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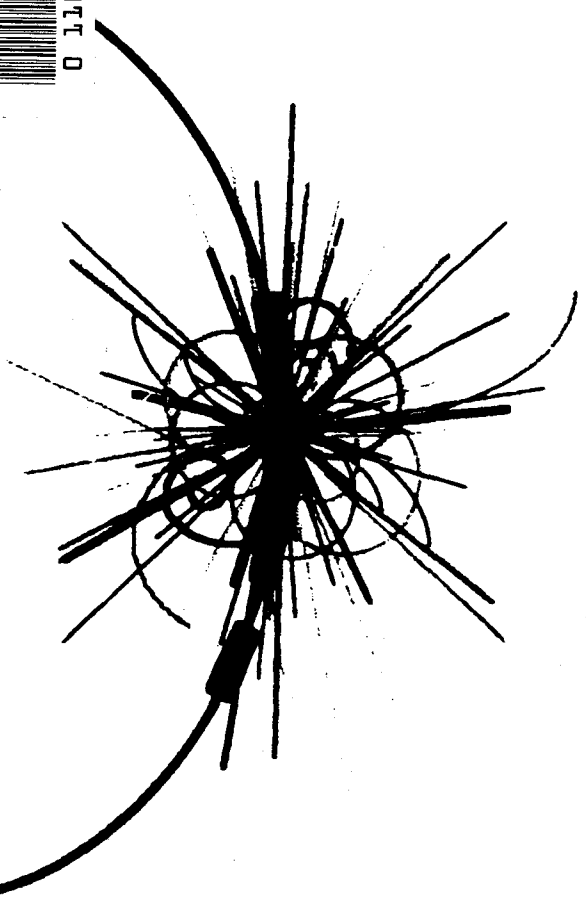

UTAP REPORT

Recommendations Following the Meeting of November 18-19, 1991 Held at the SSC Laboratory, Dallas, Texas

SUPERCONDUCTING SUPER COLLIDER LABORATORY

UNIVERSITIES RESEARCH ASSOCIATION

SSC UNDERGROUND TECHNOLOGY ADVISORY PANEL

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December 18, 1991

Mr. Jon Ives
Dr. Timothy E. Toohig
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Re: Report entitled "Recommendations Following the Meeting of November 18-19, 1991 Held at the SSC Laboratory, Dallas, Texas"

Gentlemen,

On behalf of the Underground Technology Advisory Panel (UTAP), I am submitting a final copy of the referenced report. The final report includes changes and refinements to the draft report, as recommended by UTAP members and other reviewers.

We are pleased to assist you. We all look forward to future activity and involvement in the Superconducting Super Collider.

Sincerely,

T. D. O'Rourke

T. D. O'Rourke

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enc.

HAC9584

Recommendations Following the Meeting of November 18-19, 1991 Held at the SSC Laboratory, Dallas, Texas

By

The Underground Technology Advisory Panel (UTAP)

To

Mr. Jon Ives and
Dr. Timothy E. Toohig

Superconducting Super Collider Laboratory

December 16, 1991

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INTRODUCTION

This report summarizes recommendations made by the Underground Technology Advisory Panel (UTAP) to the Superconducting Super Collider (SSC) Laboratory, subsequent to meetings held on November 18-19, 1991. The Panel was convened at the request of Mr. Jon Ives, Associate Director, Conventional Construction Division (CCD), and Dr. Timothy E. Toohig, Deputy Director, CCD, for the SSC. A list of UTAP members and meeting agenda are appended to this report. The meeting was held at the SSC Laboratory, Dallas, TX, during which time presentations were made by members of the SSC Laboratory staff and the Architect-Engineer/Construction Manager (A-E/CM) on site characterization, field and laboratory testing program, anticipated construction, and management issues. Information conveyed at the meetings is in the public domain, and is collected and filed as part of the SSC Laboratory Notes which are available through the SSC Laboratory.

In preparation for the meeting, UTAP members received copies of reports, correspondence, and construction drawings either issued by the SSC Laboratory or prepared by Parsons Brinckerhoff/Morrison Knudsen (PB/MK), the A-E/CM for the SSC project. The following materials were reviewed in advance by UTAP members:

- Collider Elevation Change Package
  with enclosure entitled "Proposed Change in Collider Placement."

- IR Hall C-3 Report:
  Experimental Facilities - Interaction Region Study Draft Phase C-3 Report
  An Overview of Detector Hall Construction Cost Comparison Based on Phase C-1 and C-2 Studies.

