

Charles Fairhurst.

Professor Emeritus, University of Minnesota, Minneapolis, MN. USA

Curriculum Vitae.

Expertise Rock Mechanics, Mining Engineering, Geological Isolation of Nuclear Waste

Education Ph.D. (Mining Engineering), 1955, Sheffield University, England.
B.Eng. (Mining Engineering, with First-Class Honours), 1952
Sheffield University, England

Professional Affiliations Fellow, American Rock Mechanics Association (ARMA), Member, American Society of Civil Engineers (ASCE); Society of Mining Engineers (SME)– US;; International Society of Rock Mechanics (ISRM), Sigma XI;

Honors Member: U.S. National Academy of Engineering (1991); Royal Swedish Academy of Engineering Sciences (1979); Honorary Doctorates: University of Sheffield, England (1997); National Institute of Lorraine, France (1996); St. Petersburg Mining Academy & Technical University, Russia (1996); University of Minnesota (May 2000); Advisory Professor, Tongji University, Shanghai, China (1995); Officier, Légion d’Honneur (France) 2013. Fellow ISRM, Fellow, ARMA, SME Presidential Citation 2017

Professor Emeritus, University of Minnesota (1997); Distinguished Professor of Mining Engineering & Rock Mechanics, University of Minnesota (1982)

Member, Science and Technology Review Panel, U.S. Department of Energy; Board of Governors, Geo-Institute of the ASCE (1998-2001); President, ARMA (1995-1997); President, ISRM (1991-1995); Member, “Salzburg Circle” (predecessor to ISRM, 1962-1966); Corresponding Member, International Büro of Rock Mechanics, Berlin, Germany (1963-1970); Chair, U.S. National Committee on Rock Mechanics (1972-1974); President, American Underground Space Association (1976–1977)

Leopold Müller Award, ISRM (2003); U.S. National Committee on Rock Mechanics, Special Award: 25 Years of Distinguished Achievements (1983); American Underground Space Association 1981 Pergamon Medal; AIME Outstanding Achievement Award, Rock

Mechanics (1972); Inter-Society Committee on Rock Mechanics Medal, Best Rock Mechanics Research Paper (with B. Haimson, 1970)

Professional Experience

1997 – Present *Itasca Consulting Group, Inc., Minneapolis, MN, Senior Consultant*
1981 – 1999 *Itasca Consulting Group, Inc., Minneapolis, Minnesota, Chairman*

 University of Minnesota(UMN)
1991 – 1997 *T. W. Bennett Professor of Mining Engineering & Rock Mechanics*
1983 – 1991 *E.P. Pfleider Professor of Mining Engineering & Rock Mechanics*
1972 – 1987 *Department of Civil & Mineral Engineering, Head*

1956 – 1970 *Res.Assoc. to Head, School of Mineral & Metallurgical Eng UMN*
1948 – 1956 *National Coal Board, England, Mining Engineer Trainee*

Project Experience.

Dr Fairhurst has supervised 25 Ph.D. students at the University of Minnesota on a variety of topics in basic and applied rock mechanics

As a private consultant and Senior Consultant with Itasca, Dr Fairhurst has more than 55 years of experience in mining rock mechanics and has consulted on rock stability problems for tunnels, dams, mines, and excavations throughout the world. He has also been actively engaged internationally for more than 30 years in the problems of geological isolation of high and intermediate-level nuclear waste.

Civil Engineering

Laboratoire Mixte (Application of Mathematics and Physics to Civil Engineering), CNRS/LCPC, Marne La Vallée, France —Member, Conseil Scientifique (1993–1997)

National Science Foundation — Member: Division of Applied Research Review Panel (1978-1980); Conference Steering Committee, Initiatives in the States Program (1985-1986); Engineering Advisory Board (1982-1985); Division of Policy and Analysis Review Panel (1978-1979); U.S. Centrifuge Facility Selection Panel (1977-1978); U.S. NSF/AIME Delegation to the Soviet Union (1977); Advisory Panel on Engineering Mechanics (1976). Chair: Advisory Sub-Committee on Civil and Environmental Engineering (1982-1984);

Spie Batignolles, France, Member, Board of Experts, Guavio Hydroelectric Project, Colombia (1985-1989)

U.S. Army Corps of Engineers — Consultant, R. D. Bailey Dam (1977-1981)

U.S. Army Corps of Engineers — Consultant, Niagara Falls Preservation Project (1968-1974)

