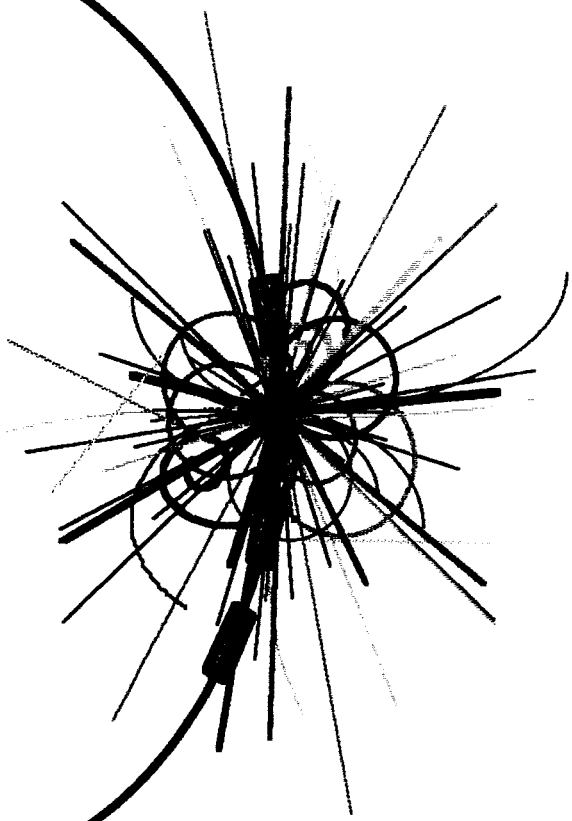
SSC-SR-1044

SSC UNDERGROUND TECHNOLOGY ADVISORY PANEL



UTAP

REPORT

Recommendations following the
meetings of December 14 and 15, 1989
held in Dallas, Texas

SUPERCONDUCTING SUPER COLLIDER LABORATORY

UNIVERSITIES RESEARCH ASSOCIATION

SSC UNDERGROUND TECHNOLOGY ADVISORY PANEL

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Translink Joint Venture

Mr. James A. Lilly
Morrison-Knudsen

Mr. Eugene Waggoner
Consultant

Recommendations Following the Meetings of December 14-15, 1989 held at SSC Laboratory, Dallas, Texas

By

The Underground Technology Advisory Panel (UTAP)

To

Mr. Robert M. Matyas and

Dr. Timothy E. Toohig

Superconducting Super Collider Laboratory

January 11, 1990

SSC UNDERGROUND TECHNOLOGY ADVISORY PANEL

Thomas D. O'Rourke, Chairman
10 Twin Glens Road Ithaca, New York 14850 607-272-4029

January 11, 1990

Mr. Robert M. Matyas
Dr. Timothy E. Toohig
Superconducting Super Collider Laboratory
2550 Beckleymeade Avenue
Dallas, TX 75237

Re: Report entitled "Recommendations Following the Meetings of December 14-15, 1989 held at SSC Laboratory, Dallas, Texas"

Gentlemen:

On behalf of the Underground Technology Advisory Panel (UTAP), I am submitting a final copy of the referenced report. A draft copy of the report was issued on 19, December, 1989, and was circulated among UTAP members for comment. The final report includes changes and refinements to the draft report, as recommended by UTAP members.

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

Sincerely,

Tom O'Rourke

T. D. O'Rourke

TDO:kjs
enc.

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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 December 14 and 15, 1989. The panel was convened at the request of Dr. Timothy Toohig, Conventional Facilities Coordinator 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 subcontractors on site characterization, field and laboratory testing program, startup tunnel, experimental halls, and main beam tunnels and shafts. Information conveyed at the meetings is in the public domain, and has been collected and filed as part of the SSC Laboratory Notes which are available through the SSC Laboratory.

Recommendations pertaining to geotechnical site characterization, large diameter drilled hole, startup tunnel, groundwater and subsidence monitoring, location of the ring, and experimental halls are summarized under the headings which follow.

GEOTECHNICAL SITE CHARACTERIZATION

The panel believes that the site exploration program being organized by the Earth Technology Corporation (ERTC) is well planned and moving efficiently. The composite geologic reference column is impressive and should be elaborated as new data are developed.

It would be timely to establish a facility for preservation and display

of representative cores and samples for use by the Architect-Engineer/Construction Manager (A-E/CM) and construction contractors. This might involve setting up a secure space with humidity and temperature control. Type samples with transparent polymer coatings might be used for display of representative cores.

Observations of shaft excavations and tunneling provide for direct viewing of EFS and other rock under construction conditions. Once first construction starts, prospective bidders for future work should be notified that they are invited to visit and observe. In addition, it might be helpful to bidders to make a demonstration boring during the bidding period to display the conditions of rock strata.

The display of information for the first tunnel segment, E1-E2, gives an opportunity to perfect procedures for recording and plotting information from the borings and testing. Much progress has been made by ERTC in this respect. We suggest that natural scale cross-sections be drawn across the boot-shaft intersection and across the intersection of side tunnels with running tunnels at right angles to the strike of faults or shears. The principal identification data from the borings and from the laboratory testing should be plotted directly at the boring locations on the sections by symbol in abbreviated form.

Investigations involving excavation and special field testing should be videotaped. The tapes should be available for viewing in a special room or building where cores are kept and geologic logs and sections are displayed on wall charts.

