in Venezuela and in a potash mining area in Canada.

Keyword(s): oil extraction, non-metal mining, survey methods, survey equipment, monitoring methods, vertical displacement

Location(s): Venezuela, Canada

Chudek, M., K. Podgorski, Z. Szczepaniak. Badanie Zachowania Sie Kabli Telekomunikacyjnych, Ukladanuch na Terenach Szkod Gorniczych (Investigation of Behavior of Telecommunication Cables Laid in Areas Affected by Mining Subsidence). Przeglad Gorniczy, v. 24, no. 9, 1968, p. 403-411.

Keyword(s): utilities

Chudek, M., A. Pach, R. Zylinski, W. Olaszowski. Problmy Utrzymania Rorgiagow na Terencah Gorniczych (Problems of Pipeline Maintenance in Mining Areas). Przeglad Gorniczy, v. 25, no. 3, 1969, p. 119-124.

Keyword(s): pipelines

Chudek, M. Size and Shape of the Protecting Pillars Under Surface and Underground Structures for the Conditions of Great Depths. IN: Strata Control in Deep Mines: Proceedings 11th Plenary Scientific Session of the International Bureau of Strata Mechanics, World Mining Congress, Novosibirsk, June 5-9, 1989, Balkema, Rotterdam, p. 61-72.

When mining in the vicinity of surface structures, it is necessary to define protecting pillars beneath the structures to prevent damage due to settlement. The size and shape of these pillars depends on strength of the rock massif, mining depth, angle of inclination of beds, thickness of overburden, and whether faults are present. The basis of design of protecting pillars, taking these factors into account is discussed with particular reference to mining and geological conditions of Poland.

Keyword(s): geologic features, overburden, mine design, pillar strength

Location(s): Poland

Chugh, Y. P., K. Chandrashekahr, R. Missavage, S. Ober. An Analysis of Subsidence Movements Associated with an Abandoned Shallow Room-and-Pillar Coal 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. 194-203.

An area in the midwestern United States overlying abandoned room-and-pillar mine workings at shallow depth has been experiencing subsidence movements with associated damage to surface structures. Other coal companies in the area have also been having similar experience. A 16-month cooperative study between a mining company and the Department of Mining Engineering at Southern Illinois University, Carbondale, was developed

Keyword(s): abandoned mines, room-and-pillar, geologic features, hydrology, surface structural damage, rock mechanics, instrumentation, coal mining

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

Chugh, Y. P., A. Van Besien, eds. Proceedings, First Conference on Ground Control Problems in the Illinois Coal Basin. Southern Illinois University at Carbondale, 1980, 301 p.

The Conference consisted of five sessions on geology of the Illinois Basin and geologic factors affecting mining, ground control in the room-and-pillar mining system, artificial supports, longwall mining, and subsidence. The primary objectives of the conference were to compile and disseminate available information and experience related to ground control, and to present current operating problems and ongoing ground control research pertinent to basin mines.

Keyword(s): ground control, coal mining, mine operation, subsidence research, active mines, abandoned mines, room-and-pillar, longwall, geologic features, floor stability, modeling, roof bolting, mine design

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

Chugh, Y. P., R. A. Missavage. Effects of Moisture on Strata Control in 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. 70-88.

Moisture has been known to influence strata failures in coal mines for a long time. A concise review of what is known about effects of moisture on strata control with emphasis on the Illinois Basin Coal mines is presented in this paper.

Keyword(s): coal mining, ground control, lab testing, roof stability, roof bolting

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

Chugh, Y. P., J. Bauer, C. Bandopadhay, C. Bollier. Subsidence Prediction Due to Auger Mining of Coal Pillars. IN: Workshop on Surface Subsidence Due to Underground Mining, Morgantown, WV, 1981.

Keyword(s): prediction, coal mining

Chugh, Y. P., A. Okunola, M. Hall. Moisture Absorption and Swelling Behavior of the Dykersburg Shale. Transactions Society of Mining Engineers, v. 268, 1981, p. 1808-1812.

Effects of moisture absorption on the behavior of the Dykersburg shale overlying the Harrisburg coal seam in southern Illinois are presented in this paper.

Keyword(s): roof stability, lab testing, coal mining, rock mechanics

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

Chugh, Y. P., J. Bauer, C. Bandopadhay. Effect of Weak Floor Interaction on Stability of Mine Openings. IN: Proceedings, Meeting of Petroleum Society of the Canada Institute of Mining and the Canadian Symposium on the Engineering Application of Mechanics, June, 1982, National Research Council of Canada, Ottawa, Ontario, p. 37-43.

This paper presents the results of weak floor interaction on the stability of coal pillars and mine openings. The results are based on analytical studies using a two-dimensional (plane strain) elastic-plastic finite element model. The effects of varying soft floor thickness, lateral stress field, and depth of mining were the primary variables investigated.

Keyword(s): floor stability, mine operation, coal mining, finite element, modeling

Location(s): United States

Chugh, Y. P., M. Karmis, eds. State-of-the-Art of Ground Control in Longwall Mining and Mining Subsidence. Proceedings of Symposium, Society of Mining Engineers of the American Institute of Mining, Metallurgical and Petroleum Engineers Fall Meeting, September, 1982, 271 p.

Keyword(s): ground control, longwall, coal mining

Location(s): United States

Chugh, Y. P., R. D. Caudle, C. Bandopadhay. Analysis of Soft Floor Interaction in Underground Mining at an Illinois Basin Coal Mine. 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. 383-390.

This paper presents the results of analytical and field studies to analyze the effects of soft floor on underground room-and-pillar mining. Two-dimensional finite element analyses were used to analyze the effect of soft floor on stress distribution in and around mine openings and coal pillars during mine development and retreat mining. Field studies involved measurement of convergence and sag in roadways and intersections during mine development and retreat mining, bearing capacity of floor, and measurement of pillar deformations ahead of retreat mining. The analytical and field studies data were used to prepare (1) design charts for determining the safe percentage of coal extraction to minimize floor heave for varying soft floor thickness and strength of underclay, and (2) guidelines to contain floor heave.

Keyword(s): rock mechanics, floor stability, coal mining, mine design

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

Chugh, Y. P., R. Missavage, R. D. Caudle, S. Ober, K. V. K. Prasad. Effect of Pillar Extraction on Roof Control. Annual Meeting of the American Mining Congress and International Coal Show, Chicago, May, 1984.

Keyword(s): roof stability, roof support, pillar extraction, coal mining

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

Chugh, Y. P., P. Singh. A Study of the Long-Term Strength of Herrin Coal from a Southern Illinois 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. 46-54.

This paper attempts to develop the long-term strength data from Herrin Seam coal from a selected site in southern Illinois. Unconfined compressive strength tests were conducted on about 3.0-inch cubical model coal pillars to study changes in their mechanical behavior with increasing stress and to identify critical stress levels for long-term stability. Two creep tests were also conducted on model coal pillars to study their time-dependent behavior and to determine if their time to failure could be predicted.

Keyword(s): coal mining, rock mechanics, pillar strength, modeling, lab testing

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

Chugh, Y. P. In-Situ Strength Characteristics of Coal Mine Floor Strata in Illinois. U.S. Bureau of Mines OFR 16-87, 1986, contract JO256002, 160 p.

This report presents data on bearing capacity and in-place shear strength characteristics of immediate floor strata. An attempt was made to correlate the field data with laboratory-determined strength-deformation characteristics and engineering index properties of floor strata from ongoing studies.

Keyword(s): in situ testing, floor stability, coal mining, active mines

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

Chugh, Y. P., K. Chandrashekhar, R. D. Caudle, S. Shankar, R. Nath. Effects of Soft Floor Interaction in Room-and-Pillar Coal Mining. 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. 33-43.

This paper presents results of geotechnical studies to analyze the effects of weak floor on the stability of mine openings and coal pillars in a room-and-pillar coal mine in central Illinois. Immediate floor strata cores were studied in the laboratory for engineering index properties. Ultimate bearing capacity tests were conducted in the field under as-mined and soaked-wet conditions. Borehole shear tests were performed to determine in-place cohesive strength and angle of internal friction. Floor substrata movements, differential roof strata movements, pillar load changes and surface subsidence were also being monitored over a mining panel.

Keyword(s): coal mining, room-and-pillar, floor stability, lab testing, in situ testing, geotechnical, pillar strength, computer, monitoring methods, monitoring equipment, surface subsidence damage, survey methods, finite element

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

Chugh, Y. P., R. Nath, S. Shankar. Time-Dependent Behavior of Immediate Weak Floor Strata from an Illinois Coal Mine. IN: Proceedings 6th International Conference on Ground Control in Mining, June 9-11, 1987, Department of Mining Engineering, West Virginia University, Morgantown.

The paper discusses laboratory and field studies to analyze time-dependent deformation behavior of immediate weak floor strata in an Illinois coal mine. In the laboratory, core samples of the immediate floor strata were subjected to incremental creep tests under unconfined compressive stress. Both axial and lateral creep deformations were recorded. A linear viscoelastic model was developed to represent the laboratory time-dependent behavior of immediate floor strata. Such a model may be acceptable for the design of partial extraction mining systems having extraction ratios of 40% to 60%. Field observations of roof-floor convergence at the mine also indicated a time-dependent behavior similar to that observed in the laboratory.

Keyword(s): coal mining, lab testing, in situ testing, time factor, floor stability, rock mechanics,

modeling, partial extraction, finite element, geotechnical, viscoelastic model

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

Chugh, Y. P., K. Chandrashekhar, R. D. Caudle. A Field Geotechnical Study of the Effects of Weak Floor Strata on Underground Coal Mining in Illinois. IN: Key Questions in Rock Mechanics, Proceedings 29th U.S. Symposium, Minneapolis, MN, June 13-15, 1988, P.A. Cundall, R.L. Sterling, and A.M. Starfield, eds., Balkema, Rotterdam, p. 681-690.

This paper details results to date of a geotechnical field study in a room-and-pillar mine. The primary objective of the study was to acquire data on roof/pillar/weak floor interactions so data could be compared with results of analytical studies.

Keyword(s): coal mining, floor stability, rock mechanics, geotechnical, room-and-pillar, finite element, lab testing, in situ testing, instrumentation, monitoring methods

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

Chugh, Y. P., S. Kuscu, A. Atri, R. Sweigard. Subsidence Monitoring at a Shallow Partial Extraction Room-and-Pillar Mine in Midwestern United States. 13 p.

Trough or sag type surface subsidence may be observed above partial extraction shallow (less than 100 m deep) room-and-pillar mines particularly where the coal seam is associated with weak and thick underclays in the floor. This paper presents results of subsidence studies at such a mine. The specific objectives of the study were to (1) analyze subsidence movements for vertical and horizontal displacements and strain profile characteristics and (2) correlate subsidence movements with observed underground movements.

Keyword(s): room-and-pillar, coal mining, partial extraction, active mines, floor stability, agriculture, monitoring methods, monitoring design, monitoring equipment, survey data processing, vertical displacement, horizontal displacement

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

Chugh, Y. P., A. Atri, J. Dougherty. Laboratory and Field Characterization of Immediate Floor Strata in Illinois Basin Coal Mines. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings of 30th U.S. Symposium, 1989, A.W. Khair, ed., Balkema, Rotterdam, p. 47-54.

Laboratory and field geotechnical characterization studies of weak floor strata were conducted at six mines during the period from 1985 to 1988. Correlation analysis among engineering index properties and laboratory and field determined strength-deformation properties were conducted to identify simple tests that can be used to estimate ultimate bearing capacity and deformation properties of immediate floor strata. It was concluded that the ultimate bearing capacity and strength-deformation properties of weak floor strata can be estimated from tests of natural moisture content, atterberg limits, and axial swelling strain. Indirect tensile strength was found to be a better estimator of UBC than unconfined compressive strength.

Keyword(s): floor stability, coal mining, active mines, lab testing, in situ testing, geotechnical, rock mechanics

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

Chugh, Y. P., A. Atri. Subsidence Monitoring at a Shallow Partial Extraction Room-and-Pillar Mine in Midwestern United States. 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. 715-722.

Subsidence may be observed above partial extraction shallow room-and-pillar mines where the coal seam(s) is associated with weak and thick claystone in the floor. This paper presents results of subsidence studies at such a mine.

Keyword(s): monitoring methods, partial extraction, room-and-pillar, coal mining, floor stability, time factor, vertical displacement, angle of draw, horizontal displacement, active mines

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

Chugh, Y. P., W. M. Pytel, O. Pula. A Modified Approach for Design of Coal Pillars for Weak Floor Strata Conditions. 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. 111-124.

This paper briefly describes and illustrates a modified approach for design of coal pillars under weak floor strata conditions considering UBC as well as pillar settlement. The approach is based on an approximate solution for estimation of the UBC for a shallow foundation on a two-layered rock system. Similarly, deformability underneath a full-

size pillar is estimated from deformability calculated from the plate loading tests. The effect of adjacent pillars on the UBC and deformability of coal pillars in a panel is also considered using foundation engineering analysis techniques. Design of pillars based on limiting settlements considers both differential settlements as well as mean settlement of pillars in a panel.

Keyword(s): mine design, coal mining, pillar strength, room-and-pillar, pillar extraction, floor stability, modeling, in situ testing, prediction

Location(s): United States

Chugh, Y. P., C.-C. Lia, X.-H. Weng, K. Chandrashekhar. An Analysis of the Effect of Augering of Coal Pillars on Mine Stability and Surface Subsidence. 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. 191-207.

Mine stability and subsidence effects of auger mining coal pillars during retreat mining are analyzed with finite element techniques. The analyses show that auger mining is possible and should not cause the remnant structure to be unstable if the first auger hole is located at least 3.5 feet away from the coal rib and spacing between auger holes is at least 2 feet. Results presented in this paper should also be valid if auger holes are developed on all four sides of a pillar.

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

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

Chugh, Y. P., M. E. Phillips, K. Chandrashekhar, A. K. Atri, S. E. Haq. Identification of Mine Characteristics, Conditions, and Procedures for Design of Stable Partial Extraction Room-and-Pillar Mines 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. 1-17.

Stability of partial extraction room-and-pillar mines depends on a number of interrelated geological, geotechnical and engineering (mine design) parameters. Identification and correlation of these parameters is a logical first step in understanding the causes of mine instabilitities and developing design guidelines. This paper discusses an attempt to identify and subsequently develop commonly encountered roof lithologic sequences associated with the No. 6 coal seam in Illinois. The association of these lithologic sequences with observed mine stability and artificial roof support performance is presented. Based on an analysis of specific instabilities such as roof falls, floor squeezes and surface subsidence for different geological and mining conditions, an attempt is made to identify appropriate safety factors for mine design in Illinois.

Keyword(s): coal mining, room-and-pillar, partial extraction, roof stability, roof support, floor stability, geologic features, mine design, geotechnical, engineering, pillar strength, roof bolting

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

Chugh, Y. P., Z. Yu, P. E. Miller. A Ground Control and Subsidence Study of a Longwall Mine in Southern Illinois. IN: Proceedings 4th Conference on Ground Control for Midwestern U.S. Coal Mines, November 2-4, 1992, Y.P. Chugh and G. Beasley, eds., Southern Illinois University, Carbondale, p. 195-216.

This paper presents the results of an ongoing field geotechnical study in a longwall mine in southern Illinois. The study includes both surface and underground instrumentation and monitoring. Surface subsidence monitoring includes vertical and horizontal deformations of monuments along and across the study panel, and underground instrumentation includes measurement of changes with face retreat in vertical pressure and horizontal deformation of chain pillars, and roof-floor convergence, roof sag, and floor heave in entries. An attempt is made to correlate the surace and in-mine ground movements. A hyperbolic tangent equation appears to fit changes in pillar deformation, convergence, and surface subsidence data as a function of face position.

Keyword(s): longwall, monitoring methods, active mines, instrumentation, in situ testing, monitoring equipment, survey methods, survey data processing, modeling, floor stability, roof stability, mine design, coal mining, pillar strength

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

Chugh, Y. P., W. M. Pytel. Analysis of Alternate Room-and-Pillar Mining Geometries Using the SIU Panel.2D Model. 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. 71-91.

This research is an attempt to develop alternate mine geometries with variable size pillars along and across a panel based on safety factors and pillar settlement considerations.

Keyword(s): floor stability, modeling, room-and-pillar, mine design, active mines, pillar strength

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

Chugh, Y. P., Z. Yu, P. E. Miller. A Ground Control and Subsidence Study of a Longwall Mine in Southern Illinois. IN: Proceedings, Illinois Mining Institute, Centennial Year, 1992, p. 4-25.

This paper presents the results of an ongoing field geotechnical study in a longwall mine in southern Illinois. The study includes both surface and underground instrumentation and monitoring. Surface subsidence monitoring included vertical and horizontal deformations of 65 monuments along and across the study panel. Underground instrumentation included measurement of changes with face retreat in vertical pressure and horizontal deformation of chain pillars, and roof-floor convergence, roof sag, and floor heave in entries. An attempt was made to correlate the surface and in-mine ground movements. A hyperbolic tangent equation appears to fit changes in pillar deformation, convergence, and surface subsidence data as a function of face position. The developed equations may be used by the mining industry to plan additional supports in entries, vacating surface structures, and in planning land use over mined-out areas.

Keyword(s): longwall, geotechnical, coal mining, instrumentation, monitoring methods, monitoring equipment, vertical displacement, horizontal displacement, survey design, survey methods

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

Chugh, Y. P., ed. Ground Control in Room-and-Pillar Mining. Proceedings Conference on Ground Control in Room-and-Pillar Mining, August, 1980, Southern Illinois University, Carbondale, SME-AIME, 1982, 157 p.

This proceedings contains 26 technical papers on ground control practices in coal and noncoal mines.

Keyword(s): room-and-pillar, coal mining, mine design, mine safety, ground control, roof stability, bumps, metal mining, rock mechanics, roof support, pillar strength, modeling, monitoring methods, abandoned mines, monitoring equipment, backfilling

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

Chugh, Y. P., ed. Proceedings, Second Conference on Ground Control Problems in the Illinois Coal Basin, May 29-31, 1985, Southern Illinois University, Carbondale, 158 p.

Falls of roof, ribs, and sides account for more than 50% of fatal and non-fatal injuries in the U.S. and Illinois underground coal mines. The need for better control of the ground from a safety point of view is therefore quite apparent. Additionally, uncontrolled surface and subsurface movements due to ground failures can significantly impact agricultural lands, water resources, and fish and wildlife habitats and cause damage to surface structures. Therefore, control of the ground during mining is also imperative from social, economic, and environmental points of view. The papers presented in this volume represent research advances and industry experience in ground control since the similar conference held in 1980. Surface subsidence and its control has drawn considerable public attention in Illinois in the recent past, and several papers on the subject are included.

Keyword(s): ground control, coal mining, subsidence research, geologic features, mine safety, agriculture, wildlife, environment, hydrology

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

Ciesielski, R., M. Czosnowski. The Construction of a Passenger Chairlift in a Mining Subsidence Area and its Protection. 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. 597-605.

A recreational chair lift was constructed in the territory of the Park of Culture and Recreation at Chorzow, in the center of the Silesian industrial district of Poland. The area in which the park is located is not suitable for general building purposes since it is subjected to large mining subsidence movements which are on a continuing basis.

Keyword(s): construction, surface structural damage, coal mining, engineering, horizontal displacement, monitoring methods

Location(s): Poland

Ciesielski, R. Dynamic Mining Influences on Surface Structures - Analysis and Methods of Evaluation. IN: Ground Movements and Structures, Proceedings 4th International Conference, University of Wales College of Cardiff, J.D. Geddes, ed., July 8-11, 1991, Pentech Press, London, 1992, p. 305-337.

These investigations into the problem of dynamic mining influences in two regions of Poland according to current practice, show that this problem can be serious for buildings in these regions, and can lead to damage or deterioration of buildings, particularly old ones.

Keyword(s): surface structural damage, active mines, abandoned mines

Location(s): Poland

Cifelli, R. C., H. W. Rauch. Dewatering Effects from Selected Underground Coal Mines in North-Central 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, p. 249-263.

This study documented the effects of underground coal removal on groundwater levels at selected mine sites in northern West Virginia, as observed from water wells, springs, and streams. This research should be useful to coal companies and regulatory agencies as an aid in recommendations for future water well locations and specifications in areas of existing or proposed underground coal mines

Keyword(s): subsurface water, surface water, hydrology, coal mining, active mines, abandoned mines, inflow

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

Cizek, K. Packing Goaf with Sand and Granulated Slag by the Flushing Process. Colliery Guardian, v. 85, 1903, p. 1274.

This article gives a general description of sand and granulated slag flushing, under German towns. Benefits included a substantial increase in coal extraction, no subsidence at the surface, and prevention of fire.

Keyword(s): hydraulic backfilling, stowing, mine fires, historical

Location(s): Germany

Clark, R. G., E. T. Haws, M. Stephen. Mining Subsidence Beneath PFA Disposal Lagoons at Brotherton Ings, Yorkshire. IN: Ground Movements and Structures, Proceedings 3rd International Conference, University of Wales Institute of Science and Technology, Cardiff, J.D. Geddes, ed., 1984, Pentech, London, 1985, p. 281-297.

This paper sets out the background and operational problems associated with a major ash disposal complex. Ground conditions are somewhat unusual, with periglacial effects exacerbated by past mining subsidence. Continued mining beneath the site has necessitated the adoption of special constructional and operational procedures to enable safe and economic ash disposal to continue without interruption.

Keyword(s): mine waste, abandoned mines, active mines, surface subsidence damage, engineering, coal mining

Location(s): United Kingdom

Cleary, E. T. Robbing Mine Supports May Have Caused Shenandoah Subsidence. Engineering News Record, v. 124, 1940, p. 358-380.

This article describes the area and the damages at the scene of a large subsidence event; it covers how utility companies met the problem.

Keyword(s): coal mining, utilities, surface structural damage, pillar extraction

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

Clemens, J. M. Monterey No. 1, A Modern Coal Mine. Mining Follows the Quadrant Plan. Coal Mining and Processing, v. 9, no. 6, 1972, p. 38-43.

The operations at the Monterey coal project, an underground working in southern Illinois, are described. It was decided to extract only 50% of the seam leaving pillars of adequate size to provide overburden support. Continuous mining machines and belt transportation are employed. Details of the roof support are given.

Keyword(s): roof support, mine design, mine operation, pillar strength, room-and-pillar, coal mining, active mines

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

Coal. Longwall Use Could Collide With Tighter Subsidence Controls. July 1990, v. 96, no. 7, p. 9.

The coal industry's increased use of longwall systems appears on a collision course with the federal government's move toward tighter controls over subsidence.

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

Location(s): United States

Coal. Virginia Court Upholds Longwalling. v. 95, no. 12, December, 1990, p. 78-80.

A coal mine in southwestern Virginia came close to being permanently barred from longwalling in a January 1990 decision by the Virginia Supreme Court.

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

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

Coal Age. Anthracite Mine-Cave Situation. v. 14, no. 13, 1918, p. 598-601.

Early development of coal mining in Scranton, Pennsylvania, is described, including agreements between coal companies and townspeople regarding compensation for and protection against surface structural damage as a result of subsidence.

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

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

Coal Age. Hydraulic Stowage at Home and Abroad. v. 25, 1924.

This article is a general discussion of hydraulic stowing methods and application in various countries. It includes a detailed discussion, by Charles Enzian, of Griffith's proposal to blast the roof down and blast the floor up to form supporting pillars.

Keyword(s): hydraulic backfilling, stowing, coal mining

Coal Age. Longwall Mining. McGraw-Hill, New York, 1965.

Longwall mining equipment and procedure is described, including a series of pictures. The article also discusses the advantages and disadvantages of longwall mining and its application in United States coalfields.

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

Location(s): United States

Coal Mining and Processing. Can Mining Operations be Planned to Minimize Subsidence? v. 4, no. 9, 1967, p. 38-41, 47.

This article discusses the use of underground measures (mine design methods) as a means of minimizing subsidence.

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

Location(s): United Kingdom, United States

Coal Mining and Processing. How to Calculate Factors in Mining Subsidence. v. 4, no. 5, May, 1967, p. 28-33 (first of a three-part series).

With the extension of mining beneath residential and industrial areas, it is becoming increasingly important to work minerals in such a way that subsidence damage is kept to a minimum and that as little mineral as possible is sterilized in pillars of support. This dual aim can only be achieved with a knowledge of ground movement and its relation to mine workings. For many years little was known about the nature of ground movement, and subsidence calculations were therefore very approximate. In recent years, affected areas have been carefully measured and observed, and the principles of ground movement caused by extraction of stratified deposits are now more fully understood.

Keyword(s): mine design, backfilling, stowing, mine waste, time factor, coal mining, longwall, prediction

Location(s): United Kingdom, United States

Coal Mining and Processing. What Happens When the Ground Subsides? v. 4, no. 7, July, 1967, p. 20-23.

This article discusses the components involved in the vertical and horizontal movement within a subsidence trough. The paper also discusses strain, which is the extension or compression of the ground within the subsidence zone per unit of length; also, the degree and direction to which any surface site will tilt depending on the subsidence; and finally, the choice that may be made in designing structures so they will be able to withstand subsidence.

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

Location(s): United Kingdom, United States

Coal Mining and Processing. Illinois to Conduct Subsidence Study. v. 19, no. 10, 1982, p. 17.

Keyword(s): coal mining, subsidence research

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

Coal News. States Can Determine Subsidence Liability, Supreme Court Rules. No. 5039, April 1, 1991, National Coal Association, Washington, D.C., p. 1-2.

In a ruling of major significance, a federal appeals court has reversed a lower court decision

and upheld a U.S. Interior Department regulation that leaves to state law the extent of subsidence liability of underground coal mining operations.

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

Location(s): United States

Coates, D. F. Pillar Loading. Research Report, Department of Mines and Technical Surveys, Ottawa, Canada, 1965-1966.

This paper describes laboratory experiments and field measurements used to derive new hypotheses for determining pillar loads. The report includes a series of equations including such factors as span of mining zone, height and breadth of pillars, position of pillars in the mining zone, variations between deformability of pillars and wall rocks, and the effects on both normal and transverse field stresses.

Keyword(s): pillar strength, mine design, room-and-pillar, rock mechanics, lab testing, in situ testing

Location(s): Canada

Coates, D. F., A. Ignatieff. Prediction and Measurement of Pillar Stresses. Canadian Mining Journal, v. 87, January, 1966, p. 50-56.

The author presents a new hypothesis for predicting the loading of pillars, taking into account the structural features of the system. Included are measurements of pillar stresses in underground iron mines in Canada and Sweden, and uranium mines in Canada.

Keyword(s): prediction, pillar strength, metal mining

Location(s): Canada, Sweden

Coates, D. F. Rock Mechanics Principles. Mines Branch, Canadian Department of Energy, Mines, and Resources, Monograph 74, Ch. 4, 1970, p. 4-1 - 4-25.

The mechanics of pillars is discussed from three aspects: the load applied to the pillar, the strength of the pillar, and the reaction of the roof and floor to pillar stresses.

Keyword(s): rock mechanics, pillar strength

Coates, D. F., M. Gyenge. Incremental Design in Rock Mechanics. Mining Research Centre, Mines Branch, Department of Energy, Mines and Resources, Canada, Mines Branch Monograph 880, 1973, p. 5-1 - 5-15.

The authors formulate mathematical subsidence-prediction methods for underground mining operations. These methods can be used to calculate subsidence over flat-lying ore bodies, steeply dipping veins, and massive ore bodies that lead to cover caving.

Keyword(s): vertical displacement, horizontal displacement, rock mechanics, prediction, modeling, mathematical model, metal mining

Location(s): Canada

Coates, D. F. Rock Mechanics Principles. Canadian Department of Energy, Mines and Resources, Mine Branch Monograph 74, 1970, rev. 1974.

The mechanics of pillars is discussed from three aspects: pillar load, pillar strength, and the reaction of the roof and floor to pillar stresses.

Keyword(s): rock mechanics, pillar strength, ground control, mine design

Location(s): Canada

Coates, D. R. Large Scale Land Subsidence. IN: Mega-Geomorphology, R. Gardner and H. Scoging, eds., Oxford University Press, Oxford, 1983, p. 212-233.

Keyword(s): geologic features, surface subsidence damage

Cochran, W. Mine Subsidence--Extent and Cost of Control in a Selected Area. U.S. Bureau of Mines IC 8507, 1971, 32 p. (NTIS PB 236 093)

The USBM investigated subsidence caused by recent underground mining, estimated the extent of damages, and formulated a procedure for evaluating subsidence costs.

Keyword(s): mitigation, economics, ground control, active mines

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

Coe, C. J., S. M. Stowe. Evaluating the Impact of Longwall Coal Mining on the Hydrologic Balance. IN: Proceedings Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation, December 2-7, 1984, University of Kentucky, Lexington, p. 395-403.

An approach has been developed to evaluate changes in the hydrologic balance associated with land subsidence above longwall mining operations in the Appalachian Coal Basin. This method consists of developing hydrogeologic cross sections to define specific aquifers and aquitards which exist within the overburden. The cross sections can be used to define the premining hydrologic flow

pattern wihin the mine overburden and the lithologic composition of a well, spring, or pond where no previous data were available. Then the water sources are mapped in relationship to the mine development plan. Hydrographs are developed to evaluate changes in water level in a well or the flow characteristics of a spring or stream with respect to the passing of the longwall mine face. Two site case histories are presented.

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

Location(s): Appalachian Coal Region, United States

Coe, C. J., S. M. Stowe. Evaluating the Impact of Longwall Coal Mining on the Hydrologic Balance. IN: Proceedings, National Water Well Association Conference on the Impact of Mining on Ground Water, Denver, CO, 1984, p. 348-359.

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

Cohen, S. Taking the Surprises Out of Subsidence. Landmarc, July/August, 1989, p. 4-13.

This article discusses various coal companies' efforts to cooperate with landowners and repair surface properties during and after longwall mining. An accompanying sidebar covers USBM subsidence prediction models and foundation monitoring studies.

Keyword(s): longwall, structural mitigation, surface structural damage, coal mining, land mitigation, law, subsurface water, foundations, monitoring equipment, prediction

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

Colaizzi, G. J., R. H. Whaite, D. L. Donner. Pumped-Slurry Backfilling of Abandoned Coal Mine Workings for Subsidence Control at Rock Springs, Wyoming. U.S. Bureau of Mines IC 8846, 1981, 100 p.

This report describes a pumped-slurry backfilling demonstration project for abandoned mine workings. It also contains background information on other hydraulic backfilling methods.

Keyword(s): hydraulic backfilling, economics, abandoned mines, coal mining

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

Colaizzi, G. J., M. R. Virta, D. L. Groy, M. R. Schmidt. Coal Mine Subsidence Control Case Studies, Colorado Springs, 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. 235-253.

Subsidence of the land surface over abandoned underground coal mines is a continuing problem in Colorado Springs. Subsidence events pose varying problems depending on subsidence type, local geology, and proximity to buildings and other improvements.

Keyword(s): abandoned mines, grouting, hydraulic backfilling, surface structural damage, foundations, coal mining, geologic features

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

Cole, K., I. Statham. General (Areal) Subsidence Above Partial Extraction Mines - Part 1. Ground Engineering, v. 25, no. 2, March, 1992, p. 45-55.

Isolated examples of trough subsidence above partial extraction mines have been reported in the United Kingdom, crownhole subsidence being more common. General subsidence results from deterioration and ultimate collapse of ground at or above the working level. Categories of collapse condition for partial extraction mines are outlined. Mine pillar collapse mechanisms and the many contributing factors are examined. Pillar stress and strength calculations considering geological and geometric parameters are illustrated.

Keyword(s): partial extraction, pillar strength, engineering, coal mining

Location(s): United Kingdom

Cole, K., I. Statham. General (Areal) Subsidence Above Partial Extraction Mines - Part 2. Ground Engineering, v. 25, no. 3, April 1992, p. 36-40.

Failure processes in coal mines are further examined, with results of tests on coal pillars summarized, comparisons made between strengths of coal and overburden pillars, and failure of overburden pillars in coal mines considered. Effects of quality of overburden rock, mine flooding, uneven pillar loading, and mine layout and mining procedures are discussed. Finally, remedial grouting and assessment of collapse potential are described.

Keyword(s): partial extraction, pillar strength, coal mining, overburden, grouting, engineering

Location(s): United Kingdom

Cole, K. W. Building Over Abandoned Shallow Mines--A Strategy for the Engineering Decisions on Treatment. Ground Engineering, v. 20, no. 4, 1987, p. 14-30.
Keyword(s): abandoned mines, surface structural damage, structural mitigation, engineering, construction, architecture, land-use planning

Colliery Engineering. Flushing Anthracite Workings. v. 33, 1913, p. 537.
This article describes the first uses of hydraulic backfilling of anthracite mines. Both remote and controlled flushing were used for roof support, to prevent subsidence, and allow pillar removal.
Keyword(s): hydraulic backfilling, mine waste, anthracite, coal mining, roof support, pillar extraction

Colliery Engineering. Effect of Coal Mining on the Surface. v. 33, May 1913, p. 548-552; v. 33, June 1913, p. 617-622.
Keyword(s): surface subsidence damage, coal mining

Colliery Engineering. Hydraulic Stowing in Pennsylvania. v. 28, July, 1951, p. 329.
Two methods of controlling surface subsidence are described: (1) hydraulic flushing with comparatively fine-grain material, and (2) manual and mechanical stowage of material.
Keyword(s): hydraulic backfilling, stowing
Location(s): Pennsylvania, Appalachian Coal Region, United States

Colliery Engineering. Power Stowing Installation. v. 31, no. 366, August, 1954, p. 266.
Keyword(s): stowing

Colliery Engineering. Hydraulic Stowing in Poland. v. 31, December, 1954, p. 529 (abstract only).
This abstract describes the status of hydraulic backfilling in Poland at that time.
Keyword(s): hydraulic backfilling, stowing
Location(s): Poland

Colliery Engineering. Crushing Stowing Material. v. 33, no. 388, June, 1956, p. 264.
Keyword(s): stowing

Colliery Engineering. Pneumatic Stowing in Spain. v. 34, no. 396, February, 1957, p. 54.
Keyword(s): pneumatic backfilling, stowing
Location(s): Spain

Colliery Engineering. Steel Bars and Stowing. v. 34, no. 398, April, 1957, p. 176.
Keyword(s): stowing

Colliery Engineering. Stowage Dirt Transport. v. 34, no. 399, May, 1957, p. 221.
Keyword(s): stowing

Colliery Engineering. Stowing in Inclined Seams. v. 34, no. 403, September, 1957, p. 395.
Keyword(s): stowing

Colliery Engineering. Hydraulic Stowing in Poland. v. 35, February, 1958, p. 91 (abstract only).
This abstract describes hydraulic backfilling operations in Poland where seams are up to 79 feet thick.
Keyword(s): hydraulic backfilling, stowing
Location(s): Poland

Colliery Engineering. Preparation of Pit Stone for Stowage. v. 38, no. 450, August, 1961, p. 332.
Keyword(s): stowing

Colliery Engineering. Simultaneous Coal Getting and Stowing. v. 39, no. 459, May, 1962, p. 204.
Keyword(s): stowing, coal mining

Colliery Engineering. Successful Debut of Bien Breaker Stower. v. 41, no. 486, August, 1964, p. 312.
Keyword(s): stowing

Colliery Guardian. Hydraulic Packing in German State Mines. November 1, 1912, p. 903.
This article includes a comparative chart illustrating the purpose of backfilling, increase in production, fill material, and quantity and particle size of fill for the mine.
Keyword(s): hydraulic backfilling
Location(s): Germany

Colliery Guardian. Support of Railways. v. 107, 1914, p. 523 and 1400.
This article discusses the rights of railway owners and mineral owners and the English law of 1845.
Keyword(s): historical, law, railroads
Location(s): England

Colliery Guardian. Mining Subsidence in India. August 11, 1922, p. 330.
A Subsidence Committee noted the following conditions that may be deemed peculiar to India:

(1) absence of packing, except in a few recent cases, none of which were old enough to enable definite conclusions to be drawn; (2) the considerable thickness of the seams; and (3) the high proportion of hard sandstones and low proportion of shales or soft rocks in the strata.

Keyword(s): coal mining, geologic features, stowing, pillar extraction

Location(s): India

Colliery Guardian. Mine Subsidence. v. 179, March 10, 1949, p. 333-335.

Colliery Guardian. The Hydraulic Transport of Coal in Poland. v. 197, October, 1958, p. 542.

Keyword(s): backfilling, coal mining

Location(s): Poland

Colliery Guardian. Hydraulic Stowing. August 8, 1963, p. 185-187.

An example is given of hydraulic sand backfilling under pressure to fill old mine voids in Great Britain.

Keyword(s): abandoned mines, hydraulic backfilling

Location(s): England

Colliery Guardian. Mining Under Coventry. v. 207, September 12, 1963, p. 324-327.

This article describes a partial extraction system to be used in England. The seam is 20 to 30 feet thick, at a depth of 2,100 feet.

Keyword(s): surface structural damage, partial extraction

Location(s): England

Colliery Guardian. Controlling Subsidence. v. 210, August 7, 1964, p. 176.

Keyword(s): ground control, coal mining

Collins, B. J. Measurement and Analysis of Residual Mining Subsidence 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. 3-29.

This paper is based upon a research project into the long-term or residual aspects of mining subsidence. The work was carried out in conjunction with the National Coal Board.

Keyword(s): instrumentation, monitoring methods, survey methods, survey data processing, survey equipment, time factor, horizontal displacement, vertical displacement

Location(s): Wales, United Kingdom

Collins, S. L. Coal and Coal Mining. IN: Guidebook for the 45th Annual Field Conference of Pennsylvania Geologists--Land Use and Abuse the Allegheny County Problem, Pittsburgh, Pennsylvania, October 3 and 4, 1980, Department of Environmental Resources, Bureau of Topographic and Geologic Survey, Harrisburg, PA, p. 19-24.

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

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

Colorado School of Mines. Rock Mechanics Instrumentation Program for Kaiser Steel Corporation's Demonstration of Shield-Type Longwall Supports at York Canyon Mine, Raton, New Mexico. U.S. Department of Energy Contract AC01-74ET12530, 1981, 303 p. (NTIS DOE/ET/12530-1)

Chapter 5 describes the surface instrumentation used to measure vertical and horizontal movement and extent of surface subsidence. Results are then compared with results of predictions made by the National Coal Board of Britain.

Keyword(s): vertical displacement, horizontal displacement, monitoring design, monitoring installation, monitoring equipment, survey methods, survey equipment, survey data processing, rock mechanics, longwall, National Coal Board, coal mining, instrumentation, prediction

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

Concrete and Construction Engineering (London) Large Reservoir Designed for Mine Subsidence. v. 46, no. 12, 1951, p. 353-358.

Keyword(s): construction, surface water, engineering

Concrete and Construction Engineering (London) Foundations to Resist Subsidences. v. 51, no. 9, 1956, p. 491-493.

Keyword(s): construction, foundations

Concrete and Construction Engineering (London) A Tower Liable to Subsidence. v. 51, no. 10, 1956, p. 500-501.

Keyword(s): construction, surface structural damage

Connelly, M. A. The Uses of Geologic Structural Analyses in Predicting Roof Conditions in Coal Mining. IN: Proceedings of Symposium on Stress and Failure Around Underground Openings, University of Sydney, New South Wales, Australia, 1967, paper 13, p. 1-2.

Keyword(s): prediction, roof stability, coal mining, geologic features

Conover, D. P., K. Y. Haramy, K. Hanna. Methods to Determine Pillar Stress Distribution and its Effect on Stability. 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. 419-424.

The effects of stress distribution on pillar stability were evaluated through rock mechanics studies conducted in three underground room-and-pillar coal mines. Results of the three field instrumentation programs are presented to illustrate the use of borehole pressure cells to determine vertical stress distribution in coal pillars at various stages of mine development. Vertical stresses and stress changes are determined using methods developed at the USBM. Measured stress distributions are compared against theoretical distributions and possible explanations for observed behavior are discussed. Results indicate that stresses and stress changes calculated from pressure cell data are inconsistent with theoretical values; however, the data are useful for qualitative evaluation of trends over time. Calculated values are found to be sensitive to coal properties and initial setting pressures of the cells.

Keyword(s): pillar strength, rock mechanics, room-and-pillar, coal mining, instrumentation

Location(s): United States

Conroy, P. Rock Mechanics Studies, United States Bureau of Mines, Longwall Demonstration, Old Ben Mine No. 24, Benton, Illinois, Phase III. Preliminary report Panel 2, June, 1970, 18 p.

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

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

Conroy, P. Rock Mechanics Studies, United States Bureau of Mines, Longwall Demonstration, Old Ben Mine No. 24, Benton, Illinois, Phase III. Preliminary report panel 1, Job No. 7734-002-07, August, 1977, 39 p.

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

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

Conroy, P. Rock Mechanics Studies, Longwall Demonstration at Old Ben 24, Benton, IL. Phase I and II Report, submitted to U.S. Bureau of Mines, 1979, 57 p.

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

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

Conroy, P. J. Subsidence Above A Longwall Panel in the Illinois No. 6 Coal. Preprint 3293, ASCE Convention and Exhibit, Pittsburgh, PA, April, 1978, p. 77-92.

The mining discussed in this paper was the first successful application of longwall in Illinois. This panel was part of a cooperative agreement between Old Ben Coal Company and the USBM. As part of the agreement, subsidence monitoring (including TDR) was performed on the surface. Instrumentation also monitored the progressive caving of the overlying strata.

Keyword(s): coal mining, longwall, surface subsidence damage, monitoring methods

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

Conroy, P. J. Longwall Coal Mining. Dames and Moore Engineering Bulletin, no. 52, August, 1980, p. 13-26.

This article outlines experience gained during a feasibility and demonstration study of longwall coal mining in the Illinois Basin. Geotechnical investigations included a premining study to review the previous attempts at longwall mining and to perform in situ rock mechanics tests. Results were used as a basis to formulate recommendations for the longwall supports to be used in the demonstration. TDR (Time Domain Reflectometry) was used in the monitoring program.

Keyword(s): longwall, engineering, rock mechanics, geotechnical, instrumentation, coal mining

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

Conroy, P. J., J. H. Gyarmaty, M. L. Pearson. Demonstration of Subsidence Monitoring System. U.S. Department of Energy contract AC01-78ET10029, Dames and Moore, Park Ridge, IL, June, 1981, 435 p. (NTIS DOE/ET/10029-T1)

This study was conducted to provide additional data on coal mine subsidence to serve as a basis for the development of subsidence control technology. The study involved installing, monitoring, and evaluating three subsidence monitoring instrument systems: (1) structure performance, (2) performance of supported systems, and (3) performance of caving systems. Objectives of the instrument program were: (1) to select, test, assemble, install, monitor, and maintain all instrumentation required for implementing the monitoring systems; and (2) to evaluate the performance of each instrument individually and as part of the appropriate monitoring system or systems. Twelve instruments were selected and implemented. The data acquired with each instrument were discussed and evaluated for applicability in terms of quality and effectiveness in characterizing subsidence. Recommendations include the use of an automatic level and rod extensometer for measuring structure performance, and the automatic level, steel tape extensometer, FBPX, FPBI, USBM borehole deformation gauge, and vibrating wire stressmeters for measuring the performance of caving systems. Instruments recommended for measuring the performance of supported systems were identical to that of the caving system. Alternatives are also discussed.

Keyword(s): monitoring design, monitoring installation, monitoring equipment, survey methods, survey equipment, survey data processing, instrumentation

Location(s): United States

Conroy, P. J., E. A. Curth. Longwall Mining in Illinois. IN: Longwall-Shortwall Mining, State of the Art, 1981, R.V. Ramani, ed., AIME, New York, p. 191-199.

This chapter discusses the history and development of longwall mining in Illinois, including equipment, roof supports, and present practice.

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

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

Conroy, P. J., J. H. Gyarmaty. Planning Subsidence Monitoring Programs Over Longwall Panels. 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. 225-234.

This paper presents guidelines and recommendations for the design and implementation of a comprehensive subsidence monitoring program.

Keyword(s): monitoring design, monitoring equipment, monitoring methods, survey methods, survey equipment, horizontal displacement, longwall, economics, ground control, National Coal Board, coal mining

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

Conroy, P. J., J. H. Gyarmaty. Subsidence Monitoring--Case History. 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. 148-153.

This paper summarizes subsidence research performed at a mine site in West Virginia, with a generalized geological description of the site to allow comparison of data with those of similar sites.

Keyword(s): monitoring design, monitoring installation, monitoring equipment, survey methods, survey equipment, instrumentation

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

Conroy, P. J. Subsidence Monitoring to Verify Analytical Models. IN: Proceedings Conference on Ground Control in Room-and-Pillar Mining, Southern Illinois University at Carbondale, August 6-8, 1980, Y.P. Chugh, ed., SME-AIME, New York, 1982, p. 127-132.

Most subsidence monitoring to date has been surface monitoring to develop empirical relationships of the magnitude and extent of subsidence effects. Federal regulations are forcing a better understanding of subsidence. Empirical methods of subsidence prediction may not be adequate because these relationships may not be valid between or even within coal fields. A better understanding of the mechanics of subsidence is required to develop and verify analytical models.

Keyword(s): modeling, coal mining, prediction, law, longwall, monitoring methods, monitoring design, geologic features

Location(s): United States

Conroy, P. J., J. H. Gyarmaty. Characterization of Subsidence Over Longwall Mining Panels--Eastern Coal Province. U.S. Bureau of Mines OFR 192-83, Contract JO133920, Dames & Moore, 1983, 165 p.

Keyword(s): longwall, coal mining, monitoring methods

Location(s): Appalachian Coal Region, United States

Conroy, P. J., J. Gyarmaty. The Mid-Continent Field: Results of a Subsidence Monitoring Program. IN: Surface Mining Environmental Monitoring and Reclamation Handbook, L.V.A. Sendlein, et al., eds., Coal Extraction and Utilization Research Center, Southern Illinois University at Carbondale, U.S Department of Energy Contract no. DE AC22 80ET 14146. Elsevier, New York, 1983, p. 681-708.

A subsidence monitoring program was conducted over two longwall panels at the Old Ben Mine No. 24 located near Benton, Illinois, as part of the USBM Longwall Demonstration project. The results of this study may be useful to future longwall mining subsidence monitoring plans for mines located in the Illinois Basin having similar geologic and topographic properties.

Keyword(s): longwall, active mines, monitoring methods, geologic features, vertical displacement

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

Cook, N. The Design of Underground Excavation. IN: Failure and Breakage of Rock, Proceedings 8th Symposium on Rock Mechanics, University of Minnesota, September 15-17, 1966, C. Fairhurst, ed., AIME, New York, 1967, p. 167-193.

This paper deals with stresses contained within rock masses both before and after excavation, and with energy released as a result of underground excavation. The discussion includes the design of excavations to minimize energy changes and to control rock failure underground with the main emphasis on the calculation of stresses and not with actual physical layouts of mining operations.

Keyword(s): rock mechanics, mine design

Location(s): South Africa

Cook, N. G. W., K. Hodgson, J. P. M. Hojem. A 100-MN Jacking System for Testing Coal Pillars Underground. Journal South African Institute of Mining and Metallurgy, v. 68, 1967, p. 192-195.

Keyword(s): pillar strength, ground control, in situ testing, coal mining

Location(s): South Africa

Cooley, W. C. Survey of Foreign Technology for Stowing in Underground Coal Mines. Final report on U.S. Bureau of Mines Contract JO275041 with Terraspace, Inc., Rockville, MD, Report #TR-420-1, May 30, 1978, 60 p.

This report is a historical summary and bibliography of foreign technology concerning backfilling as a means of limiting subsidence.

Keyword(s): stowing, literature search, coal mining

Location(s): Soviet Union, Poland, Germany, United States

Cooper, R. E. Discussion on Subsidence Due to Coal Workings. IN: Institution of Civil Engineers, Minutes of Proceedings, v. 135, 1898, p. 132-135.

Keyword(s): coal mining, historical

Cope, E. The Progress of Mechanized Packing in North Staffordshire. Transactions, Institute of Mining Engineers, v. 115, 1955, p. 651; also Colliery Guardian, v. 191, no. 4934, September, 1955, p. 351.

Keyword(s): stowing, coal mining

Location(s): United Kingdom

Corapcioglu, M. Y., W. Brutasaert. Viscoelastic Aquifer Model Applied to Subsidence Due to Pumping. Water Resource Research, v. 13, 1977, p. 597-604.

Keyword(s): fluid extraction, modeling, viscoelastic model, phenomenological model, subsurface water, hydrology

Corbett, B. O. Abandoned Mine Workings Beneath Monklands District General Hospital, Airdrie. IN: Mineworkings 84: Proceedings of the International Conference on Construction in Areas of Abandoned Mineworkings, Edinburgh, 1984, M.C. Forde, et al., eds., Engineering Technics Press, Edinburgh, p. 52-63.

Keyword(s): abandoned mines, surface structural damage

Corbett, R. G. Effects of Coal Mining on Ground and Surface Water Quality, Monongalia County, West Virginia. The Science of the Total Environment, v. 8, no. 1, July, 1977, p. 21-38.

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

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

Corden, C. H. H. The Recording of Boundary Distortion in Mining Subsidence. Ph.D. Thesis, University of Leeds, UK, 1964, 146 p.

Location(s): United Kingdom

Corden, C. H. H., H. J. King. A Field Study of the Development of Surface Subsidence. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 2, no. 1, 1965, p. 43-55.

The field measurement of surface subsidence presents many difficulties. The use of the usual survey techniques yields a static, or instantaneous picture of the displacements along the axis of measurement. These are not, however, necessarily capable of analysis, especially if the line is either multi-directional or, being uni-directional, is oblique to the developing contours of subsidence. The experience gained in a field scheme for the absolute measurement of tilt and strain was useful in the design and use of the apparatus described in this article.

Keyword(s): rock mechanics, survey methods, survey equipment, monitoring equipment, vertical displacement, survey design, monitoring design

Cording, E. J., T. D. O'Rourke, M. Boscardin. Ground Movements and Damage to Structures. 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. 516-537.

The results of studies on buildings adjacent to tunnels and excavations are summarized. Measurements of lateral strain, tilt and differential settlement were made in a brick bearing wall structure during excavation of a tunnel adjacent to the structure. For other structures, the available movement data consisted of settlements. In these cases, maximum settlements and slopes were related to observed building damage.

Keyword(s): surface structural damage, tunnelling, foundations, longwall, architecture, horizontal displacement, vertical displacement

Cordova, R. M., R. W. Mower. Fracturing and Subsidence of the Land Surface Caused by the Withdrawal of Ground Water in the Milford Area, Utah. U.S. Department of the Interior, Geological Survey Journal of Research, v. 4, 1976, p. 505-510.

Keyword(s): fluid extraction

Location(s): Utah, United States

Corson, D. R. Field Evaluation of Hydraulic Backfill Compaction at the Lucky Friday Mine, Mullan, Idaho. U.S. Bureau of Mines RI 7546, August, 1971.

Results are given for a 4-year monitoring program of two test sites where normal filling procedures were used and compared to vibratory compaction.

Keyword(s): hydraulic backfilling

Location(s): Idaho, United States

Cortis, S. E. Coal Mining and Protection of Surface Structures Are Compatible. Mining Congress Journal, v. 55, June 1969, p. 84-89.

This paper discusses Pennsylvania's Bituminous Mine Subsidence and Land Conservation Act of 1966. It summarizes the formulas, regulations and standards developed to control mine subsidence and determine surface areas of potential damage above active mines for prevention of damage to surface structures.

Keyword(s): surface structural damage, law, government, bituminous, active mines, coal mining

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

Corwine, J. W. A Longwall Demonstration at Old Ben Mine No. 24, Illinois. IN: Proceedings Illinois Mining Institute, v. 84, 1976, p. 72-79.

This paper is a status report on the longwall demonstration, equipment used, and the initial results.

Keyword(s): longwall, coal mining

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

Cotecchia, V. Subsidence Phenomena Due to Earthquakes: Italian Cases. 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. 829-840.

Subsidence phenomena may have a more or less slow development or, when triggered by earthquakes, a very rapid evolution. The latter is the case of the modifications in the elevation of entire regions following very violent seismic events. Among the natural causes of the modifications, a basic role is undertaken by the seismo-tectonic component, whose primary effects are tectonic dislocations of the bedrock. In more superficial soils, another not less important consequence is given by minor dislocations caused by various sudden effects of the seismic action.

Keyword(s): geologic features, surface subsidence damage, seismic, soils

Location(s): Italy

Coulomb, C. Application des Regles de Maximis et Minimus a quelques Problemes de Statique Relatifs a l'Architecture. Memiors de Savants etrangers de l'Academie des Sciences de Paris, 1773.

Keyword(s): prediction theories

Coulthard, M. A., A. J. Dutton. Numerical Modelling of Subsidence Induced by Underground Coal Mining. IN: Key Questions in Rock Mechanics, Proceedings of the 29th U.S. Symposium, Minneapolis, MN, June 13-15, P.A. Cundall, R.L. Sterling, and A.M. Starfield, eds., 1988, Balkema, Rotterdam, p. 529-536.

The subsidence induced by single panel coal extractions has been calculated with continuum and distinct element stress analysis. Nonlinear material models in programs FLAC and UDEC, which allow a more realistic representation of the behaviour of the roof strata, reproduce the observed qualitative change in subsidence profiles that occurs in the transition from sub-critical to super-critical panel widths. The programs therefore have the potential to provide reliable subsidence prediction in new geological and mining environments.

Keyword(s): modeling, coal mining, prediction, empirical model

Location(s): Australia

Courtney, W. J., M. M. Singh. Feasibility of Pneumatic Stowing for Ground Control in Coal Mines. Illinois Institute of Technology Research, Report No. D 6068, 1972, 128 p. (Available from USBM Library, Mining Research Center, Spokane, WA.)

Keyword(s): pneumatic backfilling, stowing, ground control, coal mining

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

Cox, D. W. Modelling Stochastic Behaviour Using the Friction Table with Examples of Cracked Brickwork and 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. 307-328.

The friction table has been widely applied to demonstrate the behaviour of rock slopes. The same methods can be applied to other fissured or discontinuous media such as brickwork or rock in a subsidence zone. The paper demonstrates the effect of different ground deflections on crack patterns in brickwork. The secondary effect of window and door openings on the pattern are also shown. A stereographic method of crack measurement is detailed.

Keyword(s): stochastic model, modeling, surface structural damage

Craft, J., T. Crandall, J. Holbrook, G. Kelley, W. Remy. Madisonville Areawide Subsidence Investigation. Final Report, Office of Surface Mining, Pittsburgh, September, 1986, 175 p. (NTIS PB91-164806)

This report discusses an areawide subsidence investigation, conducted by Office of Surface Mining in Madisonville, KY, to determine mechanisms of abandoned underground mine subsidence and to access potential for future subsidence. Information and data from geotechnical investigations, subsidence damage surveys, borehole camera inspection of conditions in abandoned mines, and previous subsidence investigations are analyzed. Geologic data and damage survey reports, pillar strength calculations, abandoned mine gas information, and a general discussion of available abatement techniques are appended to this report.

Keyword(s): abandoned mines, coal mining, geotechnical, monitoring methods, pillar strength, geologic features

Location(s): Kentucky, United States

Craft, J. L., T. M. Crandall. Mine Configuration and its Relationship to Surface Subsidence. IN: Association of Engineering Geologists Symposium Series No. 4, Building Over Underground Mines--Subsidence Considerations, October 1987, p. 37-50.

Knowledge of the mine configuration is essential to a subsidence investigation and the interpretation of the subsidence mechanism(s). The investigator should obtain all available mine maps in the subsiding area and establish survey control points to accurately tie the mine map to the surface. Once established and confirmed by drilling, mine geometry and the exploratory drilling data can be evaluated to determine the failure mechanism which resulted in the surface disturbance. Only after the failure mechanism has been determined, can an effective stabilization program be implemented.

Keyword(s): abandoned mines, active mines, coal mining, prediction, geologic features

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

Craft, J. L. Classification of Coal Mine Related Subsidence East of the Mississippi River, U.S.A. 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. 69.

Field investigation of surface subsidence associated with active and abandoned underground coal mine sites in the Eastern United States has established evidence for the classification of mine related surface subsidence. The classification is based on the interrelationship between overburden thickness, geology, topography, and mine plan. The subsidence types are: Pit, Room, Sag, and Cantilever Beam Subsidence.

