DISTRIBUTION
WM S/F ~~3101.1~~ 101.2
WMRP r/f
NMSS r/f
CF
REBrowning
MJBell
JBunting
PAltomare
MRKnapp
LBarrett
LBHigginbotham
HJMiller
RRBoyle
SCoplan
JLinehan
JKennedy
RJWright & r/f
PDR

101.1/RJW/84/07/17

JUL 23 1984

Mr. O. L. Olson
U. S. Department of Energy
Richland Operations Office
BWIP Project Office
P. O. Box 550
Richland, WA 99352

Dear Mr. Olson:

I enclose a memorandum to me from John Buckley dated July 5, 1984. It calls attention to a typographical error in Appendix V, Volume 2 of NUREG-0960.

Would you please call this matter to the attention of those who may be interested.

Thank you.

Sincerely,

"ORIGINAL SIGNED BY"

Robert J. Wright
Senior Technical Advisor
Repository Projects Branch
Division of Waste Management
Office of Nuclear Material
Safety and Safeguards

WM Record File 101.2
WM Project 10
Docket No.
PDR ✓
LPDR
Distribution:

(Return to WM, 623-SS)

8408060295 840723
PDR WASTE
WM-10 PDR

OFC	:WMRP	:WMRP	:GREEVES	:	:	:
NAME	:RJWright	:HJMiller	:	:	:	:
DATE	:7/18/84	:7/ /84	:	:	:	:

00916

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

JUL 05 1984

MEMORANDUM FOR: Robert J. Wright
Repository Projects Branch
Division of Waste Management

FROM: John T. Buckley
Engineering Branch
Division of Waste Management

SUBJECT: CORRECTION IN PAGE v.5 OF THE DSCA

A short time ago I was informed of a typing error in the BWIP DSCA which was published in March 1983 as NUREG-0960. The error occurs on page v.5 of NUREG-0960 Vol.2 which is entitled "Draft Site Characterization Analysis of the Site Characterization Report for the Basalt Waste Isolation Project."

Attached for your transmittal to BWIP is a copy of the published version of page v.5, a copy of the corrected page v.5 and a copy of the original wording as presented to the NRC by Engineers International in February, 1983.

If you have any questions regarding the contents of this memo please contact me.

John T. Buckley

John T. Buckley
Engineering Branch
Division of Waste Management

Enclosure:
As stated

~~8407260069~~ 5pp.

2.3.1 Engineering Mechanics

Design approaches based on engineering mechanics considerations are the rock classification schemes, and analytical solutions to analyze stability. Rock classification systems address most of the factors governing the stability of underground openings in rock, i.e., basic rock strength, fracturing, water conditions, and overall geologic setting. The RMSD method proposed by Kendorski (1980) is basically a discounting method in which the intact rock strength is discounted according to the nature and degree of fracturing to obtain the rock mass strength. This value can be used for analytical computations as well as an indicator of overall rock mass competence. The Geomechanics System of Bieniawski (1979) develops a relationship of span versus standup time. The Q-System of Barton, Lien, and Lunde (1974) is fairly simple, but is not recommended for the design of shotcrete and rock reinforcement. The system proposed by Terzaghi (1946) computes a dead rock load due to loosening, and is widely used for the design of steel arch support in tunnels.

These systems either enable or directly yield generalized support recommendations. Application of these systems to circumstances outside the classification data base requires discretion by the user. Thus, the particular requirements of nuclear waste repositories, especially thermomechanical effects, will require some modification of the direct results obtained from classification systems before an adequate preliminary design is obtained for any single repository concept. However, various repository concepts can be readily compared for long-term stability and constructibility using classification approaches. Typically, recommendations from the various classification systems are compared to otain preliminary rock mechanics design concepts.

Classical engineering mechanics approaches are based on arriving at a balance of forces acting on an opening. Driving forces are the rock loads, and resisting forces come from the rock mass competence and the support system. The in situ material properties of the rock and support must be known for such an approach to be meaningful.

Simple elastic theory (Obert and Duvall, 1967) gives a first approximation of the distribution and magnitude of stresses and destressed zones surrounding an opening. However, the assumptions of homogeneity, isotropy, and linear elasticity implicit in elastic theory are seldom met in rock masses. Elastic theory also does not allow for the effects of rock reinforcement. However, even with these limitations, simple elastic analyses yield useful, though conservative, information for conceptual design of structures in rock.