- IR Hall C-2 Report:
  Experimental Facilities - Interaction Region Study Phase C-2 Report
  Construction Cost Comparison of Detector Hall for GEM Detector at IR4 and IR5 Sites
  Cut and Cover Construction and Cavern Construction
  10/4/91

- IR Hall C-1 Report:
  Experimental Facilities - Interaction Region Study Phase C-1 Report
  Construction Cost Comparison of Detector Hall for SDC Detector at

IR1 and IR8 Sites
Cut and Cover Construction and Cavern Construction
9/24/91

Before the meetings, members of the Panel participated in several site visits. On November 16, several UTAP members visited the construction site of the Cole Park Detention Vault, North Central Expressway, Dallas as the guests of Albert H. Halff Associates, Inc. During this visit, underground works in Austin Chalk were observed. On November 17, field trips were conducted with UTAP, SSC Laboratory, Texas National Research Laboratory Commission (TNRLC), and Department of Energy (DOE)-affiliated participants to recent cuts and natural exposures of Taylor Marl and Austin Chalk. Also on November 17, UTAP members toured the site of the SSC Exploratory Shaft, including inspection of the shaft which had been advanced at a 16.5-ft diameter in Austin Chalk to a depth of approximately 195 ft.

The materials received in advance, as well as the construction site and field visits, helped to focus discussion during the meetings. The construction site visits, in particular, helped to clarify aspects of the in-situ nature of the rock and its performance during construction operations. An agenda of site visits is contained in the appendix of this report.

The report is organized to address issues covered in the agenda for the 18-19 November meeting and to comment on several additional items, not specifically identified in the agenda, but nonetheless brought to the attention of UTAP by discussions during the meeting. The report covers management issues which pertain in large measure to conventional construction, including advantageous use of geology, schedule and cost management, site safety, annual work program, construction contract units, and staffing. The report covers technical issues, with observations and recommendations pertaining to site visits, N-15 Magnet

Delivery Shaft, tunnel issues, hydraulic fracture tests, design and construction of the east halls, site exploration for the east halls, and hydrogeology of the SSC site. The report also covers some broad management issues which, because they can affect seriously the ability to carry out the conventional construction program, deserve consideration from upper levels of SSC Laboratory and DOE management. These issues are covered at the end of the report and involve dialogue with SSC management, change order control, contingency management, incremental funding, and NRC recommendations for better management.

ADVANTAGEOUS USE OF GEOLOGY

A critically important factor in the design, construction, and operation of the SSC is the advantageous use of geology. Accordingly, the Panel is pleased that recommendations have been forwarded from the SSC Laboratory to DOE regarding changes in the Collider placement and relocation of the two major detectors to the East Complex.

The proposed adjustments in main beam tunnel elevation and strike will reduce substantially the tunneling in Eagle Ford Shale (EFS), thereby reducing potentially difficult construction at the same time that significantly increased lengths of tunneling in Austin Chalk are realized. Given the generally excellent characteristics of Austin Chalk, these proposed changes take advantage of the most desirable geologic conditions with attendant cost savings. In addition, relocation of the two main detectors from the West to East Complex changes the foundation rock from EFS to Austin Chalk, thereby increasing the stability and improving long-term performance of the detector foundations. The Panel concurs with cost estimates developed by the A-E/CM which show little cost difference between east and west hall construction.

The Underground Technology Advisory Panel strongly endorses the proposed

changes which allow the project to make advantageous use of site geology. Furthermore, the DOE is encouraged to respond affirmatively in a timely manner to the proposed changes. It would be helpful to receive DOE concurrence at a suitable time before the December 18 opening of the first tunnel bid documents, so appropriate adjustments can be made without delaying the bidding process and contract award.

SCHEDULE AND COST MANAGEMENT

At the time of the meeting, it was apparent that no fully integrated schedule had been implemented for the SSC project. The Panel was informed that the first cost-loaded integrated work schedule is nearly ready and that it will be issued about mid-December. Currently, the A-E/CM schedule has been developed in significant detail and is being used to manage the conventional construction portion of the overall SSC development.

It must be the highest priority to get a cost-loaded, fully integrated schedule in place and to gain respect and familiarity with it by all in the organization. The lack of this communication tool has inhibited the management process to date.

The National Research Council (NRC) Report of 1989[1] addressed the need for a fully integrated schedule as a high priority recommendation. Consistent with the recommendations in this document, it is expected that a schedule integrating all project tasks on a time and cost-related basis will improve significantly the quality of scope descriptions for each annual work plan and A-E/CM task, work order, or construction contract, as well as properly coordinate

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[1]Subcommittee on Contracting Practices for the Superconducting Super Collider, "Contracting Practices for the Underground Construction of the Superconducting Super Collider," National Research Council, National Academy Press, Washington, D.C., 1989.

conventional construction activities with the installation of project equipment by others.

Two aspects of scheduling that are vital in the management of a project are: 1) timely process of developing a schedule by senior management involved in each element of the project, so they can think through the design and construction and thereby promote coherent planning, and 2) the communication of the ideas of management to colleagues and other institutions affiliated with the project. The people who are charged with managing construction need to control the schedule input. Each participating group should have a system integrator who will be able to concentrate on arbitrating the interfaces, not dictating them. Any group should be able to scrutinize and comment on any other group's input.

It will be important to maintain software to support the schedule. Such software should be utilized by the many and varied organizations which contribute to the overall facility, and thereby assure a maximum of efficiency in communication among all groups. The schedule should be accessible through computer screens and menus friendly to personnel, so that communications are improved across all interfaces. The hardware and software should allow reconciliations on a daily basis for executive management review.

