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SITE-SPECIFIC DESIGN OF THE SUPER COLLIDER IN TEXAS*

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Synopsis

This paper will outline the scope of the Superconducting Super Collider (SSC), underground works and present the current accelerator layout. After a brief overview of the site geotechnical characteristics, emphasis will be placed upon the possibilities for the incorporation of mechanical excavation technology into the construction of the various underground structures.

Introduction

The SSC Laboratory facilities, sited some 25 miles south of the city of Dallas, Texas, (see figure 1) will provide the United States with the most powerful high energy physics, colliding beam particle machine yet envisaged and as such it will allow man to probe

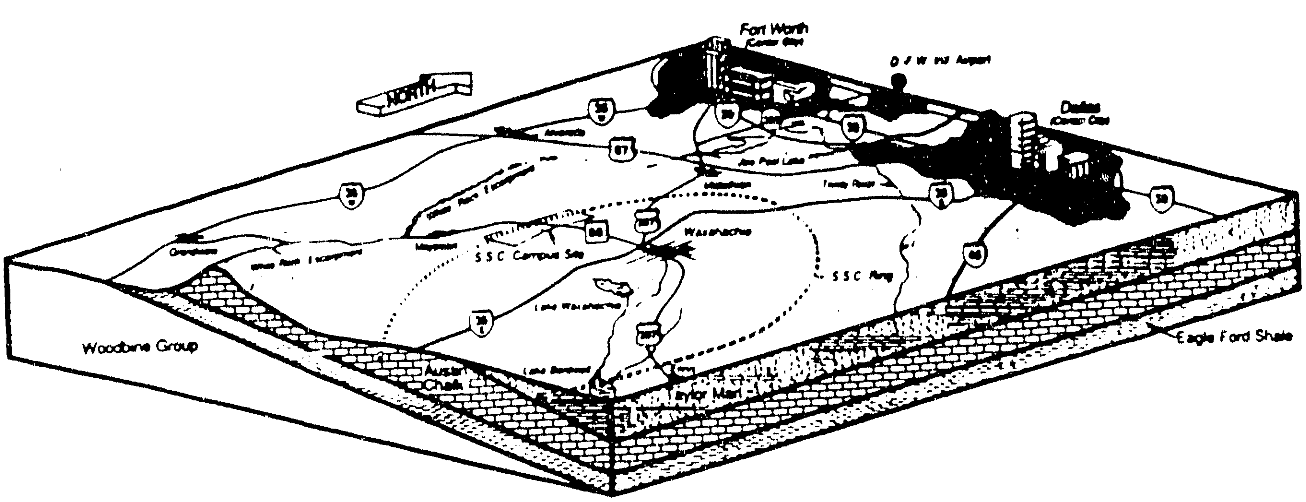

Figure 1 - Schematic Location of SSC Facilities

deeper into the sub-nucleic regime of forces and matter.

The machine follows a conventional colliding beam layout, taking the relatively slow moving, low energy protons through a series of accelerators (Linear Accelerator - LINAC, Low Energy Booster - LEB, Medium Energy Booster - MEB, High Energy Booster - HEB) into the 54 mile SSC main tunnel, where both clockwise and counterclockwise particle orbits are accelerated within separate magnet strings (see figure 2). Along these magnet strings, proton-proton collisions are produced at precise interaction points and it is here that the experimental physicists will be able to observe the results of collisions taking place at energies never before attained.

The main components of the accelerator and experimental facilities will be housed underground within the bedrock materials of the Texas site. A total of some seventy miles of tunnel and four experimental halls are to be constructed for initial operation of the machine which will be commissioned before the arrival of the next millenium.

A sizeable amount of accelerator and experimental services will be housed on surface, and a series of some 30 shafts will be used to provide access for installation drops and give the necessary umbilical connections for power, cooling, ventilation, machine control networks, etc.

