Finite Element Analysis of Unanchored Structures Subjected to Seismic Excitation

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Abstract

The objective of this analysis is threefold: (1) to determine the residual stress distribution in two unanchored structures, the waste package and drip shield, subjected to seismic excitation; (2) to estimate the extent and spatial distribution of the area of the two structures for which the residual first principal stress exceeds certain limits; (3) to determine whether or not separation of interlocking drip shield segments occurs during the vibratory ground motion.

Introduction

Two sets of analyses are performed to meet the objective: the first is focused on the waste package and the second on the drip shield.

A cutaway view on the first model is presented in Figure 1.

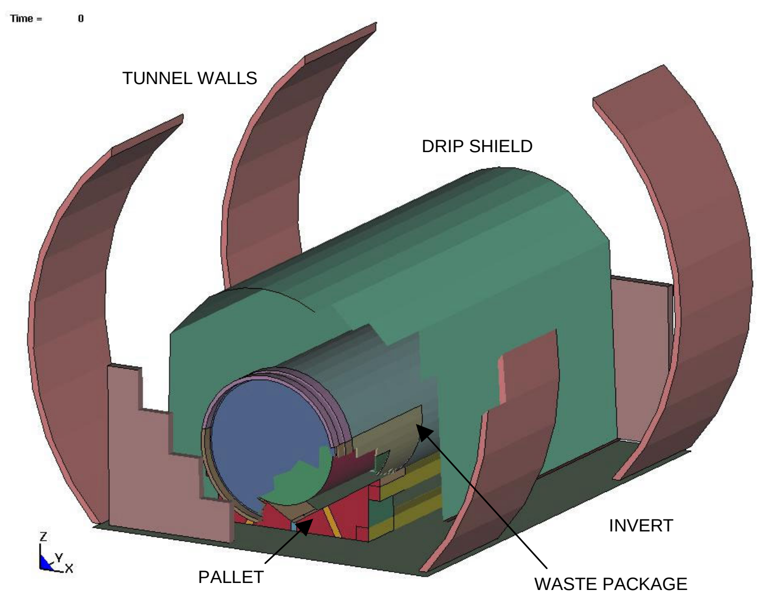

Figure 1. Setup for Waste Package Analysis

A similar view of the setup for the drip shield analysis is presented in Figure 2.

The three components of the ground motion time history are simultaneously applied on the invert surface. The momentum is transferred to all unanchored objects solely by friction and impact.

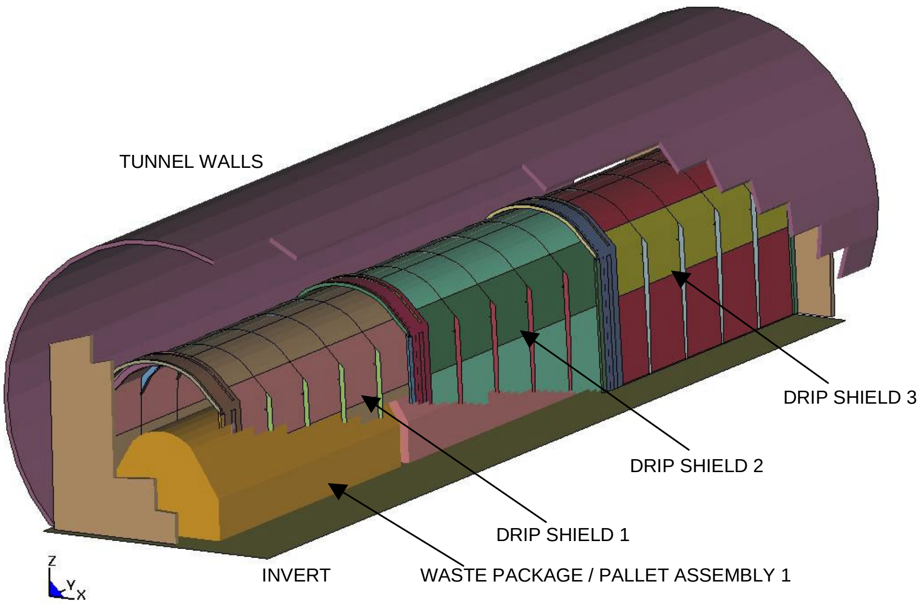

Figure 2. Setup for Drip Shield Analysis

The analyses are probabilistic. For each analysis, a set of 15 simulations is performed at 2 different ground motion levels. The friction coefficients are randomly sampled from a uniform distribution; the ground motion acceleration time histories are randomly sampled as well (see Table 1).

Table 1. Stochastic Simulation Parameters

Realization	Ground Motion	Friction Coefficient (-)	
		Metal to metal	Metal to rock
1	7	0.80	0.34
2	16	0.33	0.49
. . .			
15	3	0.46	0.78

Each simulation is performed in two steps: (1) the vibratory part and (2) the post-vibratory relaxation.

Structural calculations of the unanchored objects exposed to vibratory ground motion are beset with complexities inherent to the nature of the problem:

- The complexity of the finite element model
- The intensity of the applied loads
- The highly nonlinear nature of the problem (large deformation plasticity, nonlinear constitutive behavior of materials, friction, impacts, etc.)
- The physical phenomena span multiple spatial and temporal scales.

These complexities impose extreme computational requirements. Consequently, it is necessary to sacrifice some details while retaining all pertinent features of the problem. The effects of these simplifications are studied and discussed in detail.