

6/26/94

CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

TRIP REPORT

SUBJECT: Workshop on Rock Mechanics Issues in Repository Design and Performance Assessment
(Account Nos. 5702-441, -623, -641, -642, -723, -741; 5704-039)

DATE AND PLACE: September 19-20, 1994
Rockville, MD

AUTHORS: W.C. Patrick, R.D. Manteufel, R.G. Baca, A. Chowdhury, A. Ghosh, S. Hsiung, M. Ahola, S. Mohanty, and G. Ofoegbu

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PERSONS PRESENT:

Approximately 50 people attended the workshop, representing a spectrum of interests, including: U.S. Department of Energy (DOE), Nuclear Regulatory Commission (NRC), Center for Nuclear Waste Regulatory Analyses (CNWRA), State of Nevada, Sandia National Laboratories (SNL), Livermore National Laboratory (LLNL), Atomic Energy of Canada Limited (AECL), Intera/M&O, Nuclear Waste Technical Review Board (NWTRB), and Royal Institute of Technology (Sweden).

BACKGROUND AND PURPOSE OF TRIP:

The objective of the workshop was to examine the rock mechanics issues in repository design and performance assessment, with emphasis on thermal and seismic loads and the role of seals in repository performance. The goals of the workshop included: (i) stimulate the exchange of technical information among those parties actively investigating rock mechanics issues relevant to the proposed high-level waste repository at Yucca Mountain (YM), (ii) identify/confirm rock mechanics issues important to repository design and performance assessment, and (iii) identify the role and performance level of seals for shafts, ramps, and boreholes to meet the repository performance objectives.

The workshop was intended for engineers and scientists in fields of rock mechanics, hydrogeology, mining engineering, structural geology, seismic and earthquake engineering, etc., especially those interested in design and performance assessment of a high-level nuclear waste repository.

SUMMARY OF PERTINENT POINTS:

The workshop spanned two days in which three main topical sessions and associated panel discussions were covered: (i) Rock Mechanics Issues in Repository Design, (ii) Near-Field Coupled Processes, and (iii) Sealing of Rock Mass for High-Level Waste Repository.

Rock Mechanics Issues in Repository Design

Professor Z.T. Bieniawski (Pennsylvania State University) opened the technical component of the workshop, highlighting the public visibility and scrutiny of the repository program. Among his criticisms of the DOE program were (i) there is essentially no integration of Rock Mechanics and Repository Design; (ii) many recent changes that are often described as "programmatic" (e.g., MPC, thermal loading, ramps, extended retrieval, etc.) introduce major technical changes to design; (iii) the current design methodology "leaves much to be desired," and suggested DOE examine Suh's (1990) seminal delineation of design principles; (iv) rock mechanics design activities are often not using state-of-the-art principles and techniques; and (v) he is unable to reconcile the as-built work at Yucca Mountain with what ESF Design Package 1C contains. He discussed a new approach to design which was based on a more scientific approach. The step-by-step approach consisted of three distinct domains: objectives, solutions, and construction.

Dr. K. Kim (Columbia University) addressed probabilistic approaches in rock mechanics design. He provided an analysis of laboratory data from the Basalt Waste Isolation Project (BWIP) using extreme value statistics. He finds very good comparison of data with theoretical distributions for compressive and tensile stresses, modulus, and Goodman Jack tests. Participants noted that this is largely an exercise in statistical fitting, rather than a predictive methodology. A suggestion was made to use this technique to obtain a statistical fit to R. Price's 1983 data, and then compare the resulting curve to more recent and complete data sets from Yucca Mountain.

Dr. P.H.S.W. Kulatilake (University of Arizona) addressed his new peak shear strength model. He used spectral methods to analyze joint roughness. In this analysis, Kulatilake treated roughness as a 1-D space variable and determined the relationship between the spectral coefficient β and fractal dimension: $\beta = 5 - 2D$. This approach applies to stationary roughness distributions. He noted the need to add a parameter for nonstationary aspects of roughness distributions (i.e., large-scale roughness).

Dr. G. Ofoegbu (CNWRA) addressed the results of recent studies at the Lucky Friday mine concerning seismic effects on groundwater. He noted complications of seismic, seasonal, mine drawdown, and longer term seismic effects. Two main conclusions were that (i) the model under-predicts the effects of earthquakes above about 2.5 magnitude, (ii) these are only statistical relationships, further work is needed to obtain a mechanistic understanding, and (iii) from his field data, only small effects have been measured (changes in head less than 1 m).

Dr. S. Hsiung (CNWRA) summarized CNWRA research on the effects of repetitive seismic loads, drawing upon the results of field studies at the Lucky Friday Mine and laboratory 1/15 scale-model seismic simulations. This work has important implications for design, since current design methods address single peak-magnitude events rather than the "fatigue" effects of repeated lower-magnitude events.

