A-1755

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Sandia National Laboratories
Albuquerque, New Mexico 87185

FEB 17 A11:27

February 15, 1986 87

Mr. John Peshel
Engineering Branch
Division of Waste Management
U.S. Nuclear Regulatory Commission
7915 Eastern Avenue
Silver Spring, MD 20910

Dear Mr. Peshel:

The enclosed monthly report summarizes the activities during the month of January for FIN A-1755.

If you have any questions, please feel free to contact me at FTS 844-8368 or L. R. Shipers at FTS 846-3051.

Sincerely,

Robert M. Cranwell

Robert M. Cranwell
Supervisor
Waste Management Systems
Division 6431

RMC:6431

Enclosure

Copy to:
Office of the Director, NMSS
Attn: Program Support Branch
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3656

PROGRAM: Coupled Thermal-Hydrological-Mechanical Assessments and Site Characterization Activities for Geologic Repositories

FIN#: A-1755

CONTRACTOR: Sandia National Laboratories

BUDGET PERIOD: 10/86 - 9/87

DRA PROGRAM MANAGER: J. Peshel

BUDGET AMOUNT: 250K

CONTRACT PROGRAM MANAGER: R. M. Cranwell

FTS PHONE: 844-8368

PRINCIPAL INVESTIGATOR: L. R. Shipers

FTS PHONE: 846-3051

PROJECT OBJECTIVES

To provide technical assistance to NRC in the assessment of coupled thermal-hydrological-mechanical phenomena and site characterization activities for high-level waste repositories.

ACTIVITIES DURING JANUARY 1986

Activities and Accomplishments

The review of the BWIP Document titled "Task V Engineering Study No. 11: Shaft Casing Design Criteria and Methodology" was completed. Written comments are provided as an attachment to this monthly report. Assuming that the DOE will pursue the design methodology outlined in that document, it would be useful for the NRC to be able to verify specific numerical results generated by the DOE. Therefore, we recommend that a task be initiated to develop a software package for that purpose. Such a package or program would carry out the various steps of the methodology, using all the appropriate equations and formulae, and link it to pre- and/or post-processors for probabilistic analyses. For example, Sandia's Latin lypercube sampling (LHS) program could be used to sample input data from ranges and distributions of design parameters and properties; multiple applications of the proposed shaft casing design procedure could be applied to obtain a distribution of point-value solutions.

A technical paper on retrievability, authored by Nataraja et al., was reviewed at NRC's request. Comments were transmitted to Dr. Nataraja during the last week of January. Continuous progress is being made on the installation and testing of the STEALTH codes on Sandia's computing system. Frequent telephone conversations with the NRC staff on technical matters (design, rock mechanics,heat transfer, numerical modeling etc.) took place during January. Information was provided on the "COVE 3" Project under which three sets of thermohydrologic calculations are being performed with NORIA, WAFE, and TOUGH computer codes at three different national laboratories. A list of proposed subtasks to be completed under this contract was also prepared this month and sent to the NRC for review.

Travel

L. Shipers attended a three day short course on ground water flow and contaminant transport at Princeton University on January 26-28, 1987. A trip report is included as an attachment to this monthly report.

Problems Encountered

None.

TRIP REPORT

L. Shipers attended a three day short course on the subject of groundwater flow and contaminant transport modelling at Princeton University during January 26-28, 1987. The course instructors were Prof. George Pinder, Prof. A. Celia, and Dr. David P. Ahifeld. On the first day of the course an overview of basic geological concepts and features salient to groundwater flow was presented. On the second day numerical techniques for the solution of partial differential equations and their utilization in groundwater models was presented. The last day was concerned the the details of the implementation and use of the Princeton Transport Code (PTC). The PTC is a computer code developed to model groundwater flow and contaminant transport. A copy of the PTC and accompanying documentation were provided to all attendees at the short course. Evening sessions were provided for presentation of field cases and for hands-on experience in running the PTC.

The PTC is a computer code capable of modelling both groundwater flow and transport in a fully three-dimensional, anisotropic, nonhomogenious porous media. The code is structured so that it will run on an IBM PC computer. An alternating direction implicit (ADI) numerical procedure is used in the code. In a horizontal layer a finite element procedure is used. This allows a variable size, non-rectangular grid to be constructed in a horizontal layer. The horizontal layers are then coupled vertically using a finite difference procedure. While this coupling requires that all layers have the same horizontal gridding, the thickness and elevation of an individual layer may vary as a function of the spatial location. The groundwater flow and contaminant transport calculations are not performed simultaneously within the code. Rather, the steady-state groundwater flow solution is first calculated and the resulting flow field is used as input data for the contaminant transport calculations. It should be noted that while transient flow calculations can be performed this structure restricts contaminant transport calculations so that they may only be performed under steady-flow conditions.

It should be noted that the governing equations for groundwater flow in a porous media and the temperature distribution in a conducting media have the same general form. This along with the decoupled nature of the groundwater flow and transport solutions within the code, suggest potential of the use of the code for thermal and coupled thermal-mechanical applications. It is possible that modifications to the PTC could result in a fully three-dimensional, transient thermal conduction code for anisotropic, nonhomogeneous media that is well suited to repository modelling applications and capable of running on an IBM PC.

