Geotechnical Assessment and Foundation Recommendations
Proposed Foundation Structure

2205 Gardenia Dr.
Austin Texas, 78727

Client: Advanced Consulting Engineers, Inc.

SIMPLIFIED ENGINEERING & CONTRACTING (SEC) Solutions LLC
407 Forest St
Liberty Hill, TX – 78626

August 22, 2023

Project Number: 23192

Client: Ash Tariq

Advanced Consulting Engineers, Inc.

Subject: *Geotechnical Assessment and Foundation Recommendations*

Future Commercial Development at 2205 Gardenia Dr., Austin Texas, 78727.

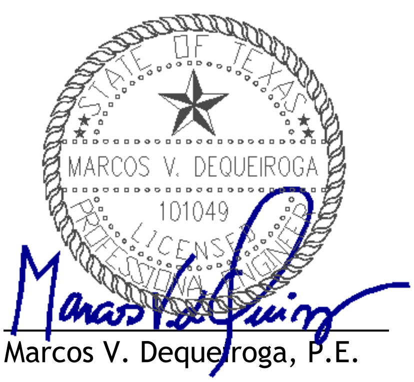
SEC Solutions LLC is pleased to submit the results of the geotechnical study for the above-referenced project. This report briefly presents the findings of the study along with our conclusions and foundation design recommendations for the proposed commercial development at *2205 Gardenia Dr., Austin Texas, 78727.*

We appreciate the opportunity to serve you and look forward to working with you in other future projects.

Should you have any questions regarding this report, please do not hesitate to email us at *office@sectexas.com* or call us at (512) 215-4364.

Respectfully submitted,

SEC Solutions LLC



Marcos V. Dequeiroga, P.E.

TBPE Firm No. 15009

TABLE OF CONTENTS

ATTACHMENTS

I. FOUNDATION RECOMMENDATIONS

1. Introduction

The intent of this report is to provide geotechnical parameters for the design of a conventionally reinforced ("rebar") or post-tensioned slab on grade foundation. The site was visually inspected by qualified personnel and available soils/geologic data was gathered and analyzed. The job was authorized by *Ash Tariq* with Advanced Consulting Engineers, Inc.

2. Project Description

The project consists of a new one-story commercial/retail structure. The superstructure loads will likely be supported by a continuous perimeter concrete grade beam, monolithically poured with the slab foundation. The estimated superimposed loads can be assumed to be in the range of 1,500 to 2,500 pounds per linear foot applied to the soil along the perimeter of the foundation and 200 pounds per square foot applied by the concrete slab. Column reactions are estimated to be approximately 50kips. Design guidelines for conventionally reinforced foundation slab are provided by the Wire Reinforcement Institute (*Design of Slab-on-Ground Foundations, 1981*) and the FHA BRAB report #33 (1968). *If the foundation system chosen by the foundation Engineer differs from description above, the Geotechnical Engineer must be notified immediately to adapt design recommendations given in this report to the foundation type chosen.*

Design and construction of a post-tension foundation shall follow guidelines set forth by the Post-Tension Institute (PTI) publications *"Design of Post-Tensioned Slabs-on-Ground"*, 3rd Edition (2008) and "Construction and Maintenance Manual for Post-Tensioned Slab-on-Ground Foundations" (2006).

3. Site Geology

The site is located in Austin, Travis County, Texas. The geologic map (Geologic Atlas of Texas, Austin Sheet, Texas, Bureau of Economic Geology, The University of Texas at Austin, 1974) shows the site located in the ***Austin Chalk***

(Kau) Formation. The Austin Chalk consists of beds of impure chalky limestone, containing 85 percent or more of calcium carbonate, interstratified with beds of softer marl. It is usually of an earthy texture, free from grit, and on fresh exposure softer, so that it can be cut with a handsaw, but on exposure more indurated. A partial geologic map of the location is shown on Figure 1.

4. Visual Inspection and Geotechnical Boring

At the time of inspection and field work evidence of fill material was observed at 12" (B1 & B2). The site presents low to moderate topography, Figure A. Evidence of groundwater was found during subsurface exploration at 8ft (B-1) below existing grade.

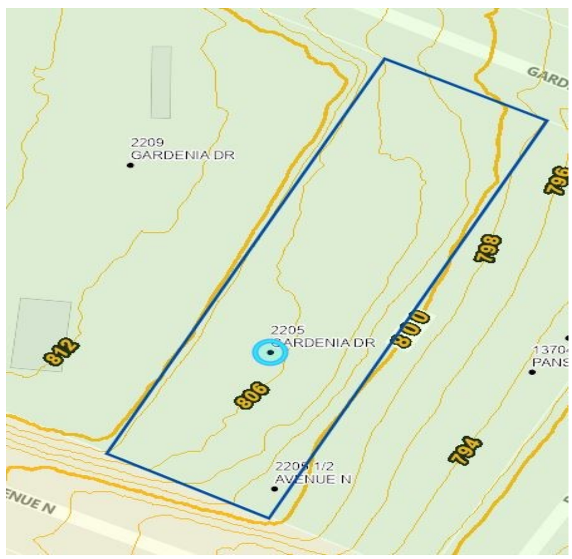


Figure A. Site Topographic Map (Source: COA Property Profile). Contour lines: 2ft (light) 10ft (heavy).

A site evaluation was conducted by a representative of SEC and *four soil borings* were advanced by direct push and auger drilling to a final depth of 15 feet below existing grade elevation (Ref. Boring Log). A two-inch outside diameter split barrel (split-spoon) sampler and open solid barrel samplers were used to collect subsurface samples. Samples were visually classified by a representative of SEC onsite and placed in sealed containers to reduce moisture loss and disturbance during transport to the lab. Samples are analyzed at the lab. A log of boring is included in this report.

Based upon the results of the subsurface exploration program, a geotechnical laboratory testing program was established. The following tests on cohesive soil samples were performed: sieve analysis, Atterberg Limit determinations and water content determinations.

5. Site Stratigraphy

Tables 1a through 1d provide a subsurface description of a generalized nature to highlight the major stratification features and material characteristics. The boring log shows specific information at the boring location(s). The boring log includes soil descriptions, stratifications, penetration resistance, and groundwater information (if encountered) at the approximate location of the sample observed. The stratifications shown on the boring log represent the conditions only at the actual boring location. Variations may occur and should be expected across the site. The stratifications represent the approximate boundary between subsurface materials and the actual transition may be gradual. The borings were advanced to a final depth of 15 feet.