Keyword(s): overburden, coal mining, surface subsidence damage, surface structural damage, roof stability, pillar strength

Location(s): United States

Crane, W. R. The Use of Concrete for Mine Support. Transactions, Institution of Mining Engineers, v. 37, 1909, p. 560.

This article stresses versatility, strength, and lack of maintenance of concrete versus timber for support.

Keyword(s): roof support

Crane, W. R. Subsidence and its Relation to Drainage in the Red Iron Mines of the Birmingham District, Alabama. Transactions, AIME, v. 75, 1927, New York, p. 837-872.

Cave-ins near the outcrop and fracturing of the surface were the most pronounced manifestations of disturbance by the red-ore mines of the Birmingham District. Because the orebed was overlain by water-bearing formations, fracturing of the top rock was important enough to warrant adoption of protective measures.

Keyword(s): metal mining, subsurface water

Alabama, United States

Crane, W. R. Subsidence and Ground Movement in the Copper and Iron Mines of the Upper Peninsula, Michigan. U.S. Bureau of Mines B 295, 1929, 66 p.

Keyword(s): surface subsidence damage, metal mining

Location(s): Michigan, United States

Crane, W. R. Essential Factors Influencing Subsidence and Ground Movement. U.S. Bureau of Mines IC 6501, 1931, 14 p.

The author assesses joints and faulting in a mining area to predict possible subsidence.

Keyword(s): angle of draw, prediction, geologic features

Location(s): United States

Creveling, J. B. Factors Affecting the Strength of Subcoal Materials and the Prediction of Strength from Index Properties. M.S. Thesis, University of Missouri-Rolla, 1976.

Keyword(s): floor stability, lab testing, coal mining

Crook, J. M., D. P. McNicholl. The Monitoring of Ground Movements Due to Deep Coal Mining and Their Implications for Large-Scale Development Proposals at Warrington New Town (UK). 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. 527-544.

Warrington New Town was designated in 1968, and it is planned to increase the population to 190,000 by 1991. Approximately 30% of the New Town area would be subject to underground mining and associated ground movements would represent a constraint both in terms of the timing of development in areas undergoing active subsidence and the type and form of developments in areas to be undermined in the future. To be able to commit development in the mining areas with confidence, a systematic approach to the problem was adopted.

Keyword(s): coal mining, instrumentation, monitoring design, monitoring methods, land-use planning, surface structural damage, abandoned mines, active mines

Location(s): United Kingdom

Crossfield, J. K. Ground Settlement Monitoring by Digital Photogrammetry. IN: Proceedings, 45th Annual Meeting of American Society of Photogrammetry, Washington, D.C., March 18-24, 1979, p. 600-606.

Keyword(s): monitoring equipment, monitoring methods

Location(s): United States

Crouch, S. L., C. Fairhurst. The Mechanics of Coal Mine Bumps and the Interaction Between Coal Pillars, Mine Roof, and Floor. U.S. Bureau of Mines OFR-53-73, February 22, 1973, 97 p. (NTIS PC A05/MF A01)

This report describes research done on the mechanics of coal mine bumps over a 26-month period.

Keyword(s): room-and-pillar, bumps, pillar strength, floor stability, roof stability, coal mining
Location(s): United States

Crouch, S. L. Two-Dimensional Analysis of Near-Surface Single-Seam Extraction. International Journal of Rock Mechanics and Mining Sciences and Geomechanics Abstracts, v. 10, no. 2, March, 1973, p. 85-96.

This paper describes a digital computer method for calculating the stresses and displacements induced by underground excavations in a single flat-lying seam that is arbitrarily near the surface of the earth. The method is developed by superposition from solutions previously given for a displacement discontinuity, or dislocation, in an otherwise continuous, linearly elastic, infinite rock mass. The new solution can be applied to complicated extraction patterns in the plane of a seam in a semi-infinite mass, the surface of which can be subjected to arbitrary prescribed extractions.

Keyword(s): phenomenological model, elastic model, modeling, rock mechanics

Crouch, S. L., C. Fairhurst. Analysis of Rock Mass Deformations Due to Excavations. IN: Rock Mechanics Symposium, Winter Annual Meeting of American Society of Mechanical Engineers, Detroit, November 11-15, 1973, D.L. Sikarskie, ed., American Society of Mechanical Engineers, New York, p. 25-40.

The major difficulty in attempting to calculate stresses and displacements caused by underground excavations is that the material characteristics and detailed geologic structure of the rock mass usually are unknown. The ideas presented in this paper are based on the assumptions that the rock mass can be characterized as a linearly elastic material and that any nonlinear behavior is confined to the immediate vicinity of the excavations or to any known major structural features within the mass.

Keyword(s): geologic features, rock mechanics, engineering, surface structural damage, modeling

Crowell, D. L. Drilling for Mine Subsidence Mitigation. Ohio Mineral Industries Report, 1990, Ohio Department of Natural Resources, Division of Geological Survey, 7 p.

The Ohio Geological Survey completed a 39-hole drilling project as part of a mine-subsidence mitigation investigation. The U.S. Office of Surface Mining provided funding to devise the mitigation plan. Part of this plan required holes to be drilled into the Wellston mine complex to determine the extent of mining activity and the progress of subsidence under that portion of the city with the greatest number of subsidence complaints.

Keyword(s): abandoned mines, mitigation, coal mining, geotechnical, historical, surface structural damage
Location(s): Ohio, United States

Culshaw, M. G., A. C. Waltham. Natural and Artificial Cavities as Ground Engineering Hazards. Quarterly Journal of Engineering Geology, 20, 1987, p. 139-150.

Keyword(s): geologic features, engineering, land-use planning

Culshaw, M. G., F. G. Bell, J. C. Cripps, M. O'Hara, eds. Planning and Engineering Geology. Geological Society Engineering Geology Special Publication No. 4, Proceedings of Conference, 1987, 641 p.

The papers in this symposium review the relationship between planning and engineering geology and its development in response to increasing public awareness of environmental conservation and restoration needs.

Keyword(s): engineering, abandoned mines, land-use planning, coal mining, non-metal mining, remote sensing, geophysical, hydrology, prediction
Location(s): United Kingdom, Jamaica, China

Culshaw, M. G., P. D. Jackson, D. M. McCann. Geophysical Mapping Techniques in Environmental Planning. 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. 171-177.

Geophysical information can be used to identify geological features, some of which may be a problem during the planning, design, or construction of a new development.

Keyword(s): abandoned mines, geophysical, seismic, roads
Location(s): United Kingdom

Culver, H. E. Coal Resources of District III (Western Illinois). Illinois State Geological Survey, Mining Investigation Bulletin 29, 1925, 128 p.

Keyword(s): coal mining, historical
Location(s): Illinois, Illinois Coal Basin, United States

Culver, H. E. Coal Resources of District III. Illinois State Geological Survey, Mining Investigation Bulletin 29, 1925, 128 p.

Keyword(s): coal mining, historical

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

Cummings, R. A., M. M. Singh. Investigation and Abatement of Subsidence Damage at the Heltsley Residence, Indiana. IN: Mine Subsidence, Society of Mining Engineers Fall Meeting, St. Louis, MO, September, 1986, M.M. Singh, ed., SME, Littleton, CO, p. 65-71.

In April 1984 a subsidence depression formed directly beneath a two-story frame residence near Linton, IN, causing 2 ft of separation between the floor and walls, and damaging both the foundation and interior of the building. The Office of Surface Mining undertook the rehabilitation of the area under its emergency response program. This paper describes the investigation performed to determine the cause, severity, and extent of the problem. Abandoned mine workings were found approximately 55 to 60 feet below the house. Based on the findings, remedial measures were prescribed. An abatement program consisting of grouting the mine voids was recommended, and specifications prepared. These were implemented, and the area has been successfully stabilized.

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

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

Cundall, P.A. A Computer Model for Simulating Progressive Large Scale Movements in Blocky Rock Systems. IN: Proceedings International Symposium on Rock Mechanics, 1971, 8 p.

Keyword(s): computer, prediction, rock mechanics, modeling

Curth, E. A. Relative Pressure Changes in Coal Pillar During Extraction: A Progress Report. U.S. Bureau of Mines RI 6980, July 1967, 20 p.

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

Location(s): United States

Curth, E. A. Roof Support Problems in Longwall Mining: A Study in the United States and Germany in 1971. IN: Proceedings U.S. 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. 101-114.

Observations at 12 selected longwall operations in the United States indicated that roof control at the face was achieved even under adverse conditions. A study in Germany included 25 mine trips and the Essen Research Center's techniques for the evaluation of roof and support.

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

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

Curth, E. A., M. D. Cavinder. Longwall Mining the Herrin No. 6 Coalbed in Southern Illinois. IN: Proceedings, Illinois Mining Institute, 1977.

In April 1975, the USBM awarded a cost-sharing contract to Old Ben Coal Co. with the objective of demonstrating that the Herrin Coal in southern Illinois can be mined by longwall methods using shield-type roof supports. Earlier attempts at longwalling using chocks ended in failure.

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

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

Curth, E. A. Safety Aspects of Longwall Mining in the Illinois Coal Basin. U.S. Bureau of Mines IC 8776, 1978, 37 p.

Keyword(s): The USBM and Old Ben Coal Co. participated in a cost-sharing contract to demonstrate longwall mining in the Herrin No. 6 coalbed in southern Illinois. A premining investigation laid the groundwork for specifying a roof-support system designed to control hazardous ground. Lemiscate-type roof shields were selected. A rock mechanics program and geological mapping provided early warning capability and criteria for equipment design. The effect of mining on the surface was monitored by a surface survey to develop subsidence-prediction criteria for the Illinois coal basin. The major adverse condition was the occurrence of limestone concretions, called coal balls, in massive pods. The shields provided adequate roof control even in faulty ground. The accident rate was low.

Keyword(s): longwall, mine operation, coal mining, mine safety, survey methods

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

Curth, E. A. Design of Longwall Mining Systems. IN: Proceedings 1st Conference on Ground Control Problems in the Illinois Coal Basin, Southern Illinois University at Carbondale, August 22-24, 1979, Y.P. Chugh and A. Van Besien, eds., 1980, p. 165-207.

The Illinois Coal Basin contains significant reserves and is one of the important coal-producing provinces in the United States in close proximity to consumers. Room-and-pillar methods are prevalent, with the result that the average coal recovery approximates 50% and roof control is difficult. The alternative is longwall mining, with the potential for better ground control, generally easier compliance with safety standards, improved productivity and higher resource recovery.

Keyword(s): coal mining, longwall, mine design, finite element, economics

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

Cyrul, T., Z. Kleczek, A. Zorychta. Certain Polish Experiences in Controlling and Predicting the Surface Subsidence Due to Mining. SME-AIME Preprint No. 86-82, for presentation at the SME Annual Meeting, New Orleans, LA, March 2-6, 1986, 9 p.

Poland has achieved high coal production despite unfavorable mining and geological conditions by introducing new and original solutions to the mining practice. This paper deals only with surface subsidence and protection against mining influences in the Upper Silesian Coalfield.

Keyword(s): longwall, surface structural damage, mine design, pillar extraction, geologic features, coal mining

Location(s): Poland

Da Costa, A. M., C. Fairhurst. Comparison of Numerical Modeling with Predictions from Laboratory Tests and Field Observations of Deformation in a Potash Mine in Sergipe, Brazil. IN: Proceedings 26th U.S. Symposium on Rock Mechanics, Rapid City, SD, June 26-28, 1985, E. Ashworth, ed., Balkema, Rotterdam, 1985, p. 239-249.

This paper examines the application of two numerical methods (the finite element method and the displacement discontinuity method) to practical examples in the simulation of the behavior of mining excavations in the Taquari-Vassouras Mine in Brazil.

Keyword(s): modeling, finite element, computer, rock mechanics, lab testing, in situ testing, non-metal mining

Location(s): Brazil

Daemen, J. The Effect of Protective Pillars on the Deformation of Mine Shafts. Rock Mechanics, v. 4, No. 2, October, 1972.

Keyword(s): pillar strength, mine design, rock mechanics

Daemen, J. J. K., M. Hood. Subsidence Profile Functions Derived from Mechanistic Rock Mass Models. 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. 124-139.

This paper considers the first phase of an assessment of the use of mechanistic subsidence models, namely the possibilities and problems associated with estimating the large-scale rock parameters needed to use some of the elastic solutions for subsidence calculations by treating the solutions as profile functions.

Keyword(s): vertical displacement, horizontal displacement, empirical model, modeling, profile function

Dahl, H. D. Mine Subsidence as a Problem in Coulomb Plasticity. M.S. Thesis, Pennsylvania State University, State College, 1967, 84 p.

Keyword(s): modeling, phenomenological model, plastic model

Dahl, H. D. A Finite Model for Anisotropic Yielding in Cavity Loaded Rock. Ph.D. Dissertation, Pennsylvania State University, 1969, 155 p.

Keyword(s): modeling

Dahl, H. D., R. C. Parsons. Ground Control Studies in the Humphrey No. 7 Mine of Christopher Coal Division, Consolidation Coal Company. AIME Centennial Annual Meeting, New York, NY, 1971, AIME Preprint 71-AM-101.

A comprehensive research effort was directed toward improving ground stability in the Humphrey and nearby mines having similar roof conditions.

Keyword(s): ground control, roof stability, coal mining

Location(s): United States

Dahl, H. D. Two and Three Dimensional Elastic-Elastoplastic Analyses of Mine Subsidence. IN: Proceedings 5th International Strata Control Conference, 1972, Paper No. 28, 5 p.

The author discusses finite element models used to simulate subsidence phenomena and correlates the results obtained to field data from Britain and the United States. The U.S. data are from observations over mines in western Pennsylvania and West Virginia.

Keyword(s): continuum mechanics, finite element, phenomenological model, elastic model, plastic model, modeling

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

Dahl, H. D., R. C. Parsons. Ground Control Studies in the Humphrey No. 7 Mine, Christopher Coal Division, Consolidation Coal Company. Transactions AIME, v. 252, 1972, p. 211-222.

To improve roof stability, Continental Oil Company's research program, initiated in 1969, was directed toward defining the geological parameters that affect the severity of roof conditions in any particular area of the mine. In addition, the program was seeking to define why roof falls in the Humphrey No. 7 mine (and in northern West Virginia-southwestern Pennsylvania coal mining areas) are oriented so that they occur primarily in north-south rooms or entries. Conclusions and recommendations from this study of roof fall orientation are given.

Keyword(s): coal mining, roof stability, geologic features

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

Dahl, H. D., D. S. Choi. Measurement and Prediction of Mine Subsidence Over Room and Pillar Workings in Three Dimensions. IN: Proceedings AIME Annual Meeting, Dallas, TX, February 23-28, 1974.

Subsidence data are compiled for a mine practicing modified room-and-pillar extraction in a flat seam, 6 feet thick and 500 to 600 feet deep in the eastern United States. Overlying topography is rugged. A three-dimensional mathematical model was used to duplicate observed effects. The model assumes subsidence is a result of deformation governed by elastic-frictional plastic stress-strain relationships. Good agreement between observed and modeled effects are obtained. Discussion of observed effects is included.

Keyword(s): prediction, modeling, mathematical model, coal mining, room-and-pillar

Location(s): Appalachian Coal Region, United States

Dahl, H. D., D. S. Choi. Some Case Studies of Mine Subsidence and Its Mathematical Modeling. IN: Proceedings, 15th U.S. Rock Mechanics Symposium, Custer State Park, SD, September 17-19, 1973, E.R. Hoskins, Jr., ed., ASCE, 1975, p. 1-21.

Ground movements have been monitored over mines in southwest Pennsylvania in which coal is produced both by room-and-pillar and longwall methods. Three-dimensional contour maps of subsidence have been obtained in which face position is considered an independent variable. These field data are compared with a three-dimensional analytical model incorporating a frictional yield criteria in the constitutive relation. In addition, the effect of topography on subsidence is presented and discussed.

Keyword(s): vertical displacement, mathematical model, prediction, longwall, room-and-pillar, survey data processing, modeling, coal mining

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

Dahl, H. D., H. A. VonSchonfeldt. Rock Mechanics Elements of Coal Mine Design. 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. 4A1-4A9.

The purpose of this paper is to outline some of the design techniques being used in industry for improved roof and ground control. The discussion is restricted to coal mining in single, more or less horizontal, seams. It covers a basic analysis concept that can be applied to the design of longwall development headings, to recommend pillar extraction schemes, to the caving properties of the overburden over longwall panels, subsidence prediction and the design of long-term main entries.

Keyword(s): coal mining, rock mechanics, mine design, longwall, pillar extraction, prediction

Location(s): United States

Damberger, H. H. Analysis of Geological Structures That Influence Roof Stability in Room and Pillar Mines in the Herrin (No. 6) Coal Member, Ill. Presented at the 1976 AIME Annual Meeting, Las Vegas, NV, February 24, 1976.

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

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

Damberger, H. H., W. J. Nelson, H.-F. Krausse. Effect of Geology on Roof Stability in Room-and-Pillar Mines in the Herrin (No. 6) Coal of Illinois. Illinois State Geological Survey Reprint 1980-P, 1980. Reprinted from Proceedings of 1st Conference on Ground Control Problems in the Illinois Coal Basin, August 22-24, 1979, Y.P. Chugh and A. Van Besien, eds., Southern Illinois University, Carbondale, 1980, p. 14-32.

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

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

Damberger, H. H., W. J. Nelson, H.-F. Krausse. Effect of Geology on Roof Stability in Room-and-Pillar Mines in the Herrin (No. 6) Coal of Illinois. IN: Proceedings 1st Conference on Ground Control Problems in the Illinois Coal Basin, August 22-24, 1979, Y.P. Chugh and A. Van Besien, eds., Southern Illinois University, Carbondale, 1980, p. 14-32.

Roof stability in underground mines in the Herrin Coal is dependent upon the lithology and geologic structure of the rocks overlying the coal.

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

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

Dames and Moore. Rock Mechanics Studies, United States Bureau of Mines Longwall Demonstration, Old Ben Mine, No. 24, Benton, Illinois; Phase III--Preliminary Report, Panel 1. Job No. 07734-002-07, 1977.

Keyword(s): rock mechanics, longwall, coal mining

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

Daniels, J., L. D. Moore. The Ultimate Crushing Strength of Coal. Engineering and Mining Journal, v. 10, August, 1907, p. 263-268.

Keyword(s): pillar strength, coal mining

Darmody, R. G., I. J. Jansen, S. G. Carmer, J. S. Steiner. High Extraction Mining: Effects on Corn Yields. IN: Proceedings National Symposium on Mining, Hydrology, Sedimentology, and Reclamation, Springfield, IL, December 7-11, 1987, Office of Engineering Services, University of Kentucky, Lexington, p. 203-208.

The impact of coal mine subsidence-induced effects on corn yields in 1985 and 1986 in Illinois was investigated. The study areas were photographed from the air, and areas deemed to have subsidence-induced effects were delineated on the photos after photo analysis. Sites for corn yield sampling were harvested in the fall of each year.

Keyword(s): agriculture, coal mining, active mines, longwall, high-extraction retreat, photography, subsidence research

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

Darmody, R. G., I. J. Jansen, S. G. Carmer, J. S. Steiner. Effects of Coal-Mine Subsidence on Corn Yields in Illinois. IN: Agronomy Abstracts, Proceedings 79th Annual Meeting of American Society of Agronomy, Atlanta, GA, November 29-December 4, 1987 p. 25.

The effect on corn yields of underground coal mine induced subsidence was studied in Illinois. Two types of coal mines with planned subsidence were studied, longwall and high-extraction retreat. Subsided areas were inventoried by means of aerial photography. Areas with obvious increase in soil wetness or with change in topography due to mining were marked on the photos. Corn yields were sampled in the fall of each year. Although the overall reduction in yield was slight, when calculated on a weighted area average basis, areas associated with longwall mining had significantly greater decrease in yield than did areas associated with high-extraction retreat mining.

Keyword(s): agriculture, high-extraction retreat, longwall, photography, soils

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

Darmody, R. G., J. S. Steiner, I. J. Jansen, S. G. Carmer. Agricultural Impacts of Coal Mine Subsidence: Evaluation of Three Assay Methods. Journal of Environmental Quality, v. 17, No. 3, 1988, p. 510-513.

A microcomputer and spread sheet program were used to store and analyze data from a collection of maps and aerial photographs in a research project concerning the agricultural impacts of underground coal mine induced subsidence. The overall objective of the research project was to assess the damage to agricultural production caused by underground coal mine subsidence. The work reported here details the development and evaluation of the method used to meet the overall objective.

Keyword(s): survey data processing, computer, subsidence research, photography, agriculture

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

Darmody, R. G., I. J. Jansen, S. G. Carmer, J. S. Steiner. Agricultural Impacts of Coal Mine Subsidence: Effects on Corn Yields. Journal of Environmental Quality, v. 18, no. 3, July-September, 1989, p. 265-267.

Underground coal mining methodology is moving toward techniques that cause immediate planned subsidence of the overlying land. Damage done by subsidence to structures has been documented, but the effects on agricultural productivity are undocumented. This study was conducted to (1) determine the extent of measurable subsidence effects associated with planned subsidence mining, (2) measure the impact of subsidence on corn yield, and (3) compare the effects of longwall and high extraction retreat mining methods. Five locations in southern Illinois were included in the 3-year study.

Keyword(s): agriculture, coal mining, active mines, longwall, high-extraction retreat

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

Darmody, R. G., F. W. Simmons, T. J. Bicki, S. D. Harding. Coal Mine Subsidence Effects on Soils and Hydrology. IN: Agronomy Abstracts, American Society of Agronomy 81st Annual Meeting, October 15-20, 1989, Las Vegas, NV, p. 261.

Research was undertaken to determine the effects of coal mine subsidence on soils and hydrology in southern Illinois. Areas to be undermined by planned subsidence types of mines were characterized prior to mining. Soil

investigation pits were excavated to allow profile description and collection of samples for bulk density, saturated hydraulic conductivity, particle size, shear strength, and penetrometer resistance. Saturated hydraulic conductivity was also determined in the field by means of a Bouwer double tube hydraulic conductivity device. Piezometers were installed at various depths.

Keyword(s): agriculture, soils, hydrology, active mines, coal mining, longwall, high-extraction retreat

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

Darmody, R. G., T. J. Bicki. Use of Civil Engineering Fabrics in Pedological Field Research. Soil Science Society of America Journal, v. 53, no. 6, November-December 1989, p. 1912.

During the course of a field research project involving the effects of mine subsidence on soils in southern Illinois, the need to routinely re-examine pedons from soil pits was realized.

Keyword(s): agriculture, soils, in situ testing, coal mining, active mines

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

Darmody, R. G. Illinois Mine Subsidence Research Program: The Agronomic Contributions. 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. 119-129.

This paper describes three agronomic projects to investigate the impact of coal mine subsidence on agriculture: an assessment of the impact of coal mine subsidence on corn yields, an evaluation of subsidence mitigation, and an evaluation of the direct impact of subsidence on agricultural soils.

Keyword(s): agriculture, active mines, coal mining, mitigation, soils, hydrology, subsidence research

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

Darmody, R. G., R. T. Hetzler, F. W. Simmons. Coal Mine Subsidence: The Effect of Mitigation on Crop Yields. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 183-188.

Longwall coal mining in southern Illinois occurs beneath some of the best agricultural land in the United States. This region is characterized by highly productive, nearly level, and somewhat poorly drained soils. Subsidence from longwall mining causes changes in surface topography, which alters surface and subsurface hydrology. These changes can adversely affect agricultural land by creating wet or ponded areas that can be deleterious to crop production. Although most subsided areas showed little impact from subsidence, some areas experience total crop failure. Coal companies are required by law to mitigate subsidence damage to cropland. The objective of this study was to test the effectiveness of mitigation in restoring grain yields to their pre-mined levels.

Keyword(s): agriculture, land mitigation, active mines, longwall, coal mining, hydrology, subsurface water, soils, reclamation

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

Darmody, R. G., R. T. Hetzler, F. W. Simmons. Coal Mine Subsidence: Effects of Mitigation on Crop Yields. International Journal of Surface Mining and Reclamation, 6, 1992, p. 187-190.

Subsidence from longwall underground coal mining adversely impacts agricultural land by creating wet or ponded areas. Although most subsided areas showed little impact, some areas, usually less than 1.5 ha in size, may experience total crop failure. Coal companies mitigate subsidence damaged cropland by installing drainage waterways or by adding fill material to raise the grade. The objective of this study was to test the effectiveness of mitigation in restoring corn and soybean yields to pre-mined levels. Fourteen sites in southern Illinois were selected for study. Corn and soybean yields from mitigated and nearby undisturbed areas were compared for 4 years. Results varied due to differing weather and site conditions. Mean corn yields overall, however, were significantly lower on mitigated areas. There was no significant difference in overall mean soybean yields. Soil fertility levels were similar and did not account for yield differences.

Keyword(s): agriculture, land mitigation, coal mining, longwall, active mines, soils

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

Darn, D. Predicting and Evaluating Subsidence with the Carbs Eagle. Lands & Mineral Surveying, v. 5, no. 11, November 1987, p. 594-597.

Predicting the degree of subsidence likely to be caused by mining has always been based on "rule of thumb" calculations using various formulas that relate to the zone of influence and the depth of the

workings. Computer aided design now gives much more accurate results. The author explains the development and function of the Carbs Eagle software package, both in general terms and in its application for tracking and predicting subsidence. The program can be used for all types of underground extraction that may affect the surface and also for surface modeling applications in quarrying, tunnelling, and civil engineering.

Keyword(s): prediction, modeling, computer, coal mining, metal mining, tunnelling, survey data processing, geologic features, overburden, active mines, engineering, land-use planning

Location(s): United Kingdom

Darton, N. H. Notes on Sand for Mine Flushing in the Scranton Region. U.S. Bureau of Mines B 25, 1912, p. 72.

This bulletin deals with the history and condition of mining operations in the Scranton, Pennsylvania, area.

Keyword(s): backfilling, coal mining, historical

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

Das, B., V. Singh. Theoretical Investigation Into the Angle of Break in Relation to the Depth. Journal of Mines, Metals and Fuels, v. 21, April, 1973, p. 110-112.

Keyword(s): modeling

Das, M. N., D. Barat, R. K. Prasad, P. R. Sheorey. Considerations for Influence of Overburden Depth on Coal Strength. IN: Proceedings, International Symposium on Underground Engineering, New Delhi, India, April 14-17, 1988, B. Singh, ed., Balkema, Rotterdam, p. 55-60.

As reported elsewhere, a large number of in situ strength data for Indian coal seams, when plotted against depth, show a downward trend indicating that the in situ strength is underestimated at depth because testing is generally done in the failed rock zone. An increase in the depth of cover increases the failure zone, causing more deteriorated rock to be tested. In the case of small scale laboratory strength, the influence of depth is insignificant except at greater depth. Further systematic investigations were carried out in a single seam at Barmondia Colliery to confirm the findings more conclusively.

Keyword(s): in situ testing, lab testing, pillar strength, coal mining, overburden, rock mechanics

Location(s): India

Daunesse, C., Y. Reimbaud. The Mining Subsidence in the Nord and Pas-de-Callius Coalfield. Ann. Mines, October, 1963, p. 589-633 (in French).

Location(s): France

Davies, B. L., R. Smith. The Influence of Coal Mining on Maintenance, Design and Construction of Highway Bridges and County-Owned Structures in South Yorkshire (UK). 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. 545-561.

This paper describes the approach taken by the South Yorkshire County in establishing an internal mining adivsory service. It discusses the evolution of a policy in regard to the protection of the County's interests in those structures, whether highway or building for which the County has a direct responsibility, and gives examples of mining related problems that it has dealt with during the first 3 years of its existence.

Keyword(s): construction, surface structural damage, structural mitigation, coal mining, roads, National Coal Board, active mines, abandoned mines

Location(s): United Kingdom

Davies, J. B. A Novel Method of Conveying Culm into Old Workings to Support the Roof. Colliery Engineering, v. 14, August, 1893, p. 11.

This article describes a method of introducing culm and water at the Black Diamond Colliery, near Kingston, PA.

Keyword(s): backfilling, hydraulic backfilling, mine waste

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

Davies, J. D. Circular Tanks on Ground Subject to Mining Subsidence. Civil Engineering and Public Works Review, London, v. 55, no. 648, 1960, p. 918-920.

Keyword(s): surface structural damage

Location(s): England

Davis, G. H. Formation of Ridges Through Differential Subsidence of Peatlands of the Sacramento San Joaquin Delta, California. U.S. Geological Survey Professional Paper 475-C, 1963, p. 162-165.

Keyword(s): geologic features

Location(s): California

Davis, G. H. Land Subsidence Related to Head Decline at Baton Rouge, Louisiana. Geological Society of America, Special Paper 101, (abstract), 1968, p. 354.

Keyword(s): fluid extraction, subsurface water
Location(s): Louisiana, United States

Davis, G. H., H. B. Counts. Further Examination of Subsidence at Savannah, Georgia, 1955-1975. 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. 347-354.

Keyword(s): hydrology
Location(s): Georgia, United States

Davis, G. H. Land Subsidence and Sea Level Rise on the Atlantic Coastal Plain of the United States. Environmental Geology and Water Sciences, 10, 1987, p. 67-80.

Keyword(s): surface water, geologic features
Location(s): United States

Davis, P. K. Model Studies for Optimum Hydraulic Backfilling of Underground Coal Mines Through Boreholes for Subsidence Control. 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. 345-359.

Research on the feasibility of disposing of a slurried mixture of flue gas desulfurization sludge and fly ash in abandoned underground mines has been ongoing since 1985. In addition to disposing of this waste material in an environmentally acceptable manner, it was anticipated that another significant advantage to this method would be subsidence prevention.

Keyword(s): modeling, hydraulic backfilling, coal mining, mine waste, abandoned mines, literature search
Location(s): Illinois, Illinois Coal Basin, United States

Davis, S. N., F. L. Peterson, A. D. Halderman. Measurement of Small Surface Displacements Induced by Fluid Flow. Water Resource Research, v. 5, 1969, p. 129-138.

Keyword(s): fluid extraction, survey methods

Dawson, R. F. Land Subsidence Problems. IN: Proceedings ASCE Surveying and Mapping Division, v. 89, no. SV2, Paper 3531, June, 1963, p. 1-12.

Regional subsidence occurred in the Texas Gulf Coast area due to oil and groundwater withdrawal, resulting in consolidation of clay strata by increasing intergranular pressure.

Keyword(s): fluid extraction, surface water, subsurface water, hydrology
Location(s): Texas, United States

Dawson, R. F. Land Subsidence Problems. IN: Proceedings ASCE Journal of Surveying and Mapping Division, v. 91, no. SU1, 1965, p. 53-54.

Dean, J. W. Old Mine Shafts and Their Hazards. The Mining Engineer, London, March, 1967, v. 126, no. 78, p. 368-377.

Keyword(s): abandoned mines, historical

Dearman, W. R., A. Strachan, D. P. Roche, C. Vincett. Influence of Mining Subsidence on Pipelines. Bulletin of the International Association of Engineering Geologists, 25, 1982, p. 19-24.

Keyword(s): pipelines, utilities

Decherf, J., A. Vandewalle, A. Caron. Le Probleme des Affaissements Miniers Dams le Bassin du Nord-Pas-de-Calais (Problem of Mine Subsidence in the Nord-Pas-de-Calais Basin). Industrie Minerale, St. Etienne, France, v. 62, no. 5, 1980, p. 295-313.

Location(s): France

Deere, D. U., A. J. Hendron, F. D. Patton, E. J. Cording. Design of Surface and Near-Surface Construction in Rock. IN: Failure and Breakage of Rock, Proceedings 8th Symposium on Rock Mechanics, University of Minnesota, September 15-17, 1966, C. Fairhurst, ed., AIME, New York, p. 237-302.

In designing a structure founded in near-surface rock, the authors think that evaluating the engineering properties of the rock mass is one of the most important steps. This paper emphasizes the determination of the engineering properties of the in situ rock mass, both the deformation modulus and shear strength, although not to the exclusion of other aspects of the problem of rock behavior and engineering design.

Keyword(s): mine design, rock mechanics, geotechnical, tunnelling, lab testing

Deere, D. V. Subsidence Due to Mining--A Case History from the Gulf Coast Region of Texas. IN: Proceedings 4th Symposium on Rock Mechanics, State College, PA, March 30-April 2, 1961, Bulletin

Mineral Industry Experiment Station, v. 76, The Pennsylvania State University, p. 59-64.

Sulfur extraction by the Frasch process from the cap rock of numerous salt domes in the Gulf Coast Region of the United States has produced subsidence of the surface over mining areas. A record of measurements of the surface subsidence and the associated horizontal movements extending over a period of 2.5 years is presented from an operation in Texas.

Keyword(s): non-metal mining, survey data processing, monitoring methods, horizontal displacement

Location(s): Texas, United States

Degirmenci, N., D. J. Reddish, B. N. Whittaker. A Study of Surface Subsidence Behaviour Arising from Longwall Mining of Steeply Pitching Coal Seams. IN: Proceedings, 6th Coal Congress, Zonguldak, Turkey, May, 1988, 27 p.

Keyword(s): longwall, coal mining, vertical displacement, geologic features

Degraff, J. V. Selected Bibliography on Land Subsidence. U.S. Department of Agriculture, R-4 Intermountain Region, G-R-4-78-2, February 8, 1978, 25 p.

Land subsidence associated with extractions of solids or fluids creates serious land management problems. In an effort to provide a source of information on specific aspects of this phenomena, this bibliography was compiled. The citations were compiled from government articles, books, and recent journals. Most of the references are from 1960 to 1977. All references to subsidence due to wetting or applicatiion of fluids were excluded. The bibliography is divided into two sections: (1) extractions of solids and (2) extractions of fluids. This dichotomy reflects the differences in extent and effect of subsidence resulting from these two actions.

Keyword(s): literature search, coal mining, metal mining, non-metal mining, fluid extraction

Location(s): United States

Degroot, H. P., A. MacDonald. Experimental Stoping on the No. 5 Seam, Greenside Colliery. South African Journal Institute of Mine Surveying, v. 21, no. 1, March 1981, p. 120-128.

Keyword(s): backfilling, coal mining

Location(s): South Africa

Dehasse, L. Raising Buildings Sunk by Mine Subsidence. Revue Universelle des Mines, October, 1935; also Colliery Guardian, v. 152, 1936, p. 103.

This paper recommends that buildings constructed in subsidence-susceptible areas should be designed such that they can be readily raised to their original level.

Keyword(s): surface structural damage, structural mitigation, construction

DeJean, M., J. P. Lamy. Utilisation de l'Ordinateur Pour la Prevision des Affaissements Dans les Houilleres du Bassin du Nord et du Pas-De-Calais (Subsidence Prediction by Computer in the Collieries of the North and Pas-De-Calais Coal Basin). Industrie Minerale, St. Etienne, France, no. 3, 1975, Supplement to June 1975, p. 335-338.

Keyword(s): prediction, computer

Location(s): France

DeJean, M. J. P., F. Martin. Amplitude of Subsidence of Underground Openings Subject to the Influence of Mining Adjacent and Below. IN: Proceedings 4th Annual Symposium on Subsidence in Mines, Wollongong, Australia, February 20-22, 1973, A.J. Hargraves, ed., Australasian Institute of Mining and Metallurgy, Illawara Branch, Paper 4, p. 4-1- 4-7.

An underground opening situated above a mined seam is subject to subsidence and deformations. This subsidence can only be measured if deformations remain slight, but this only occurs above the worked area. For this reason this study is confined to this aspect of underground work. Two types of models of behavior were considered. Comparison with experimental results shows that actual values lie somewhere between those indicated by the two theories considered.

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

Location(s): France

DeLong, R. M. Coal-Mine Subsidence in Ohio. Ohio Geology Newsletter, Fall 1988, Ohio Department Natural Resources, Division of Geological Survey, Columbus OH, 4 p.

For more than a century and a half, underground coal mining has been an active industry in eastern Ohio. During this period, about 4,000 underground mines, ranging in size from a few acres to several square miles, have honeycombed the surface. Several generations of coal mining have left us with both a tradition of mining and a legacy of abandoned mines from the "pick and

shovel" era. Now, with an expanding population and its demand on space, the problems inherent in this legacy of abandoned mines are being investigated. One of the problems at the forefront is that of mine subsidence--caving or distortion of the ground surface due to collapse of underground mine workings. The cost of repairing damage to homes and other structures due to mine subsidence can total tens of thousands of dollars.

Keyword(s): surface structural damage, coal mining, abandoned mines, room-and-pillar, historical, structural mitigation, reclamation, roads, backfilling, grouting, insurance

Location(s): Ohio, United States

DeMarco, M. J., J. R. Koehler, P. H. Lu. Characterization of Chain Pillar Stability in a Deep Western Coal Mine - Case Study. Preprint no. 88-76, for presentation at the SME Annual Meeting, Phoenix, AZ, January 25-28, 1988, 12 p.

Beginning in late 1985 and continuing through 1987, USBM personnel investigated longwall chain pillar and entry design in two- and three-entry gateroad systems at a deep underground coal mine in central Utah. To evaluate their respective stability characteristics, four chain pillars and two longwall panels within the two separate entry systems were instrumented with USBM hydraulic borehole pressure cells to continuously monitor vertical and horizontal pillar and panel stresses through adjacent panel retreat. In addition, supplemental entry closure information was obtained from sites located in the vicinity of the instrumented pillars. The findings presented in this report demonstrate the practicality of evaluating mine pillar stability using in situ methods.

Keyword(s): pillar strength, coal mining, mine design, mine safety, in situ testing, longwall, instrumentation, monitoring equipment, ground control

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

DeMarco, M. J., J. R. Koehler, P. H. Lu. Characterization of Chain Pillar Stability in a Deep Western Coal Mine--A Case Study. Mining Engineering, December, 1988, p. 1115-1119.

Beginning in late 1985 and continuing through 1987, USBM personnel investigated longwall chain pillar and entry design in two and three-entry gateroad systems at a deep underground coal mine in central Utah. To evaluate their respective stability characteristics, four chain pillars and two longwall panels within the two separate entry systems were instrumented with USBM hydraulic borehole pressure cells to continuously monitor vertical and horizontal pillar and panel stresses through adjacent panel retreat. In addition, supplemental entry closure information was obtained from sites located in the vicinity of the instrumented pillars. The findings presented in this report demonstrate the practicality of evaluating mine pillar stability using in situ methods.

Keyword(s): pillar strength, yielding supports, coal mining, longwall, mine design, monitoring methods, monitoring equipment

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

DeMaris, P. J., R. A. Bauer. Geology of a Longwall Mining Demonstration at Old Ben No. 24: Roof Lithologies and Coal Balls. IN: Proceedings Illinois Mining Institute 85th Annual Meeting, October 13-14, 1977, Springfield, IL.

A longwall mining demonstration in the Herrin Coal involved the extraction of three adjacent panels by the longwall method. The ISGS was involved in the project for two reasons: (1) to detail the geology of the roof and relate the geologic features to the behavior of the roof during mining operations, and (2) to study the nature and occurrence of coal balls (carbonate petrifications of peat) encountered during this demonstration.

Keyword(s): coal mining, longwall, geologic features, roof stability, active mines

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

DeMaris, P. J., R. A. Bauer. Geology of a Longwall Mining Demonstration at Old Ben No. 24: Roof Lithologies and Coal Balls. Illinois State Geological Survey Reprint 1978-J, 1978, Reprinted from Proceedings of Illinois Mining Institute, 1977, v. 85, p. 80-91.

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

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

DeMaris, P. J., R. A. Bauer, R. A. Cahill, H. H. Damberger. Geologic Investigation of Roof and Floor Strata: Longwall Demonstration, Old Ben Mine No. 24. Prediction of Coal Balls in the Herrin Coal. Final Technical Report, Part 2. Illinois State Geological Survey Contract/Grant Report C/G 1983-2, 1983, 69 p. (NTIS DE83-011414)

Coal-ball areas, large deposits of mineralized peat in the coal seam, obstructed longwall mining in

the Herrin Coal at Old Ben Mine No. 24. In-mine mapping located coal balls under transitional roof, areas where the roof lithology alternates between the Energy Shale and the Anna Shale/Brereton Limestone. Specifically, coal balls occur under eroded exposures or "windows" of the marine Anna Shale/Brereton Limestone in the Energy Shale.

Keyword(s): roof stability, floor stability, longwall, geologic features, coal mining

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

DeMaris, P. J., R. A. Bauer. Identification of Mine Subsidence on Aerial Photographs in Central Illinois. Illinois State Geological Survey Contract/Grant Report, C/G 1983-7, 1983, 31 p.

This report evaluates the use of stereo pairs of aerial photography over and in the vicinity of a coal mine for the detection of subsidence due to underground coal mining in a glaciated area of central Illinois. The study area chosen was examined on 11 sets of imagery taken between 1939 and 1977. A number of sites where subsidence was previously documented are visible on the photos and were used for comparison with other anomalies found on the photos.

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

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

Denkhaus, H. G. A Critical Review of the Present State of Knowledge Related to the Strength of Mine Pillars. Journal of the South African Institute of Mining and Metallurgy, v. 63, 1962, p. 59-75.

This paper summarizes knowledge concerning mine pillars as in-place support. The author discusses pillar loading, spacing, size, shape, and resulting pillar strength. The article includes a discussion of results and their applications in practical mining problems.

Keyword(s): pillar strength

Location(s): South Africa

Denkhaus, H. G. Critical Review of Strata Movement Theories and Their Applications to Practical Problems. Journal of the South African Institute of Mining and Metallurgy, March, 1964, p. 310-332.

This paper is an attempt to review the various theories of strata movement and stability that have been propounded and to assess their practical significance. With a view to the variety of such theories, the survey cannot claim completeness, but the author is of the opinion that all the threories can be grouped into three major categories, namely the dome theories, the trough theories, and the continuum theories.

Keyword(s): prediction theories, modeling

Department of the Environment. Reclamation of Derelict Land: Procedure for Locating Abandoned Mine Shafts. Planning, Regional and Minerals Directorate, London, 1976.

Keyword(s): reclamation, abandoned mines, land-use planning

Location(s): England

Department of the Environment. Limestone Mines in the West Midlands: The Legacy of Mines Long Abandoned. Department of the Environment, July, 1983.

Keyword(s): non-metal mining, abandoned mines

Location(s): England

Dershowitz, W., I. Miller. Practicality and Sophistication in Subsidence Modeling for Geothermal Systems. IN: Proceedings 22nd U.S. Rock Mechanics Symposium, Massachusetts Institute of Technology, Boston, 1981, p. 131-136.

Keyword(s): modeling, rock mechanics

Location(s): United States

Deutscher Verband Fuer Wasserwirtschaft, E.V. Proceedings International Symposium on Fossil Fuel Production and Water Resources. Duesseldorf, Federal Republic of Germany, September, 1976, 470 p.

Keyword(s): hydrology, coal mining

Devis, R. S. Hydraulic Packing at Ballarpur Colliery. Transactions Mine Geology Institute of India, v. 10, pt. 2, 1916, 53 p.

Keyword(s): hydraulic backfilling, stowing, coal mining, historical

Location(s): India

Dhar, B. B., S. Ratan, C. Amarendra. Environmental Impact as a Result of Large Underground Excavations--A Modeling Approach. IN: Proceedings International Symposium on Large Rock Caverns, Helsinki, August 25-28, 1986, Pergamon Press, v. 1, 1986, p. 771-782.

Mine workings have been simulated in an electric tank analogue, and closure distributions calculated from the voltage distributions as found in the analogue. Surface subsidences have been

determined using a numerical model. Predicted and measured subsidences above two Indian coal mines are compared. A number of additional mining and geological factors that should be incorporated into the analysis of subsidence to improve its accuracy are examined.

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

Location(s): India

Dhar, B. B., B. K. Shrivastava, S. K. Gupta. Effect of Staggering of Longwall Panels in Contiguous Seams--A FEM Approach. IN: Proceedings, International Symposium on Underground Engineering, New Delhi, India, April 14-17, 1988, B. Singh, ed., Balkema, Rotterdam, p. 195-198.

Mining of contiguous seams has always been a problem, because extraction of one seam affects the extraction of the other. The design of such workings has forced mining engineers to look for effective conservation with safety. General practice has been that with flat or slightly dippping seams, the pillars/panels are designed in such a way that they are vertically above each other. To demonstrate the effect of staggering panels, a FEM program has been developed and used for the present analysis. Three different cases of contiguous workings were considered for simulation. In case one, excavations are assumed to be one above the other, while in the second and third cases they are assumed to be staggered. The analysis has shown that the staggering of panels adversely affects the stability of parting pillar and the coal seam ahead of the face. The results thus demonstrate that while designing contiguous seam workings, a mathematical simulation based on FEM principles is possible for safe extraction design of such coal seams.

Keyword(s): finite element, mathematical model, modeling, multiple-seam extraction, longwall, coal mining

Location(s): India

Di Molfetta, A., G. P. Giani. Numerical Model of Subsidence Phenomena Due to Mining Exploitation. IN: Proceedings International Symposium on Engineering in Complex Rock Formations, November 3-7, 1986, Beijing, China, Pergamon Press.

A numerical model for subsidence phenomena forecasting is presented. The subsidence is caused by mining exploitations, characterized by from both underground excavation and dewatering. The model studies separate the dewatering and the mechanical behavior. The dewatering study is examined with an analytical model that examines this phenomenon, obtaining the lowering of the piezometric heads, on the basis of water flow pumped and vice versa. The subsidence study examines, with the finite element method, the surface settlements on the basis of the dewatering and the underground excavation solutions.

Keyword(s): modeling, subsurface water, finite element, hydrology

Location(s): Italy

Dials, G. Subsidence Control-Underground Mines. Preprint 79-83, for presentation at SME-AIME Fall Meeting, New Orleans, LA, February 18-22, 1979, 2 p.

Keyword(s): ground control

Dickinson, J. Subsidence Due to Colliery Workings. Transactions, Manchester Geological Society, London, v. 25, 1898, p. 600.

Keyword(s): coal mining, historical

Dierks, H. A. Pneumatic Stowage. Coal Age, v. 36, no. 9, September, 1931, p. 466.

This article details the development of two types (low pressure and high pressure) of pneumatic stowage systems in Germany as an alternative to hydraulic backfilling of active mines.

Keyword(s): stowing, pneumatic backfilling, active mines

Location(s): Germany

Dierks, H. A. Hydraulic Backfilling as Europe Practices It. Coal Age, v. 36, no. 7, 1931, p. 351.

This article contains a brief background of hydraulic backfilling as developed in the United States. It describes hydraulic backfilling as conducted in Europe.

Keyword(s): hydraulic backfilling

Location(s): United States, Europe

Dierks, H. A. Pneumatic Stowage Makes Rapid Strides in Mines in Germany. Coal Age, v. 36, no. 9, September, 1931, p. 466.

Keyword(s): pneumatic backfilling, stowing

Location(s): Germany

Dierks, H. A. Backfilling Permits Recovery of Abandoned Pillars While Preserving Surface Improvements. Coal Age, v. 38, no. 8, August, 1933, p. 255-258.

This article describes the use of hydraulic flushing in a mine in Scranton, Pennsylvania, as a

means of permitting complete robbing of two coal seams that had been previously mined out.

Keyword(s): hydraulic backfilling, surface structural damage, abandoned mines, room-and-pillar, multiple-seam extraction, pillar extraction, coal mining

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

Dimova, V. I. Influence of Surface Load on the Equation of Mine Subsidence. Direct and Inverse Problems. IN: Proceedings 6th International Congress International Association of Engineering Geology, Amsterdam, August 6-10, 1990, v. 4, Balkema, Rotterdam, p. 2645-2649.

Underground excavations and surface structures disturb the initial state of the host rock mass, and their influences may interact if both are present. The case for an idealized homogeneous medium is examined. The effect of a surface load on the equation of the subsidence trough above a mine, and correct design of an underground structure so as not to interfere with a super-incumbent surface structure are considered. Numerical and analytical solutions to these problems are described.

Keyword(s): surface structural damage, mine design, modeling, engineering

Dinsdale, J. R. Roof Fracturing. Colliery Engineering, v. 10, 1933, p. 161-164, 168.

This article is a mathematical discussion of stresses in and failure of a roof beam; it considers the roof as a beam supported at both ends.

Keyword(s): roof stability

Dinsdale, J. R. Ground Pressure and Pressure Profiles Around Mining Excavations. Colliery Engineering, v. 12, 1935, p. 406-409; v. 13, 1936, p. 19-20, 27.

Keyword(s): roof stability

Dinsdale, J. R. Ground Failure Around Excavations. Institution of Mining and Metallurgy Transactions, 1937, v. 46, 1936-37, p. 673-701.

Keyword(s): ground control

Dismuke, S. R., D. E. Nicholas, P. F. Cicchini. Pillar Recovery at the Buick Mine. IN: Mine Subsidence, Society of Mining Engineers Fall Meeting, St. Louis, MO, September, 1986, M.M. Singh, ed., SME, Littleton, CO, p. 131-143.

This paper describes a pillar recovery program, conducted in a lead and zinc ore mine, which allowed the company to better regulate the grade of ore produced. One constraint on pillar recovery was that a shale could not be disturbed to the point that aquifers above it might be affected.

Keyword(s): metal mining, partial extraction, finite element, lab testing, rock mechanics, subsurface water

Location(s): Missouri, United States

Dixon, D. Y., H. W. Rauch. Study of Quantitative Impacts to Ground Water Associated with Longwall Coal Mining at Three Mine Sites in the Northern West Virginia Area. IN: Proceedings 7th International Conference on Ground Control in Mining, August 3-5, 1988, S.S. Peng, ed., West Virginia University, Morgantown, p. 321-335.

The objectives of this study were to document the hydrologic impacts of longwall mining on groundwater, identify the factors affecting the extent of dewatering, and develop empirical trends to predict the extent of dewatering and recovery in advance of mining. The study was confined to three mine sites in north-central West Virginia. At each site, available groundwater supplies were identified and monitored for dewatering effects and recovery.

Keyword(s): subsurface water, longwall, hydrology, prediction, overburden, coal mining, active mines

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

Dixon, D. Y. A Study of Dewatering Effects at Three Longwall Mines in the Northern Appalachian Coal Field. M.S. thesis, Department of Geology and Geography, West Virginia University, Morgantown, 1988, 250 p.

Keyword(s): subsurface water, longwall, coal mining, hydrology, active mines, geologic features

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

Dixon, D. Y., H. W. Rauch. The Impact of Three Longwall Coal Mines on Streamflow in the Appalachian Coalfield. IN: Proceedings 9th International Conference on Ground Control in Mining, June 4-6, 1990, S.S. Peng, ed., West Virginia University, Morgantown, p. 169-182.

The objectives of this study were to document the hydrologic impacts of longwall mining on streams, identify the factors affecting the extent of stream dewatering, and develop empirical trends to predict the extent of dewatering and recovery of streams in advance of mining.

Keyword(s): longwall, hydrology, surface water, coal mining, inflow

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

Dixon, J. C., K. B. Clarke. Field Investigation Techniques. IN: Site Investigations in Areas of Mining Subsidence, F.G. Bell, ed., Newnes-Butterworths, London, 1975, p. 40-74.

In dealing with geotechnical problems in areas of mining subsidence, it is axiomatic that the more that is known about the soil and rock profile affected by the mining operations the easier will be the solution of the problem. This chapter sets out the current field procedures in subsurface exploration in the widest sense and includes methods of exploring below the ground surface by direct, semi-direct, and indirect means; the various types of sample that can be obtained; and the range of in situ tests that may be carried out.

Keyword(s): in situ testing, geologic features, geotechnical, rock mechanics, subsurface water, coal mining, monitoring methods

Location(s): United Kingdom

Dixon, J. D., M. A. Mahtab, T. W. Smelser. Procedures for Determining Support of Excavations in Highly Yielding Ground. U.S. Bureau of Mines RI 8990, 1985, 19 p.

This report for stabilization of excavations in highly yielding ground involves nonlinear modeling of the progressive relaxation of the zones of rock mass around the excavations where Coulomb criterion of failure is exceeded. Stresses are calculated by using a computer code. The approach is applied to analysis of stability and support requirements for an entry in a longwall coal mine.

Keyword(s): longwall, ground control, modeling, mathematical model, computer, rock mechanics, roof support, mine design, finite element, coal mining

Location(s): United States

Dixon, J. S. Some Notes on Subsidence and Draw. Transactions, Mining Institute of Scotland, v. 7, 1885, p. 224-233.

The author made observations at Bent Colliery on the amount and mode of occurrence of subsidence and draw from working the coal. The excavation averaged 5.5 feet in height.

Keyword(s): historical, angle of draw, coal mining, survey methods

Location(s): United Kingdom

Djahanguiri, F. Rock Mechanics for a Longwall Mine Design; Carbon County Coal Company. 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, p. 1C5-1 - 1C5-12.

This paper presents the pre-development rock mechanics study for underground mining of a thick coal seam. This study includes the geotechnical investigation and testing of coal and coal measure rocks for the proposed mine site. Extensive uniaxial, triaxial, shear, Brazilian, and point tension tests produced information about the rock substance and rock mass properties of the area. The geotechnical site investigation furnished information about structural geology, joint patterns and orientation of structural features. Geophysical borehole logging and seismic relfection contributed to this study.

Keyword(s): rock mechanics, longwall, coal mining, geotechnical, lab testing, geologic features, mine design, floor stability, pillar strength

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

Dobbels, D., G. G. Marino, J. W. Mahar. Mine Subsidence at the Pistor Residence, Belleville, Illinois. Report for the Abandoned Mined Lands Reclamation Council, 1985, 50 p.

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

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

Dobson, W. D., E. L. J. Potts, R. G. S. Roberts, K. Wilson. Surface and Underground Development at Peterlee, Co. Durham. Colliery Guardian, pt. 1, v. 198, no. 5127, June 4, 1959, p. 691-697; pt. 2, v. 198, no. 5128, June 11, 1959, p. 723-730.

The new town of Peterlee is unique, in that it is being developed in a coal mining area in which about 30 million tons of coal are still being mined. The town was first suggested in an attempt to resolve a housing demand. Clearly, both surface and underground interests had to be considered. Certain basic principles were agreed for use in the surface and mining development in the designated area. Those were (1) that the major subsidence effects would take place within 5 years of extraction and (2) that the subsidence effects would extend beyond the working area to a distance equal to one-third of the depth to the seam, except under special circumstances. The National Coal Board also

agreed to sterilize about 1 million tons of coal beneath an area reserved for the town center.

Keyword(s): land-use planning, coal mining, National Coal Board, longwall, angle of draw, vertical displacement, horizontal displacement, survey data processing, surface structural damage, structural mitigation, roads, utilities, pipelines

Location(s): United Kingdom

Dobson, W. D., E. L. Potts, R. G. S. Roberts, K. Wilson. The Coordination of Surface and Underground Development at Peterlee, Co., Durham. Transactions Institute of Mining Engineering, London, v. 119, 1959-60, p. 279-300.

This paper describes the results of subsidence survey research performed in 1958 in Durham, England, with monitoring network design and surface/underground development procedures also included. The work was undertaken to provide information for the building and design of surface structures in an area where coal continues to be worked. The coordination of surface and underground development by "time phasing" and the close cooperation between surface and underground planning is described, together with certain special precautions incorporated into the design of housing and public utilities to serve a town that will house 30,000 people when completed. Reference is also made to the design of factory buildings in the industrial area.

Keyword(s): surface structural damage, mine design, monitoring design, monitoring methods, survey methods, survey design, active mines, coal mining, land-use planning, structural mitigation, utilities, construction, foundations

Location(s): England

Domenico, P. A., M. D. Mifflin. Water From Low-Permeability Sediments and Land Subsidence. Water Resource Research, v. 1, 1965, p. 563-567.

Keyword(s): fluid extraction, hydrology

Domenico, P. A., M. D. Mifflin, A. L. Mindling. Geologic Controls on Land Subsidence in Las Vegas Valley. IN: Proceedings 4th Annual Engineering Geology and Soils Engineering Symposium, Moscow, ID, 1966, Idaho Department of Highways, Boise, p. 113-121.

Keyword(s): fluid extraction, geologic features

Location(s): United States

Domenico, P. A. Land Subsidence in Las Vegas Valley, Nevada. Geological Society of America Special Paper 101 (abstract), 1968, p. 55.