Document Title: Task V Engineering
Study No. 11 - Shaft Casing Design
Criteria and Methodology

Document Number: SD-BWI-ES-028 Rev. 0

Reviewer: K.K. Wahi

In addition to providing general and specific comments, lists of input sets by category and input combinations (used in the design equations) have been prepared in this review. This logical rearrangement makes it easier to comprehend the document. It also sets the stage for designing a computer program shaft liner design with the proposed methodology. General and specific comments follow.

Minimum Input Set

Geometrical Factors:

Ring stiffener height	b_s
Ring stiffener thickness	t_s
Casing/liner (shell) thickness	t
Radius of shell	R
Centroidal radius	R_c
(Combined stiffener and shell as shown in Fig. 3-1)	
Misalignment (curvature) radius of curvature	R_{cc}
Radius to mid-lug	R_r
Length of liner between stiffeners	L
Shell eccentricity	e
Lift lug moment of inertia about horizontal axis	I_r
Unsupported length of shell (liner) between stiffeners	L_u

Material Properties:

Young's modulus of liner material	E
Poisson's ratio of liner material	ν
Minimum Yield Stress	F_y
Secant Modulus of liner	E_s
Nominal tensile strength of weld metal	F_{tw}
Wave speed coefficients	α_ϵ, α_k
Apparent wave speed	C_a
Linear cfft. of thermal expansion	α

Loads:

Generic load factor	Λ
Vertical load on life lug (static)	W
Maximum ground acceleration	A_{max}
Weight of casing and fluid at pt. x	P_{xb}
Unfactored external pressure	P_b
Bending moment at mid-bay	M_m
Torsion moment/length for lift lug	T_o
Temperatures	T_i, T_f, ΔT

Important Input Parameter Combinations:

$$\gamma_1 = P\sqrt{3(1 - \nu^2)}/[2E(t/R)^2]$$

$$\beta = \sqrt[4]{3(1 - \nu^2)}/\sqrt{Rt}$$

$$\theta = \beta L$$

$$D_1 = Et^3/[12(1 - \nu^2)]$$

$$\alpha_2 = \beta(L_f - b_s)/2$$

$$\lambda_1 = \sin\alpha_2 \sinh\alpha_2$$

$$\lambda_2 = \cos\alpha_2 \sinh\alpha_2$$

$$\lambda_3 = \sin\alpha_2 \cosh\alpha_2$$

$$\lambda_4 = \cos\alpha_2 \cosh\alpha_2$$

$$\eta_1 = 0.5\sqrt{1 - \gamma_1}$$

$$\eta_2 = 0.5\sqrt{1 + \gamma_1}$$

$$F_1 = \frac{4}{\theta}(\cosh^2\eta_1\theta - \cos^2\eta_2\theta)/D_2$$

$$F_2 = 1.82(\frac{1}{\eta_2}\cosh\eta_1\theta \sin\eta_2\theta + \frac{1}{\eta_1}\sinh\eta_1\theta \cos\eta_2\theta)/D_2$$

$$F_3 = 1.82(\frac{1}{\eta_2}\cos\eta_2\theta \sin\eta_2\theta + \frac{1}{\eta_1}\sinh\eta_1\theta \cosh\eta_1\theta)/D_2$$

$$F_4 = 1.82\left(\frac{1}{\eta_2}\cosh \eta_1\theta \ \sin \eta_2\theta + \frac{1}{\eta_1}\sinh \eta_1\theta \ \cos \eta_2\theta\right)/D_2$$

$$D_1 = 1.82\left(\frac{1}{\eta_1}\cosh \eta_1\theta \ \sinh \eta_1\theta + \frac{1}{\eta_2}\sin \eta_2\theta \ \cos \eta_2\theta\right)/D_2$$

$$\alpha_1 = t_s b_s (R/R_c)^2/(tL_f)$$

$$\beta_1 = b_s/L_f$$

$$\delta = \sqrt{0.91(1 - \nu^2)}$$

The previous quantity represents deviation from a 'ν' value equal to 0.3

$$K_b = \frac{\delta(1 - 0.5\nu)\alpha_1 F_4}{\alpha_1 + \beta_1 + (1 - \beta_1)F_1}$$

$$K_R = \frac{(1 - 0.5\nu)\alpha_1}{\alpha_1 + \beta_1 + (1 - \beta_1)F_1}$$

General Comments

- If there is any possibility of incorporation the exploratory shaft(s) into the repository design (as mentioned on p. 12), the ES should be considered as being "important to safety."

- The study is comprehensive in that it appears to have considered all important factors and phenomena that could affect the shaft liner system.

- There is a tendency to interchange exploratory shaft design and functions and those of repository shafts (e.g., p. 18).

- The repository is referred to as being a "limited radioactive inventory facility" in several places. This arbitrary designation is questioned here.

- The section on Design Equations and Factors (3.2) is too cursory and does not provide any discussion on the limits of applicability of these equations. Moreover, no alternative equations or criteria are indicated.