Table 1a. Site Stratigraphy (B-1)

Stratum	Approximate Depth (ft)	Approximate Thickness (ft)	Liquid Limit (LL)	Plasticity Index (PI)	USCS Symbol
Stratum I	*At Surface*	*5.0*	75	46	*Gravelly* **CLAY (CH)**: *very pale brown, medium*
Stratum II	*5.0*	*8.0*	92	61	**CLAY (CH)**: *reddish yellow w/ white streaks, medium to very stiff*
Stratum III	*13.0*	*At depth of termination, approx. 15ft*	87	54	**CLAY (CH)**: *dark grey/yellowish red (mix), very stiff*

Table 1b. Site Stratigraphy (B-2)

Stratum	Approximate Depth (ft)	Approximate Thickness (ft)	USCS Symbol
Stratum I	*At Surface*	*11.0*	**CLAY (CH)**: *very pale brown, medium to very stiff.*
Stratum I	*11.0*	*At depth of termination, approx. 15ft*	**CLAY (CH)**: *dark grey/yellowish red (mix), very stiff*

Table 1c. Site Stratigraphy (B-3)

Stratum	Approximate Depth (ft)	Approximate Thickness (ft)	Liquid Limit (LL)	Plasticity Index (PI)	USCS Symbol
Stratum I	*At Surface*	*2.0*	72	44	*Gravelly* **CLAY (CH)**: *very pale brown, medium*
Stratum II	*2.0*	*9.0*	80	48	**CLAY (CH)**: *reddish yellow w/ white streaks, medium to very stiff*
Stratum III	*11.0*	*At depth of termination, approx. 15ft*	88	50	**CLAY (CH)**: *dark grey/yellowish red (mix), very stiff*

Table 1d. Site Stratigraphy (B-4)

Stratum	Approximate Depth (ft)	Approximate Thickness (ft)	USCS Symbol
Stratum I	*At Surface*	*3.0*	*Gravelly* **CLAY (CH)**: *very pale brown, soft*
Stratum II	*3.0*	*5.0*	**CLAY (CH)**: *reddish yellow w/ white streaks, medium to stiff*
Stratum III	*8.0*	*At depth of termination, approx. 15ft*	**CLAY (CH)**: *dark grey/yellowish red (mix), very stiff*

6. Foundation Design Parameters

The results of site exploration and laboratory testing indicate that this building site presents a ***high potential for soil induced movement of the foundation structure***. ***The effective Plasticity Index (PI) for this site is 60. The Potential Vertical Rise (PVR) is approximately 6½"*** (TxDOT Method Tex-124-E).

The natural (unimproved) condition of the subgrade *is not recommended* for the proposed development. The builder/owner has the option to improve the soil condition by removing the expansive clays under the proposed foundation to a specified depth as recommended in this report and replacing it with compacted select fill material or other available chemical injection techniques. The design parameters given in this report are based on:

(a) Select Fill: excavation of the expansive clay soil and subsequent replacement with compacted select fill (refer to Table 2 for depth of removal of natural clays/ replacement with compacted select fill and resulting design parameters) (Ref. Section 6.1);

(b) Chemical Injection: The purpose of this procedure is to introduce a chemical solution that will aid in controlling natural variations in moisture content of the expansive clay soils by altering its molecular nature (Ref. Section 6.2).

(c) Drilled Piers, ref. Section 6.3.

6.1. Select Fill

Presented in Table 2a are the parameters for the design of post-tension ribbed foundation. These values are given for the 3rd. Edition of the Post-Tension Institute "Design of Post-Tensioned Slabs-on-ground", 2008. ***Table 2a also shows design parameters for the clay removal/fill placement option, with multiple depths of clay replacement***. For this site the following information was also obtained:

- Allowable Bearing Capacity (*F.S.: 2.5*):
  2,000 PSF (12 inches into compacted select fill)
  3,000 PSF (24 inches into compacted select fill)
- Thornthwaite Moisture Index: - 10

Table 2a. PTI Design Parameters: 3rd. Edition.

Design PI	PVR	Center Lift		Edge Lift	
		e_m (FT)	y_m (IN)	e_m (FT)	y_m (IN)
24[1]	2”	9.0	5.0	1.06	1.42
17[2]	1”	9.0	5.2	0.67	0.90

Notes:

[1] Remove 5ft of natural CLAYS (CH) and replace with 6ft (min.) of compacted select fill per *Section 7*.

[2] Remove 6ft of natural CLAYS (CH) and replace with 7ft (min.) of compacted select fill per *Section 7*.

6.2. Chemical Injection

If treatment by chemical injection is preferred, ***it is recommended that the treatment of surficial soils extends to a minimum depth of approximately 10ft below existing grade to limit vertical movements to one inch***. Recommendations for pressured chemical injection methods are provided as follows:

- *Prior to the start of injection operations, the building pad should be staked out to accurately delineate the building footprint;*
- *Injection should be made to a depth of 10ft on 5ft centers each direction, covering an area of a minimum of 5ft outside the building footprint. Chemical solution should be added in accordance with the manufacturer's recommendations;*

- *Injections should be continued until a pocket penetrometer reading of 3.0 TSF or less is obtained on undisturbed soil samples throughout the injected depth;*
- *A minimum of 12 inches of select fill should' be placed over the entire injected subgrade as soon as is practical after completion of injection operations.*
- *A Testing Lab should be retained to provide post-injection field and laboratory testing to evaluate the effectiveness of the injection process.*

Upon completion of injection operations, the exposed surface should be scarified and re-compacted to 95% of the maximum dry unit weight of the soil per ASTM D-1557. Select fill should then be placed in maximum loose lifts of 6 inches to attain slab final elevation. Select fill shall be compacted to 95 percent of maximum density per ASTM D1557 at a moisture content of +/- 2% of optimum.

A minimum of 2ft embedment into natural grade is required. With the reduction of the design PVR, the following design parameters are recommended for conventional (rebar) and post-tension foundation:

- Potential Vertical Rise (PVR): ***1"*** *(TxDOT Method Tex-124-E)*.
- Allowable Bearing Capacity: **2,000psf** *(2ft into natural grade)*.