U.S. Geological Survey — Member, Advisory Panel on Earthquake Research (1973-1977)

Geothermal Energy

2011- present, Member, (EGS) Enhanced Geothermal Systems Analysis/Validation Panel US DOE Geothermal Systems Office

Mining

Mines Dominiiale de Potasse d'Alsace, Thailand — Potash Mine Design (1981 - 1983)
Martin Marietta Corporation — Consultant, Lunar Drilling and Rock Blasting Programs (1973-1975)

National Academy of Science/National Research Council — Chair, Committee on Feasibility of Returning Coal Mine Wastes to Underground (1973-1974)

Petrobras Mineracao Corporation, Brazil — Consultant, Potash Mine Design (1975-1989)

American Institute of Mining Engineers — Member, Committee on Rock Mechanics (1969-1973)

Nuclear Testing & Waste Isolation

Chairman, IAEA (Vienna) International Centres of Excellence Network –Waste Disposal Technologies (2003-2007)

Member, Science and Technology Panel, Office of Civilian Radioactive Waste Management, U.S. Department of Energy (2002–2006)

Member, Monitored Geological Repository (MGR) Advisory Board, Yucca Mountain (1999-2001)

Atomic Energy of Canada Limited (AECL) — Chair, Peer Review on the Tunnel Sealing and Mine-by Experiments at the Underground Research Laboratory, Pinawa (1995–2004)

ANDRA (French Radioactive Waste Agency) — Member, Conseil Scientifique (1993–2005)

International Stripa Project, Sweden: Member, Project Overview Committee (1993)

Ecole Polytechnique, Palaiseau, France — Member, Conseil Scientifique de G.3S, Groupement pour l'Etude des Structures Souterraines de Stockage (Underground Waste Storage Group) (1992-2003)

International Geomechanical Commission — Chair, invited by the French Government to study the effects of underground nuclear tests in French Polynesia on the stability and hydrology of the atolls Mururoa and Fangataufa (1995-1999)

U.S. Atomic Energy Commission (AEC) — Member, Oak Ridge National Laboratory Advisory Panel on Radioactive Waste Disposal in Lyons Salt Mine, Kansas (1971)

U.S. National Academy of Sciences — Vice Chair: Board on Radioactive Waste Management (BRWM) (1989-1995); BRWM Waste Management; Chairman, Waste Isolation Pilot Project (WIPP) Committee (1989-1997). Senior Advisor, WIPP Advisory Panel (1985-1989)

U.S. National Academy of Sciences/National Research Council — Member, Committee on Technical Bases for Yucca Mountain Standards (1993-1995); NAS/NRC Committee on Rethinking High Level Waste Disposal [Report 1990]; NAS/NRC Panel on the Savannah River

(Nuclear) Plant (1978); NAS/NRC Advisory Panel on Bedrock Disposal (Underground Disposal of Radioactive Wastes) (1971)

U.S. Nuclear Regulatory Commission (NRC) — Member, Advisory Committee on Nuclear Waste (1997–1999)

U.S. Office of Science and Technology (OST) — Member, Policy Panel on U.S. Radioactive Waste Management Program (1978)

Rock Mechanics

American Society for Testing and Materials — Member, Subcommittee on Rock Mechanics (1966-1969)

American Society of Civil Engineers — Chair: Committee on Rock Mechanics (1978-1980); ASCE/AIME Underground Construction Research Council (1974-1975)

International Congress on Rock Mechanics — Chair, Technical Program (1974)

Los Alamos Scientific Laboratory, New Mexico — Member, Hydraulic Fracturing, Geothermal Energy, and Rock Blasting Studies (1975-1981)

National Science Foundation (2004 –present). Advisor on Geoscience and Engineering (S1 et seq.). DUSEL (Deep Underground Science and Engineering Laboratory)

Publications

Fairhurst C. (2013) “Fractures and Fracturing –Hydraulic Fracturing in Jointed Rock,” Keynote Lecture,. Effective and Sustainable Hydraulic Fracturing. International Conference, Brisbane May 20-22 Proc. *Edited by Andrew P. Bungler, John McLennan and Rob Jeffrey, ISBN 978-953-51-1137-5, 1000 pages, Publisher: InTech, <http://www.intechopen.com/books/effective-and-sustainable-hydraulic-fracturing/fractures-and-fracturing-hydraulic-fracturing-in-jointed-rock>*

Damjanac, B., and C. Fairhurst. (2009) “Evidence for a Long-Term Strength Threshold in Crystalline Rock,” *Rock Mech. & Rock Eng.* (Springer Verlag), 2009

Elsworth, D., and C. Fairhurst. (2007) “Some Opportunities for Science and Engineering at DUSEL,” in *Rock Mechanics: Meeting Society's Challenges and Demands (1st Canada-U.S. Rock Mechanics Symposium, Vancouver, May 2007)*, Vol. 2: *Case Histories*, pp. 1085-1090, E. Eberhardt et al., Ed. London: Taylor & Francis Group, 2007.

