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Title: Mechanical Behavior of the Near-field Host Rock Surrounding Excavations

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Mechanical Behavior of the Near-field Host Rock Surrounding Excavations

Fuel Cycle Research & Development

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EXECUTIVE SUMMARY

This report is being prepared under the FY14 activity FT-14LA0818069, Mechanical and Hydrological Behavior of the Near-Field Host Rock Surrounding Excavations, and fulfills the Los Alamos National Laboratory deliverable M4FT-14LA08180610, which in PICS:NE is titled "Draft report, Test Plan for Mechanical and Hydrological Behavior of the Near-field Host Rock Surrounding Excavations." Since the report is an intermediate deliverable intended as input to the eventual test plan for this test, rather than being an actual test plan, the activity title is used as the title of this document to avoid confusion as to the contents in the report.

This report summarizes efforts to simulate mechanical processes occurring within a hypothetical high-level waste (HLW) repository in bedded salt. The report summarizes work completed since the last project deliverable, "Coupled model for heat and water transport in a high level waste repository in salt ", a Level 2 milestone submitted to DOE in September 2013 (Stauffer et al., 2013).

MECHANICAL MODELING TO SUPPORT FIELD TEST DESIGN

Introduction:

Excavations created in a salt present a unique opportunity to measure and characterize *in situ* development of the excavation disturbed zone (EDZ). This test will provide data to characterize and quantify the time-dependent mechanical behavior and hydrologic response of test-room near-field host rock and establish boundary conditions for any test that might be executed in an excavation. A Test Plan will be developed to identify instrumentation and their arrangements for making rock displacement and strain measurements at locations that will also measure gas or brine fluid flow so that unambiguous correlations can be established between rock deformation/strain and permeability changes. The Test Plan will describe how to measure undisturbed initial and boundary conditions (e.g., undisturbed permeability) prior to any type of transient test, such as a large-scale thermal test, and how to measure deformation/strain and permeability changes during the evolution of a transient test such as the LSTT. The test plan will include test objectives, test strategy, parameters to be monitored, test configuration, test control, instrumentation and data acquisition required for monitoring, layout of instrumentation, the data quality objectives, quality assurance, facilities, equipment, and schedules, and costs. Test objectives will be correlated with the objectives of an overall safety case for a generic repository for heat-generating waste in bedded salt, as well as the ability of the test to resolve identified uncertainties.

Numerical model development (Oct 2013 – Sept 2014).

During the 2014 fiscal year, a model was constructed using the code FEHM (Kelkar et al. 2014) to access the perturbations of the in situ stress field resulting from the layout the test area.

As a first step towards constructing a model for the in-situ stress measurement test, we developed a simple model to investigate the disturbance caused by the existing tunnels and drifts in the vicinity of the proposed test location. A schematic perspective of the test layout is shown in Figure 1 (DOE/CBFO, 2013).

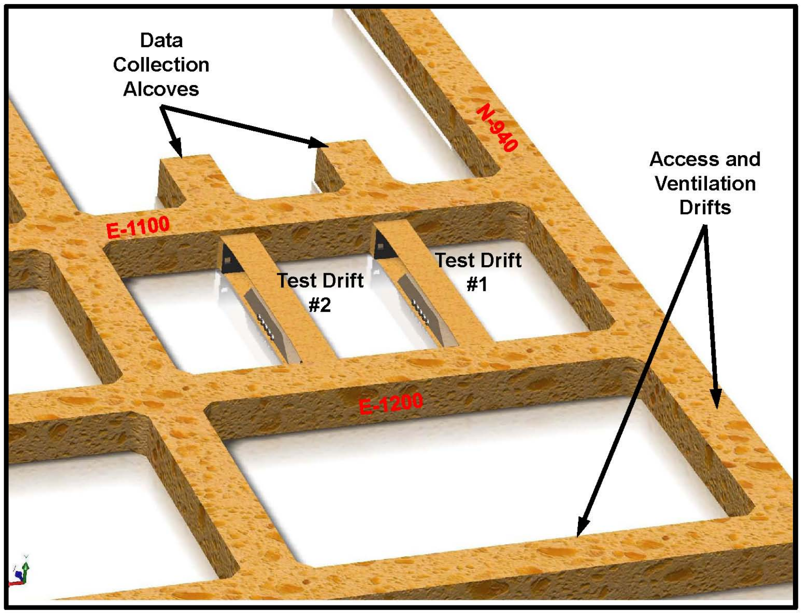

Figure 1: Perspective View of the Test Layout for the SDDI Thermal Test (source: DOE/CBFO, 2013)