The parameters for a rebar slab design are provided by the Wire Reinforcement Institute (*Design of Slab-on-Ground Foundations, 1981) and the FHA BRAB report #33 (1968*). Following are the design parameter for a conventionally reinforced stiffened slab on grade with deep perimeter beam:

- Climatic Rating (Cw): **18**
- BRAB Support Index (C): **0.90**
- 1-C: **0.10**
- WRI Cantilever Length (lc): **5.0 FT**
- BRAB Slab **Type III**

Presented in Table 2b are the parameters for the design of post-tension ribbed foundation. These values are given for the **3rd. Edition** of the Post-Tension Institute "*Design of Post-Tensioned Slabs-on-ground*", 2008. For this site the following information is available:

- Thornthwaite Moisture Index: **- 12**

Table 2b. PTI Design Parameters: 3rd. Edition. ***Perimeter beam penetrating a minimum of 2ft into existing grade. Design PVR: 1" (Chemical Injection)***

		Center Lift	Edge Lift
Edge Moisture Variation Distance	e_m (FT)	**9.0**	**5.0**
Differential Vertical Soil Movement	y_m (IN)	**0.7**	**0.9**

6.3. Deep Foundation: Drilled Piers

The following recommendations applied to drilled piers anchoring *a minimum of* 15ft into existing clay substratum. Foundation engineer shall make final recommendation for pier depth based on design parameters given below. If a group of piers or closely spaced piers are used, a minimum center to center spacing of 3.0 shaft diameters should be used to develop the end bearing values given below. If different shaft diameters are used, then the larger shaft diameter should be used to establish the center to center spacing. Closer spacing could negatively affect adjacent piers. Piers spaced closer than 3.0 diameters center to center should be evaluated on a case by case basis.

Piers penetrating existing clays substratum will be subject to high uplift forces due to moisture induced swelling of clays. Pier shall anchor uplift forces into the length of the pier below the Active Zone by means of *negative skin friction*. If piers are underreamed (belled) the uplift will be resisted by downward gravity forces from the superstructure plus the weight of the soil above the underream extending out from the edge of the bell on a 45-degree angle. *A minimum separation of 12in must be provided between final grade* *elevation and bottom of slab/bottom of stiffening beams. This separation can be accomplished by carton forms (e.g. SureVoid® Void Boxes) under slab and beams. The design of the elevated structure shall be governed by the Latest Edition of the American Concrete Institute "Building Code Requirements for Structural Concrete and Commentary", ACI-318.* Presented in Table 3 are the pier design parameters for piers bearing into expansive clay stratum. The factor of Safety of 2.5 was applied to End Bearing values.

Table 3. Drilled Piers design parameters.

Description Parameter	Value
Minimum pier diameter	12in
Uplift Force: *12" dia. Pier/9ft active zone depth*	52 kips
End Bearing pressure *(net allowable), 15ft below grade*	6,500 psf
Side Friction (net allowable): *for section of the pier length embedded beyond the depth to the Active Zone (9 ft)*	450 psf
Estimated maximum total settlement	1"
Estimated differential settlement	½"

Drilled piers to be reinforced throughout their length with a minimum of one 1% percent longitudinal reinforcing steel by cross sectional area of the pier. Reduction of this recommended amount may be acceptable if the cross-sectional area of the pier is larger than required due to loading conditions. However, a minimum of ½ percent reinforcing steel by cross sectional area is recommended.

7. Structural Fill

Structural fill maybe used in order to provide a flat building pad for the foundation or as a method to improve soil conditions by replacing some of the highly expansive clays with properly compacted fill. Fill material shall be composed of crushed limestone meeting all of the requirements of 2014 TxDOT

Item 247, Type A, Grade 1 or 2; and shall have no more than 15 percent of the material passing the No. 200 sieve. As an overall requirement, all imported soils for structural fill should conform to the following Atterberg values:

- Maximum Liquid Limit: 30
- Maximum Plasticity Index: 15

Fill placement should be performed in lifts of 6in to 8in loose thickness. Each lift must be moisture conditioned and mechanically compacted to attain 95 percent of the maximum dry density determined by the *Modified Proctor Test (ASTM D 1557)* and at moisture content within a range of *3 percent below to 3 percent above optimum moisture content*. The appropriate lift thickness will depend on the Contractor's equipment and the moisture content and quality of the fill material. *Proof-rolling of the exposed surface shall be accomplished following undercutting of the shallow clay soils to identify any soft or unstable soils. If present, these must be removed from the area prior to select fill placement*. The placement of fill shall extend at least 5ft beyond the footprint of the foundation. Failure to comply with these requirements will invalidate all the conclusions in this report as well as the design recommendations.

If a third-party company is hired to perform quality control of the placement and compaction of the select fill, records for the sampling and test results must be submitted to the geotechnical engineering company for review and approval.

8. Surface Drainage

The property must be positively graded at all times to provide for rapid removal of surface water runoff from the foundation system and to prevent ponding of water under floors or seepage toward the foundation system at any time during or after construction. Ponded water will cause undesirable soil swell and loss of strength. As a minimum requirement, finished grades should have slopes of at least 5 percent or 6" drop within the first 10 feet from the exterior walls to allow surface water to drain positively away from the structure. The slope gradient away from the foundation may be reduced to 3 percent for paved areas.

All surface water should be collected and discharged into outlets approved by the civil engineer. Landscape mounds must not interfere with this requirement. In addition, each lot should drain individually by providing positive drainage or sufficient area drains around the buildings to remove excessive surface water.

9. Requirements for Landscaping Irrigation

Sprinkler systems should not be installed where they may cause ponding or saturation of foundation soils within 5 feet of the walls or under a structure. Ponding or saturation of foundation soils may cause soil swell, consequent loss of strength, and movement of the foundation and slab.

Irrigation of landscaped areas should be strictly limited to the amount necessary to sustain vegetation. Excessive irrigation could result in saturating, weakening, and possible swelling of foundation soils.