Dr. S. Serata (Serata Geomechanics) described a dry fracture stress measurement technique. His focus was on development and use of instruments for *in situ* stress and modulus determinations. The instrument was reported to be useful for on-site quality assurance audits.

In the audience discussion that followed, a number of questions and concepts were advanced. Dr. R. Manteufel asked why so few rock mechanics issues were raised in the context of PA, and offered three hypotheses: (i) unknown issues; (ii) DOE and NRC organizational structures foster isolation; or (iii) rock mechanics doesn't really impact performance. Dr. Voegelle countered that he believes that rock mechanics issues simply get "rolled up" into other concerns and secondary effects. Dr. Patrick also countered that PA is typically focussed on long-term post-closure issues while many rock mechanics issues are design, construction, and operation issues. Several questions addressed the possibility that DOE's emphasis on long-lived containers might make geology less critical to system performance. The NRC defense-in-depth concept and regulatory basis were summarized to address this matter.

Dr. Gao questioned Bieniawski's earlier comments on the "factor of safety" (FS) being a "factor of ignorance." In reply, Bieniawski acknowledged the favorable public perception associated with $FS > 1$. However, he believes that the rock mechanics community needs to move to failure probability (Note: $FS = 1$ is about $p = 50$ percent).

Steve Blair, Lawrence Livermore National Laboratory (LLNL), sees a role for rock mechanics, even with the emphasis on the MPC. Specific concerns, in his view, include spalling, design of support systems, waste retrieval, and chemical effects of supports on corrosion and colloid formation.

As a result of further questions, Dr. Voegelle reiterated the role of the PPA as one of moving the program forward. He noted that DOE's focus would probably be more on 10 CFR Part 960 rather than on 10 CFR Part 60. This will *de facto* change priorities. With respect to the MPC, they fully intend to bound or set ranges of parameters within which they will operate.

DAY TWO, SEPTEMBER 20, 1994

Near-Field Coupled Processes

The second day of technical sessions opened with Dr. W. Boyle discussing the "evolution" of DOE's site characterization strategy. He noted that the PPA "came from top down," contrary to the earlier statements by Dr. Voegelle. The description of the intent of the Site Characterization Plan (SCP) appears to be quite different from the understanding of the CNWRA. Dr. Boyle characterized the SCP as indicating "everything that could be known" versus "what needs to be known." This does not appear to be consistent with how the SCP presents specific data-gathering activities in the context of the DOE Issue Resolution Strategy. Furthermore, he asserted that the PPA will "ultimately" yield the "content of the SCP;" however, not the same tests or number of tests. Broadly speaking, DOE plans to focus on (i) standard tests, (ii) larger volumes, and (iii) preservation of samples.

Dr. F. Tsai (Woodward Clyde Federal Services) discussed the results of his drift-scale thermomechanical analyses in the context of retrievability. These calculations (i) consider "blast cooling" of a heated repository; (ii) employ discrete discontinuum analysis (DDA); (iii) show very high horizontal stress due to thermal effects (60-70 MPa); (iv) indicate major opening of horizontal joints and the potential for blocks falling from the crown upon cooling; and (v) indicate joint aperture changes of up to 1 mm, the equivalent permeability of $1.0 \times 10^{-11} \text{ m}^2$ [about the same as what Buscheck uses as a base permeability].

Dr. S. Mohanty discussed recent experiments on the effects of mechanical loading on fracture permeability. His early results indicate (i) changes in normal load of 8 MPa produce about a 35 percent change in permeability; (ii) hysteresis in the effect of load on permeability; and (iii) about a 350 percent

PROBLEMS ENCOUNTERED:

None.

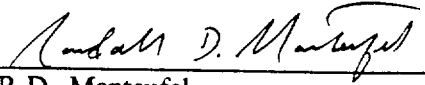
PENDING ACTIONS:

None.

RECOMMENDATIONS:

None.

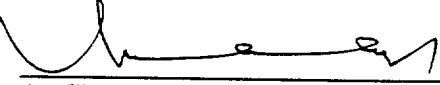
SIGNATURES:



R.D. Manteufel
Sr. Research Engineer

10/6/94
Date

CONCURRENCE SIGNATURES AND DATE:



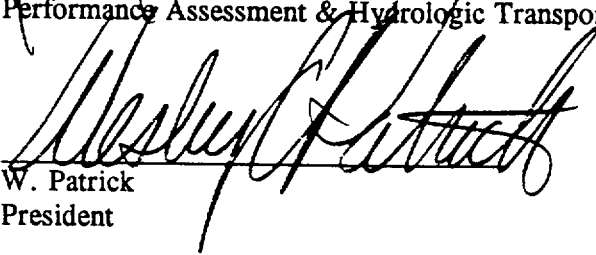
A. Chowdhury, Manager
Repository Design, Construction, & Operations

10/18/94
Date



R.G. Baca, Manager
Performance Assessment & Hydrologic Transport

10/17/94
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W. Patrick
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10/19/94
Date