It may be advantageous to develop a three-dimensional representation of the site. For example, a geologic peg model could be built for viewing at the

same location where other site materials are kept. The model would be at least 8 by 10 ft in plan, with a topo sheet on the base board indicating where various SSC facilities will be. The geologic conditions at each borehole would be represented by clear plastic rods on which various strata and rock types are painted above the base depth of the hole. Colored strings can connect the tops and bottoms of principal formations. Thin plastic sheets can show faults. Such models have proved useful on other jobs. They help prospective contractors, non-geotechnical scientists, and lay persons visualize site conditions.

More extensive use should be made of angle holes, particularly during the exploratory program for the startup tunnel. Angle holes would be appropriate in the direction along which geologic sections are to be taken; that is, a hole starting above the side tunnel should be angled in a direction to cross the adjacent running tunnel. Additional discussion of angle holes is provided in the section of this report which addresses technical issues for the startup tunnel.

As indicated in the first UTAP report following the meetings of April 30, May 2 and 3, 1989, a concerted effort should be made to collect and review information about the field performance of the Eagle Ford Shale (EFS) in urban excavations and quarries. Sources of information are the records of recent excavations and foundation performance associated with high rise buildings in Dallas. Efforts should be made to collect and summarize this information in preparation for the next UTAP meeting.

It is important to recognize that the site exploration and testing programs will develop substantial amounts of rock core, field measurements, and laboratory test results. It is appropriate, therefore, to devise a plan for

organizing the core and associated data in ways which allow for optimal use of the information for 1) design, and 2) as a basis for contractor bid. The panel encourages SSC Laboratory staff and subcontractors to think carefully about how to communicate and utilize data in the most efficient manner. It is especially important to organize information for rapid and efficient assimilation by the A-E/CM when selected.

LABORATORY AND FIELD TESTING

The panel was reassured to learn of the methods being adopted for quality control and uniformity of procedures in the subcontract laboratory testing. The program for storing data and interpreting the test properties appears to be well planned.

All current methods for assessing in-situ stress states are imperfect, and alternative procedures are advisable. Therefore, the panel concurs with the recommendation that hydrofracturing tests be made in selected test borings in addition to the dilatometer testing underway. There is, however, some concern about the ability to obtain meaningful results from hydrofracturing. Because there is uncertainty about the ability to perform successful hydrofracturing for the depths and geologic conditions at the site, such testing should be pursued on a limited basis in one or two holes. Care should be taken to set the dilatometer in several different orientations during testing to probe adequately for directional effects.

It would be of interest to expand the correlation of strength versus the angle bedding makes with axial load as more cores of the EFS are available from angle holes. Attention should be paid in this correlation to the strength of sheared or fractured samples where the direction of failure in the

test corresponds to the discontinuity or plane of weakness.

The cooperative testing at the Universities of Texas and Illinois appears to be well planned. Professors Olsen and Mesri should be asked to give their opinions on type and number of hand-cut samples and the specific methods of cutting out and preserving these samples. This also is an opportunity to obtain samples for testing to determine the degree to which anisotropy affects the strength and modulus. Emphasis should be placed by the university laboratory testing on time-expansion effects of the EFS. If practical, the influence of negative pore pressures in restraining swell should be ascertained with pore pressure measurements. Coring at 3-in. diameter should not be undertaken unless the hand-cut samples prove unsatisfactory for their purposes or show that 3-in.-diameter cores will result in substantially improved accuracy with respect to swell tests. Three-in.-diameter cores could be taken from the hand-cut samples, or taken directly during the excavation of the Large Diameter Drilled Hole.

LARGE DIAMETER DRILLED HOLE

The panel approves of the general plan for evaluating the in-situ performance of EFS by means of the Large Diameter Drilled Hole (LDDH). The location and depth of the hole are appropriate, although additional consideration should be given to its diameter. The currently plannned 8-ft-diameter provides little room for the installation of multiposition extensometers (MPBX's). Since a considerable portion of the cost may be associated with mobilization and standby of the excavation contractor, savings could be realized by using a larger diameter hole to allow room for easier and more rapid installation of the MPBX's. An increased diameter has additional advantages

in influencing a larger zone of in-situ rock, developing greater displacements, and providing more opportunities for observations and measurements. The panel recommends that diameters of 10 to 12 ft be evaluated.

The proposed instrumentation appears to be unbalanced with respect to density of radial vs. vertical measurement stations. It would be desirable to add another line of heave point extensometers and to reduce the number of inclinometers and MPBX's. The panel recommends that four to six inclinometers be used, as opposed to the eight currently proposed. The levels of MPBX's in the Austin Chalk should be reduced from three to two, with one level remaining at about 5 ft above the contact of Austin Chalk and EFS. The upper level of MPBX's in the Austin Chalk need only include two MPBX's, with four at the level closest to the Austin Chalk/EFS contact. In the EFS, it seems that two levels of four MPBX's would be appropriate, with one level approximately 5 ft below the Austin Chalk/EFS contact. The MPBX's should be installed at 90° intervals around the hole so that convergence measurements can be made between opposite devices. The two MPBX arrays in the EFS could be installed at an offset of approximately 45° with respect to each other to obtain measurements that would reflect anisotropic effects.

It would be advantageous to install heave point extensometer stations in the upper levels of the EFS to measure near surface heave at several locations before the bottom of the hole is reached. To reduce the potential for damage and increase the accuracy of alignment, it may be advisable to install the vertical heave point extensometers when the hole has been extended to substantial depth. On the basis of the analytical modeling performed to date, it appears as if this level would be 30 to 60 ft above the Austin Chalk/EFS contact. Care should be taken to use a grout for the heave point column that

will not induce swelling or alteration of adjacent EFS. The grout should be compatible in stiffness with EFS.

