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SSC Underground Technology
Advisory Panel

UTAP

Report

Assessment of Tunnel Ground Conditions
for a Two-year "Stand-by" Period

27-29 January 1994

Superconducting Super Collider Laboratory
Universities Research Association

INTRODUCTION

This report summarizes observations, assessment of ground conditions, and recommendations pertaining to the Collider main ring tunnel at the Superconducting Super Collider (SSC). The report has been prepared by J. P. Gould, D. G. Hammond and D. R. McCreath of the Underground Technology Advisory Panel (UTAP), who were requested by Dr. Timothy E. Toohig, Deputy Director, Conventional Construction Division (CCD) of the SSC Laboratory, to investigate "stand-by" mode ground conditions and respond to the issues outlined below.

The Chairman of UTAP, T. D. O'Rourke, was contacted by Dr. Toohig and asked to assemble UTAP to inspect the tunnel in light of the intended plan developed by the U. S. Department of Energy (DOE) to place the tunnel in a "stand-by" mode for a period not exceeding two years. UTAP members Gould and McCreath arrived in DeSoto in the evening of January 27, and attended a UTAP Pre-Briefing from 8 pm to 10 pm at the Holiday Inn (Wintergreen). Participants at this Pre-Briefing meeting included CCD and PB/MK staff, and a listing of persons attending is appended to this report.

The charge to the Panel was to complete a site visit underground, and to make observations which permitted comment on the specific scope of work which was defined by DOE as:

> "It is the Department of Energy's intention to either turn over the SSC tunnel to another owner/user or to abandon the tunnel. Either one of these two events could occur within two years, but no later than two years.
>
> In order to meet the above objective, the DOE is planning to place the tunnel in a 'stand-by' mode. This mode assumes no usage, no major structural collapse, no physical inspection unless to meet a safety or environmental requirement.

> Safety and environmental implementation will be per recommendations from the Bureau of Reclamation (see memo dated 12/20/93 from DeWayne A. Campbell and Mark H. McKeown of U.S.B.R, Denver Office). Please inspect the tunnel in light of the above plan and furnish us with your comments."

A copy of the referenced U.S.B.R. memo is appended to this report. UTAP members Gould and McCreath, accompanied by CCD and PB/MK personnel, visited the N30-N35 and N45-N50 tunnel sections on the morning of 28 January, 1994. UTAP member Hammond met with personnel from the SSC Laboratory Environment Safety and Health Division during this same time period. UTAP members reassembled at the Central Facility in the afternoon of 28 January 1994 and prepared a draft response to the specified charge. This response was delivered orally during a meeting with SSC Laboratory management and DOE at the Central Facility, 4:30 pm on 28 January 1994. A list of attendees is attached.

SITE VISIT

This section summarizes field observations made during the site visits to the N30-N35 and N45-N50 tunnel on 28 January, 1994.

The main tunnel was entered through the shaft at N35. Inspection was conducted from approximately Station 615+00 to Station 533+00, traveling by railcar and making a series of stops as required to allow detailed assessment of conditions. Areas inspected included zones affected by the bentonite marker bed which the Panel had previously inspected on August 19 and 20, 1993. Reference should be made to the UTAP Report dated September 9, 1993, for more detailed discussion of these areas. In general, the Panel noted that, while some additional degradation had occurred in these areas, neither the degree nor the extent of such degradation was unexpected.

A second entry to the tunnel was made through the N45 shaft, at approximately Station 903+30, and inspection of the tunnel was conducted on foot to approximately Station 898+30. The Panel noted that no significant degradation had occurred in this area since initial construction of the tunnel.

MECHANISMS OF ROCK DEGRADATION IN THE TUNNEL

As discussed in the UTAP report dated 9 September 1993, the mechanisms which underlie the time-dependent degradation of rock in the tunnel include stress redistribution, moisture exchange (both drying and wetting), presence and properties of clay-rich zones of rock, and the presence of structural features such as joints and faults. These mechanisms interact in complex ways, and lead in certain locations to a slow, continuing process of raveling and disintegration, including invert heave in some areas. Currently, the primary factor driving the continuation of these processes is the hydrogeologic imbalance between the tunnel and the surrounding rock mass. These processes are most often manifested by the break-back of the tunnel crown to a flat bedding plane, by the formation of corbels in the shoulders, or by localized dental self-excavation of the rock along and adjacent to a clay-rich zone.

Within the tunnel, these processes are most evident between Shafts N30 and N35, notably from approximately Stations 600+00 to 535+00. This area was inspected by UTAP members in August 1993, and again during this meeting in January 1994. During this five-month interval, some additional degradation had occurred. In the Panel's opinion, this form of degradation will not lead to major structural collapse of the tunnel during the two-year stand-by period, although it will create increasingly hazardous conditions with respect to personal access. Despite this fact, we are of the opinion that personnel access could be re-established through these areas within the stand-by period, provided that due care was paid to development of an appropriate re-entry protocol.