10. Trees

The presence of trees near the foundation will change the suction profile used in the determination of the design parameters. Typically, all large trees in the vicinity of the foundation pad should be removed to avoid larger than anticipated foundation movement. The expression "large trees" usually refers to trees with a diameter of the trunk equal or more than 24". If removal of the trees is not permitted, the geotechnical engineer must be notified of the presence of large trees in order to adjust the design recommendations. Alternatively, a tree barrier may be installed alongside the perimeter of the foundation to prevent tree roots from changing the moisture content under the slab.

11. Utilities

Pipe zone backfill (i.e. material beneath and immediately surrounding the pipe) may consist of a well-graded import or native material less than ¾ inch in maximum dimension compacted in accordance with recommendations provided above for engineered fill.

Trench zone backfill (i.e. material placed between the pipe zone backfill and the ground surface) may consist of native soil compacted in accordance with recommendations for engineered fill (Ref. 7. Structural Fill).

Where import material is used for pipe zone backfill, we recommend it consist of fine-to-medium-grained sand or a well-graded mixture of sand and gravel and that this material not be used within 2 feet of finish grades. In general, uniformly graded gravel should not be used for pipe or trench zone backfill due to the potential for migration of (1) soil into the relatively large void spaces present in this type of material and (2) water along trenches backfilled with this type of material.

All utility trenches entering buildings and paved areas should be backfilled entirely with native materials or concrete. Where the trenches pass under the building perimeter and curb line, the length of the backfill zone should extend at least 3 feet to either side of the crossing and should replace both the pipe zone (bedding and shading) and trench zone material. This is to prevent surface water from percolating into the imported trench backfill material and moving under the foundation and pavement where such water would remain trapped in a perched condition.

12. Driveways/Parking Areas

Driveways and other flat-work structures should be constructed structurally independent of the foundation system. This allows flatwork movement to occur with a minimum of foundation distress. Driveway slabs should be conventionally reinforced to control crack width and frequency. Additionally, control joints should be provided to control cracking (8ft to 10ft on centers, max.). Driveway slabs should have a minimum thickness of 4 inches and should slope away from the buildings to prevent water from flowing toward the building.

II. PAVEMENT RECOMMENDATIONS

A pavement section is a layered system designed to distribute concentrated traffic loads to the subgrade. Performance of the pavement structure is directly related to the physical properties of the subgrade soils and traffic loadings. Soils are represented for pavement design purposes by means of a soil support value for flexible pavements and a modulus of subgrade reaction for rigid pavements. Both values are empirically related to strength. The traffic loading condition considered in this repot anticipates ***Light-duty vehicles*** (typical traffic loading will be limited to standard automobiles) with eventual heavily loaded vehicles.

Two pavement systems were considered for the project: *flexible* (*hot mix asphaltic concrete, HMAC*) and *rigid* (*Portland cement concrete, PCC*). Typically, the HMAC section has a lower first cost than the PCC pavement section. However, the PCC section is preferred in heavy loaded areas, where a lower maintenance cost over its life span is expected when compared to an HMAC section.

The asphaltic concrete and Portland cement concrete (PCC) pavement sections were designed in general accordance with the American Association of State Highway and Transportation Officials (AASHTO).

13. Recommendations for Hot Mix Asphaltic Concrete (HMAC).

Recommended pavement thickness utilizing HMAC are shown on Table 4.

Table 4. Flexible Pavement Thickness

MATERIAL TYPE	FLEXIBLE PAVEMENT SYSTEM (THICKNESS)	
	Light Traffic (20,000 ESALs*)	Heavy Traffic (100,000 ESALs*)
Hot Mixed Asphaltic Concrete (HMAC) thickness (meeting TXDOT Item 340; Type D)	2 in	3 in
Compacted Granular Base Material (meeting TXDOT Item 247)	24 in	32 in
Total Thickness	26 in	35 in

18-kip ESAL

13.1. Subgrade Preparation

a. The initial step in subgrade preparation is to strip and remove from the construction area all topsoil, organics, non-engineered fill, and any deleterious materials <u>*to a minimum depth of 6 inches below the existing ground surface*</u>. If expansive clays (CH) are encountered, they should be completely removed to adequate subgrade. After stripping operations are completed within the proposed pavement areas, ***additional excavation should be performed, where necessary to achieve the design subgrade elevation shown on Table 4***.

b. The exposed raw subgrade soils shall be compacted to a minimum density of 98% of the maximum dry density, as determined by the Modified Proctor (ASTM D1557), and at or above the optimum moisture content. Any soft spots must be removed and re-compacted in place.

c. Fills should be compacted in 8 inches (loose lifts, maximum) and meet the Texas Department of Transportation's current Standard Specifications Item 132, Embankment, Density Control.

d. Scarify and re-compact the exposed subgrade under controlled density procedures to the depth recommended in ***Table 4*** of this report or to a minimum of 6 inches, whichever is greater. Compaction of the subgrade shall be to a minimum of 98 percent and less than 100 percent of its maximum dry density when determined in accordance with TxDOT procedure TEX 114-E. The subgrade shall be no less than its optimum moisture to no greater than 4% above its optimum moisture content at time of testing. This moisture content shall be maintained until the first lift of base is placed.

13.2. Base Course

a. Base material shall be composed of crushed limestone base meeting all of the requirements of 2014 TxDOT Item 247, Type A, Grade 1 or 2; and shall have no more than 15 percent of the material passing the No. 200 sieve.

b. Thickness of the base course shall be a minimum as recommended in Table 3. Fill should be compacted in 8 inches (loose lifts, maximum) and meet the Texas Department of Transportation's current Standard Specifications Item 132, Embankment, Density Control.

c. Base course compaction shall be at least 98 percent of its maximum dry density as determined by TxDOT procedure TEX 113-E but shall not exceed 100 percent. The moisture content during compaction and testing shall be maintained within 3 percent of optimum moisture content. Density control by means of field density determination shall be exercised.

d. After compaction, testing and curing of the base material, the surface should be primed using a MC-30 prime coat or an approved equal.