Although

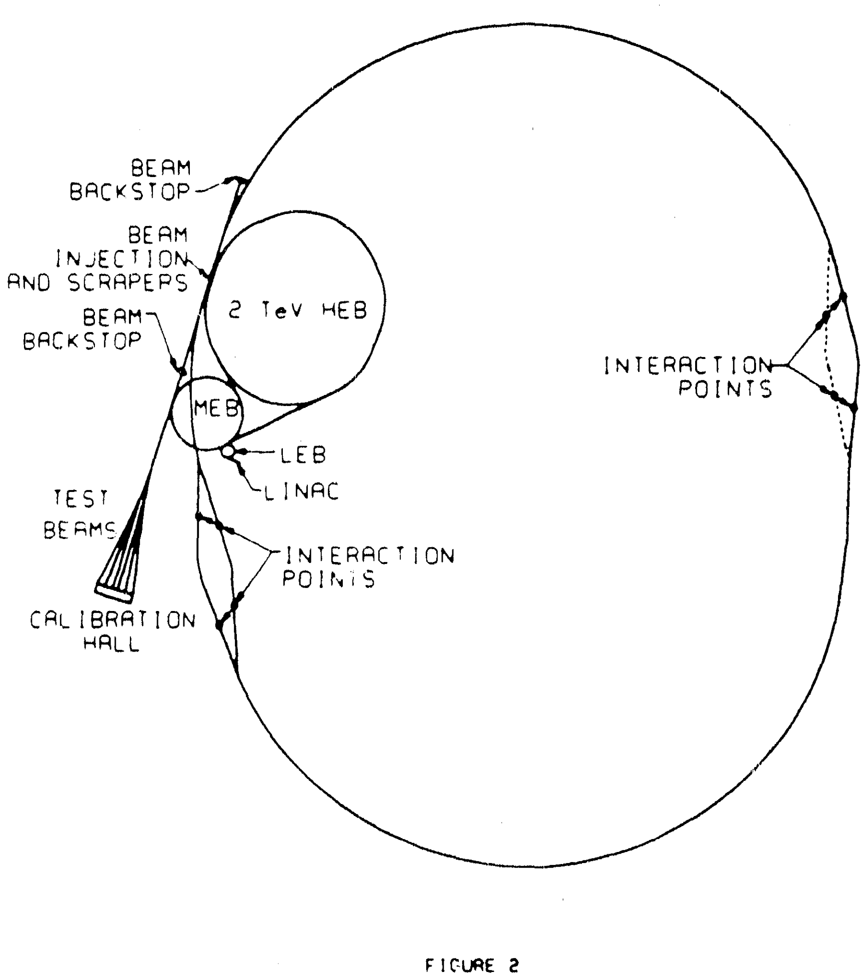

FIGURE 2

SSC ACCELERATOR SCHEMATIC

NOT TO SCALE

similar in conception and technical design to existing experimental facilities elsewhere, the SSC will be by far the biggest machine of its kind ever constructed and it represents a formidable logistical challenge to all involved. The Laboratory will undertake parallel design and construction of accelerator and experimental facilities on a scale never before attempted.

Site Geology

General

As is shown schematically in figure 1, the underground structures are sited within a set of Upper Cretaceous rocks, which dip gently to the southeast. Of this set the Taylor, Austin, and Eagle Ford Groups make-up the rock structure within which the laboratory complex will be housed. Only the Taylor and Austin rocks outcrop at the site and are locally covered by terrace and alluvial deposits lying along present-day or ancient stream alignments.

Inactive normal faulting is commonly encountered around the site, giving offsets of up to 50 feet. The faults are usually localized in character and the contact surfaces generally tight and sealed by calcite at depth.

Description of the site Geological Units

Overburdens

Recent alluvial and Quaternary terrace deposits overlie parts of the site and thicknesses of up to 50 feet were encountered during the initial site investigation. Care has been taken to ensure that such deposits are precisely defined and avoided for the tunnel and hall excavations by optimization of the ring structure. The service shafts will also be located outside flood plain limits and deep overburden zones where practicable.

Above the Austin Chalk only thin topsoil and weathered zones are present; unweathered bedrock is normally obtained within ten feet from the surface. Above the Taylor Marl weathering has been more extensive and depths to fresh rock of up to 50 feet may be expected.

Taylor Marl

At the site location only the lowermost formation of the Taylor Group is present. This marl is in essence a claystone containing varying amounts of calcareous material. A relatively high percentage of illite and montmorillonite clays are present within the rock matrix (60-70%). Occasionally bentonite-rich or chalk interbedding is present within the structure. Care is needed to prevent the onset of alteration during excavation and support work given the presence of these clay materials.