In the neighborhood of the test location, there are four major drifts (N-940, N-780, E-1100, and E-1200) and two test drifts (Test Drift #1 and Test Drift #2). Removal of the material to create the drift is expected to perturb the stress field out to many diameters from the drift wall with respect to its original state. Hence the test layout will have to be taken into account in the mechanical model of the system. We have started the effort in this direction by constructing a simplified model of a single drift in an otherwise undisturbed formation. The geometry of the system is symmetric about the drift axis; hence a quarter model was constructed, as shown in figure 2.

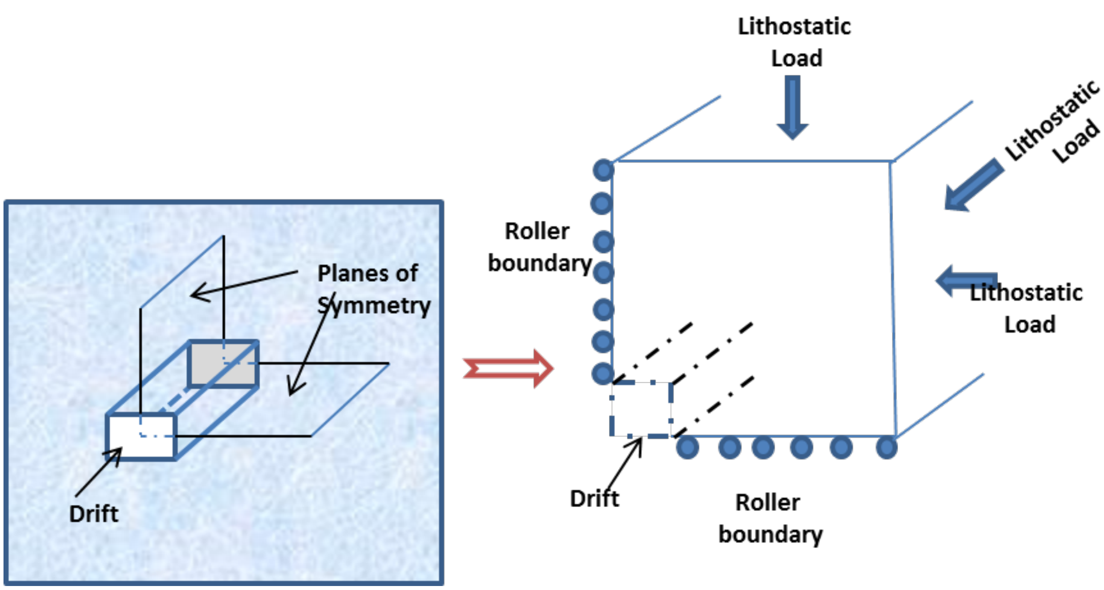

Figure 2. A schematic of the drift showing the planes of symmetry and the boundary conditions used in the stress model

A three dimensional grid consisting of 360,450 nodes arranged in 344960 hexahedral elements was constructed, with refined grid spacing near the drift and the front wall of the model, coarsening out to the boundaries. The model represented a rectangular brick-shaped domain 200’ x 80’ x 200’ with the 8’ x 80’ x 8' lower left hand corner removed to represent the drift. The narrowest node spacing was 0.2' near the drift and ~5' near the far boundary. The grid, with a close up of the refinement is shown in Figure 3.

