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Raba-Kistner Consultants, Inc.

Engineers, Geologists, Chemists, Water Planners
Hygienists and Environmental Scientists

SOIL AND FOUNDATION STUDY

FOR

ACCELERATOR SYSTEM STRING TEST (ASST) FACILITY

SURFACE STRUCTURE - E1 SITE

SUPERCONDUCTING SUPER COLLIDER PROJECT
ELLIS COUNTY, TEXAS

SOIL AND FOUNDATION STUDY

FOR

ACCELERATOR SYSTEM STRING TEST (ASST) FACILITY

SURFACE STRUCTURES - E1 SITE

SUPERCONDUCTING SUPER COLLIDER PROJECT
Ellis County, Texas

Prepared for

THE PB/MK TEAM

By

RABA-KISTNER CONSULTANTS, INC.

Project No. ASA91-020-00
April 5, 1991

EXECUTIVE SUMMARY

Subsurface foundation conditions at the site of the proposed SSC Service Area and ASST Facilities at the E1 Site were explored by six borings drilled to depths varying from 18.6 to 35 ft below existing grade. Laboratory tests were performed on selected specimens to evaluate the engineering characteristics of the various soil and rock strata encountered in our borings. Our study was supplemented by field exploration and laboratory analyses performed previously by Mason-Johnston and Associates (MJA Report No. 5730.02, dated February 1, 1991).

The soils/rock encountered at this site may be grouped into three generalized strata. Stratum I consists of firm to hard, plastic to highly plastic, brown to dark brown clays; Stratum II consists of soft to moderately hard, tan, fossiliferous, weathered limestone; and Stratum III consists of moderately hard, gray, unweathered limestone. Total potential vertical movements varying from 1/2 to 1-3/4 in. were estimated for at-grade construction at this site due to the swelling characteristics of the Stratum I clays. We recommend that the potentially active Stratum I clays be completely removed from beneath all soil-supported building slabs and pavements to reduce expansive soil-related movements to negligible values.

The proposed structures may be supported on straight drilled shafts bearing a minimum of 2 ft into the Stratum III unweathered limestone. The drilled shafts may be designed using a maximum allowable end bearing capacity of 71,000 psf. In addition, the drilled shafts may be designed for allowable side shear resistances in compression and tension of 22,600 psf and 11,200 psf, respectively, for that portion of the shaft penetrating unweathered limestone. Temporary casings may be needed at the time of pier construction to control ground water seepage.

The ASST string enclosure may be supported on the preferred shallow beam and slab foundation. Grade beams and widened pads founded in the weathered Stratum II limestone may be designed using an allowable bearing pressure of up to 8,500 psf, while beams and pads bearing in compacted, select structural fill may be proportioned using a maximum allowable bearing capacity of 2,500 psf.

Engineers, Geologists, Chemists, Water Planners, Hygienists and Environmental Scientists

Raba-Kistner Consultants, Inc.

12821 W. Golden Lane
P.O. Box 690287, San Antonio, TX 78269-0287
(512) 699-9090 FAX (512) 699-6426

Project No. ASA91-020-00
April 5, 1991

Mr. Charles Daugherty
The PB/MK Team
Redbird Business Center, Building 5
5610 Redbird Center Drive, Suite 400
Dallas, Texas 75237

Soil and Foundation Study
Accelerator System String Test (ASST) Facility
Surface Structures - E1 Site
Superconducting Super Collider Project
Ellis County, Texas

Dear Mr. Daugherty:

Submitted here is a report of our study of soil and foundation conditions at the proposed E1 Service Area and ASST Facilities of the Superconducting Super Collider Project located in Ellis County, Texas.

Presented in this report are our conclusions and recommendations pertaining to the type and depth of foundations and associated allowable bearing pressures for the structures contemplated. Verbal progress reports and draft copies of field and laboratory data have been provided to The PB/MK Team during the conduct of this analysis.

This engineering report has been prepared for the use of The PB/MK Team and their design representatives for design purposes in accordance with generally accepted Geotechnical Engineering practices. This report may not contain sufficient information for purposes of other parties or other uses. This study was authorized by Abraham Dennis, Subcontract Administrator, under Subcontract No. SC-A43-1013, dated February 4, 1991. Notice to proceed on services under this subcontract was authorized on February 25, 1991.

We appreciate the opportunity to assist in the development of this project. Please call should you have questions concerning the recommendations presented herein or other aspects of the project.

Very truly yours,

RABA-KISTNER CONSULTANTS, INC.

A. Scot Harrell

A. Scot Harrell, P.E.
Project Manager
Geotechnical Engineering

STATE OF TEXAS
A. SCOT HARRELL
69103
REGISTERED PROFESSIONAL ENGINEER

ASH/mp
Copies submitted: Above (7)

Project No. ASA91-020-00
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INTRODUCTION

Raba-Kistner Consultants, Inc., has completed the authorized subsurface exploration and foundation analysis for the proposed El Service Area and ASST Facility of the West Campus of the Superconducting Super Collider Project in Ellis County, Texas. This report briefly describes the procedures utilized during this study and presents the findings along with our evaluation of the data and recommendations for site preparation and foundation design. This work was conducted under PB/MK Subcontract No. SC-A43-1013, dated February 4, 1991.

SCOPE OF OUR SERVICES

The broad objectives of this study were:

- To evaluate the engineering characteristics of the soil/rock stratigraphy present at the site by an adequate number of borings and laboratory tests.
- To utilize the data together with previous information gathered at the site by others to formulate recommendations for the design of foundations to support the proposed structures and provide construction guidelines.
- To perform earth resistivity and conductivity studies across the site for use in evaluating corrosivity potential of at-grade and buried structures.

LIMITATIONS

The analyses and recommendations submitted in this report are based on the data obtained from six borings drilled at this site, and a review of the findings of others (Mason-Johnston & Associates Report No. 5730.02, dated February 1, 1991). This report may not reflect the exact variations of subsurface conditions across this site. The nature and extent of variations across the site may not become evident until construction commences. If variations then appear evident, it may be necessary to reevaluate our recommendations after performing on-site observations and tests to establish the engineering significance of the variations.

SUBSURFACE EXPLORATION

Borings

Subsurface conditions at the site were explored by six borings drilled at the locations shown on the Plan of Borings, Plate I, in the Illustrations section of this report. The boring locations were selected and surveyed in the field by representatives of PB/MK prior to the start of our field activities. Grid coordinates and surface elevations for the boring locations were provided by PB/MK, and are shown on the individual boring logs. The borings were drilled to depths varying from 18.6 to 35 ft below existing grade. The subsurface exploration was conducted in substantial accordance with established accepted Geotechnical Engineering procedures.

Sampling

The following samples were collected as a part of our subsurface exploration procedure:

Type of Sample	ASTM Procedure	Number Collected
Split-Spoon (with Standard Penetration Test)	D 1586	1
Undisturbed Shelby Tube	D 1587	12
NX Core, feet	D 2113	121

Representative portions of all soil samples, as well as all rock core recovered, were sealed to reduce moisture loss, placed in protective containers or core boxes, and transported to our laboratory for testing.

Standard penetration tests results are noted as "blows per ft" on the boring logs. Where hard or dense materials were encountered, the tests were terminated at 50 blows even if one foot of penetration had not been achieved. These data are conservatively reported as 50 blows per ft in this report.

Samples will be retained in our laboratory for 30 days after submittal of this report. Additional storage time may be arranged at the request of the client.

Field Logs

A field log was prepared for each boring by a staff geologist. Each log contains information concerning the boring method, samples attempted and recovered, indications of the presence of various materials such as silt, clay, gravel, sand or rock and observations of ground water. It also contains an interpretation of soil/rock conditions between samples. Therefore, these logs contain both factual and interpretive information.

Presentation of the Data

The final logs represent our interpretation of the contents of the field logs for the purpose delineated by our client. The final logs are included in the Illustrations section of the Engineering Report, Plates 2 through 7. A key to classification terms and symbols used on the logs appears on Plate 8.

Resistivity/Conductivity Surveys

Earth resistivity and conductivity surveys were conducted at the site at specific grid locations selected and staked by PB/MK representatives. The purpose of the surveys was to provide information for use in evaluating the corrosivity potential of the soils/rock underlying this site.

An ABEM Terrameter Soil Resistance Meter was used for the earth resistivity study. The meter readout of the ABEM Terrameter is in voltage divided by the current, V/I.

The Wenner array was used to conduct a majority of the resistivity survey. Exceptions were grid points C-8 and C-9 (spoils stockpile area), where soundings were conducted using a 4-electrode Price array. Diagrams showing both arrays are presented on Plates 9 and 10. For the Wenner array soundings, the I_1 and I_2 electrodes were placed 7.5 ft from the meter in opposite directions. The V_1 and V_2 electrodes were placed 2.5 ft from the meter in opposite directions. The distance between the I and V electrodes is known as the "A" spacing. Apparent resistivity readings were recorded for only the 5 ft "A" spacing under the Wenner array.

For the Price array soundings, the I_1 and I_2 electrodes were placed 22.5 ft from the meter in opposite directions. The V_2

electrode was placed in front of the meter at the center of the array. The V_1 electrode was initially placed 7.5 ft from the meter on the side of the I_1 electrode and moved in 5 ft increments toward the I_1 electrode. The apparent resistivity was recorded at each increment from the deepest reading to the shallowest reading. The "A" spacings for the Price soundings ranged from 5 to 15 ft.

The conductivity survey was performed using a Geonics EM-31D electromagnetometer. The EM-31 measures the apparent electrical conductivity of the subsurface to depths as much as about 20 feet. The conductivity survey was conducted to assess possible anomalies between resistivity survey points. No strong anomalous readings were recorded during our walk of the resistivity survey site.

Data Reduction The data from the resistivity soundings were reduced on an electronic spreadsheet using Lotus 123. The equations and warp factor corrections are included in the spreadsheet. The Barnes' Layer Method is used to calculate the apparent resistivities for each "A" spacing or depth reading.

Data Presentation The data for all soundings are tabulated on Plates 11 through 16 in the Appendix.

LABORATORY TESTING

Classification

In the laboratory, each sample was examined and classified by a geotechnical engineer. As a part of this classification procedure, the natural water contents and unit dry weights of selected specimens were determined. Liquid and plastic limit tests were performed on representative specimens to determine the plasticity characteristics of the surficial soil stratum. These tests were also helpful in the evaluation of the swell potential of the surficial soils.

Strength Tests

Estimates of the shear strengths of the cohesive soil specimens were obtained with a calibrated hand penetrometer. The shear strengths of selected intact rock core specimens were determined from unconfined compression tests.

Presentation of the Data

In summary, the following tests were conducted in the laboratory to evaluate the engineering characteristics of the soils/rock:

Type of Test	ASTM Procedure	Number Conducted
Natural Moisture Content	D 2216	10
Atterberg Limits	D 2217, D 4318	3
Unit Dry Weight	D 2166	10
Unconfined Compression	D 2938	10

The results of these tests are presented in graphical or numerical form on the appropriate boring log and Plates 17 through 26. For ease of reference, the results have been tabulated on Plate 27.

GENERAL SITE CONDITIONS

Topography

The project site consists of an open, native grass-covered tract of land most recently used for agricultural and livestock grazing purposes. The topography in the site vicinity is described as rolling, with the ground surface at the West Campus site sloping gently downward in an east-southeasterly direction. Existing site drainage is considered to be fair to poor. Recent rains had substantially softened the ground surface prior to our mobilization to the site.

Site Geology

The Austin Chalk is composed of alternating hard and soft layers of white to grayish white, chalky, marly, pyritic and fossiliferous limestone containing some clayey seams. Unweathered Austin Chalk is generally gray or white to grayish-white, and ultimately weathers to produce a thin veneer of dark to light brown, clayey soils containing caliche and platy limestone fragments. The upper portion of the Austin Chalk consists of tan, slightly vugular, moderately weathered limestone containing thin beds of glauconitic, fossiliferous limestone.

Fracturing is common within the limestone portions of the Austin Chalk. These fractures may be open, with some dissolution, or closed, and may contain clays and secondary calcite deposits.

Minor faulting may also be found within the Austin Chalk. The faulting is inactive and displacements are generally less than 10 ft.

Stratigraphy

The soils/rock encountered at this site may be grouped into three generalized strata with similar physical and engineering properties, as described below.

Stratum I consists of brown to dark brown clays and extends to depths varying from 0.8 to 4 ft below existing grades. These clays to grade to tan, calcareous clays at the bottom of the stratum. These clays are indicated to be plastic to highly plastic, with measured plasticity indices varying from 30 to 41 percent. Designated as CH soils under the Unified Soil Classification System (USCS), clays of this plasticity are generally recognized to possess moderate to high shrink/swell potential. The results of the hand penetrometer tests conducted on undisturbed specimens indicate clay consistencies varying from firm to hard.

Stratum II consists of tan, weathered limestone of the Austin Chalk Formation and extends to depths varying from 4.1 to 14.5 ft below existing grades. Vugular zones and intermittent close partings and fractures are common within this stratum. Recovery ratios and rock quality designations (RQD) measured for core runs performed in this stratum substantiate the weathered, vugular nature of the limestone, with RQD values varying from 0 to 75 percent. Unconfined compressive strengths measured for specimens of the weathered limestone vary from 44 to 110 tsf, indicating soft to moderately hard induration.

Stratum III consists of gray to light gray, unweathered limestone of the Austin Chalk Formation and extends to at least the 18.6 to 35 ft termination depths of the borings. Intermittent close partings and clayey/shaley seams are common in this stratum within the depths explored. Recovery ratios were generally excellent for core runs performed in this stratum, while RQD values were variable, ranging between 7 and 92 percent. Unconfined compressive strengths measured for specimens of the unweathered limestone vary from 9 tsf to in excess of 150 tsf, with the lower value indicative of a clayey/shaley core specimen.

Ground Water

Ground water seepage was noted in a number of the borings at the interface of the Stratum I clays and the Stratum II weathered limestone. Ground water seepage is also believed to exist within the upper reaches of the Stratum II weathered limestone underlying this site. Ground water observations were not possible upon commencement of the rock coring operations, since drilling fluids were used to advance the borings through the limestone strata. However, upon completion of the coring operations, attempts were made to bail the drilling fluids from the boreholes for subsequent water level readings. In all instances, water infiltration into the borehole exceeded our ability to bail the hole of much water.