The use of a concrete plug at the bottom of the hole in conjunction with stress cells is unlikely to produce meaningful measurements. In lieu of this approach, it would be better to leave the bottom of the shaft open to the atmosphere for medium- and long-term observations. If it is desirable to measure swelling pressure, a structurally reinforced bottom plug should be anchored into the underlying rock and strains in the tie rods should be monitored to evaluate the total uplift force.

The instrumented steel ring should be installed between MPBX levels in EFS, and the excavation then should be advanced below the installed ring. It is important to establish the ring in firm and near continuous contact with fresh surfaces of EFS.

Close communication during planning and field installation of the LDDH should be maintained with those who will be performing specialized laboratory tests of the EFS. Additional analytical studies and forecasts of LDDH behavior are encouraged. Parametric studies should focus on the effects of in-situ stress, softening of the shale, interface strength at the Austin Chalk/EFS contact, and shaft diameter.

STARTUP TUNNEL: MANAGEMENT AND CONTRACTING ISSUES

On the basis of the current project schedule, it is anticipated that an A-E/CM for the SSC conventional facilities will be selected in February, 1990. Subsequent review and approval time leads to the expectation that the A-E/CM will be aboard by late May, 1990.

It is recognized that while it would be desirable to have the A-E/CM

prepare the contract documents for the startup tunnel, time will not permit it, and it will be necessary and desirable to utilize another design firm engaged for this set of contract documents only, at as early a date as possible. The panel believes that this firm should start work by 30 January, 1990 to achieve satisfactory results, and that if work is not started by 28 February, 1990, the attempt to go to construction contract bid by 30 September, 1990 will not be successful.

The SSC Laboratory intends to establish a Startup Tunnel Task Force to formulate requirements and criteria as instructions to and guidance for a design firm which will do the detailed design and prepare a set of contract documents ready for bidding. The location and general requirements are understood to be in two portions, based on anticipated fund availability. The basic contract will extend from Shafts E1 to F1 (with an additional 2000 ft and RF shaft adjoining the location of shaft E1). There also will be an option of adding a segment from Shafts F1 to E2 after award of the contract when and if funds become available. The Task Force should complete the basic requirement plan, e.g., niches, environmental requirements and constraints, as well as technical specifications, e.g., tunnel lining and basic contractual terms and conditions.

To meet the very tight schedule, the panel makes the following recommendations:

- Put forward a subcontract for the preparation of contract documents for the startup tunnel to be ready for bidding by 30 September, 1990 to a firm experienced in tunnel design and in construction matters. Select a firm that has recent successful experience in design and construction of tunnels, and that has currently available manpower and management resources, permitting immediate start on the job when given notice to proceed. Location of an office near SSC is almost imperative. As an example, a firm such as Brown and Root of Houston could meet these qualifications. In addition, other

companies appear to have similar experience, size, and geographic location, such as DeLeuw Cather and Howard Needles (HNTB).

- The selected firm should be the designer of record for this contract, having developed the entire contract package, with the A-E/CM to exercise general supervision only after assuming A-E/CM responsibilities.

- The Startup Tunnel Task Force should have directions ready for the designer, allowing rapid progress on this package, and keeping it clean and simple. A simple and direct approach should be taken, even if it means that later system-wide decisions may result in this segment being nonstandard in part, or requiring retrofit.

- Provisions should allow the contractor to select construction methods and equipment. As discussed in the next section of this report, the lining system and tunneling equipment must be compatible.

- Because of the short design period and the fact that this is the initial project and the first SSC tunnel in EFS, a relatively conservative design should be developed. A prudent approach, however, does not preclude current technology and innovative procedures. It may be possible, for example, to encourage innovation through Value Engineering provisions in the contract documents.

- The Tunnel Task Force should be the liaison between the subcontractor and the client (the Physics Group) furnishing and interpreting requirements, and expeditiously resolving uncertainties or open questions.

- Have documents prepared describing the segment for which funds are expected to be available in September, 1990 as a base bid. Set forth the remainder as an option, to be exercised after award of the contract if and when funds become available. With this caveat, the method for determination of the low bidder should be spelled out in bidding documents. The panel recommends that it be the combination of base bid plus option.

There is ample precedence in construction practice for setting up design contracts for individual segments of an underground system. Several metro systems, such as the Washington, D.C. Metro, were developed as separate work packages by section designers under the supervision of a general A-E/CM.

STARTUP TUNNEL: TECHNICAL ISSUES

It is recommended that exploration along the startup tunnel be concentrated at shaft locations, in areas where the tunnel face will be in both shale and chalk, and in areas where jointing or faulting in the EFS is a possibility. Angle borings in the vicinity of known or suspected concentrations of joints, shears, and faults should be performed. In addition, angle borings should be considered at locations where adits from shafts intersect the main beam tunnel. Much of the exploration emphasis should be placed on the conditions of the EFS.

Geotechnical staff and contractors currently working on the project should prepare a geotechnical data summary* for the contract section that can be used by the section designer and, ultimately, potential construction contractors. A geotechnical interpretive report* for use in design and inclusion in the contract documents also should be prepared by the geotechnical team. The final version of the report should be compatible with the section design and should be a cooperative effort between the section designer and the geotechnical team.