Keyword(s): fluid extraction

Location(s): Nevada, United States

Doney, E. D. Birth of a Longwall--Initial Planning to Post-Subsidence Mitigation. 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. 220-226.

The first longwall mining system at Kerr-McGee's Galatia Mine was implemented on May 3, 1989. Start-up of the longwall face represented the successful conclusion of an effort begun nearly 4 years earlier. This paper presents a case history of the processes that led to the implementation of the longwall, and the subsequent mining of the first 7,900-foot-long panel.

Keyword(s): coal mining, longwall, mine design, land mitigation, mine operation, multiple-seam extraction, economics, active mines

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

Doney, E. D. Birth of a Longwall--Initial Planning to Post-Subsidence Mitigation. IN: Proceedings 9th International Conference on Ground Control in Mining, June 4-6, 1990, S.S. Peng, ed., West Virginia University, Morgantown, p. 298-302.

This paper presents a case history of the processes that led to the implementation of a longwall at the Kerr-McGee Coal Corporation's Galatia Mine.

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

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

Doney, E. D., S. S. Peng, Y. Luo. Subsidence Prediction in Illinois Coal Basin. IN: Proceedings 10th International Conference on Ground Control in Mining, June 10-12, 1991, West Virginia University, Morgantown, p. 212-219.

Based on the subsidence data collected through a comprehensive subsidence monitoring program conducted over two longwall panels in an Illinois coal mine, mathematical models have been proposed for predicting final and dynamic subsidence in the Illinois Coal Basin.

Keyword(s): prediction, coal mining, monitoring methods, active mines, mathematical model, longwall

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

Donner, D. Federal Reclamation Projects Branch Fiscal Year 1985 Objectives. 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. 15-18.

This paper identifies the steps necessary to establish a more efficient and effective program for the abatement of coal mine related environmental problems.

Keyword(s): reclamation, environment, abandoned mines, coal mining

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

Donner, D. L., R. H. Whaite. Investigation of Subsidence in Rock Springs, Sweetwater County, Wyoming. Unpublished Open-File Report, 1969, U.S. Bureau of Mines, Washington, D.C., 14 p.

Keyword(s): coal mining, abandoned mines

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

Dortmund Board of Mines. On the Influence of Coal Mines Under Marl Capping Upon the Earth's Surface in the Dortmund District. Zeit fur das Berg Hutten und Salinen Wesen, v. 45, 1897, p. 372.

Keyword(s): coal mining, geologic features, overburden, historical

Location(s): Germany

Dott, G. Pneumatic Stowing in the Wemyss Coal Field. Colliery Engineering, v. 16, 1939, p. 261-265.

The author describes advantages of this method in a mine that had problems of steep gradient and frequent fires.

Keyword(s): coal mining, pneumatic backfilling, mine fires, geologic features

Location(s): England

Dougherty, P. H., M. Perlow. The Macungie Sinkhole, Lehigh Valley, Pennsylvania: Cause and Repair. IN: Karst Hydrogeology: Engineering and Environmental Applications, Proceedings, 2nd Multidisciplinary Conference on Sinkholes and the Environmental Impacts of Karst, Orlando, 1987, B.F. Beck and W.L. Wilson, eds., Balkema, Rotterdam, p. 425-435.

Keyword(s): geologic features

Location(s): Pennsylvania, United States

Dowding, C. H., M. B. Su, K. O'Connor. Choosing Coaxial Cable for TDR Monitoring. 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. 153-162.

This paper presents recommendations for choosing coaxial cables appropriate for mining applications of Time Domain Reflectometry (TDR) to monitor rock mass movements. Mining applications are illustrated with examples, and the operating principle of TDR is discussed briefly. Items that affect the result of the monitoring system performance include the coaxial cable selected, the grouting material used, and the installation procedure.

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

Dowding, C. H., M. B. Su, K. O'Connor. Principles of Time Domain Reflectometry Applied to Measurement of Rock Mass Deformation. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 25, no. 5, 1988, p. 287-297.

Time Domain Reflectometry (TDR) is an electrical pulse testing technique originally developed to locate faults in coaxial power transmission cables. Recently, this technique has been adapted for monitoring deformation of cables grouted into rock masses. Rock mass movements deform the grouted cable, which locally changes cable capacitance and thereby the reflected wave form of the voltage pulse. By monitoring changes in these reflection signatures, it is possible to monitor both local extension and local shearing. This paper concentrates on the electromagnetic wave theory necessary to quantitatively relate changes in cable geometry to changes in reflected voltage signatures. A finite element model is employed to numerically simulate capacitance changes for deformed geometries produced in the laboratory, and the effect of signal attentuation and resolution of two deformities is assessed on the basis of laboratory test results. Finally these models are employed to extract heretofore unrealized information from previously collected field data.

Keyword(s): monitoring equipment, instrumentation, monitoring methods, finite element, modeling, longwall, coal mining

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

Dowding, C. H., M. B. Su, K. O'Connor. Measurement of Rock Mass Deformation with Grouted Coaxial Antenna Cables. Rock Mechanics and Rock Engineering, v. 22, no. 1, January-March, 1989, p. 1-23.

Techniques presented show how reflected voltage pulses from coaxial antenna cable grouted in rock masses can be employed to quantify the type and magnitude of rock mass deformation. This measurement is similar to that obtained from a combined full profile extensometer and inclinometer. Rock mass movements deform the grouted cable, which locally changes cable capacitance, and thereby the reflected wave form of the voltage pulse. Thus, by monitoring changes in these reflection signatures, it is possible to monitor rock mass deformation.

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

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

Down, C. G., J. Stocks. Subsidence. IN: Environmental Impact of Mining, Halsted Press, John Wiley & Sons, New York, 1977, p. 311-335.

The discussion in this chapter was oriented towards stratified deposits and particularly the European coalfields, since most of the available data pertained to this type of mining.

Keyword(s): environment, land-use planning, prediction, roof stability, multiple-seam extraction, empirical model, profile function, influence function, surface structural damage, room-and-pillar, coal mining

Location(s): United Kingdom, Europe

Draper, J. C. Surface Movement in the Vicinity of Pillars Left in Gob Areas. SME-AIME Annual Meeting, New York, 1964, SME AIME Preprint 64FM3, 19 p.

This paper describes the results of surface surveys of subsidence above and adjacent to coal pillars left to protect three gas wells.

Keyword(s): mine waste, pillar strength, horizontal displacement, vertical displacement, utilities, survey data processing, survey methods

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

Drent, S. Some Considerations on the Connection Between Time-Curves and the Thickness of the Noncarboniferous Overburden in the South Limburg Coal Field. IN: Proceedings European Congress on Ground Movement, Leeds, England, 1957, p. 49-57.

Keyword(s): overburden, time factor, coal mining, geologic features

Drent, S. Time-Curves and the Thickness of Overlying Strata. Colliery Engineering, v. 34, no. 401, July, 1975, p. 271-278.

This paper describes the non-carboniferous overlying strata in the South Limburg coalfield.

Keyword(s): horizontal displacement, time factor, coal mining, overburden

Drumm, E. C., R. M. Bennett, W. F. Kane. Mechanisms of Subsidence Induced Damage and Techniques for Analysis. IN: Mine Induced Subsidence: Effects on Engineered Structures, Proceedings of the Symposium, Nashville, TN, May 11, 1988, ASCE Geotechnical Special Publication No. 19, p. 168-188.

Structural damage due to mining-induced subsidence is a function of the nature of the structure and its position on the subsidence profile. A point on the profile may be in the tensile zone, the compressive zone, or the no-deformation zone at the bottom of the profile. Damage to structures in the tension zone is primarily due to a reduction of support during vertical displacement of the ground surface, as well as shear stresses between the soil and structure resulting from horizontal displacements. The damage mechanisms due to tension can be investigated effectively using a two-dimensional plane stress analysis. Structures in the compression zone are subjected to positive moments in the footing and large compressive horizontal stresses in the foundation walls. A plan strain analysis of the foundation wall is used to examine compression zone damage mechanisms. The structural aspects affecting each mechanism are identified, and potential mitigation techniques are summarized.

Keyword(s): surface structural damage, vertical displacement, horizontal displacement, abandoned mines, active mines, insurance, modeling, computer, structural mitigation, foundations

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

Drzezla, B., S. Czypionka. Prakiyczne Zastosowanie Wzorow Do Obliczania Krzywizn Przekrojow Pionowych Niecki Osiadania (Practical Use of Formulas for Calculating Vertical-Cross-Section

Curvatures of a Subsidence Trough). Przeglad Gorniczy, v. 27, no. 10, 1971, p. 457-462.
Keyword(s): prediction

Drzezla, B. Informacja O Programach Dla Maszyny Cyfrowej Do Obliczania Deformacji Gorotworu Przy Eksploatacji Gorniczej (Computer Systems Programming for Calculating the Deformation of Rock Masses as Effect of Mining Exploitation). Przeglad Gorniczy, v. 30, no. 3, 1974, p. 164-170.
Keyword(s): computer, prediction

Drzezla, B. Zmiennosc Zasiegu Wplywow Eksploatacji W Gorotworze (Variability of the Range of Effects Due to Mine Working in Rock Masses). Przeglad Gorniczy, v. 35, no. 10, 1979, p. 413-418.

Duigon, M. T., M. J. Smigaj. First Report on the Hydrologic Effects of Underground Coal Mining in Southern Garrett County, Maryland. Maryland Geological Survey Report of Investigations No. 41, 1985, 99 p.
This report describes preliminary findings on the hydrogeologic system in southwestern Garrett County, Maryland, where a large underground coal-mining operation had recently begun. A network was established to gather streamflow, water-level, and water-quality data.
Keyword(s): subsurface water, hydrology, coal mining, room-and-pillar, pillar extraction
Location(s): Maryland, United States

Dulaney, R. L. The Structural Strength of Coal Mine Floors. M.S. Thesis, Virginia Polytechnic Institute, Blacksburg, VA, 1960, 73 p.
Keyword(s): floor stability, coal mining

DuMontelle, P. B., E. D. McKay, P. J. Ehret, R. D. Gibson. Mine Subsidence and Unstable Loess in Southwestern Illinois. IN: Geological Society of America Abstracts with Programs, North-Central Section, 13th Annual Meeting, Duluth, MN, May 10-11, 1979, p. 228.
Keyword(s): engineering, soil mechanics, coal mining, soils, surface structural damage, abandoned mines, geologic features
Location(s): Illinois, Illinois Coal Basin, United States

DuMontelle, P. B. The Illinois Mined Land Subsidence Program. Illinois in the '80s...Trends in Natural Resource Management. Illinois Institute of Natural Resources, 1980, p. 60-63. (NTIS PB82-177114)
Keyword(s): land-use planning, coal mining, subsidence research
Location(s): Illinois, Illinois Coal Basin, United States

DuMontelle, P. B., R. E. Yarbrough, R. S. Pocreva. Review of Underground Mining Practices in Illinois as Related to Aspects of Mine Subsidence with Recommendations for Legislation. Illinois State Geological Survey, Champaign, Institute of Natural Resources Document 80/10, 1980, 142 p.
This report was prepared to provide information to introduce and review background events associated with mine subsidence, to describe underground mining practices in Illinois, to describe mine subsidence and building alternatives to reduce subsidence damage, to review legal aspects of mines subsidence, to explain public access to underground mine maps, and to state the findings and recommendations for future work.
Keyword(s): law, government, coal mining, surface structural damage, structural mitigation, insurance, abandoned mines, active mines
Location(s): Illinois, Illinois Coal Basin, United States

DuMontelle, P. B., S. C. Bradford, R. A. Bauer, M. M. Killey. Mine Subsidence in Illinois: Facts for the Homeowner Considering Insurance. Illinois State Geological Survey, Environmental Geology Notes 99, 1981, 24 p.
This booklet covers the geology of Illinois, the areas undermined, the mining methods used, the types of subsidence, and the effects of subsidence.
Keyword(s): surface structural damage, subsurface structural damage, construction, insurance, coal mining, historical
Location(s): Illinois, Illinois Coal Basin, United States

DuMontelle, P. B., E. D. McKay, R. D. Gibson. Geology and Subsidence Monitoring of Backfilling Projects in Southwestern Illinois--Television Probes of Injection Borings. 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. 155-157.
The USBM backfilled abandoned mines at selected sites in southwestern Illinois in an attempt to support failing mine openings. The ISGS assisted the Bureau by developing geologic and engineering

information. As part of this investigation, television probes of 15 injection probes in Belleville augmented conventional methods of study.

Keyword(s): abandoned mines, backfilling, mine waste, grouting, monitoring equipment, coal mining

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

DuMontelle, P. B., R. A. Bauer, R. D. Gibson, J. W. Mahar, R. Yarbrough. Procedures Used in Illinois to Identify Sag Subsidence Resulting from Underground Coal Mining. Paper presented to Association of Engineering Geologists, 1983, San Diego, CA.

Keyword(s): surface subsidence damage, coal mining

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

DuMontelle, P. B., R. A. Bauer. The Mid-Continent Field: General Characteristics of Surface Subsidence. 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. 671-680.

The coal seams of the Illinois Basin comprise a major part of the Mid-Continent Region. Since the latter part of the 1800s, more than 750,000 acres of Illinois land have been undermined for coal. Subsidence of the surface was documented by early workers. And, from time to time, new studies and techniques have provided a better understanding of why mine openings fail and how these failures are expressed at the surface. The detailed case studies in this paper were designed to monitor expected changes characteristic of the Illinois Basin. A brief discussion of the basin setting, mining methods, and typical subsidence events may be helpful.

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

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

DuMontelle, P. B., R. A. Bauer. A Mine Subsidence Research Program for Illinois: Coal and Crops Working Together. IN: Proceedings Illinois Mining Institute, October, 1985, p. 45-50.

The Illinois Mine Subsidence Research Program was initiated in 1985 to develop guidelines for mining to control and mitigate adverse effects on prime farmland by underground coal mining while maximizing coal recovery of coal resources.

Keyword(s): coal mining, subsidence research, agriculture

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

DuMontelle, P. B., R. A. Bauer. The Second Year Progress Report of the Illinois Mine Subsidence Research Program. IN: Proceedings Illinois Mining Institute, October, 1986, p. 46-52.

Keyword(s): subsidence research, coal mining, agriculture

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

DuMontelle, P. B., R. A. Bauer. The Illinois Mine Subsidence Research Program: An Update. IN: Mine Subsidence, Proceedings, Society of Mining Engineers Fall Meeting, September, 1986, M.M. Singh, ed., St. Louis, MO, p. 87-89.

In 1985, participants of the multi-year Illinois Mine Subsidence Research Program conducted surveys of subsidence effects on crop production from current high-extraction mining methods, selected a site to characterize overburden materials and changes in aquifers produced by subsidence from high-extraction mining, characterized floor materials in three mines, and established bibliographic reference and database files.

Keyword(s): subsidence research, coal mining, active mines, agriculture, monitoring methods, overburden, hydrology, lab testing, in situ testing, computer, literature search, law, government

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

DuMontelle, P. B., L. R. Powell. Illinois Mine Subsidence Research Program. 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. 89.

The authors introduce a series of papers in the Symposium that describe the current research of the Illinois Mine Subsidence Research Program.

Keyword(s): subsidence research, active mines

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

Duncan, N., M. A. Devane, J. M. Hickmott. The Analysis of Localised Ground Subsidences. 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. 565-580.

Localized ground subsidences may occur where cavities exist in the ground as a result of the presence of a number of features including mine workings, tunnels, poorly backfilled shafts and, directly or indirectly, from underlying carbonate rocks susceptible to erosion or solutioning. The methods of analysis described permit conclusions to be drawn on the type and probability of failure in cases where cavities are known to exist. When failures have unexpectedly occurred, analytical methods may give some guidance on the depth and dimensions of the cavities activating the subsidence and thus be of assistance in the design of remedial measures.

Keyword(s): geologic features, surface subsidence damage, soils, surface structural damage

Location(s): United Kingdom

Dunham, R. K., A. G. Thurman, R. D. Ellison. The Use of Geological/Geotechnical Investigation as an Aid to Mine Planning. 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. 1C4-1-1C4-6.

Procedures for geological/geotechnical investigation of a property are outlined and demonstrated by example. Information available with limited field work is listed; studies adaptable to the typical drilling process are summarized; and the requirement for monitoring and further assessment during mine development is noted.

Keyword(s): mine design, geologic features, geotechnical

Location(s): United States

Dunham, R. K., R. L. Stace. Interaction Problems in Multiseam Mining. IN: Proceedings 19th U.S. Symposium on Rock Mechanics, Stateline, NV, May 1-3, 1978, Y.S. Kim, ed., University of Nevada-Reno, p. 174-188.

Interaction effects from earlier workings in seams above or below a seam presently being mined are a constant problem in the U.K. coalfields and are beginning to create difficulties in the United States. On the basis of a series of case studies, this paper attempts to define the major parameters governing the interaction mechanism. A broad relationship between the amount of damage caused by a rib edge or remnant pillar and the major parameters is developed from the case study results.

Keyword(s): multiple-seam extraction, coal mining, ground control, longwall, mine design

Location(s): United Kingdom

Dunker, R. E., R. I. Barnhisel, R. G. Darmody, eds. Proceedings of the 1992 National Symposium on Prime Farmland Reclamation. Department of Agronomy, University of Illinois, Urbana.

This symposium brought together reclamationists from industry, government, and research institutions in a national forum to present and discuss current issues related to prime farmland reclamation.

Keyword(s): reclamation, mitigation, land mitigation, agriculture, soils

Location(s): United States

Dunn, J. R., G. M. Banino, W. D. Ernst. The Physical and Chemical Characteristics of Available Materials for Filling Subsurface Coal Mines. Contract JO155182, Dunn Geoscience Corporation, U.S. Bureau of Mines OFR 151-77, 1977, 282 p. (NTIS PB 274 702)

This report studies the critical physical and chemical characteristics of available high-bulk materials that might be used to fill abandoned rooms in anthracite coal mines of eastern Pennsylvania and bituminous coal mines of western Pennsylvania.

Keyword(s): backfilling, abandoned mines, coal mining, anthracite, bituminous

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

Dunrud, C. R. Some Engineering-Geologic Controls on Coal Mine Subsidence; Effects of Subsidence on Mining, Conservation of Coal Reserves, and on the Environment. IN: Engineering Geology and the Natural Resources Energy Spectrum, Association of Engineering Geologists Annual Meeting, Program Abstracts, 1974, no. 17, p. 23.

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

Dunrud, C. R. Effects of Coal Mine Subsidence in Selected Mines of Utah, Colorado, & Wyoming from Viewpoint of Engineering Geologist. IN: Proceedings 88th Annual Meeting Geological Society of America, Salt Lake City, UT, October 20-22, 1975, p. 165-174.

Keyword(s): coal mining, engineering
Location(s): Utah, Colorado, Wyoming, Rocky Mountain Coal Region, United States

Dunrud, C. R. Some Environmental and Resource-Recovery Problems Associated with Past Underground Coal Mining Activities in the Western Powder River Basin, Wyoming. IN: Geological Society of America Abstracts with Programs, 89th Annual Meeting, Denver, November 8-11, 1976, Geological Society America, v. 8, no. 6, p. 846-847. (NTIS Accession No. 77-47508)
Keyword(s): coal mining, abandoned mines, environment, room-and-pillar, overburden, mine fires, reclamation
Location(s): Wyoming, Rocky Mountain Coal Region, United States

Dunrud, C. R., F. W. Osterwald. Coal Mine Subsidence Near Sheridan, Wyoming. Bulletin Association of Engineering Geologists, v. 15, no. 2, 1978, p. 175-190.
Keyword(s): coal mining
Location(s): Wyoming, Rocky Mountain Coal Region, United States

Dunrud. C. R., F. W. Osterwald. Effects of Coal Mine Subsidence in the Western Powder River Basin, Wyoming. U.S. Geological Survey OFR 78-473, 1978, 71 p.
Keyword(s): coal mining
Location(s): Wyoming, Rocky Mountain Coal Region, United States

Dunrud, C. R., R. H. Morris, eds. Selected Papers; Seminar on Coal Mining Activities and Concepts of Multiple Land Use. Session Papers, Seminar on Coal Mining Activities and Concepts of Multiple Land Use, Denver, CO, May 6-7, 1976. Association of Engineering Geologists Bulletin v. 15, no. 2, 1978, p. 145-251. (NTIS Accession No. 79-25371)
Keyword(s): land-use planning, coal mining, reclamation
Location(s): United States

Dunrud, C. R. Coal Mine Deformation, Western Powder River Basin. IN: The Energy Lands Programs of the U.S. Geological Survey, Fiscal Year 1976, J.O. Maberry, compiler. U.S. Geological Survey Circular No. 778, 1978, p. 33-35.
Keyword(s): coal mining
Location(s): Wyoming, Rocky Mountain Coal Region, United States

Dunrud, C. R. Some Engineering Geologic Factors Controlling Coal Mine Subsidence in Utah and Colorado. U.S. Geological Survey Professional Paper 969, 1979, 39 p.
Keyword(s): coal mining, engineering, geologic features
Location(s): Utah, Colorado, Rocky Mountain Coal Region, United States

Dunrud, C. R., F. W. Osterwald. Effects of Coal Mine Subsidence in the Sheridan, Wyoming, Area. U.S. Geological Survey Professional Paper 1164, 1980, 49 p.
Keyword(s): coal mining
Location(s): Wyoming, Rocky Mountain Coal Region, United States

Dunrud, C. R. Coal Mine Subsidence--Western United States. IN: Man-Induced Land Subsidence, Geological Society of America Reviews in Engineering Geology VI, 1984, T.L. Holzer, ed., p. 151-194.
This report discusses the nature and extent of subsidence in the western United States, subsidence processes in underground and surface coal mines, and factors controlling subsidence in order to provide a basis for further study and analysis of subsidence. Results of case studies of subsidence and fires caused by underground mining, subsidence hazards, subsidence prediction and control, and land use are also discussed. The report also compares results of subsidence in the western United States with those of other countries.
Keyword(s): coal mining, surface subsidence damage, active mines, abandoned mines, land-use planning
Location(s): Rocky Mountain Coal Region, United States

Dunrud, C. R. Subsidence--An Important Aspect of Land Use Planning Above Abandoned Underground Coal Mines. IN: Association of Engineering Geologists Symposium Series No. 4, Building Over Underground Mines--Subsidence Considerations, October 1987, p. 3-36.
Subsidence effects, as predicted from geologic and mining conditions, should be incorporated into land use plans before development begins. Time and money spent in formulating comprehensive land use plans before development are small compared to the time and money spent later on mitigation.
Keyword(s): land-use planning, coal mining, abandoned mines, overburden, economics
Location(s): United States

Dutton, A. J., J. L. Meek. Discrete Element Modelling of Vertical Stress Changes Induced by Longwall Mining. IN: Proceedings 1st U.S. Conference on Discrete Element Methods, Golden, 1989.

Keyword(s): modeling, longwall

Duvall, W. I. Stress Analysis Applied to Underground Mining Problems, and Stress Analysis Applied to Multiple Openings in Pillars, Parts I and II. U.S. Bureau of Mines RI 4387, November, 1948.

This report is a discussion of average and maximum stress distributions as a function of the shape of openings and as percent of coal recovery.

Keyword(s): pillar strength, coal mining

Location(s): United States

Dyni, R. C. Subsidence Investigations Over Salt-Solution Mines, Hutchinson, KS. U.S. Bureau of Mines IC 9083, 1986, 23 p.

The USBM, in cooperation with the Solution Mining Research Institute, conducted surface and subsurface investigations over five solution-mined salt cavities in the area of Hutchinson, Kansas. The purpose of these investigations was to determine the mechanisms that lead to the formation of sinkholes above collapsed solution cavities.

Keyword(s): non-metal mining, geologic features

Location(s): Kansas, United States

Dyni, R. C. Subsidence Resulting from Multiple-Seam Longwall Mining in the Western United States--A Characterization Study. U.S. Bureau of Mines IC 9297, 1991, 20 p.

This report details the investigation of multiple-seam longwall subsidence from 1978 to 1989. A field investigation monitored ground surface movements over four upper-seam longwall panels and six lower-seam panels. The characteristics of the subsidence occurring as a result of mining these panels are examined; in particular, the angle of draw, subsidence development, total magnitude and areal extent, and critical width are evaluated and discussed. Comparisons are also made between the characteristics of multiple-seam longwall subsidence and single-seam longwall subsidence that occurred at the same site.

Keyword(s): multiple-seam extraction, longwall, angle of draw, coal mining, monitoring methods, survey methods, survey design, survey equipment, survey data processing, National Coal Board

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

Ealy, D. L., R. E. Mazurak, E. L. Langrand. A Geological Approach for Predicting Unstable Roof and Floor Conditions in Advance of Mining. Mining Congress Journal, March, 1979, p. 17-22.

Keyword(s): roof stability, floor stability, geologic features

Earth Satellite Corporation (Washington, D.C.) Use of Photo Interpretation and Geological Data in the Identification of Surface Damage and Subsidence. Appalachian Regional Commission Report ARC-73-111-2554, 1975, 104 p. (NTIS PB 242 468)

Multi-sensor, multi-level remote sensing was examined for utility in detecting and delineating the surface expression of mine subsidence in the Northern Anthracite Coal Field of Pennsylvania. The objectives were to determine not only those sensors and analysis techniques that offer the best results in the identification of mine subsidence, but to identify areas of potential subsidence so they can be considered in future planning and zoning processes.

Keyword(s): photography, surface subsidence damage, geologic features, remote sensing, anthracite, land-use planning

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

Eaton, L. Surface Effects of the Caving System. Mining and Science Press, v. 97, September, 1908, p. 428-429.

Keyword(s): surface subsidence damage, historical

Eaton, L. Sand Filling Through Pipes and Boreholes. Transactions, AIME, v. 102, February 1932, p. 33.

This article discusses backfilling of active mines by various processes including hand stowage, hydraulic, pneumatic, and a combination of hydraulic and pneumatic.

Keyword(s): hydraulic backfilling, pneumatic backfilling, active mines

Eavenson, H. M. Mining an Upper Bituminous Seam After a Lower Seam Has Been Extracted. Transactions, AIME, v. 69, 1923, p. 398-405.

In many of the bituminous coal districts of the United States, more than one seam of workable coal exists and, in most cases, the lower seam is the more attractive because of either its greater thickness or its superior quality. Apprehension that the mining of a seam will destroy the availability of all overlying seams has hindered the development of many fields and has led to the unprofitable working of certain seams to save them from an expected total loss. A study was made of operating methods applied to superimposed seams, and these cases form the basis of this paper.

Keyword(s): multiple-seam extraction, coal mining, bituminous, active mines

Location(s): West Virginia, Pennsylvania, Maryland, Appalachian Coal Region, United States, South Africa, Scotland

Edgerton, A. T., F. Ruskey, D. N. Williams. Microwave Radiometric Investigations of Mine Subsidence in Rock Springs, Wyoming. U.S. Bureau of Mines Contract H0110156, Aerojet-General Corporation, January, 1971, 97 p. (NTIS PB 203 671)

Keyword(s): instrumentation, monitoring equipment, coal mining, abandoned mines

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

Edl, J. N., Jr., W. F. Eichfeld. Subsidence Related Data from Four Representative United States Coal Mines. Special Study Laboratory Report S & SE 78-2, Joint Research Project No. 14-01-0001-1451, Carbondale Mining Technology Center, U.S. Department of Energy, 1978.

Keyword(s): survey data processing, lab testing, coal mining

Location(s): United States

Edl, J. N., Jr. The Effect of Geotechnical Factors on the Subsidence Response. IN: Proceedings 1st Conference on Ground Control Problems in the Illinois Coal Basin, August 22-24, 1979, Southern Illinois University, Carbondale, 1980, p. 268-282.

The purpose of this paper is to discuss the effects of selected geotechnical factors on subsidence. The information presented necessarily relies heavily on subsidence experience from European countries as subsidence research is still in the early stages in the United States.

Keyword(s): geotechnical, coal mining, National Coal Board, overburden

Location(s): United States, Europe

Edmonds, C. N. Towards the Prediction of Subsidence Risk Upon the Chalk Outcrop. Quarterly Journal of Engineering Geology, 16, 1983, p. 261-266.

Keyword(s): prediction

Edmonds, C. N., C. P. Green, I. E. Higginbottom. Subsidence Hazard Prediction for Limestone Terrains, As Applied to the English Cretaceous Chalk. 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. 283-293.

Soluble carbonate rocks often pose a subsidence hazard to engineering and building works due to the presence of either matastable natural solution features or artificial cavities. It would be advantageous if areas liable to subsidence could be identified in a cost-effective manner in advance of planning and ground investigation.

Keyword(s): prediction, modeling, land-use planning, geologic features

Location(s): United Kingdom

Edwards, J. L. The Effects and Mechanisms of Floor Heave as Observed in the South Newcastle Coalfield. IN: Proceedings, 19th Symposium on Advances in the Study of the Sydney Basin, 1985, Department of Geology, University of Newcastle, New South Wales, p. 68-69.

Floor heave has long been a problem in the mining of various tabular deposits. The manifestation of this phenomenon is an upheaval of the roadway floor by the suggested mechanisms of either plastic flow or rigid buckling, or in some cases a combination of both. The presence of mechanical discontinuities, such as joints and faults, is seen to have an apparent compounding effect in creating the problem, leading to the proposal that drivage direction may have a role to play in minimizing floor heave in critical roadways.

Keyword(s): floor stability, coal mining, geologic features, mine design, room-and-pillar

Location(s): Australia

Ege, J. Mechanisms of Surface Subsidence Resulting from Solution Extraction of Salt. IN: Man-Induced Land Subsidence, Reviews in Engineering Geology VI, T.L. Holzer, ed., The Geological Society of America, 1984, p. 203-221.

Extraction of soluble minerals, whether by natural or man-induced processes, can result in localized land-surface subsidence. The subsidence is caused by partial or total collapse of underground cavities resulting from dissolution of salt or other soluble evaporites. In many cases, subsidence is ultimately related to the strength limit of the overlying rocks that form the unsupported roof above the cavity.

Keyword(s): non-metal mining, fluid extraction

Location(s): United States

Ege, J. R. Surface Subsidence and Collapse in Relation to Extraction of Salt and Other Soluble Evaporites. U.S. Geological Survey OFR 79-1666, 1979, 33 p.

Extraction of soluble minerals, whether by natural or man-induced processes, can result in localized land-surface subsidence and more rarely sinkhole formation. This report summarizes experience in ground subsidence and collapse over cavities formed by either natural or artificial means in saline rocks.

Keyword(s): non-metal mining, surface subsidence damage

Location(s): United States

Eggelsmann, R. F. Subsidence of Peatland Caused by Drainage, Evaporation, and Oxidation. 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 151, 1986, p. 497-505.

Drainage, reclamation, and agricultural use of peatlands change their natural conditions because the layers originally have a high pore volume and high water content. The subsidence of peatland is cased by three main effects: (1) compression of peat layers below the groundwater table, if it is lowered; (2) shrinkage of peat layer upon the groundwater table by desiccation, caused by evaporation; and (3) oxidation/mineralization of the organic matter in the top layer, especially at arable land, depending on pH value.

Keyword(s): fluid extraction, surface subsidence damage, soils

Location(s): Germany

Ehret, P. J. Planning for Subsidence. Coal Mining and Processing, v. 19, no. 4, 1982, p. 130-134.

Keyword(s): coal mining, mine design

Ehret, P. J. The Regulatory Authority. 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. 609-612.

Regulatory requirements since the passage of Surface Mining Control and Regulation Act of 1977 have been in a constant state of change. It is likely that this situation will continue for quite some time as the federal Office of Surface Mining and the various state regulatory agencies learn more about the programs they are enforcing. This evolution may result in a streamlining of the regulatory process as the enforcing agencies discover the impractical aspects of the regulations, and as state-of-the-art advancements are made in both mining and the control of subsidence.

Keyword(s): law, government, reclamation

Location(s): United States

Ehret, P. J. The Regulation of Subsidence and Underground Coal Mining in Illinois. IN: Mine Subsidence, Society of Mining Engineers Fall Meeting, St. Louis, MO, September, 1986, M.M. Singh, ed., SME, Littleton, CO, p. 97-100.

With the passage of the Surface Mining Control and Reclamation Act and the implementation of state programs, underground coal mining operations are for the first time subject to government regulations regarding subsidence. These regulations now and in the future will directly affect the manner in which mining companies mine their coal. Since the promulgation of the original final regulations by Office of Surface Mining, numerous changes in those regulations have been made and many additional changes are pending in the near future. This paper will discuss state and federal approaches to regulating underground coal mines and examine issues surrounding future subsidence regulations.

Keyword(s): coal mining, law, government, geotechnical, mine design, room-and-pillar, longwall, high-extraction retreat, mitigation, reclamation

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

Ehrhardt, W., A. Sauer. Precalculation of Subsidence, Tilt and Curvature Over Extractions in Flat Formations. Bergbauwissenschaften, 1961, v. 8, p. 415-428 (in German).

Keyword(s): prediction, modeling, empirical model, stochastic model

Eichfeld, W. Photogrammetric Techniques. 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. 623-626.

This paper describes the advantages of using photogrammetric surveys for monitoring ground surface movements associated with subsidence.

Keyword(s): monitoring methods, remote sensing

Location(s): United States

Eichfeld, W., E. Ono, Y. P. Chugh, G. Chen. Application of Photogrammetric Techniques in Assessing Underground Mine Opening Deformations and Stability. 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. 587-594.

This paper describes the use of photogrammetric techniques to improve the measurement of entry deformations and the elements of roof-pillar-floor interactions.

Keyword(s): room-and-pillar, survey methods, survey equipment, photography, coal mining

Elder, B. L. A Study of Mine-Related Surface Subsidence Features Using Landsat Thematic Mapper and Seasat SAR Data; the Western Kentucky Coal Field. M.S. Thesis, Murray State University, Murray, KY, 1985, 56 p.

Keyword(s): coal mining, remote sensing, photography, surface subsidence damage

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

Elder, C. H. Evaluation of Procedures Used in Four Mine Subsidence Control Projects. Office of Surface Mining Reclamation and Enforcement, Eastern Field Operations, Ten Parkway Center, Pittsburgh, PA, October 1986.

This project was initiated by the Office of Surface Mining Reclamation and Enforcement to evaluate the effectiveness of selected procedures and materials that have been used to abate abandoned mine subsidence. Specifically, the project was designed to provide the following information: determine the lateral and vertical extent of the fill material injected into the mine voids; and, through the use of "standard" field and laboratory tests, determine the properties of the fill material, such as size distribution, strength, and in situ bearing capacity.

Keyword(s): hydraulic backfilling, pneumatic backfilling, coal mining, anthracite, bituminous,

abandoned mines, mine waste, reclamation, in situ testing, lab testing, geologic features, pillar strength

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

Elifrits, C. D. A Study of Subsidence Over a Room and Pillar Coal Mine. Ph.D. Dissertation, Department of Geological Engineering, University of Missouri, Rolla, 1980, 118 p.

As underground mining has increased in the Illinois Coal Basin, the problem of disruption of surface land use due to subsidence has increased. Throughout the past 60 years, subsidence investigations have dealt with mining depth, geometry and type of support of overburden left in place, hopefully, to prevent cavity failure. To date few investigations have been made of the geologic characteristics of a mine locale with respect to their influences on the natural events following mining of coal by room-and-pillar, high extraction mining methods. This research was completed to investigate the geologic and mining characteristics at subsidence features. Influence of geology and mining on these features was investigated.

Keyword(s): room-and-pillar, high-extraction retreat, coal mining, geologic features, remote sensing, computer, photography

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

Elifrits, C. D., D. J. Barr, N. B. Aughenbaugh. Room and Pillar Coal Mine Subsidence. International Journal of Mining Engineering, v. 1, 1983, p. 295-314.

A geographic natural resources computer database was modified to accept data files created from subsurface geological and mining information and remote sensor data. The database files were then used as variables in equations that were produced to represent relationships among the mapped parameters - geological and mining - that identify areas prone to subside, as determined from the field verified subsidence features. Also, the utility of the computer-processed remote sensor data as a tool for indication of subsided areas was evaluated.

Keyword(s): computer, room-and-pillar, prediction, land-use planning, longwall, modeling, coal mining, remote sensing

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

Elifrits, C. D., N. B. Aughenbaugh. Effects of Moisture Variations and Overburden Geology on Subsidence Proneness. SME-AIME preprint No. 83-389, for presentation at the SME-AIME Fall Meeting and Exhibit, Salt Lake City, UT, October 19-21, 1983, 5 p.

Observations made from laboratory analysis of samples of fine grained argillaceous materials (shales) subjected to various changes in moisture content have been correlated to loss of strength in the rock material. This reaction to a change in conditions (subsequent to mining) at a mine site combined with the observed relationships of surface-disturbing subsidence features at locations where the predominant overburden material is fine grained, provides a predictive tool for the subsidence engineer.

Keyword(s): coal mining, geologic features, overburden, partial extraction, lab testing, in situ testing, floor stability, roof stability

Location(s): United States

Elifrits, C. D., J. D. Rockaway. Landuse Considerations at Locations of Ground Subsidence. 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. 387-392.

Surface subsidence over areas where high extraction coal mining practices have been used frequently results in a change of land use capability. These changes require that alternative land use patterns be evaluated prior to mining to minimize potential environmental impact. This paper presents the results of a subsidence impact study conducted at Rend Lake, Illinois, where longwall coal mining beneath the reservoir and adjacent shorelines caused noticeable changes in areas subject to inundation. This necessitated additional property acquisition, reconsideration of areas qualifying for wetland designation, and modification of areas suitable for lake access and recreational facilities.

Keyword(s): coal mining, land-use planning, environment, surface water, longwall, active mines, geologic features, subsurface water, prediction, surface structural damage

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

Eltringham, J. The Reinforcement of Buildings and Their Foundations Against Mining Subsidence. Transactions, Institute of Mining Engineers, v. 66, 1923-24, p. 200-211.

A brick building was successfully constructed over an area liable to subside. The foundations were equipped with concrete rafts and the brickwork reinforced by a band of steel.

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

Location(s): United Kingdom

Ely, E. H. The Design of the Skegby Sewage Purification Works to Meet Mining Subsidence. Journal Institute of Public Health Engineering, v. 618, no. 3, 1962, p. 146-165.

Keyword(s): utilities, engineering, surface structural damage

Emery, C. L. In Situ Measurements Applied to Mine Design. IN: Proceedings 6th Symposium on Rock Mechanics, University of Missouri at Rolla, 1964, E.M. Spokes and C.R. Christiansen, eds., p. 218-230.

This paper deals with a rock mechanics study, a simple but characteristic program of measurement, analysis, and application of data to mine design. The mine concerned is an operating mine recovering about 4,000 tons per day from a bedded deposit at a depth of about 2,500 feet in Silurian sediments overlain by Devonian strata. The mine is developed by a room-and-pillar method of mining and, although mining conditions were considered to be good, there was a continuous and significant amount of maintenance caused by rock movements expressed in floor heaving, roof spalling, and pillar deterioration.

Keyword(s): mine design, rock mechanics, in situ testing, lab testing, room-and-pillar

Emrick, H. W. Establishment and Use of Monitoring Networks. 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. 211-214.

This paper states that modern subsidence monitoring should include the interdisciplinary tools from soils engineering, geophysical engineering, geological engineering, geodetic engineering, mathematical and electrical engineering data processing handling, and modeling methods. The main emphasis is on current methodology in geodesy and geodynamics.

Keyword(s): soils, engineering, geophysical, modeling, remote sensing, survey design, survey equipment, survey methods, survey data processing, monitoring design, monitoring equipment, monitoring installation, monitoring methods, coal mining

Emsley, S. J., J. W. Summers, P. Styles. The Detection of Sub-surface Mining Related Cavities Using the Micro-Gravity Technique. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May 1992. South African Institution of Civil Engineers, Republic of South Africa, p. 27-35.

The presence of mining-related cavities in the rock mass, resulting from past mining activities, often leads to restrictions in subsequent re-use of the land and poses a number of problems for future construction projects. The micro-gravity technique is a geophysical method that has been further developed to improve its use in the detection of mining-related cavities.

Keyword(s): geophysical, abandoned mines, remote sensing, seismic, surface structural damage, coal mining

Location(s): United Kingdom

Enever, J. R., J. Shepherd, J. Huntington. An Initial Mathematical Relationship Between Underground Working Conditions and Overlying Surface Topography with Reference to the Western Coalfields, N.S.W. Commonwealth Scientific and Industrial Research Organization, Mineral Physics, Mount Waverly, Victoria, Australia, Report 5, 1978, 6 p.

Keyword(s): ground control, coal mining

Location(s): Australia

Engineering and Mining Journal. The Flushing Problem in the Anthracite Region. v. 88, September 18, 1909, p. 564-565.

This article describes the danger of subsidence to surface property and also covers attempts at backfilling.

Keyword(s): backfilling, surface subsidence damage, anthracite, coal mining, historical

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

Engineering News. Concrete Column Foundation for a Building Over Coal Mine Workings. v. 67, no. 14, April, 1912, p. 633.

This paper describes the use of 8- to 12-inch diameter caissons and grade beams for support of a new home located 30 feet above an abandoned mine in Pennsylvania.

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

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

Engineering News. More Mine Cave-Ins Threaten Parts of Scranton. v. 76, 1916, p. 280.

This article discusses the lack of legal responsibility at that time among mine operators for surface subsidence damage.

Keyword(s): mine operation, law, room-and-pillar, historical, coal mining

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

Engineering News-Record. Subsurface Grouting of a Hospital Site. February 9, 1950.

This article describes pressure grouting procedure used by the U.S. Army Corps of Engineers to reconsolidate an area beneath a proposed hospital in Pennsylvania.

Keyword(s): grouting, abandoned mines

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

Engineering News-Record. Can't Dredge the Harbor?--Then Lower the Land. January 31, 1963.

A brief description is given of a planned, controlled subsidence coal mining operation designed to lower the floor of Duisberg Harbor. Induced subsidence was designed to compensate for a 6.5 foot water level drop that had reduced the efficiency of the harbor operation.

Keyword(s): surface water, coal mining

Engineering News-Record. Piling System Supports Construction Atop Mines. v. 227, no. 6, 1991, p. 19.

The owners of a 2,000-acre commercial and residential development in Birmingham, Alabama, had to develop a way to support the foundation of a seven-story, 185,000-square-foot building, which was part of a $150,000-million project to be built over abandoned coal mines that once fed steel blast furnaces.

Keyword(s): abandoned mines, coal mining, foundations, surface structural damage, architecture, geotechnical, structural mitigation, grouting

Location(s): Alabama, United States

Engineers International, Inc. Criteria for Determining When a Body of Surface Water Constitutes a Hazard to Mining. Final Report on U.S. Bureau of Mines Contract J0285011, August, 1979, 366 p.

Keyword(s): surface water

Location(s): United States

English, J. Some Notes on Subsidence. Iron and Coal Trades Review, v. 141, December 6, 1940, p. 591.

Keyword(s): coal mining

Environmental Systems Application Center, Indiana University. Illinois Basin Coal Planning Assistance Project, Coal Resources Fact Book, Volume One. Prepared for U.S. Geological Survey, Reston, VA, February 1983, in cooperation with Illinois State Geological Survey, Indiana Geological Survey, and Kentucky Geological Survey, 323 p.

Kentucky, Illinois, and Indiana share the vast coal resources of the Eastern Interior Coal province commonly known as the Illinois Coal Basin. As the United States uses more coal, pressures to develop new resources will require states and local communities to plan and manage comprehensive programs. Although some Basin resources have been developed for many years, new legislation, stricter environmental controls, increased costs, and many local agency requirements will make planning and management of coal development more difficult than in the past.

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

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

Enzian, C. Hydraulic Mine Filling. U.S. Bureau of Mines, B 60, 1913.

This bulletin reviews the history of hydraulic mine filling in active mines and its application for fire control, roof support, pillar reclamation, as well as disposing of spoil and alleviating stream pollution.

Keyword(s): roof support, room-and-pillar, hydraulic backfilling, economics, environment, mine fires, mine waste, active mines

Location(s): United States

Enzian, C. Physical and Geological Difficulties of Anthracite Mining with Special Reference to Surface Support in the Northern or Wyoming Basin. Thesis, Lehigh University, 1913.

The thesis discusses the geology of the anthracite regions and the cause of mine caves, analyzes some prominent mine caves, indicates remedial measures being taken, gives the results of

numerous tests on timber, cogs, hydrauliced culm and concrete, and indicates the solution developed for that region.

Keyword(s): anthracite, coal mining, historical, roof support, hydraulic backfilling, geologic features, land mitigation

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

Enzian, C. Mine Caving Prevented by Hydraulic Backfilling. Coal Age, April 4, 1914, p. 555.

This article describes the advantages of hydraulic backfilling, including pillar reclamation, mine waste disposal, and fewer environmental problems.

Keyword(s): hydraulic backfilling, mine waste, environment, coal mining

Esaki, T., T. Kimura, K. Shikata. Subsidence and Environmental Impacts in Japanese Coal 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. 511-518.

This paper describes the present condition of mining-induced damages in Japan and their characteristics. The change of mining operation and environmental condition has caused various significant impacts on the environment: subsidence, cave-in, springing out of groundwater, etc. The characteristics and the influences of these phenomena are discussed by investigation of the actual conditions and by fundamental studies. Some countermeasures are also introduced.

Keyword(s): coal mining, environment, subsurface water, active mines, abandoned mines, reclamation, mine waste, structural mitigation, land mitigation, geologic features, law, historical, land-use planning, inflow

Location(s): Japan

Esterhuizen, G. S. Modelling of Barrier Pillars in Bord and Pillar Workings. IN: Proceedings, International Congress on Rock Mechanics, Aachen, 1991, W. Wittke, ed., v. 2, p. 1093-1097.

Barrier pillars are designed to isolate production sections from one another so that uncontrolled failure of pillars in one section will not affect the adjacent workings. The strength of a continous barrier pillar and the load it carries are required for the design of barrier pillars. The loading conditions were determined by assuming a simple model of the load distribution in the caved and uncaved ground. The results showed that if pillars fail and the overburden caves gradually, then the load on barrier pillars will not increase significantly. However, if strong strata are present in the roof then a significant increase in load is possible. The strength of barrier pillars was further investigated using three-dimensional numerical models and by studying actual collapsed cases. It was found that if the width to height ratio is 4.0, the strength of long rectangular pillars increases signficantly over square pillars with the same width but if the width to height ratio is 10.0, the strength does not increase.

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

Location(s): South Africa

Evans, D. W., G. J. Colaizzi. Control of Mine Subsidence Utilizing Coal Ash as a Backfill Material. IN: Proceedings, 2nd Conference on Ground Control in Mining, West Virginia University, July 19-21, 1982, S.S. Peng and J.H. Kelley, eds., Morgantown, p. 222-228.

A number of methods exist to provide support for the ground overlying mines. All of these methods employ some mechanism for providing additional support to either the roof of the mine or the sides of the pillars. Since failure usually occurs due to overburden stresses transmitted to the roof and pillars, these methods employ techniques to counteract stresses induced due to the coal extraction. The applicability of any particular method will depend on the availability of backfill material, the areal extent of the affected area, and the cost. The primary use of coal ash for subsidence control has been as a backfill material for the stabilization of large areas.

Keyword(s): mine waste, hydraulic backfilling, grouting, coal mining, overburden, pillar strength, roof stability, ground control

Location(s): United States

Evans, D. W., G. J. Colaizzi, R. M. Wood. Program Development for Backfilling Mines to Prevent Mine Subsidence. IN: Proceedings, 19th Annual Engineering Geology and Soils Engineering Symposium, Pocatello, ID, March 31-April 2, 1982, C.W. Blount, ed., p. 355-364.

This paper covers the progression of steps required to initiate a backfilling program. These steps include the establishment of the need for remedial measures; the development of a drilling program to evaluate the extent of voids; the data search to obtain information; the reduction of data obtained from mine maps, publications, and drilling; the development of potential remedial actions; and

ultimately the backfilling requirements and techniques utilized to control the subsidence.

Keyword(s): hydraulic backfilling, grouting, abandoned mines, reclamation, surface structural damage, land mitigation, geologic features

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

Evans, G. S., T. Hailu, H. M. Weagraff, J. W. Warner, G. S. Lowry. The Impact of Longwall Mining on the Hydrologic Balance; Premining Data Collection. Contract J0218025, J.F. Sato & Associates, Inc., U.S. Bureau of Mines OFR 187-83, 1983, 141 p. (NTIS PB 84-113174)

Keyword(s): longwall, hydrology, surface water, subsurface water

Location(s): United States

Evans, I., D. C. Pomeroy, R. Berenbaum. The Compressive Strength of Coal. Colliery Engineering, 1961, v. 38, February, p. 75-80, March, p. 123, April, p. 172.

This series of articles discusses laboratory tests on rectangular and irregular lumps of coal to determine their compressive strengths.

Keyword(s): pillar strength, rock mechanics, lab testing, coal mining

Evans, I. D., C. D. Pomeroy. The Strength, Fracture and Workability of Coal. Pergamon Press, New York, 1966, 277 p.

Keyword(s): ground control, coal mining, pillar strength

Location(s): England

Evans, J. A., M. S. Lawrence. A Case Study on Past Shortwall Mining Methods and the Risk of Ground Subsidence in the Lanarkshire Coalfield, Scotland. IN: Engineering Geology of Underground Movements, Geological Society Engineering Geology Special Publication No. 5, F.G. Bell, et al., eds., 1988, p. 337-349.

A site investigation involving archival research and a borehole drilling program was carried out in order to assess the risk to surface stability from abandoned shallow shortwall mineworkings at a proposed housing development site. The investigations recorded the shortwall panels to be largely consolidated but also noted that several panels had been undeveloped with respect to the lower seam and that some roadways were confined to the upper seam. The borehole investigation together with the use of down-the-hole closed-circuit television also confirmed the presence of broken ground and open voids along former roadway alignments. A risk to surface stability was identified from these open voids and development constraints zones are discussed in relation to the likely mining methods. Seam depths, void heights, condition of roof strata and thickness of superficial cover are considered in the assessment of void migration mechanisms arising from such a past mining situation.

Keyword(s): shortwall, abandoned mines, coal mining, land-use planning, surface structural damage, engineering, geologic features, monitoring methods, rock mechanics, multiple-seam extraction, historical

Location(s): Scotland

Evans, R. T., A. B. Hawkins. Significance and Treatment of Old Coal Workings at Llanelli Hospital, South Wales. 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. 188-206.

The geology, past mining, and reasons for undergrouting a hospital are discussed. Abandonment plans record extensive workings in the seam beneath much of the site. Several voids were encountered during the investigation, which indicated that the coal seam was overlain by a mudstone and then a thick competent sandstone horizon. In view of the risk of pillar collapse leading to the bridging and overstressing of lateral pillars and following the experience of Bathgate in Scotland, it was considered necessary to undergrout the area on which the structures were to be built. 14,500 tons of grout were injected into 3,550 holes. Water injection tests indicated the grouting had been effective, and it is now considered that no significant future subsidence should take place.

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

Location(s): Wales

Evans, W. H. The Strength of Undermined Strata. Transactions, Institution of Mining and Metallurgy, v. 50, 1941, p. 475-532.

Keyword(s): rock mechanics, overburden

Evans, W. H., T. J. Jones. An Investigation of the Load on Packs at Moderate Depths Part II. Transactions, Institute Mining Engineers, 1946, v. 105, pt. 6.
Keyword(s): backfilling

Ewy, R. T., M. Hood. Old Ben No. 24, Subsidence Analysis and Predictive Program, User's Guide. Department of Material Science and Mining Engineering, University of California, Berkeley, April, 1982, 11 p.
Keyword(s): prediction, coal mining
Location(s): Illinois, Illinois Coal Basin, United States

Faddick, R. R., W. R. Eby. Slurry Backfilling of Mine Voids in Hanna, Wyoming. IN: Proceedings of Symposium on Mining, Hydrology, Sedimentology, and Reclamation, December 8-11, 1986, Lexington, KY, p. 209-213.

Keyword(s): hydraulic backfilling, abandoned mines, coal mining

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

Faddick, R. R., W. R. Eby. Effects of Slurry Backfilling--Lessons Learned. IN: Conference on Hydraulic Fill Structures, Colorado State University, Fort Collins, August 15-18, 1988, D.J.A. Van Zyl and S.G. Vick, eds., ASCE Geotechnical Special Publication No. 21.

In 1986 the underground coal mine voids in Hanna, Wyoming, were slurry backfilled to alleviate subsidence throughout much of the town. The project was completed successfully, but in a relative sense, because it was not without its share of difficulties. Some of these technical difficulties, pertaining to the fill material used, the operation of the pipeline system, and sequence of backfilling, are discussed with the hope that they may be interpreted as lessons for future slurry backfilling operations.

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

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

Fader, S. W. Land Subsidence Caused by Dissolution of Salt Near Four Oil and Gas Wells in Central Kansas. U.S. Geological Survey Water-Resources Investigations 27-75, 1975, 28 p.

Keyword(s): surface subsidence damage, oil extraction, non-metal mining

Location(s): Kansas, United States

Faig, W. The Use of Photogrammetry for Mining Subsidence Determination. Australian Journal Geodesy, Photogrammetry, and Surveying, v. 41, December, 1984, p. 21-35.

Keyword(s): survey methods, remote sensing

Location(s): Australia

Fairhurst, C. Laboratory Testing of Rock and its Relevance to Mine Design. IN: SME Mining Engineering Handbook, v. 1, A.B. Cummins and I.A. Given, eds., 1973, SME-AIME, New York, p. 13-36 to 13-51.

The design of engineering structures in rock is more art than science, particularly insofar as the behavior of the rock mass is concerned. This is particularly true in mine design. Progress is being made, but currently there are no widely used rational design procedures because of the difficulty of theoretical formulation of the practical problem and because of the lack of information on the mechanical properties of the rock mass affected by extraction.

Keyword(s): rock mechanics, mine design, lab testing, room-and-pillar, pillar strength

Faria Santos, C. Analysis of Floor Stability in Underground Coal Mines. Ph.D. Thesis, The Pennsylvania State University, 1988, 205 p.

Keyword(s): floor stability, coal mining, in situ testing, lab testing, geotechnical, longwall, room-and-pillar, instrumentation, geologic features

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

Faria Santos, C., Z. T. Bieniawski. Floor Design in Underground Coal Mines. Rock Mechanics and Rock Engineering, v. 2, no. 4, 1989, p. 249-271.

Floor failure and excessive heave in underground coal mines can jeopardize the stability of the whole structure, including the roof and pillars, due to differential settlements and redistribution of stress concentrations. Besides, floor failure is detrimental to haulageway operation and can lead to unacceptable conditions of high deformation. Thus, the design of any underground opening must consider roof/pillar and floor as one structural system. This paper presents guidelines for designing mine floors, including the necessary field and laboratory investigations and determining bearing capacity of the floor strata. The design methodology is based on a modified Hoek-Brown rock mass strength criterion, with modifications to the introduction of the concept of the point of critical energy relase to account for the long-term strength, the inclusion of tensile strength and the adoption of a lithostatic state of stress in the rock mass. Determining the dimensionless parameters m and s result from correlations with the RMR (rock mass rating) Geomechanics Classification. Nine case histories, both in longwall and room-and-pillar coal mining, were analyzed with the proposed methodology.

Keyword(s): coal mining, mine design, floor stability, rock mechanics, lab testing, longwall, room-and-pillar, pillar strength, geotechnical

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

Farmer, I. W., P. B. Attwell. A Note on the Similarities Between Ground Movement Around Soft Ground Tunnels and Longwall Mining Excavations. The Mining Engineer, London, v. 134, May, 1975, p. 397-405.

Keyword(s): longwall, tunnelling, geologic features

Farmer, I. W. Case Histories of Settlement Above Tunnels in Clay. 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. 357-371.

Theoretical and empirical methods for determining ground movement and surface settlement magnitudes above tunnels in soft ground usually relate the geometry of the settlement profile to the geometry of tunnelling. The importance of the tunnel construction method and the ground deformation mechanism is often underemphasized. Three case histories are introduced that show how construction and soil deformation characteristics can significantly affect settlement.

Keyword(s): tunnelling, soils, modeling, empirical model, construction

Location(s): United Kingdom

Farmer, I. W., P. F. R. Altounyan. The Mechanics of Ground Deformation Above a Caving Longwall Face. 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. 75-91.