It is important for management to realize that it will not be possible to have great detail for all elements of the facility, particularly those portions which have not been designed and, therefore, cannot be scheduled with knowledge of specifics. Judgment and allowance for the time necessary to develop and build various parts of the facility, which are only conceptual in nature, have to be accepted as the best information available. Accordingly, there will be many instances in which the resource and cost loading aspect of the schedule will be less accurate than desired.

As was discussed at the UTAP meeting, the schedule is not a one-time effort. It will be necessary to keep the schedule up to date in order to take care of unavoidable changes; review on a regular basis current cost, schedule, and scope of work items to see if any changes are needed or desirable; ensure that changes are not made inadvertently or without authorization; and make prompt and early decisions on requests for changes. Only the carefully-defined, highest level milestones should be maintained as inflexible. An integrated schedule and resource plan often is referred to as a living document, which continuously has to be updated and reconciled among the various requirements of the project. It can never be a static document that is created and exists in its original form to the end of work.

SITE SAFETY

The presentation made at the UTAP meeting with regard to site safety was excellent. Review of the site safety program has shown it to be complete, well thought out, and of high quality.

From experience at the Channel Tunnel in England, there are several issues that were of concern on that project that should be monitored carefully on the SSC development. Two issues that proved to be difficulties in the Channel Tunnel project were eye injuries and hearing degradation due to noise.

As a policy, the Transmanche Link Contracting Organization established the need for physical examination by the people working within the tunnel complex as an employment precedent. Each employee was subjected to a physical examination, including an audiologist report and lung capacity checks. Follow-up to this initial physical examination was made on an annual basis and against an employee base in excess of 5000 people. Over a three-year period, there was a distinct degradation in hearing for people who were working in certain areas of

underground construction. There currently is an analysis being made of the degradation in hearing as it related to the various underground construction activities. When the study is complete, the SSC Laboratory should avail itself of the information in the study. It seems a reasonable conclusion, however, to suggest that hearing protection for underground workers should be considered, at least in certain areas of activity.

The Channel Tunnel Project also involved a high incidence of eye injuries, in excess of 150 per month. An eye protection program was instituted, with eye protection and safety glasses being made mandatory about three years into the project. The result of this program was a decline in eye injuries to under 50 per month, with a significant reduction in the severity of the injuries that did occur. It is recommended that the SSC Laboratory review this program for possible implementation in the SSC facility.

As the A-E/CM develops and implements a substance abuse program, the SSC Laboratory should likewise consider its own programs in this regard. Such programs implemented by the Laboratory should complement and be compatible with those of the A-E/CM.

ANNUAL WORK PROGRAM

The Panel was briefed on the adoption of an annual work plan to cover the work program proposed for the A-E/CM for each fiscal year. The Panel believes this is an excellent way to set forth requirements, matching funds, and resources over an extended period for at least mid-range planning of effort and human resources, and the establishment of goals and milestones.

To be effective, annual work must be established far enough in advance of the beginning of the year to permit adequate exchanges between the SSC Laboratory and A-E/CM in the formulation of the resulting program. There appears to

be a need to accelerate this worthwhile management process. We understand the annual work plan review now involves a 4-5 month cycle, and at least this first annual work plan will be adopted late in the year it is intended to cover.

It is the Panel's impression that too many steps currently are involved in the process of work approval. The SSC Laboratory should strive to compress the time required to establish an annual work plan and to speed the process of decision making at all levels of the management.

Continuity in the allocation of funds throughout the work program must be given a high priority. Partial funding, that is funding in pieces of a task or contract, may be necessary at times because of incremental funding tied to Congressional appropriations. This uncertainty in funding poses a significant challenge to Laboratory and DOE management, and the Panel encourages timely and efficient flow of the funds at hand. There may be a tendency to regard partial funding of a task or contract, when the Laboratory has the funds, as a means of control. However, this process generally is very inefficient and costly because the work cannot be progressed to its fullest extent under such restrictions. Such controls are designed to keep something from happening, whereas controls should be designed to cause things to happen.

CONSTRUCTION CONTRACT UNITS

The Panel concurs with the use of Construction Contract Units (CCU) by the A-E/CM as a means for properly consolidating and transcribing items in the work breakdown structure (WBS), which were used for the baseline cost estimates of the project. This packaging allows for more efficient accommodation of a major contracting effort.

STAFFING

The Conventional Construction Division (CCD) continues to be responsible for leading the activity of the construction project. The CCD must have capable personnel to manage the confluence of design requirements and priorities, and should continue to build carefully to their authorized staffing level with the best talent available. Members of UTAP can be of some help with references within the industry. Senior Laboratory management must ensure that the technical divisions continue to use CCD for the integration of their needs into the construction program.