Electrical alcove spacing has been increased to approximately 2000 ft, which appears appropriate for minimal impact on tunnel cost and construction

*The geotechnical data summary should provide the factual data, presented in a clear and well-organized package. The geotechnical interpretive report sets forth the engineer's interpretations about anticipated conditions for design and construction. The interpretive report sometimes is referred to as the Geotechnical Design Summary Report (GDSR). For additional information about these reports with descriptions and examples, please refer to the following references:

1. Technical Committee on Contracting Practices, "Avoiding and Resolving Disputes in Underground Construction," Underground Technology Research Council, ASCE, New York, NY, 1989.
2. Technical Committee on Tunnel Lining Design, "Guidelines for Tunnel Lining Design," T. D. O'Rourke, Ed., Underground Technology Research Council, ASCE, New York, NY, 1984.

schedule. Spacing of the cryogenic alcoves also is consistent with a minimal effect on cost and schedule. The shaft layout and proposed excavation sequence appear feasible, and the deployment of shafts for the construction contractor and scientific use is appropriate. The tunneling contractor should be provided as much flexibility as possible for scheduling and access within the constraints necessary to meet scientific needs.

Lining designs must be compatible with excavation equipment and procedures. There may not be sufficient time in preparing this contract to allow potential contractors to submit proposals for a lining and excavation method to be included in the evaluation of bids. In this case, it will be necessary to make specific statements in the contract documents regarding the type of equipment considered appropriate for the support systems that are specified. Before the start of the section designer's work, it is recommended that acceptable lining-excavation schemes be prepared and reviewed so that specifications can be prepared once the section designer is in place.

It appears that properly designed tunneling machines and segmental lining systems will be appropriate. The machine and linings, however, must be designed to cope with potentially extensive ravelling conditions above the cutters and around the machine.

Instrumentation should be deployed in the startup tunnel to evaluate the tunnel and lining performance at select locations. Such a program needs to avoid significant interference with the contractor, and could include strain gage measurements in lining segments, lining convergence measurements, and monitoring of rock movement behind the lining. Measurements from shafts and adits adjacent to the main beam tunnel might be used to monitor rock performance as the tunneling machine passes. Emphasis should be placed on obtaining

information on overbreak and loosening near the heading. The data will be helpful in evaluating performance and preparing designs for future tunnels in shale or marl.

GROUNDWATER AND SUBSIDENCE MONITORING

The proposed array of surface monuments appears to provide suitable vertical and horizontal controls for detecting and monitoring subsidence. In addition, the panel acknowledges and supports the efforts underway to obtain access to wells so that records can be acquired of water levels throughout the area of the SSC. The panel recommends that the U.S. Geological Survey be approached formally to obtain information vested in that agency about pertinent groundwater surveys. Future vertical and horizontal surveys should be interpreted in conjunction with well data and projections of regional water demands.

The panel recommends that additional scrutiny be given to the benchmarks being used as the basis for current project coordination. These benchmarks appear to have been established many years ago. If future measurements and benchmark systems will be tied to or coordinated with these points, care must be taken to assure that the current system has been established and documented on a dependable basis.

Where master monuments are established in the Taylor Marl or shallow soil overlying the Taylor Marl, it is recommended that the stainless steel rods of the monuments be anchored well into the marl. The currently proposed bottom levels of the rods appear to be too shallow, and it is advisable to consider anchoring these devices at depths of 15 to 30 ft with the aid of rotary drilling. Consideration should be given to using one or more of the current

exploration borings for permanent, deeply anchored vertical control points.

The Texas National Research Laboratory Commission (TNRLC) should be encouraged to participate in and support surveys of regional monument arrays. There seems to be ample justification for support from TNRLC, because data on regional vertical and horizontal movement will be of value to local Texas communities, as well as the SSC.

LOCATION OF THE RING

As put forward in the previous two UTAP reports, the panel again recommends that consideration be given to raising the elevation of the ring to reduce the amount of tunneling in EFS and, more importantly, to decrease or eliminate exposure of EFS at the bases of the large detector halls. The currently proposed base elevation of the IR-2 Hall is just below the top of EFS. Even small adjustments on the order of 10 ft would improve the foundation conditions at this location. A 10-ft-thick layer of Austin Chalk above EFS, for example, would help insulate the EFS from moisture intrusion through the bottom of the excavation and provide a stable working platform for construction activities, including the installation of large diameter dowels.

An alternative approach might involve changes in the detector design. If the distance between the beam line and base of the detector could be reduced, this would elevate the bottom of the machine and potentially eliminate the need to excavate below the Austin Chalk/EFS contact. Significant benefits in excavation stability and decreased long-term settlement of the detector could be gained from this type of modification.

EXPERIMENTAL HALLS

The panel was given an overview of the layouts of experimental halls that have been used for cost estimating purposes. The panel recognizes that changes in layouts will occur when the designs of the detectors and other equipment are finalized.

The IR3-L* Hall will be located in Austin Chalk and the underlying EFS. It is envisaged presently that benched cut slopes will be excavated using a ramp down to the top of the collision hall proper. Below that elevation, vertical walls will be used.

The panel finds this solution to be reasonable in principle. It is possible, however, that substantial stabilization efforts will be necessary in the lower part of the walls and the invert, both located in the EFS.

If chamber widths are reduced and assembly halls eliminated, it may become more feasible and economical to excavate the halls as rock chambers. As discussed in the UTAP report following the meetings of September 18-19, 1989, sound rock above the crown equal to one-half to three-fourths or more of the excavation span is desirable for a rock chamber.

For an open cut or chamber excavation penetrating the EFS, it will be necessary to tie down the bottom with grouted dowels or drilled piers to minimize buckling and disturbance, as well as subsequent time-dependent settlement under the weight of the detector. To minimize differential settlement, it may be necessary to place the detectors on drilled piers.

For excavations in Taylor Marl, a construction sequence similar to that for Austin Chalk and EFS has been devised for cost estimation purposes, using somewhat flatter benched slopes. The panel recommends that alternatives using vertical supported walls be considered, too. Vertical support may consist of

drilled shafts which would be contiguous or set at relatively small separations around the excavation perimeter.