An examination of contours of vertical strain computed from three investigations of ground deformation behind caving longwall faces shows that an extensive zone of fractured and dilated rock is created above the caved area. The boundaries of the fractured zone and the magnitude of residual dilation thorughout the zone are strongly influenced by the lithology of the overlying strata.

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

Location(s): United Kingdom

Farmer, I. W., X. Tan. Outbursts and Rockbursts in Coal Mines. 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. 228-233.

A description of the factors causing outbursts and rockbursts in coal mines is given. The mechanics of both outbursts and rockbursts can be described in terms of conversion of stored strain energy in the coal and surrounding rocks into kinetic energy through failure. The major difference between the two phenomena is that gases adsorbed onto the coal structure and desorbed during deformation contribute to the energy available during outbursts and may also affect the loading and unloading characteristics associated with failure. The amount of energy involved and the type of phenomenon are related principally to gas content, depth, and rock behavior.

Keyword(s): rock mechanics, coal mining, bumps

Farquar, G. B., B. J. Douglas. Risk of Mine Related Subsidence at Ocean View. IN: Proceedings 6th Australia-New Zealand Conference on Geomechanics, Christchurch, February 3-7, 1992, New Zealand Geomechanics Society, p. 236-241.

A subsidence pit appeared in July 1998 in a residential area of Ocean View, New Zealand, above a 100-year-old abandoned coal mine. The extent of the mine and its condition were investigated. Weak overburden strata and a deteriorating and flooded mine were revealed. Mine roof failure and subsequent subsidence of sandy gravel migrating upwards to form a crownhole are considered to have caused the surface movement. Similar conditions were observed nearby. Subsidence risks have been assessed.

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

Location(s): New Zealand

Farran, C. E. The Effect of Mining Subsidence on Land Drainage. Journal Institute Water Engineering, v. 6, no. 7, 1952, p. 482-503.

This paper discusses the effects of longwall mining subsidence on flat, low-lying land in England.

Keyword(s): surface water, longwall

Location(s): England

Faulkner, R. Roof Control in the Arley Seam. Transactions, Institute of Mining Engineers, v. 81, 1930-31, p. 507-524; v. 84, 1932-33, p. 57-77, 405.

This article discusses observations of roof failure in longwall mines having shale roofs.

Keyword(s): roof stability, longwall

Fawcett, A. H., Jr., J. Aamot. Economic and Social Indicators With Reference to Land Use in Subsidence-Prone Areas in Northeastern Pennsylvania. v. 2, May, 1975, 42 p. (NTIS PB 273 918)

Keyword(s): land-use planning, economics

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

Fawcett, A. H. Jr., J. Marcou. Economic and Social Indicators with Reference to Land Use in Subsidence-Prone Areas in Northeastern Pennsylvania. Volume I. General Findings and Recommendations. Appalachian Regional Commission Report ARC-73-163-2556-1, May 1975, 150 p. (NTIS PB-273 917)

This report includes an inventory and analysis of socioeconomic and land-use data for a seven-county region covering most of the Anthracite Region of northeastern Pennsylvania. Conditions of potential land subsidence due to underground coal-mine collapse are related to land-use and other settlement characteristics. The authors conclude that land-use planning alone cannot provide a definitive solution to the problem of potential subsidence damage, but must be combined with appropriate building regulations, stabilization, and insurance programs, as well as effective state policy.

Keyword(s): coal mining, anthracite, land-use planning, insurance, subsidence research, environment, abandoned mines

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

Fayol, M. Sur les mouvement de terrain provoques par l'exploitation des mines (Effects of Coal Mining on the Surface). Bulletin de la Societe de l'Industrie Minerale, II Serie, Tome 14, 1885. Partial translation by H. F. Bulman, Colliery Engineering, v. 33, 1913, p. 548-552, 617-622.

Keyword(s): roof stability, mine design, surface subsidence damage, ground control, coal mining

Federal Register. Coal Mining Operating Regulations. May 17, 1976, C.F.R. 211: Federal Register, v. 41, no. 96, p. 20261-20273.

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

Location(s): United States

Federal Register. Coal Management, Proposed Rulemaking. Part III, March 19, 1980, U.S. Department of Interior, Bureau of Land Management, Washington, D.C., v. 44, no. 54, p. 16800-16845.

Keyword(s): law, coal mining

Location(s): United States

Federal Register. Permanent Regulatory Program: Subsidence Control, Concurrent Operations and Contemporaneous Reclamation. Office of Surface Mining Reclamation and Enforcement, Final Rule, Part VII, v. 48, no. 106, June 1, 1983, p. 24638-246452.

Keyword(s): law

Fedorowicz, L., J. Fedorowicz. Wall Structures Affected by the Static Effects of Mining Operations. 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. 370-382.

The authors of this paper have been dealing for several years with the problem of adaptation of the numerical method of rigid finite elements for the purpose of calculatingthe following: buildings subjected to bending and twisting, allowing for their two- or three-dimensional statical behavior; and floating foundations, allowing for the interaction of the superstructure and substructure, when exposed to the effects of the horizontal compression and extension of the ground at the site.

Keyword(s): surface structural damage, coal mining, finite element, modeling, foundations, horizontal displacement

Location(s): Poland

Fejes, A. J., R. D. Dyni, J. A. Magers, L. B. Swatek. Subsidence Information for Underground Mines--Literature Assessment and Annotated Bibliography U.S. Bureau of Mines IC 9007, 1985, 86 p.

The purpose of this report is to provide mining industry personnel and regulatory authorities with a subsidence reference list and annotated bibliography that will aid them in locating subsidence information and in developing their own subsidence information sources.

Keyword(s): literature search, subsidence research

Fejes, A. J. Surface Subsidence Resulting from Longwall Mining in Central Utah--A Case Study. 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. 197-204.

This paper summarizes the results of a 5-year subsidence study performed over four adjacent longwall panels in Utah. The objectives of this program were to determine the magnitude, rate, and areal extent of surface subsidence from longwall mining under the geologic and mining conditions commonly found in the western United States. The data were collected from this site to evaluate the applicability of existing prediction methods to conditions in the western United States and, if necessary, to develop new or modified prediction techniques.

Keyword(s): longwall, prediction, monitoring installation, survey design, profile function, empirical model, National Coal Board, vertical displacement, surface subsidence damage

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

Fejes, A. J. Surface Subsidence Over Longwall Panels in the Western United States. U.S. Bureau of Mines IC 9099, 1986, 21 p.

This study was directed toward developing the capability to estimate the surface subsidence resulting from longwall mining in a geologic, topographic, and mining environment common to coalfields in the western United States.

Keyword(s): geologic features, longwall, instrumentation, monitoring design, monitoring methods, monitoring installation, monitoring equipment, survey design, survey equipment

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

Fenk, J. Moeglichkeiten zur Bestimmung der Beanspruchung des Haupthangenden als Abbaufolge (Possibilities of Determining Stresses in Overburden Strata Caused by Mining Sequence). Neue Bergbautechnik, v. 2, August, 1972, p. 601-606.

Keyword(s): instrumentation, overburden

Fenk, J. Modeling of Small, Localized Surface Subsidence. Neue Bergbautechnik, v. 7, no. 6, June, 1977, p. 414-417.

Keyword(s): modeling

Ferguson, P. A. Longwall Mining Systems and Geology. Mining Congress Journal, v. 57, no. 12, 1971, p. 32-35.

Production may approach one million tons per year from one longwall mine, according to the results of this research. Several methods of roof support were developed, including yieldable arches, yieldable legs and beams, and roof trusses.

Keyword(s): coal mining, longwall, yielding supports, roof support

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

Fernandez-Rubio, R., ed. First World Congress of Water in Mining and Underground Work. SIAMOS, September 18-22, 1978, Granada, Spain, 1550 p.

Water problems in mining and underground work appear almost as a challenge. Therefore, original investigation techniques and methodologies are required. In many cases accumulated experience, in very different environments, has an extraordinary value. These problems are frequent and often complex. Many technicians and scientists have good experience in this field. However, this publication is the first one that tries to unite this experience in a world-wide participation. Contributions of specialists from 24 countries are included, therefore this publication is of strong interest for everybody connected to mining, civil engineering, geology, hydrogeology, and ecology. Volumes I and II contain the full text of the selected papers (70% in English), with an English, French, and Spanish summary, classified in six topic sections.

Keyword(s): subsurface water, coal mining, hydrology, geologic features

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

Fernando, D. A. Review of Subsidence and Stabilization Techniques. IN: Mine Induced Subsidence: Effects on Engineered Structures, Proceedings of the Symposium, Nashville, TN, May 11, 1988, ASCE Geotechnical Special Publication No. 19, p. 189-206.

This paper aims to review the causes of subsidence and the techniques used to minimize its effect on structures. Also, more economic alternative methods of ground stabilization techniques are described and proposed, to be used in this area of ground engineering.

Keyword(s): coal mining, longwall, abandoned mines, land-use planning, grouting, partial extraction, prediction theories, foundations, mine waste

Location(s): United Kingdom

Ferrari, R. Predicting the Unpredictable. IN: Proceedings 2nd International Conference on Construction in Areas of Abandoned Mine Workings, Edinburgh, 1988.

Keyword(s): abandoned mines, prediction, land-use planning

Finlay, J., A. Winstanley. Interaction of Longwall Workings. Transactions, Institute of Mining Engineers, v. 87, 1933-34, p. 172-189; v. 88, 1934-35, p. 24, 298, 415.

Investigations were made in two beds of coal separated by 71 feet of rock and mined 2 years apart by the longwall method.

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

Finol, A., S. M. Farouq Ali. Numerical Simulation of Oil Production With Simultaneous Ground Subsidence. Journal of the Society of Petroleum Engineers, v. 15, October, 1975, p. 411-424.

Keyword(s): modeling, oil extraction

Fischer, W. G., S. R. Felde. Four-North Panel, A Bold Experiment in Roof Deflection. Mining Engineering, April, 1966, p. 63-67.

This mining system leaves small yielding pillars that are meant to deform plastically and produce controlled subsidence. Conventional room-and-pillar mining equipment is used with longwall roof supports.

Keyword(s): longwall, shortwall, room-and-pillar, roof support, roof stability, mine design, yielding supports

Location(s): United States

Fischer, W. G. Time Dependent Subsidence Behavior at a Green River Trona Mine. IN: Mine Subsidence, M.M. Singh, ed., Society of Mining Engineers Fall Meeting, September, 1986, St. Louis, MO, SME, Littleton, CO, p. 111-116.

Equations developed by an early researcher in subsidence, F. Martos of Hungary, have been slightly modified to produce effective equations for predicting the time-dependent nature of Green River trona mine subsidence. Following the initial study, a survey was run to check the results 20 years after mining of the area had been completed. The final results were within a few centimeters of the value that had been projected. Mining conditions in the Green River area are ideal for this sort of study with trough type subsidence being the surface manifestation of high extraction underground room-and-pillar caving operations.

Keyword(s): time factor, prediction, prediction theories, non-metal mining

Location(s): Wyoming, United States

Fisekci, M. Y. Strata Control Instrumentation for Coal Mine Design with Special Reference to Hydraulic Mining. 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 (abstract of oral presentation), 1 p.

The paper discusses the recent development in strata control instrumentation to meet the requirements of fast moving faces of hydraulic mining in thick and steep coal seams. The paper further points out that much more effective use can be made of existing knowledge to meet the changing strata control requirements of the coal industry.

Keyword(s): coal mining, ground control, instrumentation

Fisekci, M. Y., A. Chrzanowski, B. M. Das, G. Larocque. Subsidence Studies in Thick and Steep Coal Seam Mining. IN: Proceedings 1st Annual Conference on Ground Control in Mining, West Virginia University, Morgantown, July 27-29, 1981, S.S. Peng, ed., p. 230-238.

This paper concentrates on subsidence measurements applied over the thick and steep seam mining in the Rocky Mountains Region of Western Canada. The studies to date indicate that two new subsidence monitoring techniques appear to be the most suitable methods for these conditions. The computerized telemetry and aerial photogrammetry systems are being tested for the reliability of the systems during the winter months within the network of laser surveying over the workings of the new hydraulic mine.

Keyword(s): coal mining, monitoring methods, monitoring equipment, remote sensing, survey methods

Location(s): Canada

Fisekci, M. Y., C. Chrzanowski. Some Aspects of Subsidence Monitoring in Difficult Terrain and Climate Conditions of Rocky Mountains Western Canada. 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. 182-196.

Subsidence measurement methods, applied over the thick and steep seam mining in the Rocky Mountains Region of Western Canada are described. The studies to date indicate that two new subsidence monitoring techniques appear to be the most suited methods for these conditions. The computerized telemetry and aerial photogrammetry systems are being tested for reliability during the winter months within the network of laser surveying over the workings of the new hydraulic mine.

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

Location(s): Canada, Rocky Mountain Coal Region

Fisher, A. E. J. Aspects of In-Seam Development for Subsequent Full Extraction. IN: Annual Conference, Australasian Institute of Mining and Metallurgy, May, 1976, p. 337-344.

Keyword(s): mine design, coal mining

Fitzpatrick, D. J., D. J. Reddish, B. N. Whittaker. Studies of Surface and Sub-Surface Ground Movements Due to Longwall Mining Operations. 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. 68-77.

This paper reviews current mining subsidence research at the Department of Mining Engineering, University of Nottingham. Special attention is being devoted to prediction of ground movements between the mining horizon and the surface using physical and computer-based models. The paper discusses linear and non-linear finite element methods and compares results with those from physical models and field observations. Special attention is focused on the determination of the effect of caved zones on overlying and underlying geological structures. The paper presents data from comparisons with case histories from the United Kingdom.

Keyword(s): modeling, computer, geologic features, finite element, National Coal Board, coal mining, subsidence research, prediction, prediction theories, overburden

Location(s): United Kingdom

Fitzpatrick, D. J. Modelling of Mining Subsidence Mechanisms and Prediction of Ground Movements. Ph.D. Thesis, University of Nottingham, United Kingdom, 1987.

Keyword(s): modeling, prediction, coal mining

Location(s): United Kingdom

Flaschentrager, H. Considerations on Ground Movement Phenomena Based on Observations Made in the Left Bank Lower Rhine Region. IN: Proceedings, European Congress on Ground Movement, Leeds, England, April 9-12, 1957. London Harrison, 1957, p. 58-73.

This paper presents research conducted to study the influence of incomplete convergence at the edge of workings on surface subsidence. Data were collected in Germany from mines where backfilling was used.

Keyword(s): vertical displacement, time factor, pneumatic backfilling, stowing, modeling, empirical model, influence function

Location(s): Germany

Flaschentrager, H. Consideration on Ground Movement Phenomena. Colliery Engineering, v. 35, 1958, p. 342-350, 391-397.

In this paper, the author sought to clarify the influence of the rib-side (or solid coal side) with incomplete convergence on movements at the surface. Starting with measurements in the face cavity, the conception of the face convergence curve is developed. Its significance is demonstrated from various examples. The limit angle is not changed by the face convergence already occurring in the coal in front of the working face and, consequently, there is no need for a distinction between the theoretical and practical limit angles. Finally, the time factor for underground and surface was discussed from various examples.

Keyword(s): ground control, coal mining, time factor

Fleming, R. M. Subsidence from a Mining Engineer's Point of View. Appendix A to the Report of the Subsidence Committee, Pennsylvania General Assembly, Legislative Journal, 1957, p. 4249-4252.

This appendix reviews the problems of subsidence from anthracite and bituminous mining.

Keyword(s): engineering, government, law, coal mining, anthracite, bituminous

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

Flowers, A. E. Plans for Long, Productive Life. Coal Age, v. 62, no. 2, 1957, p. 77-83.

Keyword(s): coal mining

Follington, I. L., A. K. Isaac. Failure Zone Development Above Longwall Panels. Mining Science and Technology, v. 10, no. 1, January, 1990, p. 103-116.

The controlled development of failure zones above longwall panels is necessary for maintenance of production and safety of personnel. This is particularly so where aquifers exist above and in relative proximity to coal faces. A brief review of finite element modeling of strata surrounding mining excavations is presented. Particular emphasis is given to determination of input data required for the modeling technique. In this, attention is focussed upon various methods of rating of the rock mass.

Keyword(s): overburden, longwall, subsurface water, coal mining, finite element, modeling, rock mechanics

Location(s): United Kingdom

Follington, I. L., A. K. Isaac. A Coalface Roof Failure Mechanism Beneath Strong Bridging Strata. Mining Science and Technology, v. 10, no. 2, March, 1990, p. 117-126.

An investigation into powered support performance and strata behaviour at Cotgrave Collierty followed difficulties encountered in roof control at a high production coal face.

Keyword(s): roof stability, overburden, geologic features, ground control

Location(s): United Kingdom

Follington, I. L., P. Garritty, A. Dutton. Geotechnical Aspects of Longwall Coal Mining at Cook Colliery, Queensland. IN: Computer Methods and Advances in Geomechanics, Proceedings 7th International Conference, Cairns, QLD Australia, May 6-10, 1991, v. 2, G. Beer, J.R. Booker and J.P. Carter, eds., Balkema, Rotterdam, p. 1319-1326.

This paper describes the findings of an investigation undertaken to determine the geotechnical conditions and strata response to longwall mining. The panel around which the study was based was the first longwall operation undertaken at this colliery and only the second longwall installation in Queensland. There were two main parts to the work: in situ monitoring and material testing. The in situ monitoring was undertaken in the maingate and tailgate roadways during passage of the longwall face. The instrumentation employed included roof extensometers, convergence monitors, and stress cells. The material testing was carried out on a range of samples obtained from a cored hole and from bulk samples collected underground.

Keyword(s): rock mechanics, lab testing, in situ testing, longwall, active mines, instrumentation, coal mining, monitoring equipment, monitoring methods, geotechnical

Location(s): Australia

Fonner, R. F., J. H. Reynolds. OSM Fairmont, WV, Mine Subsidence Study: Core Drilling West Virginia Geological and Economic Survey Open File Report No. 79-3, June 22, 1979, for U.S. Bureau of Mines, 26 p.

Five NX core holes were drilled at Fairmont, WV, to investigate surface subsidence and determine geologic conditions above an old mine. The area of surface subsidence was expected to increase as roof-fall, cave-in, and weathering processes continued. Bedrock over large coal pillars and in-place blocks of coal appeared relatively sound and undisturbed, while bedrock over old mine voids was broken.

Keyword(s): surface structural damage, abandoned mines, geologic features, overburden, geotechnical, coal mining, rock mechanics, soil mechanics

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

Fonner, R. F., J. S. McColloch, C. P. Messina. Core-Drill Logs for BOM Mine Subsidence Study, Duncan Hill, Clarksburg, West Virginia. West Virginia Geological and Economic Survey Open File Report No. OF8013, September, 1980, for U.S. Bureau of Mines, 11 p.

The logs of three core-drill holes, with photographs of the rock cores and interpretive remarks, are presented to the USBM for their mine subsidence studies in the vicinity of Duncan Hill, Clarksburg, West Virginia. The holes were drilled through abandoned mines in the Pittsburgh Coal during August 1980.

Keyword(s): coal mining, abandoned mines, geologic features, overburden

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

Fookes, P. G. Land Evaluation and Site Assessment (Hazard and Risk). 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. 273-282.

This paper discusses the probability of natural hazards of various kinds (including mine subsidence), and efforts to map and predict these hazards.

Keyword(s): land-use planning

Foose, R. M. Mine Dewatering and Recharge in Carbonate Rocks Near Hershey, Pennsylvania. IN: Engineering Geology Case Histories Number 7, Legal Aspects of Geology in Engineering Practice, Division of Engineering Geology, Geological Society of America, Boulder, CO, 1969, p. 45-60.

Keyword(s): subsurface water, hydrology

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

Forde, M. C., B. H. V. Topping, H. W. Whittington. Mineworkings 84: Proceedings of the International Conference on Construction in Areas of Abandoned Mineworkings. Engineering Technics Press, Edinburgh, 1984, 286 p.

Keyword(s): abandoned mines, construction, engineering, architecture, surface structural damage, land-use planning

Forrester, D. J. An Investigation Into the Effect of Undermining Colliery Spoil Heaps. Ph.D. Thesis, University of Nottingham, England, 1974, 72 p.

Keyword(s): mine waste, coal mining

Location(s): United Kingdom

Forrester, D. J., B. N. Whittaker. Effects of Mining Subsidence on Colliery Spoil Heaps. I. Mining Subsidence and Geotechnical Aspects of Spoil Heaps and Their Foundations. II. Deformational Behavior of Spoil Heaps During Undermining. International Journal of Rock Mechanics and Mining Science & Geomechanics Abstracts, v. 13, no. 4, 1976, p. 113-120, 121-133.

Mining subsidence principles are reviewed with reference to surface displacement and strain. Site conditions and local geology are discussed in relation to foundation engineering problems that are associated with surface structures, especially colliery spoil heaps. The geotechnical aspects of spoil heap foundations are examined. Spoil heap structures and the influence of formation method are discussed, and special mention is made of known subsidence effects that are associated with spoil heaps. A classification of methods of investigating subsidence effects on spoil heaps is presented.

Keyword(s): mine waste, rock mechanics, geotechnical, geologic features, angle of draw, time factor, foundations, vertical displacement, horizontal displacement

Location(s): United Kingdom

Forrester, D. J., T. R. C. Aston. A Review of Mining Subsidence Instrumentation and its Potential Application for Seabed Monitoring. Mining Science and Technology, v. 4, 1987, p. 225-240.

Extraction of the extensive minable coal reserves in the offshore portion of the Sydney Coalfield in Nova Scotia is constrained by the amount of subsidence generated at the seafloor. Field-proven undersea subsidence guidelines are therefore required to allow the optimal recovery of these reserves without producing unacceptable risks regarding major water inflows to the mine workings. To monitor seafloor subsidence, an instrumentation scheme is required that is both rugged and capable of operating in the marine environment. The paper concludes with an examination of potential application of several monitoring techniques (including TDR).

Keyword(s): instrumentation, coal mining, geotechnical, computer, geophysical, monitoring design, monitoring equipment, monitoring installation, monitoring methods, surface water, subsurface water, time factor, geologic features, seismic, longwall, photography, active mines, inflow

Location(s): Canada, Europe, United States, United Kingdom

Forrester, D. J. Underground Coal Mining Research in Canada. IN: MinTech '91, Annual Review of International Mining Technology and Development, T.L. Carr, ed., Sterling Publications International, London, 1991, p. 16-19.

CANMET's research into underground coal mining is primarily conducted at the Cape Breton Coal Research Laboratory in Nova Scotia. The article outlines various parts of the research program concerned with strata mechanics including subsidence, and the mine environment.

Keyword(s): subsidence research, coal mining, active mines, prediction, longwall, monitoring methods

Location(s): Canada

Forster, J. Stability Investigations Applied to the Mining of Evaporites. Ph.D. Thesis, University of Newcastle Upon Tyne, United Kingdom, 1967, 201 p.

Keyword(s): non-metal mining

Location(s): United Kingdom

Forsyth, D. R., B. P. Wrench, I. B. Watt. Reconstruction of a Motorway Bridge Subjected to Severe Mining Subsidence. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May, 1992. South African Institution of Civil Engineers, Republic of South Africa, p. 139-143.

A multi-span reinforced concrete bridge crossed the M2 motorway as part of the Geldenhuis Interchange in Johannesburg. The bridge was subjected to severe differential settlements as a result of deep seated mining subsidence. After intensive monitoring and investigation, the bridge was demolished. This paper summarizes the displacements suffered by the bridge and describes the design philosophy of the replacement structure.

Keyword(s): roads, metal mining, geotechnical, monitoring methods, foundations, engineering, construction

Location(s): South Africa

Fowler, J. C., L. A. Rubin, W. L. Still. Detection, Delineation and Location of Hazard Using Ground-Probing Radar in Coal Mines. 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. 4A5-1--4A5-5.

This paper describes the use of modified ground-probing radar to easily identify many of the major hazards associated with coal mining.

Keyword(s): coal mining, geophysical, roof stability

Location(s): United States

Frankham, B. S., G. R. Mould. Mining Subsidence in New South Wales--Recent Developments. IN: Proceedings New Zealand Conference, Australasian Institute of Mining and Metallurgy, University of Auckland, May 19-23, 1980, Australasian Institute Mining and Metallurgy, Parkville, Victoria, Australia, p. 167-179.

Keyword(s): coal mining

Location(s): Australia

Frankham, B. S., L. Holla. Mining Subsidence and its Effects on Surface Development in the Coalfields of New South Wales. 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, London, 1985, p. 207-222.

An intensive program of subsidence monitoring has been undertaken in New South Wales since the mid-1960s over areas of pillar extraction, shortwall mining, and longwall mining. Much of the data that have been collected since that time have been gathered from survey grids located above working coal mines in the state. The research has now reached the stage where the maximum subsidence accompanying a given extraction pattern can be predicted with a reasonable degree of confidence.

Keyword(s): monitoring methods, coal mining, active mines, pillar extraction, shortwall, longwall

Location(s): Australia

Franks, C. A. M., J. D. Geddes. A Comparative Study by Numerical Modelling of Movements on Sloping Ground Due to 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. 377-396.

This paper describes some of the results from a preliminary study of the influence of ground surface slope on movements, based on finite element numerical modeling. Brief details are given of the procedure adopted and comparisons are made between some of the results and those obtained, using the same model and technique, for horizontal plane surfaces.

Keyword(s): modeling, longwall, coal mining, finite element, horizontal displacement, vertical displacement

Franks, C. A. M. Mining Subsidence and Landslips in the South Wales Coalfield. IN: Proceedings, Symposium on Landslides in the South Wales Coalfield, Cardiff, 1985, p. 225-230.

Keyword(s): coal mining, geologic features

Location(s): Wales

Fredrickson, R. J. Foundation Treatment for Small Earth Dams on Subsiding Soils. International Association Hydrological Sciences Publication 121, 1977, p. 553-566.

Keyword(s): foundations, structural mitigation, geologic features

Freitag, J. A., T. E. Hemminger, G. Garrison. Coal Combustion Ash Disposal Underground Injection of Fly Ash into Mined-Out Portions of Coal Mine. IN: Proceedings, Air & Waste Management Association 84th Annual Meeting & Exhibition, Vancouver, British Columbia, June 16-21, 1991, 8 p.

For Commonwealth Edison Company, the underground mine injection of fly ash has proven to be a cost effective disposal method. Due to the proximity of the mine to the generating station, transportation costs of the fly ash are substantially reduced over landfill disposal. Underground injection takes little surface space, is subject to fewer regulatory constraints than landfilling, and provides additional protection against subsidence in the mined-out areas of the coal mine.

Keyword(s): mine waste, coal mining, subsurface water, hydraulic backfilling

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

Friedel, M. J., J. A. Jessop, R. E. Thill, D. L. Veith. Electromagnetic Investigation of Abandoned Mines in the Galena, KS, Area. U.S. Bureau of Mines RI 9303, 1990, 20 p.

As part of an investigation aimed at mitigating the hazards caused by abandoned mine openings, the USBM conducted a series of electromagnetic surveys in the area of Galena, Kansas. The application of monostatic ground-penetrating radar (GPR) and inductive electromagnetic methods for detecting and delineating hazardous mine openings and attendant features was demonstrated to be feasible for shallow mine workings occurring below flat-lying areas. Features such as mine voids, fractures, and zones of subsidence were located.

Keyword(s): abandoned mines, land mitigation, structural mitigation, geophysical, metal mining

Location(s): Kansas, United States

Frieser, A. Packing of Coal Seams in Bohemia. Transactions, Institution of Mining Engineers, London, v. 10, 1895, p. 597.

This article discusses the use of hydraulic flushing to stabilize water saturated overburden during the mining of a thick brown coal seam.

Keyword(s): hydraulic backfilling, coal mining, overburden, historical

Location(s): Europe, Czechoslovakia

Fritzsche, C. H., E. L. J. Potts. Horizon Mining. George Allen and Unwin, London, 1954, 614 p.

The authors present a text dealing with coal mining practice in the layout and development of the horizon-mining system. The book includes a detailed description of roadway development and haulage systems, but does not deal with operations at the extraction face. One chapter covers strata control and surface subsidence.

Keyword(s): mine design, ground control

Fruco Engineers, Inc. Geotechnical Investigation for Illinois Department of Law Enforcement, Illinois State Police District 11 Headquarters, Maryville, Illinois. St. Louis, MO, October, 1981, 17 p. plus 4 appendices.

This report presents the results of a geotechnical investigation of subsidence conditions at the Illinois State Police District 11 Headquarters at Maryville. The purpose was to perform an engineering evaluation of the subsurface conditions at the site, including the underlying abandoned coal mine, to determine the suitability of the existing facility for continued use. The scope of the investigation consisted of the following: (1) gathering and studying available site information from soil, geologic, and mining literature references; (2) conducting a field investigation to define the type and condition of the subsurface materials and the state of the underlying abandoned coal mine; (3) developing the necessary laboratory test data; and (4) performing engineering analyses and evaluation.

Keyword(s): abandoned mines, surface structural damage, coal mining, geotechnical, lab testing, rock mechanics, in situ testing, geologic features, engineering

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

Fry, R. C. Case Study in Monitoring Mining Induced Subsidence Using Photogrammetry and Conventional Surveys. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, Morgantown, WV, June 1-4, 1992, S.S. Peng, ed., West Virginia University, p. 263-271.

Underground coal mining has been active within the East Mountain property since the mid-1950s. As a result, coal from two seams has been extracted within large areas allowing surface subsidence to occur. Annual subsidence monitoring began in 1981 with the use of on-the-ground conventional monumentation, surveying, and photogrammetric monitoring. The data collected have shown the time benefits of photogrammetry, as well as the relationship between observed subsidence and the geometry of the mined out area below.

Keyword(s): survey methods, survey equipment, monitoring methods, photography, remote sensing, coal mining, multiple-seam extraction, longwall, active mines

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

Fuqua, W. D., R. Richter. Photographic Interpretation as an Aid in Delimiting Areas of Shallow Land Subsidence in California. IN: American Society of Photogrammetry Manual of Photographic Interpretation, Appendix A of Ch. 6, 1960, p. 442-456.

Keyword(s): fluid extraction, photography, remote sensing, prediction

Location(s): California, United States

Fuqua, W. D. Shallow and Deep Subsidence Areas in West Central San Joaquin Valley. IN: Annual Field Trip Guidebook, California Geological Society, Central Portion of Great Valley of California, San Juan Bautista to Yosemite Valley, Sacramento, 1963, p. 59-64.

Keyword(s): fluid extraction

Location(s): California, United States

Gabrysch, R. K. Land Surface Subsidence in the Houston-Galveston Region, Texas. International Association Hydrological Sciences Publication 88, 1970, p. 43-54.

Keyword(s): fluid extraction, surface subsidence damage

Location(s): Texas, United States

Gabrysch, R. K. Methods of Predicting Land-Surface Subsidence in the Houston-Galveston Region, Texas. Geological Society of America, Abstracts with Programs, v. 6, 1974, p. 748.

Keyword(s): prediction, fluid extraction

Location(s): Texas, United States

Gaddy, F. L. A Study of the Ultimate Strength of Coal as Related to the Absolute Size of the Cubical Specimens Tested. Virginia Polytechnical Institute Bulletin, August, 1956, p. 1-27.

Keyword(s): pillar strength, lab testing, coal mining

Location(s): United States

Gaffney, D. V., M. M. Stewart, N. K. Chakravorti, R. M. Hays. Feasibility of Using Cemented Backfill in Active Underground Coal Mines to Prevent Subsidence. U.S. Bureau of Mines contract JO295001, Michael Baker, Jr., Inc., U.S. Bureau of Mines OFR 92-82, 1981, 218 p. (NTIS PB 82-244252)

This report details the use of cemented backfill in active underground coal mines to minimize or prevent subsidence.

Keyword(s): stowing, active mines, coal mining

GAI Consultants, Inc. Survey of Ground Surface Conditions Affecting Structural Reponse to Subsidence. Phase I Report to Twin Cities Mining Research Center, U.S. Bureau of Mines, Contract No. JO295017, April, 1980, GAI Consultants, Inc., Pittsburgh, PA, 15146, 35 p.

This document summarizes visits to and information exchanged with subsidence experts in Great Britain.

Keyword(s): coal mining, soils, surface structural damage, geologic features, abandoned mines, active mines, National Coal Board, horizontal displacement, vertical displacement, backfilling, grouting, modeling, tunnelling, multiple-seam extraction, land-use planning

Location(s): United Kingdom

GAI Consultants, Inc. Abandoned Mined Lands Reclamation Control Technology Handbook, Chapter 2. Mine Subsidence Control. Prepared for U.S. Department of the Interior, Office of Surface Mining Reclamation and Enforcement, Contract J5101109, January 28, 1981, 37 p.

This chapter describes the various Abandoned Mined Lands funding priorities and subsidence abatement methods that may be used. A discussion of the advantages and disadvantages of the various abatement methods and the cost of implementation are included, as are a series of decision matrices and cost estimation guidelines, which are useful for evaluating and selecting the most appropriate abatement methods for a particular project.

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

Location(s): United States

Gall, V., D.-W. Park. Effective Iterative Technique in Numerical Modeling to Simulate Progressive Failure in Underground Coal Mines. 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. 313-320.

Park and Gall developed a large scale three-dimensional, finite-element model for a longwall coal mine using a supercomputer. The Hoek-Brown failure criterion, which describes the behavior of rock masses, was adopted for the determination of element failure. Simulated stresses and stress redistributions are therefore realistic, but a large amount of computer time had to be consumed due to the numerous iterations that were necessary to reach an equilibrium state. In this paper, an improved method of iteration is introduced. Using this method, the number of iterations was reduced, thus the computer time was considerably reduced.

Keyword(s): coal mining, modeling, finite element, computer, longwall

Location(s): Alabama, United States

Gallagher, R. T. A Method of Determining Subsidence in Mining With Particular Reference to Block Caving. Ph.D. Thesis, Colorado School of Mines, Golden, 1941, 128 p.

This thesis studies the use of subsidence forces to cave rock in mining, using geophysical methods to locate the line of break. Seismic measurement of caving proved the most useful tool.

Keyword(s): geophysical, seismic, prediction

Location(s): United States

Gallant, W. D., T. R. C. Aston. Instrumentation and Geotechnical Monitoring Techniques Used in the Sydney Coalfield, Nova Scotia. Canadian Geotechnical Journal, v. 28, June, 1991, p. 327-337.

Since 1982, a group has been involved in assessing the behavior of mine openings in the underground workings of the Sydney Coalfield in Nova Scotia. This paper examines a variety of geotechnical instrumentation and monitoring techniques used to assess strata behavior during the different phases of longwall mining operations: gateroad deformation, floor heave, intersections, gateside pack behaviour, and subsidence monitoring.

Keyword(s): instrumentation, monitoring methods, geotechnical, longwall, coal mining, floor stability

Location(s): Canada

Gallant, W. D., D. J. Forrester, D. A. Payne. Determination of the Stopline Subsidence Profile of Phalen 2 West Panel from within a Near Horizontal Borehole over the Panel Stopline. IN: Proceedings 10th International Conference on Ground Control in Mining, June 10-12, 1991, S.S. Peng, ed., West Virginia University, Morgantown, p. 220-224.

The subsidence profile over the stopline of a longwall panel was observed. A novel technique was designed and implemented to determine vertical displacements of the overlying strata from within a near horizontal borehole drilled over the 2 West panel. Restrictions on data collection techniques due to the submarine nature of the coalfield are discussed.

Keyword(s): longwall, monitoring methods, monitoring equipment, instrumentation, multiple-seam extraction, coal mining, vertical displacement, horizontal displacement

Location(s): Canada

Gallavresi, F., G. Rodio. Soil Upheaving by Grouting to Safeguard Zones Affected by Significant Subsidence Problems: Its Application to Venice as Peculiar Example. IN: Land Subsidence, Proceedings 3rd International Symposium on Land Subsidence, Venice, Italy, March 19-25, 1984, A.I. Johnson, L. Carbognin, and L. Ubertini, eds.,International Association Hydrological Sciences Publication No. 151, 1986, p. 707-715.

The subsidence of Venice, at present essentially due to natural causes only, is characterized by very small rate. Nevertheless, the general situation of the lagoon town is still dramatic because of the high subsidence values that have occurred in the past.

Keyword(s): soils, surface subsidence damage, land mitigation

Location(s): Italy

Galvin, J. M. The Significance, Behavior and Influence of Ashfill on South African Thick Seam Mining Operations. Chamber of Mines of South Africa, Research Report No. 9/82, January, 1982.

Keyword(s): backfilling

Location(s): South Africa

Galvin, J. M., K. G. Anderson. Design of Multi-Seam Workings at Shallow Depth Under Tidal Waters. 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. 352-361.

Multiseam mining has been carried out beneath Lake Macquarie in New South Wales since 1982. Three seams, which cover 40 to130 meters, are mined simultaneously. Subsidence control was the major factor influencing choice of mining method and layout of workings, which were designed according to 1974 guidelines. These guidelines are re-evaluated in the light of state-of-the-art rock mechanics knowledge and local subsidence data collected since 1974. The design according to the guidelines is seen to be conservative, and improved extraction is possible.

Keyword(s): multiple-seam extraction, surface water, rock mechanics, mine design, coal mining

Location(s): Australia

Gamble, J. C., R. E. Gray. Subsidence Control and Alternatives for Areas Above Abandoned Coal Mines. IN: Proceedings 41st Annual Meeting of American Society of Photogrammetry, Boulder, CO, March 6-8, 1975, p. 62.

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

Location(s): United States

Gamble, J. C., R. E. Gray. Subsidence Control and Alternatives for Areas Above Abandoned Coal Mines. IN: Proceedings Northeastern Section Meeting of the Geological Society of America, Syracuse, New York, March 7, 1975, 12 p.

Mine subsidence can cause severe damage to structures located above abandoned mines. Alternatives in dealing with potential damage problems include subsidence control, construction

of structures resistant to subsidence damage, land-use planning to minimize problems, subsidence insurance, and acceptance of risk of possible damage.

Keyword(s): abandoned mines, coal mining, surface structural damage, overburden, utilities, ground control, insurance, construction, land-use planning, foundations, hydraulic backfilling, pneumatic backfilling, grouting, roof stability

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

Gamble, J. C., R. E. Gray. Mine Subsidence and Mine Subsidence Control. The Encyclopedia of Applied Geology, Encyclopedia of Earth Science Series, R.W. Fairbridge and C.W. Finkl, Jr., eds. Dowden, Hutchinson & Ross, Stroudsburg, PA, 1976.

Keyword(s): ground control, coal mining

Gambolati, G. Estimate of Subsidence in Venice Using a One-Dimensional Model of the Subsoil. IBM Journal of Research Development, v. 16, March, 1972, p. 130-137.

Keyword(s): modeling

Location(s): Italy

Gambolati, G., R. A. Freeze. Mathematical Simulation of the Subsidence of Venice, I: Theory. Water Resources Research, v. 9, no. 3, June, 1973, p. 721-733.

Keyword(s): modeling, mathematical model

Location(s): Italy

Gambolati, G., P. Gatto, R. A. Freeze. Mathematical Simulation of the Subsidence of Venice, II: Results. Water Resources Research, v. 10, no. 3, June, 1974, p. 563-577.

Keyword(s): modeling, mathematical model

Location(s): Italy

Gamzon, L. Hydraulic Stowing at French Collieries. Colliery Engineering, v. 34, 1914, p. 289.

This article describes the use of hydraulic stowing in 1909 to prevent surface subsidence.

Keyword(s): hydraulic backfilling, stowing, coal mining

Location(s): France

Gang, Y., Z. Guoquan, C. Jixian. Research on Sliding Layers for Buildings Subjected to Mining Subsidence. 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. 430-442.

The provision of a sliding layer is a structural measure for preventing damage to buildings due to mining. The authors made model tests on the sliding layer, analyzed and compared the materials for sliding layers, and carried out an analysis, by means of the finite element method, of the stress in a building wall subjected to mining.

Keyword(s): surface structural damage, foundations, lab testing, finite element, modeling, coal mining, horizontal displacement, structural mitigation

Location(s): China

Ganow, H. C. A Geotechnical Study of the Squeeze Problems Associated with the Underground Mining of Coal. Ph.D. Thesis, University of Illinois, Urbana, 1975.

Keyword(s): floor stability, geotechnical, coal mining

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

Ganow, H. C. Results of Long Term Ground Surface Measurements at the Hoe Creek III Site. 10th Underground Coal Gasification Symposium, Williamsburg, VA, August 12-15, 1984, 17 p.

Ground surface subsidence was first observed over the Hoe Creek burn cavity 21 days after gasification ceased. It manifested itself as a small circular depression or sink and was followed 5 days later by the formation of a second collapse structure. Concurrently, a single large elliptically shaped depression, whose major axis parallels the experimental axis, slowly formed over the burn cavity. These features appear to represent two distinctly different deformation modes. The first mode includes discrete voids that propagate rapidly upward. The second mode is represented by the elliptically shaped classical subsidence depression that forms slowly by a strata bending. Seventeen isolation type survey monuments have been used to track both the horizontal (one dimensional) and vertical motion components intermittently over a 54-month span. The resulting data set is combined with ground surface sketches and post-burn core drilling results and provides an important case study against which numerical and centrifugation model results can be compared.

Keyword(s): coal gasification, modeling, monitoring methods, monitoring equipment, survey methods, horizontal displacement, vertical displacement, environment

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

Gardner, B. H., F. Carr, E. Martin. Longwall Design Improvement in Coal Mines Using Finite Element Analysis. IN: Research & Engineering Applications in Rock Masses, Proceedings 26th Symposium on Rock Mechanics, South Dakota School of Mines & Technology, Rapid City, June 26-28, 1985, E. Ashworth, ed., Balkema, Rotterdam, p. 693-694.

This mine design method draws together three distinct elements of technique: infinite element simulation, stress control via yielding pillars, and specialized techniques for geomechanical behavioral monitoring of underground openings.

Keyword(s): mine design, finite element, modeling, longwall, roof support, yielding supports, monitoring methods

Location(s): Alabama, United States

Gardner, F. P., G. Hibberd. Subsidence--The Transference of Ground Movement to Surface Structures. The Mining Engineer, London, v. 121, 1961-62, p. 19-36.

Keyword(s): surface structural damage, coal mining

Location(s): United Kingdom

Garner, J. H. Report on the Effect of Mining (Coal) Subsidence on Sewers and Sewage Disposal Works in the West Riding of Yorkshire. The West Riding of Yorkshire Rivers Board, December, 1945.

Keyword(s): utilities, coal mining

Location(s): United Kingdom

Garrard, G. F. G., R. K. Taylor. Collapse Mechanisms of Shallow Coal-Mine Workings from Field Measurements. IN: Engineering Geology of Underground Movements, Geological Society Engineering Geology Special Publication No. 5, F.G. Bell, et al., eds., 1988, p. 181-192.

Simple stereo-photographic techniques were employed to look in detail at more than 150 shallow (<75 m) collapsed old workings exposed in the high walls of 18 opencast coal sites across the country. Sixty variables, including collapse dimensions and various ratios, were defined to characterize the workings and the resulting data analyzed statistically. The data were compared with existing theories and design recommendations and used to develop new empirical relationships. The study shows that at shallow depths the crushing of coal pillars is rare and that bulking and arching, considered to be complementary mechanisms, are the normal limiting factors on the height of collapse. The collapse height of the working was found to be proportional to the span width. Where span widths are known or can be estimated, the following relationship for collapse height is suggested: collapse height = 2.68 x span width. This relationship encompasses all but one observed collapse structure. The existing established relationship, based on bulking theory, of collapse height = 10 x seam thickness is shown to be valid and encompasses all observed collapse structures.

Keyword(s): coal mining, abandoned mines, pillar strength, room-and-pillar, prediction, remote sensing

Location(s): United Kingdom

Garritty, P. Water Percolation into Fully Caved Longwall Faces. IN: Strata Mechanics, Proceedings of the Symposium, University of Newcastle-upon-Tyne, April, 1982, I.W. Farmer, ed., Elsevier, New York, p. 25-29.

Production at a number of mines operating off the North-East coast has been seriously affected by the percolation of major water feeders onto working coal faces. A detailed study of the factors affecting the incidence and distribution of water feeders was undertaken, using operational geological and hydrological data.

Keyword(s): subsurface water, coal mining, longwall, hydrology, geologic features, overburden, inflow

Location(s): United Kingdom

Garza, S. Artificial Recharge for Subsidence Abatement at the NASA-Johnson Space Center, Phase I. U.S. Department of the Interior, Geological Survey, Open-File Report 77-219, 1977, 82 p.

Keyword(s): fluid extraction

Location(s): Texas, United States

Gaskell, P., D. J. Reddish, B. N. Whittaker. Subsurface Ground Movements Associated with Longwall Mining. IN: Proceedings 7th International Conference on Ground Control in Mining, Morgantown, WV, 1988, S.S. Peng, ed., West Virginia University, p. 195-204.

This paper examines the development of rock movement between a longwall extraction horizon and the surface for a fully caved mining situation. Physical modeling has been used to examine the mechanics of ground movement and the propagation of fractures around the longwall working. The paper discusses dimensional anlaysis, model construction, and measurement technique, and data

processing of the results into effective graphical forms for further study.

Keyword(s): longwall, coal mining, ground control, overburden, modeling, vertical displacement, horizontal displacement, National Coal Board

Gauna, M., K. R. Price, E. Martin. Yield Pillar Usage in Longwall Mining at Depth--No. 4 Mine, Brookwood, Alabama. 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. 695-702.

Jim Walter Resources No. 4 Mine extracts coal at 610 to 670 m of depth. Yield pillar designs, using pillars 6.1 and 7.6 meters wide alongside the longwall headgate entry, were established in two adjacent longwall gate sections. The experimental yield pillar-abutment pillar areas were formed for comparison to chain pillar gate road designs of equal size. Data were collected through monitoring roadway deformational behavior during longwall mining. Yield pillars in conjunction with abutment pillars offered improved roadway stability and improved resource recovery.

Keyword(s): room-and-pillar, instrumentation, mine design, longwall, yielding supports, pillar strength

Location(s): Alabama, United States

Geddes, J. D., D. W. Cooper. Structures in Areas of Mining Subsidence. The Structural Engineer, London, v. 40, no. 3, March, 1962, p. 79-93, and 377-381.

This paper examines structural design methods used in areas with potential subsidence problems. These methods range from foundations offering maximum resistance to earth movements to articulated frames offering little or no resistance.

Keyword(s): vertical displacement, horizontal displacement, surface structural damage, structural mitigation, ground control, architecture, foundations, engineering

Location(s): England

Geddes, J. D. The Effect of Horizontal Ground Movements on Structures. 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. 623-646.

This paper concetrates on the interaction between soils and essentially horizontal foundation surfaces on which the loading resulting from the movements is delivered in the form of shearing (frictional) stresses. A simplified look is taken at the problem and some factors of importance are described and illustrated by laboratory and field experiments. It is shown how the behaviour of foundations can be explained in a rational and quantitative way. Attention is focused on cases produced by underground mining activities.

Keyword(s): surface structural damage, soils, foundations, horizontal displacement, coal mining

Location(s): United Kingdom

Geddes, J. D. Construction in Areas of Large Ground Movement. 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. 949-974.

Large ground movements (those greater than 50 mm) may be produced by a variety of factors. Some are natural and some man-made; some are controllable and others not. They have at least one feature in common and that is the potential or actual difficulty they present to civil/structural engineers in carrying out their work. Conventional practice would regard vertical settlements of 50 mm as a desirable limit to be set as a design objective for rafts on natural soils. Individual footings would be designed for a settlement typically half this value.

Keyword(s): surface structural damage, construction, engineering, geologic features, soils, fluid extraction, tunnelling, coal mining

Geddes, J. D. The Behaviour of a CLASP-System School Subjected to Mining Movements IN: Large Ground Movements and Structures, Proceedings International Conference, University of Wales Institute of Science and Technology, Cardiff,1977, John Wiley & Sons, New York, 1978, J.D. Geddes, ed., p. 579-596. (NTIS Accession No. 79-22637)

A detailed study of the behavior of a CLASP-system school was carried out as part of a wider investigation into aspects of design to counter mining subsidence.

Keyword(s): coal mining, foundations, surface structural damage, engineering, construction, multiple-seam extraction, monitoring methods, National Coal Board

Location(s): United Kingdom

Geddes, J. D., D. Kennedy. Structural Implications of Horizontal Ground Strains. 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. 610-629.

It is well established that, in the vicinity of underground mining, tunnelling and deep excavations, ground movements with horizontal as well as vertical components are developed at ground surface level. These generally vary in magnitude with time as the workings progress. Structural foundations placed at the surface of, or within, the moving ground are subjected to horizontal forces generated at the soil/foundation interface.

Keyword(s): horizontal displacement, coal mining, tunnelling, foundations, subsurface subsidence damage, surface subsidence damage, soils, modeling, surface structural damage

Geddes, J. D., D. Kennedy. Mining Ground Movements and Tied Portal Frames. 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. 396-410.

In earlier papers, a method of calculation was developed that determined the horizontal forces created at the interface between a continuous structure and the moving ground that supported it. This was made on the basis of the idealization that the structure was sufficiently flexible so as to deform under the influence of the vertical ground movements without any redistribution of the vertical support reactions along its length and that the interface relationship was essentially frictional in nature. A similar method is applied here to multi-bay tied portal frames, but it makes allowance for the variation in vertical support reactions as the structure is exposed to vertical and horizontal ground movements of the kind produced by mining activity.

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

Location(s): United Kingdom

Geddes, J. D., ed. Large Ground Movements and Structures. Proceedings of International Conference, University of Wales Institute of Science and Technology, Cardiff, July 4-7, 1977, John Wiley & Sons, New York, 1978, 1074 p.

This book contains papers dealing with such topics as the estimation and measurement of surface and near-surface ground movements due to the extraction of coal, tunnelling, the presence of old underground workings, large excavations, hillside instability and creep, reclaimed and back-filled areas. The effects of such movements on structures are discussed.

Keyword(s): surface structural damage, coal mining, ground control, tunnelling, active mines, abandoned mines, instrumentation, monitoring methods

Geddes, J. D., ed. Ground Movements and Structures. Proceedings of 2nd International Conference, University of Wales Institute of Science and Technology, Cardiff, 1980, Pentech, London, 1981, 964 p.

Keyword(s): surface structural damage, ground control, coal mining

Geddes, J. D., ed. Ground Movements and Structures. Proceedings of 3rd International Conference, University of Wales Institute of Science and Technology, Cardiff, 1984, Pentech, London, 1985, 876 p.

Keyword(s): surface structural damage, ground control, coal mining

Geddes, J. D., ed. Ground Movements and Structures. Proceedings 4th International Conference, University of Wales College of Cardiff, July 8-11, 1991, Pentech, London, 1992, 826 p.

The papers presented in this volume cover such topics as the estimation and measurement of surface and near-surface ground movements of reclaimed and backfilled land due to excavations, trenches, tunnelling, coal mining, and seasonal changes. The book is intended for civil and structural engineers, geologists, mining engineers, surveyors, and others concerned with structures on moving ground.

Keyword(s): surface structural damage, coal mining, active mines, abandoned mines, tunnelling, grouting, backfilling, structural mitigation, foundations, engineering

Geertsma, J. Land Subsidence Above Compacting Oil and Gas Reservoirs. Journal of Petroleum Technology, 1973, p. 734-744.

Keyword(s): fluid extraction, oil extraction

Geertsma, J., G. Van Opstal. A Numerical Technique for Predicting Subsidence Above

Compacting Reservoirs, Based on the Nucleus of Strain Concept. Verhandelingen, Koninklijke Nederlands Geologisch Mijnbouwkundig Genootschap, v. 28, 1973, p. 63-78.

Keyword(s): prediction, modeling, subsurface water

General Assembly of Pennsylvania. Bituminous Mine Subsidence and Land Conservation Act. Commonwealth of Pennsylvania, 1966, 12 p.

This document contains laws enacted in 1966 to protect the public health, welfare, and safety by regulating the mining of bituminous coal.

Keyword(s): law, mine design, government, mine safety, mine operation, surface structural damage, coal mining, bituminous

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

Geng, D. Y., S. S. Peng. Surface Subsidence, Overburden Behavior, and Structural Damages Due to Longwall Mining--Two Case Studies. Department of Mining Engineering, West Virginia University, Morgantown, November 1983, 19 p.

This report investigates the subsidence caused by two longwall panels, with data analyzed in terms of zone of advance influence and delay angle of maximum subsidence velocity.

Keyword(s): surface structural damage, mine design, longwall

Gentry, D. W. Rock Mechanics Instrumentation Program for Kaiser Steel Corporation's Demonstration of Shield-Type Longwall Supports at York Canyon Mine, Raton, New Mexico. Kaiser Steel Corporation contract RD-R-0174, Colorado School of Mines, Golden July, 1976, 456 p.

This report presents the results of a rock mechanics instrumentation program designed to determine the rock mass response due to longwall mining of a thick coal seam, with details on the geology and instrumentation.

Keyword(s): monitoring design, monitoring installation, monitoring equipment, survey methods, survey equipment, rock mechanics, longwall, roof support, coal mining

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

Gentry, D. W., J. F. Abel, Jr. Rock Mass Response to Longwall Mining. Mines Magazine, v. 66, no. 3, 1976, p. 11-12, 28-29.

Keyword(s): longwall, coal mining, overburden

Gentry, D. W., J. F. Abel, Jr. Rock Mass Response to Mining Longwall Panel 4N, York Canyon Mine. Mining Engineering, v. 30, no. 3, 1976, p. 273-280.

Keyword(s): longwall, coal mining, overburden

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

Gentry, D. W., C. L. Stewart. Surface and Underground Rock Response, Longwall Panel 4N, York Canyon Mine. IN: Proceedings 2nd Symposium on Underground Mining, National Coal Association/ Bituminous Coal Research Coal Conference and Expo III, Louisville, KY, October 19-21, 1976, p. 184-205.

Keyword(s): longwall, overburden, coal mining

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

Gentry, D. W., C. L. Stewart. Surface Response to Longwall Mining. Mines Magazine, v. 67, no. 3, 1977, p. 11-12, 22-23; v. 67, no. 4, 1977, p. 16-18.

Keyword(s): longwall, coal mining

Gentry, D. W., J. F. Abel, Jr. Surface Response to Longwall Coal Mining in Mountainous Terrain. Bulletin Association of Engineering Geologists, v. 15, no. 2, December, 1978, p. 191-220.

The response of the ground surface above longwall panels in a virgin geologic environment can only be approximated by prediction models developed from subsidence measurements made in other coal mining districts. Above the 10-foot-thick seam longwall at the York Canyon Mine, west of Raton, New Mexico, the measured angle of draw was 5 to 15 degrees which is 0.09 to 0.27 times the depth, outside the panel. This compares to the British National Coal Board predicted angle of draw of 35 degrees, 0.7 times the depth. The measured subsidence effects outside of the panel did not extend even one-half as far as the NCB predictions. However, measured subsidence at York Canyon closely compared with NCB predictions.

Keyword(s): monitoring design, monitoring installation, monitoring equipment, survey methods, survey equipment, survey data processing, longwall, coal mining, prediction, National Coal Board

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

Gentry, D. W., C. L. Stewart, R. P. King. Rock Mechanics Instrumentation Program for Kaiser Steel Corporation's Demonstration of Shield-Type Longwall Supports at York Canyon Mine, Raton, New Mexico. Final Report, Department of Energy, 1981, DE-AC01-74ET12530.

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

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

Gentry, D. W., C. L. Stewart. Characterization of Subsidence Over Multiple Lift Longwall Panels. U.S. Department of Energy Contract AC22-80PC-30118, Mine Subsidence Engineering Final Technical Report, 1982, 135 p. (NTIS DOE/PC/30118-T4)

This report describes the procedures and equipment used in installing and removing a subsidence monitoring network in rugged terrain.

Keyword(s): monitoring design, monitoring installation, monitoring equipment, survey methods, survey equipment, longwall, coal mining

Germanis, E., G. W. Smith. Criteria for Design and Tolerance of Structures and Services to Subsidence Movements. IN: Proceedings 4th Annual Symposium on Subsidence in Mines, Illawarra Branch, Australian Institute of Mining and Metallurgy, A. Hargraves, ed., February 20-22, 1973, p. 12-1--12-10.