13.3. Material Specifications (HMAC)

The asphaltic concrete surface course shall be plant mixed, hot laid Type D surface meeting the master specifications requirements of 2014 TXDOT Standard Specifications Item 340. The mix shall be compacted between 92 (minimum) and 95 percent of the maximum theoretical density as measured by TEX-227-F. The asphalt cement content by percent of total mixture weight shall fall within a tolerance of ±0.3 percent asphalt cement from the specific mix. In addition, the mix shall be designed so 75% to 85% of the voids in the mineral aggregate (VMA) are filled with asphalt cement. The grade of the asphalt cement shall be PG 64-22 or higher performance grade. Aggregates known to be prone to stripping shall not be used in the hot mix. If such aggregates are used, measures shall be taken to mitigate this concern. The mix shall have at least 70 percent strength retention when tested in accordance with TEX-531-C.

Pavement specimens, which shall be either cores or sections of asphaltic pavement, will be tested according to Test Method TEX-207-F. The nuclear density gauge or other methods which correlate satisfactorily with results obtained from Project pavement specimens may be used when approved by the Engineer. Unless otherwise shown on the plans, the Contractor shall be responsible for obtaining the required pavement specimens at their expense and in a manner and at locations selected by the Engineer of Record or City official.

13.4. Drainage

Insufficient or improper drainage which allows saturation of the pavement subgrade and/or the supporting granular pavement materials will reduce the performance and service life of the pavement systems. The following are basic drainage requirements for the surface and subsurface at this site:

- Any subsurface seepage at the site which may occur at sufficiently shallow depths should be intercepted by drainage ditches or below grade by a French drains system.
- Final site grading should eliminate depressed areas near/adjacent to curbs which may allow surface runoff water to pond and infiltrate into the underlying soils. Curbs must completely penetrate base materials and should be installed to sufficient depth to reduce infiltration of water beneath the curbs.

- Pavement surfaces should be constructed and maintained to help minimize surface ponding. Surface cracks should be promptly sealed to reduce infiltration of surface water into the pavement section.

14. Recommendations for Concrete Pavement (PCC)

Recommended concrete pavement thickness utilizing Portland cement concrete (PCC) is shown on Table 5.

Table 5. Flexible Pavement Thickness

	RIGID PAVEMENT SYSTEM THICKNESS	
	Light Traffic (20,000 ESALs*)	Heavy Traffic (20,000 ESALs*)
Reinforced Concrete	**5 in**	**6 in**
Compacted Granular Base Material (meeting TXDOT Item 247)	**16 in**	**24 in**
Total Pavement Thickness	**21 in**	**30 in**

18-kip ESAL

14.1. Subgrade Preparation

See recommendations on the preceding section on HMAC pavement.

14.2. Material Specifications

Concrete shall meet requirements for Item 360, *Concrete Pavement*, of the TxDOT's Standard Specifications. The concrete for paving shall develop a minimum compressive strength of 4,000 psi (*28-day compressive strength, F'c*). Temperature and Shrinkage Reinforcing shall consist of ***#4 rebar spaced at 12" on centers***, ***each direction***. Concrete reinforcement should be placed at

407 Forest St
Liberty Hill, TX 78626
(512) 215-4364

approximately 1/3 of the pavement thickness (t) below the surface but not less than 2 inches.

Control joints shall be 10 to 15 feet on centers each way. The reinforcing steel must not run continuously through the joints. Smooth doweled expansion joints with bituminous fiber or red wood filler should be installed at contact with rigid structures (e.g., slabs on grade). Use of control joints will improve the performance of the concrete pavement. In particular, control joints should be constructed wherever the concrete pavement leans upon another structural element subject to a different magnitude of movement, such as: light poles, retaining walls, building foundations, or manholes.

Based on projects with similar vehicular loading, we recommend that dowels be provided at transverse joints within the slabs located in the travel lanes of heavily loaded vehicles. Additionally, curbs and/or pans should be tied to the slabs. The dowels and tie bars will help minimize the risk for differential movements between slabs to assist in more uniformly transferring axle loads to the subgrade.

It is recommended that the control joints be sealed with a rubberized asphalt or silicate joint sealer. The material proposed for use for joint sealer shall be submitted to the Engineer a minimum of 10 days prior to its use. After construction, the control joints should be inspected periodically and resealed, if necessary.

14.3. Drainage

See recommendations on the preceding section on HMAC pavement (13.4).

III. Report Limitations

The recommendations of this report are based on the information provided regarding the proposed construction as well as the subsoil conditions encountered at the test hole location(s). If the proposed construction is modified or re-sited, or if it is found during construction that subsurface conditions differ from those described on the test hole logs, the conclusions and recommendations of the report should be considered invalid unless the changes are reviewed, and the conclusions and recommendations modified or approved in writing.

The analysis, conclusions and recommendations contained in this report are based on the site conditions as they existed *at the time exploratory test hole was performed*. It is assumed that the test holes are representative of the subsurface conditions throughout the site. If there is a substantial lapse of time between the submission of our report and the start of the work at the site, or if conditions have changed due to natural causes or construction operations at or adjacent to the site, we recommend that this report be reviewed to determine the applicability of the conclusions and recommendations considering the changed conditions and time lapse. This report is applicable only for the project and site studied.

Our professional services were performed, our findings obtained, and our recommendations proposed in accordance with generally accepted engineering principles and practices. This warranty is in lieu of all other warranties either expressed or implied. Test findings and statements of professional opinion do not constitute a guarantee or warranty, expressed or implied. The pavement construction recommendations presented in this report do not account for uncontrollable conditions such as improper subgrade preparation, improper fill material, presence of large trees close to the pavement, unforeseen groundwater conditions or improper drainage.

The scope of our services did not include any environmental assessment or investigation for the presence or absence of wetlands, hazardous or toxic materials in the soil, surface water, groundwater or air, on or below or around this site.

Field Test Procedures

Standard Penetration Test (SPT)

This test consists of driving the split spoon sampler (SS) into the ground using a standard weight slide hammer (140 lb. hammer) with 30 inches of fall. The sampler is driven 6 inches into the ground and then the number of blows to advance the sampler an additional 18 inches is counted. The amount of blows necessary to advance the sampler the last 12" is designated SPT value or N-value. The N-value provides an indication of the relative density of the subsurface soil and is used in empirical geotechnical correlation to estimate relative density and shear strength of the soils (Table I). The procedure follows ASTM D3441 – ASTM D1586.