Shallow ground water seepage at this site is believed to be transient in nature, occurring most commonly during and after periods of heavy precipitation. Drainage provisions will be required in the final designs for the Service Area and ASST Facilities to control shallow ground water seepage beneath the building foundations, particularly those buildings with sublevel pits and trenches.

ENGINEERING DESIGN ANALYSES

Structural Information

Based on information provided on the furnished drawings and conversations with design team members, we understand the Service Area and ASST Facilities consist of the Accelerator System String Test (ASST) building comprised of a laydown shop/alcove and string enclosure, the ASST Compressor building, the ASST Refrigeration and Magnet Control building, the Central Utilities Plant building, and assorted smaller, ancillary support buildings. Present plans call for the structural steel-frame buildings to be supported on straight drilled shafts, and the concrete floor slabs to be supported at-grade or on structural fill. An exception to the above is the string enclosure of the ASST building, which is to be founded on a shallow, monolithic beam and slab foundation. Relatively light loads are to be carried by the foundation systems, with anticipated column loads ranging between 50 and 150 kips. Contact pressures beneath the ASST string enclosure are expected to range between 800 and 1500 psf.

With the exception of the string enclosure, proposed finished floor elevation for the Service Area and ASST Facilities is 759.5 ft. Based on the existing topography, cuts varying from 1 to 2.5 ft are anticipated to achieve finished grades for these facilities. Substantially greater cuts (varying from 6.5 to 25 ft in depth) will be required for the isolated pits/trenches located in the ASST Refrigeration/Magnet Control and Compressor Buildings. Finished floor for the string enclosure (ASST) will generally follow existing grades, uniformly sloping from El. 759.5 ft to El. 752.9 ft.

Design Considerations

Review of the borings and test data indicates that the following factors will affect foundation design and construction at this site:

1) The site is generally characterized by a gently sloping topography, a subsurface stratigraphy consisting of surficial clays overlying weathered/unweathered limestone, and shallow ground water seepage.

2) The surficial clays are plastic to highly plastic, and are generally recognized to possess moderate to high shrink/swell potential under fluctuating moisture conditions. Fortunately, the shallow nature of these soils render their complete removal a viable option for mitigation of expansive soil-related problems beneath the buildings.

3) The limestone underlying the site is generally weathered within the upper reaches of the formation, grading to unweathered at relatively shallow depths. The unweathered limestone will provide excellent support for the proposed improvements.

4) Proposed finished grades and foundation schemes will require excavation/penetration of appreciable amounts of the limestone underlying this site. Suitable rock excavation equipment, possibly in conjunction with localized blasting (if acceptable), will be required to expeditiously perform site grading and foundation construction at this site.

5) Shallow ground water seepage is anticipated on a transient basis at this site. Provisions will be required to handle both short term drainage problems (such as seepage encountered during foundation construction/excavation) and long term dewatering beneath the buildings.

Vertical Movements

Expansive soil-related ground movements were estimated for slab-on-grade construction at this site using the Texas State Department of Highways and Public Transportation procedure (TSDHPT, Tex-124-E) for predicting Potential Vertical Rise (PVR). Total vertical movements varying from 1/2 to 1-3/4 in. were estimated for existing grades at this site. A minimum 1.0 psi surcharge load was assumed to act on the active subgrade clays, and theoretically dry soil moisture conditions were expected to govern.

Based on proposed finished floor elevations, a significant percentage of the potentially active Stratum I clays will be removed as a result of site clearing and grading operations. Due to the movement-sensitive nature of a number of the facilities, we recommend that the active surficial clays be completely removed from beneath all buildings and the excavations backfilled to finished grade using compacted, select structural fill.

Foundation Selection

As mentioned previously, straight drilled shaft foundations are preferred to support the proposed facilities. Plans have been developed using the recommendations and design criteria presented in the previously referenced Mason-Johnston & Associates report. We have reviewed the report and plans in light of our findings, and provide the following confirmatory foundation recommendations and design criteria.

FOUNDATION RECOMMENDATIONS

Straight Drilled Shafts

The proposed structures may be supported on straight drilled shafts founded a minimum of 2 ft into the Stratum III unweathered limestone. Based on the existing stratigraphy and proposed finished grades, drilled shaft lengths are expected to vary between 7 and 19 ft.

Bearing Capacity Straight drilled shafts bearing in the Stratum III unweathered limestone may be designed for a maximum allowable end bearing capacity of 71,000 psf. In addition, the drilled shafts may be designed using an allowable side shear resistance in compression of 22,600 psf and an allowable side shear resistance in tension of 11,200 psf for that portion of the shaft penetrating unweathered limestone.

These allowable end bearing and side shear capacities were evaluated using a factor of safety in excess of 3 with respect to the design shear strength.

A review of the furnished structural plans reveals that the individual drilled shaft foundations are adequately spaced to negate consideration of bearing capacity reductions resulting from overlapping stresses. However, once drainage plans are more complete, consideration should be given to evaluating the effects (if any) of drilled shafts located in close proximity to excavated and backfilled drainage trenches.

Settlements Straight drilled shafts bearing at the minimum specified depth in the Stratum III unweathered limestone are expected to experience settlements of less than 1/2 in.

Lateral Capacity We understand that isolated drilled shafts for the ASST Facilities will be subjected to lateral loads resulting from wind and earth backfill forces acting on the structures. A modulus of subgrade reaction of up to 350 kips per sq ft per ft of pier diameter may be used for designing piers subjected to lateral loading at the top of the pier. The above subgrade modulus is applicable for that portion of the shaft embedded within the Stratum II or Stratum III limestone. Pier embedment above the limestone formation should either be neglected in calculations regarding lateral loading of the drilled shafts, or assigned a low subgrade modulus value indicative of the structural backfill materials placed at the site. The above subgrade modulus may be used in soil/structure interaction analyses to predict shaft deflections and bending moments. The shafts should be dimensioned to limit deflections to tolerable values and reinforced to prevent failure of the shaft materials.

Rigid Beam and Slab Foundations

The proposed ASST string enclosure building may be supported on the preferred shallow, monolithic beam and slab foundation. Grade beams should be a minimum of 12 in. wide and founded at a minimum depth of 18 in. below finished grade in or on top of the Stratum II weathered limestone, or compacted, select structural fill. Widened pads at beam intersections or concentrated column loads should be a minimum of 30

in. wide and also founded a minimum of 18 in. below finished grade in or on top of the Stratum II limestone, or compacted, select structural fill.

Grade beams and widened pads bearing in or on top of the Stratum II limestone may be designed using an allowable bearing capacity of up to 8,500 psf. Grade beams and widened pads bearing in compacted structural fill may be proportioned using a maximum allowable bearing capacity of 2,500 psf, provided the structural fill materials are selected and placed in accordance with the recommendations outlined in the "Construction Guidelines" section of this report. The above allowable bearing capacities were evaluated using a factor of safety of 3 or greater with respect to the design shear strength. Settlements of less than 3/4 in. are anticipated for this foundation scheme.

Floor Slabs

Floor slabs for the Service Area and ASST Facilities may be soil-supported. As mentioned previously, we recommend that the Stratum I clays be completely removed from beneath the building floor slabs, and the resulting excavations backfilled to finished grade using compacted, select structural fill. We further recommend that the exposed limestone subgrade be overexcavated, where necessary, to allow placement of a minimum 4 in. thick sand or gravel cushion beneath the concrete slabs, thereby providing a level working surface and reducing the possibility of stress concentrations in slabs spanning both rock and compacted structural fill materials. A suitable vapor barrier (such as polyvinyl chloride sheeting) should be placed between the concrete slab and the underlying sand/gravel cushion.

EXCAVATION RECOMMENDATIONS

Considerations

Equipment/Techniques In general, excavations in the order of 1 to 2.5 ft in depth are anticipated for final site grading for a majority of the Service Area and ASST Facilities. Exceptions include the pits and trenches housed in the ASST Compressor and Refrigeration/Magnet Control Buildings, where excavations of up to 25 ft are anticipated. Due to the relatively shallow nature of the alluvial soils, excavations of this magnitude will require removal of

substantial quantities of both the weathered and unweathered limestone underlying this site.

Past experience with materials such as these indicate that ripping is possible within the weathered rock region, although high power excavation equipment is required and excavation is typically slow and costly. Localized blasting may prove to be the most practical and expeditions method for the deeper pit/trench excavations, although local building codes and existing development may prohibit blasting operations at this site. It is recommended that contractors interested in bidding on the earthwork for this site excavate test pits to evaluate the excavatability of the materials.

Ground Water Ground water seepage was observed at relatively shallow depths (within 5 ft of existing grade) during the field exploration phase of our study. Shallow seepage should be anticipated during foundation excavation and construction at this site, particularly during and immediately following periods of heavy precipitation. Provisions should made to control ground water seepage entering excavations. Consideration should be given to installing the permanent trench drain networks proposed for the building perimeters prior to the start of excavation operations for the structural pits/trenches. Small quantities of seepage not intercepted by the perimeter trench drains may be controlled by conventional sump and pump methods of dewatering in the excavations. Greater seepage quantities entering the excavations may require more sophisticated techniques, such as the construction of deep slurry cutoff walls.

Provisions should also be made to prevent surface runoff from entering the open excavations. Temporary earthen berms should be installed or swales cut on the uphill side of the excavations to divert surface runoff away from the open holes.

Sidewall Stability Decisions concerning safe slopes for the pit/trench excavation sidewalls will depend on the integrity of the limestone exposed within the excavations, the length of time the excavations are open, and ground water seepage entering the excavations. Near-vertical walls may be possible if the exposed limestone is free of extremely weathered zones and weakened fractured

or fault planes, seepage is minimal, and the excavations will be open for only a short period of time. Flatter or benched sideslopes will be necessary in areas of extreme weathering and/or weakened planes, and significant seepage. Decisions concerning safe sideslopes for the excavations are best made on the basis of observations of the Geotechnical Engineer both during and after completion of the excavation. OSHA Guidelines and applicable Building Codes should be followed with respect to construction techniques and timing, and with consideration for the engineering characteristics of the soils/rock encountered at this site.

SUBLEVEL WALL DESIGN RECOMMENDATIONS

The walls of the deep pits situated within the Service Area will act as retaining structures in addition to transferring vertical loads. Equivalent fluid densities for computation of lateral soil pressures acting on the pit walls were evaluated for various backfill materials. The materials and their associated equivalent fluid densities are tabulated below in preferential order for use as backfill materials.

Backfill Material	Equivalent Fluid Density, PCF
Free Draining Granular Soils (Clean Sands or Gravels)	45
Pit Run Granular Soils (LL of 35 or less; PI between 6 and 12)	55
Inert Structural Fill (Crushed Stone)	60

Neither the effects of surcharge loads, such as construction equipment, vehicular loads and future storage near the walls, nor ground water seepage pressures have been considered in the estimated equivalent fluid densities tabulated above. However, these surcharge loads and ground water pressures should be considered in designing any walls subjected to lateral earth pressures.

Backfill Placement It has been our experience that large thicknesses of clean, uniformly graded, gravel backfill materials may experience significant surface settlements after construction. Such

settlements can be damaging to any flatwork constructed over the fill materials, since the settlements are differential between locations supported on the fill and others which may be either connected to the pier-supported building or supported on natural, undisturbed rock. Based on our past observations, differential settlements on the order of 1 to 2 in. may be experienced for the backfill thicknesses anticipated for the deep pits in the Compressor Building.

Options available for reducing potential post-construction differential settlements for granular backfill areas overlain by flatwork are outlined below. The options listed below may be used either singly or together to reduce potential backfill settlements.

(1) Add sufficient water during gravel placement and compaction to lubricate the interparticle contacts in the gravel and promote densification. The perimeter drainage system should be installed and operating prior to the start of gravel placement and wetting.

(2) Use sufficient vibratory compaction to achieve significantly increased densification. We recommend that a hand-guided vibratory roller or vibratory plate compactor having a maximum weight no greater than 3000 lbs and a frequency no greater than 2500 rpm (50 hertz) be used over each lift of gravel backfill in a series of 3 (minimum) and 4 (maximum) passes over the entire backfill area. Lift thicknesses shall not exceed 12 in. for vibratory plates and 18 in. for vibratory rollers. No compaction equipment should extend closer than 18 in. to the basement walls during compaction.

(3) Use a well graded granular soil for wall backfill.

(4) Replace the upper 3 ft of granular backfill materials supporting flatwork with lean concrete or "K-crete", to help bridge over localized differential movements and distribute such movements more evenly. A plastic barrier or 6 in. thick clayey soil barrier should be installed over the granular fill in areas where "K-crete" is to be placed.

<u>Drainage</u> Provisions should be included in the pit/trench wall designs to drain potential seepage that may infiltrate the backfill and result in hydrostatic pressures acting on the walls.

Perimeter drain systems for sublevel walls typically consist of perforated plastic pipes placed in filter trenches excavated parallel to the base of the walls for their entire length. For backfills

consisting of inert structural fill (crushed stone) or low permeability soils, the trenches should be backfilled to finished grade with free draining coarse sand or gravel. If gravel is used, the gravel should be surrounded by a nonwoven geotextile filter fabric (such as Mirafi 140N, manufactured by the Celanese Corporation, or equivalent) to protect the gravel from clogging by intrusion of fine silt and clay particles. A geosynthetic drainage composite (such a Miradrain or equivalent) may be substituted for the sand or gravel drainage medium extending up the back of the wall. For backfill soils of low permeability, an inclined granular drainage blanket placed between the excavated face and the backfill may also be used in conjunction with the wall drainage system to facilitate drainage of the backfill.

Drainage pipes located at the base of the walls should be sloped to provide gravity flow to a centralized sump pit. Cleanouts should be provided at the ends of the drain pipes and at sharp bends so that they may be cleaned periodically.

Provisions should also be included in the overall drainage design for the collection and disposal of ground water seepage which may infiltrate structural fill materials placed beneath the floor slabs. Subfloor drainage may be accomplished using the perimeter trench drainage system shown on the furnished plans, or by sloping the top of the exposed subgrade, from a highpoint or series of ridges located along interior pier/column rows, downward to a series of swales running parallel and midway between the interior pier/column rows. The swales, in turn, should be sloped to the base of a collector trench or a central sump pit equipped with an intermittent-duty pump.

Waterproofing Consideration should also be given to proper waterproofing of the pit/trench walls. Waterproofing of the pit/trench walls for capillary moisture is often accomplished by painting the wall exteriors with a bituminous material. For greater seepage quantities, such as those anticipated for this site, membrane waterproofing is required.