Fairhurst, C., B. Damjanac and T. Brandshaug. “Rock Mass Strength and Numerical ‘Experiments’,” in *Publications of the Geotechnical Institute No. 2006-5, Proceedings 35 (Geomechanics Colloquium, November 2006)*, pp. 1-20. Freiberg, Germany: Technical University Mining Academy Freiberg, 2007.

Mas Ivars, D., N. Deisman, M. Pierce and C. Fairhurst. “The Synthetic Rock Mass Approach — A Step Forward in the Characterization of Jointed Rock Masses,” in *The Second Half Century of Rock Mechanics (11th Congress of the International Society for Rock Mechanics, Lisbon, July*

2007), Vol. 1, pp. 485-490, L. Ribeiro e Sousa, C. Olalla, and N. Grossmann, Eds. London: Taylor & Francis Group, 2007.

Fairhurst, C. “Nuclear Waste Disposal and Rock Mechanics: Contributions of the Underground Research Laboratory (URL), Pinawa, Manitoba, Canada,” *Int. J. Rock Mech. Min. Sci.*, **41**, 1221-1227 (2004).

Fairhurst, C. “Radioactive Waste Isolation — One Small Step for Geology; One Giant Leap for Rock Mechanics.” Leopold Muller Award Presentation. 10th International ISRM Congress, Johannesburg, September 2003.

Fairhurst, C. “Stress Estimation in Rock: A Brief History and Review,” *Int. J. Rock Mech. & Min. Sci.*, **40**, 957-973 (2003).

Fairhurst, C., and C. Carranza-Torres. “Closing the Circle — Some Comments on Design Procedures for Tunnel Supports in Rock,” in *Proceedings of the University of Minnesota 50th Annual Geotechnical Conference (February 2002)*, pp. 21-84. J. F. Labuz and J. G. Bentler, Eds. Minneapolis: University of Minnesota, 2002.

Carranza-Torres, C., and C. Fairhurst. “Aplicación del Método de Convergencia-Confinamiento al Diseño de Túneles en Macizos Rocosos Que Satisfacen el Criterio de Rotura de Hoek y Brown,” in *IngeoTÚNELES*, pp. 69-123. C. López-Jimeno, Ed. Tunnelling Engineering Series, Vol. 4. Madrid: Escuela Técnica Superior de Ingenieros de Minas, 2001.

Fairhurst, C. “Rock Mechanics of Underground Nuclear Explosions,” *ISRM News J.*, **6**(3), 21-27 (2001).

Carranza-Torres, C., and C. Fairhurst. “Analysis of Tunnel Support Requirements Using the Convergence-Confinement Method and the Hoek-Brown Rock Failure Criterion,” in *GeoEng 2000 (Proceedings of the International Conference on Geotechnical & Geological Engineering, Melbourne, November 2000)*, Paper UW1244. Lancaster, Pennsylvania: Technomic Publishing, 2000.

Carranza-Torres, C., and C. Fairhurst. “Application of the Convergence-Confinement Method of Tunnel Design to Rock Masses That Satisfy the Hoek-Brown Failure Criterion,” *Tunn. & Underground Space Tech.*, **15**(2), 187-213 (2000).

Carranza-Torres, C., and C. Fairhurst. “Some Consequences of Inelastic Rock-Mass Deformation on the Tunnel Support Loads Predicted by the Einstein and Schwartz Design Approach,” in *Trends in Rock Mechanics (Proceedings of Sessions of Geo-Denver 2000)*, pp. 16-49. J. F. Labuz et al., Ed. Reston, Virginia: ASCE, 2000.

Damjanac, B., C. Fairhurst and T. Brandshaug. “Numerical Simulation of the Effects of Heating on the Permeability of a Jointed Rock Mass,” in *Proceedings of the 9th ISRM Congress on Rock Mechanics*. Paris, Vol. 2, pp. 881-885. Rotterdam: Balkema, 1999.