Table I. Correlation between the SPT N-value, Friction Angle and Relative Density

N-value	Density	Relative Density (%)	Friction Angle
< 4	Very Loose	<20	<30
4-10	Loose	20-40	30-35
10-30	Compact	40-60	35-40
30-50	Dense	60-80	40-45
> 50	Very Dense	>80	>45

Laboratory Tests

Laboratory tests were performed on selected samples to aid in soil classification and to evaluate physical properties of the soils, which may affect the geotechnical aspects of project design and construction. A description of the laboratory testing program is presented below.

Sieve Analysis

Sieve analyses were performed to evaluate the gradation characteristics of the material and to aid in soil classification. Tests were performed in general accordance with ASTM Test Method C 136 and D 2487.

Atterberg Limits

Atterberg Limits tests were performed to aid in soil classification and to evaluate the plasticity characteristics of the material. Additionally, test results were correlated to published data to evaluate the shrink/swell potential of near-surface site soils. Tests were performed in general accordance with ASTM Test Method D 4318. Atterberg Limits refer to the following:

Liquid Limit (LL): water content corresponding to the behavior change between the liquid and plastic states of silt or clay.

Plastic Limit (LL): water content corresponding to the behavior change between the plastic and semisolid states of silt or clay.

Shrinkage Limit (SL): water content corresponding to the transition from semisolid to solid state of silt or clay.

Moisture Content

Moisture content tests were performed to evaluate moisture-conditioning requirements during site preparation and earthwork grading. Moisture content was evaluated in general accordance with ASTM Test Method D 2216.

Moisture-Density

Standard proctor tests were performed on bulk soil samples to evaluate maximum dry density and optimum moisture content. Test procedures were in general accordance with ASTM Test Method D 2937.

15. References

1. American Society of Civil Engineers (ASCE), Texas Section, Recommended Practice for The Design of Residential Foundations, Version 1, January 1, 2003.
2. American Concrete Institute (ACI) 302.1R-04, Guide for Concrete Floor and Slab Construction.
3. American Society of Civil Engineers (ASCE), Texas Section, Guidelines for the Evaluation and Repair of Residential Foundations, Version 1, January 1, 2003.
4. Post-Tensioning Institute. Design of Post-Tensioned Slabs-on-Ground.3rd ed. USA, with 2008 Addendum, Post-Tension Institute, Phoenix, Arizona.
5. Criteria for Selection and Design of Residential Slab-On-Ground, Report#33 to the Federal Housing Administration, Publication 1571, National Academy of Sciences, Washington, D.C., 1968.
6. Design of Slab-On-Ground Foundations. Walter L. Snowden. Wire Reinforcement Institute (WRI). August 1981 and March 1996 (Update).
7. Das, B. M., Advanced Soil Mechanics, McGraw-Hill Company, New York. 1987.
8. Das, B. M., Principles of Geotechnical Engineering, PWS-Kent Publishing Company, Boston, MA, 665 p. 1990.Geologic Map of Texas, Austin Sheet, Bureau of Economic Geology, The University of Texas at Austin. 1981.
9. Geologic Map of Texas, Austin Sheet, Bureau of Economic Geology, The University of Texas at Austin. 1981.

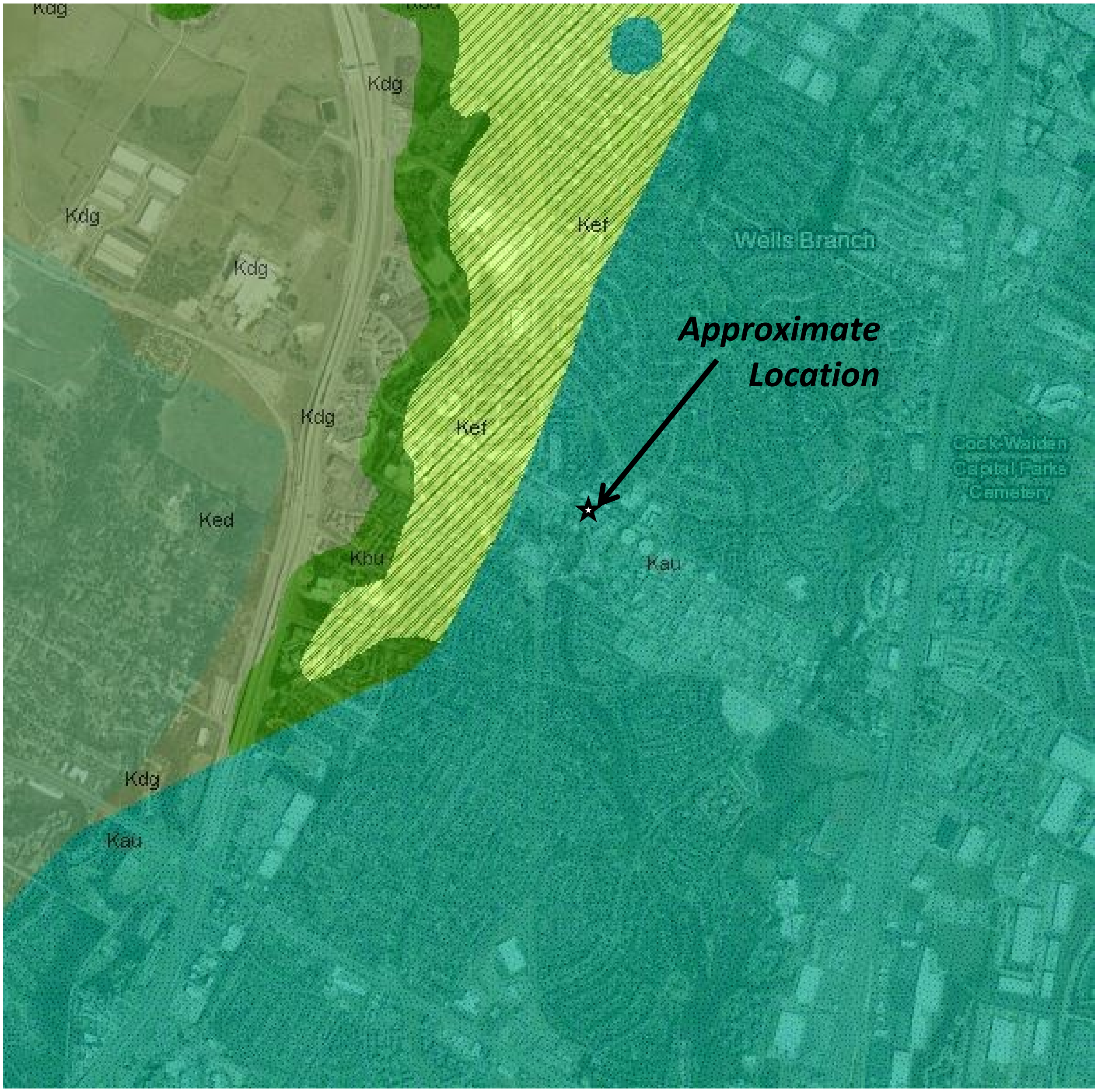


Figure 1. Partial Geological Map. Geologic Atlas of Texas, Austin Sheet, Bureau of Economic Geology, The University of Texas at Austin, 1981.