The Taylor Marl is readily classed as a "soft rock" for excavation purposes. A table of average rock properties is given in Figure 3. From an analytical standpoint a good correlation is noted between carbonate content and Uniaxal Compressive Strength (Nelson, 1987).

Austin Chalk

The Austin Chalk consists of a grey micro-granular calcite matrix with occasional claystone interbedding. The calcite content of the material is on average around 85%.

Again, although generally stronger than the Taylor Marl and less susceptible to deterioration, this rock is "soft" in excavation terms and is considered to present an excellent housing material for all the subsurface laboratory housings.

Figure 3

Representative Average Physical Properties of SSC Rock Materials

Parameter	Taylor Marl	Austin Chalk	Eagle Ford Shale
Compressive Strength (psi)	400	2230	310
Dry Density (pcf)	122	128	120
Water Content (%)	16	12	15
Slake Durability (%)	23	91	9
Carbonate Content (%)	23	85	6
Liquid Limit	80	30	93
Plasticity Index	51	10	63

Source: Texas National Research Laboratory Commission, 1987

Eagle Ford Shale

Only the upper part of the Eagle Ford Group will be touched by the excavation works. The "soft" black-gray monmorillonite shale has a considerable shrink-swell potential and is highly susceptible to alteration. As with the marl, the presence of carbonate improves the strength parameters of the material. In this material great care will be taken to protect all excavated facesand prevent large-scale heave or settlement developing.

Hydrology

The main bedrock water table is sited more than 250 feet below the tunnel plane. Perched water tables are present in the overlying alluvial and terrace deposits but the intact strata are relatively impermeable and any connection with superficial aquifers should be limited to connecting fracture networks, few of which are expected to be at tunnel depth.

Site Geotechnical Optimization

Following improved topographic and subsurface detail and changes in the machine layout, the complex has been precisely defined within the host strata. From a geotechnical perspective, efforts were made to maximize the amount of hall tunnel and shaft structures in the chalk and marl. However owing to machine and topographic constraints it was not possible to avoid the shale completely and a compromise was struck between construction and accelerator operational parameters. The profile shown in Figure 4 represents a balance between such construction and operational considerations. The planar tilt of the ring will

