ISRM Tribute to Dr. Evert Hoek

C. Fairhurst and E.T. Brown

November 11, 2024

Dr. Evert Hoek, a long-time international leader in rock engineering, passed away peacefully July 6, 2024, after a brief illness, at home in Vancouver, Canada. In their own words, his family "adored" him.

The international rock mechanics community grieves with you. We have lost a major leader in our field, a close colleague and friend—but we are all better for having known him.

Evert was born on August 23,1933, in what was then Rhodesia (now Zimbabwe) in Southern Africa. His parents were farmers. He studied Mechanical Engineering at Cape Town University and met his wife Theo there. They have two children, son Peter and daughter Dorothy (Fairholm). Theo passed away in 2013. Evert married Bonnie in 2014. He retired in 2018. Throughout his remarkable and busy career Evert was a devoted husband and father. A private celebration of Evert's life has been arranged by Bonnie and the family.

The international rock mechanics community grieves with you. We have lost a world leader in our field, but we are all the better for his major contributions and for having known him.

After receiving his M.Sc. degree in Mechanical Engineering from Cape Town University in 1957, Evert joined the Council for Scientific and Industrial Research (CSIR) laboratory in Pretoria, to conduct research on mechanics and stress analysis. He inherited "a large photo-elastic stress analysis unit". This had been assembled by a staff member, who had decided to retire soon after it was completed.

In 1960, a major collapse at the Clydesdale underground coal mine, Coalbrook, killed 435 miners—the worst accident in South African history. At the same time, rockbursts in the deep gold mines of the Witwatersrand were killing many miners annually (for details, see the report by the Leon Commission of Inquiry (2005)[1]. Dr Francis G. ("Pinky") Hill, a visionary mining leader in South Africa, was urging research on this issue.

In 1963, Dr. M.D.G. Salamon was appointed Director of Research for the South African Coal Mining Research Controlling Council.

In1964, the government Chamber of Mines established the Mining Research Laboratory (MRL) with Dr. N.G.W. Cook as Director.

In 1966, Dr. Salamon was made Director of Research into the Stability of South African coal mines, and then appointed Director of the Collieries Research Laboratory of the Chamber of Mines of South Africa.

CSIR joined the search for answers, with Evert in the lead. So began his career in Rock Mechanics/Engineering. This period is described in the Preface[2] of his book "Practical Rock Engineering". It was at this time—in his own words, that he "stumbled into" rock mechanics.

Evert had a great ability to identify the major technical issues and questions facing contemporary industry. This informed the research areas that he and his research groups worked on in South Africa, in the UK and later in Canada, all to the great benefit of the local and international mining and civil engineering industries. Although, as evidenced by his PhD thesis and his early series of papers published in the SAIMM Journal, he was well able to solve more complex and difficult analytical problems, his published solutions tended to be as simple and as clear as possible. and oriented to practical issues. This may have been what caused so much of his work to be readily adopted in industrial

[1] https://www.klasslooch.com/leon_commission_of_inquiry.htm

[2] https://static.rocscience.cloud/assets/resources/learning/hoek/1.-Preface.pdf (pp 3-13)

practice. In both South Africa and at Imperial College, London, he developed a range of effective laboratory and field test equipment. This again reflected his clear engineering thinking, but also, perhaps, his early education and training in mechanical engineering.

Evert was a master communicator in both the written and spoken word. He was always able to give extremely clear keynote lectures and other presentations without the assistance of notes—and, unlike so many of our colleagues, to conclude on or before the expiry of the allotted time! This characteristic was still very much in evidence when he spoke at a colloquium held in Brisbane, Australia, to mark Ted Brown's final retirement on 4 December 2018, by which time he was about 85 years of age. His ability to illustrate technical points with clear, beautifully drawn sketches added to the power of his technical communications. We understand that his first wife, Theo, helped him with some of his drawings, but this doesn't detract from Evert's skill in this regard.