CONSTRUCTION GUIDELINES

Site Drainage

Drainage is an important key to the successful performance of any foundation or pavement scheme. Good surface drainage should be established prior to and maintained after construction to prevent water from ponding within or adjacent to the building or pavement areas. Gutters with downspouts which collect storm waters from the roof and direct them away from the building foundations are recommended.

Site Preparation

Natural subgrades to support structural fill or pavements should be stripped of all Stratum I clays and organic topsoil.

Select Structural Fill

Materials used as select structural fill preferably should be a crushed stone or gravel aggregate. It is recommended that materials specified for use as select structural fill meet the Texas State Department of Highways and Public Transportation 1982 Standard Specification for Construction of Highways, Streets and Bridges, Item 248, Type A, Grade 1 (crushed stone). Alternative structural fill materials should not be considered as a substitution for the recommended granular fill at this site without written approval of the Geotechnical Engineer.

Select structural fill should be placed in loose lifts not exceeding 8 in. in thickness and compacted to at least 95 percent of maximum density as determined by ASTM D-698 (Standard) Compaction Test. The water content of the fill should be maintained within 3 percent (above or below) of the optimum water content until final compaction.

Foundation Construction

Prior to placement of reinforcing steel and concrete, foundation excavations for shallow beam trenches and spot footings (column pads) for the ASST string enclosure should be examined by the Geotechnical Engineer or his representative. The purpose of this examination is to see that the footing dimensions are as specified by the project plans, that the bearing materials at the bottom of the excavations are either

similar to those encountered in our borings or have been selected and placed in accordance with the project documents, and that loose material and water are NOT present in the excavations.

If soft materials are encountered in the foundation excavations, they should be removed as directed by the Geotechnical Engineer and replaced with either compacted non-expansive fill material or lean concrete up to the specified foundation bearing elevation.

Reinforcing steel should be checked for size and proper placement prior to concrete placement.

Utilities

If utility trenches extend to or below a depth of 5 ft below construction grade, the contractor or others may be required to develop a trench safety plan to protect personnel entering the trench or trench vicinity. Such designs and safety plans, which could include designs for sloping and benching or various types of temporary shoring, should be developed in accordance with current OSHA guidelines and other applicable industry standards.

Drilled Shafts

Field Observations Each drilled shaft excavation must be examined by a qualified individual who is familiar with the geotechnical aspects of the stratigraphy, structural configuration, foundation design details and assumptions prior to placing concrete. This is to observe that:

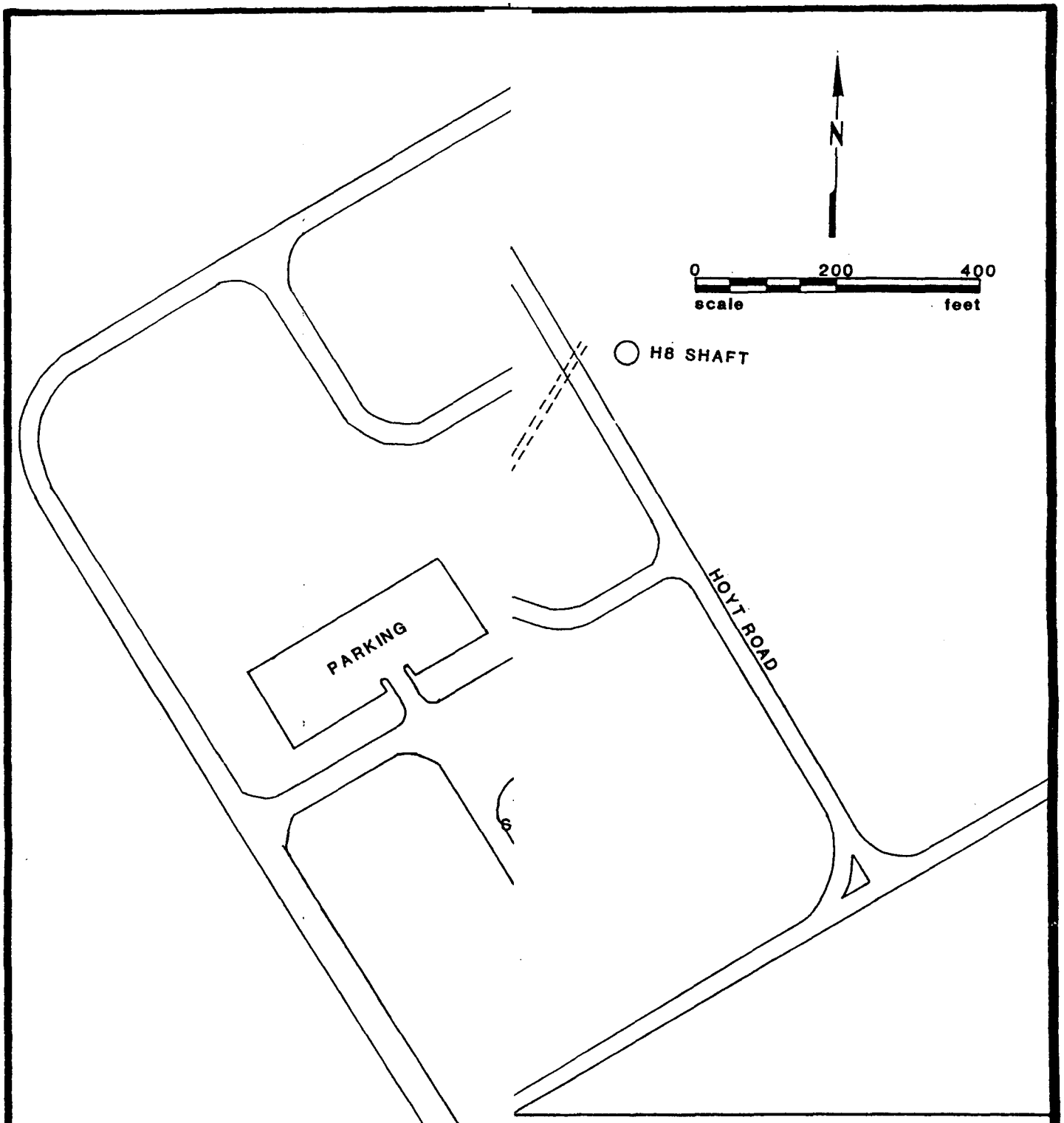
- The shaft has been drilled to the specified dimensions at the correct depth established by the previously mentioned criteria;
- The pier shaft has been drilled plumb within specified tolerances along its total length; and
- Excessive cuttings, buildup and soft, compressible material have been removed from the bottom of the excavation.

Placement of concrete should be accomplished as soon as possible for each shaft excavation to reduce changes in the moisture content or the state of stress of the foundation bearing materials. No shafts should

be concreted without the approval of the Engineer. No completed shaft excavation should be left open overnight without concreting.

Casing Ground water seepage was observed in the boreholes at depths varying from 1 to 5 ft below existing grades at the time of our subsurface exploration. Ground water seepage may be encountered at the time of pier construction, especially after periods of heavy rainfall. We recommend that the bid documents require the foundation contractor to specify unit costs for different lengths of casing which may be required.

ILLUSTRATIONS



LEGEND

AST-8 ⊙ BORING LOCATION

Raba - Kistner
Consultants, Inc.

gineers • Geologists • Scientists • Chemists

PLAN OF BORINGS

IPERCONDUCTING SUPER COLLIDER

SHOWN PROJ. NO.: ASA91-020-00 DWG. NO.: 1

: GD CHK BY: ASH APPD: DATE: 3/20/91

LOG OF BORING NO. AST-8
E1 SITE - SSC PROJECT
WAXAHACHIE, TEXAS

Raba-Kistner Consultants, Inc.

DRILLING METHOD: Mud Rotary

LOCATION: N6818786 E2449010

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WEIGHT, pcf	COHESION, TON/SQ FT (0.3 0.6 0.9 1.2 1.5 1.8 2.1)	PLASTIC LIMIT / WATER CONTENT / LIQUID LIMIT (10 20 30 40 50 60 70)	%-200
			SURFACE ELEVATION: 753.90'					
			CLAY, Firm to Stiff, Brown, Slightly Moist to Moist - with calcareous nodules and some limestone fragments 0.8'					
5			LIMESTONE, Weathered, Moderately Hard, Tan to Whitish-Tan 4.1'		123			39.4
10			LIMESTONE, Unweathered, Hard, Gray - light gray below 4.6' - slightly clayey to 6.3' - harder below 6.3' - dark gray, clayey from 12.7' to 13.2' and below 17.7'		127			75.2
15								
20								
25			START: 3:00 PM END: 5:15 PM					
30								
35								
40								
45								
50								

Core Run #	Core Depth (ft)	% Rec	% RQD
1	0.8-3.1	87	0
2	3.1-5.3	91	0
3	5.3-9.8	100	7
4	9.8-19.9	96	92

NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT.

DEPTH DRILLED: 19.9'	DEPTH TO WATER:	PROJ. No. ASA91-020-00
DATE DRILLED: 3-4-91	DATE MEASURED:	PLATE 2

LOG OF BORING NO. AST-9
E1 SITE - SSC PROJECT
WAXAHACHIE, TEXAS

Raba-Kistner Consultants, Inc.

DRILLING METHOD: Mud Rotary

LOCATION: N6818702 E2448806

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL SURFACE ELEVATION: 755.60'	BLOWS PER FT	UNIT DRY WEIGHT, pcf	COHESION, TON/SQ FT (0.3 0.6 0.9 1.2 1.5 1.8 2.1) / PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT (10 20 30 40 50 60 70)	%-200
			CLAY, Firm to Hard, Dark Brown, Moist - with calcareous nodules and limestone fragments - water on underlying limestone surface (< 1") 1.8'		119		54.9
5							
10			LIMESTONE, Weathered, Moderately Hard, Tan - with some glauconitic specks and close intermittent seams/partings - 45-degree inclined fracture at 4.6' - medium gray, clayey in close partings at 7.1' 7.1'		123		25.2
15							
20			LIMESTONE, Unweathered, Moderately Hard, Slightly Fossiliferous with intraclasts and relict burrow structures - dark gray from 11' to 12' - clayey from 17.5' to 18'				
25			START: 7:25 AM END: 9:20 AM				
30							
35							
40							
45							
50							

Core Run #	Core Depth (ft)	% Rec	% RQD
1	1.8-4.1	48	0
2	4.1-8.6	91	44
3	8.6-18.6	100	86

DEPTH DRILLED: 18.6'	DEPTH TO WATER:	PROJ. No. ASA91-020-00
DATE DRILLED: 3-5-91	DATE MEASURED:	PLATE 3

NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT.

LOG OF BORING NO. AST-10
E1 SITE - SSC PROJECT
WAXAHACHIE, TEXAS

Raba-Kistner Consultants, Inc.

DRILLING METHOD: Mud Rotary

LOCATION: N6818615 E2448600

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL SURFACE ELEVATION: 758.20'	BLOWS PER FT	UNIT DRY WEIGHT, pcf	COHESION, TON/SQ FT (0.3 0.6 0.9 1.2 1.5 1.8 2.1) / PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT (10 20 30 40 50 60 70)	%-200
			CLAY, Firm to Very Stiff, Dark Brown, Moist - with calcareous nodules, roots, and some limestone fragments - grading to tan - less weathered calcareous clay below 1.5' 1.9'				
5							
10			LIMESTONE, Weathered, Moderately Hard, Slightly Glauconitic - some close seams, one 45-degree inclined fracture in Core Run #1 - vugular from 4.5' to 5' - slightly fossiliferous below 5' 5.7'		98		4.6
15							
20			LIMESTONE, Unweathered, Shaley, Dark Gray, Slightly Intraclastic - mottled light and dark gray, clayey, softer with close partings at 8' - light gray, moderately hard to 12.1' - clayey, dark gray at 13.6' - light gray with some partings to 15.2' - dark gray with some medium size intraclasts to 18.2' - parting frequency decreasing with depth				
25							
30							
35			START: 9:35 AM END: 11:00 AM				
40							
45							
50							

Core Run #	Core Depth (ft)	% Rec	% RQD
1	2.2-4.5	22	0
2	4.5-9.2	100	89
3	9.2-19.2	100	93

DEPTH DRILLED: 19.2'	DEPTH TO WATER:	PROJ. No. ASA91-020-00
DATE DRILLED: 3-5-91	DATE MEASURED:	PLATE 4

NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT.

LOG OF BORING NO. AST-11
E1 SITE - SSC PROJECT
WAXAHACHIE, TEXAS

Raba-Kistner Consultants, Inc.

DRILLING METHOD: Mud Rotary

LOCATION: N6818810 E2448547

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL SURFACE ELEVATION: 759.90'	BLOWS PER FT	UNIT DRY WEIGHT, pcf	COHESION, TON/SQ FT (0.3 0.6 0.9 1.2 1.5 1.8 2.1) PLASTIC LIMIT / WATER CONTENT / LIQUID LIMIT (10 20 30 40 50 60 70)	%-200
			CLAY, Firm to Stiff, Dark Brown, Moist - with roots and some limestone fragments - grading downward into tan calcareous clay - water at 2.9 3.0'	50			
5							
10			LIMESTONE, Weathered, Medium Hard, Tan - slightly fossiliferous and glauconitic - few close partings from 5.2' to 5.6', from 6.2' to 6.8, and from 9' to 12.4' - soft, clayey from 11.9' to 12.7' 12.7'				
15					118		39.3
20			LIMESTONE, Unweathered, Soft to Medium Hard, Gray to Dark Gray - some intraclasts, slightly fossiliferous - close partings from 14.7' to 14.9' - dark gray, clayey from 15.3' to 15.8' - close partings from 16' to 16.2' - inclined fracture at 17.8' - dark gray, clayey from 18.2' to 20.2' - close partings from 20.7' to 21.1', from 21.5' to 21.8', and from 23.4' to 23.7'				
25							
30							
35							
40			START: 7:10 AM END: 9:00 AM				
45							
50							

Core Run #	Core Depth (ft)	% Rec	% RQD
1	4.0-9.0	100	75
2	9.0-19.0	98	60
3	19.0-24.0	100	73

DEPTH DRILLED: 24.0'	DEPTH TO WATER:	PROJ. No. ASA91-020-00
DATE DRILLED: 3-7-91	DATE MEASURED:	PLATE 5

NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT.

LOG OF BORING NO. AST-12
E1 SITE - SSC PROJECT
WAXAHACHIE, TEXAS

Raba-Kistner Consultants, Inc.