Three basic types of subsidence occur in the Newcastle and Wyong districts. Their effects can cause serious damage to structures that have not been suitably designed. There are generally accepted design principles to accommodate subsidence movements. The main difficulty for the designer is to assess the most suitable application of the design principles. To assist in this regard there are various design suggestions for structures such as small cottages, tall buildings, swimming pools, reservoirs and bridges.

Keyword(s): utilities, surface structural damage, engineering, coal mining, active mines, abandoned mines, structural mitigation, foundations

Location(s): Australia

Germanis, E., S. Valliappan. Mining Subsidence at the Graving Dock Site, New Castle. IN: Symposium on Recent Developments in the Analysis of Soil Behavior and Their Application to Geotechnical Structures, University of New South Wales, Australia, 1975, 14 p.

Keyword(s): surface structural damage

Location(s): Australia

Ghose, A. K. Extraction Below Surface Structures--An Appraisal of the Jharia Coalfield Situation. Journal of Mines, Metals & Fuels, v. 29, no. 12, 1981, p. 347-354, 366.

Keyword(s): surface structural damage, coal mining

Location(s): India

Ghouzi, D. Mining Subsidence and its Impact on the Environment: The Example of the Nord/Pas-de-Calais Coalfield. IN: Proceedings European Conference on Coal and the Environment, Session 3, Minerals and the Environment, v. 4, nos. 2 & 3, September, 1982, p. 93-98. ISSN 0142-7245.

Public opinion is less and less willing to tolerate the various harmful effects of mining subsidence. Compensation for damage can become a major cause for concern for mining companies. The object of this report is to try to identify the main potential effects of mine workings, both on finances, and on the environment itself, to further the debate.

Keyword(s): coal mining, economics, environment, vertical displacement, horizontal displacement, surface structural damage, hydrology, utilities, hydraulic backfilling, pneumatic backfilling, stowing, railroads, roads

Location(s): France, Poland, Soviet Union, Europe

Gibbs, H. J. A Laboratory Testing Study of Land Subsidence. IN: Proceedings 1st Pan-American Conference on Soil Mechanics and Foundation Engineering, Mexico City, 1959, v. 1, p. 13-36.

Keyword(s): lab testing

Gibson, R. D., G. G. Marino. Mine Subsidence - Laur Case, Du Quoin Illinois. Illinois Abandoned Mined Lands Reclamation Council, September, 1981, 8 p.

This report details investigation of pit-type subsidence over an abandoned mine.

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

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

Gibson, R. D. Subsidence Rapid Response Team Quarterly Progress Report, April 1 through June 30, 1981. Illinois Abandoned Mined Lands Reclamation Council, July, 1981, 17 p.

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

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

Gibson, R. D. Subsidence Rapid Response Team Quarterly Progress Report, January 1 through March 31, 1981. Illinois Abandoned Mined Lands Reclamation Council, April, 1981, 18 p.

This report details subsidence investigations in four Illinois counties.

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

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

Gibson, R. D. Mine Subsidence, O'Kraski Residence, Streator, Illinois. Illinois Abandoned Mined Lands Reclamation Council, July 1981, 9 p.

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

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

Gibson, R. D. Mine Subsidence, Bruce Park Case, Energy, Illinois. Illinois Abandoned Mined Lands Reclamation Council, September, 1981, 8 p.

This report details investigation of pit-type subsidence over an abandoned mine in a city park in Energy, Illinois. The pit measured 21 feet in diameter and was approximately 21 to 25 feet deep.

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

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

Gibson, R. D., J. W. Mahar. Monitoring Techniques of Small Structures Subjected to Subsidence Induced Ground Movements. IN: Abandoned Mine Reclamation Symposium, November 3-5, 1982, Ohio University-Belmont County, St. Clairsville, OH, p. 4-2--4-9.

The response of structures to subsidence induced ground movements is dependent upon the sensitivity of the structure as well as its orientation and position within the area of subsidence. On site evaluation of vertical displacement, horizontal strain, tilt, and damage surveys, aids decisions for optimum placement of monitoring points and interpreting structural damage data.

Keyword(s): surface structural damage, coal mining, abandoned mines, vertical displacement, horizontal displacement, monitoring methods

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

Gibson, R. D., J. W. Mahar. The Mid-Continent Field: Structural Monitoring. 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. 709-716.

This paper provides a conceptual framework from which an efficient monitoring program can be designed. The authors state that in a structural monitoring program, the response of the structures to ground movements should be determined, and the future performance of the structure on a site-specific basis should be estimated. Field techniques and monitoring point installation are discussed from a mechanical and application point of view. Finally, the proposed monitoring method is meant to provide the reader with an integrated approach for checking preliminary assumptions (building location and orientation relative to ground movements), modifying predictions (changes in structural response due to an outward extension of the subsidence profile), and accurately predicting future structural response.

Keyword(s): abandoned mines, coal mining, room-and-pillar, monitoring methods, monitoring installation, surface structural damage, monitoring equipment, vertical displacement, horizontal displacement, prediction

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

Gibson, R. D. Mine Subsidence Camp Butler Site Riverton, Illinois, Progress Report, May 1982 to June 1983. Illinois Abandoned Mined Lands Reclamation Council, Springfield, March, 1984, 30 p.

This report details investigation of sag-type subsidence that formed over an abandoned room-and-pillar mine. Damage to the structures located within the sag developed primarily within the first few weeks of the subsidence event. Continued ground movements reuslted in only minor additional damages.

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

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

Gibson, R. D., B. C. Schottel. Computerized Modeling of Coal Mine Subsidence Profiles. IN: Proceedings National Symposium on Mining, Hydrology, Sedimentology, and Reclamation, December 7-11, 1987, Springfield, IL, University of Kentucky, Lexington, p. 249-252.

The intent of this paper is to illustrate two techniques that can be used to model ground movements with curves that are mathematically derived from single Sourier series or polynomial expansion (and least squares method) equations. The advantages in expressing ground movements in terms of mathematical equations is that the speed and accuracy of the computer can be utilized to perform the computations and graphically portray the results. The examples of ground movement modeled in this paper are associated with sag-type subsidence. By definition, sag subsidence is a descriptive term for those failures within underground room-and-pillar mines that propagate to the ground surface and form elliptically shaped depressions.

Keyword(s): coal mining, prediction, computer, modeling, room-and-pillar, mathematical model

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

Gibson, R. D., B. C. Schottel. A Case History Illustrating the Application of Computerized Modeling of Coal Mine Subsidence Profiles and the Development of a Settlement Prediction Technique. 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. 369-376.

A single-story brick school building is being structurally damaged by sag-type subsidence developing over an abandoned coal mine. The T-shaped building is positioned in the sag so that the intersection of all three wings coincides with the center of maximum subsidence. Two of the wings originate outside the event and extend through the tension and compression zones; the third wing extends from the inflection point into the compression zone. The ground movements were monitored via standard level surveying techniques and analyzed employing a computer modeling technique.

Keyword(s): coal mining, computer, modeling, prediction, surface structural damage, foundations, architecture, abandoned mines, survey methods, construction, room-and-pillar, survey data processing, vertical displacement, horizontal displacement

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

Giedl, J. G. Subsidence Hazard Assessment Relating to Abandoned Coal Mines: Wonthaggi Coalfields Region of South-West Gippsland, Victoria. IN: Proceedings 19th Symposium on Advances in the Study of the Sydney Basin, 1985, Department of Geology, University of Newcastle, New South Wales, p. 71-81.

Wonthaggi, in south-western Gippsland, is an area where extensive black coal mining has occurred from the early 1840s until the late 1960s. The area is largely undermined by a number of mines of varying depths and extraction thickness. Undermined areas are prone to subsidence and the Borough of Wonthaggi often requests the Department of Minerals and Energy of Victoria (DME) to evaluate the extent of undermining and associated subsidence potential of proposed building allotments. The flow of requests and the need to constantly refer back to old plans of various scales meant that more suitable means for managing such requests was needed. A set of new plans to a common metric scale, detailing all old mine locations, current surface road locations, and subsidence risk zones, was devised to enable rapid processing of any requests and eliminate the need to refer back to ageing workings plans. The Subsidence Risk Zone classification scheme for the Wonthaggi region had to be created because existing risk classifications were not applicable in this coalfield. The integration of plans of numerous scales and a variety of data was done via computer.

Keyword(s): coal mining, abandoned mines, computer, land-use planning

Location(s): Australia

Gilboy, A. E. Ground Penetrating Radar: Its Application in the Identification of Subsidence Solution Features--A Case Study in West-Central Florida. IN: Karst Hydrogeology: Engineering and Environmental Applications, Proceedings of the 2nd Multidisciplinary Conference on Sinkholes and the Environmental Impacts of Karst, Orlando, 1987, B.F. Beck and W.L. Wilson, eds., Balkema, Rotterdam, p. 197-203.

Keyword(s): monitoring equipment

Location(s): Florida

Giles, J. R. A. Identification of Former Shallow Coal Mining from Aerial Photographs: An Example from West Yorkshire. 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. 133-136.

The presence of shallow mine workings is a major constraint on planning in areas of exposed coalfield. The examination of large scale aerial photographs offers a rapid reconnaissance method of identifying such workings.

Keyword(s): coal mining, remote sensing, abandoned mines, engineering, historical

Location(s): United Kingdom

Gilluly, J., U. S. Grant. Subsidence in the Long Beach Harbor Area, California. Bulletin of the Geological Society of America, v. 60, March, 1949, p. 461-530.

Surveys and other observations in the area of Long Beach Harbor, California, indicate a general subsidence of a large area. It is also highly significant that the subsidence, as indicated by tide-gauge records, first became notable in 1937, shortly after the beginning of the development of the Wilmington oil field. The effects of a variety of mechanisms which could lead to surface subsidence are discussed, but the discussion emphasis is on the effect of petroleum extraction on the overlying surface.

Keyword(s): fluid extraction, oil extraction

Location(s): California, United States

Girrens, S. P., C. A. Anderson, J. G. Bennett, M. Kramer. Numerical Prediction of Subsidence With Coupled Geomechanical-Hydrological Modeling. IN: Proceedings of 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. 63-70.

This paper investigates the development of a coupled finite element geomechanical-hydrology code applied to the problem of predicting groundwater disturbances associated with mine subsidence. It includes analyses of hydrologic modeling.

Keyword(s): vertical displacement, horizontal displacement, subsurface water, hydrology, prediction, finite element, modeling

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

Gloe, C. S., J. P. James, R. J. McKenzie. Earth Movements Resulting from Brown Coal Open Cut Mining--Latrobe Valley, Victoria. IN: Proceedings 4th Annual Symposium on Subsidence in Mines, A.J. Hargraves, ed., Australasian Institute Mining & Metallurgy, Wollongong, New South Wales, Australia, 1973, p. 8-1 - 8-11.

Large vertical and horizontal earth movements have resulted from the development of deep and extensive open cuts in brown coal deposits. The movements are not only of significance to safe mining operations, but also affect adjacent areas in which major power-generation projects are located.

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

Location(s): Australia

Gloe, C. S. Land Subsidence Related to Brown Coal Open Cut Operations, Latrobe Valley, Victoria, Australia. IN: Proceedings 2nd International Symposium on Land Subsidence, Anaheim, CA, IAHS-AIHS Publication No. 121, December, 1976, p. 399-407.

Keyword(s): surface subsidence damage, coal mining

Location(s): Australia

Glover, C. M. H., N. E. Webster. The Law Relating to Damage by Mining Subsidence and Its Effect on Mining Practice. Transactions Institute of Mining Engineers, London, v. 118, 1958-59, p. 75-99, 456-459.

Legislation in Great Britain imposed on the National Coal Board the general liability to pay compensation for damage resulting from mine subsidence. The development and consequences of this legislation are discussed together with known factors relating to subsidence damage including the precalculation of the amplitude and timing of subsidence. Preventative measures such as solid stowing are considered. The importance of subsidence damage to the mining industry is discussed.

Keyword(s): vertical displacement, horizontal displacement, law, prediction, National Coal Board, backfilling, stowing, mine operation, coal mining

Location(s): United Kingdom

Glover, T. O. Surface Subsidence Due to Underground Coal Mining in Illinois. Presented at SME/AIME Fall Meeting, St. Louis, MO, October 19-21, 1977, SME/AIME preprint 77-F-324, 8 p.

Keyword(s): surface subsidence damage, coal mining

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

Goldreich, A. H. Theory of Land Subsidences in Coal Regions. With Special Regard to the Railway Subsidences of the Ostrau-Karwin Coal District.

Julius Springer, Berlin, 1913, translated by O.L. Schwarg, in Unpublished Manuscripts, Illinois State Geological Survey Library, Champaign, 178 p.

In this manuscript, the author describes the geological conditions of the Ostrau-Karwin coal district. A theory of land subsidence in consequence of coal mining is also given.

Keyword(s): coal mining, railroads, geologic features, historical

Location(s): Germany

Golze, A. R. Land Subsidence--Why the State is Concerned. IN: Proceedings 2nd Geologic Conference on Landslides and Subsidence, Los Angeles, 1966, California Resources Agency, Sacramento, p. 97-104.

Keyword(s): fluid extraction

Location(s): California, United States

Goodman, R., S. Korbay, A. Buchignani. Evaluation of Collapse Potential Over Abandoned Room-and-Pillar Mines. Bulletin Association of Engineering Geologists, v. 17, no. 1, 1980, p. 27-37.

This paper summarizes the procedure used to evaluate surface subsidence hazards posed by abandoned room-and-pillar workings beneath a school site. If the workings are deeper than about 150 feet, the expense of providing deep foundations may be prohibitive and filling the mines may be required. However, if it can be demonstrated that the pillars can support the overburden safely, the site may be used without such expenses. This was done at the particular site by examining the implications of failure of isolated pillars on the stability of contiguous pillars and the roof. The method used is applicable only if reliable mine maps can be obtained.

Keyword(s): abandoned mines, room-and-pillar, surface structural damage, grouting, pillar strength, rock mechanics

Gormley, J. T., J. J. Gusek, V. Scovazzo. Case Study: The Glenrock, Wyoming Subsidence Control Project. SME Fall Meeting, St. Louis, MO, September 1986, SME-AIME, p. 83.

Glenrock, Wyoming, is underlain by two abandoned coal mines. Subsidence events have been recorded over the years, with increasing frequency in recent years. As part of Wyoming's Abandoned Mine Lands Program, investigations including mining history/methods/mappings, subsurface drilling, and material site searches were performed. Portions of the mines less than 80 feet from the surface were identified as probable for subsidence. Subsidence control by hydraulic backfill was selected. Design included search and injection boreholes; water supply from the mines; and slurry mixing, transport, and injection systems. Injection system performance and backfill success is being monitored during construction.

Keyword(s): hydraulic backfilling, abandoned mines, coal mining

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

Gorrell, G. R., K. M. McGuire. Major Issues in Subsidence Regulation. IN: Proceedings 2nd Workshop on Surface Subsidence due to Underground Mining, Morgantown, WV, June 9-11, 1986, S.S. Peng, ed., West Virginia University.

The legal issues surrounding the regulation of subsidence are among the major concerns facing the underground mining industry today. Whether subsidence occurs almost immediately as a result of longwall mining or without warning as a result of room-and-pillar mining conducted years ago, the resulting disputes are highly controversial and typical of the disputes involving the competing interests of surface and mineral estate owners. Until recently, the law governing these disputes was firmly established under the common law. The passage of the SMCRA, the utilization of new mining technologies, and the general heightened environmental awareness of our times, however, have interjected new issues into this area of the law. State and federal court decisions and administrative agency interpretations have helped clarify some of the issues. As evidenced by the many recent lawsuits between operators, surface owners, and regulatory agencies, many uncertainties still exist.

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

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

Granda, A., J. Casas, J. L. Sastre. Geophysical Prospecting for Mined Areas Identification, "San Jose" Mine Case History (Caceres - Spain). IN: Mine Water, Proceedings 2nd International Congress, Granada, Spain, September 1985, R. Fernandez-Rubio, ed., v. 2, p. 943-951.

Geophysical methods, especially those of resistivity, offer interesting possibilities for use in the study of some problems that are related with subsurface water and mine diggings. Particularly attractive due to its versatility, ease of use, and good results, the "mise-a-la-masse" method is

perhaps the one that has the greatest potential use in this field. The present work is concerned with a trial carried out in the "San Jose" Mine (Caceras, Spain). This mine has been abandoned for years, and the authors sought to check the effectiveness of the method to define the position of the old drifts and the approximate magnitude of the exploitation. The results obtained have been completely satisfactory and, on the basis of these results, a more complete study has been planned.

Keyword(s): geophysical, abandoned mines, subsurface water, hydrology

Location(s): Spain

Grant, U. S. Subsidence of the Wilmington Oil Field, California. IN: Geology of Southern California Bulletin 170, Sec. 3, Ch. 10, Engineering Aspects of Geology, Division of Mines, State of California Department of Resources, 1954, p. 19-24.

This article describes and discusses surface subsidence as a result of oil extraction from the Wilmington oil field of California. The author discusses horizontal displacements as a result of subsidence and suggests artificial repressuring of oil zones to delay or retard future subsidence but not as a mechanism to restore the surface to its original elevation.

Keyword(s): oil extraction, horizontal displacement

Location(s): California, United States

Grard, C. Mining Subsidence and the Means Permitting the Limiting of Their Effects on the Surface. Revue de L'Industrie Minerale, v. 51, January, 1969, p. 35-70 (in French).

Keyword(s): surface structural damage, ground control

Location(s): France

Gray, R. E. Mine Subsidence and Support Methods in the Pittsburgh Area. American Society of Civil Engineers Annual Meeting, Preprint No. 758, 1968, 37 p.

Keyword(s): ground control, coal mining

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

Gray, R. E., U. G. Henderson. Subsurface Stabilization, Hatfield's Ferry Power Station. Structures and Hydraulics Committee Minutes, Pennsylvania Electric Association, Engineering Section, January, 1969.

The use of grout columns to stabilize an undermined site for the construction of an electric power station is discussed.

Keyword(s): subsurface structural damage, utilities, grouting

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

Gray, R. E., J. F. Meyers. Mine Subsidence and Support Methods in the Pittsburgh Area. IN: Proceedings Journal of the Soil Mechanics and Foundations Division, American Society of Civil Engineers, v. 96, no. SM4, Paper 7407, July 1970, p. 1267-1287.

The Pittsburgh area exhibits two distinct subsidence problems: (1) active mining at depths of 300 feet or more beneath the surface; and (2) subsidence associated with structures located over old mine workings at relatively shallow depths. In areas of active mining, subsidence damage is prevented by leaving coal pillars in place to support the ground surface. For structures located over old mines with shallow cover, the method of support selected is dictated by the cost and the degree of risk the owner is willing to accept.

Keyword(s): surface structural damage, mine design, grouting, room-and-pillar, ground control, backfilling, engineering, construction, geologic features, coal mining, active mines, abandoned mines

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

Gray, R. E. Mine Subsidence. IN: Geology of the Pittsburgh Area, W. R. Wagner, et al., Pennsylvania Geological Survey, General Geology Report G59, 1970, p. 111-116.

This section describes subsidence problems from both active and abandoned bituminous coal mines in the Pittsburgh area. Protective measures are discussed, including pillar support, grout columns, and backfilling.

Keyword(s): backfilling, grouting, abandoned mines, active mines, room-and-pillar

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

Gray, R. E. Mine Subsidence, Support, and Stabilization in Western Pennsylvania. IN: Geological Society of America Annual Meeting, Field Trip Guidebook, 1971, no. 6, p. 25-35.

Keyword(s): surface subsidence damage, coal mining

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

Gray, R. E., H. A. Salver. Discussion of State of Predictive Art in Subsidence Engineering by B. Voight and W. Pariseau. IN: Proceedings American Society Civil Engineers, Journal of Soil Mechanics & Foundations Division, v. 97, no. SM1, January, 1971, p. 258-260.

Keyword(s): prediction

Location(s): United States

Gray, R. E., H. A. Salver. Foundation Support in an Undermined Substation. American Society of Civil Engineers, National Structural Meeting, Cleveland, OH, April 25, 1972.

This paper describes the use of fly ash injection, grout columns, predrilled piles, and caissons for support of roads and structures in an undermined power substation.

Keyword(s): surface structural damage, foundations, utilities, grouting, pneumatic backfilling, mine waste

Location(s): United States

Gray, R. E., J. C. Gamble, R. J. McLaren, D. J. Rodgers. State of the Art of Subsidence Control. Appalachian Regional Commission Report ARC-73-111-2550, 1974, 182 p.

This report discusses methods of controlling or preventing surface subsidence damage above active and abandoned mines; it contains annotated bibliographies.

Keyword(s): vertical displacement, horizontal displacement, mine design, backfilling, monitoring design, monitoring installation, monitoring equipment, ground control, mine operation, literature search, active mines, abandoned mines, coal mining

Location(s): Appalachian Coal Region, United States

Gray, R. E., H. A. Salver, J. C. Gamble. Subsidence Control for Structures Above Abandoned Coal Mines. IN: Subsidence Over Mines and Caverns, Moisture and Frost Actions, and Classification, Transportation Research Record 612, 1976, Part 1, Transportation Research Board, Washington D.C., 1976, p. 17-24. (NTIS PB 272 844)

Subsidence of the ground surface above abandoned coal mines can cause serious damage to surface facilities. Two categories of techniques used in controlling subsidence are selective support for structures and filling of voids caused by past mining operations. The particular methods used must be adapted to the local geologic setting and the mining methods used to extract the coal, as well as the support requirements of the structure because these factors vary within any given site and from one locality to another. This paper presents a case history of subsidence control for an electric substation.

Keyword(s): surface structural damage, abandoned mines, ground control, coal mining, pneumatic backfilling, grouting, mine waste, anthracite, bituminous, historical, foundations

Location(s): Appalachian Coal Region, United States

Gray, R. E., R. W. Bruhn, R. J. Turka. Study and Analysis of Surface Subsidence Over the Mined Pittsburgh Coalbed. Contract J0366047, GAI Consultants, Inc., U.S. Bureau of Mines OFR 25-78, 1977, 374 p. (NTIS PB 281 511)

The purpose of the study was to investigate cases of subsidence over abandoned mined-out areas of the Pittsburgh Coal identified from published and unpublished sources. It was also to determine through a consideration of the geology, topography, climate, mining activity, and evidence at ground surface, what mechanisms control subsidence and under what circumstances it takes place. The report identifies 354 incidents of subsidence in the 8,000-square-mile Pittsburgh Coal Region.

Keyword(s): abandoned mines, bituminous, rock mechanics, surface structural damage, room-and-pillar, economics, partial extraction, insurance, historical, coal mining

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

Gray, R. E., R. W. Bruhn. Subsidence Above Abandoned Coal Mines. 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. 253-271.

This paper reviews the development of coal mining in the United States; it includes a discussion on subsidence characteristics including modes, time effects, overburden thickness, and lithology.

Keyword(s): vertical displacement, horizontal displacement, backfilling, abandoned mines, longwall, room-and-pillar, historical, time factor, economics, coal mining

Location(s): United States

Gray, R. E., R. J. McLaren. Research Needs in Subsidence Abatement Over Abandoned Mines. 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. 259-273.

A review of subsidence abatement methods resulted in identification of items where research may impact the current state of technology in mine subsidence control. These research needs are presented to stimulate discussion of their importance in subsidence abatement and to encourage funding agencies, researchers, and practitioners to work on them.

Keyword(s): abandoned mines, hydraulic backfilling, pneumatic backfilling, grouting, subsidence research, surface structural damage, structural mitigation

Location(s): United States

Gray, R. E., R. W. Bruhn. Coal Mine Subsidence--Eastern United States. IN: Man-Induced Land Subsidence, Geological Society of America Reviews in Engineering Geology VI, 1984, T.L. Holzer, ed., p. 123-149.

Underground coal mining has occurred beneath eight million acres of land in the United States, two million of which have been affected by subsidence. Most of this mining has taken place in the eastern half of the country (east of the 100th meridian), where thousands of acres in urban areas are threatened by subsidence.

Keyword(s): coal mining, active mines, abandoned mines, surface structural damage, vertical displacement, horizontal displacement

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

Gray, R. E. Coal Mine Subsidence and Structures. IN: Mine Induced Subsidence: Effects on Engineered Structures, Proceedings of the Symposium, Nashville, TN, May 11, 1988, ASCE Geotechnical Special Publication No. 19, p. 69-85.

This paper briefly reviews the magnitude of the subsidence problem in the United States resulting from underground coal mining, presents the similarities and differences between subsidence over abandoned and active mines, contrasts the experience in the United States with Europe; and considers the role of ground-structure interaction and structural details in subsidence damage.

Keyword(s): coal mining, surface structural damage, abandoned mines, engineering, active mines, prediction, horizontal displacement, foundations

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

Gray, R. E. Subsidence Over Abandoned 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. 322-344.

Underground coal mining has occurred in the United States for more than 200 years, resulting in almost 70,000 abandoned or inactive underground mines. The risk of subsidence over these abandoned mines is dependent upon the amount and extent of mining and the characteristics of the mine floor, the coal pillars, and the overburden.

Keyword(s): abandoned mines, coal mining, surface structural damage, historical, overburden, pillar strength, floor stability, land-use planning, backfilling, insurance, structural mitigation, soils

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

Gray, R. E., R. W. Bruhn, R. J. Turka, K. K. Kohli. Guidance Manual on Subsidence Control. GAI Consultants, Inc., Monroeville, PA., Office of Surface Mining Reclamation and Enforcement Technical Report 596, 1991, 127 p. (NTIS PB91-228403)

This manual was developed as an aid for the preparation of subsidence control plans for underground coal mining operations. It describes the subsidence process and reviews available subsidence prediction methods. Each mining area is unique and different states have different regulatory program requirements, consequently, clear communication between the state regulatory authority and the mine operator is needed so that specific needs and requirements of the subsidence control regulations are understood and met.

Keyword(s): room-and-pillar, longwall, shortwall, coal mining, law, partial extraction

Location(s): United States

Gray, R. E., R. W. Bruhn. Structural Damage - Mine Subsidence or ??? IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 113-120.

This paper presents information on distress to structures and briefly reviews a number of causes of ground movements other than subsidence. These include mass movements, dissolution, erosion, frost action, shrinking and swelling, yield into excavations, and compressibility.

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

Location(s): United States

Grayson, R. L., G. Mishra. Understanding and Controlling Subsidence Over A Longwall Panel. Session paper, American Mining Congress 1982 Coal Convention, St. Louis, MO, May 9-12, 1982, 23 p.

A private residence located at mid-panel, length-wise and width-wise, was undermined by a longwall unit operating in the Pittsburgh coal seam. The surface, approximately 400 feet above the seam, was closely monitored for subsidence effects. This paper presents action taken in an attempt to minimize subsidence damage to the dwelling. It also presents the results from biweekly survey-grid monitoring. Subsidence development curves, contour maps, differential settlement data, and pictures reflecting the extent of damage to the surface structure are presented in an analysis of the situation.

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

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

Green, J. H. Compaction of the Aquifer System and Land Subsidence in the Santa Clara Valley, California. U.S. Department of the Interior, Geological Survey Professional Paper 450-D, Geological Survey Research 1962, p. D175-D178.

Keyword(s): fluid extraction, hydrology

Location(s): California, United States

Green, J. H. The Effect of Artesian-Pressure Decline on Confined Aquifer Systems in Areas of Land Subsidence. Journal of Geophysical Research, v. 67, 1962, p. 3532.

Keyword(s): fluid extraction, hydrology

Greenfield, R. J., P. M. Lavin, R. R. Parizek. Geophysical Methods for Location of Voids and Caves. IN: Proceedings 2nd International Symposium on Land Subsidence, Anaheim, CA, IAHS-AIHS Publication No. 121, December, 1976, p. 465-484.

Keyword(s): geophysical

Greenwald, H. P., E. R. Maize, L. Hartman, G. S. Rice. Studies of Roof Movement in Coal Mines, I. Montour 10 Mine of the Pittsburgh Coal Co. U.S. Bureau of Mines B 25, 1912.

Keyword(s): roof stability, coal mining

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

Greenwald, H. P., S. Avins, G. S. Rice. Compressibility and Bearing Strength of Coal in Place. U.S. Bureau of Mines Technical Paper No. 527, 1933, 12 p.

In an experimental mine, tests were made by applying a pressure from a hydraulic jack against a coal face.

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

Location(s): United States

Greenwald, H. P., E. R. Maize, I. Hartmann, G. S. Rice. Studies of Roof Movement in Coal Mines. U.S. Bureau of Mines RI 3355, 1937, 41 p.

Laboratory and in situ strength measurements were performed on specimens of Pittsburgh sandstone, Pittsburgh coal, and mine props through a cooperative agreement with the Pittsburgh Coal Company.

Keyword(s): roof stability, roof support, mine waste, rock mechanics, lab testing, in situ testing, coal mining, literature search

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

Greenwald, H. P. Physics of Subsidence and Ground Movement in Coal Mines. Applied Physics, v. 8, no. 7, 1937, p. 462-469.

The author describes or reviews tests run by various investigators on the properties of coal and coal-measure strata.

Keyword(s): floor stability, mathematical model, pillar strength, time factor, lab testing, overburden, coal mining, rock mechanics, geotechnical

Greenwald, H. P., H. C. Howarth, I. Hartmann. Experiments on Strength of Small Pillars of Coal in the Pittsburgh Bed. U.S. Bureau of Mines Technical Paper No. 605, 1939, 22 p.

Tests for compressive strength and other properties were performed in situ on seven small coal pillars.

Keyword(s): pillar strength, in situ testing, floor stability, coal mining
Location(s): Pennsylvania, Appalachian Coal Region, United States

Greenwald, H. P., E. R. Maize. Studies of Roof Movements in Coal Mines. U.S. Bureau of Mines RI 3452, 1939.
This report discusses floor heave, timber failures, the effect of overlying sandstone, and the magnitude of surface subsidence with regard to roof studies in the Crucible Mine.
Keyword(s): roof stability, overburden, floor stability, coal mining
Location(s): Appalachian Coal Region, United States

Greenwald, H. P., H. C. Howard, I. Hartmann. Progress Report--Experiments on Strength of Small Pillars of Coal in the Pittsburgh Bed. U.S. Bureau of Mines RI 3575, June, 1941.
This report presents results of five compression tests on in situ pillars.
Keyword(s): pillar strength, rock mechanics, in situ testing, coal mining
Location(s): Pennsylvania, Appalachian Coal Region, United States

Greenwald, H. P. Surface Factors Affecting Pillar Recovery. Mining Congress Journal, v. 35, no. 3, 1949, p. 54-57.
Keyword(s): pillar extraction, coal mining

Gren, K. Modelling the Propagation of the Effects of Mining Exploitation by Means of a Photoelectric Analog. IN: Proceedings, International Science Symposium on Mine Surveying, Mining Geology and the Geometry of Mine Deposits, Prague, Czechoslovakia, August 26-30, 1969, Conference Paper I/1, v. 1, Sec. 1, 1969, 17 p.
Keyword(s): modeling

Gresley, W. S. Culm Filling: How It May Be Used Advantageously in Mining Anthracite by the Longwall System. Colliery Engineering, v. 14, September, 1893, p. 32.
This article suggested applications to modify the longwall system to recover more coal. The method required suitable terrain and plenty of available fill.
Keyword(s): stowing, longwall, anthracite, coal mining, geologic features, historical
Location(s): United States

Griffith, W. Flushing of Culm in Anthracite Mines. Journal of the Franklin Institute, v. 149, 1900, p. 271.
This article covers the first use of hydraulic backfilling for subsidence prevention and roof control in anthracite coal mines.
Keyword(s): hydraulic backfilling, roof stability, anthracite, coal mining

Griffith, W. Method of Supporting Mine Roofs by Blasting Down Roof and Blasting Floor Up. United States Patent no. 1,004,419, Mines and Minerals, v. 32, 1911, p. 279 and 402.
Griffith's patent was a proposal for blasting the roof and/or floor and allowing the fractured rock, which bulks and occupies a larger volume, to remain in place as permanent support pillars. The rock could also act as a dam for hydraulic backfilling materials.
Keyword(s): hydraulic backfilling, roof support
Location(s): United States

Griffith, W., E. T. Conner. Mining Conditions Under the City of Scranton, PA, Report and Maps. U.S. Bureau of Mines B 25, 1912, 89 p.
Mine plans and cross sections of the Scranton area are included. Strength and compressibility of anthracite pillars and backfill materials are discussed.
Keyword(s): backfilling, mine waste, historical, roof support, pillar strength, coal mining, anthracite
Location(s): Pennsylvania, Appalachian Coal Region, United States

Grigorovich, V. T., Y. A. Makhan'ko, A. V. Isaev. Surface Subsidence During the Working of a Sequence of Seams at the "Kaierkan" Pit of the Noril'sk Coalfield. Soviet Mining Science, no. 2, 1965, p. 86-93.
Surface effects and subsidence parameters of mining the upper four seams at the Noril'sk Coalfield, where permafrost extends to 200 meters, are discussed.
Keyword(s): multiple-seam extraction, surface subsidence damage, geologic features, coal mining
Location(s): Soviet Union

Grim, R. E., V. E. Allen. Petrology of the Pennsylvanian Underclays of Illinois. Bulletin, Geological Society of America, v. 49, 1938, p. 1485-1514.
Keyword(s): floor stability, lab testing
Location(s): Illinois, Illinois Coal Basin, United States

Grond, G. J. A. Disturbances of Coal Measures Strata Due to Mining Activity. Iron and Coal Trades Review, v. 160, 1949, p. 1323-1326, 1377-1382, 1445-1449; v. 161, 1950, p. 37-40, 85-88, 135-137, 197-200, 244-251, 295-297, 394-397.

This series of articles gives a short history of subsidence investigations and early theories, principally those from Germany.

Keyword(s): historical, prediction, overburden, subsidence research, coal mining

Location(s): Germany

Grond, G. J. A. The Precise Topographical Measurements in Coal-Mine Underground Works. IN: Proceedings International Conference About Rock Pressure and Support in the Workings, Liege, Belgium, April 24-28, 1951, Institut National de l'Industrie Charbonniere, 15 p.

When we want to get an exact idea of movements and pressures occurring in works and galleries, it is very useful and even necessary, first to consider movements occurring at a certain distance from the face. This paper deals with research made in this field by the surveyors of the Dutch State Mines. The observations made in Holland do not apply integrally to other coal districts, for in one single district we observe fairly considerable differences and contradictions. It will be useful, however, to compare them with observations made abroad, for the methods of observation are often nearly identical, and the results may give us more accurate ideas.

Keyword(s): coal mining, survey methods, overburden, monitoring methods, geologic features

Location(s): Holland

Grond, G. J. A. A Critical Analysis of Early and Modern Theories of Mining Subsidence and Ground Control. Powney-Parker Publicity Services, Ltd., 1st ed., 1953, 57 p.

The author provides a critical analysis of European subsidence prediction methods, including both early and modern theories.

Keyword(s): vertical displacement, horizontal displacement, prediction, prediction theories, ground control, historical

Location(s): Europe

Grond, G. J. A. Ground Movements Due to Mining. Colliery Engineering, v. 34, April, 1957, p. 157-158; v. 34, May, 1957, p. 197-205.

The author discusses theories of ground movements occasioned by the winning of minerals, particularly with coal mining. Survey observations are considered, in particular exact survey measurements to establish an outline of the phenomena of movement in their various aspects.

Keyword(s): surface subsidence damage, overburden, coal mining, survey methods, prediction, prediction theories

Location(s): United Kingdom

Grond, G. J. A. Ground Movements Due to Mining With Different Types of Strata and at Different Depths. IN: Proceedings of European Congress on Ground Movements, Leeds, England, April 9-12, 1957, London Harrison, p. 115-127.

The author discusses the theory of arch support with respect to mine subsidence by summarizing papers presented by other investigators in this field.

Keyword(s): overburden, geologic features

Growitz, D. J. Hydrogeologic Factors that May Affect Mine Drainage in the Anthracite Region of Pennsylvania, Eastern United States. Symposium on Water in Mining and Underground Works, SIAMOS--78, Granada, Spain, 1978, p. 153-172.

Hydrologic and water-quality data collected during a 2-week period of average flow were used in a regional analysis of mine drainage in the anthracite coal region of Pennsylvania. The analysis shows that the flow and quality of mine drainage are influenced by (1) proportion of land surface in the coal fields disturbed by mining, (2) residence time of mine water, (3) changes in the hydrologic system due to cessation of pumping and the recovery of water levels, and (4) method of mining.

Keyword(s): hydrology, coal mining, anthracite, subsurface water, environment, surface water, mine waste

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

Groy, D. L., R. C. Moore. Application of Electrotelluric Geophysical Techniques to Subsurface Void Exploration in Subsidence Investigation and Control. Final Report to Office of Surface Mining, Reclamation and Enforcement by Goodson & Associates Inc., Denver, CO, January, 1989, 176 p. (NTIS PB90-267246)

Results from a series of evaluations on the Petro-Sonde instrument emphasize the difficulty in delineating subsurface cavities. The degree of success achieved in detecting coal at Marissa, Illinois, indicates that the instrument may not be suited for detailed site characterization, but it may be useful as a preliminary investigative tool.

Keyword(s): abandoned mines, coal mining, geophysical

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

Guangxiao, D., Z. Yiaoqi. Land Subsidence in China. IN: Land Subsidence, Proceedings 3rd International Symposium on Land Subsidence, 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. 405-414.

The most serious land subsidence occurs in areas with thick and fine-grained loose sediments or with shallow-buried karst, which is mainly attributed to groundwater pumping for water supply or dewatering of the mine. It is also closely related to the local geological environments. The paper describes the engineering geological and hydrogeological conditions and their influence on land subsidence in some of the studied areas. It also gives a brief account of measures to bring land subsidence under control.

Keyword(s): surface subsidence damage, geologic features, fluid extraction

Location(s): China

Guither, H. D., S. A. Neff. Appraisal of Farmland Overlying Underground Coal Mines. Journal of the American Society of Farm Managers and Rural Appraisers, October, 1983, v. 47, no. 2, p. 49-50.

Extensive literature of underground coal mining exists but the documentation concerning its economic effects on agriculture is limited. Underground mining does use smaller amounts of surface lands than surface mining for comparable coal production. The coal is extracted without disturbing the upper soils, unless subsidence, planned or unplanned, occurs. In view of the growing concern for damage from mine subsidence, a research project was begun in Illinois to assess the economic effects and policy implications of underground coal mining upon agricultural land. Part of this project involved an effort to determine the effects of subsidence upon land values.

Keyword(s): land values, land-use planning, agriculture, economics, coal mining, mine waste, abandoned mines, active mines, surface water

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

Guither, H. D. The Economic Effects of Subsidence from Underground Coal Mining on Agricultural Land in Illinois. Research Report to U.S. Bureau of Mines Twin Cities Mining Research Center, Minneapolis, MN, Contract No. HO222010, 1984, 60 p.

In a survey of Illinois agricultural extension advisers, subsidence was reported in 31 counties. The most frequently reported problems were standing water, depressions, disruption of surface drainage, broken tile lines, and reduced crop yields.

Keyword(s): agriculture, surface subsidence damage, economics, surface water, subsurface water, utilities, coal mining

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

Guither, H. D. Coal Mine Subsidence on Illinois Farmland. Illinois Agricultural Economics Staff Paper, no. 84E-297, July 1984, 6 p.

This paper suggests the need for further research into the areas of identification of where subsidence has occurred, complete yield sampling and tests, and best mitigation methods.

Keyword(s): agriculture, land mitigation, active mines, coal mining, economics, longwall, high-extraction retreat, room-and-pillar, land values

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

Guither, H. D., J. Hines, R. A. Bauer. The Economic Effects of Underground Mining Upon Land Used For Illinois Agriculture. Department of Energy and Natural Resources, Document 85/01, Springfield, IL, 1985.

The objectives of this project were to inventory acreage overlying underground mines in Illinois, assess the extent of subsidence overlying coal mines, assess economic effects of subsidence for landowners, gather information about tax assessment policies in subsidence areas, and develop and assess policy alternatives to deal with subsidence problems on Illinois agricultural land.

Keyword(s): economics, agriculture, coal mining, law, land mitigation, insurance, soils, surface structural damage, active mines, abandoned mines

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

Guither, H. D. The Mine Subsidence Threat to Soils. Journal of Soil and Water Conservation, January-February, 1986, p. 21-23.

This article covers subsidence, the extent of the problem in relation to the 1977 Federal Surface Mining Control and Reclamation Act, the extent of damage, and agricultural costs of subsidence from a 1983 survey of Illinois extension advisers.

Keyword(s): soils, agriculture, environment, law, surface subsidence damage, coal mining

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

Gullachsen, B. C. Hydraulic Stowing in the Gold Mines of the Witwaterstrand. Transactions Institution of Mining Engineers, London, v. 48, 1914-15, p. 122-139.

This paper describes mechanics of sand filling in gold mines of South Africa.

Keyword(s): hydraulic backfilling, stowing, metal mining

Location(s): South Africa

Gupta, R. N., I. W. Farmer. Relations Between Strata Deformation and Support Performance on Longwall Faces. IN: Strata Mechanics, Proceedings of the Symposium, University of Newcastle-upon-Tyne, April, 1982, I.W. Farmer, ed., Elsevier, New York, p. 7-12.

Keyword(s): longwall, overburden, rock mechanics

Gupta, R. N., I. W. Farmer. Strata Deformation and Support Performance at a Longwall Face. IN: Proceedings 5th International Congress, International Society for Rock Mechanics, Melbourne, April, 1983.

During a series of detailed observations on three retreating longwall faces at Westoe Colliery, Tyne and Wear, United Kingdom, the effect of setting pressure on support performance and strata deformation was investigated. Increased setting pressures, resulting in an increase in setting load density, were shown to reduce convergence and face spalling as well as roof flaking. This was shown to result mainly from the change in roof strata deformation from a wedge shaped compression zone with tension at the face edge to an even beam shaped compression zone over the face area.

Keyword(s): longwall, rock mechanics, overburden, coal mining, roof support

Location(s): United Kingdom

Gupta, R. N., K. P. Mukherjee. Pillar Extraction in a Multi-Section Working of a 13m Thick Seam Based on Strata Deformation Investigations. IN: Proceedings 2nd Conference on Ground Control Problems in the Illinois Coal Basin, May 1985, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 98-106.

A retreating system of pillar extraction in a two-section working was developed based on considerable strata deformation investigations. The system was successfully used to extract pillars in a 13.4 m thick seam at a colliery in Jharia Coalfield (India). Earlier attempts to extract two sections simultaneously proved abortive and resulting in puncturing of parting and overriding of pillars, which led to complete loss of a few panels. The success of the new method is a result of extracting the bottom section pillars in the destressed zone. It provides good face ventilation; better strata conditions; and concentration of work in a few places, enabling effective supervision, enhanced production, increased productivity, and maximum percentage of extraction. It also minimizes loss of coal in the form of ribs.

Keyword(s): coal mining, pillar extraction, ground control

Location(s): India

Gurtunca, R. G., E. H. R. Schumann. Computer Simulation of Surface Subsidence Using a Displacement Discontinuity Method. IN: Proceedings, SANGORM Symposium, October 21, 1986, Sandton, South Africa, International Society for Rock Mechanics, South African National Group, p. 81-87.

Results of computer modeling of surface subsidence above longwalls at three different collieries are described. A computer program based on the displacement discontinuity method was used to simulate subsidence profiles and maximum subsidence. Modeling of static and dynamic profiles were carried out separately; results show a linear relationship between elastic parameters of the surrounding rock, the thickness of dolerite, and the face advance.

Keyword(s): computer, modeling, longwall, prediction, finite element, geologic features, coal mining

Location(s): South Africa

Gusek, J. J., J. T. Gormley. Tube-A-Manchette Grouting As An Abandoned Mine Stabilization Method. IN: Proceedings, Symposium on Evolution of Abandoned Mine Land Technologies, Riverton, WY, June 14-16, 1989, p. 336-355.

A method of stratified grouting and a high-strength, high-fluid grout mixture was used to

stabilize the near-surface rock beneath a school in Superior, Wyoming. The school is undermined and damage was related to the probability of trough subsidence, which caused differential settlement in the foundation units.

Keyword(s): abandoned mines, surface structural damage, grouting, foundations, structural mitigation, geologic features, historical, coal mining, economics

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

Gustkiewicz, J. Fleksyjne Deformacje Terenu W Zasiegu Wplywow Eksploatacji Gorniczej (Flexural Deformations of the Surface Within the Area of Mining Effects). Archiwum Gornictwa, v. 17, no. 2, 1972, p. 83-116.

Keyword(s): surface subsidence damage

Gustkiewicz, J., A. Kanciruk, L. Stanislawski. Some Advancements in Soil Strain Measurement Methods with Special Reference to Mining Subsidence. Mining Science and Technology, v. 2, no. 4, 1985, p. 237-252.

Investigations of phenomena associated with rock mechanics make it necessary to carry out long-term measurements of two- and three-dimensional states of strains. Studies have been conducted for a number of years to design measuring devices that can be installed in the soil to allow long-term observation of the strain states. The basis of these instruments is a vibrating-wire strain transducer. The effects of environmental factors on the measuring instrumentation installed in the soil over a number of years was also investigated.

Keyword(s): soils, monitoring methods, monitoring equipment, rock mechanics, soil mechanics

Location(s): Poland

Haas, C., S. Tangchawal. Relation Between Engineering Properties and Clay Mineralogy for Illinois Coal Mine Roof Shales and Underclays. 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. 48-72.

This research was undertaken to determine if the engineering properties and moisture-sensitive index properties of Illinois coal mine roof shales and underclays are related to clay and non-clay mineral content. A full suite of laboratory property tests were performed on core from five mines in the Illinois Basin. The results, in the form of regression equations, indicate that (1) engineering properties have a high degree of correlation with the total clay mineral content, mixed-layer mineral content, and quartz content; and (2) the moisture absorption phenomena are nearly direct functions of total clay minerals, mixed-layer minerals, illite, and quartz. The higher the clay mineral and clay-size contents in the materials, the lower will be the rock durability and stability.

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

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

Habenicht, H., E. Urschitz. Rib Pillar Extraction--An Alternative to Long Walling and Short Walling. SME-AIME Preprint No. 86-65, for presentation at the SME Annual Meeting, New Orleans, LA, March 2-6, 1986, 13 p.

Requirements for full extraction in underground coal mining call for inexpensive, safe techniques to be competitive with conventional methods. Longwall and shortwall systems are to some extent employed for this purpose. Another method would be rib pillar extraction and pillar extraction. These methods are compared with respect to procedure, equipment, safety, roof control, investment, output, performance, and costs.

Keyword(s): longwall, shortwall, economics, pillar extraction, roof stability, coal mining, mine design

Hackett, P. An Elastic Analysis of Rock Movement Caused by Mining. Transactions AIME, v. 118, no. 7, April, 1959, p. 421-433.

This paper describes work done at the University of Nottingham by Professor R. Hill. Hill's conception of a longwall working was a horizontal crack in an infinite medium. Hill also suggested the methods by which the existence of a free surface and the result of excavation closure are investigated, and he formed the basic problem for the allowance of crushing of the coal.

Keyword(s): continuum mechanics, phenomenological model, ground control, elastic model, longwall, modeling

Location(s): England

Hackett, P. Prediction of Rock Movement by Elastic Theory Compared With Insitu Measurements. Rock Mechanics & Engineering Geology, Supplement 1, 1964, p. 88-102.

Keyword(s): prediction, elastic model, modeling, phenomenological model, rock mechanics, in situ testing

Haimson, B., C. Fairhurst. In-situ Stress Determination at Great Depth by Means of Hydraulic Fracturing. IN: Rock Mechanics-Theory and Practice, Proceedings 11th Symposium on Rock Mechanics, University of California, Berkeley, June 16-19, 1969, W.H. Somerton, ed., SME-AIME, New York, 1970, p. 559-584.

This paper extends the criterion for hydraulic fracturing and reports on some laboratory tests on simulated boreholes. Some interesting field results are also mentioned.

Keyword(s): rock mechanics, lab testing

Location(s): United States

Hake, S. S. A Review of Engineering Geological and Geotechnical Aspects of Town and Country Planning with Particular Reference to Minerals and the Extractive Processes. 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. 69-74.

The objective of this paper is to demonstrate the importance of, and connection between, town and country planning matters and the need for engineering geological and geotechnical assessments. One section considers Britsh Coal's rights of working and their obligation to consult and to make reparations for subsidence damage caused by underground coal mining activities.

Keyword(s): land-use planning, law, government, coal mining, structural mitigation

Location(s): United Kingdom

Hakelberg, F. Flexible Bituminous Bases for Areas of Mining Subsidence. Strassen-Asphalt und Tiefbau-Technik, v. 9, 1956, p. 657 (in German); also Road Abstract No. 247, March, 1957 (in English).

Keyword(s): surface subsidence damage, construction, roads

Halat, W. An Analysis of the Behaviour of the Roof Over the Longwall Working. Gornictwo, Quarterly of Stanislaw Staszic Academy of Mining and Metallurgy, Cracow, Poland, v. 15, no. 4, 1991, p. 247-257 (in Polish; English summary).

Computer calculations were realized for the discrete numeric rock mass model corresponding to the geological-mining conditions of one of the Hard Coal Mines. Critical state of the rock mass was described by the Coulomb-Mohr flow function. The results were analyzed graphically. In areas where the rock mass was destroyed, forming relaxed zones, values of secant module of the stress-deformation rock mass characteristic, in the form of a laminar plan, were determined. The varying values of the secant module, not being a characteristic features of strength properties, may determine the changes in the rock mass structure destruction.

Keyword(s): modeling, finite element, coal mining, longwall, active mines, roof stability, computer

Location(s): Poland

Halbaum, H. W. G. The Action, Influence and Control of the Roof in Longwall Workings. Transactions Institute of Mining Engineers, London, v. 2, 1903, 22 p.

Keyword(s): longwall, roof stability, roof support

Halbaum, H. W. G. The Great Planes of Strain in the Absolute Roof of Mines. Transactions Institute of Mining Engineers, London, v. 6, 1905, 18 p.

Keyword(s): roof stability

Hall, B., S. Glynn. Road Crossing of Mined Out Reef Outcrops: Two Case Histories. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May 1992, South African Institution of Civil Engineers, Republic of South Africa, p. 185-191.

The crossing of mined-out gold reef outcrops by new roads posed particular challenges as economical alternative solutions were sought. The geotechnical investigations and the alternatives to the more frequently used but expensive grouting methods are described.

Keyword(s): grouting, roads, metal mining, geotechnical, monitoring methods

Location(s): South Africa

Hall, B. M. Subsidence Prediction Methods and Instrumentation for Caved Longwall Coal Mines. Mineral Resources Engineering and Management Program, Northwestern University, Evanston, IL, MREM R107, August, 1980, 128 p.

Thirty-three subsidence models for caved longwall coal mines are investigated. The emphasis of this study includes evaluation of the ability of the models to predict subsidence, examination of the assumptions in the models, and indication of the areas for improvement. The data from four instrumented longwall panels are presented to determine which geologic traits influence the amount and pattern of subsidence, and if in situ data can be obtained to improve the prediction methodology.

Keyword(s): vertical displacement, horizontal displacement, survey methods, survey equipment, prediction, longwall, prediction theories, coal mining, empirical model, stochastic model, phenomenological model, elastic model, mathematical model, viscoelastic model

Location(s): Illinois, New Mexico, West Virginia, Illinois Coal Basin, Rocky Mountain Coal Region, Appalachian Coal Region

Hall, B. M., C. H. Dowding. Prediction of Subsidence from Full Extraction Coal Mining. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 19, no. 3, June, 1982, p. 305-312.

The authors examine empirical and phenomenological methods for predicting subsidence over longwall panels.

Keyword(s): vertical displacement, horizontal displacement, longwall, prediction, prediction theories, coal mining, empirical model, phenomenological model

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

Hall, H. C. Masonry Buildings: Construction on Subsidence Sites. IN: Proceedings, North American Masonry Conference, August 14-16, 1978, University of Colorado, Boulder, Masonry Society, Denver, Paper 84, 1978, 12 p.

Keyword(s): engineering, construction, architecture

Location(s): United States

Hall, M., R. J. Orchard. Subsidence Profile Characteristics. Chartered Surveyor, v. 95, no. 8, February, 1963, p. 422-428.

Keyword(s): survey data processing

Hall, R. D. Squeezes in Mines and Their Causes. Mines and Minerals, v. 30, no. 5, 1909, p. 286-287.

Keyword(s): floor stability

Hall, R. D. The Strength of Mine Roofs. Mines and Minerals, v. 30, 1910.

Keyword(s): roof stability

Hall, R. D. Permanent Roof Sustension. Coal Age, v. 1, January 20, 1912, p. 481.

The article describes and supports Griffith's process of blasting up the floor and blasting down the roof to produce roof supports and dams for hydraulic flushing.

Keyword(s): hydraulic backfilling, roof support, coal mining

Ham, B. W. The Impact of Underground Coal Mining on Farming. IN: Mining and Environment, A Professional Approach, National Conference, Brisbane, July 1987, p. 33-40.

The proportion of coal production from underground operations in Queensland is likely to increase in the future. A portion of this increase will come from mines working under farming areas. The degree of compatibility between underground coal mining operations and farming is examined. Two case histories are considered in detail.

Keyword(s): coal mining, agriculture, surface water, soils, longwall, room-and-pillar, subsurface water, multiple-seam extraction

Location(s): Australia

Hambleton, R. B. Inspectorial Aspects of Subsidence with Special Reference to the Newcastle Coal Fields. 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 14, p. 14-1--14-3.

Technical aspects of the administration of the Mine Subsidence Compensation Act (1961) are investigated by the New South Wales (Australia) Mines Inspectorate. Some areas are extensively undermined by ancient coal workings, some of which are very close to the surface. In other areas, coal deposits are being mined at greater depths or will be mined in the not too distant future.

Keyword(s): surface subsidence damage, coal mining, active mines, abandoned mines, surface structural damage, law, government, structural mitigation, mitigation, land mitigation

Location(s): Australia

Hammond, A. J., G. W. Plant. The Stabilization of Outcrop Workings for a Multi-Storey Building in Johannesburg. IN: Proceedings, SANGORM Symposium, October 21, 1986, Sandton, South Africa, International Society for Rock Mechanics, South African National Group, p. 53-58.

The desire for land close to the central building district and the consequent escalation in cost led to a reappraisal of undermined ground in this area. This paper describes the investigation and treatment of a site required for development of a multi-story building. The treatment method chosen enabled physical inspection of the actual workings, and the stabilization consisted of the construction of concrete buttresses followed by specialized grouting.

Keyword(s): abandoned mines, metal mining, historical, engineering, construction, surface structural damage, geotechnical, foundations

Location(s): South Africa

Hanes, J., J. Shepherd. Mining Induced Cleavage, Cleats and Instantaneous Outbursts in the Gemini Seam at Leichhardt Colliery, Blackwater, Queensland. IN: Proceedings, Australasian Institute of Mining and Metallurgy, no. 277, March, 1981, p. 17-26.

Megascopic and microscopic studies of cleats and mining induced cleavage in the first workings at Leichhardt Colliery revealed the presence of four distinct fracture sets. Microscopic studies confirmed underground observations of the fracture sets.

Keyword(s): coal mining, geologic features, active mines

Location(s): Australia

Hanna, K., K. Haramy, D. Conover. Field Investigations of Roof and Pillar Stability in Coal Mine Intersections. IN: Proceedings 2nd Conference on Ground Control Problems in the Illinois Coal Basin, May 1985, Y.P. Chugh, ed., Southern Illinois University, Carbondale, p. 76-83.

This report describes a rock mechanics instrumentation program conducted in an underground coal mine in central Illinois. This research project was designed to provide a basic understanding of pre- and post-mining roof stresses, pillar loading, strata movement, floor heave, and bolt loading at coal mine intersections. The instrumentation plan, a description of the instruments installed in and around a four-way intersection, and the data obtained during the development of the intersection are presented. Data collected include physical properties of coal and rock, strata lithology, strata movements, in situ stresses, mining-induced stresses, and roof bolt loading. An analysis of observations made and instrumentation results obtained during development and initial monitoring of the intersection is also presented.