Fairhurst, C., and B. Damjanac. “The Excavation Damage Zone — An International Perspective,” in *Distinct Element Modeling in Geomechanics*, pp. 1-26. V. M. Sharma et al., Eds. New Delhi: Oxford & IBH Publishing, 1999.

Fairhurst, C., and L. Lorig. “Improved Design in Rock and Soil Engineering with Numerical Modelling,” in *Distinct Element Modelling in Geomechanics*, pp. 27-46. V. M. Sharma et al., Eds. New Delhi: Oxford & IBH Publishing, 1999.

Damjanac, B., C. Fairhurst and T. Brandshaug. "Numerical Simulation of the Effects of Heating on the Permeability of a Jointed Rock Mass," in *Proceedings of the 9th ISRM Congress on Rock Mechanics*. Paris, Vol. 2, pp. 881-885. Rotterdam: Balkema, 1999.

Fairhurst, C. "Some Recent Developments at Yucca Mountain, USA with Comments on Repository Design," in *Actes Des Journées Scientifiques ANDRA 1999 (Nancy, France, December 7-9, 1999)*, pp. 463-480. Les Ulis: EDP Sciences, 1999.

Fairhurst, C., and B. Damjanac. "The Excavation Damage Zone — An International Perspective," in *Distinct Element Modeling in Geomechanics*, pp. 1-26. V. M. Sharma et al., Eds. New Delhi: Oxford & IBH Publishing, 1999.

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Fairhurst, C. "Rock Mechanics and Nuclear Waste Repositories (Keynote Paper)," in *Proceedings of the International Workshop on the Rock Mechanics of Nuclear Waste Repositories (Vail, Colorado, June 1998)*, pp. 1-45. S. Saeb and C. Francke, Eds. Alexandria, Virginia: ARMA, 1999.

International Geomechanical Commission (C. Fairhurst et al.). *Underground Nuclear Testing in French Polynesia* Damjanac, B., and C. Fairhurst. "Ecoulement Tri-Dimensionnel d'Eau Sous Pression dans les Milieux Fracturés," in *La Sécurité Des Grands Ouvrages, Hommage À Pierre Londe*, pp. 5-19. Paris: Presses Pontes et Chaussées, 2000.

Hart, R., and C. Fairhurst. (2000) "Application of Discontinuum Modeling in Geotechnical Studies for Nuclear Waste Isolation," in *Geocology and Computers (Proceedings of the 3rd International Conference on Advances of Computer Methods in Geotechnical and Geoenvironmental Engineering, Moscow, February 2000)*, pp. 15-28. S. A. Yufin, Ed. Rotterdam: Balkema, 2000.

Fairhurst, C. "Structural and Hydrological Consequences of Underground Nuclear Testing on the Atolls of Mururoa and Fangataufa, in French Polynesia," presented at the GeoEng 2000, Melbourne, Australia, November 2000.

Fairhurst, C., B. Damjanac and R. Hart. "Numerical Analysis as a Practical Design Tool in Geo Engineering," in *Slope Stability 2000 (Proceedings of Sessions of Geo-Denver 2000)*, pp. 169-183. D. V. Griffiths, G. A. Fenton, and T. R. Martin, Eds. Reston, Virginia: ASCE, 2000.

Carranza-Torres, C., and C. Fairhurst. "Elasto-Plastic Analysis of Elliptical Cavities in Rock Subject to Non-Hydrostatic Loading," in *FLAC and Numerical Modeling in Geomechanics (Proceedings of the Conference, Minneapolis, September 1999)*, pp. 215-223. C. Detournay and R. Hart, Eds. Rotterdam: Balkema, 1999.

Carranza-Torres, C., and C. Fairhurst. "The Elasto-Plastic Response of Underground Excavations in Rock Masses That Satisfy the Hoek-Brown Failure Criterion," *Int. J. Rock Mech. & Min. Sci.*, **36**, 777-809 (1999).

Damjanac, B., C. Fairhurst and T. Brandshaug. "Numerical Simulation of the Effects of Heating on the Permeability of a Jointed Rock Mass," in *Proceedings of the 9th ISRM Congress on Rock Mechanics*. Paris, Vol. 2, pp. 881-885. Rotterdam: Balkema, 1999.