DRILLING METHOD: Mud Rotary

LOCATION: N6818688 E2448464

DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL SURFACE ELEVATION: 760.50'	BLOWS PER FT	UNIT DRY WEIGHT, pcf	COHESION, TON/SQ FT (0.3 0.6 0.9 1.2 1.5 1.8 2.1) / PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT (10 20 30 40 50 60 70)	%-200
			CLAY, Stiff to Very Stiff, Dark Brown, Moist - with calcareous nodules, roots, and limestone fragments - marly, tan at 2.2' 2.2'				
5			LIMESTONE, Weathered, Moderately Hard, Tan - with close partings - scattered horizontal solution fractures from 6' to 6.5' - slightly fossiliferous 7.8'		113	22.1	
10					111	41	
15			LIMESTONE, Unweathered, Hard, Gray - with clayey interval of close intermittent partings from 7.8' to 9.5' - darker gray, clay content increases below 14.5' - intraclastic with possible ripple structures with depth				
20							
25			START: 11:40 AM END: 12:45 PM				
30							
35							
40							
45							
50							

Core Run #	Core Depth (ft)	% Rec	% RQD
1	2.2-4.5	26	0
2	4.5-9.5	92	63
3	9.5-19.5	100	93

NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT.

DEPTH DRILLED: 19.5'	DEPTH TO WATER:	PROJ. No. ASA91-020-00
DATE DRILLED: 3-5-91	DATE MEASURED:	PLATE 6

LOG OF BORING NO. AST-13
E1 SITE - SSC PROJECT
WAXAHACHIE, TEXAS

Raba-Kistner Consultants, Inc.

DRILLING METHOD: Mud Rotary

LOCATION: N6818649 E2448355

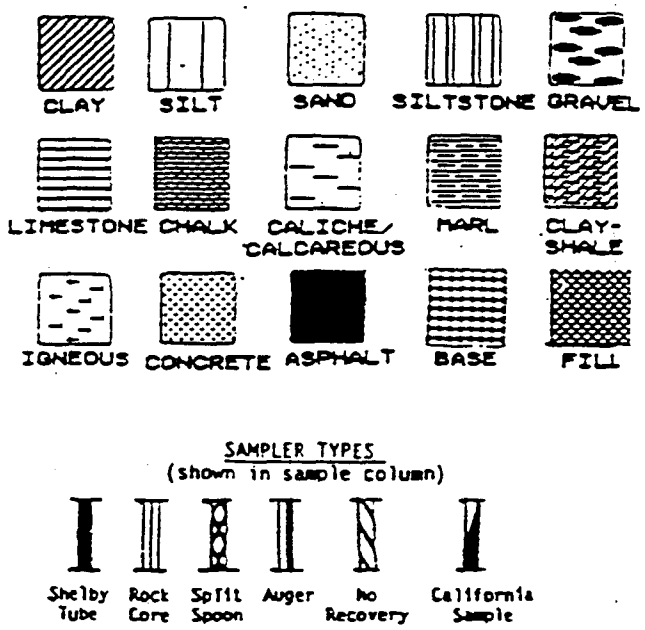
DEPTH, FT	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL SURFACE ELEVATION: 762.00'	BLOWS PER FT	UNIT DRY WEIGHT, pcf	COHESION, TON/SQ FT (0.3 0.6 0.9 1.2 1.5 1.8 2.1) / PLASTIC LIMIT — WATER CONTENT — LIQUID LIMIT (10 20 30 40 50 60 70)	%-200
			CLAY, Stiff to Hard, Dark Brown, Moist - with calcareous nodules, roots, and limestone fragments - grading into tan, marly, calcareous clay 4.0'				
5			LIMESTONE, Weathered, Soft to Moderately Hard, Tan - with some horizontal fractures and some ferrous staining along seams - core loss between 4' and 7.2' - hard, fossiliferous with more continuous recovery below 7.2' - 45-degree angle fracture at 7.7' - close partings from 10.2' to 13' 14.5'				
10					114		52.7
15							
20			LIMESTONE, Unweathered, Moderately Hard, Gray - with some intraclasts - mottled light and dark gray below 16'		116		71.3
25							
			- close partings and more clayey from 26.6' to 27.4' and from 31' to 31.4'				
30							
35			START: 12:50 PM END: 3:00 PM				
40							
45							
50							

Core Run #	Core Depth (ft)	% Rec	% RQD
1	4.0-9.0	56	27
2	9.0-18.5	100	75
3	18.5-28.0	100	73
4	28.0-35.0	100	74

DEPTH DRILLED: 35.0'	DEPTH TO WATER:	PROJ. No. ASA91-020-00
DATE DRILLED: 3-5-91	DATE MEASURED:	PLATE 7

NOTE: THESE LOGS SHOULD NOT BE USED SEPARATELY FROM THE PROJECT REPORT.

SYMBOLS AND TERMS USED ON BORING LOGS



STRENGTH TEST RESULTS

- Pocket Penetrometer
- Torvane
- Unconfined Compression

TRIAXIAL COMPRESSION

- Unconsolidated-undrained
- Consolidated-undrained

- C Cohesion (Total)
- Angle of Internal Friction (Total)

- C Cohesion (Effective)
- Angle of Internal Friction (Effective)

NOTE: Values symbolized on boring logs represent shear strengths unless otherwise noted.

TERMS DESCRIBING CONSISTENCY, CONDITION OR TEXTURE

Terms used in this report to describe soils with regard to their consistency or conditions are in general accordance with the discussion presented in Article 45 of SOIL MECHANICS IN ENGINEERING PRACTICE, Terzaghi and Peck, John Wiley & Sons, Inc. 1967, using the most reliable information available from the field and laboratory investigations. Terms used for describing soils according to their texture or grain size distribution are in accordance with the UNIFIED SOIL CLASSIFICATION SYSTEM, as described in Technical Memorandum No. 3-357, Waterways Experiment Station, March 1953.

TERMS CHARACTERIZING SOIL STRUCTURE

Slickensided	having inclined planes of weakness that are slick and glossy in appearance
Fissured	containing shrinkage cracks, frequently filled with fine sand or silt; usually more or less vertical
Laminated	composed of thin layers of varying colors and texture
Interbedded	composed of alternate layers of different soil types
Calcareous	containing appreciable quantities of calcium carbonate
Well graded	having wide range in grain sizes and substantial amounts of all intermediate particle sizes
Poorly graded	predominantly of one grain size, or having a range of sizes with some intermediate size missing

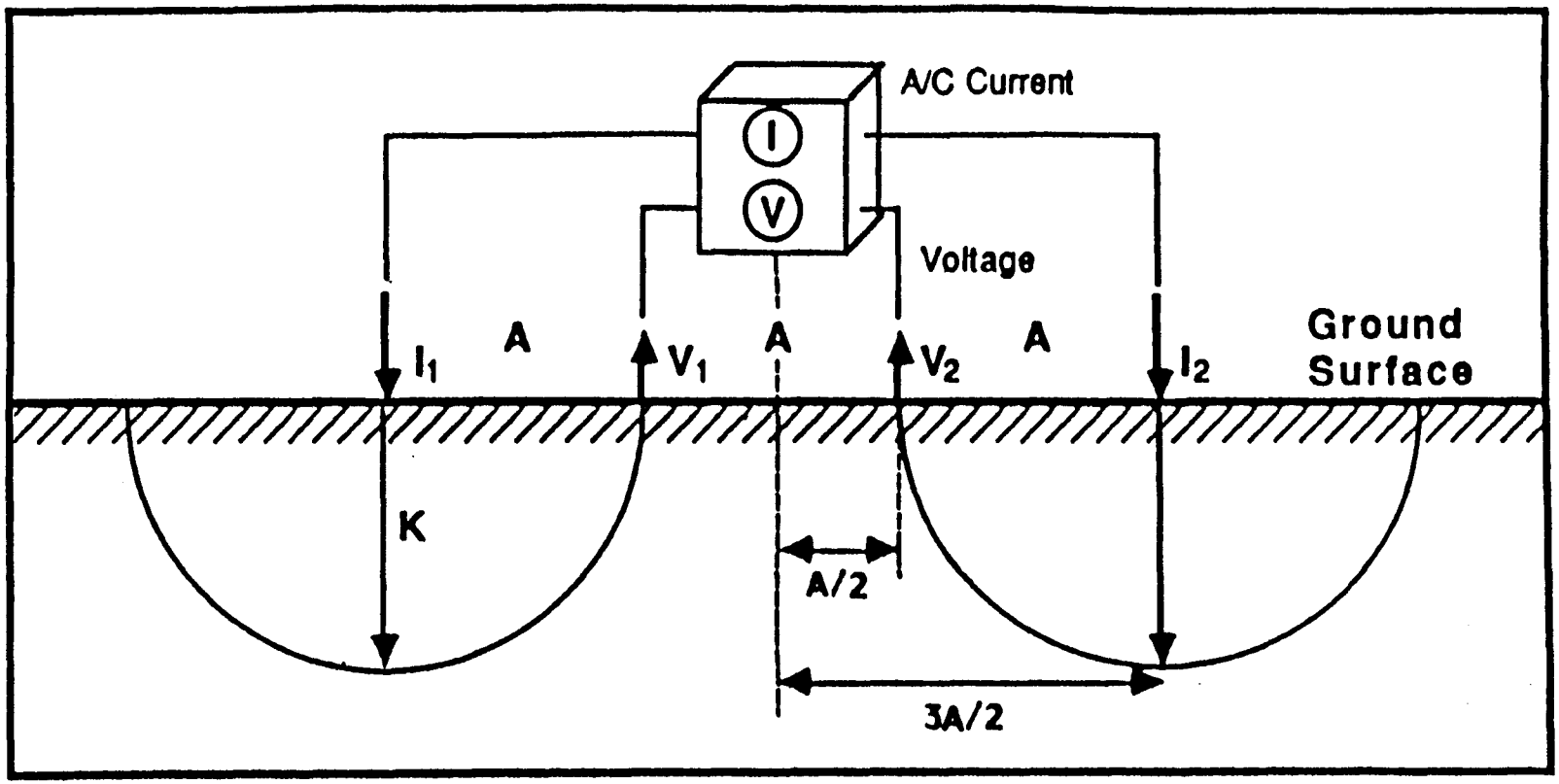
TERMS DESCRIBING CONSISTENCY OR CONDITION

RELATIVE DENSITY		COHESIVE STRENGTH			PLASTICITY	
Penetration Resistance, blows per ft	Relative Density	Penetration Resistance, blows per ft	Consistency	Cohesion TSF	Plasticity Index	Degree of Plasticity
0-4	Very loose	0-2	Very Soft	0-0.125	0-5	None
4-10	Loose	2-4	Soft	0.125-0.25	5-10	Low
10-30	Medium Dense	4-8	Firm	0.25-0.5	10-20	Moderate
30-50	Dense	8-15	Stiff	0.5-1.0	20-40	Plastic
>50	Very Dense	15-30	Very Stiff	1.0-2.0	>40	Highly Plastic
		>30	Hard	>2.0		

NOTE: Slickensided and fissured clays may have lower unconfined compressive strengths than shown above because of planes of weakness or cracks in the soil. The consistency ratings of such soils are based on penetrometer readings.

Proj. No. ASA91-020-00

Raba-Kistner Consultants, Inc



LEGEND

I_1, I_2 = Current Electrodes

V_1, V_2 = Voltage Electrodes

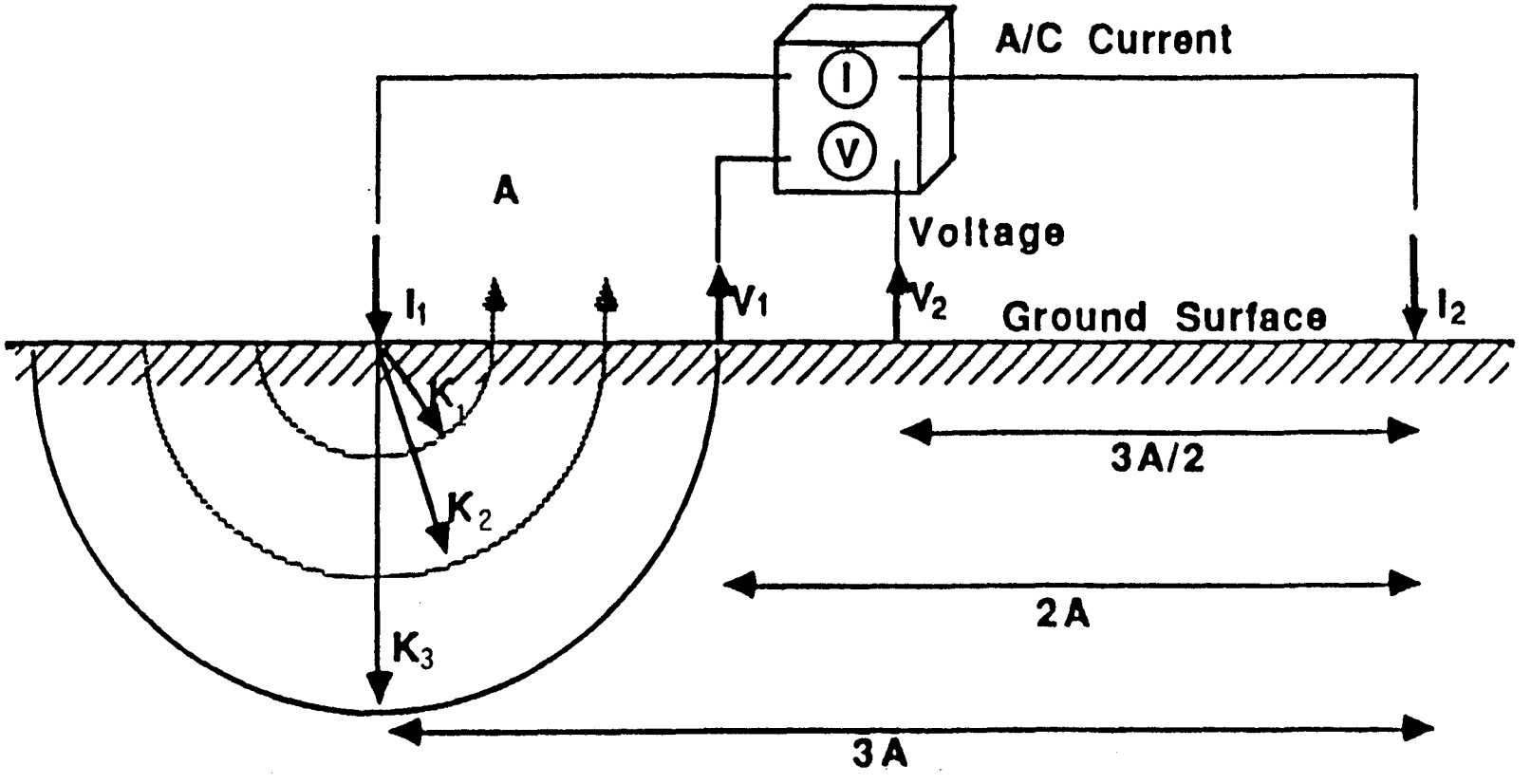
A = "A" Spacing

K = Penetration Depth

WENNER ARRAY

Raba-Kistner Consultants Inc

Proj. NO. ASA91-020-00
PLATE 9



LEGEND

I_1, I_2 = Current Electrodes

V_1, V_2 = Voltage Electrodes

A = "A" Spacing

K = Penetration Depth

PRICE ARRAY

(From Price, 1988)

Raba-Kistner Consultants Inc.