Keyword(s): coal mining, rock mechanics, instrumentation, roof stability, roof support, roof bolting, pillar strength, geologic features, geotechnical, in situ testing, mine safety, monitoring methods

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

Hanna, K., D. Conover, P. H. Lu. Integrity Factor Approach to Assess the Stability of Room-and-Pillar Mines. 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. 20-29.

The integrity factor approach was developed by the USBM to assess the stability of mine pillars and has been applied primarily to longwall chain pillars. Recently, this approach was applied to a room-and-pillar mine in the Illinois Coal Basin. A special configuration of hydraulic borehole pressure cells was installed in a pillar to determine the in situ strength-and-stress relationship of the coal pillar and to verify the applicability of the integrity factor approach. Results indicate that the integrity factor approach is applicable to the assessment of pillar stability. The integrity factor approach may be a realistic and effective approach for room-and-pillar mine design.

Keyword(s): room-and-pillar, mine design, monitoring equipment, instrumentation, coal mining, pillar strength

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

Hanna, K., D. P. Conover. Design of Coal Mine Entry Intersections. SME Preprint 88-39, for presentation at SME Annual Meeting, Phoenix, AZ, January 25-28, 1988, 11 p.

This paper describes a method to improve coal mine entry intersection design and considers the effect of in situ stresses, local geologic conditions, rock physical properties, and mining sequence. Development of the method is discussed, including the results of field instrumentation studies and numerical modeling investigations. Ground control studies conducted by the USBM in two underground mines in the Illinois Coal Basin have shown that in situ horizontal stresses and roof geology have a critical effect on intersection stability. Methods to reduce the adverse effects of these parameters are emphasized. Typical failure behavior is presented to illustrate proposed control methods to alleviate adverse ground conditions.

Keyword(s): coal mining, mine design, geologic features, rock mechanics, instrumentation, modeling, roof stability, roof bolting, ground control, horizontal displacement, vertical displacement

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

Hanna, S., P. Corlew, D. Cote. Surface Subsidence Monitoring: Surveying Techniques. 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. 613-622.

The objective of the paper is to describe survey procedures that can be used in least-cost subsidence monitoring systems for mines of various sizes, types, and regions.

Keyword(s): monitoring methods, vertical displacement, horizontal displacement, monitoring equipment, survey equipment, survey methods, survey design, monitoring installation

Location(s): United States

Hannon, J. B., B. E. McGee. Ground Subsidence Associated with Dewatering of a Depressed Highway Section. IN: Subsidence over Mines and Caverns, Moisture and Frost Actions, and Classification, Transportation Research Record 612, F.R. Zwanzig, ed., 1976, National Academy of Sciences, Washington, D.C., 83 p. (NTIS PB 272 844)

Subsidence of land areas adjacent to construction of an interstate highway is reported. Foundation settlements of structures adjacent to a depressed section occurred as a result of pumping groundwater during construction dewatering operations. Preliminary recommendations and actual construction dewatering operations are discussed. The stability of the Sacramento River levee and the possibility of piping during high water were significant factors in planning the dewatering operation.

Keyword(s): roads, hydrology, subsurface water, foundations, fluid extraction

Location(s): California, United States

Hao, Q.-W., Y. P. Chugh. Surface Subsidence Characteristics Resulting from Secondary Mining in an Illinois 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. 285-300.

Surface subsidence characteristics resulting from secondary mining (pillar notching) were studied for three pillar sizes (solid): 70 x 70 feet, 70 x 55 feet, and 55 x 55 fet. Two patterns of subsidence trough were observed: shallow and deep. The former occurred over 70 x 70 feet pillars, and subsidence characteristics were similar to those observed over unnotched areas. Maximum subsidence of about 0.10 feet was observed in this area. The deep trough was observed over the 70 x 55 and 55 x 55 feet pillars. In this case, more than 2 feet of maximum subsidence was observed; about half of which occurred immediately after the development of pillar notches. This quick subsidence was casued by the sinking of the pillars into weak floor strata. Deformations in the deep trough were much larger than those in the shallow trough but still smaller than those due to longwall mining.Surface subsidence was correlated with the pillar settlement.

Keyword(s): pillar extraction, coal mining, active mines, pillar strength, floor stability, partial extraction, room-and-pillar, survey methods, survey design, geologic features, survey equipment

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

Hao, Q.-W., Y. P. Chugh. Potential of a Void Diffusion Model to Predict Longwall Subsidence in the Illinois Coal Basin. IN: Proceedings 9th International Conference on Ground Control in Mining, June 4-6, 1990, S.S. Peng, ed., West Virginia University, Morgantown, p. 199-206.

The authors attempt to apply a simplified non-homogenous void diffusion model (NHVDM) to predict surface subsidence for longwall mining in Illinois. A generalized error function subsidence profile is derived from this model. The model validation indicates that the NHVDM approach appears to fit the observed subsidence data as well or better than the error and the trigonometric functions, particularly around the trough edge areas.

Keyword(s): longwall, coal mining, modeling, overburden

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

Hao, Q. W., W. M. Ma. Void Diffusion Models for Analysis and Prediction of Mine Subsidence. IN: Rock Mechanics Contributions and Challenges: Proceedings 31st U.S. Symposium, Golden, CO, June 18-20, 1990, Balkema, Rotterdam, p. 203-210.

A variety of methods of exist for prediction of surface subsidence over longwall mines. The Void Diffusion Model, based on physical concepts, is developed for conditions in Chinese coal mines. The concept of void diffusion with bulking is introduced. The three physical principles, conservation of void volume, linear void diffusion, and linear void convection are presented and used to derive governing equations. Model validation against field data is shown.

Keyword(s): modeling, prediction, longwall, coal mining

Location(s): China

Hao, Q.-W., Y. P. Chugh, W.-M. Ma. Prediction of Longwall Mine Subsidence Based on a Nonlinear Void Diffusion Model. IN: Proceedings VIII Congress International Society for Mine Surveying, September 22-27, 1991, University of Kentucky, Lexington, UKY BU154, p. 279-282.

In this paper, a nonlinear finite element approach of the void diffusion model is established to predict mine subsidence. The nonlinear characteristic curve of void diffusion coefficient can be estimated from a subsidence profile observed at a half-infinite mining condition. Relationships between the void diffusion coefficient and the subsidence value, which are the bases for nonlinear prediction, were formulated for a Chinese coal field and a United States coal mine.

Keyword(s): modeling, finite element, coal mining, active mines, longwall, prediction
Location(s): China, United States

Hao, Q. W., Y. P. Chugh. An Engineering Approach to Predict Subsidence Likelihood Over Abandoned Coal Mines in Illinois. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 189-196.

In this paper, the authors attempt to develop engineering-based approaches for estimating safety factors against pillar and floor failures and predicting the likelihood of subsidence events over abandoned coal mines in Illinois. There are two critical problems involved in the analysis: determination of geotechnical properties and consideration of time effect. The authors attempt to solve the problems by generating hypotheses, which are then used to modify existing engineering models for estimating pillar and floor safety factors.

Keyword(s): abandoned mines, coal mining, prediction, floor stability, pillar strength, engineering, modeling, geotechnical
Location(s): Illinois, Illinois Coal Basin, United States

Hao, Q.-W., Y. P. Chugh. Subsidence Modeling in Abandoned Coal Mines in Illinois: Implications for GIS-Based Risk Assessment. 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. 353-372.

This paper examines some of the background materials related to mine subsidence problems and subsidence modeling in Illinois. The results of statistical and engineering analyses based on a well developed Abandoned Mine Subsidence Events Database are presented. Finally, the concepts and models of predicting subsidence risk and the implications for GIS-based subsidence risk assessment are suggested.

Keyword(s): abandoned mines, coal mining, modeling, insurance
Location(s): Illinois, Illinois Coal Basin, United States

Harada, K., T. Yamanouchi. Land Subsidence in the Saga Plain, Japan, and Its Analysis by the Quasi-Three-Dimensional Aquifer Model. Geotechnical Engineering, v. 14, no. 1, 1983, p. 23-54.

Keyword(s): surface subsidence damage, modeling, subsurface water, fluid extraction
Location(s): Japan

Haramy, K. Y., J. A. Magers, J. P. McDonnell. Mining Under Strong Roof. 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. 179-194.

Strong roof helps minimize roof fall problems in coal mine entries. The inability of strong roof to cave readily may contribute, however. to major ground control problems in longwall and retreat mining operations. The concern expressed by mine operators prompted this USBM study to analyze the effects of strong roof members on ground stability around longwall openings. The problem was approached from three directions: development of a theory to analyze the strain energy conditions in the coal and surrounding strata, modeling of the effects of different thicknesses and strengths of coal and roof strata, and field instrumentation of powered supports in two longwall mines.

Keyword(s): roof stability, geologic features, coal mining, longwall, high-extraction retreat, modeling, instrumentation, roof support, bumps, rock mechanics, active mines, overburden
Location(s): Colorado, Utah, Rocky Mountain Coal Region, United States

Haramy, K. Y., J. P. McDonnell, L. A. Beckett. Control of Coal Mine Bursts. Mining Engineering, April 1988, p. 263-267.

Dangerously high stress areas can be controlled by proper mine planning and/or destressing. This paper reviews practical methods to detect and destress high-stress zones along coal faces. The USBM investigated stress-related burst problems and destressing efforts at a cooperating mine. Laboratory tests of the drilling yield method for high stress detection were conducted to determine the correlation between the volume of cuttings obtained and the magnitude of the applied stress. A three-dimensional computer modeling program was used to evaluate the effectiveness of stress relief methods.

Keyword(s): bumps, coal mining, mine design, geologic features, computer, modeling, finite element, boundary element, lab testing
Location(s): Rocky Mountain Coal Region, United States

Haramy, K. Y., R. O. Kneisley, B. T. Brady. Analysis of Major Failure Through Integration of Static and Dynamic Rock Mechanics Investigation. IN: Proceedings 7th International Conference on Ground Control in Mining, August 3-5, 1988, S.S. Peng, ed., Morgantown, WV, p. 218-227.

This study reports the unique combination of both static and dynamic instrumentation for monitoring a longwall panel in a deep western coal mine and shows that the two methods used in tandem provide information to understand the causes of a major bump.

Keyword(s): coal mining, instrumentation, monitoring methods, monitoring equipment, monitoring design, longwall, bumps, rock mechanics, geologic features

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

Haramy, K. Y., R. O. Kneisley. Comparative Study of Western US Longwall Panel Entry 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. 125-132.

This paper summarizes ground control studies of longwall panel entry systems in two coal mines in the western United States. Comparisons are presented of in situ pressure change measurements and assessments of chain pillar and entry behavior under a wide range of cover. Results indicate that no one entry system design is universally applicable and that site-specific factors need to be considered for panel entry design. Relationships between overburden depth, face advance, and magnitude and location of the forward abutment are discussed for western operations. In addition, analysis indicates that use of yield pillars may reduce or eliminate some stress-related problems that plague longwall panel entry design.

Keyword(s): longwall, mine design, coal mining, overburden, yielding supports, instrumentation, geologic features, bumps

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

Haramy, K. Y., R. O. Kneisley. Yield Pillars for Stress Control in Longwall Mines--A Case Study. International Journal of Mining and Geological Engineering, v. 8, no. 4, December 1990, p. 287-304.

Yield pillars fail on isolation from the coal seam and allow general lowering of the roof and transfer of overburden load to adjacent panels. Chain pillar behavior in a mine in Utah with a history of bumps in both longwall and room-and-pillar sections is described. Chain pillars generally yield as designed but are influenced by very localized conditions. Chain pillars effectively destress the longwall entries, improve stress control and recover, and reduce bump potential. Pre-longwall experience indicates the presence of a pressure arch having a width that increases with depth.

Keyword(s): yielding supports, pillar strength, longwall, active mines, bumps, ground control, mine design, room-and-pillar, geologic features

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

Haramy, K. Y., W. C. Smith, R. O. Kneisley. Automated Ground Control Monitoring. 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. 227-235.

Ground failures induced by an accumulation of stress near the longwall face have necessitated development of a reliable monitoring system capable of rapidly and effectively receiving, processing, and transmitting rock behavior information. This allows for quick adjustments in mine planning to prevent ground failures. The inclusion of a remotely located, high-speed computer in the monitoring system increases the rate at which data can be collected, processed, and analyzed. The objective of the initial phase of the program was to design an effective automated data monitoring system (ADMS). It consists of a primary, commercially available computer linked to an underground array of pressure sensors installed in and around a working longwall panel. An experimental system is presently operating in a coal mine in the western United States.

Keyword(s): ground control, monitoring methods, monitoring equipment, monitoring design, longwall, mine design, computer, instrumentation, coal mining, mine safety, active mines

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

Harding, S. D. Barite Authigenesis in Illinois Soils. M.S. Thesis, Department of Agronomy, University of Illinois at Urbana-Champaign, 1991, 118 p.

Two similar and adjacent soils in southern Illinois, one with abundant barite and one without, were chosen for this study. The locations were chosen in conjunction with a mine subsidence study over active longwall panels.

Keyword(s): soils, longwall, active mines, hydrology, agriculture, land mitigation

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

Hardy, H. R., R. M. Belesky. Potential Application of Seismic and Acoustic Emission/Microseismic Techniques to the Monitoring of Highway Subsidence. Department of Mineral Engineering, Pennsylvania State University, University Park, June, 1986. (NTIS PB86-232592/WNR)

This report discusses the problem of highway subsidence and considers the possible application of seismic and acoustic emission/microseismic techniques for monitoring such subsidence. A recent monitoring study is referenced. Results are considered to be directly relevant to problems of karst- or mining-induced subsidence.

Keyword(s): roads, geologic features, coal mining, monitoring methods, monitoring equipment, monitoring design, seismic, utilities, instrumentation

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

Hardy, H. R., Jr., L. A. Beck. Microseismic Monitoring of a Longwall Coal Mine. Volume II--Determination of Seismic Velocity. U.S. Bureau of Mines OFR 30(2)-80, by Pennsylvania State University, October 31, 1977, 232 p. (NTIS PB 80-163405)

This is volume 2 of a three-volume report dealing with the microseismic monitoring of a longwall coal mine. The report describes the evaluation of a number of different field techniques and the seismic velocity data obtained at a Pennsylvania mine site. Three different methods were employed to evaluate seismic velocities: surface refraction, downhole, and transmission. In all cases, the seismic sources were either located on surface (mechanical impact) or near-surface (explosive charges). It was found that a mechanical source could be conveniently utilized to determine shallow velocities and make bedrock-regolith interface depth determinations. For deeper velocity determinations, suitable explosive charge sources were required. In general, refraction data did not always plot in a linear manner, and some subjective interpretation was necessary. The downhole method was useful for incremental vertical velocity evaluation; however, the transmission method provided the most consistent average vertical velocity data.

Keyword(s): seismic, monitoring methods, longwall, coal mining, active mines, geophysical, overburden

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

Hardy, H. R., Jr., B. A. Anani, A. W. Khair. Microseismic Monitoring of a Longwall Coal Mine. Volume III--Field Study of Mine Subsidence, Grant G0144013, Pennsylvania State University, U.S. Bureau of Mines OFR 30(3)-80, October 31, 1977, 141 p. (NTIS PB 80-163413. Also available in set of 3 reports: PC E15, NTIS PB 80-163389.)

This is volume 3 of a three-volume report dealing in general with the microseismic monitoring of a longwall coal mine. The research presented was undertaken as part of the overall microseismic project in an effort to relate, if possible, observed microseismic activity with surface subsidence. Field measurements of subsidence carried out at a central Pennsylvania coal mine are described. Comparative analysis of actual field results with data obtained using empirical and finite element techniques was undertaken. Comparison of field results with published NCB data revealed marked differences. The influence of stronger rock beds overlying the coal seam in the current study was assumed to be the main cause. Use of the general Gaussian profile resulted in a satisfactory fit to the field data, provided the value of the maximum field subsidence was used in the analysis. In general, when low tensile strengths were assumed for the associated rocks, finite element techniques gave results that compared well with the field data. The study also indicates that, at shallow depths, there is a marked difference in subsidence over dip and rise sides of the coal face, maximum subsidence shifts more towards the dip side. Finally, time-dependent formations were insignificant shortly after mining operations ceased.

Keyword(s): seismic, longwall, monitoring methods, coal mining, survey methods, finite element, empirical model, National Coal Board, overburden, active mines

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

Hardy, H. R., Jr., G. L. Mowrey, E. J. Kimble, Jr. Microseismic Monitoring of a Longwall Coal Mine. Volume 1--Microseismic Field Studies, Pennsylvania State University, U.S. Bureau of Mines OFR 30(1)-80, August 31, 1978, 320 p. (NTIS PB 80-163397)

This is volume 1 of a three-volume report on the microseismic monitoring of longwall coal mines. Volume 1 deals mostly with the detailed aspects of the microseismic field study; however, brief references are made to other secondary studies described in volumes 2 and 3. During the field study, a mobile microseismic monitoring facility and associated transducers were employed to detect and record microseismic activity above a longwall panel in Pennsylvania. The fundamental objectives of the study were (1) to evaluate the feasibility of detecting microseismic activity originating from longwall mining operations using an approximately planar, near-surface, geophone array installed above the longwall and (2) to attempt to locate the sources of various microseismic events. The investigation proved that, using the techniques developed, it is possible to detect microseismic events at depths of more than 400 feet and at horizontal distances in excess of 800 feet from the source. The majority of the events had frequencies on the order of 10 to 100 Hz, and particle velocities of 50 to 300 microips. When a suitable velocity model was used, most of the events located were computed to be within 100 feet vertically of the coal seam and 50 feet horizontally of the longwall face.

Keyword(s): seismic, longwall, coal mining, monitoring methods, geophysical, overburden, active mines

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

Hardy, W. Removing Pillars in Coal Mines. Mining World, v. 26, March 9, 1907, p. 334-335.

This paper discusses backfilling, removing pillars under surface water, and management of water in mines.

Keyword(s): surface water, pillar extraction, backfilling, mine operation, coal mining

Location(s): United States

Hares, S., J. Silar. Application of Isotope Techniques and Well Logging in Investigating Ground Water Influenced by Mining. IN: Proceedings 1st World Congress of Water in Mining and Underground Work--SIAMOS, September 18-22, 1978, Granada, Spain, R. Fernandez-Rubio, ed., p. 199-206.

Keyword(s): hydrology, subsurface water

Location(s): Czechoslovakia

Hargraves, A. J., ed. Subsidence in Mines. Proceedings 4th Annual Symposium on Subsidence in Mines, Wollongong, Australia, February 20-22, 1973, Illawarra Branch, Australasian Institute of Mining & Metallurgy, 110 p.

Topics cover prediction methods, monitoring techniques, mine design, hydrological effects, and structural problems as related to mine subsidence.

Keyword(s): vertical displacement, horizontal displacement, surface structural damage, subsurface structural damage, surface water, subsurface water, mine design, monitoring design, monitoring installation, survey methods, survey equipment, survey data processing, prediction theories, monitoring methods

Location(s): Australia, England, United States

Harlow, E. H., P. Weaver. Land Subsidence Problems--Discussion. IN: Proceedings, ASCE Journal Surveying and Mapping Division, v. 89, no. SU3, 1963, p. 217-223.

Keyword(s): fluid extraction

Location(s): United States

Harper, D. Mine Subsidence in Indiana. Department of Natural Resources, Geological Survey Special Report 27, Bloomington, IN, 1982, 17 p.

This publication reviews past and present mining practice and subsidence problems in southwestern Indiana.

Keyword(s): coal mining, abandoned mines, active mines, room-and-pillar, historical

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

Harris, A. G. Stabilization and Filling of Abandoned Deep Coal Mines in the Mahoning Valley of Ohio. IN: Proceedings 88th Annual Meeting Ohio Academy of Science, Tiffion, April 20-22, 1979 (abstract only), Ohio Journal Science, v. 79, p. 26. (NTIS Accession No. 79-26227)

Keyword(s): abandoned mines, coal mining, backfilling, engineering, reclamation, environment

Location(s): Ohio, United States

Harris, F. K. C. Town and Country Plannings. Colliery Guardian, v. 178, January 27, 1949, p. 139-143; v. 178, February 10, 1949, p. 178-180.

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

Location(s): England

Harrison, V., G. D. Fyles. Observations on a Three Dimensional Approach to Mining Subsidence. IN: Proceedings 23rd Annual Conference Engineering Group of the Geological Society, Engineering

Geology of Underground Movements, University of Nottingham, September 13-17, 1987, p. 273-285.

The National Coal Board Subsidence Engineers Handbook, first published in 1965, enables rapid subsidence prediction at a given site. Its widespread acceptance has led to ground movement being described by vertical lowering and lateral strain. Subsidence is not, however, merely a two-dimensional phenomenon. The implications of ground movement in three dimensions are examined using the subsidence model of Burton (1984).

Keyword(s): prediction, prediction theories, National Coal Board, vertical displacement, horizontal displacement, modeling, coal mining

Hart, P. A. Investigations into the Role of Groundwater in Promoting Floor Heave in Coal Mine Gateroads. 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 geological environment of two South Wales collieries at which site investigations were carried out is summarized. This is followed by a review of identified geological parameters and their effects on floor heave under the headings of discontinuities, mineralogy, and groundwater. Methods of underground site investigation, laboratory testing, and data treatment are summarized. The effect of an increase of groundwater content on mechanical parameter values was quantified for laboratory tested rock cores and in situ interbedded strata sections. The extent to which groundwater affects floor heave was found to be controlled by the mineralogical and structural nature of the floor strata.

Keyword(s): coal mining, floor stability, lab testing, geologic features, subsurface water, hydrology, in situ testing, rock mechanics, overburden

Location(s): Wales, United Kingdom

Hart, P. A. Application of Lithic and Structural Geological Data to the Assessment of Ground Stability Above Shallow Abandoned Coal Mines. 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. 137-149.

Borehole log data gathered during a subsidence investigation in 1978-1979 were used to derive a classification scheme for coal measure rocks. The results of height of void migration above workings were compared to those arising from use of Piggot & Enyon's (1977) geometrical collapse zone method and Bieniawski's (1980) Rock Mass Rating scheme. It was concluded that the analysis helps to assess areas of greatest instability, which thus aids land-use planning and also the planning of ground investigations, ground stabilization, and re-development.

Keyword(s): coal mining, geologic features, abandoned mines, land-use planning, surface structural damage, room-and-pillar

Location(s): Wales, United Kingdom

Hart, S. S. History and Evolution of Mining and Mining Methods. 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. 25-37.

The underground coal mines that are currently of concern to subsidence professionals in Colorado were generally mined between 1860 and 1960. Careful study of dates of mining, production records, mine maps, and interviews with former miners can aid in predicting current mine conditions.

Keyword(s): historical, abandoned mines, room-and-pillar, coal mining

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

Hartman, H. L., ed. Proceedings of the Fourth Symposium on Rock Mechanics, March 30, 31, and April 1, 1961. Bulletin 76 of the Mineral Industries Experiment Station, November, 1961, Pennsylvania State University, University Park.

Keyword(s): rock mechanics, modeling, pillar strength, ground control

Hartmann, I., H. P. Greenwald. Effect of Changes in Moisture and Temperature on Mine Roof, First Report on Strata Overlying the Pittsburgh Coal Bed. U.S. Bureau of Mines RI 3588, October, 1941, 40 p.

The objectives of the work described in this report were to determine the relative importance of humidity and temperature changes on the expansion and contraction of mine-roof rock samples; to determine the stresses that might result from such expansions and contractions and to

correlate this information with the physical properties of the rocks; to determine the expansion and disintegration of rocks immersed in water; and to study the effectiveness of paints and cement coatings in reducing absorption of moisture.

Keyword(s): coal mining, roof stability, mine safety, lab testing, mine operation

Location(s): Appalachian Coal Region, United States

Harza Engineering Co. Comprehensive Ground Control Study of a Mechanized Longwall Operation. Final Report-Volume 1, Contract H0230012, U.S. Bureau of Mines OFR 5(1)-77, 1976, 151 p. (NTIS PB 262 475)

Keyword(s): longwall, ground control, coal mining

Location(s): United States

Harza Engineering Co. Comprehensive Ground Control Study of a Mechanized Longwall Operation. Final Report-Volume II, Contract H0230012, U.S. Bureau of Mines OFR 5(2)-77, 1976, 270 p. (NTIS PB 262 476)

Keyword(s): longwall, coal mining, ground control

Location(s): United States

Hasenfus, G. J., K. L. Johnson, D.W.H. Su. A Hydrogeomechanical Study of Overburden Aquifer Response to Longwall Mining. IN: Proceedings 7th International Conference on Ground Control in Mining, Morgantown, WV, August 3-5, 1988, S.S. Peng, ed., West Virginia University, p. 149-162.

This paper presents the results of an extensive hydrological and geomechanical monitoring program that was conducted at a longwall coal mine in West Virginia. The field program included monitoring of groundwater levels, overburden hydraulic conductivity, overburden movement, and surface subsidence relative to the passage of the longwall. Overburden geology and rock strength characteristics were evaluated prior to mining. A postmining corehole was drilled to evaluate main roof fracturing. An overburden response model is proposed based on the correlations between hydrological and geomechanical data.

Keyword(s): overburden, hydrology, subsurface water, geologic features, rock mechanics, roof stability, modeling, longwall, coal mining, surface subsidence damage, instrumentation, survey methods, vertical displacement, survey equipment, monitoring methods, monitoring equipment, monitoring installation, monitoring design, seismic, geophysical, finite element

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

Hatheway, A. W. Engineering Geology of Subsidence at San Manuel Mine. Mining Engineering, 1964, v. 16, p. 92.

Keyword(s): metal mining, engineering

Location(s): Arizona, United States

Hatheway, A. W. Engineering Geology of Subsidence at San Manuel Mine, Pinal County, Arizona. M.S. Thesis, 1966, University of Arizona, Tucson, 110 p.

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

Location(s): Arizona, United States

Hatheway, A. W. Subsidence at San Manuel Copper Mine, Arizona. IN: Southern Arizona Guidebook 3, Geological Society of America, Cordilleran Section, 64th Annual Meeting, 1968, Arizona Geological Society,Tucson, p. 113-124.

Keyword(s): metal mining

Location(s): Arizona, United States

Hatheway, A. W. Subsidence at San Manuel Copper Mine, Pinal County, Arizona. IN: Engineering Geology Case Histories, G.A. Kiersch, ed., Geological Society of America, 1968, no. 6, p. 65-81.

Keyword(s): metal mining

Location(s): Arizona, United States

Hatheway, A. W. Subsidence at San Manuel Copper Mine, Arizona. Geological Society of America Special Paper 121, 1969, p. 511.

Keyword(s): metal mining

Location(s): Arizona, United States

Hatton, T., J. E. Turney. Annotated Bibliography of Subsidence Studies Over Abandoned Coal Mines in Colorado. Colorado Geological Survey Information Series 22, Department of Natural Resources, Denver, CO, June, 1989, 123 p.

This bibliography is a compilation of data on coal mine subsidence studies along the Front Range of Colorado. The information contained within can be used to facilitate further study of undermined areas subject to increased development pressure from Colorado's growing population. Specific mine investigation studies were obtained from private consultants and public sources. Many of these

reports are available for review in the offices of the Colorado Geological Survey and the Division of Mined Land Reclamation.

Keyword(s): coal mining, abandoned mines, literature search, historical, land-use planning, land mitigation, reclamation, surface structural damage

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

Hawkins, A. B., D. Tomlinson. Planning and Construction of an Industrial Site on the Bristol 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. 439-446.

This paper examines the progress of a large industrial/retail development on the Bristol Coalfield, from the planning stage through the site investigation to the construction phase. The planning history of the site, the local geology, and the history of mining in the area are reviewed. In localized areas, the ground had subsided by as much as 1.5 m.

Keyword(s): land-use planning, construction, abandoned mines, coal mining

Location(s): United Kingdom

Hawkins, A. B., S. Morley, T. S. Swainson, D. M. Tyson. Don Valley Stadium, Sheffield, UK. 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. 283-301.

This paper discusses the design and construction of a new sports stadium in an area where abandoned mines were present. The investigations for and treatment of the old mine workings form the main emphasis of the paper. The ground problems were exacerbated by the presence of the Kirkbridge Dike across part of the site and the lack of adequate records of past mining, particularly in a near-surface high quality seam. Excavation of soft ground identified during one of the rigorous formation inspections located a series of tunnels leading from an adit that had not been apparent at the time of grouting.

Keyword(s): abandoned mines, coal mining, land-use planning, structural mitigation, backfilling, grouting, engineering, construction, architecture, foundations, land values

Location(s): United Kingdom

Hay, W. Damage to Surface Buildings Caused by Underground Workings. Transactions, Institute of Mining Engineers, London, v. 36, 1908, p. 427-436; v. 37, 1909, p. 354-355, 647-648.

Keyword(s): surface structural damage

Haycocks, C., J. M. Townsend, G. M. Neall, L. P. Johnson. Design Optimization in Underground Coal Systems: Section 1. Structural Parameters of Coal Measure Rocks. Section 2. Longwall Mining System Strata Simulator. Section 3. Design Criteria for Underground Roof-Truss Support Systems. Interim Report, April-June 1977. Virginia Polytechnic Institute and State University, Blacksburg, DOE Contract/Grant EX-76-C-01-1231 report, December, 1977, 52 p. (NTIS FE-1231-9)

Research in areas related to coal mining is described. Computer programs related to longwall mining were developed and tested. Sampling and testing of coal specimens was performed, especially with respect to the effects of size and shape (cylinder versus cube) of the specimens on the measured properties. Loading rate was found to be of significance. The literature of supports in underground mining was reviewed, especially with respect to roof bolts and roof trusses.

Keyword(s): coal mining, active mines, rock mechanics, longwall, computer, modeling, roof bolting, roof support, room-and-pillar, in situ testing

Location(s): Alabama, United States

Haycocks, C., C. D. Breeds. Design Optimization in Underground Coal Systems. Interim Report, January--March, 1978. Report on U.S. DOE Contract/Grant EX-76-C-01-1231, Virginia Polytechnic Institute and State University, Blacksburg, June, 1978, 58 p. (NTIS FE-1231-12)

Research in the planning and simulation of longwall mining is reported. The mechanical properties of coal were studied with respect to the size and shape of the specimen and the loading rate. Finally, the potential of roof trusses as roof supports was studied with respect to design and properties by the use of photoelastic models, computer calculation, and field experience with trusses instrumented with strain gages.

Keyword(s): coal mining, active mines, longwall, modeling, rock mechanics, roof support, computer, instrumentation, monitoring equipment, in situ testing

Location(s): United States

Haycocks, C., C. D. Breeds. Design Optimization in Underground Coal Systems. Interim Report, October--December 1977. Virginia Polytechnic Institute and State University, Blacksburg, DOE Contract/Grant EX-76-C-01-1231 report, March, 1978, 54 p. (NTIS FE-1231-11)

Results of measurements of the mechanical properties of coal samples are summarized. Some dependence of measured strength on the loading rate was found. Information and computer programs were developed for longwall mining simulation and economic analysis. Roof truss type supports were studied further by theory, photoelastic models, and experimental and field data.

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

Location(s): United States

Haycocks, C. Design Optimization in Underground Coal Systems. Sections 1--4. Interim Report, January--March 1979. Virginia Polytechnic Institute and State University, Blacksburg, DOE Contract/Grant EX-76-C-01-1231 report, June 1979, 66 p. (NTIS FE-1231-16)

This report describes work on a longwall simulator with a detailed examination of the potential for utilizing a roof characterization factor in the estimation of roof stability. The benefits of this approach are a much more realistic evaluation of roof conditions and, therefore, a more accurate prediction of strata responses during underground mining. The report includes the theory, modeling method, experimental and field data, and data analysis and correlation; it also includes development and maintenance of computer programs used in the work.

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

Location(s): United States

Haycocks, C., M. Karmis, E. Topuz. Optimizing Productive Potential in Multi-Seam Underground Coal Mining. IN: Coal Conference & Expo VI, McGraw-Hill, 1981.

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

Haycocks, C., M. Karmis, B. Ehgartner. Multiple Seam Mine Design. IN: State-of-the-Art of Ground Control in Longwall Mining and Mining Subsidence, Y.P. Chugh and M. Karmis, eds., 1982,, SME-AIME, p. 59-65.

Considerable valuable experience in multi-seam mining comes from British mining operations where interaction problems are common and the longwall is the primary method used. Limitations persist in the application of much of this information to conditions in the United States because of variation in layouts between advancing and retreating longwall systems and the inherent differences in the geologic environment. Field data are available for room-and-pillar operations in the United States and, where successful pillaring operations have been carried out, close parallels may be drawn with ground control mechanisms in longwall operations.

Keyword(s): multiple-seam extraction, longwall, ground control, mine design

Location(s): United States, United Kingdom

Haycocks, C., M. Karmis, E. Barko, J. Chaman, S. Hudock, B. Ehgartner, S. Webster. Ground Control Mechanics in Multiple-Seam Mining. U.S. Bureau of Mines OFR 7-84, 1984.

Keyword(s): ground control, multiple-seam extraction

Location(s): United States

Haycocks, C., W. Wu, Y. Zhou. Integrated Design for Stability in Multiple-Seam Mining. IN: Eastern Coal Mine Geomechanics, Proceedings, Bureau of Mines Technology Transfer Seminar, Pittsburgh, PA, November 19, 1986, U.S. Bureau of Mines IC 9137, p. 44-56.

Research into ground control problems resulting from mining in a multiple-seam environment has been carried out using statistical analysis, numerical modeling, and body-loaded multilayer photoelastic analysis in conjunction with numerous case studies. Findings demonstrate situations under which the worst ground control conditions can be expected to occur for a specified geologic environment, depth, innerburden spacing, and mining geometry. Special emphasis has been placed on the effect of upper pillar load transfer on the lower seam in terms of pillar and floor stability and roof control.

Keyword(s): geologic features, ground control, multiple-seam extraction, modeling, mine design, computer, finite element, prediction

Location(s): Appalachian Coal Region, United States

Haycocks, C., Y. Zhou. Multiple-Seam Mining--A State-of-the-Art Review. IN: Proceedings 9th International Conference on Ground Control in Mining, June 4-6, 1990, S.S. Peng, ed., West Virginia University, Morgantown, p. 1-11.

The relevant literature concerning ground control, mine planning, and reserve conservation in multi-seam mining is reviewed. Factors affecting interaction, interaction mechanisms, and design guidelines are presented in detail. The impact of multi-seam mining on future mining, measures for ameliorating negative interaction effects, and future research needs are also discussed.

Keyword(s): multiple-seam extraction, ground control, longwall, room-and-pillar, coal mining, time factor, pillar strength, overburden, geologic features

Haycocks, C., M. Karmis. Subsidence Effects in Multiple Seam Mining. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, June 1-4, 1992, S.S. Peng, ed., Morgantown, WV, p. 94-99.

Subsidence induced innerburden shearing and stress fields, whether active or passive, frequently contribute to significant ground control failures in overlying seams. In this paper, proven multi-seam technology is used on upper seams to forecast and quantify the magnitude and severity of damage and the increased mining risk due to interaction. Increased upper seam ground control problems are demonstrated using hazard mapping, which provides a viable technique for utilizing damage predictions in design.

Keyword(s): multiple-seam extraction, overburden, prediction, ground control, active mines, abandoned mines, mine design, geologic features

Location(s): United States

Hayes, G. R., Jr. Stresses Imposed on a Pipeline by Longwall Mining. IN: American Gas Association, Operating Section Proceedings, No. 80-T-65, 1980, p. T-309--T323.

This paper discusses the results of a testing program being conducted by Columbia Gas Transmission Corporation to determine the effects and behavior of its LINE 20 pipeline while under the influence of ground subsidence caused by longwall mining. LINE 20 is a continuously welded 12-3/4" O.D. x 0.250" wall steel pipeline, with a Specified Minimum Yield Strength of 42,000 PSI. Maximum Allowable Operating Pressure is 617 PSIG. The total longwall mining operation consists of seven panels, four of which are directly beneath the pipeline. Each panel to be longwall mined is approximately 650 feet wide and approximately 5,000 feet long. The coal seam varies in thickness from 64 to 68 inches, with a horizontal slope of essentially 0 degrees. The depth of the coal varies from 800 to 1,000 feet from the surface.

Keyword(s): coal mining, pipelines, longwall, utilities, monitoring methods, monitoring equipment, vertical displacement, horizontal displacement, survey data processing

Location(s): United States

Hazen, G. A. Practical Pillar Design Problem Encountered Under Deep Cover and with Different Block Geometric Pillar. U.S. Bureau of Mines OFR 75-77, Grant No. GO144139, 1975. (NTIS PB-266705)

Keyword(s): pillar strength

Location(s): United States

Hazen, G. A., S. M. Sargand. The Effect of Longwall Mining on Surface Subsidence of Highways and Bridges. Final report to Ohio Department of Transportation by Ohio University, Athens, College of Engineering and Technology, Civil Engineering, November, 1985, 142 p.

For this study subsidence profiles over three longwall panels mined beneath state highways in southeastern Ohio were measured. The average maximum subsidence was 3.5 feet. The average maximum compressive strain recorded was 0.008 in./in. Three predictive methods for the determination of displacements and strains were compared: the National Coal Board graphical method, the profile method with empirical constants determined for southeastern Ohio, and a finite element program. Excellent subsidence agreement was found with the profile method, and reasonable strain agreement was determined with the finite element model.

Keyword(s): rock mechanics, longwall, coal mining, roads, surface structural damage, prediction, prediction theories, National Coal Board, profile function, finite element

Location(s): Ohio, United States

Hazen, G. A., S. M. Sargand. The Effect of Longwall Mining on Surface Subsidence of Highways and Bridges. SME-AIME Preprint 87-10, for presentation at the SME Annual Meeting, Denver, CO, February 24-27, 1987, 6 p.

Predictions of structural damage from high-extraction mining are dependent on the magnitude of the expected horizontal strains. Three methods for predicting subsidence characteristics are considered in this paper: the graphical method, the profile method, and the finite element method.

Keyword(s): roads, prediction theories, empirical model, finite element, profile function, geologic features, rock mechanics, computer, coal mining

Location(s): Ohio, United States

Hazen, G. A., S. M. Sargand. Methods for Assessing Effects of Longwall Mining on Surface Subsidence. Mining Engineering, June, 1988, p. 451-454.

This study monitored longwall mining subsidence profiles over three panels mined beneath state highways in southeastern Ohio. The average maximum subsidence was 1.07 m (3.5 feet). The average maximum compressive strain recorded was 0.008 mm/mm. Three predictive methods for the determination of displacements and strains were compared: the National Coal Board (NCB) graphical method, the profile method with empirical constants determined for southeastern Ohio, and a finite element excavation program. Excellent subsidence agreement was found with the profile method, and reasonable strain agreement was determined with the finite element program.

Keyword(s): longwall, finite element, National Coal Board, modeling, coal mining, prediction, surface structural damage, geologic features, overburden, lab testing, in situ testing, rock mechanics, geotechnical, elastic model, phenomenological model, profile function, empirical model, roads

Location(s): Ohio, United States

Hazine, H. I. A Study of the Surface Strains Produced by Mining Subsidence. Master's Thesis, University of Nottingham, U.K., 1977.

Keyword(s): surface subsidence damage, survey data processing, horizontal displacement

Location(s): United Kingdom

He, G., T. H. Wilson. Changes in the Seismic Properties of the Cover Produced by Longwall 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. 327-334.

Common offset seismic data collected over two active longwall panels at different stages of mining reveal that significant arrival time delays are produced in reflections from different levels within the mine cover. Mining-induced arrival time delays are also observed beyond the edges of the mine over unmined areas. Reflection arrival time delays increase with reflector depth and are laterally variable. The arrival time delays are produced by reductions of seismic velocity within the overburden. Reflection arrival time delays from a major strong unit located neutrally within the cover are proportional to subsidence; however, delays in other events are not.

Keyword(s): longwall, active mines, overburden, coal mining, seismic, modeling, geophysical

Location(s): United States, Appalachian Coal Region

He, G., T. H. Wilson. Longwall Mine Subsidence and its Effect on Seismic Properties of the Overburden. IN: Society Exploration Geophysics 59th International Meeting and Exposition, October 29-November 2, 1989, Dallas, Extended Abstracts, p. 368-371.

Common offset seismic data collected over an active longwall panel at different stages of mining reveal that significant arrival time delays occur for reflections from different intervals within the overburden. Subsidence correlates best with arrival time delays observed for a reflection from a thick sandstone located neutrally within the overburden. Mining-induced arrival time delays are also observed beyond the edges of the panel over unmined areas. These delays are produced by mining induced reductions of seismic velocity within the overburden.

Keyword(s): longwall, seismic, overburden, coal mining, geophysical, monitoring methods

Location(s): Appalachian Coal Region, United States

He-yuan, S. Mechanism of Land Subsidence and Deformation of Soil Layers in Shanghai. 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. 425-433.

This paper, based on an analytical study of data collected from in situ observations and laboratory experiments, endeavours to expound the mechanism of land subsidence and the rule of deformation of the soil layers in Shanghai. Particular mention is made of a close analysis of the unit deformation, which reveals that the values of deformation of the soil layers can be readily evaluated by normalizing the observed deformation of different soil strata according to the range of variation of the groundwater table and that the characteristics of the residual deformation of

various soil strata can be observed in terms of the ratio between rebound and compression.

Keyword(s): soils, fluid extraction

Location(s): China

Healy, P. R., J. M. Head. Construction Over Abandoned Mine Workings. Construction Industry Research and Information Association Special Publication 32/Property Services Agency Civil Engineering Technical Guide 34, London, 1984, 94 p.

This is a guide for engineers planning the development of undermined sites. It describes British mining methods of the past and present, as well as giving techniques for consolidation of old mine workings and foundation design options.

Keyword(s): construction, foundations, abandoned mines, engineering, surface structural damage, geotechnical, longwall, room-and-pillar, National Coal Board, backfilling, grouting, historical

Location(s): England, Scotland, Wales

Heasley, K. A., L. W. Saperstein. Practical Subsidence Prediction for the Operating Coal 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. 54-67.

The purpose of this paper is to present and demonstrate a subsidence-predictive method (SPASID) that can be functionally used by the practicing mining engineer. Such a method will hopefully give the coal operator and mining engineer additional flexibility necessary to protect the surface from subsidence damage.

Keyword(s): prediction, coal mining, mine design, prediction theories, empirical model, influence function

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

Heasley, K. A., L. W. Saperstein. Computer Modeling of the Surface Effects of Subsidence Control Methods. 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. 189-196.

This paper details the development and application of a system for modeling the effects of subsidence control methods on surface subsidence over longwall coal panels. The term "subsidence control methods" as used in this paper should be understood to cover coal pillars, packwalls or any backfills used to support the mine roof and to limit the effects of surface subsdience. The work began by choosing an appropriate subsidence predictive method on which to superimpose the effects of different control schemes.

Keyword(s): modeling, empirical model, prediction, computer, longwall, influence function, finite element, backfilling, ground control

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

Heasley, K. A., L. W. Saperstein. An Investigation Into the Use of Backfill Zones and Yielding Pillars for Subsidence Control. IN: Mine Subsidence, Society of Mining Engineers Fall Meeting, September, 1986, M.M. Singh, ed., St. Louis, MO, SME, Littleton, CO, p. 19-27.

This paper investigates the use of backfill zones and yielding pillars for subsidence control. The investigation begins by choosing an appropriate subsidence predictive technique to simulate the proposed subsidence-control schemes. Two case studies are performed in order to delineate the accuracy and utility of the chosen predictive technique. The results of these case studies are then used to establish appropriate sets of regional site parameters. Next, a detailed analysis of the major variables affecting the outcome of the subsidence-control simulations is conducted and graphical displays of the exact sensitivity of the surface subsidence to these variables are given.

Keyword(s): backfilling, yielding supports, coal mining, computer, prediction, prediction theories

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

Heasley, K. A., L. W. Saperstein. Recent Insight into Longwall Strata Movements Deduced from Subsidence Analysis. Mining Engineering, v. 39, no. 7, September 1987, p. 872-876; also SME Fall Meeting preprint 86-331, 1986.

A number of novel hypotheses are developed that provide a fresh perspective on the characterization of strata movements associated with longwall mining. Subsidence measurements are analyzed with an influence-function-based computer program. Using an inverse application of the traditional influence-function technique, easily obtained surface displacements are used to analyze some of the complicated, expensive, and difficult-to-measure movements of the intermediate roof strata in a longwall panel.

Keyword(s): coal mining, roof stability, longwall, influence function, empirical model, computer, vertical displacement

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

Heasley, K. A., K. Barron. A Case Study of Gate Pillar Response to Longwall Mining in Bump-Prone Strata. IN: Proceedings Longwall USA Conference, 1988, Pittsburgh, PA, p. 91-105.

Keyword(s): pillar strength, bumps, longwall

Heathcote, F. W. L. Movement of Articulated Buildings on Subsidence Sites. IN: Proceedings Institute of Civil Engineers, v. 30, February, 1965, p. 347-368.

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

Hedley, D.G.F. An Evaluation of Roof Stability at a Canadian Salt Mine. IN: Fifth International Strata Control Conference, London, no. 30, 1972, 6 p.

Keyword(s): roof stability, non-metal mining, ground control

Location(s): Canada

Hellewell, E. G. The Influence of Faulting on Ground Movement Due to Coal Mining: The UK and European Experience. The Mining Engineer, January, 1988, v. 316, p. 334-337.

Keyword(s): geologic features, coal mining

Location(s): United Kingdom, Europe

Helm, D. C. Field-Based Computational Techniques for Predicting Subsidence Due to Fluid Withdrawal. IN: Man-Induced Land Subsidence, Reviews in Engineering Geology VI, The Geological Society of America, 1984, T.L. Holzer, ed., p. 1-22.

Choice of a predictive technique for land subsidence is based on the availability of appropriate field data. If only the depth and thickness of compressible beds can be estimated, a simple hand calculation is available as a predictive technique and for many purposes is adequate.

Keyword(s): fluid extraction, prediction, modeling

Location(s): California, Texas, United States, New Zealand

Helmhacker, R. Land Subsidence at Brux, Bohemia. Transactions Institute of Mining Engineers, London, v. 10, 1895-96, p. 583.

Keyword(s): surface subsidence damage

Location(s): Europe

Henry, F. D. C. Structures Liable to the Effects of Mining Subsidence. IN: The Design and Construction of Engineering Foundations, McGraw-Hill, 1956, Chapter 9, p. 392-412.

The chapter discusses the mechanics of mine subsidence, effects of subsidence on structures, as well as subsidence due to mining of material other than coal, and construction considerations to offset the effects of subsidence.

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

Henry, J. J. The Geological Input Into Land-Use Planning in Lothian Region, Scotland. 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. 583-587.

The paper describes the geological input into the land-use planning system at both strategic and local levels in relation to the stability of land and minerals required by the extractive industries.

Keyword(s): land-use planning, geologic features, coal mining, abandoned mines, government, law

Location(s): Scotland, United Kingdom

Henshaw, H., D. W. Phillips. Underground and Surface Strata Movements. Transactions Institute Mining Surveyors, 1942, v. 22, no. 2.

Keyword(s): surface subsidence damage, subsurface subsidence damage, overburden

Herbert, C. A., J. J. Rutledge. Subsidence Due to Coal Mining in Illinois. U.S. Bureau of Mines Bulletin 238, 1927, 59 p.

In 1916, the USBM, Illinois Geological Survey, and University of Illinois, working under a cooperative agreement, began an investigation of the subsidence of the surface above coal-mining operations. Four widely separated places where mining was in progress were selected as observations stations: one in the northern Illinois longwall coal field, one in the central Illinois coal field where the room-and-pillar panel system of mining was being used, and two in the thick coal of southern Illinois where the room-and-pillar panel system of mining was employed. These four points of mining activity gave a rather wide opportunity for observing subsidence when different mining methods were used.

Keyword(s): horizontal displacement, ground control, descriptive theories, backfilling, room-and-pillar, coal mining, historical, subsidence research, surface structural damage, geologic features

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

Herd, W. The Suggested Application of Hydraulic Stowing to Undersea Coal Workings, with Special Reference to the Sydney Coalfield. Canadian Institute of Mining and Metallurgy, Bulletin No. 103, November, 1920, p. 835-845.

Although at the time (1920) the hydraulic stowing of mines to minimize subsidence was used successfully in Europe, South Africa, and Australia, the English-speaking countries were slow to adopt this method.

Keyword(s): hydraulic backfilling, stowing, angle of draw, historical, surface water, coal mining

Location(s): Poland, Europe, Australia, United States

Herring, J. R., S. B. Roberts, R. G. Hobbs. Characterization of Extent of Mining, Mine Fire, and Subsidence: A Case Study at Marshall, 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. 39-80.

Several of the abandoned underground coal mines located near Marshall, Colorado (in the Boulder-Weld Coalfield), were studied to characterize the possibility of subsidence and the hazard posed by those mines, including the few that are on fire.

Keyword(s): abandoned mines, mine fires, surface structural damage, utilities, pipelines, surface water, historical, remote sensing, photography, survey design, survey methods, monitoring design, monitoring methods, coal mining

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

Herring, J. R. Geologic Road Log from Denver Federal Center to Marshall, Colorado. A Visit to the Boulder-Weld Coal Field and Some Considerations of Burning, Subsiding Coal 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, (appendix) p. 299-315.

The author describes a field trip in the Denver area, focusing primarily on the hazards and problems of land use associated with abandoned underground coal mines and their potential for subsidence and spontaneous combustion.

Keyword(s): abandoned mines, land-use planning, mine fires, surface subsidence damage, coal mining

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

Herron, T. J. The Detection and Delineation of Subsurface Subsidence by Seismic Methods. Thesis, Geophysics Department, Michigan College of Mines and Technology, 1956.

Keyword(s): seismic, subsurface subsidence damage, geophysical

Location(s): United States

Herwig, H. The Effect of Rock Pressure on Roof Conditions in the Face. Glueckauf, v. 117, no. 21, 1981, p. 1419-1423.

Keyword(s): roof support, roof stability

Hesse, A. W. What Shall We Use for Roof Support in Coal Mines? Coal Age, v. 5, February 28, 1914, p. 354.

This article compares the advantages and disadvantages of oak, pine, chestnut, T-rails, and I-beams.

Keyword(s): roof support, coal mining, historical

Hesse, A. W. The Facts About Draw. Coal Age, v. 63, September, 1958, p. 98-100.

Keyword(s): angle of draw, coal mining

Hetzler, R. T., R. G. Darmody, F. W. Simmons, S. D. Harding. Coal Mine Mitigation: Effectiveness for Agricultural Restoration. IN: Agronomy Abstracts, American Society of Agronomy 81st Annual Meeting, October 15-20, 1989, Las Vegas, NV, p. 37.

A study was initiated in 1988 to evaluate the effectiveness of current methods for mitigation of coal mine subsidence damage for restoring agricultural productivity. Soil and crop samples from 13 mitigated areas were compared to nearby reference areas. Soil texture, bulk density, moisture, and fertility were analyzed. There were no detectable differences in yields between reference and mitigated sites in 1988 despite differences in soil parameters. The unusually dry weather in 1988 may have influenced the results. The research is being continued to eliminate weather as a variable.

Keyword(s): mitigation, coal mining, agriculture, land mitigation, soils, active mines

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

Hetzler, R. T., R. G. Darmody, F. W. Simmons. Evaluation of Soil Physical Parameters from Mitigated and Undisturbed Cropland. IN: Agronomy Abstracts, American Society of Agronomy/Soil Society of America 82nd Annual Meeting, San Antonio, TX, October 21-26, 1990, p. 39.

Underground coal mining in southern Illinois causes surface land subsidence that can affect crops by disrupting water drainage. Affected areas have been mitigated by cutting drainage ditches, adding fill material, or both. Soil physical properties from mitigated farmland and nearby undisturbed areas were studied.

Keyword(s): agriculture, soils, land mitigation, coal mining, longwall, active mines, hydrology

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

Hetzler, R. T., R. G. Darmody. Coal Mine Subsidence Mitigation: Effects on Soil and Crop Yields. 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. 129-135.

The objective of this study was to test the effectiveness of mitigation in restoring grain yields to their pre-mined levels. Seventeen sites in Jefferson and Franklin Counties in Illinois were selected for the 4-year study. The sites represented conventional mitigation techiques on the predominate soils in the area.

Keyword(s): land mitigation, agriculture, active mines, coal mining, soils

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

Hetzler, R. T. Coal Mine Subsidence Mitigation: Effectiveness for Agricultural Restoration. M.S. Thesis, University of Illinois, Department of Agronomy, January, 1992, 115 p.

The objective of this study was to assess the effects of mitigation on agricultural soils. Bulk density, soil strength, soil texture, hydraulic conductivity, and soil moisture were measured in an attempt to identify factors which may be limiting crop yields at mitigated sites. Fill material at most mitigation sites had SiL to SiCL textures, massive structure, and traffic-induced compaction interfaces. Additional reclamation work such as installing tiles to provide adequate drainage in fill, or deep tillage to alleviate compaction, may improve current mitigation methods.

Keyword(s): land mitigation, agriculture, active mines, longwall, coal mining, mitigation, soils

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

Heuze, F. E., R. E. Goodman. Room and Pillar Structures in Competent Rock. IN: Underground Rock Chambers, ASCE Symposium on Water Resources Engineering, Phoenix, AZ, January 13-14, 1971, p. 531-565.

This paper discusses construction of room-and-pillar mine layouts and rock mechanics parameters required for construction.

Keyword(s): room-and-pillar, mine design, rock mechanics

Location(s): United States

Heuze, F. E. Geotechnical Studies for Room and Pillar Mine Design. IN: Proceedings Mini Symposium on Application of Geotechnical Data to Underground Mine Design, SME-AIME Fall Meeting, Mini Symposium Series No. 78-1, 1978, p. 1-15.

Keyword(s): room-and-pillar, mine design, geotechnical

Location(s): United States

Hibberd, P. Transference of Ground Movement to Surface Structures. Transactions Institute Mining Engineers, October, 1961.

This paper is a record of research from three sites in Scotland, where various types of structures were damaged by subsidence, including a church, traditional houses, and brick walls. Theoretical aspects of the transmission of ground movements to structures are considered, including field data. The influence of soil type, type of foundation, and depth to workings are noted.

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

Location(s): Scotland

Hickmann, T. J., J. R. Nawrot. Potentially Hazardous Abandoned Mine Entries, Summary Report: Phase I, Previously Recorded Problem Sites. Cooperative Wildlife Research Laboratory, Southern Illinois University, Carbondale, 1979.

This report summarizes the Wildlife Laboratory's inventory, investigation, and evaluation of approximately 75 potentially hazardous mine entries.