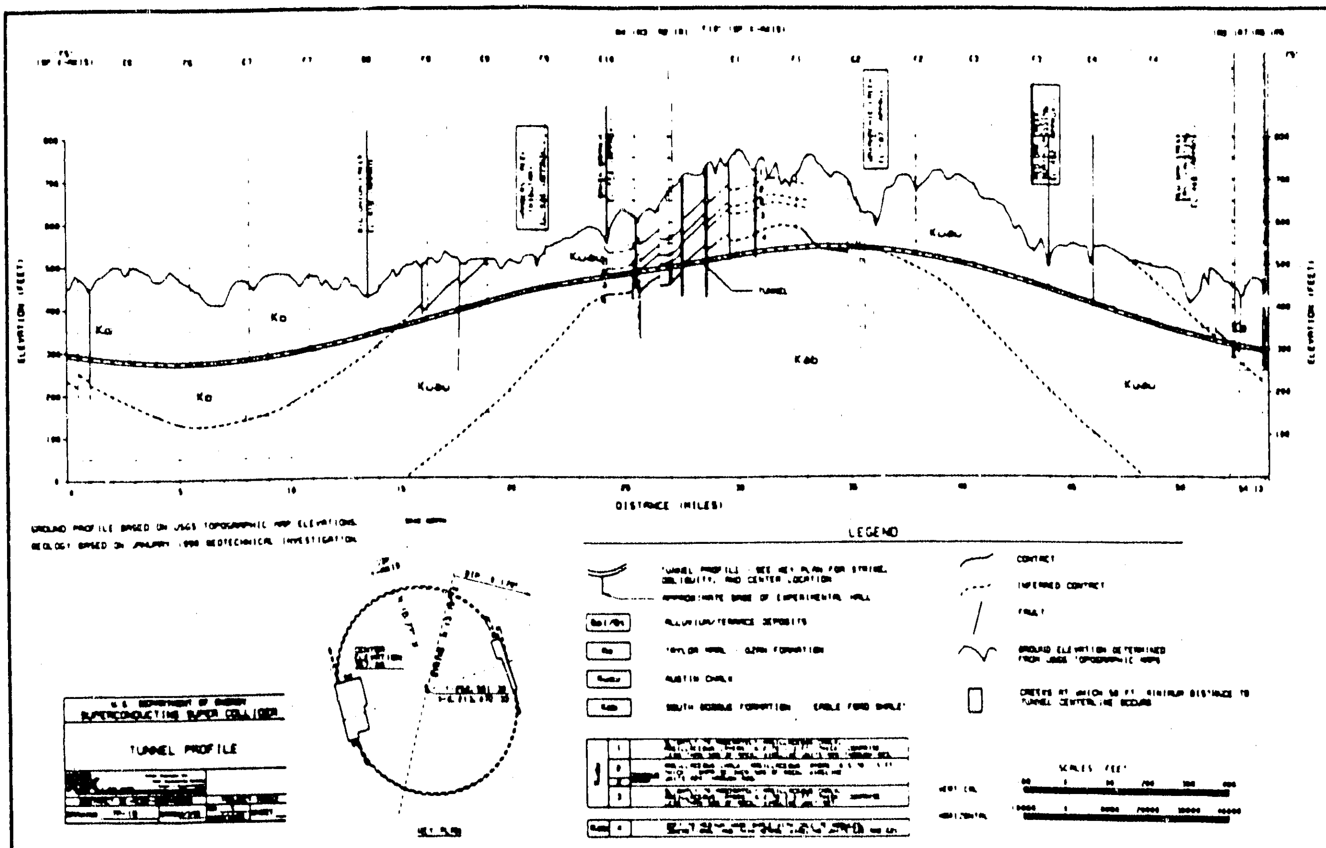

Figure 4 - Longitudinal Geological Profile along the Tunnel Path (54 miles)

be approximately 0.2°, which will produce relatively shallow tunnel and shaft depths, ranging from 75 to 250 feet. Similarly the four experimental hall sites, which are presently being considered as potential open-cut structures, are sited at depths of 200 feet to floor level

Mechanical Excavation Applications on the SSC Site

The Texas site conditions are extremely favorable for the adoption of mechanized excavation techniques and it is probable that no significant drill and blast work will be performed during construction. Tunnel boring machines and roadheaders should give excellent advance rates for all the tunnel and chamber excavations. In the experimental halls, open-cuts using heavy plant techniques (ripper, face shovel, etc.) are envisaged.

The use of shallow drilled shaft structures is being considered in various areas of the project, from site investigation through to providing a final design element.

To aid investigation of the Eagle Ford Shale, the material upon which the larger experimental detectors will be founded, plans have been developed for large scale in-situ tests within a 12 foot (10 foot at base) drilled shaft, (see Figure 5). The investigation will be carried out next to the largest detector housing to study the rock behavior upon excavation and under controlled reloading conditions. "LS'AR", the detector in question presently weighs-in at approximately 50,000 tons and will be sited in a subsurface housing with a floor space requirement of 130 ft x 360 ft. The stability of all the machine elements, magnets and detectors is essential to successful laboratory operation. The detectors in Eagle Ford Shale represent, at this stage of the project, the highest risk element to the the long-term structural stability of the underground complex. Long-term settlement or uplift, caused by swelling, either of which could be generated by the Eagle Ford Shale material, would considerably reduce machine performance or require a complete shut-down for realignment operations. Given the overriding requirement for a stable machine foundation, drilled piers may well prove to be the best means of stiffening the rock matrix. In fact, measures may well be taken to stiffen the foundation strata well before the final excavation level is reached, in order to reduce final heave levels at formation level. An attractive application of drilled piers is also in the pre-support of deeper overburdens and the soft rock matrix for circular shaft and experimental hall sidewalls.

Shaft diameters of between 8 and 60 feet are being considered at present to fulfill a variety of installation and operational functions. Accelerator magnets are at present planned to be dropped down main shafts sited at 5.4 mile intervals. These large shafts which may well be up to 60 feet in diameter will serve for all the principal machine utility connections. Secondary shafts, interspaced between the main shafts will be equipped primarily to serve for personnel evacuation and ventilation. At the experimental zone locations at least two shafts per hall are envisaged to facilitate equipment and personal access.