Proj. No. ASA91-020-00
PLATE 10

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**************************************************
**********                                **********
**********    RESISTIVITY DATA SHEET      **********
**********            PROFILE             **********
**********                                **********
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SUPERCONDUCTING SUPER COLLIDER

PROJECT NO: ASA91-020-01
DATE: MARCH 13-15, 1991
METER: ABEM TERRAMETER
TYPE OF ARRAY: 4-ELECTRODE WENNER ARRAY

STATN NO.	A SPACING (FEET) A	ELECTRODE PLACEMENT (FEET) V1,V2	I1,I2	METER READING (V/I) M	CURRENT (MILLIAMPS) I	SCALE S	DIAL VALUE (OHMS) D	BARNES LAYER METHOD (OHM-CM) R
A2	5	2.5	7.5	3.28	20	1000	41.22	6282
A3	5	2.5	7.5	4.45	20	1000	55.92	8522
A4	5	2.5	7.5	2.40	20	1000	30.16	4596
A5	5	2.5	7.5	5.09	20	1000	63.96	9748
A6	5	2.5	7.5	4.09	20	1000	51.40	7833
A7	5	2.5	7.5	5.47	20	1000	68.74	10476
A8	5	2.5	7.5	3.64	20	1000	45.74	6971
A9	5	2.5	7.5	2.52	20	1000	31.67	4826
A10	5	2.5	7.5	2.27	20	1000	28.53	4347
A11	5	2.5	7.5	1.14	20	1000	14.35	2187
A12	5	2.5	7.5	1.42	20	1000	17.87	2723
A13	5	2.5	7.5	3.73	20	1000	46.87	7143
B2	5	2.5	7.5	4.46	20	1000	56.05	8541
B3	5	2.5	7.5	2.29	20	1000	28.78	4386
B4	5	2.5	7.5	4.81	20	1000	60.44	9212
B5	5	2.5	7.5	4.04	20	1000	50.77	7737
B6	5	2.5	7.5	3.29	20	1000	41.34	6301
B7	5	2.5	7.5	3.91	20	1000	49.13	7488
B8	5	2.5	7.5	4.89	20	1000	61.45	9365
B9	5	2.5	7.5	5.90	20	1000	74.14	11299
B10	5	2.5	7.5	2.95	20	1000	37.07	5650
B11	5	2.5	7.5	2.00	20	1000	25.13	3830
B12	5	2.5	7.5	2.51	20	1000	31.54	4807
B13	5	2.5	7.5	2.46	20	1000	30.91	4711
C2	5	2.5	7.5	5.11	20	1000	64.21	9786
C3	5	2.5	7.5	2.69	20	1000	33.80	5152

STATN NO.	A SPACING (FEET) A	ELECTRODE PLACEMENT (FEET) V1,V2	I1,I2	METER READING (V/I) M	CURRENT (MILLIAMPS) I	SCALE S	DIAL VALUE (OHMS) D	BARNES LAYER METHOD (OHM-CM) R
C4	5	2.5	7.5	2.91	20	1000	36.57	5573
C5	5	2.5	7.5	2.58	20	1000	32.42	4941
C6	5	2.5	7.5	2.49	20	1000	31.29	4769
C7	5	2.5	7.5	2.40	20	1000	30.16	4596
C8	5	2.5	7.5	SOUNDING	20	1000	0.00	0
C9	5	2.5	7.5	SOUNDING	20	1000	0.00	0
C10	5	2.5	7.5	3.17	20	1000	39.84	6071
C11	5	2.5	7.5	2.28	20	1000	28.65	4366
C12	5	2.5	7.5	2.72	20	1000	34.18	5209
C13	5	2.5	7.5	4.42	20	1000	55.54	8465
D2	5	2.5	7.5	6.68	20	1000	83.94	12793
D3	5	2.5	7.5	4.43	20	1000	55.67	8484
D4	5	2.5	7.5	3.88	20	1000	48.76	7431
D5	5	2.5	7.5	3.54	20	1000	44.48	6780
D6	5	2.5	7.5	1.65	20	1000	20.68	3152
D7	5	2.5	7.5	2.10	20	1000	26.39	4022
D8	5	2.5	7.5	1.28	20	1000	16.11	2455
D9	5	2.5	7.5	1.04	20	1000	13.11	1997
D10	5	2.5	7.5	996	20	1	12.52	1907
D11	5	2.5	7.5	3.62	20	1000	45.49	6933
D12	5	2.5	7.5	4.22	20	1000	53.03	8082
D13	5	2.5	7.5	5.64	20	1000	70.87	10801
E2	5	2.5	7.5	5.20	20	1000	65.35	9959
E3	5	2.5	7.5	1.64	20	1000	20.55	3131
E4	5	2.5	7.5	5.44	20	1000	68.36	10418
E5	5	2.5	7.5	4.10	20	1000	51.52	7852
E6	5	2.5	7.5	2.06	20	1000	25.89	3945
E7	5	2.5	7.5	1.71	20	1000	21.48	3273
E8	5	2.5	7.5	1.62	20	1000	20.41	3110
E9	5	2.5	7.5	2.45	20	1000	30.79	4692
E10	5	2.5	7.5	865	20	1	10.87	1657
E11	5	2.5	7.5	3.75	20	1000	47.12	7182
E12	5	2.5	7.5	NOT STAKED	20	1000	0.00	0
E13	5	2.5	7.5	NOT STAKED	20	1000	0.00	0
F2	5	2.5	7.5	4.70	20	1000	59.06	9001
F3	5	2.5	7.5	2.00	20	1000	25.07	3821
F4	5	2.5	7.5	1.34	20	1000	16.86	2570
F5	5	2.5	7.5	3.46	20	1000	43.48	6626
F6	5	2.5	7.5	5.43	20	1000	68.24	10399
F7	5	2.5	7.5	2.54	20	1000	31.92	4864
F8	5	2.5	7.5	1.72	20	1000	21.56	3286
F9	5	2.5	7.5	3.74	20	1000	47.00	7163
F10	5	2.5	7.5	5.69	20	1000	71.50	10897
F11	5	2.5	7.5	4.23	20	1000	53.16	8101
F12	5	2.5	7.5	5.50	20	1000	69.11	10533

STATN NO.	A SPACING (FEET) A	ELECTRODE PLACEMENT (FEET) V1,V2	I1,I2	METER READING (V/I) M	CURRENT (MILLIAMPS) I	SCALE S	DIAL VALUE (OHMS) D	BARNES LAYER METHOD (OHM-CM) R
F13	5	2.5	7.5	4.28	20	1000	53.78	8197
G2	5	2.5	7.5	4.23	20	1000	53.16	8101
G3	5	2.5	7.5	2.06	20	1000	25.89	3945
G4	5	2.5	7.5	1.09	20	1000	13.67	2084
G5	5	2.5	7.5	2.86	20	1000	35.94	5477
G6	5	2.5	7.5	4.96	20	1000	62.33	9499
G7	5	2.5	7.5	2.93	20	1000	36.82	5611
G8	5	2.5	7.5	2.53	20	1000	31.79	4845
G9	5	2.5	7.5	3.68	20	1000	46.24	7048
G10	5	2.5	7.5	3.21	20	1000	40.34	6148
G11	5	2.5	7.5	4.43	20	1000	55.67	8484
G12	5	2.5	7.5	2.43	20	1000	30.54	4654
G13	5	2.5	7.5	5.49	20	1000	68.99	10514
H2	5	2.5	7.5	7.25	20	1000	91.11	13885
H3	5	2.5	7.5	5.33	20	1000	66.98	10208
H4	5	2.5	7.5	2.46	20	1000	30.91	4711
H5	5	2.5	7.5	1.32	20	1000	16.59	2528
H6	5	2.5	7.5	3.81	20	1000	47.88	7297
H7	5	2.5	7.5	5.78	20	1000	72.63	11069
H8	5	2.5	7.5	3.21	20	1000	40.34	6148
H9	5	2.5	7.5	1.26	20	1000	15.88	2421
H10	5	2.5	7.5	3.12	20	1000	39.21	5975
H11	5	2.5	7.5	3.71	20	1000	46.62	7105
H12	5	2.5	7.5	3.65	20	1000	45.87	6990
H13	5	2.5	7.5	1.26	20	1000	15.81	2409
I2	5	2.5	7.5	5.49	20	1000	68.99	10514
I3	5	2.5	7.5	6.43	20	1000	80.80	12314
I4	5	2.5	7.5	6.03	20	1000	75.78	11548
I5	5	2.5	7.5	2.68	20	1000	33.68	5133
I6	5	2.5	7.5	1.45	20	1000	18.23	2779
I7	5	2.5	7.5	4.11	20	1000	51.65	7871
I8	5	2.5	7.5	3.48	20	1000	43.73	6665
I9	5	2.5	7.5	4.61	20	1000	57.93	8829
I10	5	2.5	7.5	1.69	20	1000	21.24	3237
I11	5	2.5	7.5	NOT STAKED	20	1000	0.00	0
I12	5	2.5	7.5	4.49	20	1000	56.42	8599
I13	5	2.5	7.5	4.73	20	1000	59.44	9058
J2	5	2.5	7.5	NOT STAKED	20	1000	0.00	0
J3	5	2.5	7.5	7.82	20	1000	98.27	14976
J4	5	2.5	7.5	6.27	20	1000	78.79	12008
J5	5	2.5	7.5	6.96	20	1000	87.46	13329
J6	5	2.5	7.5	1.59	20	1000	20.03	3053
J7	5	2.5	7.5	1.52	20	1000	19.15	2919
J8	5	2.5	7.5	1.28	20	1000	16.02	2442
J9	5	2.5	7.5	3.24	20	1000	40.72	6205

STATN NO.	A SPACING (FEET) A	ELECTRODE PLACEMENT (FEET) V1,V2	I1,I2	METER READING (V/I) M	CURRENT (MILLIAMPS) I	SCALE S	DIAL VALUE (OHMS) D	BARNES LAYER METHOD (OHM-CM) R
J10	5	2.5	7.5	5.14	20	1000	64.59	9844
J11	5	2.5	7.5	4.64	20	1000	58.31	8886
J12	5	2.5	7.5	4.56	20	1000	57.30	8733
J13	5	2.5	7.5	1.15	20	1000	14.41	2197

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**************************************************
**********                                **********
**********    RESISTIVITY DATA SHEET      **********
*********         SOUNDING C8            **********
**********                                **********
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SUPERCONDUCTING SUPER COLLIDER

PROJECT NO:	ASA91-020-01
DATE:	MARCH 15, 1991
METER:	ABEM TERRAMETER
TYPE OF ARRAY:	4-ELECTRODE PRICE ARRAY

A SPACING (FEET) A	ELECTRODE PLACEMENT (FEET) V1	V2	METER READING (V/I) I1,I2	M	CURRENT (MILLIAMPS) I	SCALE S	WARP FACTOR Q	DIAL VALUE (OHMS) D	BARNES LAYER METHOD (OHM-CM) R
5	17.5	0	22.5	3.88	20	1000	0.727	35.45	5402
10	12.5	0	22.5	1.52	20	1000	0.885	16.93	4939
15	7.5	0	22.5	771	20	1	1.000	9.69	3452

D = 4*PI*M*S*Q/1000

R = A*D*12*2.54 FOR LAYER 1

$$R = \frac{(A2-A1)*(D1*D2)}{(D1-D2)}*12*2.54 \text{ FOR DEEPER LAYERS}$$

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**************************************************
**********                              **********
**********    RESISTIVITY DATA SHEET    **********
**********        SOUNDING C9           **********
**********                              **********
**************************************************
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SUPERCONDUCTING SUPER COLLIDER

PROJECT NO: ASA91-020-01
DATE: MARCH 15, 1991
METER: ABEM TERRAMETER
TYPE OF ARRAY: 4-ELECTRODE PRICE ARRAY

A SPACING (FEET) A	ELECTRODE PLACEMENT (FEET) V1	V2	I1,I2	METER READING (V/I) M	CURRENT (MILLIAMPS) I	SCALE S	WARP FACTOR Q	DIAL VALUE (OHMS) D	BARNES LAYER METHOD (OHM-CM) R
5	17.5	0	22.5	2.98	20	1000	0.727	27.22	4149
10	12.5	0	22.5	1.08	20	1000	0.885	12.03	3284
15	7.5	0	22.5	590	20	1	1.000	7.41	2946