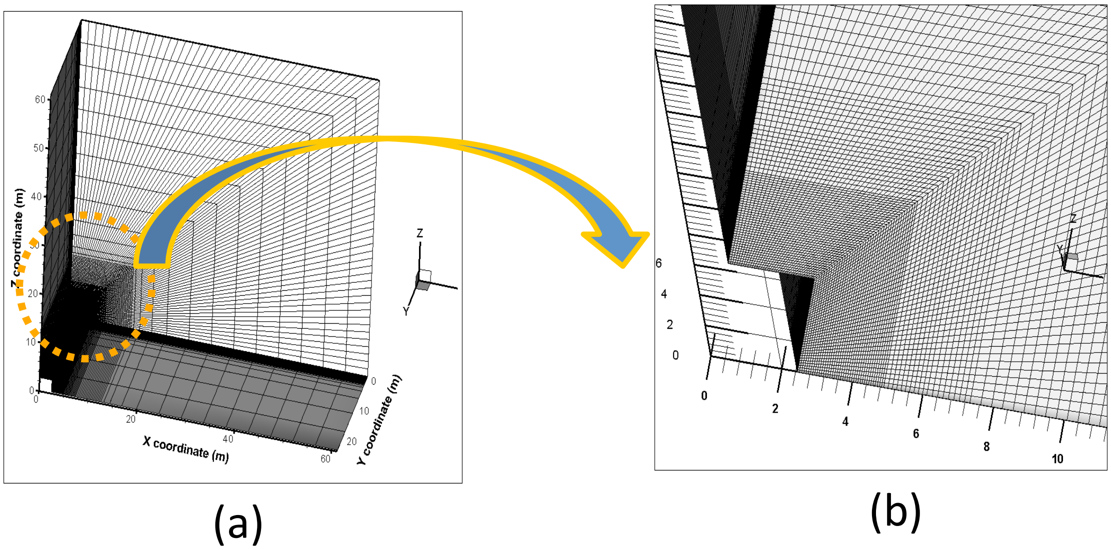

Figure 3. (a) the entire domain and grid ; (b) showing a close-up of the region around the drift.

A lithostatic far field stress of 24 MPa, corresponding to a nominal depth of 1 km, was applied on the three far-field faces on the model. Since salt is expected to creep and yield, over long periods of time it is expected that the stress field in the salt will become lithostatic. The model considered here elastic deformation only, which may be a reasonable approximation for short times. Future modeling will include plastic deformation. A nominal value of 10 MPa for the Young's modulus and 0.15 for the Poisson's ration (Du et al. 2012) was used. As we move forward, we will coordinate property values from Rutqvist at al (2014).

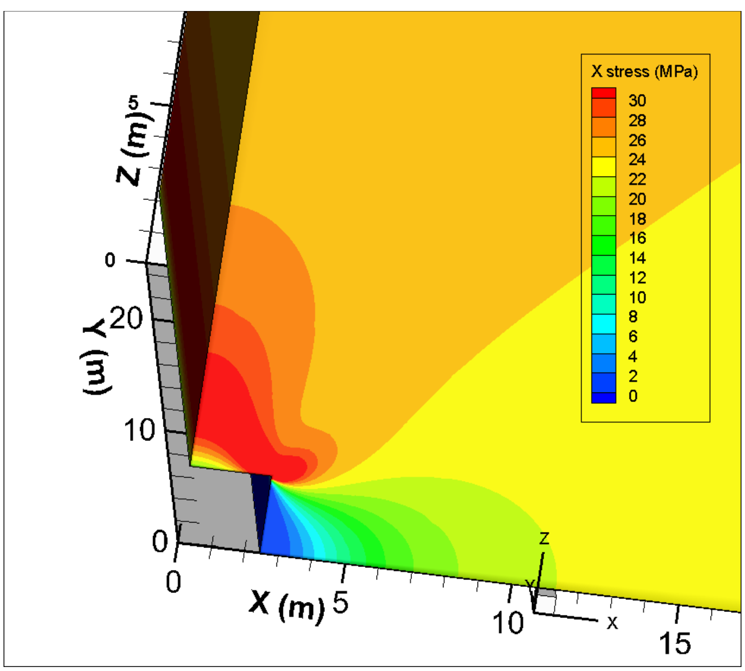

Figure 4. Contours of the horizontal stress field perpendicular to the drift axis.