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

Higginbottom, I. E. Methods of Development in Areas of Ancient Shallow Coal Mining. 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. 273-286.
Keyword(s): coal mining, abandoned mines, land-use planning

Hilbig, R. Lehmann's Trough Theory. Colliery Engineering, v. 34, no. 404, October, 1957, p. 413-416.
This article is a discussion of the general validity of this theory.
Keyword(s): prediction theories, room-and-pillar, coal mining
Location(s): Europe

Hilbig, R. On the General Validity of Lehmann's Trough Theory. IN: Proceedings European Congress on Ground Movement, Leeds, England, April 9-12, 1957, London Harrison, p. 199-201.
Keyword(s): prediction theories, room-and-pillar, coal mining

Hill, J. G., D. R. Price. The Impact of Deep Mining on an Overlying Aquifer in Western Pennsylvania. Ground Water Monitoring Review, v. 3, no. 1, 1983, p. 138-143.
This study is a site-specific hydrogeologic analysis conducted before, during, and after mining at a site located over a selected longwall mining panel. Data from subsidence and groundwater monitoring networks placed over the study panel were collected, compiled, and analyzed to provide documentation of the mechanics of groundwater fluctuations caused by mining. The study deals specifically with water-level fluctuations in aquifers used for domestic water supplies.
Keyword(s): subsurface water, hydrology, coal mining, longwall, overburden, inflow
Location(s): Pennsylvania, Appalachian Coal Region, United States

Hill, J. L. III. The Influence of Stream Valleys on Coal Mine Ground Control. IN: Proceedings 7th International Conference on Ground Control in Mining, August 3-5, 1988, S.S. Peng, ed., Morgantown, WV, p. 247-258.
Over 50 mines of the Appalachian and Illinois Basins are presently experiencing poor ground conditions believed to be caused by overlying stream valleys. The USBM is conducting research into the causes of this problem with the aim of developing a predictive method for determining the safe limits of mining beneath stream valleys. In addition, the factors that control instability in these regions will be analyzed to provide design guidelines for adjusting support requirements.
Keyword(s): coal mining, ground control, geologic features, mine design
Location(s): Appalachian Coal Region, West Virginia, Illinois Coal Basin, United States

Hill, J. R. M., M. McDonald, L. M. McNay. Support Performance of Hydraulic Backfill: A Preliminary Analysis. U.S. Bureau of Mines RI 7850, 1974, 12 p. (NTIS PB 231 985)
Keyword(s): hydraulic backfilling
Location(s): United States

Hill, L. R., M. Burr. Hydraulic Filling of a Coal Seam at Lens, Pas-de-Calais, France. Engineering and Mining Journal, v. 82, 1906, p. 543.
This article describes hydraulic flushing in which fill material is transported dry to the working level, where it is mixed and gravity fed to the stowing area.
Keyword(s): hydraulic backfilling, stowing, coal mining
Location(s): France

Hill, R. D., E. R. Bates. Acid Mine Drainage and Subsidence. Final Report U.S. Environmental Protection Agency Contract EPA/600/12, Industrial Environmental Research, April, 1978, 38 p. (NTIS PB 281 092)
Keyword(s): environment, mine waste, surface water
Location(s): United States

Hindman, C. A., C. G. Treworgy. Use of a Geographic Information System to Evaluate the Potential for Damage from Subsidence of Underground Mines in Illinois. IN: Proceedings 9th International Symposium on Computer-Assisted Cartography, April 2-7, 1989, Baltimore, MD, p. 483-492.
This paper describes the use of geographic system information (GIS) technology to evaluate the risk of damage to structures from mine subsidence in Illinois. Maps and tables created with the GIS are used to show the coincidence of underground

mines with urban areas and to estimate the number and total value of housing units exposed to subsidence risk.

Keyword(s): computer, coal mining, metal mining, non-metal mining, abandoned mines, land-use planning, insurance, surface structural damage

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

Hinrichs, D. R. Utilization of Geophysical Logs in the Evaluation of Subsurface Conditions for Mine Subsidence Studies. 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. 121-131.

Conventional rotary drilling in combination with lithologic and down-hole geophysical logging has proven to be the most cost-effective method for investigating abandoned mine conditions and coal seam geometries along the Colorado Front Range.

Keyword(s): abandoned mines, geophysical, overburden, monitoring methods, coal mining

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

Hiortdahl, S. N. Hydrologic and Mining Data from an Area of Underground Coal Mining in Garrett County, Maryland. Report of Investigations No. 41-A, Maryland Geological Survey, Baltimore, 1988, 81 p.

The report presents the results of hydrologic monitoring from 1981-1984 in an area removing coal by the room-and-pillar method. At the end of this phase of the study, mining was approximately 50% complete and affected 1,650 acres. Water levels in several observation wells completed in confined zones both above and below the mine declined from tens to hundreds of feet in response to pumpage of mine drainage. Seepage measurements along local streams indicated losses of stream flow to the local groundwater systems occurred and varied in location and magnitude from year to year.

Keyword(s): hydrology, monitoring methods, subsurface water, room-and-pillar, active mines, coal mining, inflow

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

Hiramatsu, Y., Y. Oka. On the Earth Pressure Phenomena Around a Long Wall Working Place. Journal Mining & Metallurgy Institute Japan, v. 73, 1957, p. 817-822.

Keyword(s): longwall

Location(s): Japan

Hiramatsu, Y., Y. Oka. Stress Measurements in Roofs, Floors, and Pillars. IN: Proceedings 4th International Conference on Strata Control and Rock Mechanics, 1964, Henry Krumb School of Mines, Columbia University, New York, 1965, 13 p.

Investigations were conducted to determine the influence of a longwall working upon stresses in the roof and floor. In addition, theoretical studies were carried out on the method of stress measurement as well as on the implication of the variations in stress.

Keyword(s): longwall, in situ testing, instrumentation, roof stability, floor stability, pillar strength, rock mechanics

Hiramatsu, Y., Y. Oka. Precalculation of Ground Movements Caused by Mining. International Journal Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 5, February, 1968, p. 399-414.

This paper describes the principle and the technique of a new method of precalculating the ground movements caused by mining coal seams or ore bodies. In this method, functions of influence, which by integration give the influence factors, are used. This method is adaptable to computer analysis and can be used to determine subsidence and horizontal displacements, inclinations, strains, and curvatures.

Keyword(s): vertical displacement, horizontal displacement, prediction, computer, rock mechanics, coal mining, metal mining, influence function

Location(s): Japan

Hiramatsu, Y., H. Okamura, K. Sugawara. Surface Subsidence and Horizontal Displacement Caused by Mining Inclined Coal Seams. IN: Proceedings 4th Congress International Society for Rock Mechanics, Montreux, Switzerland, September 2-8, 1979, Balkema, Rotterdam, p. 665-670.

Keyword(s): rock mechanics, horizontal displacement, surface subsidence damage

Hiramatsu, Y. Deep Underground Excavations, Especially Tunnels and Coal Mining, and the Subsidence Caused by Them. IN: Rock Mechanics for Resource Development, Mining and Civil Engineering, Proceedings 5th Congress International

Society for Rock Mechanics, Melbourne, Australia, 1983, Balkema, Rotterdam, v. 3, Section G, p. G167-G184.

This report briefly describes recent research on the geomechanics and geotechnology of deep underground excavations. Special attention is shown to tunnels and coal mining, as well as the ground subsidence caused by them. These are the topics under the Sub-Theme C2, C3 and C4 in this Congress. This report introduces the important part of the papers submitted to this Congress under these Sub-Themes to suggest particular areas for discussion.

Keyword(s): coal mining, tunnelling, rock mechanics, longwall, room-and-pillar, modeling, prediction

Hiramatsu, Y. Deep Underground Excavations: Tunnels, Coal Mining, and 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. G207-G208.

This paper gives the state of investigation on rock mechanics on these three topics.

Keyword(s): tunnelling, rock mechanics, coal mining

Hirt, A. M., A. Shakoor. Determination of Unconfined Compressive Strength of Coal for Pillar Design. Mining Engineering, v. 44, no. 8, August, 1992, p. 1037-1041.

The compressive strength of coal and its variation within and between seams was determined for four Pennsylvania coal seams. Large coal blocks were obtained from 12 coal mines. The cubes were tested for compressive strength. The results were then used to compute actual pillar strength.

Keyword(s): pillar strength, coal mining, lab testing, active mines, rock mechanics

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

Hisatake, M., T. Ito. Three-Dimensional Boundary Element Analysis of Surface Subsidence Caused by Shallow Tunnel Driving. Doboku Gakkai Rombun Hokokushu, no. 327, November, 1982, p. 107-114.

Keyword(s): boundary element, modeling, tunnelling

Hislam, J. L. Site Improvement Techniques--Mine Infilling. 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. 121-130.

Keyword(s): coal mining, abandoned mines, backfilling

Hobba, W. A., Jr. Effects of Underground Mining and Mine Collapse on the Hydrology of Selected Basins in West Virginia. West Virginia Geological Survey RI-33, 1982, 84 p.

This report examines the effects of mining and collapse on hydrology in two contrasting situations: where the mined coal is above and below major streams. It includes a glossary.

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

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

Hobbs, D. W. The Strength and the Stress-Strain Characteristics of Coal in Triaxial Compression. Journal of Geology, v. 72, March, 1964, p. 214-231.

Keyword(s): rock mechanics, lab testing, coal mining, pillar strength

Hodkin, D. L., R. K. Dunham, I. W. Farmer. Deformation of Coal Measures Strata Above a Retreating Longwall Face. IN: Proceedings 20th U.S. Symposium on Rock Mechanics, Austin, TX, June 4-6, 1979, University of Texas, p. 517-524.

Vertical settlements at various depths above the centerline of a shallow caving longwall face were measured by levelling and by using an anchor extensometer system installed in two underground boreholes drilled from abandoned pillar workings 75 meters above the face. Differential settlement between the upper and lower levels was found to be greater than expected; this is attributed partly to the presence of strong, good quality sandstones in the Coal Measures cyclothem. Considerable damage and collapse of workings at the upper level occurred 30 to 40 meters after passage of the face at the lower level and coincided with the predicted zone of peak tensile strain.

Keyword(s): longwall, vertical displacement, rock mechanics, survey methods, instrumentation, monitoring methods, overburden, coal mining, active mines

Location(s): United States

Hoffmann, H. The Effects of Direction of Working and Rate of Advance on the Scale-Deformation of a Self-Loaded Stratified Model of a Large Body of Ground. 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. 397-411.

The subsidence model, made of synthetic foam, consisted of several plates separated by paper strips; it was designed to study the effects of subsidence on overburden strata.

Keyword(s): mine design, rock mechanics, modeling, overburden

Holla, L. Empirical Prediction of Subsidence Movements in the Southern Coalfields of New South Wales, Australia. IN: The Developing Science and Art of Minerals Surveying, Proceedings VIth International Congress, International Society for Mine Surveying, Harrogate, September 9-13, 1985, Balkema, Rotterdam, p. 557-567.

The empirical approach has been followed by the New South Wales Department of Mineral Resources for predicting subsidence. In the past, ground movements were predicted making use of the Subsidence Engineers' Handbook prepared by the National Coal Board. An intensive program of subsidence research resulted in the development of prediction curves for New South Wales that were found to be significantly different to the curves in the United Kingdom. This report summarizes the results of research and highlights some problems encountered during the process of standardizing empirical curves for the Southern Coalfields of New South Wales.

Keyword(s): prediction, prediction theories, coal mining, active mines, National Coal Board, longwall, yielding supports, monitoring methods

Location(s): Australia

Holla, L. The Minimisation of Surface Subsidence by Design of Mine Workings. IN: Proceedings Australasian Institute Mining Metallurgy, v. 240, 1985, p. 53-59.

Keyword(s): mine design

Location(s): Australia

Holla, L. Evaluation of Surface Subsidence Characteristics in the Newcastle Coalfield of New South Wales. The Coal Journal, v. 11, 1986, Australia, 12 p.

Keyword(s): coal mining, surface subsidence damage

Location(s): Australia

Holla, L., B. Hughson. State-of-the-Art of Mining Under Public Utilities in New South Wales. IN: Proceedings, Symposium on Ground Movement and Control Related to Coal Mining, Illawarra, Australia, N.I. Aziz, ed., August, 1986, Australasian Institute of Mining and Metallurgy, p. 334-340.

Large amounts of coal lie sterilized under roads, railways, pipelines, and power transmission lines. Mining to extract these resources will cause subsidence, but not necessarily unacceptable damage to the utility. The establishment of acceptable standards of damage, where the value of mined coal is much greater than reparation costs, and means of achieving limited damage are examined. Procedures for mining under each utility are presented. In the light of overseas experience, improvements in current recovery under railways may be possible.

Keyword(s): coal mining, roads, railroads, pipelines, utilities

Location(s): Australia

Holla, L., M. Buizen. The Ground Movement, Strata Fracturing and Changes in Permeability Due to Deep Longwall Mining. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 28, no. 23, 1991, p. 207-217.

Strata movement due to longwall retreat mining was studied in the Southern coalfield, near Sydney, Australia. Subsurface deformation was monitored by recording the movements of a series of anchors, installed at various depths in a borehole drilled over a longwall panel. Bulk strata permeability was measured by packer tests before and after mining. Pre-mining and post-mining fractures were compared. Vertical strains the overburden varied from 0.5 to 4 mm/m. Tensile strains extended from the surface to 112 m depth and were less than 0.5 mm/m. Increases in permeability and number of fractures were seen but no correlation was evident.

Keyword(s): overburden, longwall, instrumentation, monitoring equipment, monitoring methods, coal mining, subsurface water, hydrology

Location(s): Australia

Holla, L. Some Aspects of Strata Movement Relating to Mining Under Water Bodies in New South Wales, Australia. IN: Proceedings 4th International Mine Water Congress, Ljubljana (Slovenia)-Portschach (Austria), September 1991, p. 233-244.

Successful mining layouts for mining coal under large water bodies should ensure that a substantial thickness of overburden strata remains undisturbed

to prevent the flooding of mine workings. One of the criteria followed in many countries for controlling sub-surface strata disturbance is to specify a limit on the rockhead tensile strain. However, the generally specified rockhead strains are well in excess of the strain required to cause surface fracturing. It therefore leads to the conclusion that the composition of strata between the cracked zone on the surface and the caved zone above the extracted seam plays an important role in preventing water inflows into the mine workings. Ductile beds like shales, mudstones, and clay bands appear more effective than sandstone beds of the same thickness.

Keyword(s): coal mining, surface water, overburden, geologic features, mine design, longwall, rock mechanics, inflow

Location(s): Australia

Holla, L. Ground Movement Due to the Mining of Thick Coal Seams at Shallow Depths and its Effect on Surface Structures. 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. 193-208.

The primary objectives of an intensive program of research are to define the ground movement pattern in the coalfields of New South Wales, to develop empirical models capable of predicting surface and subsurface subsidence prior to mining, and to quantify the extent of damage to different types of structures under different levels of ground movement. This paper includes some aspects of subsidence investigation into the effect of mining shallow seams on the surface and surface structures.

Keyword(s): coal mining, surface structural damage, active mines, longwall, monitoring methods, survey methods, survey data processing, horizontal displacement, vertical displacement, pipelines, utilities, railroads

Location(s): Australia

Holland, C. T. Pillar Deformation in a Bituminous Coal Mine. Transactions AIME, v. 130, 1938, p. 333-357.

This is a study of the compressive effect upon adjacent remaining pillars when selected pillars were pulled in the Pittsburgh seam.

Keyword(s): coal mining, pillar extraction, pillar strength, in situ testing, bituminous

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

Holland, C. T., E. Thomas. Coal Mine Bumps: Some Aspects of Occurrence, Cause and Control. U.S. Bureau of Mines B 535, 1954, 36 p.

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

Location(s): United States

Holland, C. T. Mineral Content. A Factor in Weathering of Mine Roof. Mining Congress Journal, v. 42, no. 1, 1956, p. 49-54.

Keyword(s): rock mechanics, ground control, roof stability

Holland, C. T., F. L. Gaddy. Some Aspects of Permanent Support of Overburden on Coalbeds. IN: Proceedings West Virginia Coal Mining Institute Spring Meeting, June 22-23, 1956, and 49th Annual Meeting, November 2-3, 1956, West Virginia Coal Mining Institute, 1957, p. 43-65.

This paper considers the support of overburden from these aspects: load on coal bed before mining, stress or load produced by mining, strength of coal and pillars, load capacity of the roof and floor,effect of water on roof and floor material, composition of load-bearing rocks, and safety factors.

Keyword(s): overburden, pillar strength, roof stability, floor stability, mine safety, coal mining

Location(s): United States

Holland, C. T. Cause and Occurrence of Coal Mine Bumps. Transactions SME-AIME, v. 211, 1958, p. 994-1004.

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

Holland, C. T. Notes on the Theory of a Maximum Pressure Arch and Yield Pillar Techniques as Applied to Entry Panel Design. IN: Proceedings Coal Mining Institute of America, 1961, p. 68-78.

The author discusses yield pillar theory of entry design so that some roof problems and rock bursts are eliminated in mines at depths of 400 to 2,000 feet below the surface.

Keyword(s): mine design, roof support, roof stability, yielding supports

Location(s): United States

Holland, C. T. Design of Pillars for Overburden Support, Part I-II. Mining Congress Journal, v. 48, no. 23-24, 1962.

The author uses field tests to support laboratory theories on pillar design for permanent support of overburden in coal beds. The effect of water on floor rock is briefly discussed.

Keyword(s): floor stability, pillar strength, mine design, overburden, coal mining, in situ testing, lab testing

Holland, C. T. The Strength of Coal in Mine Pillars. IN: Proceedings 6th Symposium on Rock Mechanics, University of Missouri at Rolla, 1964, E.M. Spokes and C.R. Christiansen, eds., p. 450-466.

This paper discusses the strength of coal based on the specimen size and the least dimension of the specimen. Various parameters affecting the coal strength are discussed and, based on experimental data, a series of conclusions regarding coal strength are presented.

Keyword(s): rock mechanics, pillar strength, coal mining, lab testing, room-and-pillar

Location(s): United States

Holland, C. T. Final Report on the Effect of Mining Upon and Methods of Protecting Earthfill Dams Located in the Wheeling Creek Area. Report to U.S. Department of Agriculture, Soil Conservation Service, Morgantown, WV, March 20, 1965.

This report describes required support in the form of unmined coal beneath proposed earth dams in Pennsylvania and West Virginia.The current (1965) state of knowledge concerning subsidence parameters and coal strength for the area and seams in question is summarized to justify recommendations presented.

Keyword(s): pillar strength, surface structural damage, coal mining

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

Holland, C. T., D. A. Olsen. Interfacial Friction, Moisture, and Coal Pillar Strength. Transactions AIME, v. 241, 1968, p. 323-328.

This paper discusses the development of a formula for estimation of coal pillar strength. One of the factors involved in the formula is the coefficient of friction between the coal pillar and the adjacent rock with which it is in contact. The results of studies on sandstone, limestone, shale, and coal, and the coefficient of friction between coal and the preceding three rock types under wet and dry conditions are presented.

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

Location(s): United States

Holland, C. T. Thirty Years' Experience in Applying Rock Mechanics to Roof Control in Coal Mining. AIME Preprint 71-F-347, 1971.

This paper reviews the historical and current methods of roof control, including pillar/room dimension, rock bolting, geological considerations, and depth of overburden.

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

Location(s): United States

Holland, C. T. Mine Pillar Design. IN: SME Mining Engineering Handbook, v. 1, A.B. Cummins and I.A. Givens, eds., 1973, SME-AIME, New York, p. 13-96 to 13-118.

Pillar design presupposes a knowledge of the pertiment geology of the area involved. This takes in the following aspects of the local geology but is not necessarily limited to them: (1) thickness of the overburden and its involved strata, (2) stress field or fields affecting the area, (3) structural strength of the rocks overlying and underlying the bed, (4) jointing system affecting the rocks of the area, and (5) water that might enter the bed and its effects upon the rocks involved.

Keyword(s): pillar strength, ground control, mine design, geologic features, overburden, yielding supports, coal mining

Location(s): United States

Holland, C. T. Pillar Design for Permanent and Semi-Permanent Support of the Overburden in Coal Mines. IN: Proceedings 9th Canadian Rock Mechanics Symposium, Montreal, 1973.

Keyword(s): rock mechanics, mine design, pillar strength, yielding supports, overburden

Holm, J. D. Mine Subsidence Insurance for Colorado: A Risk Management Approach. 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. 281-298.

The State of Colorado is in the final stages of developing a Subsidence Insurance Program that will be operated by one or more private insurance companies. The state's involement is necessitated by provisions in the federal legislation enabling the program. Also, no specific subsidence risk insurance is currently available in the market place.

Keyword(s): insurance, law, abandoned mines, reclamation, pneumatic backfilling, hydraulic backfilling, structural mitigation, coal mining

Location(s): Colorado, Rocky Mountain Coal Region, Pennsylvania, Illinois, West Virginia, Kentucky, Ohio, United States

Holt, D. N., B. R. Marker. Benefits of Engineering Geology for Land Use Planning in Areas of Past Metalliferous Mining. 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. 75-80.

Metalliferous mining in the United Kingdom has left an inheritance of subsidence and contamination that can affect the viability and suitability of land for present and future use.

Keyword(s): metal mining, land-use planning, geologic features, mine waste, subsurface water

Location(s): England, United Kingdom

Holzer, T. L. Ground Failure in Areas of Subsidence Due to Groundwater Decline in the United States. IN: Proceedings 2nd International Symposium on Land Subsidence, Anaheim, CA, IAHS-AIHS Publication No. 121, December, 1976, p. 423-433.

Keyword(s): hydrology, subsurface water, fluid extraction

Location(s): United States

Holzer, T. L., W. Thatcher. Modeling Deformation Due to Subsidence Faulting. 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. 349-357.

A relation between aseismic surface faulting and groundwater withdrawal from alluvial basins undergoing human-induced land subsidence has been suggested or implied by several investigators. In this paper, an additional approach is proposed and illustrated for analyzing the origin of surface faulting within areas of gorundwater withdrawal. The conceptual basis for the approach is that by modeling surface deformation computed from repeated precise geodetic surveys across faults, the approximate depth of fault rupture may be inferred.

Keyword(s): modeling, fluid extraction, geologic features

Location(s): Arizona

Holzer, T. L. Preconsolidation Stress of Aquifer Systems in Areas of Induced Land Subsidence. Water Resources Research, Washington, D.C., 1981, p. 693-704.

Keyword(s): hydrology, subsurface water, subsurface subsidence damage, overburden

Location(s): United States

Holzer, T. L. Ground Failure Induced by Ground-Water Withdrawal from Unconsolidated Sediment. IN: Man-Induced Land Subsidence, Reviews in Engineering Geology VI, 1984, T.L. Holzer, ed., The Geological Society of America, p. 67-105.

Ground failures, ranging from long tension cracks or fissures to surface faults, are caused by human-induced water-level declines in more than 14 areas in the contiguous United States. These failures are associated with land subsidence caused by compaction of underlying unconsolidated sediment. The greatest economic impact from ground failure is in the metropolitan region of Houston-Galveston, Texas, where more than 86 surface faults have caused millions of dollars of damage and losses of property value.

Keyword(s): subsurface water, fluid extraction, geologic features, land-use planning

Location(s): Texas, California, Arizona, United States

Holzer, T. L. Land Subsidence: Its Impacts and Costs in the U.S. Underground Space, v. 9, no. 5-6, 1985, p. 260-263.

This paper discusses land subsidence of all types which was either directly or indirectly caused by human activity, including subsurface mining, withdrawal of groundwater and petroleum from unconsolidated sediment, drainage of peat and muck soils, groundwater withdrawal from limestone, solution mining, and surface application of water to undercompacted sediment. Human-induced subsidence occurs in at least 38 states in the United States.

Keyword(s): economics, abandoned mines, surface structural damage, surface water, subsurface water, vertical displacement, oil extraction, metal mining, non-metal mining, coal mining, fluid extraction

Location(s): United States, Italy, Illinois, Louisiana, Florida, Texas, Virginia, California

Holzer, T. L., ed. Man-Induced Land Subsidence. Geological Society of America Reviews in Engineering Geology Volume VI, 1984, GSA, Boulder, CO, 221 p.

Recognizing the vital roles of engineering geologists and hydrogeologists in the prediction, control, and mitigation of human-induced land subsidence, a GSA symposium on the subject was held at the annual meeting in 1980. Nine of the papers presented were expanded into this volume, which compiles comprehensive summaries of the mechanisms of land subsidence in the United States and the techniques that have been developed to predict and mitigate it. Papers were arranged into three categories: (1) fluid withdrawal from porous media, (2) drainage of organic soil, and (3) collapse into manmade and natural cavities.

Keyword(s): fluid extraction, engineering, prediction, oil extraction, soils, coal mining, non-metal mining

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

Hood, M., R. T. Ewy, L. R. Riddle, J. J. K. Daemen. Empirical Methods for Subsidence Prediction and Their Applicability to U.S. Mining Conditions. Final Report, Contract No. 62-0200, Department of Material Science and Mining Engineering, University of California, Berkeley, October, 1981, 241 p.

This work program had two major objectives: to update the understanding of European and other relevant subsidence prediction methods, and to evaluate the applicability of these methods to mining conditions in the United States. The scope of the work was broad, calling for a collection of case histories and an examination of the influence of mining methods, mine geometry, and geological features on the various prediction techniques. The empirical subsidence prediction technique can be divided into four categories: an empirical data technique, a profile function technique, an influence function technique, and a stochastic technique.

Keyword(s): prediction theories, empirical model, angle of draw, literature search, prediction, modeling, coal mining, National Coal Board, vertical displacement, horizontal displacement, time factor, profile function, influence function, stochastic model

Location(s): United States

Hood, M., R. T. Ewy, L. R. Riddle. Empirical Methods of Subsidence Prediction--A Case Study. IN: Procedings 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. 100-122.

Subsidence profiles above two adjacent panels in Illinois are compared with profiles predicting subsidence behavior obtained using the National Coal Board method, the profile function method, and the influence function method.

Keyword(s): vertical displacement, horizontal displacement, prediction, longwall, empirical model, National Coal Board, profile function, influence function

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

Hood, M., R. T. Ewy, L. R. Riddle. Empirical Methods of Subsidence Prediction--A Case Study From Illinois. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 20, no. 4, August, 1983, p. 153-170.

Subsidence profiles above two adjacent panels in Illinois are compared with profiles predicting subsidence behavior obtained using the National Coal Board method, the profile function method, and the influence function method.

Keyword(s): prediction, coal mining, prediction theories, empirical model, profile function, influence function, National Coal Board

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

Hooker, V. E. A Method of Evaluating Room and Pillar or Panel Design. IN: Proceedings U.S. Bureau of Mines Technology Transfer Seminar on Ground Control Aspects of Coal Mine Design, Lexington, KY, March, 1973; U.S. Bureau of Mines IC 8630, 1974, p. 44-48.

Pillar stresses and strengths were measured and used to evaluate the stability of pillars in an underground mine. Uniaxial and triaxial strength tests were conducted both on samples which contained no plane of weakness (solid) and on those which contained planes of weakness. For unconfined specimens containing planes of weakness the strength reduction can be as large as 73%. In situ stress determinations were made in the pillars and rib wall. Results indicated that pillars were not carrying the calculated loads expected from extraction ratios. The vertical stress magnitude in the rib wall was 1.8 times that expected from overburden indicating additional load transmission in this region.

Keyword(s): room-and-pillar, ground control, mine design, pillar strength, lab testing, in situ testing, rock mechanics

Location(s): United States

Hooker, V. E. Stress Fields--What is Known About Them. 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. 22-27.

Results of investigations into the nature and extent of in situ stress fields show that the stresses applied to a rock mass in which mining is done may be composed of gravitational, thermal, or tectonic stresses. The magnitudes and directions of the stress components seem to correlate with geological features. The horizontal components of stress are compressive and generally unequal.

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

Location(s): United States

Hopkins, D. L., N. G. W. Cook. A Model Based on the Minimization of Strain Energy as a Tool in the Design of Coal Pillars. 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. 177-184.

Stresses in coal pillars have been analyzed using a model based on the minimization of strain energy. In addition to the deformation of the pillars, the model accounts for deformation of the roof and floor and mechanical interaction between pillars. The model is used to calculate the distribution of stress in isolated pillars and arrays of pillars before any yielding has occurred. The effect of mechanical interaction is studied by changing the spacing between pillars and spatial geometry of the arrays.

Keyword(s): coal mining, modeling, pillar strength, mine design, yielding supports

Hopkins, M. E. Coal Geology and Underground Mining, 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. 1-13.

Because of the relatively thick and persistent coal seams, resulting from uniform depositional environments prevailing over wide areas, underground mining conditions in the Illinois Coal Basin are generally favorable for large, highly productive mines. A wide variety of problems, however, result from recognizable geologic conditions. Undoubtedly, the most important group of geologic factors affecting minability relate to the nature of the stratigraphic section over the coal and its amenability to roof control. Significant depositional variations involving competent and non-competent roof strata are present on regional and local scales.

Keyword(s): geologic features, roof stability, coal mining, floor stability

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

House Committee on Interior and Insular Affairs. Surface Mining Control and Reclamation Act of 1977. House Report 95-218, Washington, D.C., 1977.

Keyword(s): reclamation, mitigation, law, coal mining

Location(s): United States

Houser, F. N. Sequence of Surface Movement and Fracturing During Sink Subsidence, Nevada Test Site. U.S. Geological Survey, Report USGS-474-56, 1970.

Keyword(s): surface subsidence damage

Location(s): Nevada, United States

Howard, J. F., R. E. Wright. Evaluation Procedure of Critical Factors of Mining Impact on Ground Water Resources. IN: Water Resources Problems Related to Mining, Proceedings 18th Symposium American Water Resources Association, Minneapolis, June, 1974, R.F. Hadley and D.T. Snow, eds., p. 22-31.

Water resource problems associated with mining activities have commonly been confined either to the acquisition or the disposal of water as needed or as created by the mining process. With the dawn of environmental regulations, the interaction of water and earth systems became a major factor for consideration in the environmental impact assessment that must be prepared to acquire a mining permit.

Keyword(s): hydrology, subsurface water, coal mining, environment, law, government

Location(s): United States

Howell, F. T., P. L. Jenkins. Some Aspects of the Subsidences in the Rocksalt Districts of Cheshire, England. International Association Hydrological Sciences Publication 121, 1977, p. 507-520.

Keyword(s): non-metal mining

Location(s): England

Howell, F. T., P. L. Jenkins. Centrifuge Modelling of Salt Subsidence Features. Application of Centrifuge Modelling to Geotechnical Design, W. H. Craig, ed., Balkema, Rotterdam, 1985, p. 193-202.

Keyword(s): modeling, non-metal mining

Howell, M., C. W. Amos. Improved Geophysical Techniques for Survey of Disturbed Ground. IN: Site Investigations in Areas of Mining Subsidence, F.G. Bell, ed., Newnes-Butterworths, 1975, p. 103-108.

Two new techniques have been developed that appear to provide improved geophysical methods for locating a variety of sub-surface features, particularly old mine workings, filled quarries, cavities, faults, culverts, and similar phenomena.

Keyword(s): survey methods, geophysical, seismic

Howell, R. C., F. D. Wright, J. A. Dearinger. Ground Movement and Pressure Changes Associated with Shortwall Mining. 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. Hustrluid, eds., University of Utah, Salt Lake City, p. 4A31-4A36.

A rock mechanics study of a shortwall mining system was conducted. The objective of the study was to obtain data on surface subsidence over a portion of the mined area, strata subsidence in the mined area, and underground stress changes and displacements in and near natural support elements of the mining system. The mine was located in the moderately rough mountainous terrain of eastern Kentucky.

Keyword(s): rock mechanics, shortwall, ground control, instrumentation, monitoring methods, coal mining, survey methods, overburden

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

Howes, M. R., M. A. Culp, H. Greenberg, P. E. VanDorpe. Underground Coal Mines of Centerville, Iowa, and Vicinity. Iowa Department of Natural Resources Open File Report 86-2, 1986, Iowa Geological Survey Bureau, Iowa City, 93 p.

Extensive underground mining occurred in the Centerville area between 1850 and 1971. Coal production was exclusively from the Mystic Coal Member of the Labette Shale (Pennsylvanian). This study documents the location and extent of abandoned coal mines and known occurrences of mine-related problems in the area. A map is included, which shows the location and extent of coal mines and a compilation of mine-related information including historical and physical data.

Keyword(s): coal mining, abandoned mines, historical, land-use planning, longwall, room-and-pillar

Location(s): Iowa, United States

HRB-Singer, Inc. Detection of Abandoned Underground Coal Mines by Geophysical Methods. Water Pollution Control Research Series 14010 EHN, for the Environmental Protection Agency and the Pennsylvania Department of Environmental Resources, April, 1971, 94 p.

Acid drainage produced by abandoned coal mines continues to cause serious water pollution problems. Without knowing the exact location of the concealed openings and the extent of the mine, the application of proven abatement techniques is virtually impossible. Drilling is the only known method for accurately determining the location and extent of the mine voids, but this is extremely expensive. This project attacks the problem through field studies of the following geophysical methods: electrical resistivity, self-potential, infrared radiometry, total field and differential magnetometry, seismic refraction and reflection, very low frequency electromagnetic and induced polarization over well documented drift coal mines.

Keyword(s): geophysical, abandoned mines, environment, coal mining, subsurface water

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

HRB-Singer, Inc. Proposed Techniques for Evaluating Subsidence Risk and Planning and Engineering Alternatives for Use by Housing and Urban Development (HUD) and Local Governments (Task E). State College, PA, Energy and Natural Resources Program Dept., HUD contract H-2385, June, 1977, 120 p. (NTIS PB 81-100992)

Urban areas in 21 states suffer from problems of subsidence from underground mining operations. Other urban areas along the Atlantic and Gulf coasts suffer from subsidence in wetlands, and about 33 million people live on limestone terrains that also may be affected by subsidence. This report discusses techniques that can be used by Department of Housing and Urban Development and by local government personnel to evaluate risks and planning and engineering alternatives for mitigating hazards resulting from (1) land subsidence, (2) subsidence occurring in organic wetlands and (3) subsidence in carbonate (karst) terrains. Techniques for determining the likelihood and magnitude of these types of subsidence are described, and various planning options available at the state, regional, and local level of government are discussed. Engineering techniques, including subsurface stabilization, stabilization of foundations, and special architectural or structural measures appropriate for the types of subsidence conditions are examined.

Appendices are included on the feasibility of providing technical guidance and on representative costs of hazard mitigation components.

Keyword(s): vertical displacement, horizontal displacement, law, mine design, backfilling, land-use planning, environment, geologic features, surface structural damage, structural mitigation, mitigation, land mitigation, fluid extraction, coal mining, engineering, government, architecture, foundations, economics

Location(s): United States

HRB-Singer, Inc. Community Land Subsidence. Final Report, U.S. Department of Housing and Urban Development, Washington, D.C., Contract H-2385, 1977.

Keyword(s): land-use planning, government, environment

Location(s): United States

HRB-Singer, Inc. The Nature and Distribution of Subsidence Problems Affecting HUD and Urban Areas. Task A, HUD Contract H-2385, 1977, 113 p. (NTIS PB 80-17277-8)

Keyword(s): government, land-use planning, surface subsidence damage

Location(s): United States

Hsiung, S. M., S. S. Peng. Chain Pillar Design for U.S. Longwall Panels. SME-AIME Preprint 84-323, SME-AIME Fall Meeting, Denver, CO, October 24-26, 1984, 18 p.

Chain pillar design formula under weak roof condition was developed by statistically analyzing the results from the three-dimensional finite element parametric analyses. The parameters such as mechanical properties of the roof and floor strata, overburden depth, panel width and length, and coal strength were incorporated in the formula. A conversion formula that transfers a rectangular chain pillar into a square chain pillar of equal strength is proposed. The influence of high in situ horizontal stresses, which are often encountered in the coalfield, on chain pillar stability is discussed.

Keyword(s): longwall, coal mining, mine design, finite element, rock mechanics, roof stability, pillar strength, geotechnical

Hsiung, S. M., S. S. Peng. Design Guidelines for Multiple Seam Mining. Coal Mining, Part I, v. 24, no. 9, September 1987, p. 42-46; Part II, v. 24, no. 10, October 1987, p. 48-50.

Causes of ground control problems in multiple-seam mining can be classified into five types. These problems cannot be eliminated completely without sacrificing coal reserves. Problems can be reduced, however, if the interaction effects are fully understood and proper mining plans are correctly implemented.

Keyword(s): multiple-seam extraction, active mines, coal mining, geologic features, mine design, mine operation, pillar strength, finite element, longwall, room-and-pillar, ground control, subsurface water, partial extraction

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

Hsiung, S. M., S. S. Peng. Control of Floor Heave with Proper Mine Design--Three Case Studies. Mining Science and Technology, v. 4, 1987, p. 257-272.

The results of three case studies on the control of floor-heave problems are presented. Finite element modeling was employed to identify causes of excessive floor heave, propose remedial measures, and evaluate the effectiveness of mine layout design in controlling floor heave. Five chain pillar designs were modeled in this third study.

Keyword(s): floor stability, active mines, mine design, finite element, modeling, geologic features, overburden, pillar strength, roof stability, bumps, longwall

Location(s): United States

Hsiung, S. M., P. M. Lin, S. S. Peng. Structure and Ground Surface Damages Due to Subsidence. IN: Proceedings Conference on Mine Drainage and Surface Mine Reclamation, U.S. Bureau of Mines IC 9184, v. 2, 1988, p. 362-371. (NTIS PB 90-269457)

Keyword(s): surface structural damage

Location(s): United States

Hubbard, J. S. Longwall Experience at the Gateway Mine. Mining Congress Journal, v. 57, no. 10, 1971, p. 43-47.

The installation of a longwall system in the Pittsburgh seam is described. The author states that when the system is specifically designed for a seam, it is one of the safest methods of mining coal. One of the reasons for the increased safety is the use of self-advancing hydraulic roof supports.

Keyword(s): coal mining, longwall, mine design, roof support, mine safety

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

Huck, P. J., Y. P. Chugh, M. Jennings. Subsidence Control in Abandoned Coal Mines: U.S. Practices. 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. 151-154.

Large areas of coal reserves in the United States have been undermined by the room-and-pillar method during the past century. These abandoned mines generally cause subsidence of the ground surface many decades after mining. The authors discuss the methods by which subsidence in abandoned mines may be controlled, including point support methods and areal backfilling.

Keyword(s): coal mining, abandoned mines, local backfilling, grouting, pneumatic backfilling, hydraulic backfilling, room-and-pillar

Location(s): United States

Huck, P. J. Monitoring Techniques for Blind Backfilling - Overview. 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. 117-125.

A variety of techniques and instruments may be used to monitor the progress of blind backfilling in abandoned mines. No single ideal system is available that will fill the needs of the variety of backfilling methods used and site conditions encountered. The current art is reviewed and candidate systems that have potential under given circumstances are identified. In many cases, a combination of several techniques provides the optimum monitoring system. Possible directions for future development are identified.

Keyword(s): backfilling, abandoned mines, grouting, pneumatic backfilling, hydraulic backfilling, instrumentation, monitoring methods

Huck, P. J. Numerical Model of Pumped Slurry Backfilling. 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. 126-144.

Anomalous behavior of injection pressures was observed during experimental monitoring of a pumped slurry backfilling operation near Scranton, Pennsylvania. Variations in the grain size of slurry solids was suspected as the cause of the unexpected behavior. To explore the effect of grain size upon deposition of solids, an existing model was modified to permit simulation of injection pressure histories and deposit depths for slurries containing well graded grain size distributions.

Keyword(s): hydraulic backfilling, modeling, backfilling

Huck, P. J., Y. P. Chugh. Analysis and Process Monitoring of Pumped Slurry Backfilling for Subsidence Control. IN: Proceedings, 2nd Conference on Ground Control Problems in the Illinois Coal Basin, May 1985, Y.P. Chugh, ed., Southern Illinois University, Carbondale, v. 2, p. 5-12.

A pumped slurry backfilling process developed in the United States has been successfully used to control surface subsidence effects of underground mining. During the past 5 years, the USBM has directed studies to evaluate concepts for remote monitoring of the process and model the mechanisms of slurry deposition. This paper discusses process monitoring and analytical modeling studies of the backfilling process. The results indicate that process monitoring of injection pressure and flow rate can be very useful in providing information on backfill deposit geometry and mechanisms of slurry deposition.

Keyword(s): hydraulic backfilling, ground control, abandoned mines, mine waste, coal mining, modeling, computer

Location(s): United States

Huck, P. J., S. Bhattacharya. Instrumentation to Monitor Subsidence Associated With High Extraction Mining in the Illinois Coal Basin. Final Report to U.S. Bureau of Mines, Contract HO256005, Engineers International, Inc., June 1988, 60 p.

Engineers International, Inc. undertook a program from the USBM Twin Cities Research Center to select and emplace appropriate subsidence instrumentation over a high-extraction mine panel selected by cooperating Illinois state agencies. This instrumentation was to provide subsidence data for both short-term and long-term subsidence and hydrological effects of mining. The instrumentation included multipoint borehole extensometers (MPBX), observation wells, piezometers, subsidence monuments, and control monuments to provide local horizontal and vertical control. A suite of laboratory tests was conducted on specimens recovered during drilling, and rock properties data were culled from published and Engineers International file data.

Keyword(s): instrumentation, high-extraction retreat, monitoring equipment, monitoring installation, monitoring methods, monitoring design, horizontal displacement, vertical displacement, active mines, coal mining, geotechnical, rock mechanics

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

Hucka, V. J., C. K. Blair, E. P. Kimball. Mine Subsidence Effects on a Pressurized Natural Gas Pipeline. Preprint No. 83-386, for presentation at the SME-AIME Fall Meeting and Exhibit, Salt Lake City Utah, October 19-21, 1983, 10 p.

A 20-inch-diameter high-pressure natural gas pipeline crosses over a coal mine in central Utah. The room-and-pillar method with pillar extraction is being used to extract the coal from the seams. The pillars beneath the pipeline will not be extracted. An attempt has been made to predict subsidence in the area where pillars may collapse; a network of survey points has been installed along the pipeline to detect ground movements.

Keyword(s): utilities, pipelines, survey methods, survey design, multiple-seam extraction, pillar strength, coal mining, pillar extraction

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

HUD Challenge. Backfilling Abandoned Mines. v. 4, no. 9, September 1973, p. 30.

This paper describes the use of the Dowell process at Rock Springs, WY.

Keyword(s): hydraulic backfilling, abandoned mines

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

Hudgings, R. A., R. M. Bennett, L. A. Sneed. Experimental Testing of Damage Mitigation Techniques. 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. 173-176.

Two sets of six linear footings are constructed over an advancing longwall panel in southern Illinois. One set is located parallel to and directly above the centerline, while the other set is in the predicted zone of maximum tension. Each set contains a plain concrete control footing, footings with plastic-sand and plastic interface, and a reinforced concrete, post-tensioned concrete, and steel fiber reinforced concrete footing. This paper describes the preliminary analysis and construction of the test foundations.

Keyword(s): foundations, active mines, longwall, instrumentation, engineering, surface structural damage, monitoring methods, monitoring equipment, structural mitigation

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

Hudspeth, H. M., D. W. Phillips. Forces Induced by the Extraction of Coal and Some of Their Effects on Coal-Measure Strata. Transactions, Institute of Mining Engineers, v. 85, 1932-33, p. 37-57, 186-190.

This paper describes general and mathematical considerations of fractures forming in coal measure strata. Results are given of experiments with models.

Keyword(s): overburden, modeling, coal mining

Hudspeth, H. M. Ground Movement in Advance of Longwalls. Iron and Coal Trades Review, v. 126, 1933, p. 1-3.

Roadways were driven in the coal in advance of the working faces of two mines. Telescoping measuring rods were used to record raise in floor and convergence of roof.

Keyword(s): longwall, monitoring equipment, coal mining, floor stability, roof stability

Hudspeth, H. M., D. W. Phillips, A. Walker. North of England Institute of Mining and Mechanical Engineers' Support of Workings in Mines Committee--Fourth Progress Report. Transactions, Institute of Mining Engineers, v. 91, 1935-36, p. 349-367.

This paper discusses the effects of depth, width of working, strength of roof, sides, and/or floor on roof falls.

Keyword(s): roof stability, room-and-pillar, floor stability

Location(s): England

Huff, L. L., G. Jarrell, S. Jarrell. Assessment of Future Economic Tradeoffs Between Coal Mining and Agriculture. Illinois Department of Energy and Natural Resources Doc. No. 81/29, July 1982, Project No. 80.214, Springfield, IL, 406 p.

Illinois is a state with substantial energy reserves in the form of coal and is a leader in agricultural output. Of the 24.4 million acres available as the cropland base, approximately 80% (19.1 million acres) is considered prime farmland. Coal mining in Illinois has occurred since the 1860s

and will continue in the future because of the vast quantity of reserves remaining. This report discusses the reserves and potential of both surface coal mining and prime agricultural land. It goes on to analyze the potential conflict between these two activities in the future, as well as the environmental and economic impact of each.

Keyword(s): coal mining, agriculture, economics, environment, land-use planning, reclamation, surface water, subsurface water, government, law, land values

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

Hughes, R. E. The Use of Ordnance Survey Bench Marks for the Study of Large-Scale 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. 185-205.

To demonstrate the methods of bench mark surveys, the value of their readings, and their limitations, five case histories are presented. The case histories were chosen to demonstrate the use and shortcomings of such surveys. Case history 1 records an investigation where different amounts and rates of mining subsidence can be seen around the town center. Case history 2 demonstrates the relationship of surface settlement patterns and geology/mining features. Case history 3 shows the difficulty of using such surveys in rural areas, and case history 4 shows that the Ordnance Survey information can be wrong. Case history 5 illustrates how bench mark information, post dating the subsidence, can be misleading.

Keyword(s): monitoring methods, monitoring design, survey methods, survey design, survey data processing

Location(s): United Kingdom

Hunt, S. R., C. G. Treworgy. Geologic Constraints on the Mining of Shallow Coals in Illinois. SME-AIME, St. Louis, October, 1977.

Keyword(s): geologic features, coal mining

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

Hunt, S. R. Characterization of Subsidence Profiles Over Room-and-Pillar Coal Mines in Illinois. IN: Proceedings, Illinois Mining Institute, October 19-20, 1978, p. 50-66.

This paper summarizes some preliminary results of current ISGS investigations into surface subsidence resulting from coal mining in Illinois. The purpose of the study is to characterize the vertical movements that may result from various types of underground coal mining. The findings of this study, based on mining operations in a variety of geologic settings, delineate the magnitude, shape, and position of the subsidence profile. Comparisons of case histories of subsidence are based primarily on the extraction ratio and the general geometry of the mine (depth, panel width, and mining height).

Keyword(s): vertical displacement, coal mining, geologic features, room-and-pillar, high-extraction retreat, longwall

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

Hunt, S. R. Characterization of Subsidence Profiles Over Room-and-Pillar Coal Mines In Illinois. Presented at Society of Mining Engineers of AIME Annual Meeting, New Orleans, LA, February 18-22, 1979, SME-AIME Preprint 79-126, 15 p.

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

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

Hunt, S. R. Characterization of Subsidence Profiles Over Room-and-Pillar Coal Mines in Illinois. Illinois State Geological Survey Reprint 1979F, 1979, reprinted from Proceedings of Illinois Mining Institute, 86th Annual Meeting, p. 50-65.

This paper summarizes some preliminary results of ISGS investigations into surface subsidence resulting from coal mining in Illinois. The purpose of the study is to characterize the vertical movements that may result from various types of underground coal mining. The findings of this study, based on mining operations in a variety of geologic settings, delineate the magnitude, shape, and position of the subsidence profile. Comparisons of case histories of subsidence are based primarily on the extraction ratio and the general geometry of the mine (depth, panel width, and mining height.)

Keyword(s): coal mining, geologic features, active mines, abandoned mines

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

Hunt, S. R. Surface Subsidence Due to Coal Mining in Illinois. Ph.D. Dissertation, University of Illinois, Urbana, 1980, 129 p.

Subsidence of the land surface has been associated with coal mining in Illinois since the early days of the industry. Illinois Supreme Court rulings dating from 1880 testify to the extent of the

concern. However, over the years there has been very little scientific or engineering documentation of subsidence in Illinois. In Europe, on the other hand, knowledge of coal mine subsidence has progressed to a fairly advanced state, for longwall mining in particular. This study began in 1975 as a result of an investigation of roof problems in Illinois coal mines. At that time, inquiries about subsidence in Illinois lead to the realization that the literature only covered longwall mining, which was not practiced in Illinois. In addition, there was virtually no documentation of subsidence events within Illinois. Thus, comparison of subsidence occurrences either within Illinois or between Illinois and other mining districts was impossible. This study was based on a need to document subsidence in Illinois, to identify the conditions causing subsidence, and to establish a basis of characterizing the subsidence that has taken place. The investigation was primarily a field study of subsidence development.

Keyword(s): coal mining, longwall, room-and-pillar, National Coal Board, vertical displacement, geologic features, active mines, abandoned mines, overburden, soils, angle of draw, literature search, high-extraction retreat, roof support, pillar strength, floor stability, roof stability

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

Hunt, S. R., R. A. Bauer, P. B. DuMontelle. Surface Subsidence Due to Coal Mining in the Illinois Coal Basin. U.S. DOE Contract Final Report, Contract No. ET-78-G-01-3085, February 23, 1981, by Illinois State Geological Survey.

The principal goals of the study were to document subsidence case histories in terms of the mode, magnitude, and areal distribution of subsidence movements; identify geologic conditions and mining practices in Illinois and their influence on subsidence; characterize subsidence profiles for various methods of mining in Illinois; produce a data retrieval system for coal mine and subsidence information and case histories in Illinois; and investigate the coordination of land use and various underground mining methods.

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

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

Hunter, J. Pneumatic Stowing at Bullcroft Main Colliery. Transactions Institution of Mining Engineers, v. 105, 1945-46, p. 111.

This paper reviews packing of mined out areas in the subject mine prior to pneumatic backfilling; it also details backfilling devices and methods.

Keyword(s): pneumatic backfilling

Hunter, R. Longwall Mining. IN: Proceedings, 1st National Coal Association/Bituminous Coal Research Symposium on Mining Methods, Harrogate, October 30-November 1, 1974, p. 57-64.

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

Location(s): United Kingdom

Hurst, G. Avoiding Subsidence Effects in Surface Buildings. Colliery Engineering, v. 25, no. 291, May 1948, p. 158-163; v. 25, no. 292, June 1948, p. 194-198; v. 25, no. 293, July 1948, p. 230-234.

The author describes the effects of subsidence on surface structures with particular emphasis on tensional and compressional forces. Various types of buildings constructed to combat the effects of subsidence are discussed in detail.

Keyword(s): surface structural damage, foundations, engineering, construction, architecture, structural mitigation

Hurst, G. Protection of the Surface in Mining Areas. Colliery Engineering, v. 25, no. 287, January 1948, p. 14-22; v. 25, no. 288, February 1948, p. 43-46.

Keyword(s): surface subsidence damage, ground control

Hurst, G. The Lorraine Coalfield. Colliery Engineering, v. 35, September 1958, p. 374-381; v. 35, October 1958, p. 445-450.

This paper discusses the working of a nearly vertical coal seam in a French coalfield that maintained one of the highest production rates in Europe at the time. The system employed stope caving with hydraulic sand filling.

Keyword(s): hydraulic backfilling, coal mining

Location(s): France

Hurst, G., F. Owen, C. Bayrac. Some Observations on the Behavior of a Large School Subject to Mining Subsidence. Colliery Engineering, v. 43, July, 1966, p. 295-301, and August 1966, p. 343-350.

This paper describes a study of subsidence damage to a school underlain by limestone, which in turn was underlain by mine workings of two seams. The foundation of the school was constructed specially to guard against subsidence effects, but it was still damaged extensively.

Keyword(s): surface structural damage, multiple-seam extraction, foundations, architecture, structural mitigation

Location(s): England

Hurst, R. E., L. D. Boughton. Subsidence Control--Backfilling of Waterfilled Mines. IN: Proceedings Environmental Quality Conference, Washington, D.C., June 7-9, 1971, SME-AIME, Littleton, CO, p. 129-136.

Keyword(s): backfilling

Location(s): United States

Hurst, R. E. Statement Before the U.S. Senate Interior Committee on Minerals, Materials, and Fuels. December 2, 1971.

The author compared controlled and blind backfilling with the Dowell process.

Keyword(s): hydraulic backfilling

Location(s): United States

Hustrulid, W. A. A Review of Coal Pillar Strength Formulas. Rock Mechanics, v. 8, 1976, p. 115-145.

Keyword(s): pillar strength, ground control, rock mechanics, coal mining

Hutchings, R., M. Fajdiga, D. Raisbeck. The Effects of Large Ground Movements Resulting from Brown Coal Open-Cut Excavations in the Latrobe Valley, Victoria. 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. 136-161.

Large earth movements accompanied the development of brown coal open cut excavations in the Latrobe Valley, Victoria. These movements became widespread over an area exceeding 100 square km since the late 1960s. The main regional movement was subsidence caused by dewatering associated with coal winning. Other factors contributing to the observed earth movements included pressure relief, geometry of the open cuts, geologic structure of the coal deposits, lowering of the free groundwater table close to the open cuts, and water pressures in tension cracks initiating block movements of coal on clay layers.

Keyword(s): ground control, subsurface subsidence damage, surface subsidence damage, coal mining, geologic features, subsurface water

Location(s): Australia

Hyett, A. J., J. A. Hudson. In Situ Stress for Underground Excavation Design in a Naturally Fractured Rock Mass. 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. 293-300.

This paper discusses the contribution of items related to discontinuities to the total stress variability of a moderately fractured rock mass.

Keyword(s): mine design, rock mechanics, geologic features

Hylbert, D. K. Developing Geological Structural Criteria for Predicting Unstable Mine Roof Rocks. Appalachian Coal Mining Institute, Morehead State University, Contract HO133018, U.S. Bureau of Mines OFR 9-78, 1977, 249 p. (NTIS PB 276-735/AS)

Keyword(s): roof stability, coal mining, geologic features

Location(s): United States

Hylbert, P. K. The Classification, Evaluation, and Projection of Coal Mine Roofs in Advance of Mining. Mining Engineering, December, 1978, v. 30, p. 1667-1676.

Keyword(s): roof stability, coal mining

Hynes, J. L. Tri-Towns Subsidence Investigation, Weld County, Colorado: A Community-wide Approach to Hazard Evaluation and Land Use in Undermined Areas. Colorado Geological Survey Open File Report 87-3, for Division of Mined Land Reclamation, Inactive Mine Program, Department of Natural Resources, Denver, CO, 1984.

This study was undertaken for two principal reasons. The first was a response to requests by local governments to provide them with some usable data to guide them in future land-use decisions in the extensively undermined tracts within their jurisdictions. The second was to use the opportunity to test and evaluate various ideas and theories currently used in data acquisition and analysis of undermined areas, in a sense, to perform a prototype study on which further investigations could rely as a model or guide.

Keyword(s): abandoned mines, coal mining, land-use planning, reclamation, land mitigation, surface structural damage, geologic features, prediction

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

Hynes, J. L. Essential Components of a Mine Subsidence Investigation. 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. 81-86.

Many factors affect the reliability, accuracy, and usefulness of the results of a subsidence investigation above abandoned mines. Within control of the investigator are several organizational and data acquisition requirements which are critical to the success of the study, including mapping, drilling, down-hole geophysics, sampling and testing, a site survey, and site evaluation.

Keyword(s): abandoned mines, monitoring methods, survey methods, geophysical, surface structural damage, modeling, prediction, lab testing

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

Hynes, J. L., ed. Proceedings of the 1985 Conference on Coal Mine Subsidence in the Rocky Mountain Region. Colorado Geological Survey Special Publication 31, Department of Natural Resources, Denver, CO, 1986.

Impacts of subsidence are especially significant in the Rocky Mountain West where population growth and rapid community expansion have increased development pressure on significant areas of subsidence-prone ground. The present consequences of unrecognized and poorly managed subsidence hazards are much more serious in the emerging urban and suburban environment than they were in the past where they occurred primarily in agricultural lands.

Keyword(s): reclamation, abandoned mines, historical, mine fires, surface structural damage, remote sensing, photography, backfilling, grouting, hydraulic backfilling, modeling, prediction, room-and-pillar, monitoring design, structural mitigation, land mitigation, architecture, ground control, land-use planning, insurance, coal mining

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

IAHS-AIHS. Land Subsidence--Affaissement du Sol. Proceedings International Symposium, September 14-18, 1969, Tokyo, IAHS Publications No. 88 and No. 89.

IASH-AIHS. Land Subsidence Symposium. Proceedings, 2nd International Symposium on Land Subsidence, Anaheim, CA, December, 1976, IASH-AIHS Publication No. 121, 1977.

Iannacchione, A. T. Behavior of a Coal Pillar Prone to Burst in the Southern Appalachian Basin of the U.S. IN: Proceedings, 2nd International Symposium of Rockburst and Seismicity in Mines, Minneapolis, MN, 1988, p. 427-439.

Keyword(s): pillar strength, bumps, coal mining

Location(s): Appalachian Coal Region, United States

Iannacchione, A. T. Numerical Simulation of Coal Pillar Loading with the Aid of a Strain-Softening Finite Difference Model. IN: Rock Mechanics as a Guide for Efficient Utilization of Natural Resources, Proceedings 30th U.S. Symposium, A.W. Khair, ed., 1989, Balkema, Rotterdam, p. 775-782.

Numerical simulation of coal pillar loading has traditionally been a difficult task because of the unique and highly variable properties of coal and the inability of numerical procedures to duplicate these properties. This simulation was based upon material properties developed from laboratory tests of coal cubes and examined against coal pillar strength data developed from actual underground measurements. The coal cube measurements indicated the coal followed a nonlinear Mohr-Coulomb failure criterion. The in situ measurements showed that a pillar yield zone developed similar to Wilson's hypothesis and, at high confinements, the pillar core seemed to follow a psuedo-ductile behavior. The strain-softening model simulated coal cube and pillar behavior at moderate load conditions. However, at high loads the models were inaccurate, due to an inadequate failure mechanism and/or to changes in the pillar constraints at the coalbed interface.