Open cut excavations in Taylor Marl or penetrating EFS will require special measures to maintain stability of the walls, including the possibility of excavating relatively flat slopes or using long, high capacity anchored tiebacks. The chalk above the exposed EFS also will be subject to instability if the EFS is allowed to displace into the excavation. Additional excavation or support should be included in the estimates for open cut excavation.

Open excavations for experimental halls have been evaluated to date primarily as rectangular cuts with sloped walls. Some consideration should be given to large circular and vertical excavations, which would employ ring beam or other types of support. One such scheme, suggested by James Lilly, is enclosed in Appendix B as an example of this type of approach.

APPENDIX A

SSC UNDERGROUND TECHNOLOGY ADVISORY PANEL

MEETING AGENDA

Wednesday, December 13, 1989

Omni Melrose Hotel, 3015 Oaklawn Avenue, Dallas, TX 75219
Telephone: (214) 521-5151

Thursday, December 14, 1989 8:30 a.m. - 6:00 p.m.

SSC Laboratory, 2550 Beckleymeade Avenue, Building #4
Dallas, TX Telephone: (214) 708-1043

Morning Session - Presentations by SSC Staff, RTK

8:30 - 9:30	Project Status - New Layout	Timothy E. Toohig
9:30 - 10:45	Site Characterization Update Experimental Halls Injection Area Service Areas	Matt Werner
10:45 - 11:00	BREAK	
11:00 - 12:15	Testing Program, Laboratory & Field (borehole)	David Kiesling
12:15 - 1:00	LUNCH (catered, in-house)	

Afternoon Session - Presentations, continued

1:00 - 2:00	Data Formats - Data Basing - Document Archiving	David Kiesling Tracy Lundin
2:00 - 3:30	Rock Mass Computer Modeling - Constitutive Models - Opening Models, LDD/L*	Priscilla Nelson
3:30 - 3:45	BREAK	
3:45 - 5:00	Rock Mass Measurements - Instrumentation Packages - Drilled Shaft - Test Tunnel Sections	Priscilla Nelson Mack Riddle
5:00 - 6:00	UTAP Commentary/Draft Comments	

Friday, December 15, 1989 8:15 a.m. - 6:00 p.m.

SSC Laboratory, 2550 Beckleymeade Avenue, Building #4
Dallas, TX Telephone: (214) 708-1043

Morning Session - Presentations by SSC Staff, RTK

8:15 - 10:00	First Tunnel Sector Layout Construction Scenario	Tracy Lundin Timothy Toohig
10:00 - 10:15	BREAK	
10:15 - 10:45	Detector Hall Update - Modified Configurations, etc.	Mack Riddle
10:45 - 11:15	Monumentation - Regional Subsidence - Monitoring	Don Scapuzzi
11:15 - 11:30	Vibration Study Summary	Priscilla Nelson
11:30 - 12:30	LUNCH (catered, in-house)	

Afternoon Session - UTAP: Discussions & Draft Document Revision

(Suggested Schedule)

12:30 - 1:30	Site Investigation and Lab Work
1:30 - 2:30	Rock Mass Modeling and Monitoring
2:30 - 3:00	First Tunnel Sector & Hall Layouts
3:00 - 4:00	UTAP Recommendations/Action Items

ADJOURNMENT

ATTENDANCE

UTAP Meeting of December 14-15, 1989
SSC Lab, Dallas, Texas

Tor L. Brekke	UTAP Consultant
Edward J. Cording	UTAP Consultant
Robert Crawley	SSC
John Dunnicliff	Instrumentation Consultant
James P. Gould	UTAP Consultant
Jeffrey Grossholz	SSC Engr. Evaluation
David Hammond	UTAP Consultant
Edward Kavazanjian	TETC
David R. Kielsing	TETC
Jim Larsen	SSC
Jack K. Lemley	UTAP Consultant
James A. Lilly	UTAP Consultant
Tracy Lundin	SSC
Robert M. Matyas	UTAP Consultant
Priscilla Nelson	SSC
Thomas D. O'Rourke	UTAP Chairman
Mack Riddle	RTK
Donald Scapuzzi	RTK
Robert K. Tener	SSC
Timothy H. Toohig	SSC
Matt Werner	TETC

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01/15/90

APPENDIX B

MORRISON KNUDSEN CORPORATION

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PHONE (208) 386-5800

J.A. LILLY
SENIOR DEPUTY

May 5, 1989

Professor Thomas D. O'Rourke
10 Twin Glens Road
Ithaca, New York 14850

Dear Professor O'Rourke:

As we discussed, following is the constructability review.

It is generally accepted that the tunnels constructed in the Taylor Marl, Austin Chalk and Eagle Ford Shale will set footage advances beyond anything recorded to date. The continuing development of state-of-the-art machines, both full force TBM's and articulated road-header type equipment, along with improvements in muck handling and protective lining systems are on-going and should produce some spectacular speeds.

We do not see any significant differences in tunneling costs between the initial profile and the February 17, 1989 profile. Hoisting costs will be slightly higher using the revised profile (average added hoisting of 35'±).

The development of the four main equipment halls offer some interesting alternatives, all of which are considered feasible:

(1) Small shaft and cavern concept: For the construction of the physical housing facility, this is an efficient method. However, the handling and placing of equipment will be expensive.

(2) Open cut with sloping benches and 10% access ramp: Excess excavation (and backfill) and even with shotcrete slopes, there are concerns with sloughing and raveling over time. Limited work and laydown area for equipment.