Hoek's Corner[3] established by Rocscience in 1996, gave Evert the opportunity to prepare and present a series of video-taped lectures. These are all excellent, major contributions to rock engineering practice. (see e.g. the 341p. "Practical Rock Engineering") and, together with many of Evert's numerous publications, are available free to the rock mechanics/engineering community on the website. This allows everyone in rock mechanics/engineering to continue to benefit from the work of this truly major figure in our discipline. He worked as a consultant on close to 40 major rock engineering projects in many countries around the world (see e.g. Hoek's Corner "Design Challenges, Disasters and Lessons in Rock Engineering"[4]).

As shown in the table below, Evert has been recognized for his contributions by more awards than anyone in the field, from major organizations associated with rock mechanics/engineering. His lecture in 2021 "Developments in rock engineering from 1958 to 2020"[5], his last general presentation, is also essential reading for everyone in rock mechanics/engineering. Clearly, he recognized that computer models are now making valuable contributions to important engineering problems and welcomed these developments.

Evert at Malpasset Dam site (ca 1970)

Tour led by Pierre Londe (PL) (France), the leading authority on the collapse.

H. Kutter, Post Doc. with Dr. Hoek, Imperial College; Ph.D. (1967) University of Minnesota.

It was the collapse of the Malpasset Dam on the Reyran River (France), on 2 December 1960, that led Prof. Leopold Müller (Austria) to establish the

International Society for Rock Mechanics

in Salzburg, Austria, May 24 1962.

[3] https://www.rocscience.com/learning/hoeks-corner

[4] https://www.youtube.com/watch?v=wji5zK7c1Qo&t=36s

[5] 6min 40sec to 53min 09sec, https://www.youtube.com/watch?v=dy83dYaXHVY&t=5s 6min 40sec to 53min 09sec,

Dr. Evert Hoek – (Aug 23,1933 –July 6,2024) Achievements, and International Recognition

1933 Born in Southern Rhodesia (now Zimbabwe) Parents were Farmers.
1951 Enrolled University of Cape Town, South Africa 1955 B.Sc. (Mech. Eng); (1957) M.Sc. (Mech. Eng.)
1958 Research Engineer CSIR (Council for Scientific and Industrial Research), Pretoria
1965 Ph. D. University of Cape Town
1966 Reader in Rock Mechanics; 1970, Professor of Rock Mechanics, Royal School of Mines, Imperial College, London
1975 Senior Associate, Principal, Golder Associates, Vancouver
1987 Industrial Research Professor in Rock Engineering. University of Toronto
1993 Independent Consultant, Rock Engineering in Civil & Mining Engineering
2018 Retired, Vancouver
See also: Hoek's Corner[6], Preface to the book "Practical Rock Engineering"[7] and Wikipedia[8].

Honorary Doctorates

1994 University of Waterloo, Canada (D.Sc.)
2004 University of Toronto, Canada (D.Eng.)
2016 Polytechnic University of Catalonia, Barcelona, Spain

Awards

1970 Consolidated Goldfields Gold Medal, UK
1975 AIME Rock Mechanics Award, USA
1979 E. Burwell Award, Geological Society of America
1982 Sir Julius Wernher Memorial Lecture, UK
1983 Rankine Lecture, British Geotechnical Society
1985 Gold Medal, Institution of Mining and Metallurgy, UK
1991 Müller Award (First), International Society of Rock Mechanics
1993 William Smith Medal, Geological Society, UK
1993 Fellow, Royal Academy of Engineering UK
1998 Glossop Lecture, Geological Society, UK
2000 Terzaghi Lecturer, American Society of Civil Engineers
2001 Fellow, Canadian Academy of Engineering
2006 Member, US National Academy of Engineering
2008 Kersten Lecture, Univ. Minnesota

Lifetime Achievement Awards

2018 AITES (International Association of Tunnelling and Underground Space)[9]
2021 Rocscience Lifetime Achievement Medal. First Rocscience International Conference (April 21-22,2021)[10]
2021 "Developments in rock engineering from 1958 to 2020" Q&A after Lecture[11].