SITE VISITS

As described in the introductory portion of the report, visits were made to construction sites in Austin Chalk, as well as field exposures of Austin Chalk and Taylor Marl. These visits were of substantial value in evaluating the probable response of these materials during construction of the SSC facilities. In general, the observations of the Austin Chalk behavior can be characterized as being encouraging with respect to the SSC project tunnels, shafts, and IR halls. In the case of the Taylor Marl, the limited observations which could be made served to confirm that this material is highly susceptible to severe degradation as a function of time of exposure and wetting/drying cycles, and that all excavations in this material must be approached with this fact in mind. Observations from the site visits are summarized below under several headings.

Time-dependent behavior. For Austin Chalk, both the Cole Park Detention Basin site and the Exploratory Shaft site showed that this material stands up well after exposure. Where more shale-rich bands exist, there is some minor slaking and raveling of the material, but this seems to be self-stabilizing

within a very short depth (less than an inch), and should not cause any unforeseen problems. Where the major "bentonite marker bed" has been encountered at Cole Park, slaking and raveling of this material progressed to about 8 in. in depth, and apparently has stabilized at this point. Although this action caused no apparent stability problems, dental excavation and sealing of this bentonite material would be prudent wherever it is encountered in the SSC excavations, to ensure that this raveling action does not give rise to loosening and weakening of blocks within the surrounding and overlying rock. In the Exploratory Shaft, instrumentation data showed that inward movements occurred at the bentonite bed, which were arrested immediately by application of shotcrete.

The Taylor Marl, however, does degrade severely with time after exposure, although the rates of degradation apparently are variable, depending on precise composition of the specific stratum involved. The relatively low slake durability of these materials must be considered carefully in the design of the large cuts that will be made for the interaction regions in the East Complex.

To date, it has not been possible to observe the time-dependent degradation of the Eagle Ford Shale (EFS). This material soon will be exposed in the Exploratory Shaft below the 215-ft level, and in the associated test adit. Current plans call for the EFS to be covered with a clear emulsion immediately after exposure, to arrest time-dependent degradation. It is recommended that selected "windows" of EFS be left untreated initially. Observations of the speed and nature of slaking and raveling will help in defining the necessary specification requirements for the timing of surface treatment of the EFS.

Support. The performance of Austin Chalk exposed in both the Exploratory Shaft and the Cole Park caverns has been very encouraging with respect to support requirements. In both cases, the initially designed support requirements

have been relaxed in response to the observations of actual behavior during construction. In the case of Cole Park, the rock bolting requirements are being relaxed now, and in the case of the Exploratory Shaft, the requirement for shotcreting was removed in the lower part of the shaft. This experience will be factored into the support design requirements for future shafts, and UTAP strongly supports this approach. However, it should be emphasized that this experience relates only to the behavior of good quality chalk, and the ability to react rapidly with extra support in zones of poorer quality chalk will be important.

Inflow and piezometric response. Total water inflows to both the Exploratory Shaft and the Cole Park caverns are extremely small, and consistent with preliminary back-calculated values of hydraulic conductivity of about 1×10^{-8} cm/sec. This indicates that excavations in chalk can be expected to be generally dry, except for small localized seeps along faults and associated zones of relatively concentrated jointing. Somewhat increased inflows may occur in different stratigraphic units of the chalk, but these are likely to remain modest. In fact, UTAP anticipates that dust control will be an important issue in tunnel excavations. The response of the piezometers placed close to the Exploratory Shaft has been quite rapid, and indicates the formation of a steep drawdown cone. While the final, stable shape and extent of the cone is not yet established, the response to date suggests that the drainage effects of excavation in chalk, and the consequent consolidation response of the rock mass, are likely to be limited. It is recommended that this early information be utilized to undertake some "scoping calculations" concerning the possible magnitude of consolidation movements around the tunnels and excavations in chalk.

Deformation response. Results to date from instrumentation in the Exploratory Shaft are consistent with a value for the mass modulus of Austin Chalk of approximately 500 to 1000 ksi, although the results are limited, and the back-calculations also depend on the values assumed for the in-situ stresses. On the basis of observations of the in-situ condition of Austin Chalk, this modulus appears to be realistic, and can be used for initial calculations and parametric studies of the probable response of the foundations of the IR-5 and IR-8 detector halls.

Placement of a heave-gage into EFS from the base of the existing Exploratory Shaft is underway. The Panel emphasizes the importance of the data from this instrument and commends the PB/MK and Shannon & Wilson teams for the careful thinking which is going into the placement and use of this gage. The Panel supports consideration of placing a heave-gage into the base of the Magnet Delivery Shaft, practical factors permitting.

Observational approach. As noted above, the site visits have confirmed the importance of being able to modify construction requirements based on observations of actual behavior as construction proceeds. The Panel commends the PB/MK team for putting this philosophy into practice with respect to shotcreting in the Exploratory Shaft, and reiterates the importance of ensuring that this philosophy is embedded in all underground contracts.