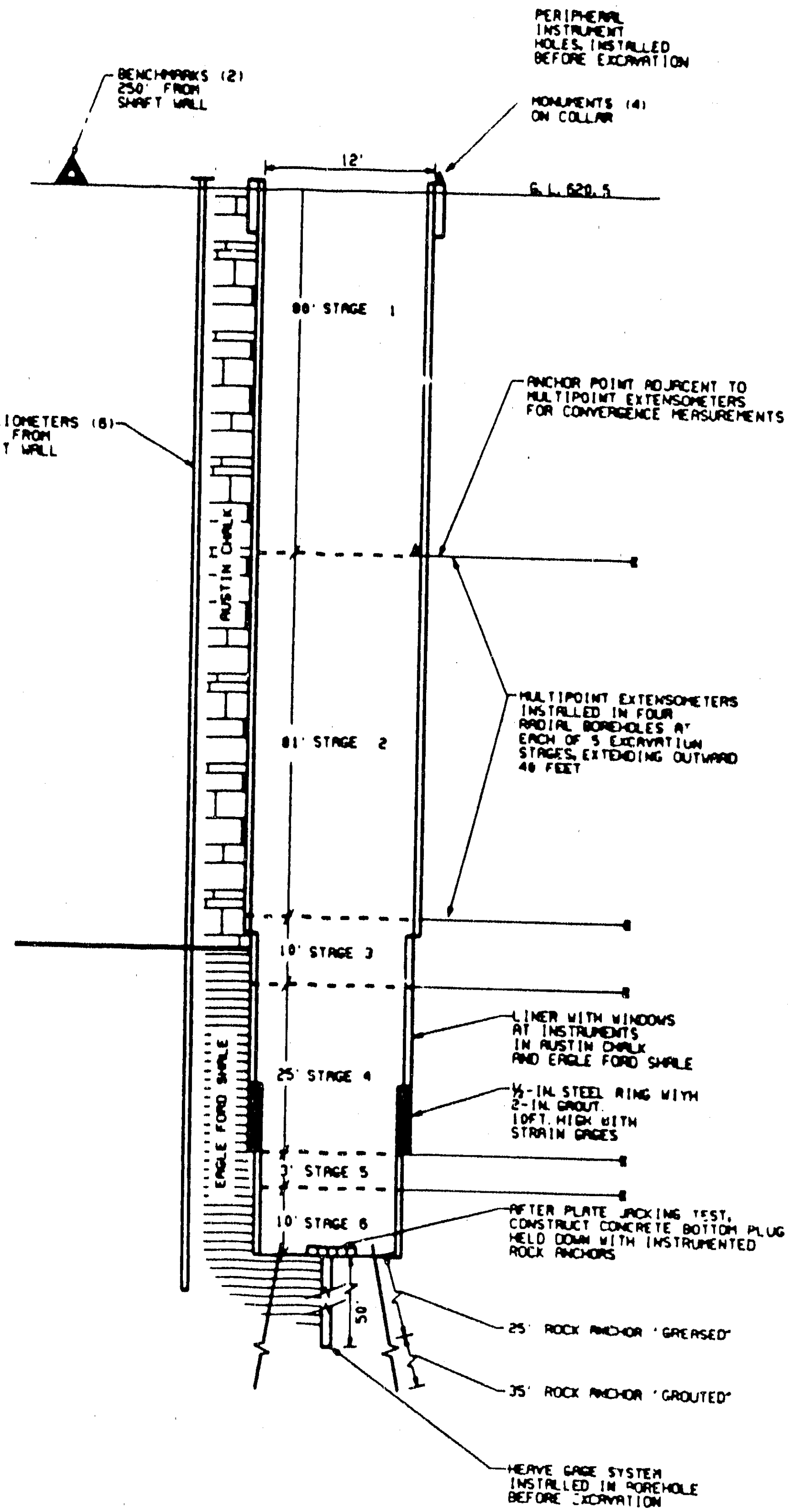

Figure 5 - Large Diameter Drilled Hole; Longitudinal Section

Concluding Remarks

Work is underway to define the near and long-term requirements of the facilities, both of which are proving difficult to pin down, given the complexity and state of the art technologies involved.

With the beginning of the land acquisition process and arrival of the new Architect-Engineer/Construction Manager it is hoped to start final engineering design and sink the first accelerator shaft in the first half of 1991.

Mechanical excavation techniques appear extremely suitable for inclusion upon the SSC project and it is hoped to benefit from industrial expertise during conception and design of all the subsurface structures.

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