Keyword(s): coal mining, modeling, pillar strength, rock mechanics, lab testing, in situ testing, longwall

Location(s): United States

Iannacchione, A. T. The Effects of Roof and Floor Interface Slip on Coal Pillar Behavior. IN: Rock Mechanics Contributions and Challenges, Proceedings of the 31st U.S. Rock Mechanics Symposium, June 18-20, 1990W.A. Hustrulid and G.A. Johnson, eds., Golden, CO, Balkema, Rotterdam, p. 153-160.

This paper discusses the importance of an interface slip mechanism between the coalbed and the surrounding strata in controlling the extent and pattern of stresses and deformations in a coal pillar.

Keyword(s): coal mining, pillar strength, rock mechanics, overburden, modeling, geologic features

Ilijn, A. S. Earth Surface Subsidence at the Areas of Gas and Oil Pumping Out. IN: Proceedings, 2nd International Symposium on Land Subsidence, Anaheim, CA, 1977, International Association Hydrological Sciences Publication, v. 121.

Keyword(s): fluid extraction, oil extraction

Illinois Abandoned Mined Lands Reclamation Council. Progress Report, 1979/1980. Abandoned Mined Lands Reclamation Council, Springfield, IL, 1980, 77 p.

In the 2 years covered by this report, the AML Reclamation Council undertook 33 reclamation projects throughout the state. Nine of those were emergencies related to abandoned mines.

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

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

Illinois Abandoned Mined Lands Reclamation Council. Quarterly Progress Report, January 1-March 31, 1981. Abandoned Mined Lands Reclamation Council, Springfield, IL, April 30, 1981, 49 p.

Keyword(s): abandoned mines, structural mitigation, land mitigation, reclamation

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

Illinois Abandoned Mined Lands Reclamation Council. Quarterly Progress Report, April 1 to June 30, 1981. Abandoned Mined Lands Reclamation Council, Springfield, IL, 1981, 35 p.

This report summarizes activities in the areas of design and reclamation, subsidence, and administration and planning for the quarter.

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

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

Illinois Abandoned Mined Lands Reclamation Council. Illinois State Reclamation Plan for Abandoned Mined Lands. Abandoned Mined Lands Reclamation Council, Springfield, IL, July, 1980, revised January 1982; supplementary resource document by Southern Illinois University Cooperative Wildlife Research Laboratory, Carbondale (2 volumes).

Section 405 of P.L. 95-87 and the respective Federal Rules identified 18 key elements that must be addressed in a State Reclamation Plan. The Illinois AML Reclamation Council addressed these elements in 18 separate sections contained in this volume.

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

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

Illinois Abandoned Mined Lands Reclamation Council. Mine Subsidence Report, Our Lord's Lutheran Church, Collinsville, Illinois. Abandoned Mined Lands Reclamation Council, Springfield, IL, 1982, 42 p.

Data presented in this technical report are intended to describe the existing site conditions at a church that has been stabilized since an initial subsidence event in 1978. The specific methods of structural repair are being developed by an architect for the church. During the course of this study, data were provided by the AML Reclamation Council to the architect to assist development of plans and specifications for the necessary repair work.

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

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

Illinois Abandoned Mined Lands Reclamation Council. Quarterly Progress Report, April 1 to June 30, 1983. Abandoned Mined Lands Reclamation Council, Springfield, IL, 1983, 68 p.

This report summarizes design and reclamation, subsidence and emergencies, and planning activities for the designated time period.

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

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

Illinois Abandoned Mined Lands Reclamation Council. Quarterly Progress Report, July 1 through September 30, 1983. Abandoned Mined Lands Reclamation Council, Springfield, IL, 1983, 72 p.

This report summarizes activities in the areas of design and reclamation, including construction grants, subsidence and emergencies, and planning. The Subsidence Response Team responded to 14 inquiries involving potential subsidence and emergency situations; only four were actually subsidence related, and one qualified for emergency abatement.

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

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

Illinois Abandoned Mined Lands Reclamation Council. A Homeowner's Guide to Mine Subsidence in Illinois. State of Illinois, April, 1992.

This brochure describes sag-type subsidence and the services provided by the Abandoned Mined Lands Reclamation Council and the Illinois Mine Subsidence Insurance Fund. It is intended to provide the homeowner with sufficient direction and background information to serve as a starting point in making future decisions.

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

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

Illinois Department of Mines and Minerals. The Surface Coal Mining Land Conservation and Reclamation Act. PA 81-1015, Amendment No. 3, Illinois Register, 1982.

Keyword(s): law, government, reclamation, environment, coal mining

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

Illinois Department of Mines and Minerals. The Surface Coal Mining Land Conservation and Reclamation Act, June 1, 1980. Land Reclamation Division, Springfield, IL, 1983, 40 p.

Section 4.02 gives a brief description of the mine operator's responsibilities for the treatment of subsidence resulting from underground mining in Illinois.

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

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

Illinois Department of Mines and Minerals. Citizen's Guide to Coal Mining and Reclamation in Illinois. Land Reclamation Division, Springfield, IL, 1985, 43 p.

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

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

Illinois House Executive Subcommittee on Mine Subsidence. Research Report and Recommendations. Illinois Legislative Council, November 29, 1976, 37 p.

This report presents an overview of Illinois subsidence problems and coal mining history, and recommends options to protect homeowners from catastrophic damage.

Keyword(s): government, law, coal mining, surface structural damage, insurance, abandoned mines, land-use planning, active mines

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

Illinois Mine Subsidence Insurance Fund. Annual Report, 1986. Illinois Mine Subsidence Insurance Fund, Chicago, IL, 1987, 12 p.

In Illinois, insurance against the damage caused to homes and other structures by the collapse of underground mines is handled by the state's private insurance industry, according to guidelines established by the legislature.

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

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

Illinois State Geological Survey, Department of Mining Engineering, University of Illinois, U.S. Bureau of Mines. Preliminary Report on Organization and Method of Investigations. Illinois State Geological Survey, Mining Investigation Bulletin 1, 1913, 71 p.

The 47th Illinois General Assembly and the Secretary of the Department of the Interior authorized an investigation of coal mining under a cooperative agreement between the ISGS, University of Illinois Mining Department, and USBM. It was believed that more efficient mining methods would save a large portion of the coal resources of the state, cut down on the rate of deaths and accidents, and make for safer mining investments. The bulletins that followed described the resources and mining practices throughout the state.

Keyword(s): coal mining, historical

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

Illinois State Geological Survey. Research Needs of Illinois' Coal Industry. Illinois State Geological Survey, Mining Investigation Bulletin 33, 1930, 89 p.

This report contains seven papers presented at a symposium at the Quarter Centennial of the ISGS. One paper discusses coal recovery and suggests mining systems that would be less wasteful.

Keyword(s): coal mining, historical

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

Imim, H. I. Memorandum of Evidence to the Committee on Mining Subsidence. Transactions, Institution of Mining Engineers, London, v. 107, 1947, p. 50-64.

This document contains observations and recommendations pertaining to subsidence legislation, legal settlements, building construction, etc., with respect to coal mining.

Keyword(s): law, construction, coal mining

Location(s): United Kingdom

Imim, H. I. A Viscoelastic Analysis of Mine Subsidence in Horizontal Laminated Strata. Ph.D. Dissertation, University of Minnesota, Minneapolis, 1965, 63 p.

Keyword(s): continuum mechanics, modeling, phenomenological model, viscoelastic model

Indraratna, B., S. Naguleswary, A. S. Balasubramaniam. Application of Physical and Mathematical Modelling in Underground Excavations. 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. 301-308.

The scope of this paper is to introduce a mathematical model based on matrix algebra in order to determine similitude quantities, which can be arranged in specific formats to simulate the field conditions and associated behavior. The formulation of a typical mathematical model applicable to geomechanics is demonstrated here. The examples provided are intended to facilitate comprehension and application of the proposed model in practice.

Keyword(s): modeling, mathematical model, physical model, tunnelling

Ingram, D. K., G. M. Molinda. Relationship Between Horizontal Stresses and Geologic Anomalies in Two Coal Mines in Southern Illinois. U.S. Bureau of Mines RI 9189, 1988, 18 p.

In situ horizontal stresses were measured to determine the influences of geologic anomalies on the regional horizontal stress field in two coal mines in southern Illinois. Stress measurements were obtained near a normal fault having a 121-foot displacement at the AMAX Wabash Mine and a large coalbed want at the Kerr-McGee Galatia No. 5 Mine. Horizontal stress measurements were completed using a USBM borehole deformation gauge. Generally, geologic anomalies appeared to have no dramatic effect on the regional horizontal stresses. However, subtle differences between stress measurements suggest an influence by the fault zone at the Wabash Mine. The larger anisotropic stress conditions at the Galatia No. 5 Mine could be responsible for the increase in kink zones and directional roof failures.

Keyword(s): geologic features, coal mining, active mines, monitoring equipment, roof stability, mine design, roof support

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

Ingram, D. K., M.A. Trevits, J. S. Walker. A Comparison of Subsidence Prediction Models for Longwall and Room-and-Pillar Conditions. IN: Coal Mining Technology, Economics and Policy 1989, American Mining Congress Coal Convention, Pittsburgh, June 19-21, 1989, p. 545-560.

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

Location(s): United States

Ingram, D. K. Surface Fracture Development Over Longwall Panels in South-Central West Virginia. U.S. Bureau of Mines RI 9242, 1989, 18 p.

This report focuses on the development of large open surface fractures over mined-out coal longwall panels. The research concentrates on defining the fractures characteristics and their controlling variables. The investigation was conducted at two mines in south-central West Virginia.

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

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

Ingram, D. K., G. M. Molinda. Geologic Discontinuities and Their Influence on the Regional Horizontal Stress Field in Southern 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. 18-38.

Previous investigations have documented that southern Illinois is influenced by a regional east-northeast to west-southwest horizontal compressional stress field. The USBM measured in situ horizontal stresses to determine the influences of geologic discontinuities on the regional horizontal stress field in two southern Illinois coal mines.

Keyword(s): geologic features, coal mining, roof stability, instrumentation, in situ testing

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

Ingram, D. K., M. A. Trevits. Characteristics of Overburden Deformation 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. 280-289.

The objective of this investigation was to characterize overburden response due to longwall mining. Subsurface strata and surface deformations were monitored during the mining of two adjacent 900-foot-wide longwall panels in southeastern Ohio.

Keyword(s): overburden, longwall, coal mining, active mines, instrumentation, monitoring methods, monitoring equipment, geologic features, rock mechanics, horizontal displacement, vertical displacement

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

Institute of Civil Engineering (London) Ground Subsidence. Thomas Telford Ltd., 1977, 99 p.

This book provides guidance to good practice for the civil engineer who is not a specialist in the area of ground subsidence. It is divided into seven sections dealing with the causes and effects of both natural and induced surface subsidence.

Keyword(s): vertical displacement, horizontal displacement, surface structural damage, subsurface structural damage, surface water, mine design, backfilling, ground control, engineering

Location(s): England

Institution of Civil Engineers. Report on Mining Subsidence. London, 1959, 52 p.; reprinted 1962.

Four subcommittees were set up to deal with bridges, public utilities, roads, and structures. Each of these subcommittees made extensive inquiries

and studied the various published reports. In some cases experts attended meetings to give evidence. From the information collected, the subcommittees prepared individual reports that were integrated to produce this report. Each subcommittee considered the subject under the following main headings: (1) types of movement, (2) effects of movement, (3) precautionary measures, (4) remedial measures, and (5) research. Certain matters, particularly under (1) and (3), which are commonly applicable, were made the subject of part 1of this report.

Keyword(s): surface structural damage, backfilling, engineering, pillar strength, coal mining, utilities, pipelines, roads, structural mitigation, mitigation, law

Location(s): United Kingdom

Institution of Mining and Metallurgy. CARE '88 Conference on Applied Rock Engineering, Newcastle upon Tyne, January, 1988. Institute of Mining and Metallurgy, Brookfield, VT, No. 0 900488 99 9, 1988, 290 p.

Papers in this volume were written by an international authorship and cover a wide range of subjects dealing with problems in rock engineering, including mine subsidence, backfilling, and monitoring.

Keyword(s): backfilling, engineering, coal mining, metal mining, monitoring methods, mine safety, modeling, prediction, rock mechanics, mine operation, foundations, tunnelling, in situ testing, soil mechanics, lab testing, mine waste

Location(s): Australia, United Kingdom, South Africa, Canada, Finland

Institution of Mining Engineers. Effects of Stowing on Surface Subsidence. Transactions, Institution of Mining Engineers, v. 107, no. 58, 1947.

Keyword(s): stowing

Institution of Municipal Engineers. Report of Special Committee on Mining Subsidence. London, 1947, 80 p.

Keyword(s): United Kingdom

Ireland, R. L., J. F. Poland, F. S. Riley. Land Subsidence in the San Joaquin Valley, California, as of 1980. U.S. Geological Survey Professional Paper 431-I, 1984, 93 p.

Keyword(s): fluid extraction

Location(s): California, United States

Irving, C. J. Some Aspects of Ground Movements. Chemical, Metallurgical, and Mining Society of South Africa Journal, v. 46, May-June, 1946, p. 278-317.

Keyword(s): surface subsidence damage

Location(s): South Africa

Irwin, R. W. Subsidence of Cultivated Organic Soil in Ontario. IN: Proceedings American Society Civil Engineers 103, 1R2, 1977, p. 197-205.

Keyword(s): soils, engineering

Location(s): Canada

Isaac, A. K., P. Neve, T. J. Bradbury. Ground Control in British Longwall Mining. Journal of Mines, Metals & Fuels, September 1983, Special Number on Update on Longwall Mining--Evolving Trends, p. 423-436.

This paper presents a brief review of ground control developments within the British longwall system and highlights two areas of research with which the authors have been closely involved. Some aspects are presented of work conducted in the South Wales Coalfield relating to (1) design of gateroad support at fast retreating longwall faces, and (2) assessment of powered support performance at longwall faces.

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

Location(s): United Kingdom, India

Isaac, A. K., B. G. D. Smart, P. Neve, A. D. Mayer. Gateroad Design at Fast Retreating Longwall Coal Faces. IN: Proceedings, 18th International Symposium on Application of Computers and Mathematics in the Mineral Industries, March 26-30, 1984, London, p. 681-693.

The successful application of numerical modeling in the general area of engineering design encouraged the development of a two-dimensional, elastic finite difference model for simulation of strata behavior around the gate roadways of fast retreating longwall coalfaces. An assessment is made of the suitability of such a model for a "soft rock" environment. Emphasis is placed on derivation of input data with a careful assessment of the physical properties of proximate strata and the elements of the permanent support system.

Keyword(s): coal mining, longwall, modeling, mine design, finite element, rock mechanics, monitoring methods, in situ testing, geotechnical, geologic features

Location(s): United Kingdom

Isaac, A. K., I. L. Follington. Geotechnical Influences Upon Longwall Mining. IN: Engineering Geology of Underground Movements, Geological Society Engineering Geology Special Publication No. 5, 1988, F.G. Bell, et al., eds., p. 233-242.

This paper describes geotechnical influences upon the planning, development, and implementation of the longwall mining system. The effects of these factors have been assessed from a series of comprehensive investigations carried out in the South Wales and South Nottinghamshire Coalfields. All the investigations involved the setting up of monitoring sites employing specially designed instrumentation to monitor the parameters outlined in the paper. In addition, detailed structural and lithological investigations have been carried out involving underground mapping, diamond drilling and logging, geotechnical core logging, and physical rock property determinations.

Keyword(s): longwall, coal mining, geotechnical, monitoring methods, instrumentation, mine design, geologic features, rock mechanics, ground control, floor stability, roof stability

Location(s): United Kingdom

Ishijima, Y., T. Isobe. The Simulation to Analyze Surface Subsidence Using Three Dimensional Finite Element Method. 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 11, 1973, p. 11-1--11-5.

Finite element method is applied to the model study using a computer to simulate the ground movements caused by mining of a horizontal coal seam. Both "open type" and "closed type" conditions are taken into account as the boundary condition on the periphery of the excavated panel. The rock material is assumed to be elastic; however, the heterogeneous aspect of the strata and the weakening of the stiffness of the rock material by failure are also taken into account. Ground movements including surface subsidence predicted by the proposed model show considerable agreement with the field observations in the coal districts. It is emphasized that a model study taking into account the effect of face advance is needed when the formation of the fractured zone around the excavation is to be simulated.

Keyword(s): finite element, modeling, computer, coal mining, prediction

Location(s): Japan

Ivey, J. B. Guidelines for Engineering Geologic Investigations in Areas of Coal Mine Subsidence: A Response to Land-Use Planning Needs. Bulletin Association of Engineering Geologists, v. 15, no. 2, 1978, p. 163-174.

The discussion is based on work done in the Boulder-Weld coalfield located in central Colorado. However, much of what is discussed and concluded here will apply in principle to other areas in which material is removed from its natural subsurface location, particularly in low dipping bedded sedimentary rocks.

Keyword(s): engineering, land-use planning, coal mining, abandoned mines, surface structural damage

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

Ivey, J. B. Coal Mine Subsidence, Past, Present, and Future, in the Rocky Mountains. 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. 1-14.

The emphasis is on Colorado in this paper. Much of what is said, however, generally and philosophically applies to the other Rocky Mountain states. Subsidence is primarily a man-made hazard that has adversely affected many types of man-made works. The potential for additional subsidence effects to be manifested exists particularly in areas where inactive mines are found.

Keyword(s): historical, land-use planning, law, surface structural damage, coal mining, abandoned mines

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

Jack, B., J. J. Steijn, N. C. Gay. The Effect of Subsidence as a Result of Shallow Mining Operations on Surface Structures--A Quantitative Case Study. Monitoring for Safety in Geotechnical Engineering, August 10, 1984, p. 67-78.

This paper describes the effects of subsidence, as a result of shallow coal mining operations, on structures at ground surface.

Keyword(s): survey methods, geotechnical, photography, instrumentation, surface structural damage, longwall, monitoring equipment, coal mining

Location(s): South Africa

Jack, B. W. Case Studies of the Effects of Surface Subsidence on Gravel and Provincial Bituminous Roads. IN: Proceedings, SANGORM Symposium, October 21, 1986, Sandton, South Africa, International Society for Rock Mechanics, South African National Group, p. 97-114.

Total extraction of coal seams can cause damage to the surface and structures undermined. Roads of various types are the predominant structures that traverse the coalfields of South Africa. Instrumentation and monitoring techniques for case studies are described and the findings given.

Keyword(s): coal mining, monitoring methods, survey methods, instrumentation, roads

Location(s): South Africa

Jack, B. W. The Effects of the Undermining of a Farmhouse by a Longwall Panel and the Subsequent Extraction of the Adjacent Longwall Panel. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May 1992, South African Institution of Civil Engineers, Republic of South Africa, p. 109-114.

A farm complex was recently undermined in the Standerton district. The ground surface and house were monitored to record changes in elevation, tilt, and strain. The condition of the buildings was assessed prior to undermining by one longwall panel and again after the extraction of an adjacent panel separated by a 30-m-wide interpanel pillar. The house was situated inside the extraction area of the first longwall panel, 12 to 35 meters in from the ribside. When the adjacent longwall was extracted, this ribside formed an interpanel pillar. After the initial undermining, the house experienced a small amount of subsidence and a very slight tilt. Extraction of the second panel increased the subsidence above the first panel and induced subsidence above the interpanel pillar. This increased subsidence at the house by a factor of four, at the same time reducing the tilt back to zero. The house was not damaged.

Keyword(s): surface structural damage, longwall, active mines, monitoring methods, horizontal displacement, vertical displacement, instrumentation

Location(s): South Africa

Jackson, G. H., J. H. Soule. Measurements of Surface Subsidence, San Manuel Mine, Pinal County, Arizona. U.S. Bureau of Mines RI 6204, 1963, 36 p.

Keyword(s): monitoring equipment, modeling, metal mining

Location(s): Arizona, United States

Jackson, P. D., D. M. McCann, D. L. Russell. Geophysical Mapping During the Planning of New Roads: An Aid to the Detection of Mine-Workings. IN: Planning and Engineering Geology, Proceedings of 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. 447-452.

Magnetic field strength and electrical conductivity surveys have been made over an extensively mined area north of Dalton-in-Furness along parts of a proposed by-pass route. This approach was successful in detecting shafts and other workings, which were brick-lined and backfilled with debris and ash, since the magnetic field and electrical conductivity values are normally higher in the vicinity of such areas.

Keyword(s): abandoned mines, roads, geophysical, land-use planning

Location(s): United Kingdom

Jacobsen, W. E., J. S. Bhutani, J. C. Elliott. Subsidence Monitoring in Conjunction with Underground Mine Flushing Operations. Contract SO144073, Mitre Corp. U.S. Bureau of Mines OFR 34-76, 1975, 154 p. (NTIS PB 250 818)

Keyword(s): monitoring design, backfilling, monitoring methods

Location(s): United States

Jacobsen, W. E., J. P. Morris. Surface Subsidence from Mining--Reduction of Trigonometric Leveling Data. Mitre Corporation, Report MTR-6899, June 1975, 24 p.

Keyword(s): survey data processing

Jacquin, C., M. T. Poulet. Study of the Hydrodynamic Pattern in a Sedimentary Basin Subject to Subsidence. Society of Petroleum Engineers Paper 2988, 45th Annual Fall Meeting SPE-AIME, Houston, TX, 1970.

Keyword(s): hydrology, oil extraction

Location(s): United States

Janes, J. A Demonstration of Longwall Mining. Final Report, U.S. Bureau of Mines Contract JO333949 with Old Ben Coal Company, 1983, OFR No. 86(1)-85, 105 p., and 86(2)-85 (Appendix).

Longwall coal mining had been conducted by Old Ben Coal Company intermittently from June 1962 to April 1970. All six attempts were abandoned before the completion of the entire panel. The most serious problem was failure to control the roof with the chock-type supports available at the time. The USBM and Old Ben entered into a cost-sharing contract to demonstrate longwall mining in the Herrin No. 6 seam in southern Illinois in April 1975. Results obtained from the first panel indicated that roof could be controlled by sheild-type supports.

Keyword(s): longwall, roof support, roof stability, floor stability, coal mining, active mines, rock mechanics, geologic features, mine safety, finite element, geotechnical

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

Jansen, R. B. Earth Movement at Baldwin Hills Reservoir. ASCE Journal Soil Mechanics & Foundation Division, v. 93, No. SM4, Paper 5330, July 1967, p. 551-575.

Keyword(s): surface water

Jarosz, A., M. Karmis. Control of Surface Movements Above Active Coal Mines in Appalachia. 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. 122-133.

This study shows that the mining geometry and configuration of panels, as well as the extraction sequence can have a substantial impact on the surface ground movement. As opposed to "fixed" mine design parameters (such as depth or mining height), other parameters are "variable" design parameters and thus can be planned accordingly. Further work must be directed towards improving these principles and examine their practical implementation so that, subsidence control can be included in mine planning and design.

Keyword(s): coal mining, vertical displacement, horizontal displacement, mine design, geologic features, surface structural damage, time factor, prediction, influence function, empirical model, active mines

Location(s): Appalachian Coal Region, United States

Jarosz, A. P. Development of A Computer System for Prediction of Subsidence. IN: COMA: Proceedings of Symposium on Construction Over Mined Areas, Pretoria, May 1992, South African Institution of Civil Engineers, Republic of South Africa, p. 67-71.

The prediction of subsidence due to underground mining, the assessment of its impact on surface structures, and its control to meet acceptable levels of surface deformations are all important considerations during the mine design process. The paper briefly reviews and compares the different prediction techniques, as well as their advantages and drawbacks. The main focus is placed on the development of a comprehensive computer system, able not only to predict the vertical and horizontal components of the ground movement, but also to assess the induced surface damages and costs related to subsidence prevention and compensation. Such an approach will make it very useful for mine planning and cost analysis of mining operations where protection of the surface and surface structures is required.

Keyword(s): prediction, surface structural damage, prediction, prediction theories, vertical displacement, horizontal displacement, economics, survey data processing, computer

Location(s): South Africa

Jenike, A. W., T. Leser. Caving and Underground Subsidence. Transactions, AIME, v. 223, no. 1, 1962, p. 67-73.

The problems of caving and underground subsidence can be considered as the failure of a highly compacted rock and its subsequent flow in the form of broken rock. The problem is complex because the propagation of failure and flow have to be considered simultaneously; the yield strength of the virgin rock and the broken rock are different; and, while under certain conditions it is sufficient to consider the virgin rock as homogeneous, the density and the yield function of broken rock are both pressure and time dependent.

Keyword(s): rock mechanics, overburden

Location(s): United States

Jenkins, H. C. Gob-Stowing Practices. Transactions, Institute of Mining Engineers, v. 81, 1931, p. 120.
Keyword(s): stowing, mine waste

Jenkins, J. D. Mechanics of Floor Penetration in Mines. Iron and Coal Trades Review, v. 171, no. 4560, 1955, p. 541-547.
Keyword(s): floor stability

Jenkins, J. D. The Bearing Capacities of Mine Floors. Colliery Guardian, v. 195, no. 5039, 1957, p. 397-400.
Keyword(s): floor stability

Jenkins, J. D. Some Investigations into the Bearing Capacities of Floors in the Northumberland and Durham Coalfields. Transactions, Institution of Mining Engineers, v. 117, part II, 1958, p. 725-738.
Keyword(s): floor stability, coal mining
Location(s): United Kingdom

Jenkins, J. R. Some Notes on Science of Roof Caving and Its Practice on Longwall Machine Faces. Transactions, AIME, v. 100, October 1940, p. 2-19.
Keyword(s): mine design, ground control, longwall, roof stability
Location(s): United States

Jennings, J. E., A. B. A. Brink, A. Louw, G. D. Gowan. Sink-Holes and Subsidence in the Transvaal Dolomites of South Africa. IN: Proceedings 6th International Conference on Soil Mechanics and Foundation Engineering, Montreal, 1965, p. 51-54.
Keyword(s): geologic features, soil mechanics
Location(s): South Africa

Jerabek, F. A. Investigations of Segregation in Discharge Fill Slurry and Compressibility of Small Sized Fill Material. M.S. Thesis, Department of Mining, The Pennsylvania State University, 1963.
This paper is an extensive study of size segregation during fill emplacement by hydraulic flushing. The author discusses sedimentation regimes, angle of repose, and compressive strength as related to particle size.
Keyword(s): hydraulic backfilling, lab testing

Jerabek, F. A., H. L. Hartman. Hydraulic Backfilling: A Method of Ground Support. AIME preprint, presented at Annual Meeting, Chicago, IL, February 14-18, 1965.
This paper discusses problems and practical applications of mine backfilling, as well as characteristics and relationships between the deposited fill material and overlying ground.
Keyword(s): hydraulic backfilling, ground control
Location(s): United States

Jerabek, F. A., H. L. Hartman. Mine Backfilling with Pneumatic Stowing. Mining Congress Journal, May and June, 1966.
These articles describe the state of the art of pneumatic backfilling based on European practices, mainly from Germany.
Keyword(s): pneumatic backfilling
Location(s): Germany, Europe

Jeran, P. W., T. M. Barton. Comparison of the Subsidence Over Two Different Longwall Panels. IN: Mine Subsidence Control, Proceedings Bureau of Mines Technology Transfer Seminar, Pittsburgh, September 19, 1985, U.S. Bureau of Mines IC 9042, p. 25-33.
The subsidences over two longwall sections operating in the northern Appalachian coal region were monitored. The panels differed in dimensions, overburden thickness, and coalbed mined. Although the final subsidence profiles differed, analysis of the data indicated the same process of subsidence operated at each panel.
Keyword(s): longwall, survey data processing, coal mining
Location(s): Pennsylvania, West Virginia, Appalachian Coal Region, United States

Jeran, P. W., V. Adamek. Subsidence Over Chain Pillars. IN: Eastern Coal Mine Geomechanics, Proceedings Bureau of Mines Technology Transfer Seminar, Pittsburgh, PA, November 19, 1986, U.S. Bureau of Mines IC 9137, p. 65-71.
Subsidence over two or more adjacent longwall panels and the intervening chain pillars was monitored at four mines in the Northern Appalachian Coal Basin. The magnitude of the subsidence over the chain pillars ranged from 0.06 to 1 foot. The width of the chain pillars affects the shape of the subsidence curve. Wider chain pillars yield a wider area of minimum subsidence. Comparison of the field-measured subsidence with precalculated subsidence over the chain pillars indicates a range of pillar deformation. The data show that, at three of the sites, additional subsidence was induced over the first panel by the mining of the second panel. Curves of the additional

subsidence are similarly shaped for these sites. This indicates that a model to predict subsidence over chain pillars could be developed with sufficient data.

Keyword(s): coal mining, pillar strength, mine design, surface subsidence damage, prediction, geologic features, survey equipment, survey equipment, survey data processing

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

Jeran, P. W., V. Adamek, M. A. Trevits. A Subsidence Prediction Model for Longwall Mine Design. IN: Mine Subsidence, Society of Mining Engineers Fall Meeting, St. Louis, MO, September, 1986, M.M. Singh, ed., SME, Littleton, CO, p. 3-8.

Lithological conditions over the Pittsburgh Coalbed cause the subsidence coefficient to vary within the area of the subsidence trough. This precludes the use of European predictive models, which are based upon a constant subsidence coefficient. Regression analysis of the distribution of subsidence coefficients from 11 USBM longwall panel studies on the location relative to the edge of the panel has yielded a third degree polynomial equation. This equation has been incorporated into a BASIC computer program for use on a PC, which allows users with no previous knowledge of the theory of subsidence to predict vertical movements over typical longwall panels in the northern Appalachian coal basin.

Keyword(s): prediction, longwall, coal mining, mine design, geologic features, computer, angle of draw, overburden, modeling

Location(s): Appalachian Coal Region, United States

Jeran, P. W., V. Adamek. Subsidence Due to Undermining of Sloping Terrain: A Case Study. U.S. Bureau of Mines RI 9205, 1988, 10 p.

Subsidence over a series of longwall panels undermining sloping terrain in southwestern Pennsylvania was monitored to verify the USBM subsidence prediction model for the northern Appalachian coal region. Comparison of the field data to model output showed close agreement. Vertical movements over each panel ceased with the mining of the adjacent panel. Horizontal movements were significantly affected by topographic slope. The distribution of horizontal strains over each panel were similar, with a zone of compression occurring over the center of each panel. The zones of compression were flanked by zones of tension toward the rib. The magnitude of the tensions were affected by the slope. The strains developed at the completion of each panel were not significantly altered by the mining of subsequent panels.

Keyword(s): longwall, prediction, modeling, coal mining, geologic features, horizontal displacement, vertical displacement

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

Jeran, P. W., V. Adamek. Subsidence Over the End of a Longwall Panel. U.S. Bureau of Mines RI 9338, 8 p.

Subsidence was monitored by the USBM over the ends of longwall panels operating in the Pittsburgh, Kittanning, and No. 2 Gas Coalbeds of the northern Appalachian Coal Basin. The final subsidence over the finishing ends of three panels in the Pittsburgh Coalbed are compared with the subsidence measured over the rib. The characteristics of subsidence are different. Data from the start of a longwall panel shows similar characteristics to the subsidence measured over the rib. A subsidence prediction model based on data gathered over the rib of a panel will not yield accurate results if it is applied to the finishing end of a longwall panel. Acceptable results may be obtained along the centerline over the starting end of a panel.

Keyword(s): monitoring methods, longwall, coal mining, active mines, prediction, modeling

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

Jeremic, M. L. Subsidence Problems Caused by Solution Mining of Rock-Salt Deposits. IN: Proceedings 10th Canadian Rock Mechanics Symposium, Kingston, September 2-4, 1975, Department of Mining Engineering, Queen's University, v. 1, p. 203-223.

Several things make it difficult to estimate subsidence that will result from solution mining. Unlike the excavations formed by underground mining methods, the outlines of the cavities formed by solution mining are not controlled and generally are not accurately known, although overall recovery can be determined (often about 12% of the formation). Moreover, the rheological properties of the assemblage of rocks and overburden above the extraction horizon and the nature of the existing stress fields are usually unknown. For these reasons, forecasts of subsidence caused by solution mining are often made by analogy with known occurrences.

Keyword(s): non-metal mining, rock mechanics, prediction, surface structural damage
Location(s): Yugoslavia, Canada

Jeremic, M. L. Influence of Shear Deformation Structures in Coal on Selecting Methods of Mining. Rock Mechanics, v. 13, 1980, p. 23-28.
Keyword(s): coal mining, rock mechanics, mine design

Jermy, C. A., F. G. Bell. Coal Bearing Strata and the Stability of Coal Mines in South Africa. IN: Proceedings International Congress on Rock Mechanics, Aachen, 1991, W. Wittke, ed., v. 2, p. 1125-1131.
Subsurface coal mining is affected by a number of properties of the strata involved: the lithological character of the rocks immediately above and below the coal seam; the sedimentary features contained within the strata; the mechanical properties of the rocks involved, notably their strength and deformation moduli; the durability of the rocks on exposure; and the incidence and geometry of discontinuities. Accordingly, core material was obtained from a number of coalfields in South Africa to investigate the influence of certain rock properties on the roof and floor stability of mines. This showed the existence of numerous distinct sedimentary facies that have different character and geotechnical properties which, in turn, influence the design and development of mines.
Keyword(s): geologic features, coal mining, mine design, floor stability, roof stability
Location(s): South Africa

Jessop, J. A., R. E. Thill. Engineering Properties of Coal Measure Rocks in the Danville Region of the Illinois Basin. IN: Proceedings, 2nd Conference on Ground Control Problems in the Illinois Coal Basin, May 1985, Y.P. Chugh, ed., Southern Illinois University, Carbondale, v. 2, p. 18-26.
Coal mining operations require information of engineering property data for all phases of mining from exploration through processing and waste disposal. Such properties are of particular concern in mine planning and design. As part of an effort by the USBM to obtain representative engineering properties for major coal-producing regions in the United States, a program was undertaken to determine the mechanical and geophysical properties of roof, floor, and overburden rocks for coal mines in the Illinois Basin. Example applications for the use of the data in mining are given for assessing pillar, roof, and floor instability.
Keyword(s): coal mining, geotechnical, geophysical, rock mechanics, engineering, roof stability, pillar strength, floor stability, modeling, abandoned mines, active mines, lab testing, in situ testing, ground control, geologic features
Location(s): Illinois, Illinois Coal Basin, United States

Jessop, J. A., C. L. Cumerlato, K. M. O'Connor. Characterizing Longwall Coal Mine Subsidence with High Resolution Seismic Reflection. 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. 391-400.
High-resolution seismic-reflection surveys were conducted at a coal mine site in southern Illinois. Premine and postmine surveys conducted above longwall panels consisted of common-depth-point data collection. Drill core and sonic logs from a nearby borehole and mine maps were used in the interpretation of the data. Processed sections show a number of interesting features that may aid in characterizing subsurface subsidence. The mined and unmined areas at these sites are clearly discernible, and seismic signatures associated with fracture zones and voids can be interpreted. In addition, reflection events from subsided areas have been identified that corroborate recently advanced theories of bridging potential of the overburden.
Keyword(s): seismic, overburden, longwall, coal mining, geophysical
Location(s): Illinois, Illinois Coal Basin, United States

Ji-xian, C. The Effects of Mining on Buildings and Structural Precautions Adopted. 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. 404-419.
The paper gives a general description of Chinese practice during the past two decades for coal mining under surface structures. Reference is made to the effects induced by surface strain, the structural precautions used and their effectiveness, and basic guidelines for use when mining under buildings.

Keyword(s): surface structural damage, coal mining, active mines, structural mitigation, horizontal displacement, vertical displacement
Location(s): China

Jian, Z., L. Monglin. Computer Program for Use in Designing Masonry Buildings in a Subsidence Region. 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. 338-343.

Studies of structural calculations for buildings in subsidence regions are relatively rare. In many countries, masonry buildings are often encountered in subsidence regions. For these reasons a computer program has been developed for the purpose of calculating the stresses and strains in masonry structures in subsidence regions.

Keyword(s): surface structural damage, coal mining, finite element, foundations, horizontal displacement, prediction
Location(s): China

Jingmin, X., E. Topuz. A Simulation Model for Longwall Mining Operations. SME-AIME Preprint No. 83-387, SME-AIME Fall Meeting and Exhibit, Salt Lake City, UT, October 19-21, 1983, 7 p.

This paper is to develops a stochastic model to simulate the production operations in longwall mining. The activities and parameters that affect the production potential of the longwall operations and the relationships between the activities are identified. An attempt is made to verify these relationships through the use of existing data. The model is then used as a computer simulator to investigate the effects of various activities and parameters on the production capacity of a panel.

Keyword(s): modeling, longwall, stochastic model, coal mining, computer

Jixian, C., H. Leting. Study of Deformation Resistant Structural Systems for Buildings in Coal Mining Areas. 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. 356-369.

This paper presents a description of the study of deformation resistant structural systems for buildings in mining areas. The technology has been applied successfully in several areas in China for various kinds of one- to five-story buildings of reinforced brick. In each of the areas mentioned, mining operations were carried out in one to five seams that were nearly level, inclined, or steeply inclined. Comprehensive observations were conducted of various movements, deformations, and stresses experienced by the ground surface and the buildings during subsidence. A large amount of measured data was obtained.

Keyword(s): surface structural damage, coal mining, structural mitigation, active mines, multiple-seam extraction, foundations, construction
Location(s): China

Johnson, A. M., R. J. Hodek, G. E. Frantti. Piping Induced Subsidence Over an Underground Mine. IN: Proceedings, Workshop on Surface Subsidence Due to Underground Mining, Morgantown, WV, November 30-December 2, 1981, S.S. Peng and M. Harthill, eds., West Virginia University, 1982, p. 268-273.

Researchers at Michican Technological University have been studying mine subsidence in the Iron River District of Northern Michigan since 1974. The district, which was active from 1881 to 1978, has had numerous cases of subsidence. Much of the subsidence resulted from rock mass failure, but some appeared to have developed primarily in the thick glacial overburden, which is a typical feature of this area. This latter observation led to the recognition that some of the surface subsidence was due to piping, i.e., loss of overburden material to the mine voids by groundwater flow.

Keyword(s): abandoned mines, metal mining, overburden, subsurface water, monitoring methods
Location(s): Michigan, United States

Johnson, C. J., C. J. Bise. Determining the Effects of New Technology on Room-and-Pillar Productivity. Mining Engineering, January 1989, v. 41, no. 1, p. 45-47.

As the coal industry in the United States moves into the next century, it is becoming more apparent that the effective application of new technology is the only way it can remain competitive in the energy marketplace. The focus of this new technology is directed toward improvements in health and safety, cost control, and productivity. Room-and-pillar mining accounts for approximately 68% of the nation's underground coal production; this percentage is not expected to decrease markedly in the near future. As such, this paper analyzes the impacts of the changing technological climate on future room-and-pillar operations by comparing a

base-case section (current) to three scenarios incorporating new or emerging technology.

Keyword(s): coal mining, economics, room-and-pillar, mine safety

Location(s): United States

Johnson, G. H., J. H. Soule. Measurement of Surface Subsidence, San Manuel Mine, Pinal County, Arizona. U.S. Bureau of Mines RI 6204, 1963.

This report discusses an investigation of the surface effects of block caving used in an Arizona copper mine. Surface survey methods included reference pins, triangulation surveying, and air photographs.

Keyword(s): survey methods, monitoring equipment, photography, surface subsidence damage, metal mining

Location(s): Arizona, United States

Johnson, J. C., M. E. Poad. Premining Stability Analysis of a Shaft Pillar at the Homestake 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. 175-182.

High-grade ore found in a shaft pillar at the Homestake Mine prompted a request for a USBM study to determine if selected areas of the shaft pillar could be mined without jeopardizing the shaft. The design approach was to perform a finite-element study of the shaft pillar. Plan view and vertical sections were developed using two-dimensional, elastic, plane strain assumptions. Input into the model consisted of in situ stress measurements, geologic mapping, rock mass properties, and previous mining history. Results from the study indicated that ore-bearing sections of the shaft pillar could be removed within the displacement tolerances acceptable for the shaft.

Keyword(s): metal mining, pillar extraction, finite element, geologic features, rock mechanics, engineering, modeling

Location(s): South Dakota, United States

Johnson, J. R. Reclamation of Abandoned Mine Site. ASCE Journal of Environmental Engineering Division, v. 105, June, 1979, p. 597-603.

Public Act 78-1293 provided for the creation of the Abandoned Mined Lands Reclamation Council (AMLRC). In early 1976, the AMLRC began to address the problem of restoring the thousands of wasted acres of abandoned mine properties, both surface and underground, to renewed productive uses. From the initial list of approximately 50 sites recommended by reclamation experts in Illinois, the Council selected three underground sites to be reclaimed in accordance with the new law.

Keyword(s): abandoned mines, reclamation, law, environment, historical, economics, mine waste

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

Johnson, K. L. Influence of Topography on the Effects of Longwall Mining on Shallow Aquifers in the Appalachian Coal Field. IN: Proceedings Third Workshop on Surface Subsidence Due to Underground Mining, S.S. Peng, ed., June 1-4, 1992, Morgantown, WV, p. 197-203.

Networks of monitoring wells were established prior to mining at four longwall mine sites in the Appalachians to monitor the effect of mining on water levels, water quality and well yield. Two of the sites were located in stream valleys and the other two sites were located on hilltops.

Keyword(s): subsurface water, hydrology, longwall, active mines, coal mining, monitoring methods, modeling

Location(s): Appalachian Coal Region, United States

Johnson, K. S. Development of the Wink Sink in West Texas Due to Salt Dissolution and Collapse. IN: Karst Hydrogeology: Engineering and Environmental Applications. Proceedings 2nd Multidisciplinary Conference on Sinkholes and the Environmental Impacts of Karst, Orlando, 1987, B.F. Beck and W.L. Wilson, eds., Balkema, Rotterdam, p. 127-136.

Keyword(s): hydrology, geologic features, engineering

Location(s): Texas, United States

Johnson, W., G. C. Miller. Abandoned Coal-Mined Lands: Nature, Extent, and Cost of Reclamation. U.S. Bureau of Mines, Special Publications, 6-79, no. 3, 1979.

Keyword(s): reclamation, abandoned mines, economics, coal mining

Location(s): United States

Johnson, W. L., T. P. Brunsing, G. F. Dana. An Area Wide Approach to Ground Stabilization. IN: Proceedings, Symposium on Evolution of Abandoned Mine Land Technologies, Riverton, WY, June 14-16, 1989, p. 307-328.

This paper describes drilling and cementatious grouting projects undertaken in Rock Springs, Wyoming, in an attempt to stabilize residential units on an individual structure basis.

Keyword(s): coal mining, abandoned mines, mitigation, grouting, structural mitigation, historical, pillar extraction, surface structural damage, geologic features, overburden

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

Johnston, G. C. Subsidence and Pillar Recovery in West Area of Marquez Mine, New Mexico. New Mexico Bureau of Mines Mineral Research Memoir No. 15, 1963, p. 256-263.

Keyword(s): pillar extraction

Location(s): New Mexico, United States

Jones, C.J.F.P. The Performance of a Clasp System School Subjected to Mining Subsidence. M.S. Thesis, University of Newcastle-Upon-Tyne, 1963.

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

Location(s): United Kingdom

Jones, C.J.F.P., J. B. Bellamy. Computer Prediction of Ground Movements Due to Mining Subsidence. Geotechnique, v. 23, no. 4, 1973, p. 515-530.

This article examines a method of determining displacement, strain, and stress components of ground deformation due to underground mining based upon the theory of elasticity and the principle of superposition.

Keyword(s): vertical displacement, horizontal displacement, prediction, computer

Jones, C.J.F.P., W. J. Spencer. The Implications of Mining Subsidence for Modern Highway Structures. 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. 515-526.

The M1 and M62 motorways in Yorkshire pass through active coalfields. It was recognized during the initial design stages of these roads that bridges and structures would be subject to large ground movements caused either by the collapse of old uncharted mine workings or as a result of active mining. To cater for this, it was established that (1) methods of predicting the extent of the ground movement would have to be developed and (2) design techniques able to accommodate these movements would be required to prevent damage or even the collapse of the bridges and structures to be built on the motorway.

Keyword(s): engineering, construction, roads, active mines, abandoned mines, coal mining, empirical model, prediction

Location(s): United Kingdom

Jones, C.J.F.P., T. D. O'Rourke. Mining Subsidence Effects on Transportation Facilities. IN: Mine Induced Subsidence: Effects on Engineered Structures, Proceedings of the Symposium, Nashville, TN, May 11, 1988, ASCE Geotechnical Special Publication No. 19, p. 107-126.

This paper presents case history information about mining subsidence effects on transportation facilities, including bridges, pavements, and culverts. Most of the field observations pertain to longwall coal mining in the United Kingdom, with commentary on how these experiences may apply to practice in the United States. Mining subsidence deformations are discussed in relation to the lengths of affected structures.

Keyword(s): roads, longwall, coal mining, National Coal Board, room-and-pillar, horizontal displacement, surface structural damage, engineering, active mines, abandoned mines

Location(s): United Kingdom, United States

Jones, D. B., H. J. Siddle, D. J. Reddish, B. N. Whittaker. Landslides and Undermining: Slope Stability Interaction with Mining Subsidence Behaviour. IN: Proceedings International Congress on Rock Mechanics, Aachen, 1991, W. Wittke, ed., v. 2, p. 893-898.

The paper reports on the findings of research into the relationship between landslide phenomena and the process of undermining sloping ground surfaces in the South Wales Coalfield. The analyses involved examination of field data from landslide sites supported by a program of investigations using physical and numerical modeling. Interaction of mining and geological influences is demonstrated to be significant. General principles of stability and the response of hill slopes to undermining are discussed.

Keyword(s): geologic features, coal mining, physical model, modeling, finite element

Location(s): Wales, United Kingdom

Jones, D. C., J. W. Hunt. Coal Mining. The Pennsylvania State University, State College, v. 3, 1950, 535 p.

Keyword(s): backfilling, coal mining

Location(s): United States

Jones, D. H. Two Case Histories of Ground Instability Caused by the Interaction Between Brick Clay Quarrying and Underground Mining. IN: Proceedings, SANGORM Symposium, October 21, 1986, Sandton, South Africa, International Society for Rock Mechanics, South African National Group, p. 39-45.

Two case histories are presented to illustrate the geotechnical interactions occurring between relatively shallow quarrying for brickmaking materials and underground mining operations. Although the intervening vertical distances between the different quarry floors and the underground workings may differ from less than 20 meters to more than a kilometer, sinkholes are a common occurrence. Brief diagnoses are made of the mechanisms responsible for the unstable ground conditions in each instance.

Keyword(s): geotechnical, non-metal mining, abandoned mines, subsurface water, coal mining, metal mining, surface structural damage

Location(s): South Africa

Jones, S. Pneumatic Backfilling--A Method for Controlling Abandoned Mine Subsidence. 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. 215-219.

Minor subsidence damage to a school building and grounds in Pennsylvania prompted an investigation of a site. This investigation determined that subsidence over an abandoned coal mine was occurring and that additional damaging subsidence would occur if reclamation measures were not taken.

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

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

Jones, T. J. Strata Movements Induced by Mining. Transactions, Institute of Mining Surveyors, January, 1945, v. 25, Pt. 1.

Keyword(s): subsurface subsidence damage

Jones, T. Z., K. K. Kohli. Subsidence Over a Room and Pillar Mine in the Appalachian Coal Province and the Use of Subsidence Predictive Methods--A Comparative Analysis. 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. 179-187.

This paper summarizes the results of a subsidence monitoring program, and provides a comparative analysis of the subsidence data collected with three popular subsidence prediction models that have been used in the region. The monitoring was conducted over a room-and-pillar panel in south-central West Virginia.

Keyword(s): prediction, prediction theories, modeling, National Coal Board, profile function, finite element, room-and-pillar, monitoring design, survey data processing, coal mining, empirical model, angle of draw

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

Joshi, R. C., D. W. Horsfield. Surface Subsidence Due to Water Seepage and the Presence of Old Mine Workings in Southern Alberta, Canada. 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. 669-673.

Surface subsidence, caused by underground coal extraction and subsequent flooding of the mine by groundwater, has occurred in southern Alberta, Canada. Records of mining activity in the area are incomplete, complicating the evaluation of the overall stability and safety of the site.

Keyword(s): railroads, abandoned mines, coal mining, geologic features, historical, room-and-pillar, floor stability, roof stability, time factor, surface structural damage, utilities

Location(s): Canada

Josien, J. P. Methods of Investigation in Longwall Faces. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 23, 1975, p. 341-345.

Keyword(s): longwall, rock mechanics

Jung, J., H. H. Jung. Safeguarding Structures in Subsidence Areas. 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. 411-429.

Developments in mining techniques, especially great increases in the speed of mining, have lead to a measurable increase in deformations at the ground surface, causing undulations or discontinuities and subsequently heavy damage to buildings and structures, sometimes even to the

point of their total loss. Buildings sensitive to deformation e.g. without sufficient elasticity, to be erected in areas of extreme subsidence movements have to be made safe in their entirety. Such a procedure is not acceptable for most of these buildings for economic reasons.

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

Location(s): Germany

Juntunen, R., M. Hiel, B. Mundie. Reclaiming Orphaned Lands Using a Pneumatic Backfill Process. American Society of Agricultural Engineers Summer meeting, Bozeman, MT, June 26, 1983, ASAE Paper No. 83-2035, 12 p.

Keyword(s): pneumatic backfilling

Kalia, H. N. Understanding Coal Geology Can Improve Underground Mine Productivity and Safety. Presented at AIME Annual Meeting, Las Vegas, NV, February 22-26, 1976. Preprint No. 76-AM-19, 14 p.

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

Location(s): United States

Kane, W. F., R. M. Bennett, P. A. Lee. Testing Program for Earth-Structure Analysis of Mine Subsidence. Report for U.S. Bureau of Mines Contract Number SO27058 and Illinois Mine Subsidence Insurance Fund, Geomechanics Engineering Group, Department of Civil Engineering, University of Tennessee, Knoxville, March 1988, 55 p.

In order to fully characterize material behavior at an Illinois subsidence test foundation site, a series of tests were performed. The results will be used in future numerical analysis of subsidence events. An extensive series of direct shear tests indicate that the construction technique of using sand and plastic under the foundation to minimize mining-induced damage may not be necessary for all situations. The ideal interface is a function of the stiffness and shear strength parameters.

Keyword(s): foundations, active mines, soil mechanics, engineering, soils, coal mining, surface structural damage, structural mitigation

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

Kane, W. F., T. L. Triplett, R. E. Yarbrough, E. W. Murphy. Earth-Structure Interaction Analysis for Subsidence Damage Mitigation. IN: Proceedings, Symposium on Evolution of Abandoned Mine Land Technologies, Riverton, WY, June 14-16, 1989, p. 79-98.

Keyword(s): structural mitigation, foundations, computer, insurance, surface structural damage, modeling, finite element, high-extraction retreat, soils, coal mining

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

Kane, W. F., R. M. Bennett, E. C. Drumm. Construction and Instrumentation of Test Foundations for Subsidence Damage Assessment. 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. 311-321.

Research into the effects of subsidence on structures is limited. A site above a longwall panel in southern Illinois was selected to construct test foundations. Several shallow foundation designs were built to investigate various damage mitigation schemes. Foundation designs included the use of plain concrete, reinforced concrete, post-tensioned concrete, concrete with plastic and sand underlayment, and concrete mixed with steel fibers. The project includes six parallel strip foundations at two test sites: one group is on the centerline of the approaching longwall panel and the other is in the predicted zone of maximum tension. To measure behavior during the event, the foundations and surrounding soil were monitored with survey monuments, strain gages, tilt meters, extensometers, soil strain gages, and inclinometers.

Keyword(s): foundations, coal mining, active mines, construction, instrumentation, surface structural damage, longwall, structural mitigation, architecture, finite element, computer, survey methods, horizontal displacement, vertical displacement, monitoring equipment, monitoring methods

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

Kaneshige, O. Methods of Underground Excavation to Avoid Damage to Existing Structures or Their Removal Because of Subsidence. IN: Geological and Geographical Problems of Areas of High Population Density, Proceedings of Symposium at Annual Meeting of Association of Engineering Geologists, Washington, D.C., October 23, 1970.

The author reviews subsidence parameters and specific Japanese mining considerations such as high population densities, dipping seams, and local geology. In reference to preventing or reducing subsidence damage, the author discusses safety pillars, a pillar system of coal mining, full stowing, and harmonic extraction. Various applications of these methods are reviewed.

Keyword(s): ground control, pillar strength, stowing, land-use planning, surface structural damage

Location(s): Japan

Kanlybayeva, Z. M. Dynamics of Displacement of a Stratum Under the Influence of Working Gently Dipping Coal Seams Based on Geological Data. 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, Supplementary volume, 12 p.

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

Kantner, W. H. Surface Subsidence Over the Porphyry Caving Blocks, Phelps Dodge Corporation, Copper Queen Branch. AIME Technical Publication 552, 1934, 13 p.; also, Transactions, AIME, v. 109, 1934, p. 181-194.

Keyword(s): metal mining, surface subsidence damage

Location(s): United States

Kapp, W. A., R. C. Williams. Extraction of Coal in the Sydney Basin from Beneath Large Bodies of Water. IN: Proceedings, Conference of the Australasian Institute of Mining & Metallurgy, 1971.

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

Location(s): Australia

Kapp, W. A. Subsidence Due to Underground Coalmining. Mine and Quarry Mechanisation, 1972, p. 115-121.

This paper presents general characteristics of subsidence over underground coal mines, including subsidence mechanics, surface effects and protection, and precautions for mining under water.

Keyword(s): surface structural damage, mine design, coal mining, surface water

Location(s): Australia

Kapp, W. A. Mine Subsidence. 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 1, p. 1-1 - 1-9.

Ground movements occur in areas where fluids or minerals are removed from below the surface. The types of movements and their magnitudes depend mainly on the nature and extent of the mining operation.

Keyword(s): coal mining, metal mining, fluid extraction, vertical displacement, horizontal displacement, geologic features

Kapp, W. A. Subsidence Kemira Colliery, New South Wales. 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 7, p. 7-1 - 7-9.

Subsidence investigations are being conducted over longwall panels and areas of pillar extraction in the coalfields around Sydney. The investigations will assist in future mine planning in areas where surface movement should be considered. One of the subsidence studies is at Kemira Colliery, where the investigations covered five longwall panels. The surface is rugged over these panels, and the depth of cover over the seam varies considerably. Some surface cracking developed. The maximum observed subsidence was 1.1 meters, and the pillars that were left between the panels affected the subsidence profile. The curves associated with the subsidence movements were calculated from the survey observations and show the effects of surface topography, geology, and the mining operations on ground movements. A comparison of the observed movements with corresponding predicted values shows that there was significantly less subsidence than that expected from the calculated values.

Keyword(s): surface subsidence damage, coal mining, longwall, pillar extraction, survey data processing, prediction, surface water

Location(s): Australia

Kapp, W. A. Study and Evaluation of the Elements of Surface Subsidence Observed at Kemira Colliery, New South Wales. M.S. Thesis, University of Sidney, Australia, 1974, 105 p.

Keyword(s): coal mining

Location(s): Australia

Kapp, W. A. The Characteristics of Subsidence Due to Underground Coal Mining at Newcastle, New South Wales. International Association of Hydrological Sciences Publication 121, 1976, p. 409-421.

Keyword(s): coal mining

Location(s): Australia

Kapp, W. A. The Characteristics of a Subsidence Trough Over an Area of Underground Coal Mining. IN: Proceedings, 2nd International Symposium on Land Subsidence, No. 2, December 13-17, 1976, Anaheim, CA. (NTIS Accession No. 78-03117)

Keyword(s): coal mining

Location(s): Australia

Kapp, W. A. Subsidence Investigations in the Northern Coalfield, New South Wales, and Their Application to the Design of Mine Layouts in Residential Areas. Presented at 11th Commonwealth Mining and Metallurgy Congress, Hong Kong, May 1978, Institute Mining and Metallurgy, London, Paper 32, 11 p.