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TUNNELING PROGRESS ON THE YUCCA MOUNTAIN PROJECT

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ABSTRACT

The current status of tunneling progress on the Yucca Mountain Project (YMP) is presented in this paper. The Exploratory Studies Facility (ESF), a key part of the YMP, has been long in development and construction is ongoing. This is a progress report on the tunneling aspects of the ESF as of January 1, 1996.

I. INTRODUCTION

The present ESF design work was started in 1992 and tunnel design specifications were initially issued for construction in 1994. The 7.6-meter-diameter Tunnel Boring Machine (TBM) built to meet YMP requirements was substantially in place as of August 1994. Tunneling with the TBM did not start in earnest until the end of 1994. Substantial time and effort was required to get procedures in place and make some equipment modifications prior to full-scale operations. It was also necessary to deal with somewhat difficult tunneling conditions and unusual procedural requirements for a tunneling project. For purposes of discussion in this summary, the tunneling has progressed in four general phases.

II. TUNNELING IN JOINTED ROCK UNDER LOW STRESS

The ESF tunnel began with initial boring into the face prepared for the TBM at the end of the 60-meter-long Starter Tunnel. Tunneling to 200 meters into the mountain was difficult because it was necessary to go through jointed rock under low stress. Large fallouts in the crown occurred routinely. Some very large fallouts were encountered and backfilling was required behind the fully lagged lining. Under those circumstances, it was not possible to propel the TBM with its vertical grippers since they must react between one another and the ground to develop propulsion force. No reaction force can develop if an overhead void is present or if underlying footing conditions are inadequate. Consequently, horizontal grippers were used almost exclusively through this section of tunnel.

It was a time of learning for the entire project and the work was done with the utmost concern for safety. Progress was slow. Ground support was accomplished in this phase of the tunnel with structural steel supports (steel sets) installed on 1.22-meter centers. For a description of the equipment and ground support designs used in the ESF, see Morris and Hansmire[1] and Hansmire, Rogers, and Wightman[2].

III. TUNNELING THROUGH THE BOW RIDGE FAULT AND SOFT ROCK

The highly anticipated and relatively large Bow Ridge Fault was encountered as expected at about 200 meters into the mountain. The fault turned out to be only a few meters wide, and crossing the fault posed only minor excavation problems. Substantial ground was lost above the TBM as it came out of the fault and backfilling and grouting of the void created was required to proceed. This situation was similar to what one might encounter by over-excavation in a soft ground tunnel. Tunneling through the soft rock material beyond the Bow Ridge Fault with a TBM designed for tunneling in hard rock proved challenging. Steering the TBM was sometimes difficult and, when the vertical grippers could not be used, getting enough reaction for propulsion was also difficult. Fortunately, runs did not occur through the face when the TBM was shut down; this was the case because the bedded, soft rock material had substantial stand-up time. These tunneling conditions existed for about 100 meters.

IV. TUNNELING THROUGH THE IMBRICATE FAULT ZONE

A hard rock tunnel section identified on geologic maps as the Imbricate Fault Zone turned out to be the most difficult tunneling to date. Imbricate faults are a closely spaced series of nearly parallel and overlapping minor faults oriented in the same direction. This section of tunnel was about 1,000 meters in length. No precedent for what tunneling conditions might be like was known. No special ground support requirements were anticipated because geologic mapping indicated only a series of faults with apparently minor displacements. This stood in contrast to the Bow Ridge Fault which had slipped on the order of 100 meters but was relatively easy to tunnel across. What the TBM encountered was rock with through-going joints which resulted from minor faulting events. With the rock under low stress, block fallouts were numerous and common. Steel sets and steel lagging were used extensively throughout this section in a conservative approach to provide appropriate ground support and maximize safety. ESF ground support is discussed in Hansmire, Rogers, and Wightman[2].

V. TUNNELING INTO THE CANDIDATE REPOSITORY FORMATION

Truly good tunnel ground conditions began at about 1,300 meters into the mountain. The frequency of rock joints and overall rock mass quality was considerably higher than experienced earlier. These conditions, together with the improved efficiency resulting from the subsurface muck conveyor installed in July 1995, made possible much more rapid tunneling advances. Under these conditions, conservative ground support consisted of using pattern rockbolts with welded wire fabric and channels. Spot rock bolting was occasionally required. Over 2,000 meters of tunnel have been excavated as of January 1, 1996, with only rockbolts, wire mesh, and channel ground support. At about 2,720 meters into the mountain, the tunnel entered the crystal-poor, devitrified part of the Topopah Spring Tuff formation (TSw2), which is the candidate geologic horizon for the emplacement of high-level nuclear waste.

VI. DISCUSSION

In view of all the physical and procedural difficulties encountered in the first three phases of tunneling, progress has been considered to be very favorable overall. Some achievements in TBM operations at Yucca Mountain to January 1, 1996 are summarized as follows:

Best 8-hour shift	24 meters
Best 24-hour day (3 shifts)	58 meters
Best 5-day week	218 meters
Total distance	3,530 meters

Four alcoves (offshoots from the TBM tunnel) of approximately 3.7 by 3.7 meters in cross section, and ranging from 37 to 60 meters in length, have been excavated while TBM tunneling has continued to advance. Alcove 1 was excavated in hard rock in 1994 by drill and blast in the Starter Tunnel prior to TBM startup. However, Alcove 2 was excavated by drill and blast in hard rock in the TBM tunnel. Some unavoidable interference with TBM operations was experienced while excavating Alcove 2 which resulted in a few days of TBM downtime; interference was minimized by limiting blasting to a single round a day in the early morning. This was not necessary in Alcoves 3 and 4 which were excavated in softer rocks with an Alpine Miner (Model AM 50 Roadheader) farther into the TBM tunnel. In addition, the latter two alcoves were excavated after the subsurface conveyor was installed which further reduced interference with TBM tunneling. Plans are being made to excavate a test area for conducting thermomechanical tests in situ, and to drive an exploration drift to investigate the Ghost Dance Fault.

As of this writing, plans are uncertain for the extent of underground excavation that will take place. Plans are certain, however, to continue tunneling through the repository block. TBM tunneling will continue to respond to site characterization requirements that are currently in evolution. More drifts and alcoves are expected to be excavated from the TBM tunnel for geologic and testing purposes.

VII. REFERENCES

1. Morris, J. P., and Hansmire, W. H., 1995, TBM Tunneling on the Yucca Mountain Project, *Proceedings of the Rapid Excavation and Tunneling Conference*, San Francisco, California, sponsored by SME and ASCE, pp. 807-822.

2. Hansmire, W. H., Rogers, D. J., and Wightman, W. D., Tunneling on the Yucca Mountain Project: Progress and lessons learned, *Proceedings of the North American Tunneling '96 Conference* (in press).