Figure 2. Project Location Map.

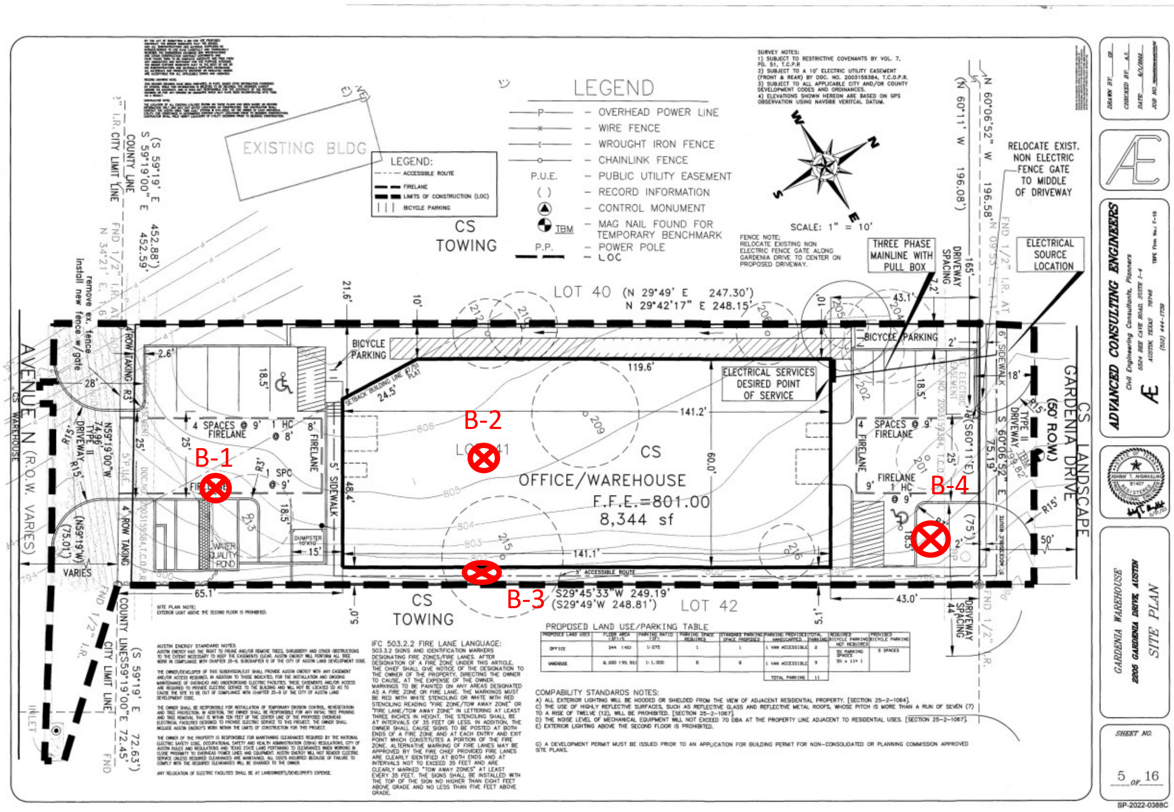


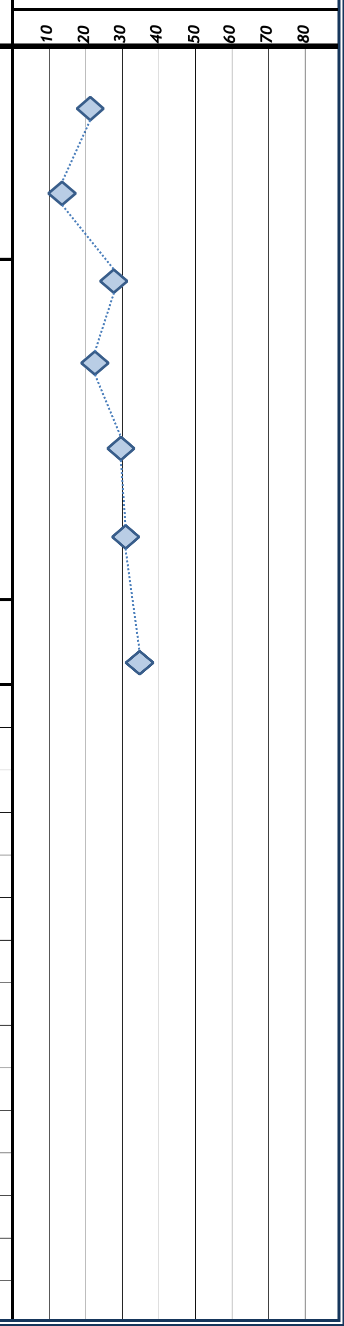
Figure 3. Boring Location Map.