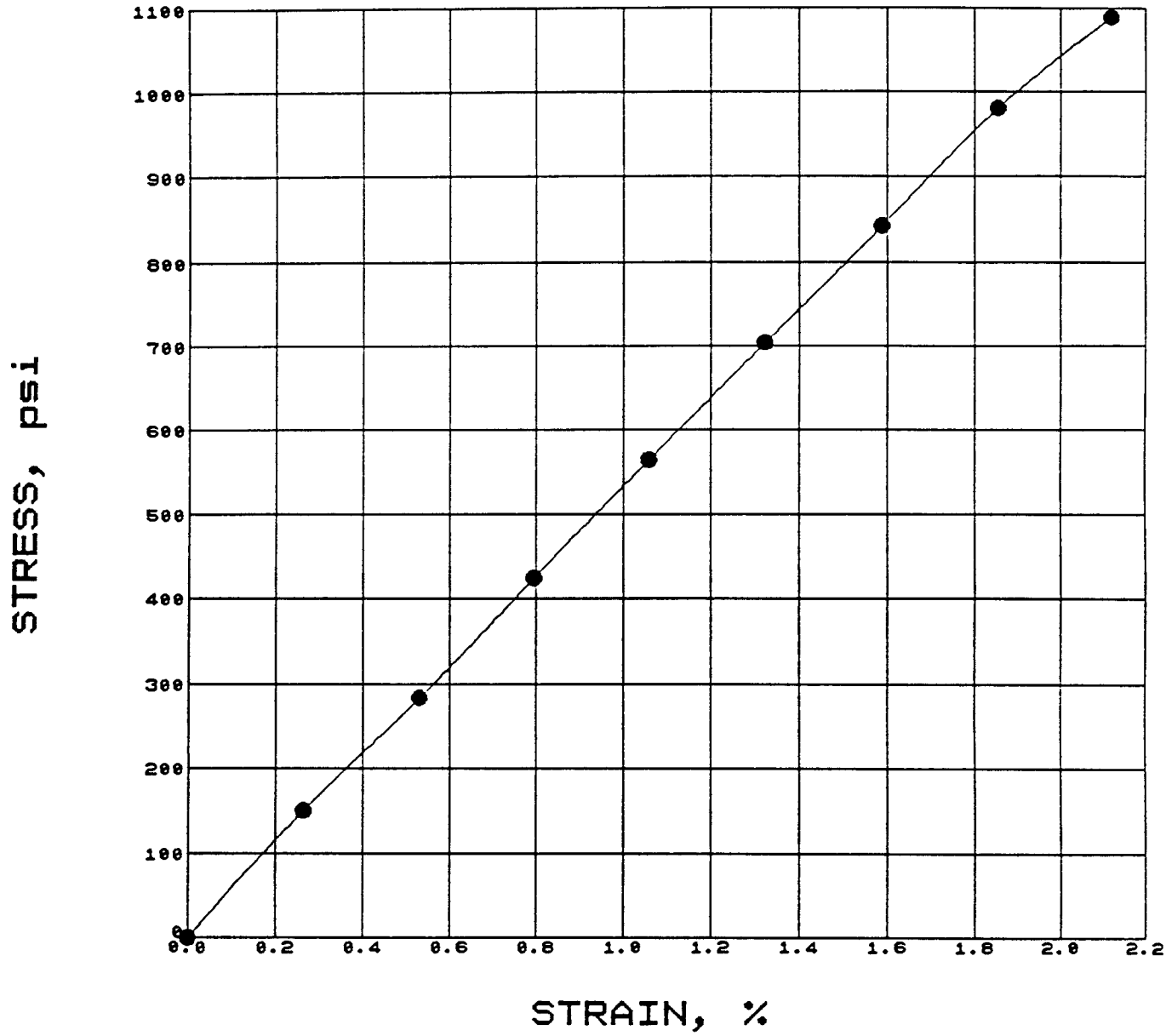
D = 4*PI*M*S*Q/1000

R = A*D*12*2.54 FOR LAYER 1

$$R = \frac{(A2-A1)*(D1*D2)}{(D1-D2)}*12*2.54 \text{ FOR DEEPER LAYERS}$$

UNCONFINED COMPRESSION TEST

E1 SITE - SSC PROJECT
WAXAHACHIE, TEXAS

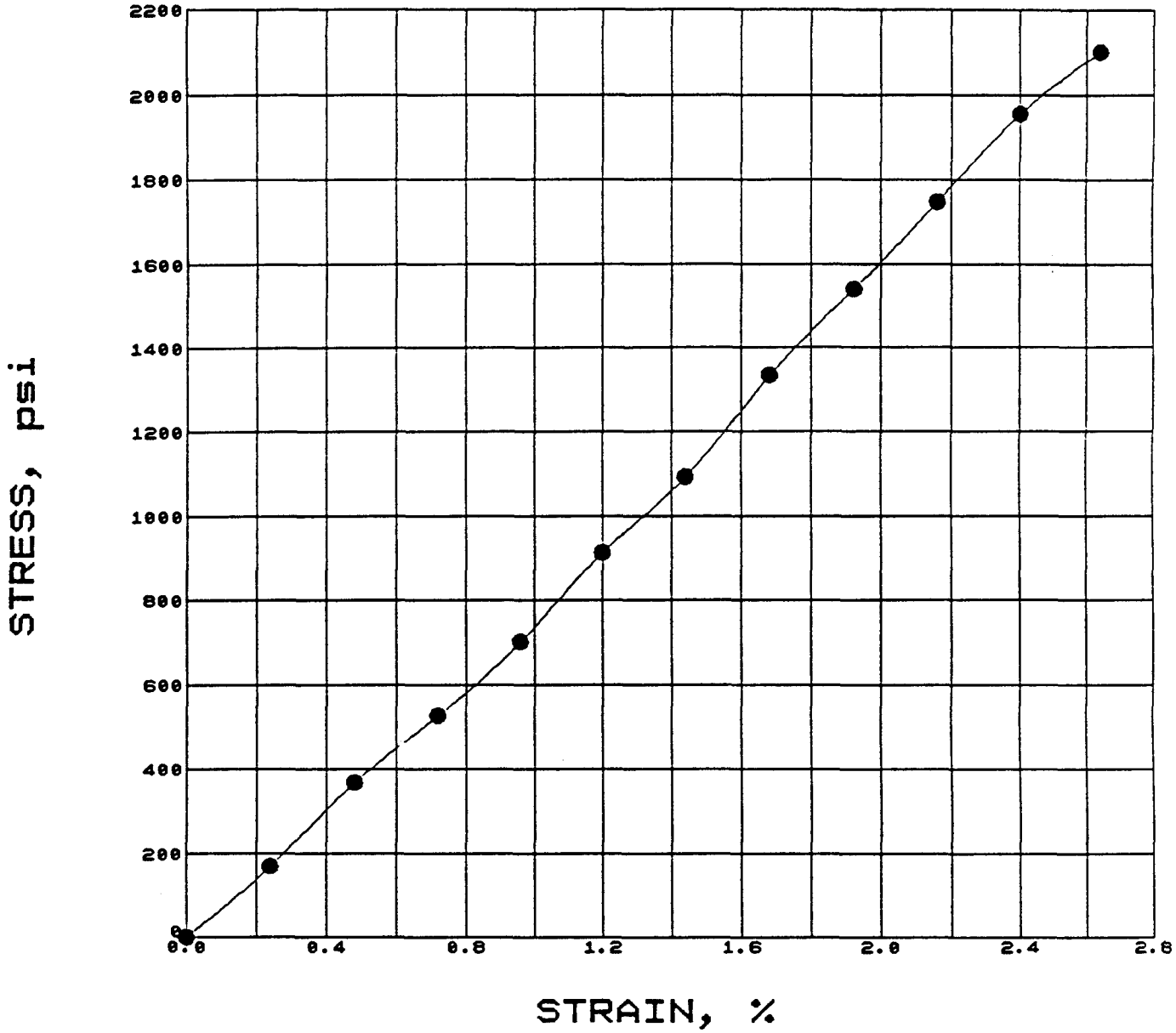


Boring No. AST-8
Depth: 3.50-4.00 ft
Material Description: Weathered Limestone (Austin Chalk)
Moisture Content: 13.66 %
Dry Unit Weight: 122.96 pcf
Stress at Failure: 1089 psi
Strain at Failure: 2.12 %
Secant Modulus: 51393 psi

Project No. ASA91-020-00

UNCONFINED COMPRESSION TEST

E1 SITE - SSC PROJECT
WAXAHACHIE, TEXAS

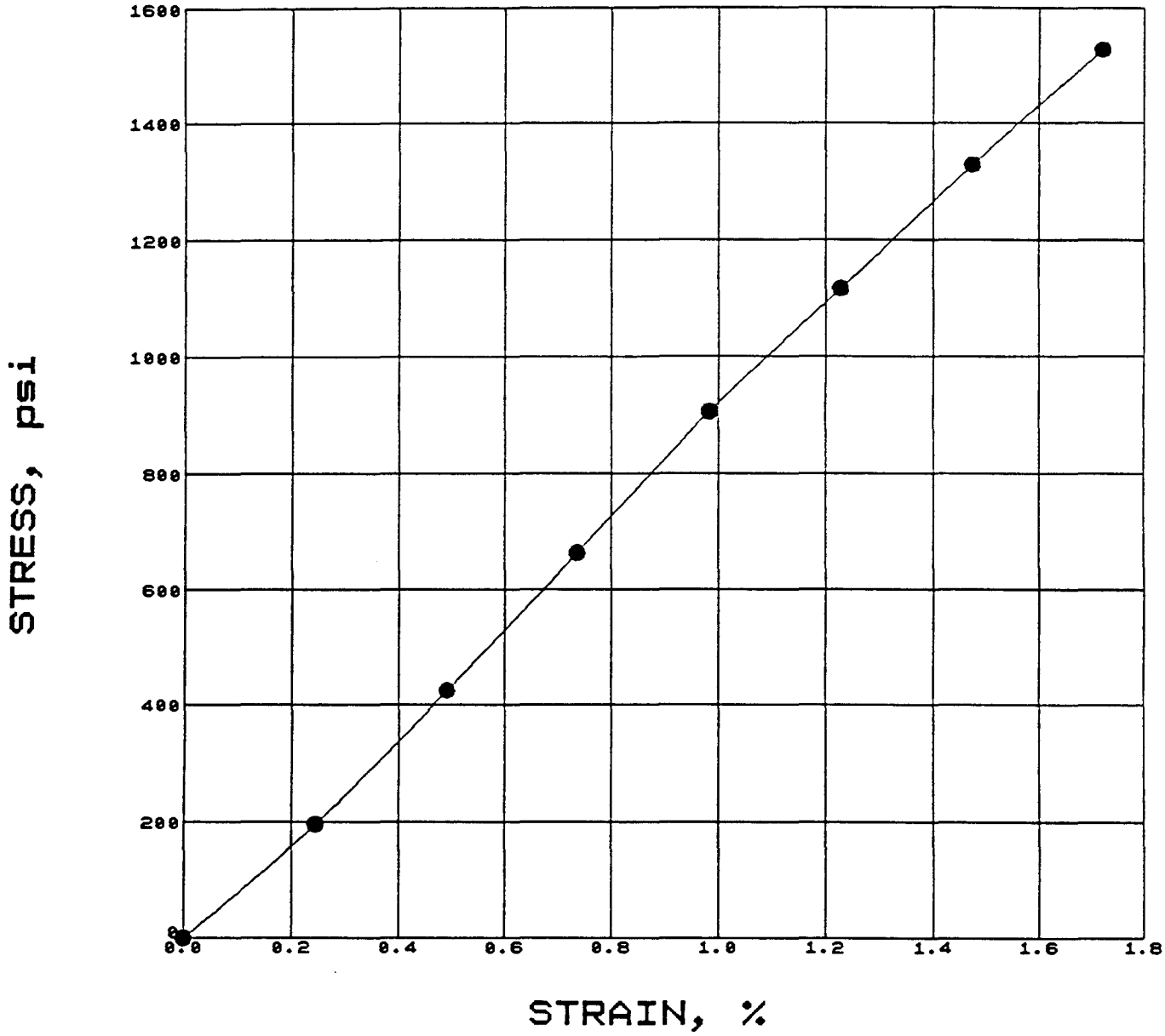


Boring No. AST-8
Depth: 8.50 ft
Material Description: Unweathered Limestone (Austin Chalk)
Moisture Content: 11.26 %
Dry Unit Weight: 127.30 pcf
Stress at Failure: 2100 psi
Strain at Failure: 2.64 %
Secant Modulus: 79514 psi

Project No. ASA91-020-00

UNCONFINED COMPRESSION TEST

E1 SITE - SSC PROJECT
WAXAHACHIE, TEXAS

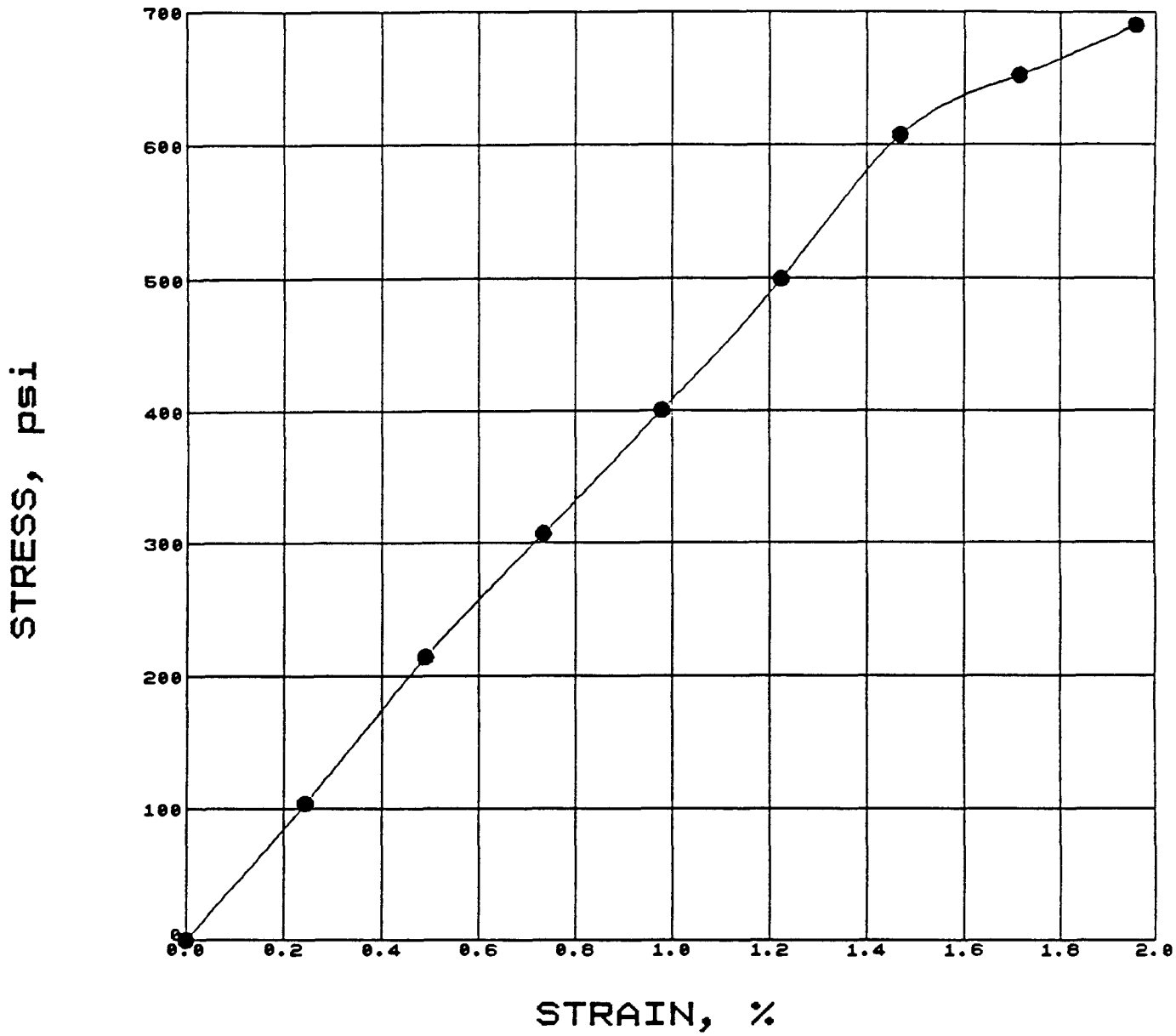


Boring No. AST-9
Depth: 5.50 ft
Material Description: Weathered Limestone (Austin Chalk)
Moisture Content: 14.81 %
Dry Unit Weight: 118.84 pcf
Stress at Failure: 1528 psi
Strain at Failure: 1.72 %
Secant Modulus: 88844 psi