- The revised (draft) Mission Plan calls for one of the exploratory shafts to be 10' to 12' in diameter. How will the recommendation (on p. 10 of the document being reviewed) that, "... the methodology be reevaluated if casing designs of diameters greater than 8 feet are necessary." be reconciled?

Specific Comments

p. 10, para. 3 - It is not stated what the "increased degree of conservatism" is and how it is applied. Further, the strength of the proposed criteria is diluted immediately by the suggestion that "... this conservatism may be justifiably reduced ..."

p. 14, para. 1 - We cannot agree with the assumption or assertion that ESTF structures, systems, or components are not important to safety and should have no adverse radiological impact or repository operation. In particular, if the ESTF shaft(s) are to become a part of the repository operation such an assumption could have irreversible consequences.

p. 14, para. 2 - The statement that, "... flooding should not cause waste canister failure" ignores the impact of flooding on retreivability. Furthermore, flooding could mean that canisters would come into contact with groundwater much sooner than anticipated and cause corrosion.

p. 14, para. 1-4 - This entire page is full of contradictions. On one hand it repeatedly talks about the liner system not being important to safety or waste isolation. On the other hand, the admission is made that its use as a portion of the repository might be precluded if the liner system is not designed using "important to safety" design criteria. The last paragraph goes on to state that the linear system should be designed as a Quality Level I item!

p. 15, para. 2 - The long-term waste storage safety goals seem to have been fabricated, without consideration of the 40CFR191 or 10CFR60 criteria. Whose safety goals are being quoted? Where is it defined that a long-term waste storage facility is a limited radioactive inventory facility?

p. 16, para. 1 - Here and elsewhere, it is unclear as to why a yield strength greater than 50 ksi is cause for concern.

p. 18, para. 1 - The design criteria are presumably for ESTF casings (6 ft diameter shafts). However, the paragraph refers to "repository" shafts or casings.

p. 19, Item 8 - Reference is made to an undated document. It is not clear who "approved" the design criteria.

p. 20, Item 4 - Are the state of California standards applicable or acceptable in Washington state?

p. 20, Item 2 of 2.2.2 - The intent of the statement is understood. However, the statement is incorrect in assuming that centralizers will result in a minimum annular space.

p. 21, Item 2 of 2.2.4 - Whereas a concern is expressed with strengths higher than 50 ksi earlier in the document, here it seems to require 50 ksi minimum yield strength.

p. 24, Item 7 - The corrosion allowances need to be better defined. Are the values given here for a 100-year period? Why is the exterior corrosion allowance only 1/10 of the interior corrosion allowance?

p. 25, Item 2 - One or two drawings should be included to describe the allowable hole alignment deviation.

p. 27, para. 2 - The reference to a limited radioactive inventory facility appears to cover MRS-like facilities. Referring to a geologic repository in that manner may conflict with NRC or EPA definitions.

p. 30, para. 2 - The magnitudes given for minimum live loads need a reference. What is the basis for selecting these numbers?

p. 31, Earth and Rock Loads - The assumption that only hydrostatic load will be applied (in the absence of creep) is not conservative. In effect, the rock and grout are assumed to apply zero radial stress to the liner. When the blind-drilling method is used, the borehole wall never achieves zero radial stress because of the pressure due to the mud in the hole. Moreover, the grout expansion probably increases the stress at the grout/rock interface some of which is transmitted through the grout on the liner.

p. 40, para. 4 - Why are local stress concentrations excluded? Is there a different kind of compensation made for localized stresses?

p. 41, Item 1 - The issue of yield strength, once again, is unclear. Is it the intent that yield strengths above 50 ksi will not receive any credit for strength in excess of 50 ksi?

p. 41, Item 6 - The discussion is unclear. It appears to imply that lifting rings on segments closer to the surface will be made progressively stronger.

pp. 44-60 - Not having access to all the references that are cited, it was not possible to verify in this review whether the equations are free of error.

Appendix A, p. 84, Item (3a) - As before, we have a philosophical disagreement with the assertion that the liner system in the ES has no radiological safety function.

Appendix B, p. 86 - The statement accompanying "Buckling" loading is not clear.

Appendix B, p. 86 - The statement accompanying "Residual Stresses ..." also does not make sense. It is the construction procedures and QA that will limit (or enhance) residual stresses. Drawings have nothing to do with it!

A-1755
1628.010
January 1986

THIS IS AN ESTIMATE ONLY AND MAY NOT MATCH THE INVOICES SENT TO NRC BY SANDIA'S ACCOUNTING DEPARTMENT.

		Current Month	Year -to- Date
I.	Direct Manpower (man-months of charged effort)	0.5	1.5
II.	Direct Loaded Labor Costs	4.0	9.0
	Materials and Services	0.0	0.0
	ADP Support (computer)	1.0	2.0
	Subcontracts	42.0	44.0
	Travel	1.0	1.0
	G & A	6.0	7.0
	Other (computer roundoff)	0.0	-1.0
	TOTAL COSTS	54.0	62.0

III. Funding Status

Prior FY Carryover	FY 87 Projected Funding Level	FY 87 Funds Received to Date	FY 87 Funding Balance Needed
None	250K	250K	None