MAGNET DELIVERY SHAFT

The decision to shift the ring has resulted in raising of the ring-shaft intersection in the Magnet Delivery Shaft, placing it just at the EFS-Austin Chalk contact, in the "Fish Beds." The EFS immediately below these materials is suspected to be particularly weak and degradable. In addition, the geometry

of the intersection is made somewhat more complex by this move. In response to these issues, PB/MK have redesigned the structural support at the base of the shaft around the portal of the running tunnel. The Panel supports the philosophy of this redesign, and wishes to emphasize two points. First, it remains essential that the reinforcement of the rock mass itself is carried out with the greatest care, to ensure that this reinforced mass becomes a key load-bearing element in the overall system, and thereby reduces the ultimate loads on the structural support system. Second, the Panel supports incremental or sequential excavation in the enlarged portal area of the beam tunnel. This complex excavation in weak rock is one of the more challenging ones to be addressed, and occurs right at the start of the underground construction activities on the project. It is particularly important to avoid problems in these areas to gain the fullest benefits for bid prices on future contracts.

TUNNEL ISSUES

The permanent structural lining, where required, will consist of four segments, 9 in. thick, with two layers of mesh and no bolting or gasket. This will be illustrated on standard contract drawings, and contractors will be invited to submit equivalent alternative linings for approval. In this case, performance requirements should be set forth, including required expansion, resistance to shield jacking forces, and degree of watertightness. Consideration should be given to requirements to resist stresses in handling, stacking, and erection. It will be helpful to develop a standard detail to carry water from any continuous seeps that are encountered in the walls to the floor drain. Considering the calcareous nature of all of the strata, it will be important to make drain lines accessible with a clean-out tool, and available for inspection at intervals.

For the circular tunnel in chalk, two standard bolt patterns are being considered. Upward-directed bolts at 30° to 40° on either side of the crown should be installed closer to the vertical than to a radial direction, in order to stitch the horizontal bedding. For unlined sections in the chalk, it would be desirable to develop a standard drainage detail, which may require a drainage chase in a leaking rock fracture plane that is bled off to the central floor drain.

Recognizing the substantial volume of backfill that will be required below the completed tunnel floor, consideration might be given to precast utility conduits which could be laid beneath the floor with appropriate cover plates. This would minimize the space occupied by them within the open tunnel, minimize the required backfill, and avoid interface with niches, openings, drain lines, and the like.

For the proposed tunnel contract packages in Austin Chalk, the current thinking is to include bid items for support along 15 percent of the tunnel, without specifying exactly where such support would be required, and making allowance for variation in quantities of ± 25 percent, without change in bid price. This approach has been found to be effective, and is supported by UTAP.

The contract packaging for the project involves separate contracts for each of tunnel excavation and tunnel finishing. The Panel expresses concern that the development of design requirements for the tunnel niches is progressing too slowly. It is important to rectify this situation as soon as possible, with clear requirements for the type, number, and location of niches.

During the meeting, concern was expressed for the interior appearance of the main beam tunnel when commissioned. Whereas the Panel encourages communication between designers and users of the facility regarding appearance, it is not necessary to improve the tunnel interior beyond safety and equipment needs.

There are many existing tunels at high energy physics laboratories, which house complex equipment with minimal lining accouterments, that are safe and highly serviceable.

During the presentations on hydrogeology, as discussed in the final section of this report, a profile of fracture intensity in Austin Chalk was provided. This profile covers the full chalk thickness between marl and shale. Since the full thickness of Austin Chalk from shale to marl contact will be intersected by the tunels, profiling of fracture intensity could prove helpful in estimating the percentage of support of various classes that will be required for tunneling in the chalk. It could be advantageous for information on fracture frequency from new borings, the current Exploratory Shaft, and the Magnet Delivery Shaft to be added to the current fracture intensity profile. This record should be elaborated through the tuneling contracts, so that as the work proceeds, designers and contractors will develop an increasingly accurate assessment of the quality of the formation. This then could be utilized to estimate better the percentage of tunnel lengths in chalk to be included in the different categories of support.

HYDRAULIC FRACTURE TESTS

The results of a series of hydro-frac tests indicate that, in Austin Chalk, the ratio of maximum horizontal total stress to total vertical overburden pressure is about 2.3. The ratio of minimum horizontal total stress to total overburden pressure is 1.7. For EFS, the ratios average about 1.6 and 1.2, respectively. These values are consistent with test results from other subcontractors in earlier exploration within Austin Chalk. Presumably, the difference in ratios between the chalk and shale is the result of a difference in the erosion history represented by the unconformity between them, and also by the more

ductile character of shale compared to chalk.

The major horizontal total principal stress is directed N33° E, subparallel to the local trend of the Balcones fault zone. Minor horizontal total principal stress is at right angles to the fault zone in the collider area. This orientation would be expected, since the regional stress state probably has been influenced by sedimentary loading and down-warping toward the Gulf embayment at the southeast, causing extension strains and a decrease in residual horizontal stresses in the southeast direction.