[6] https://www.rocscience.com/learning/hoeks-corner-rock-mechanics-reference-library
[7] https://static.rocscience.cloud/assets/resources/learning/hoek/1.-Preface.pdf
[8] https://en.wikipedia.org/wiki/Evert_Hoek
[9] https://www.youtube.com/watch?v=ne3Xa9knhzQ
[10] https://www.youtube.com/watch?v=dy83dYaXHVY&t=5s. Introduction by Dr Yacoub, CEO, Rocscience; Tribute to Dr Hoek by Dr Curran, Founder Rocscience (total 6min 40sec). Lecture by Dr. Hoek.
[11] https://static.rocscience.cloud/assets/resources/learning/hoek/RIC2021-QAwithDrHoek_V2.pdf (6min 40sec to 53mni 09sec)

How did Evert view future developments in Rock Mechanics/Engineering?

In 2018, Evert gave an interview to the ASCE Journal GeoStrata[12]. The article provides insights into Evert's views on developments and prospects in Rock Engineering—and advice for engineering students just staring their careers in rock mechanics/engineering. This is recommended reading.

He was optimistic that consulting groups would soon provide computer programs that would provide civil, mining, and geological engineers involved in underground projects, with valuable practical design assistance. Evert expressed concern in the article that current university programs in these disciplines were not providing students with an awareness of the real situations that they may encounter underground and how to apply information from their studies appropriately in practice.

To overcome this shortcoming, especially for students considering graduate studies, he urged (See Geo-Strata. p.41) "Get out there! Take a break from school and get into the real world." … He repeats this advice in the final one and a half minutes of his 2021 Lecture "Developments in Rock Engineering from 1959 to 2020"[13].

In answering the question "How will the methods and practices you've developed adapt with advances in technology?" (Geo Strata p.38), he comments on the Hoek-Brown (H-B) Criterion with GSI: "While I consider this method to be crude, it has been widely adopted and used because of the lack of suitable alternatives.".

[Note. The June 2024 ISRM Lecture by Prof. Carranza -Torres[14] provides a detailed update of the H-B criterion i.e. the strength of the intact rock under all combinations of loading. (The ISRM Lecture does not address the GSI—except in citing a practical application at the end of the Lecture)]

The Geological Strength Index (GSI)—the extent to which the intact rock strength should be reduced due to fracturing and related in situ conditions—is based on an assessment by the rock engineer and/or field geologist at the site, using a guide established and modified by Dr. Hoek and colleagues over many years. This direct involvement of field personnel in the assessment is undoubtedly part of the attraction of the H-B Criterion. It will be interesting to see how effectively numerical models will be able to replace this criterion.

Rock as it exists in the ground is certainly not the same as the refined materials—many derived from this rock—used in various other branches of engineering, and its behavior over the period involved in practical rock engineering is more difficult to define. It does have the properties of elasticity, plasticity and viscosity that allow the rock to respond to applied loads—and it does obey Newton's Laws—but it has been evolving for over 4 billion years! Although it took around 2 billion years for temperatures to drop sufficiently to allow solid rock to form—and Continental Drift, Plate Tectonics, Mountain Building, Faulting, Erosion, Ice Ages, etc. to become active—these processes have been at work for a very long time.

Mining has been practiced for over 40,000 years[15]. Throughout most of history, mining technology has developed empirically. Newton's Principia appeared in 1687. The first book in English on the "Theory of Elasticity"[16] was published in 1934. It was not until the early 1950's that rock mechanics was formally identified as a discipline, and attempts were first made to apply Newtonian mechanics to this complex material rock. Advances in computing, together with field experience, over more than the past six decades, are now starting to reveal valuable design approaches, but challenges remain.

