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RESEARCH PROJECT REPORT
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ULTIMATE STRESS IN THE SALT ENVELOPE OF A SEALED LIQUID-FILLED SOLUTION CAVERN

Final Report

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1.0 SUMMARY

This report summarizes the project work, "Ultimate Stress in the Salt Envelope of a Sealed Liquid-Filled Solution Cavern," conducted by Serata Geomechanics, Inc. (SGI) for SMRI. SGI's finite element code, REM, was used for the computer simulation portion of this study. The objective of the study was to analyze the fundamental mechanism of long-term behavior of a solution cavern sealed with a cement plug. The boundary conditions of the cavern development and the cement plugging procedure, as well as the overall scheme of analysis, are specified by SMRI in our contractual agreement dated September 30, 1983.

The study was conducted in the following three phases:

1.1 Phase 1: Equilibrium Analysis

REM computer simulation analysis for the entire process of sequential cavern development, including temperature effects, was conducted with regard to the time-dependent behavior of the cavern. A computer model of the solution cavern was developed by closely simulating the cavern formation process, and then sealing the cavern, resulting in brine pressure build-up. This simulated pressure build-up was related to the material properties of the rock salt, and further compared with the actual pressure build-up data obtained in various field observations. By verifying the close interrelation among the model behavior, material properties, and field observation, the REM model of the solution cavern was quantitatively established.

1.2 Phase 2: Plug Analysis

A REM simulation was conducted to examine plug stability during and after the pressure build-up stage by utilizing the stress-strain conditions established in Phase 1. The structural stability of the cement plug and surrounding ground were examined in this phase.

1.3 Phase 3: REM Validity Check

The validity of the REM program was confirmed and illustrated using two entirely different methods. One method compared behavior of the laboratory cavities tested at the SGI laboratory with the REM model of the same cavities. The other method compared results of the finite element cavern behavior analysis published by Ghaboussi (5) with an identical run using REM.

The major factors incorporated into the REM simulation analyses were temperature effects and material properties. Not considered in this study were the chemical reactivity of the contained fluid and the effect of impurities in the salt mass. All other design parameters, such as stress field, cavern shape, depth, size, and boundary ground conditions, were assumed to be unchanged.