As noted, moisture exchange is a key element of the rock degradation process, and this is true both for drying (and associated shrinkage), and for wetting and swelling. During the stand-by period, if continuous ventilation is maintained, then the same processes that are currently at work can be expected to continue. If ventilation is not maintained, then an atmosphere of 100% humidity will be achieved, effectively halting the drying/shrinkage process while allowing the wetting/swelling processes to continue. In

this case, with 100% humidity, the decision of whether or not to continue pumping any groundwater inflow from the tunnel will, therefore, have relatively little effect on further wetting/swelling processes in the rock around the tunnel.

In summary, the mechanisms of rock degradation in the tunnels are closely associated with moisture transfer from and to clay-rich zones in the rock. The mechanisms will continue to be operative during the stand-by period, although at somewhat modified rates depending on whether pumping is continued or discontinued, and whether ventilation is continued or discontinued. In our opinion these mechanisms will not preclude the ability to gain access to the tunnel during the stand-by period, and do not provide any over-riding basis on which to either accept or reject continuation of pumping or ventilation in the tunnels. However, from a geotechnical perspective, we consider that there is some net advantage to a procedure which negates the current groundwater imbalance by allowing it to re-saturate and return towards its pre-construction condition.

OPTIONS FOR ACTION

The two basic options are to pump from the tunnel or to simply shutdown pumps and let the water level rise toward equilibrium with the surrounding groundwater table. Each procedure has advantages and disadvantages. For the pumping option, these are:

1) Air slaking and drying of shaley seams can continue, if ventilation is encouraged.
2) Corrosion of steel support elements will continue.
3) Drawdown of surrounding groundwater will continue and expand, probably to a limited extent. This could impact water well supplies, although we understand that no complaints on that subject have yet been received.
4) Pumping will, to some extent, reduce the water directly available to promote volumetric expansion of shaley materials.
5) Tunnel access within the two-year period would be facilitated and the eventual difficulties of access caused by flooding would be greatly lessened.
6) Obviously, there are additional expenses for operation and maintenance required by continued pumping and the disposal of discharged water.

If the tunnels are allowed to flood, the following factors are involved:

1) Materials on the tunnel walls and the retained blocks which have dried will soften, the shaley material turning to mud, the chalk to fine fragments. This would allow some further deterioration back to saturated material.
2) If it has any further influence, water will have more ready access to promote volumetric swell of shaley materials. At the same time, degradation caused by the current saturation differential between the tunnel walls and the rock mass will cease.
3) Corrosion of steel support elements would be slowed as oxygen is denied to their surface.
4) Groundwater levels would be gradually restored to their original condition, and any undesired impact would be abated.
5) Flooding would eliminate the imbalance of groundwater pressures acting on the rock surrounding the tunnel and thus would have an overall stabilizing effect.
6) Access within the two-year period or at any time thereafter would require a carefully staged drawdown to avoid creating unbalanced groundwater pressures immediately surrounding the tunnel opening.
7) Flooding eliminates pumping costs and problems with discharge water.

If pumping were continued, a decision would be needed on maintaining forced air or natural ventilation. Any effort to promote ventilation will increase drying and air slaking of the exposed rock, tend to slow corrosion, facilitate access but complicate shaft closure and, of course, will add a cost element. If ventilation were eliminated the air humidity in the tunnel would probably supply an amount of moisture to the rock surface which would gradually produce the same softening and heave effects as if the tunnel had been allowed to flood. On balance, the Panel has a slight preference for not continuing ventilation.

In summary, both the options of pumping or not, and ventilating or not, have positive and negative aspects. We believe that from a geotechnical standpoint the alternatives are so closely balanced that no decisive preference can be expressed. Nevertheless, there is general agreement among the Panel members for allowing the system to re-saturate by halting further pumping and ventilation. The overall rock performance is such that whatever choices are made regarding pumping and ventilation, no catastrophic collapse will occur within the two-year stand-by period.

As a final comment, the Panel notes that there are a number of technical issues which may arise regarding future response of the hydrogeologic system and the tunnels. Presuming that the system is eventually fully re-saturated, the effect of having introduced a large conduit in the sub-surface must be addressed. In the event that future dewatering of the system is required for access, Predicting the response of the groundwater and tunnel system will be essential to develop critically important dewatering procedures to avoid serious damage to the tunnel asset. The Panel suggests that these issues should receive study during the stand-by period, based on data available from the dewatering performance of the system during construction, and on monitoring data which should be collected during recharge of the system, when this occurs.