It should be noted that the ratios are given in terms of total horizontal stress to total overburden pressure. If the all-around pore water pressure is subtracted from total stresses, the ratio of effective stresses is about 30 to 40 percent greater than that for total stress. As a practical matter, it is believed that the residual lateral stresses will be rapidly relieved in the Austin Chalk by small horizontal inward movements to an excavation. For the new position of the experimental halls on the east, the residual lateral stresses in Taylor Marl could be important for the overall pressures and load distributions carried by various support systems currently under consideration. More discussion of in-situ stress state effects is provided in the next section of this report dealing with East Hall design and construction.

DESIGN AND CONSTRUCTION OF THE EAST HALLS

As discussed in a previous portion of the report, a great advantage of moving the IR halls to the East Complex is to position the base of the halls on the firm and relatively incompressible Austin Chalk. The chalk can be regarded as equivalent to a weak to moderate concrete, with compressive strength of 2 ksi and an apparent field stress-strain modulus of about 500 to 1000 ksi. Shear stresses around the base of the halls will be on the order of 100 to 200 psi,

compared to shear strength without confinement of 1000 psi. This local safety factor of 5 or more brings about a situation where strains in the foundation will be almost entirely elastic, vertically directed, and responding rapidly to load change with little time delay.

Preliminary design concepts for the cut-and-cover excavations about 210 ft deep for the halls were presented by PB/MK. The Panel has the following comments regarding the general features of the design:

- The use of cross struts at wide vertical spacing can be supplemented by temporary tieback anchors at levels between the struts. Attention should be paid to the strain compatibility between struts and tiebacks, as discussed later in this section.

- The total vertical pressure removed by the 210-ft excavation will amount to about 30 ksf. If a third of this is taken by pore pressure reduction in chalk below the subgrade, and the chalk modulus is taken as 500 ksi, then heave of the base during excavation would amount to about 0.25 to 0.50 in. If the detector load, distributed over a stiff mat, averaged 20 ksf, the recompression settlement could be less than 0.50 in., depending on the final pore pressures beneath the hall. Thus, it now appears that the shift of the hall locations has diminished considerably the threat of settlement under the detector load itself. The very heavily loaded walls could cause hogging of the invert slab, depending on the sequence of the load application, and this possibility should be considered in the final design. Furthermore, the presence of bentonite seams may contribute to additional settlement, both on an immediate and time-dependent basis. Consideration should be given to the influence of bentonite seams on the performance of hall foundations, including the effects of seam thickness, depth below the base of the halls, and influence of multiple seams.

- Probably, the most efficient means of assuring a watertight enclosure for the halls will be to install the NATM combined drainage fleece and waterproof membrane between the temporary and permanent vertical walls, above the roof, and beneath the invert slab. Opening the fleece for permanent drainage probably is essential to guarantee watertightness. Special attention should be paid to protecting the membrane below the slab and above the roof from construction damage. Backfill placed above the roof will serve as a sump, collecting shallow inflow of groundwater from a wide area. The drainage fleece above the roof should be covered to prevent direct flow of this collected seepage into the hall permanent drainage system.

- It might be economical to offer bidders options in selecting combinations of temporary construction walls and temporary tieback anchors. It may be useful to consider the application of soil

nailing for temporary support of the Taylor Marl. Soil nailing originally was developed to support open cuts in marl for transportation projects in France. Cross struts could be incorporated in the final concrete of the floor, above the detector, and in the roof of the hall. To minimize the final positive moments in the permanent wall, consideration might be given to providing full moment connections of the permanent struts with the interior walls and between walls and invert slab.

- A vertical shaft for insertion of detector elements might consist of a slot crossing the axis of the hall at the quarter point of the length of the hall. One means of creating the vertical walls of this slot-shaped opening would be by means of deep Vierendeel trusses at the sides, spanning from wall to wall of the hall. The truss has moment connections between members to add to its stiffness. Such an arrangement would develop concentrated loads in the walls at their connections with the trusses. This increased load would be transmitted to the foundations, with the possibility of requiring deep foundation elements to provide the necessary load bearing capacity.

An important feature of the east open cuts under the revised layout will be the performance of the Taylor Marl in the sidewalls of the excavations. A potentially useful case history in a similar situation is the construction of the subway stations, 80 to 90 ft deep, in the Miocene Puente formation on Hill Street for the Los Angeles subway. The Puente is heavily overconsolidated silt with unconfined compressive strength of 200 to 400 psi, comparable to Taylor Marl. The Puente exhibited moderately high residual horizontal stress, with elastic rebound or extension strains extending outward for a considerable distance from the excavation. As a result, short tieback anchors tended to release their loads, shifting load upward to stiff, pre-loaded cross struts.

These Hill Street cases provide examples of conservative lateral pressures prescribed for temporary restraint. They contain the critical lesson that the hybrid support system of stiff cross struts and slack tieback anchors must be checked for strain compatibility, or there can be an unexpected transfer of earth loading from the yielding ties to the stiff support elements. The tiebacks should be longer than ordinary with greater unbonded length, pre-stressed

to relatively high values. Cross struts, on the other hand, should be installed with lower pre-load, possibly with compressible inserts that could relieve the large potential loading caused by the release of residual horizontal stresses.