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[12] https://cgs.ca/pdf/Evert_Hoek-GeoStrata_May_Jun_2018.pdf

[13] https://www.youtube.com/watch?v=dy83dYaXHVY&t=5s

[14] https://isrm.net/page/show/1740

[15] The Ngwenya Mine in Eswatini (formerly Swaziland) is the world's oldest mine. First operated in 42,000 BP, it was designated a UNESCO World Heritage site in 1982

[16] S. Timoshenko, McGraw Hill

Several colleagues with a sound understanding of modeling in rock have noted that numerical modeling in rock engineering involves issues not often encountered in other engineering disciplines. For example,

- "Data-limited problems [such as in rock mechanics] require a very different modelling approach from that developed in, for example, electrical or aerospace engineering and it follows that one cannot use models in rock mechanics in a conventional way, and that there is a need to adopt a distinctive and appropriate methodology in rock mechanics modelling"[17].
- "We are at the beginning of multi-scale science and multi-scale computation, with a growing need to understand not only phenomena on each of many scales, but also the interaction between phenomena at very different scales"[18].

Evert recognized these challenges and, as is clear from his 2021 lecture (discussed below) he felt that computer programs to address them are now becoming available from consulting groups.

So, how can ISRM move these developments forward?

For the first time in many decades the importance of minerals and improved mining technology, availability of powerful computer and allied systems, and development of the subsurface in general, to the future well-being of the planet and its inhabitants are being recognized by groups not traditionally associated with mining, e.g. World Bank (2017), International Energy Agency (2020).

Professor Brad Ross, University of Arizona USA[19] considers that minerals and mining are so central in this century, and the professional attributes required of mining engineers are such that a special Global Academy is needed (analogous to Military Academies in some countries) serving the mining industry world-wide.

Several parts of the world, especially mineral exporting countries (e.g. Australia, Canada, Chile, China (PRC), Eastern Europe, South Africa) have made, and are making, important contributions to mining technology, and reduction of adverse environmental impact. ISRM is well placed to stimulate awareness of and draw attention to these developments, and stimulate mining innovation in research universities, especially as leading mining companies are now developing their own applied research groups and require interdisciplinary teams of engineers.

Climate Change is a major threat to life on Planet Earth. It is primarily an above-ground issue, and subsurface engineering has a major role to play to adapt to it and provide protection to the public from the more extreme effects.

Civil engineers will find stimulating examples of subsurface applications in the book "Sweden Underground; Rock engineering and how it benefits Society" (2018)[20]. An earlier (1988) book "Going Underground" by the Royal Swedish Academy of Engineering Sciences IVA (194 pages) contains a wealth of examples of subsurface engineering. Although now out of print, a digital copy may be downloaded free of charge, courtesy of IVA[21]. The motivation for the book is described by IVA President Hans Forsberg on p.9 of 194.

It is worth noting also that Sweden, a neutral country during the USA USSR Cold War (1947 to 1992), was concerned that any outbreak of hostilities could result in nuclear fallouts and other adverse consequences for Sweden. Development of underground facilities that could be incorporated into the

[17] Int. J. Rock Mech. Min Sci.& Geomech. Abstracts. Vol.25 June 1988, pp.99-106

[18] Alexandre Chorin (2008) Foreword (p. x) to the book "Scaling" by G.I. Barenblatt, Cambridge Univ. Press. First Edition (171p)