SHAFTS

The considerations pertaining to whether or not to ventilate or dewater the tunnels are discussed in other sections of this report. If pumping on a regular basis is to be adopted, provisions can be made for operation and maintenance of a pumping system through a capped shaft. Provisions for ventilation, whether forced or natural, seem to be unnecessary and perhaps undesirable. In addition to geotechnical considerations there are concerns that providing apertures to accommodate air flow will also allow intruders to use these shaft openings to dispose of liquid and solid wastes.

We recommend that shafts be capped with a solid, heavy cover with no openings, thus effectively sealing the shafts. Provision should be made for lifting this heavy cover by a crane if access is required.

It probably would be desirable to equip each shaft cover with an inconspicuous, one-way air pressure relief valve.

CONCLUSIONS

The conclusions reached by the Panel were presented orally in the meeting of January 28 and are summarized below:

- From a geotechnical perspective, the Panel does not see any strong preference for either the pumping or non-pumping options, or the ventilation/no ventilation options.
- The DOE goal of "no major structural collapse" is consistent with the observations made by the Panel during the visit, and is consistent with the choice of either the pump or no-pump option during the standby period.
- Ventilation is not required during the standby period, from a geotechnical perspective.
- There is no geotechnical requirement for scheduled access to the tunnel during the standby period.
- Non-entry shaft caps are required for security of the facility. Such caps should be removable only by specialized equipment, in the event that re-entry is required.
- If re-entry is required, a detailed protocol must be developed and re-entry must only be allowed under strictly controlled conditions.
- Groundwater data collected during construction (drawdown) should be supplemented by monitoring data collected during reflooding of the system, as this will be essential for development of a re-entry protocol, if required.

Attendees at the UTAP Pre-Briefing, 27 January 1994

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Bob Janowski	PB/MK	214-708-6710
Jack H. Clifton	CCD	214-708-5589
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George H. Robertson	SSCL	214-708-1726
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Sam Baker	SSCL	214-708-1042
Ben Rietze	SSCL	214-708-1922
Phil Shelley	SSCL	214-708-1057
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Attendees at the UTAP Draft Briefing, 28 January1994

James Carroll	CCD	214-708-6957
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Site Visit Report
Superconducting Super Collider Tunnel Inspection, 12/14/93 through 12/16/93
Report Date: 12/20/93

At the request of the Department of Energy Superconducting Super Collider Conventional Construction Division, we visited the SSC site to inspect completed reaches of tunnel. The purpose of the inspection was to enable us to make recommendations on the type and level of action needed in order to appropriately proceed with shutdown of the project. The objective is for the tunnel to remain open for a period of from six months to two years, by which time it will be determined if other parties might be able to use the completed tunnel. On 12/14/93, we inspected tunnel reach N45 to N50. On 12/15/93 we inspected N20 through N35, and on 12/16/93, we inspected reach N40 to N45, which comprised all completed tunnels.

Prior to the site inspection, we reviewed N15 to N55 Collider Asset Management CCU A-711, Contract No. SC-C16-1262, Request for Proposal, Dated 12 November, 1993. That document described different methods of ground support augmentation for specific tunnel reaches. Type A support consists of supplemental dowels only. Typical dowels are 7 1/2 foot-long #8 bars. Type II support uses 4' by 8' panels consisting of two inches of shotcrete, covered by WWF mesh secured with six, #5 bar dowels three feet long. We recommend that if type II support were used, the WWF panels be covered with shotcrete in order to protect them from corrosion. The panels are in various positions specified in the RFP. Type III support consists of three inch thick fiber reinforced shotcrete around the full tunnel section.

The results of our inspection, and our general recommendations are presented below.

There were portions of the tunnel where some remedial work in the form of additional dowels or shotcrete would be beneficial from the standpoint of aesthetics or personnel safety if the tunnel were going to be occupied. The areas with Type A support recommended were in general, areas with little or no damage and do not need any remedial support for the interim shutdown. The type II areas could use some cosmetic and safety related cleanup but do not require any remedial support for the interim shutdown. The type III areas could use some cosmetic and safety related cleanup but in large part have reached a stable configuration and will be stable enough for the interim shutdown. We saw no areas that would require additional support to assure the integrity of the tunnel for the intrim shutdown period (up to two years). Any spalling, ravelling or rock falls that might occur in the future should be minor, and should not propagate significantly beyond the immediate vicinity of the tunnel surface. All shaft entrances to the tunnel should be capped appropriately and protected from intruders. Caps should be designed to maintain the existing natural air circulation and ventilation in the tunnels. Volumes of water in the tunnel should be relatively minor, but we recommend that accumulated water be removed by pumping at appropriate shaft locations. Increased moisture levels could aggrevate invert heave problems, and would increase the degree of slaking damage.

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