Fairhurst, C. "Some Recent Developments at Yucca Mountain, USA with Comments on Repository Design," in *Actes Des Journées Scientifiques ANDRA 1999 (Nancy, France, December 7-9, 1999)*, pp. 463-480. Les Ulis: EDP Sciences, 1999.

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Fairhurst, C., and L. Lorig. "Improved Design in Rock and Soil Engineering with Numerical Modelling," in *Distinct Element Modelling in Geomechanics*, pp. 27-46. V. M. Sharma et al., Eds. New Delhi: Oxford & IBH Publishing, 1999.

Fairhurst, C. "Rock Mechanics and Nuclear Waste Repositories (Keynote Paper)," in *Proceedings of the International Workshop on the Rock Mechanics of Nuclear Waste Repositories (Vail, Colorado, June 1998)*, pp. 1-45. S. Saeb and C. Francke, Eds. Alexandria, Virginia: ARMA, 1999.

Carranza-Torres, C., and C. Fairhurst. "A General Stability Criterion for Tunnels in Soft and Hard Ground," in *Tunnels for People (Proceedings of the 23rd General Assembly of the International Tunnelling Association, April 1997)*, pp. 29-35. J. Golser et al., Eds. Rotterdam: Balkema, 1997.

Carranza-Torres, C., and C. Fairhurst. "On the Stability of Tunnels Under Gravity Loading, with Post-Peak Softening of the Ground," *Int. J. Rock. Mech. & Min. Sci.*, **34**(3-4), Paper No. 075 (1997).

Carranza-Torres, C., C. Fairhurst and L. Lorig. "Insights on the Stability of Large Excavations from Analytical and Numerical Models," *Felsbau*, **15**(1), 45-63 (1997).

Fairhurst, C. "Geomaterials and Recent Developments in Micro-Mechanical Numerical Models," *ISRM News J.*, **4**(2), 11-14 (1997).

Fairhurst, C. "Rock Mechanics and Nuclear Waste Repositories," in *Proceedings of the International Symposium on Rock Support — Applied Solutions for Underground Structures (Lillehammer, Norway, June 1997)*, pp. 1-43. E. Broch et al., Ed. Oslo: Helli Grafisk, 1997.

Carranza-Torres, C., and C. Fairhurst. "Análisis de Estabilidad de una Falla Geológica con el Método de las Discontinuidades de los Desplazamientos (Analysis of the Stability of a Geological Fault Using the Displacement Discontinuity Method)," *Actas de la Asociación de Geología Aplicada a la Ingeniería*, **X**, 73-81 (1996).

Fairhurst, C., and B. Damjanac. "The Excavation Damage Zone — An International Perspective," in *Proceedings of the Excavation Disturbed Zone Workshop on Designing the Excavation Disturbed Zone for a Nuclear Repository in Hard Rock (Winnipeg, September 1996)*, pp. 4-14. J. B. Martino and C. D. Martin, Eds. Toronto: 1996 Int. Conf. on Deep Geological Disposal of Radioactive Waste, 1996.

Detournay, E., C. Fairhurst and J. Labuz. "A Model of Tensile Failure Initiation Under an Indentor," in *Mechanics of Jointed and Faulted Rock (Proceedings of the 2nd International*

Conference, Vienna, April 1995), Supplemental Volume, pp. 12-17. H.-P. Rossmann, Ed. Rotterdam: Balkema, 1995.

Fairhurst, C. "Three Gorges Dam Reservoir, Yangtze River, China," *Felsbau*, **13**(6), 390-394 (1995).

Damjanac, B., and C. Fairhurst. "A Note on Modelling of the Groundwater Flow and Pressure Behaviour Observed During Excavation of the SCV Drift in the Stripa Project," in *In-Situ Experiments at the Stripa Mine (Proceedings of the Fourth International NEA/SKB Symposium, Stockholm, October 1992)*, pp. 437-446. Paris: Organisation for Economic Co-operation and Development, 1994.

Fakhimi, A. A., and C. Fairhurst. "A Model for the Time-Dependent Behavior of Rock," *Int. J. Rock Mech. Min. Sci. & Geomech. Abstr.*, **31**(2), 117-126 (1994).

Fairhurst, C. "Analysis and Design in Rock Mechanics: The General Context," in *Comprehensive Rock Engineering*, Vol. 2, pp. 1-29. J. A. Hudson, Ed. Oxford: Pergamon Press, 1993.