Project No. ASA91-020-00

UNCONFINED COMPRESSION TEST

E1 SITE - SSC PROJECT
WAXAHACHIE, TEXAS

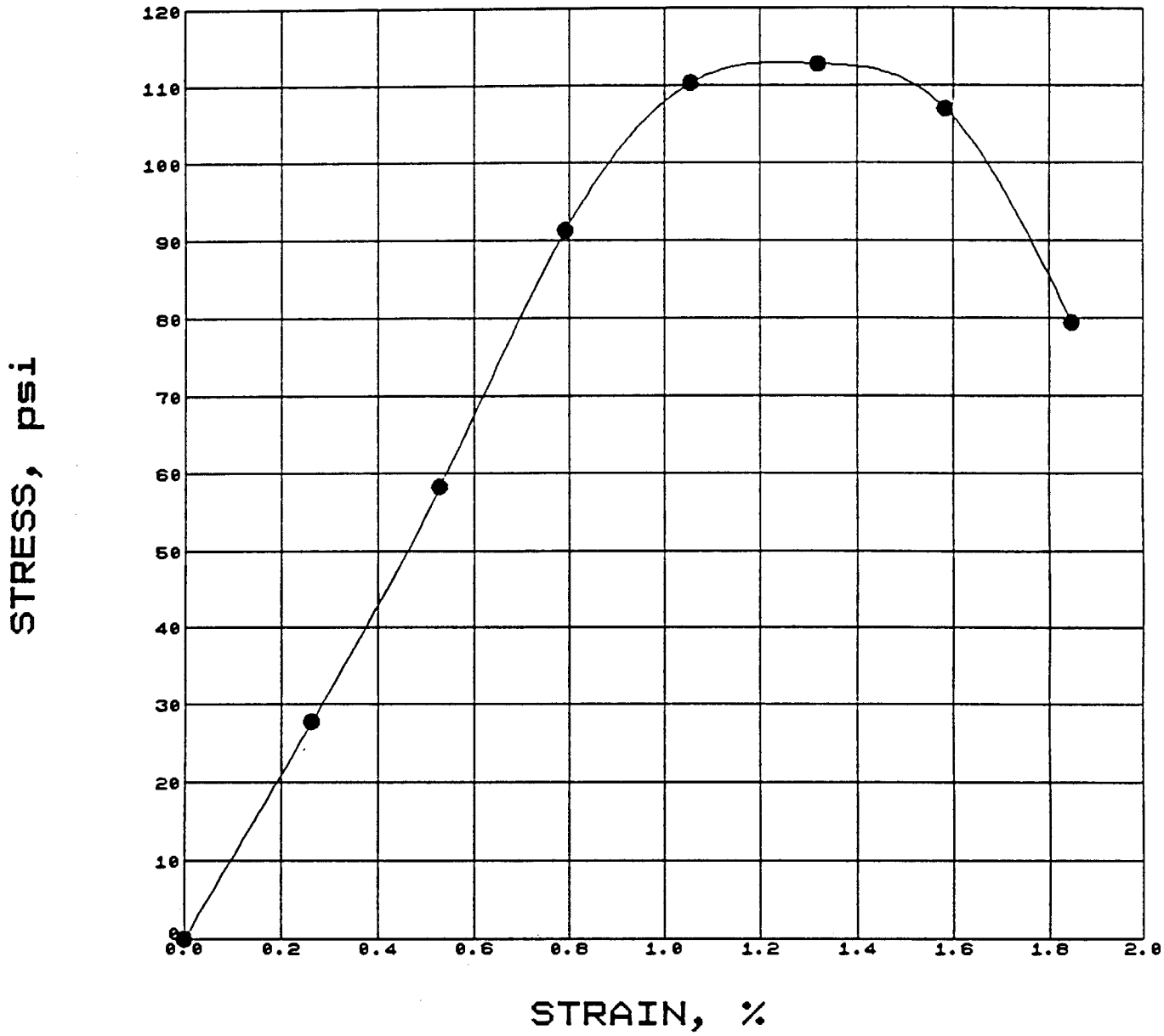


Boring No. AST-9
Depth: 11.50 12.00 ft
Material Description: Unweathered Limestone (Austin Chalk)
Moisture Content: 13.64 %
Dry Unit Weight: 123.28 pcf
Stress at Failure: 690 psi
Strain at Failure: 1.96 %
Secant Modulus: 35251 psi

Project No. ASA91-020-00

UNCONFINED COMPRESSION TEST

E1 SITE - SSC PROJECT
WAXAHACHIE, TEXAS

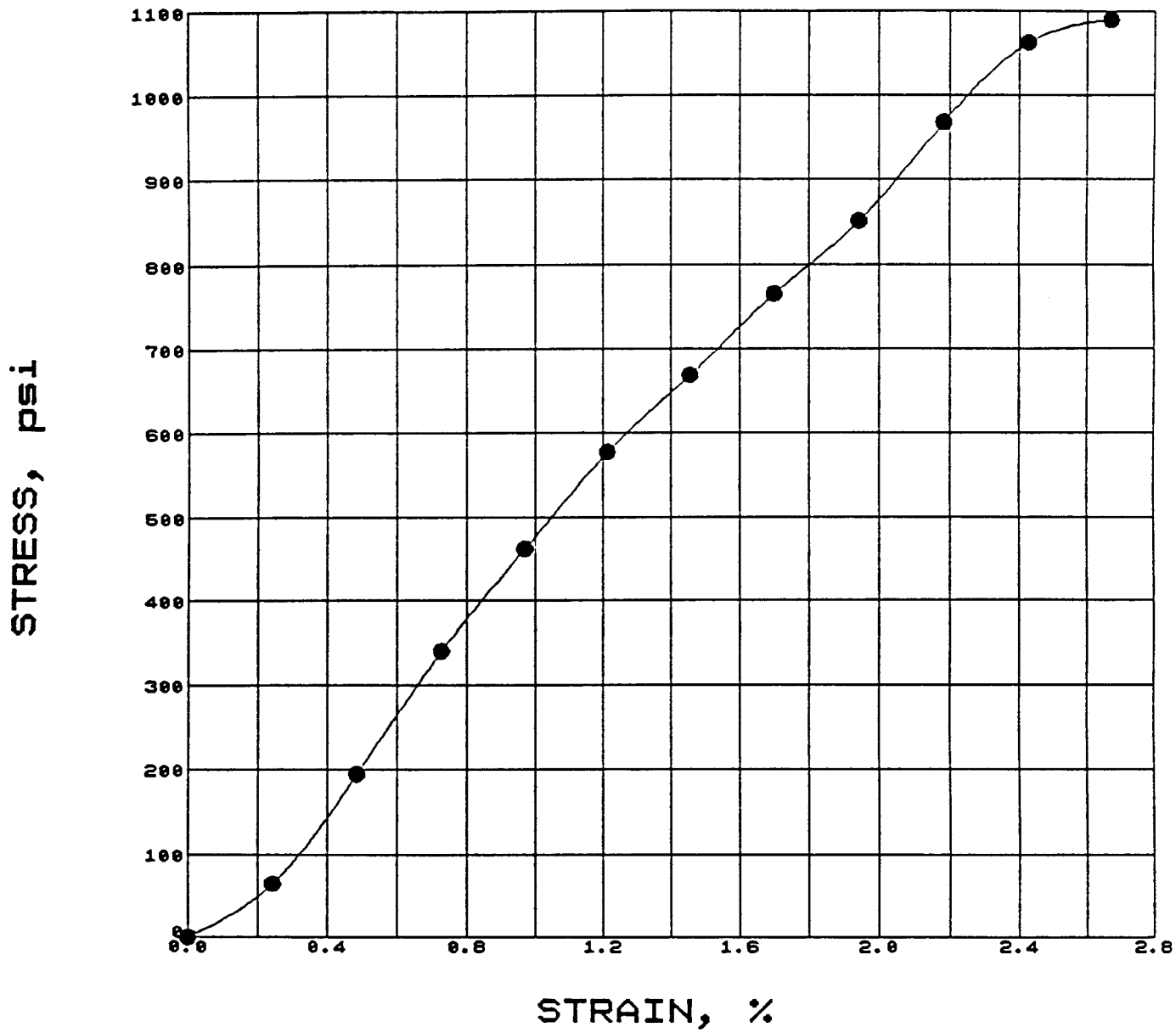


Boring No. AST-10
Depth: 14.00 ft
Material Description: Unweathered Limestone (Austin Chalk)
Moisture Content: 18.83 %
Dry Unit Weight: 97.87 pcf
Stress at Failure: 113 psi
Strain at Failure: 1.32 %
Secant Modulus: 8549 psi

Project No. ASA91-020-00

UNCONFINED COMPRESSION TEST

E1 SITE - SSC PROJECT
WAXAHACHIE, TEXAS

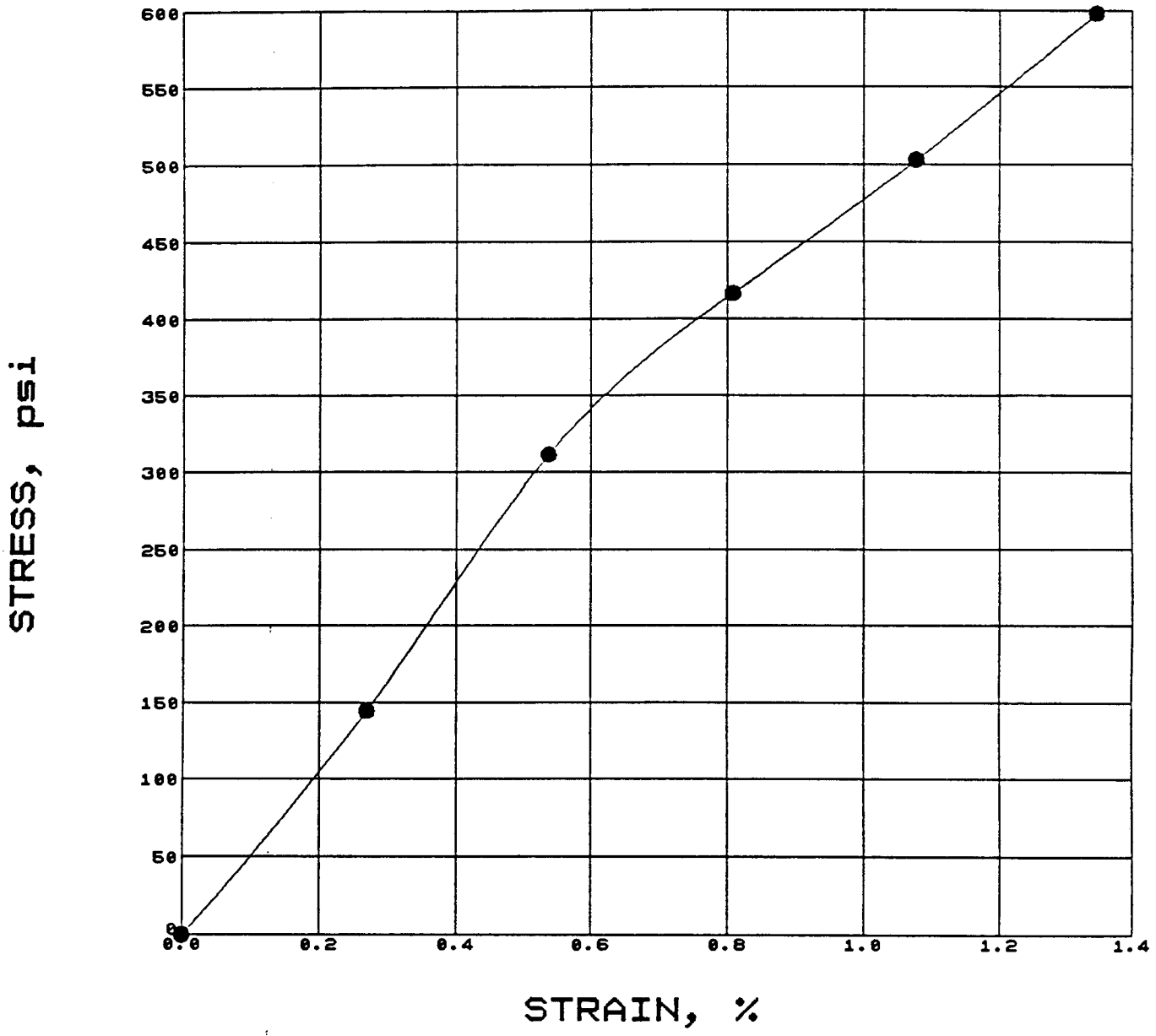


Boring No. AST-11
Depth: 16.10 ft
Material Description: Unweathered Limestone (Austin Chalk)
Moisture Content: 15.85 %
Dry Unit Weight: 117.64 pcf
Stress at Failure: 1090 psi
Strain at Failure: 2.67 %
Secant Modulus: 40833 psi