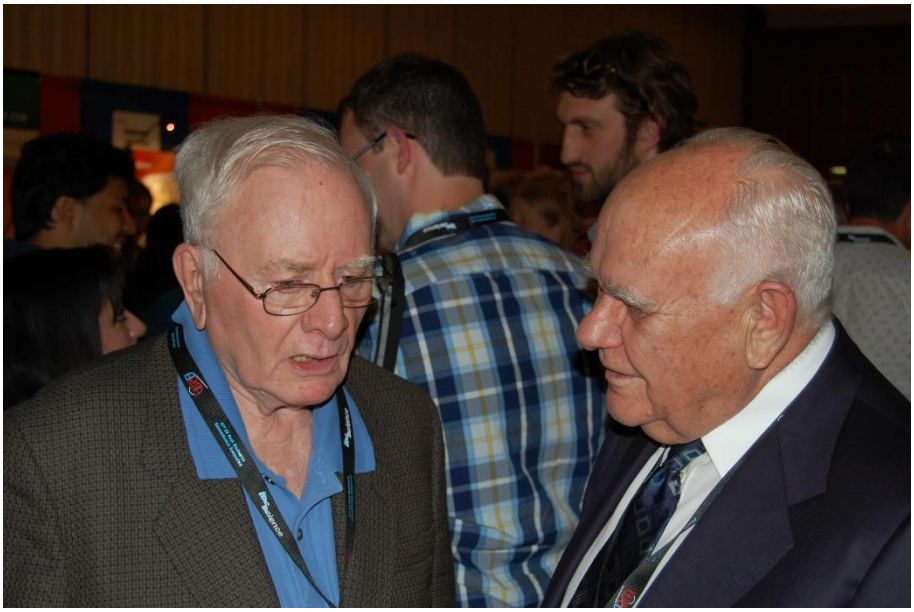
[19] https://mining.arizona.edu/person/brad-ross-phd-pe

[20] https://www.befo.se/publikationer/sweden-underground-rock-engineering-and-how-it-benefits-society/

[21] https://itasca-downloads.s3.amazonaws.com/Going+Underground.pdf

daily life of communities (e.g. subways, concert halls, shopping malls) could provide shelter in an emergency without causing panic

Exploration of Outer Space, a major international R&D emphasis since the 1960's, has yielded life-changing benefits for the world. It is now critical to pay comparable attention to the benefits of Inner Space, the world beneath our feet—and for ISRM to stimulate and draw international attention to the opportunities, the challenges and the global urgency of Exploration of Inner Space!



Evert (right) and Charles Fairhurst (left).

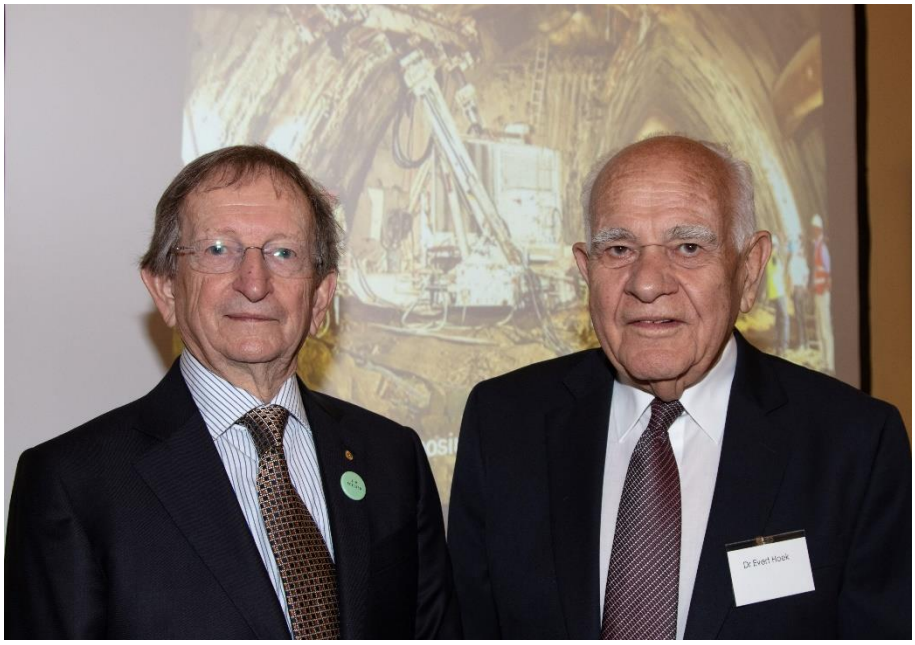
ARMA

(American Rock Mechanics Association)

Annual Meeting

San Francisco

June 2017



Evert (right) and E.T. (Ted) Brown (left)

at Dr Brown's Retirement Dinner,

Brisbane

4 Dec 2018