(3) Large area vertical shaft concept (see sketch): Much less excavation and backfill than open cut method. Better laydown areas. Size allows use of efficient excavation tools (rooters, loaders, bucket elevators, etc.)

Variations of these methods are possibilities.

Very truly yours,

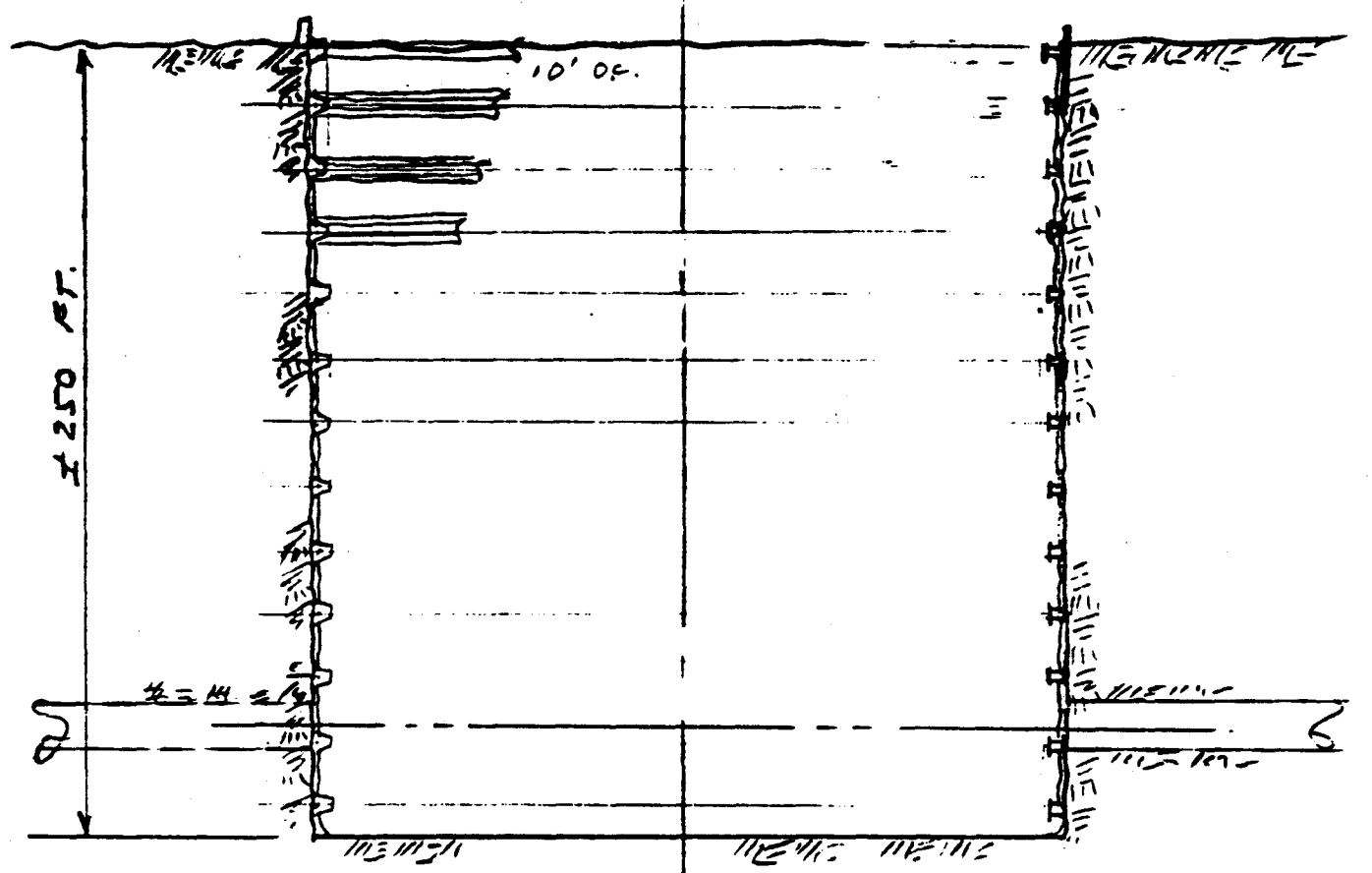
JAL/gs

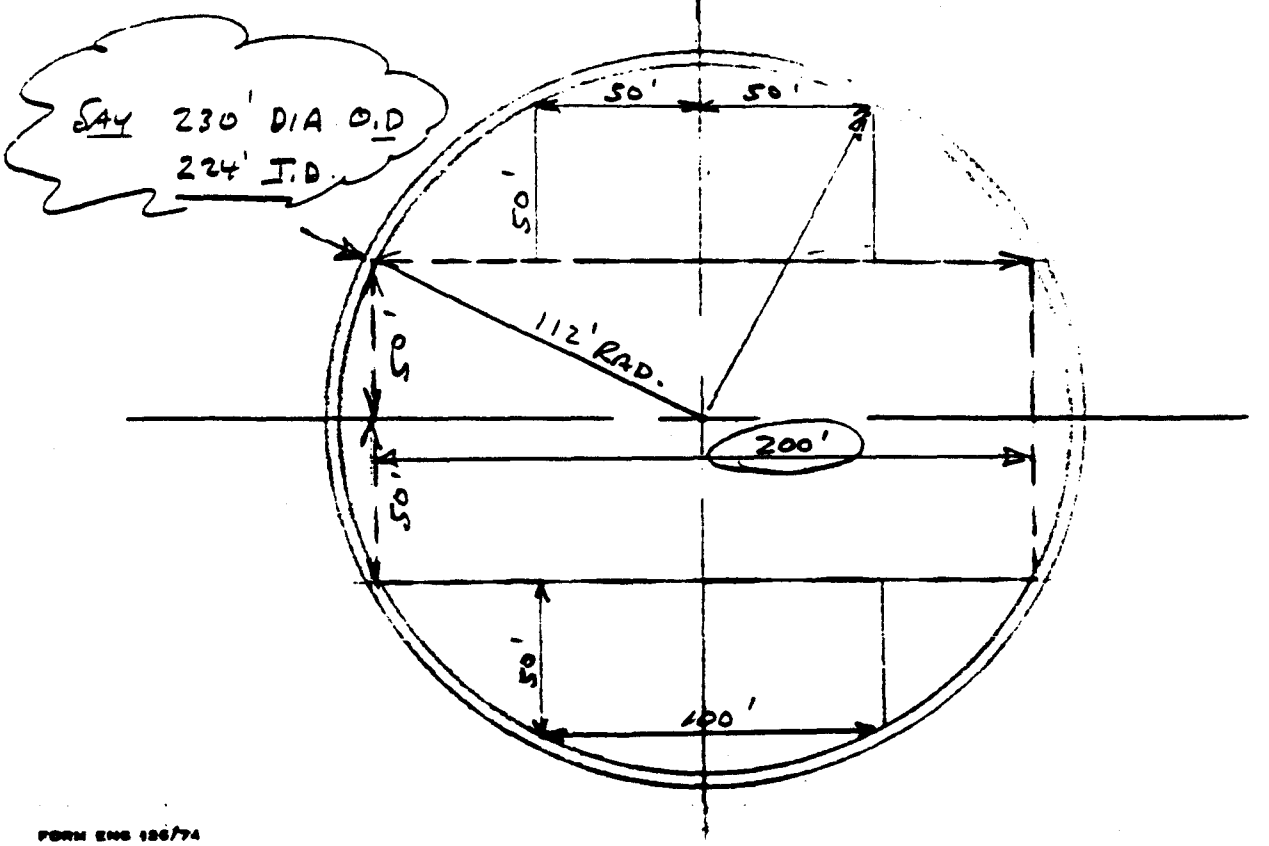
COMPANY

JOB TITLE: CONCEPT STUDY - LARGE SHAFT ? CONTRACT NO.