Project No. ASA91-020-00

UNCONFINED COMPRESSION TEST

E1 SITE - SSC PROJECT
WAXAHACHIE, TEXAS

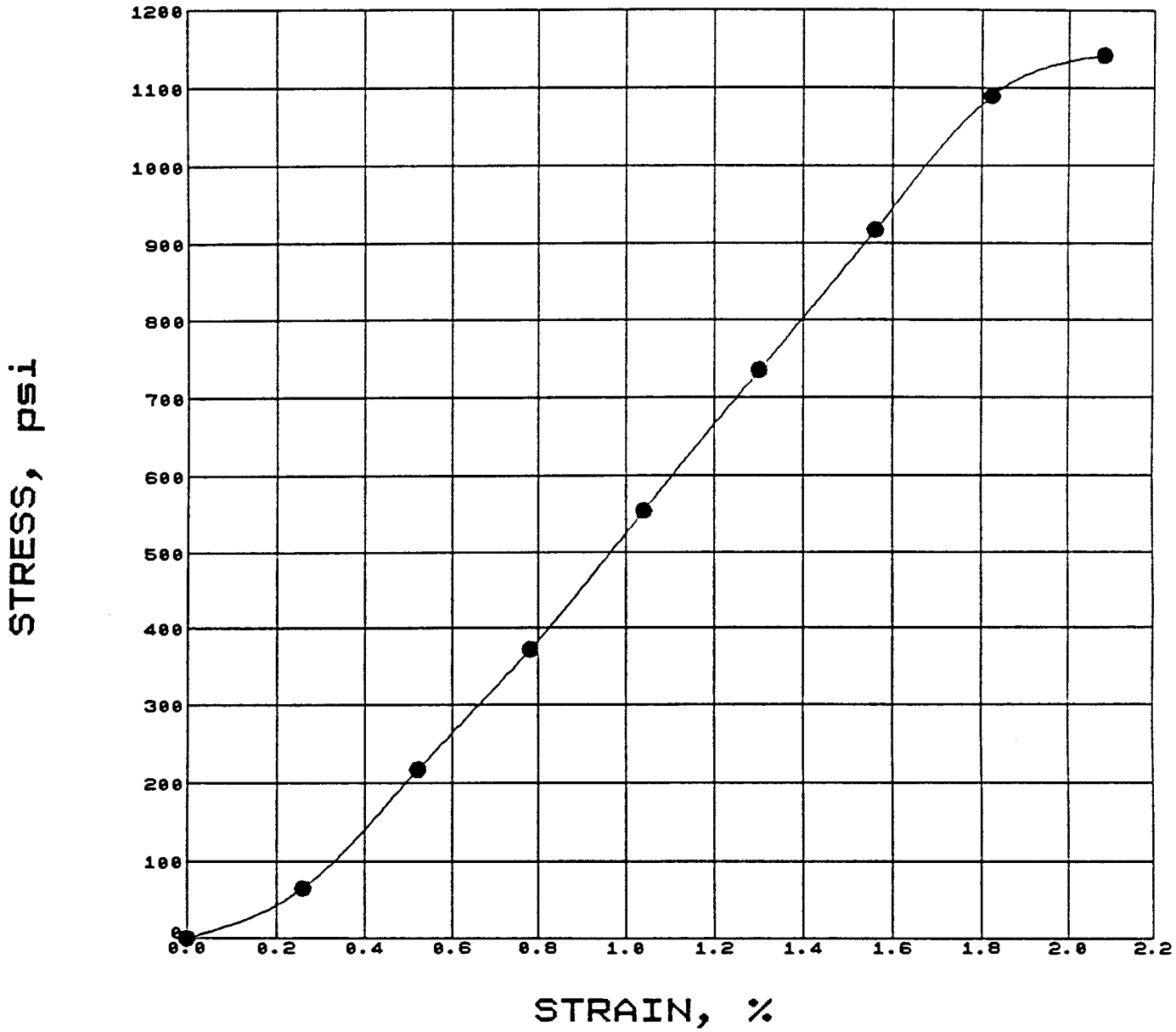


Boring No. AST-12
Depth: 7.50 8.00 ft
Material Description: Weathered Limestone (Austin Chalk)
Moisture Content: 17.38 %
Dry Unit Weight: 112.60 pcf
Stress at Failure: 598 psi
Strain at Failure: 1.35 %
Secant Modulus: 44438 psi

Project No. ASA91-020-00

UNCONFINED COMPRESSION TEST

E1 SITE - SSC PROJECT
WAXAHACHIE, TEXAS

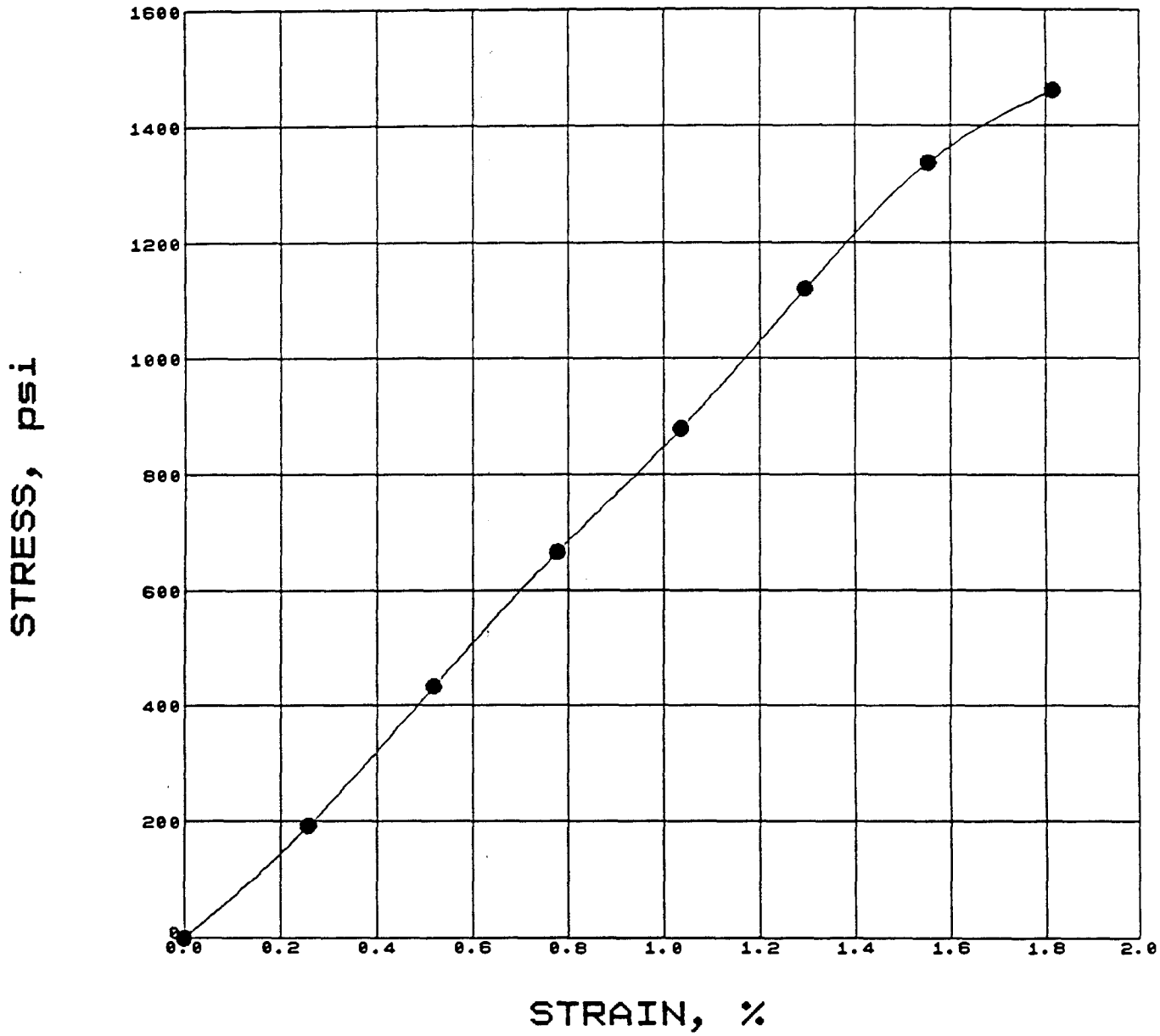


Boring No. AST-12
Depth: 13.00 13.50 ft
Material Description: Unweathered Limestone (Austin Chalk)
Moisture Content: 18.13 %
Dry Unit Weight: 111.16 pcf
Stress at Failure: 1142 psi
Strain at Failure: 2.08 %
Secant Modulus: 54822 psi

Project No. ASA91-020-00

UNCONFINED COMPRESSION TEST

E1 SITE - SSC PROJECT
WAXAHACHIE, TEXAS

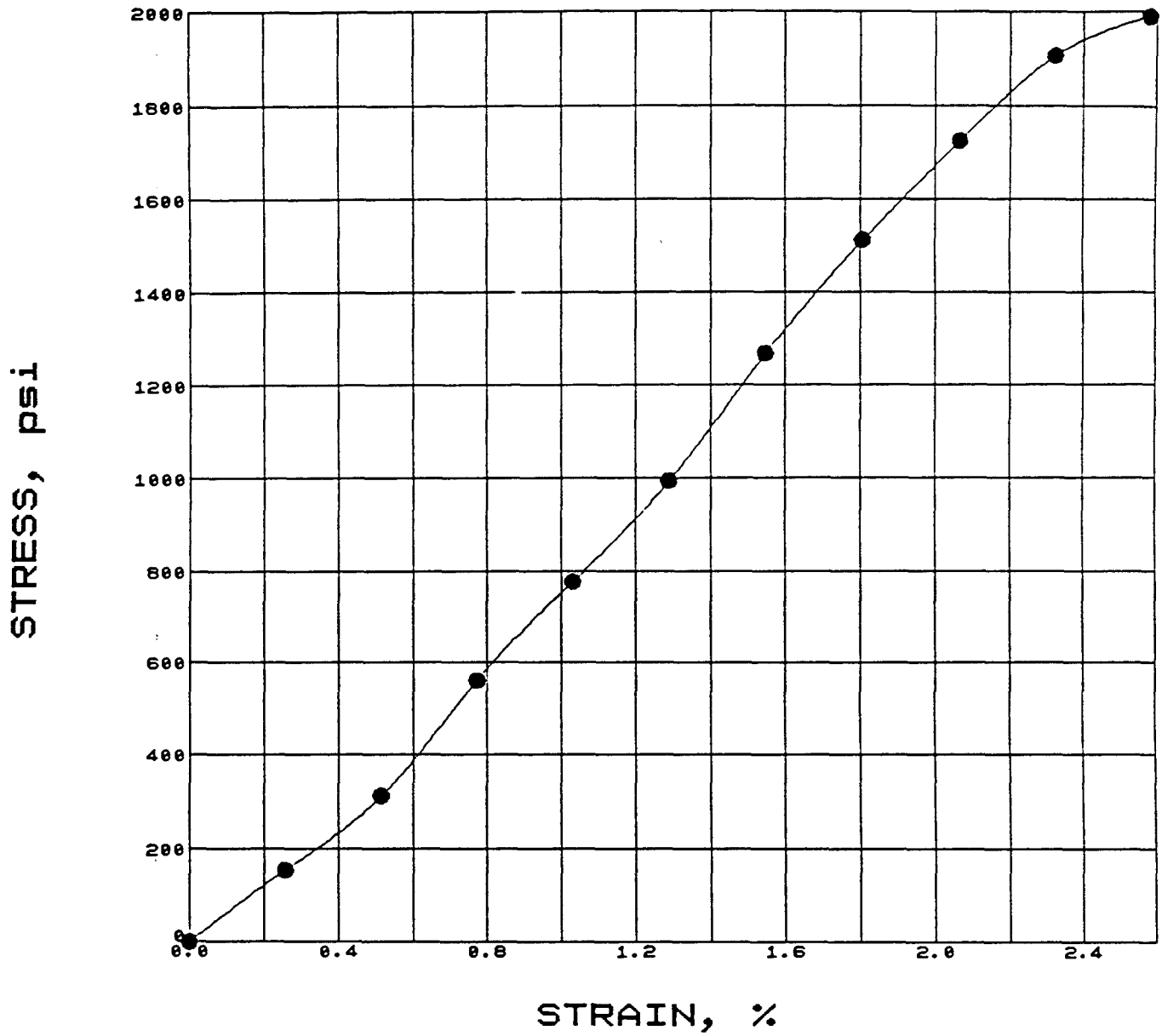


Boring No. AST-13
Depth: 10.00 ft
Material Description: Weathered Limestone (Austin Chalk)
Moisture Content: 17.17 %
Dry Unit Weight: 114.05 pcf
Stress at Failure: 1460 psi
Strain at Failure: 1.81 %
Secant Modulus: 80519 psi

Project No. ASA91-020-00

UNCONFINED COMPRESSION TEST

E1 SITE - SSC PROJECT
WAXAHACHIE, TEXAS



Boring No. AST-13
Depth: 21.00 ft
Material Description: Unweathered Limestone (Austin Chalk)
Moisture Content: 16.12 %
Dry Unit Weight: 116.17 pcf
Stress at Failure: 1989 psi
Strain at Failure: 2.58 %
Secant Modulus: 77092 psi

Project No. ASA91-020-00

RESULTS OF LABORATORY ANALYSIS

BORING NO.	DEPTH (ft)	UNIT DRY WEIGHT (PCF)	MOISTURE CONTENT (%)	UNCONFINED COMPRESSION (TSF)	ATTERBERG LIMITS LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	DESCRIPTION
AST-8	3.5 - 4	123	13.7	78.9				LIMESTONE, Weathered, Tan
	8.5	127	11.3	150				LIMESTONE, Unweathered, Gray
AST-9	5.5	119	14.8	110				LIMESTONE, Weathered, Tan
	11.5 - 12	123	13.6	50.4				LIMESTONE, Unweathered, Dark Gray
AST-10	0 - 1.5				66	25	41	CLAY, Dark Brown (CH)
	14	98	18.8	9.1				LIMESTONE, Unweathered, Dark Gray
AST-11	16.1	118	15.9	78.6				LIMESTONE, Unweathered, Gray to Dark Gray
AST-12	0 - 1.5				51	21	30	CLAY, Dark Brown (CH)
	7.5 - 8	113	17.4	44.3				LIMESTONE, Weathered, Tan
	13 - 13.5	111	18.1	82.1				LIMESTONE, Unweathered, Gray
AST-13	1.5 - 3				65	24	41	CLAY, Dark Brown (CH)
	10	114	17.2	105				LIMESTONE, Weathered, Tan
	21	116	16.1	143				LIMESTONE, Unweathered, Gray