Now that the detector foundations are in Austin Chalk, and information is becoming available on values of the mass properties of chalk, it is important to undertake scoping calculations of the probable range of deformation response of the foundations at the earliest opportunity. It appears that the design requirements for the foundations in terms of allowable deflections under various loading conditions still are not mutually understood between the PB/MK design team and the SDC/GEM groups. While recognizing that full modeling of the complex structure-foundation interactions will take some time to address, UTAP suggests that preliminary scoping calculations, using simplifying assumptions, can be used effectively to clarify the issues involved, and that these should be promoted as a basis for discussion as soon as possible.

SITE EXPLORATION FOR EAST HALLS

It is understood that now there will be a revision in the general exploration program, including four more new borings at perimeter locations for each experimental hall at the East Complex. The Panel suggests that the following supplementary measures be considered for this exploration:

- Each one of these boreholes should be considered for instrumentation. It would be desirable to place at least one deep benchmark at a position that would be available for measurements at each of the halls, to determine precisely the settlement of the detector units as they are constructed.
- Reasonably sensitive piezometers should be placed in the boreholes, probably no more than two in a single boring, separated to provide information on pore pressure changes as close as practical to the final wall location and beneath the subgrade of the excavation.
- Considering the apparent consistency of the residual stress determinations from the hydraulic fracture tests, we suggest that one

boring be utilized for a series of similar determinations in the Taylor Marl and in the upper portion of the Austin Chalk.

- The use of angled borings is encouraged at each hall for more realistic logging of fracture density in the marl and chalk.

HYDROGEOLOGY OF SSC SITE

The Panel was impressed by the presentation by Dr. Alan Dutton of the Texas Bureau of Economic Geology (TBEG), and encourages more communication among Dr. Dutton and his group, CCD personnel, and A-E/CM personnel. Of special interest for the Laboratory are the regional interpretation of piezometric readings from wells in the various rock units to be penetrated by the SSC, an assessment of changes in piezometric levels in the Woodbine and overlying formations relative to deep pumping, and the evaluation of storativity of the Woodbine formation and its relationship with compressibility and the potential for subsidence.

Instrumentation at the Exploratory Shaft has shown piezometric levels in EFS to be higher than the ground surface, indicating an upward gradient. No generally agreed explanation is available yet for this observation, and UTAP recommends further work on understanding this phenomenon.

Work has been started on understanding the regional groundwater regime in terms of the potential effects of long-term drawdown on movements of the ring. It is important to undertake some early scoping calculations of the possible order-of-magnitude effects of such regional drawdown compared to other effects, such as dewatering caused by the tunnels and excavations, to set priorities for future measurement efforts.

DIALOGUE WITH SSC MANAGEMENT

On November 18, a special meeting was convened at which UTAP members were able to discuss aspects of the project with SSC Laboratory and DOE managers.

In addition to UTAP, those present at the meeting were E. Cumesty and G. Dretke of DOE; R. Schwitters, E. Siskin, G. Robertson, J. Ives, and T. Toohig of the SSC Laboratory; and P. Gilbert and R. Curl of PB/MK.

The candid and focused discussions during the meeting were of considerable benefit to UTAP. It is believed that such meetings are helpful also for SSC Laboratory and DOE management, in that they allow for a constructive dialogue on issues critical for the SSC project. Given the advantageous nature of such communication, it is recommended that similar discussions be held in conjunction with future UTAP meetings, starting with the next scheduled UTAP meeting on 2-3 March, 1992.

CHANGE ORDER CONTROL

It is essential that changes to the project plan and requirements be tightly controlled and made or approved at a high management level. The establishment and composition of the Change Control Board appears to meet these criteria. However, decisions delayed are decisions not made. During periods of no decision or deferred decision, things that aren't desired happen and things that should be occurring never happen because it's too late.

Recent decisions on ring elevation and location of IR halls are encouraging signs that future actions might be taken promptly. The Panel applauds such activity, and encourages further action in reducing the length and protracted review process that has accompanied some of the early decisions to support changes that are critical for the project schedule.

CONTINGENCY MANAGEMENT

One particularly troubling item is the apparent lack of reserves, or contingencies, in budgets or funding programs available to the SSC Laboratory, at

least at working levels. Unforeseeable conditions or events are the rule in underground construction, and changes are likely, if not foreordained, in new and complex research projects. Prudent provision for and responsible use of reserve funds is a responsibility of the management of any project, and certainly one of the size and complexity of the SSC.

There seems a reluctance to delegate the management of any level of contingency funds down into the organization of the SSC Laboratory. This creates a lengthened decision-making process with doubtful efficiency for the outcome of the project. Aspects of contingency can be delegated to the various levels in the organization without sacrificing overall control or real management control of the program and budget.

It seems that the management of contingency is confined at too high a level within the Laboratory and DOE organizations. This constrains the decision-making process, and will inhibit the overall development of the project and increase the cost, if controls are maintained in such a severe manner.