Elastic-plastic ground reaction curve methods seek to match the support to the rock mass such that the amount of deformation allowed for corresponds both to the peak rock mass shear strength and the peak deformation resistance of the support (Egger, 1980). For the optimum use of the method, proper timing of support installation is essential. While the deformation of the support can be fairly readily evaluated, it is seldom possible to predict the ground behavior characteristic from basic geomechanics data. Field measurements of rock mass behavior are necessary, and preliminary estimates can be obtained from underground test facilities within the horizon of interest. During construction,

2.3.1 Engineering Mechanics

Design approaches based on engineering mechanics considerations are the rock classification schemes, and analytical solutions to analyze stability. Rock classification systems address most of the factors governing the stability of underground openings in rock, i.e., basic rock strength, fracturing, water conditions, and overall geologic setting. The RMSD method proposed by Kendorski (1980) is basically a discounting method in which the intact rock strength is discounted according to the nature and degree of fracturing to obtain the rock mass strength. This value can be used for analytical computations as well as an indicator of overall rock mass competence. The Geomechanics System of Bieniawski (1979) develops a relationship of span versus standup time. The Q-System of Barton, Lien, and Lunde (1974) is a detailed system with the chief advantages of considering span and in situ stress. The RSR Concept of Wickham and Tiedemann (1974) is fairly simple but is not recommended for the design of shotcrete and rock reinforcement, since the data base for these types of support did not contain sufficient examples of their use to permit definitive criteria to be developed (Wickham and Tiedemann, 1974, p. 5-24). The RSR system is far more reliable for selecting steel arch support. The system proposed by Terzaghi (1946) computes a dead rock load due to loosening, and is widely used for the design of steel arch support in tunnels.

These systems either enable or directly yield generalized support recommendations. Application of these systems to circumstances outside the classification data base requires discretion by the user. Thus, the particular requirements of nuclear waste repositories, especially thermomechanical effects, will require some modification of the direct results obtained from classification systems before an adequate preliminary design is obtained for any single repository concept. However, various repository concepts can be readily compared for long-term stability and constructibility using classification approaches. Typically, recommendations from the various classification systems are compared to otain preliminary rock mechanics design concepts.

Classical engineering mechanics approaches are based on arriving at a balance of forces acting on an opening. Driving forces are the rock loads, and resisting forces come from the rock mass competence and the support system. The in situ material properties of the rock and support must be known for such an approach to be meaningful.

Simple elastic theory (Obert and Duvall, 1967) gives a first approximation of the distribution and magnitude of stresses and destressed zones surrounding an opening. However, the assumptions of homogeneity, isotropy, and linear elasticity implicit in elastic theory are seldom met in rock masses. Elastic theory also does not allow for the effects of rock reinforcement. However, even with these limitations, simple elastic analyses yield useful, though conservative, information for conceptual design of structures in rock.

Elastic-plastic ground reaction curve methods seek to match the support to the rock mass such that the amount of deformation allowed for corresponds both to the peak rock mass shear strength and the peak deformation resistance of the support (Egger, 1980). For the optimum use of the method, proper timing of support installation is essential. While the deformation of the support can be fairly readily evaluated, it is seldom possible to predict the ground behavior characteristic from basic geomechanics data. Field measurements of rock mass behavior are necessary, and preliminary estimates can be obtained from underground test facilities within the horizon of interest. During construction,

DESIGN OF STABLE OPENINGS

prepared for

U. S. Nuclear Regulatory Commission
Washington, DC

February 1983

NRC Contract No. NRC-02-82-030
Task Order 003 - Task 1

Engineers International, Inc.
Westmont, IL

FD2
1085D

ENGINEERS INTERNATIONAL, INC.

carried out (analytical techniques). A comparison of the designs is then possible, perhaps based on cost and technical criteria. A few alternatives are then selected for detailed consideration, in which the interaction of all critical design factors is evaluated through numerical modeling; this design phase should be supported by in situ testing for specific input parameters. From this effort, design specifications and performance criteria are formulated. Finally, the conformance of the rock mass behavior with performance criteria is established by monitoring.

2.3.1 Engineering Mechanics

Design approaches based on engineering mechanics considerations are the rock classification schemes, and analytical solutions to analyze stability. Rock classification systems address most of the factors governing the stability of underground openings in rock, i.e., basic rock strength, fracturing, water conditions, and overall geologic setting. The RMSD method proposed by Kendorski (1980) is basically a discounting method in which the intact rock strength is discounted according to the nature and degree of fracturing to obtain the rock mass strength. This value can be used for analytical computations as well as an indicator of overall rock mass competence. The Geomechanics System of Bieniawski (1979) develops a relationship of span versus stand-up time. The Q-System of Barton, Lien, and Lunde (1974) is a detailed system with the chief advantages of considering span and in situ stress. The RSR Concept of Wickham and Tiedemann (1974) is fairly simple but is not recommended for the design of shotcrete and rock reinforcement, since the data base for these types of support did not contain sufficient examples of their use to permit definitive criteria to be developed (Wickham and Tiedemann, 1974, p. 5-24). The RSR system is far more reliable for selecting steel arch support. The system proposed by Terzaghi (1946) computes a dead rock load due to loosening, and is also widely used for the design of steel arch support in tunnels.

These systems either enable or directly yield generalized support recommendations. Application of these systems to circumstances outside the classification data base requires discretion by the user. Thus, the particular requirements of nuclear waste repositories, especially thermomechanical effects, will require some modification of the direct results obtained from classification systems before an adequate preliminary design is obtained for any single repository concept. However, various repository concepts can be readily compared for long-term stability and constuctibility using classification approaches. Typically, recommendations from the various classification systems are compared to obtain preliminary rock mechanics design concepts.

Classical engineering mechanics approaches are based on arriving at a balance of forces acting on an opening. Driving forces are the rock loads, and resisting forces come from the rock mass competence