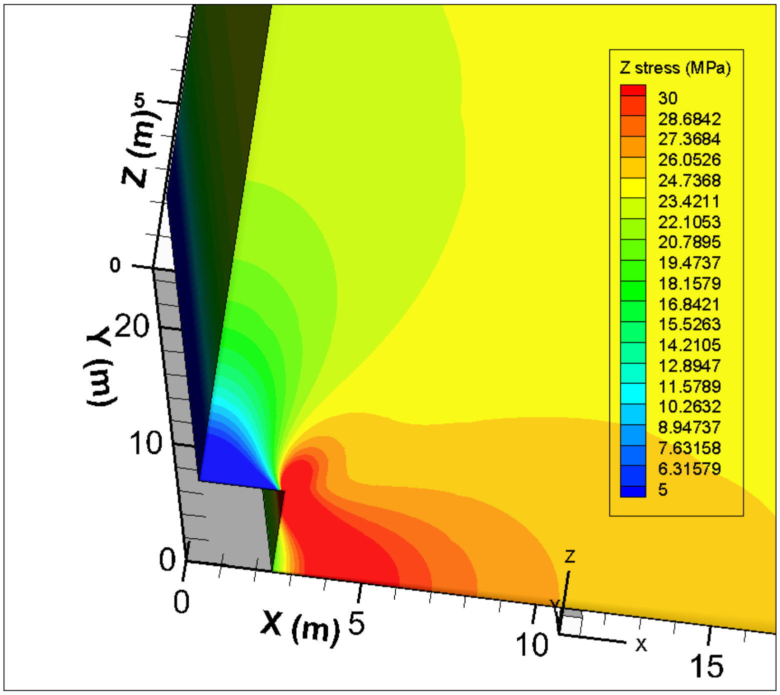

Figure 5. Contours of the vertical stress field

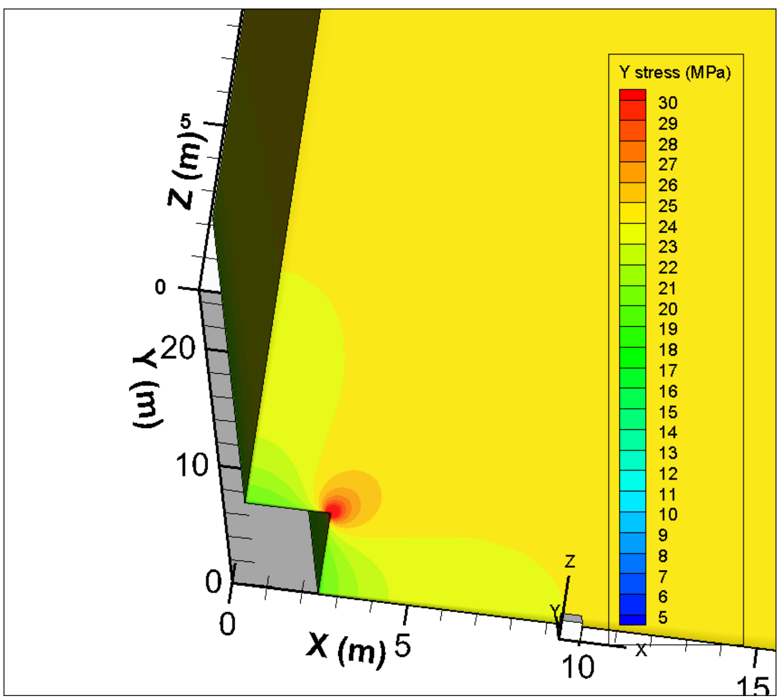

Figure 6. Contours of the horizontal stress field parallel to the drift axis.

The resulting stress field in a horizontal direction perpendicular to the axis of the drift is shown in Figure 4. Similar results are presented in Figure 5 for the vertical stress field, and in Figure 6 for the horizontal stress field parallel to the drift axis. It is seen that the stress field is disturbed up to distances in excess of

30 feet from the drift axis. This general trend is consistent with the analytical results for an idealized two dimensional solution for a plate with a hole in it (Jaeger & Cook 1979).
As seen in Figure 1, the drift layout in the area of the test is more complex than the simple case considered here. The stress field can be expected to be perturbed even more because of the existence of multiple drifts in the vicinity.

Conclusions

The existence of drifts in the salt formation disturbs the in situ stress field out to distances larger than 5 times the drift radius. Hence there is a need to take into account the details of the drift layout for estimating the stress conditions expected at the test location. Surrounding access drifts will impact the stress state in the test drifts. Access drifts should thus be included in the initial state calculations to predict changes caused by mining the test drifts.

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