DESCRIPTION: FUEL BOLLARD - MACHINERY SPACES, OPEN SHAFT W/ GUNITE SUPPORTS SHEET NO. 1 OF 3

MADE BY: W E McDaniel CHECKED BY: DATE: 5-5-85





FORM ENG 126/74

COMPANY

JOB TITLE CONCEPT STUDY – LARGE SHAFT ? CONTRACT NO.

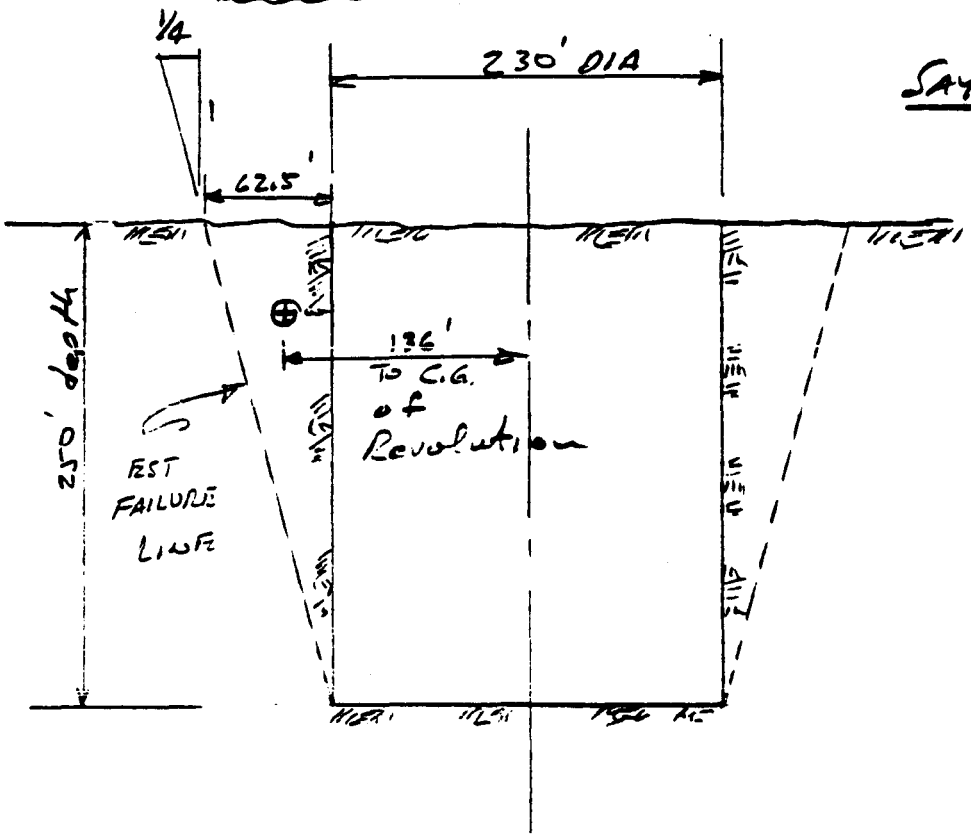
DESCRIPTION SUPER COLLIDER – MACHINERY SPACE

SHEET NO. 2 OF 3

MADE BY W. E. McDaniel CHECKED BY DATE 5-5-89

LARGE SHAFT IN SHALE OR CHALK WHAT SUPPORT WOULD BE REQ'D ?