Need exists for a shortened decision-making process. With designs moving forward, decision and direction are essential for the maintenance of the program and budget. This can be assured only by engaging fully the professionals at all levels of the organization. As the elements of the facility become more clearly defined and the program and schedule more fully developed, the need to shorten these communication and decision-making lines will become ever more pressing.

INCREMENTAL FUNDING

The 1989 National Research Council Report[1] addressed the subject of incremental funding in accordance with annual Congressional appropriations. It was concluded that funding increments should be adequate in amount, timely, and uninterrupted. Under these conditions, funding uncertainties could be

minimized, allowing the overall program to be developed with a reasonable level of flexibility.

Given the size and duration of the SSC project and the governmental appropriation and funding processes, it appears that incremental funding on an annual basis will be the rule. This process will have a restraining effect on the SSC Laboratory's ability to plan and program, and to operate most efficiently. The incremental allocation of funds promotes uncertainties which influence the way in which contracting organizations approach SSC work.

When funding uncertainty exists, it puts small and disadvantaged contractors in a difficult situation. An advanced level of management experience and risk appreciation does not generally exist in a small organization. There is a good deal of management effort required to address the possibility of funding interruptions in any contracting situation. Accordingly, it is likely that financial uncertainties will cause small contractors to price these issues into their bids for work, or else assume the risk of funding interruption under circumstances in which they are poorly equipped to do so.

The bulk of U.S.-owned businesses qualified to bid on SSC underground work are medium-sized construction contractors. These organizations generally do not have the resources to accommodate financial uncertainties, and are likely to factor this concern into bid prices. In contrast, many foreign organizations have the ability to finance and manage interruptions in the flow of funding. Incremental appropriations tend to favor these larger organizations because such companies can leverage uncertainties with larger financial bases and foreign capitalization. One, therefore, could make the case that incremental funding places medium-sized U.S. contractors at a disadvantage.

Close review should be given to this issue, and a serious effort should be made to diminish uncertainties in the funding process.

NRC RECOMMENDATIONS FOR BETTER MANAGEMENT

Throughout this report, as well as previous reports, the Panel has encouraged the SSC Laboratory to follow recommendations published in the 1989 National Research Council Report[1], which addresses contracting practices for the SSC. Two recommendations, especially pertinent for SSC Laboratory management, are to 1) make decisions promptly and firmly, and 2) delegate authority and resources to levels commensurate with their responsibilities. These recommendations are made even more forcefully in a 1978 National Research Council Report[2] addressing better management of major underground works. The Panel considers the 1978 study to be relevant for the present management and leadership of the Laboratory, and a thorough study of the report is recommended. A single copy of this publication has been sent to the Laboratory with this report.

[2]Subcommittee on Management of Major Underground Construction Projects, "Recommendations for Better Management of Major Underground Construction Projects," National Research Council, National Academy Press, Washington, D.C., 1978.

APPENDIX A

UTAP Fall Meeting
18-19 November 1991
Upstairs Conference Room, Building 4

Monday, 18 November

8:30-8:40	Welcome J. Ives
8:40-9:00	Review of Recommendations from last UTAP T. Toohig/T. Lundin
9:00-9:40	Project Design Status R. Etheridge/J. R. McDonald
9:40-10:00	Project Construction Status R. Prince/J. Bhore
10:00-10:15	Break
10:15-10:45	Annual Work Plan Overview R. Tener
10:45-12:00	Annual Work Plan R. Curl
12:00-1:00	LUNCH
1:00 - 1:45	Exploratory Shaft B. Schmidt, P. Nelson
1:45-2:00	Tunnel Safety Considerations D. Whiting
2:00-3:00	Tunnel Issues J. Monsees, T. Lundin
3:00-3:15	Break
3:15-4:15	Collision Halls Status and Design Considerations E. Crumpley, A. Gursoy
4:15-5:30	Working Session

UTAP Agenda
17-18 November 1991

Tuesday, 19 November

8:30-9:30	Hydrogeology Research Program TBEG
9:30-10:00	Hydrogeological Considerations in Design PB/MK
10:00-10:15	BREAK
10:15-11:00	Safety Considerations in the Design of the Underground Halls R. Stefanski
11:00-12:30	Closed Session
12:30-1:30	LUNCH
1:30-3:00	Closed Session & Wrap Up

UTAP FIELD TRIPS

16-17 November, 1991

SATURDAY, 16 NOVEMBER, 1991

15:00 Construction Site Visit - Cole Park Detention Vault, North Central Expressway, Dallas, TX

Mr. Thomas Knicker, P.E.
Albert H. Halff Associates, Inc.

Contractor: Granite Construction Company

SUNDAY, 17 NOVEMBER, 1991

9:45 Geological Field Trip - Marl at Local Landfill and Marl/Chalk at L. Waxahachie Spillway

P. P. Nelson, SSCL/University of Texas at Austin

14:00 SSC Exploratory Shaft

R. Curl, PB/MK

UTAP MEETING
NOVEMBER 18-19, 1991
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11/26/91