Fairhurst, C. "The Strength and Deformability of Rock Masses — An Important Research Need," in *Safety and Environmental Issues in Rock Engineering (Proceedings of EUROCK '93, Lisbon, June 1993)*, Vol. 2, pp. 931-933. L. Sousa, E. Ribeiro, and N. F. Grossmann, Eds. Rotterdam: Balkema, 1993.

Fairhurst, C. "Evolving Towards 'Mechanics Based' Design Procedures in Geomechanics (Abstract)," in *Proceedings of the 1992 Rock Engineering Symposium in Taiwan (Tainan, Republic of China, December 1992)*, p. 1. S. T. Chen et al., Eds. Tainan, Taiwan: National Cheng Kung University, 1992.

Lorig, L., and C. Fairhurst. "Three-Dimensional Discontinuum Modeling for Underground Excavations," in *Proceedings of the 1992 Rock Engineering Symposium in Taiwan (Tainan, Republic of China, December 1992)*, pp. 349-358. S.-T. Chen et al., Eds. Tainan, Taiwan: National Cheng Kung University, 1992.

Douat, C., and C. Fairhurst. "Micro-Computer Modelling and Practical Design/Monitoring of Large Underground Excavations," in *Static and Dynamic Considerations in Rock Engineering*, pp. 113-124. R. K. Brummer, Ed. Rotterdam: Balkema, 1990.

Fairhurst, C. "Design of Excavations in High Rock-Stress Conditions," in *Rockbursts and Seismicity in Mines (Proceedings of the 2nd International Symposium, Minneapolis, June 1988)*, pp. 421-423. C. Fairhurst, Ed. Rotterdam: Balkema, 1990.

Fairhurst, C. "General Report: Deformation, Yield, Rupture and Stability of Excavations at Depth in Rock," in *Rock at Great Depth*, Vol. 3, pp. 1103-1114. Rotterdam: Balkema, 1990.

Fairhurst, C., Ed. *Rockbursts and Seismicity in Mines (Proceedings of the 2nd International Symposium, Minneapolis, June 1988)*. Rotterdam: Balkema, 1990.

Fairhurst, C., and J. Pei. "A Comparison Between the Distinct Element Method and the Finite Element Method for Analysis of the Stability of an Excavation in Jointed Rock," *Tunn. & Underground Space Tech.*, **5**(1/2), 111-117 (1990).

Sellami, H., C. Fairhurst, E. Deliac and B. Delbast. "The Role of in-Situ Rock Stresses and Mud Pressure on the Penetration Rate of PDC Bits," in *Proceedings of the International Symposium*

on Mechanics and Physics of Rocks at Great Depths, Vol. 2, pp. 769-777. Pau, France: ISRM, 1989.

Fairhurst, C. "Some Observations on the Practical Utility and Limitations of Excavation Stability Analysis," in *Underground Engineering 1988*, Vol. 1, pp. 27-32. Dhanbad, India: Central Mining Research Station, 1988.

Lin, D., and C. Fairhurst. "Application of Animated Graphics in the Analysis of Large Scale Blocky Rock System Around Excavations," in *Key Questions in Rock Mechanics (Proceedings of the 29th U.S. Symposium, University of Minnesota)*, pp. 755-757. P. A. Cundall et al., Ed. Rotterdam: Balkema, 1988.

Lin, D., and C. Fairhurst. "Static Analysis of the Stability of Three-Dimensional Blocky Systems Around Excavations in Rock," *Int. J. Rock Mech. Min. Sci. & Geomech. Abstr.*, **25**(3), 139-148 (1988).

Detournay, E., and C. Fairhurst. "A Two-Dimensional Elastoplastic Analysis of a Long, Cylindrical Cavity Under Non-Hydrostatic Loading," *Int. J. Rock Mech. Min. Sci. & Geomech. Abstr.*, **24**(4), 197-211 (1987).

Fairhurst, C. "Comments on the Modeling of Coupled Thermo-Mechanical-Fluid Flow Behavior of Rock Masses," in *Coupled Processes Associated with Nuclear Waste Properties*, pp. 713-731. C. F. Tsang, Ed. Orlando: Academic Press, 1987.

Fairhurst, C., and R. D. Hart. "Verification and Validation of Coupled Mechanical/Water Flow Effects in Rock Masses: Some Possibilities and Limitations," in *GEOVAL-87 (Stockholm, April 1987)*, pp. 527-545. Stockholm: SKI, 1987.