SAY WOULD STAND FOR SOME TIME @ 1 VERT : ¼ HORIZ



VOL OF SLIDING SOIL $= \left(\frac{62.5'}{2}\right)(250') \times (136' \times 3.14 \times 2)$

$= 6{,}672{,}500$ CF $\times$ 135 PCF $=$

$= 900{,}800$ KIPS

REQ'D LATERAL RESISTANCE $= 900{,}800$ K $\times .25 = 225{,}200$ KIPS

EST RING BEAMS @ 10' C/C $= \frac{250}{10'} = 25$

Ring Compression / Ring Arc $= \frac{225200^k}{25 \times 2} = 4504$ KIPS

Check Shot-Crete:

6" × 84" × $\frac{1500 \text{ PSI}}{1000}$ = 256^k

Beam Arc. 3' × 4' = × $\frac{2500 \text{ PSI}}{1000}$ = 4320

} 5076 KIPS OK

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COMPANY

JOB TITLE Concept Study - Large Shaft CONTRACT NO.

DESCRIPTION Super Collider - Machinery Space

SHEET NO. 3 OF 3

MADE BY W. E. McDaniel CHECKED BY DATE 5-5-89

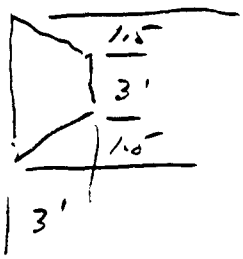
Est. Quantities:

Shaft Excav. $(.785)(230)^2(250)/27$ = 385,000 cy

6" Gunite Cover:

$250 - (25)(3.5') = 163'\text{ Ht} \times 3.14 \times 230' \times \frac{.50'}{27}$ = 2,200 cy

Gunite Beams:



$(3.14)(230') = 723'$ Circumf

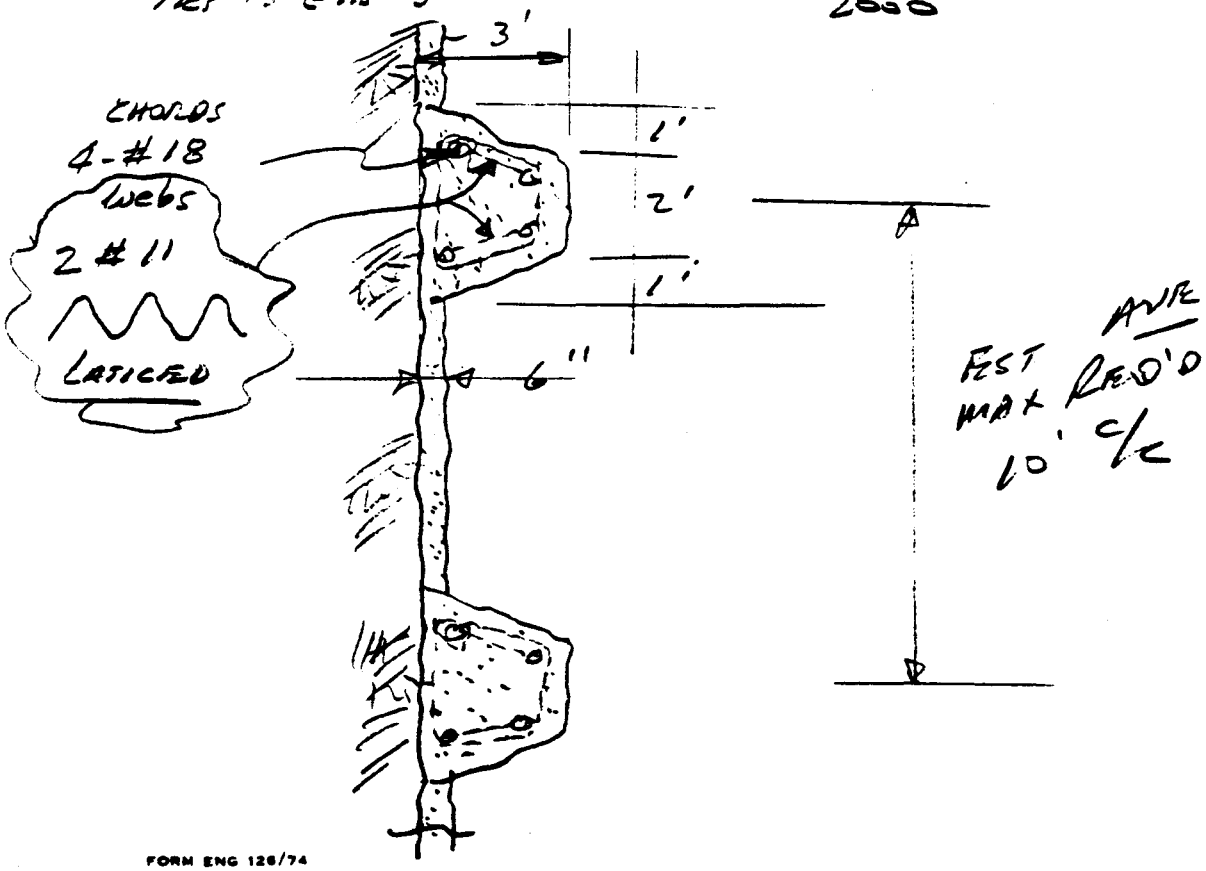
$3' \times \frac{4.5' \times 723'}{27} = 362$ cy/Tea × 26 9400 cy

11,600 cy

Rebar:

4 #18
2 #11 Webs
Ties #3 @ 1.5'

$\pm 120\#/' \times 723 = \frac{87{,}000\#/\text{Rms} \times 26}{2000}$ Say 1200 Tons



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