Lin, D., C. Fairhurst and A. M. Starfield. "Geometrical Identification of Three-Dimensional Rock Block Systems Using Topological Techniques," *Int. J. Rock Mech. Min. Sci.*, **24**(6), 331-338 (1987).

Sterling, R. L., C. Fairhurst and J. C. Carmody. "Experience in the Development of Mined Underground Space in the Minneapolis-St. Paul Area," in *Proceedings of the International Symposium on Cities and Subsurface Use (Bordeaux, France, October 1987)*, pp. 63-66. Rotterdam: Balkema, 1987.

Cundall, P. A., and C. Fairhurst. "Correlation of Discontinuum Models with Physical Observations — An Approach to the Estimation of Rock Mass Behaviour," *Felsbau*, **4**(4), 197-202 (1986).

Fairhurst, C. "In-Situ Stress Determination — An Appraisal of Its Significance in Rock Mechanics," in *Proceedings of the International Symposium on Rock Stress and Rock Stress Measurements (Stockholm, September 1986)*, pp. 3-17. O. Stephansson, Ed. Luleå: Centek, 1986.

Fairhurst, C., and D. Lin. "Fuzzy Methodology in Tunnel Support Design," in *Research and Engineering Applications in Rock Masses (Proceedings of the 26th U.S. Symposium on Rock Mechanics, South Dakota School of Mines & Technology, Rapid City, June 1985)*, pp. 269-278, E. Ashworth, Ed. Boston: Balkema, 1985.

Fairhurst, C., and A. Maia da Costa. "Comparison of Numerical Modeling with Predictions from Laboratory Tests and Field Observations of Deformation in a Potash Mine in Sergipe, Brazil," in *Research and Engineering Applications in Rock Masses*, pp. 269-278. Boston: Balkema, 1985.

St. John, C. M., E. Detournay and C. Fairhurst. "Design Charts for a Deep Circular Tunnel Under Non-Hydrostatic Loading," in *Rock Mechanics in Productivity and Protection (Proceedings of the 25th Symposium on Rock Mechanics, Northwestern University, June 1984)*, pp. 849-855. C. H. Dowding and M. M. Singh, Eds. New York: AIMMPE, 1984.

Brady, B., and C. Fairhurst. "Rock Mechanics of Underground Excavations, General Report," in *Proceedings of the 5th International Congress of Rock Mechanics (Melbourne, 1983)*. Victoria, Australia: Australian Geomechanics Society, 1983.

Fairhurst, C., and R. Sterling. "Subsurface Storage of Food (Session Report, U.N. Workshop on the Utilization of Subsurface Space in Developing Countries, Stockholm, 1982)," *Underground Space*, **7**, 249-250 (1983).

Sterling, R. L., F. Dunkel, G. Meixel and C. Fairhurst. "Underground Storage of Food (U.N. Workshop on the Utilization of Subsurface Space in Developing Countries, Stockholm, 1982)," *Underground Space*, **7**, 257-262 (1983).

Detournay, E., and C. Fairhurst. "Approximate Statical Solution of the Elastoplastic Interface in the Problem of an Infinite Medium with a Circular Hole," in *Numerical Methods in Geomechanics (Proceedings of the 4th International Conference, Edmonton, Canada)*, pp. 27-35. Rotterdam: Balkema, 1982.

Detournay, E., and C. Fairhurst. "Generalization of the Ground Reaction Curve Concept," in *Issues in Rock Mechanics (Proceedings of the 23rd Symposium on Rock Mechanics, University of California, Berkeley, August 1982)*, pp. 924-934. Littleton, Colorado: SME, 1982.

Fairhurst, C., and F. H. Cornet. "Rock Fracture and Fragmentation," in *Rock Mechanics from Research to Application (Proceedings of the 22nd U.S. Symposium on Rock Mechanics, MIT, 1981)*, pp. 21-46. Cambridge: MIT, 1981.

Fairhurst, C. "Advantages of Earth-Sheltered Building and Current Developments in the United States," *Underground Space*, **5**(1), 31-35 (July 1980).

Fairhurst, C., and J. J. K. Daemen. "Practical Inferences from Research on the Design of Tunnel Supports," *Underground Space*, **4**(5), 297-311 (1980).

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Fairhurst, C. F., et al. "Rock Mechanics Studies of Proposed Underground Mining of Potash in Sergipe, Brazil," in *Proceedings of the 4th International Congress of Rock Mechanics (Montreux, Switzerland, 1979)*, pp. 131-137. Rotterdam: Balkema, 1979.

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