PROJECT	Gardenia Warehouse	PROJECT #	23192
CLIENT:	Advanced Consulting Engineers, Inc.	PROJECT DATE:	8/22/2023
PROJECT ADDRESS:	2205 Gardenia Dr., Austin, TX, 78727	FIELD WORK DATE:	6/19/2023

BORING # **1**

DEPTH (FT)	SAMPLE TYPE	SYMBOL	**SPT FIELD DATA:** N (blows per ft) **STRENGTH (TSF)** Texas Cone Penetrometer	**SOIL DESCRIPTION**	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	MOISTURE CONTENT (%)
	SS		1-1-2 (N=3)	*Gravelly CLAY (CH): very pale brown*			
	ST			*medium*			21
	ST				75	46	14
5	SS		3-2-2 (N=4)	*...soft/medium*			
	ST			*CLAY (CH): reddish yellow, medium*			28
	ST			*w/ white streaks*	92	61	23
10	ST						30
	ST						31
				CLAY (CH): dark grey/yellowish red (mix)			
15	SS		8-11-13 (N=24)	*...very stiff*	87	54	35
20							
25							
30							

MOISTURE CONTENT (%)



OBS: HORIZONTAL LINES REPRESENT APPROXIMATE BOUNDARY OF EACH STRATUM AT THE LOCATION OF FIELD BORING

KEY TO SYMBOLS

- **SS** SPLIT SPOON SAMPLER
- **ST** SHELBY TUBE SAMPLER
- **A** AUGER SAMPLE
- **SPT** STANDARD PENETRATION TEST
- **WL** WATER LEVEL
- ▽ APPROXIMATE GROUND WATER LEVEL
- ◇ MOISTURE CONTENT (%)

LIST OF ABBREVIATIONS

NP: NON-PLASTIC

PROJECT	Gardenia Warehouse	PROJECT #	23192	BORING #	2
CLIENT:	Advanced Consulting Engineers, Inc.	PROJECT DATE:	8/22/2023		
PROJECT ADDRESS:	2205 Gardenia Dr., Austin, TX, 78727	FIELD WORK DATE:	6/19/2023		

DEPTH (FT)	SAMPLE TYPE	SYMBOL	SPT FIELD DATA: N (blows per ft) STRENGTH (TSF) Texas Cone Penetrometer	SOIL DESCRIPTION	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	MOISTURE CONTENT (%)	MOISTURE CONTENT (%) 10 20 30 40 50 60 70 80
	SS		4-4-1 (N=5)	*Gravelly CLAY (CH): very pale brown*				
				medium				
	ST							
5	SS		2-3-3 (N=6)	*...soft/medium*				
10	ST							
				CLAY (CH): dark grey/yellowish red (mix)				
15	SS		10-9-10 (N=19)	*...very stiff*				
20								
25								
30								

OBS: HORIZONTAL LINES REPRESENT APPROXIMATE BOUNDARY OF EACH STRATUM AT THE LOCATION OF FIELD BORING

KEY TO SYMBOLS

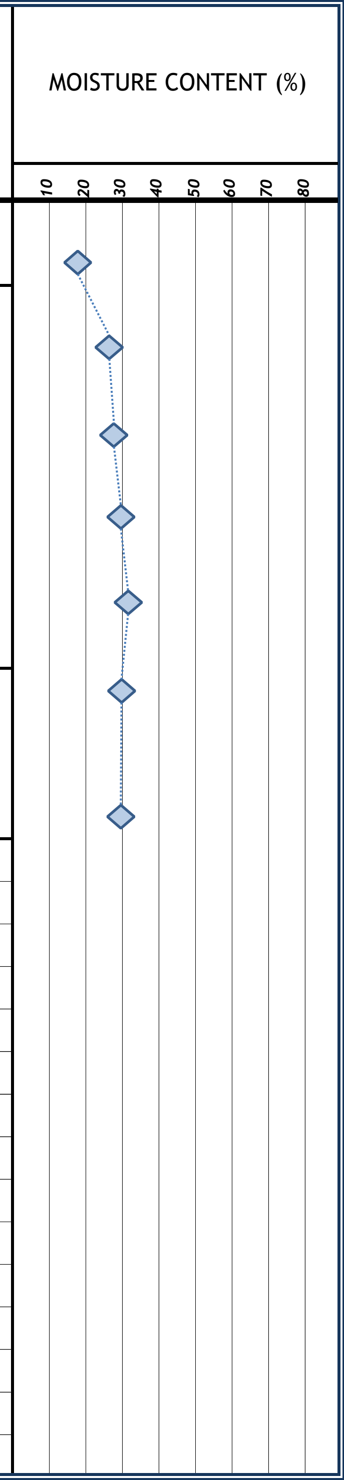
SS SPLIT SPOON SAMPLER
ST SHELBY TUBE SAMPLER
A AUGER SAMPLE
SPT STANDARD PENETRATION TEST
WL WATER LEVEL
▽ APPROXIMATE GROUND WATER LEVEL
◇ MOISTURE CONTENT (%)

LIST OF ABBREVIATIONS

NP: NON-PLASTIC

PROJECT	Gardenia Warehouse	PROJECT #	23192	BORING #	3
CLIENT:	Advanced Consulting Engineers, Inc.	PROJECT DATE:	8/22/2023		
PROJECT ADDRESS:	2205 Gardenia Dr., Austin, TX, 78727	FIELD WORK DATE:	6/19/2023		

DEPTH (FT)	SAMPLE TYPE	SYMBOL	**SPT FIELD DATA:** N (blows per ft) **STRENGTH (TSF)** Texas Cone Penetrometer	**SOIL DESCRIPTION**	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	MOISTURE CONTENT (%)
0–1	SS		2-3-4 (N=7)	*Gravelly CLAY (CH): very pale brown*			
1–2				*medium*	72	44	18
2–4	ST			*CLAY (CH): reddish yellow, medium*			27
4–5	SS		2-2-2 (N=4)				28
5–7				*w/ white streaks*	80	48	30
7–11	ST						32
11–14				*CLAY (CH): dark grey/yellowish red*			30
14–15	SS		6-10-13 (N=23)	*...very stiff*	88	50	30



OBS: HORIZONTAL LINES REPRESENT APPROXIMATE BOUNDARY OF EACH STRATUM AT THE LOCATION OF FIELD BORING

KEY TO SYMBOLS

- **SS** SPLIT SPOON SAMPLER
- **ST** SHELBY TUBE SAMPLER
- **A** AUGER SAMPLE
- **SPT** STANDARD PENETRATION TEST
- **WL** WATER LEVEL
- ▽ APPROXIMATE GROUND WATER LEVEL
- ◇ MOISTURE CONTENT (%)

LIST OF ABBREVIATIONS

NP: NON-PLASTIC

PROJECT	Gardenia Warehouse	PROJECT #	23192	BORING #	4
CLIENT:	Advanced Consulting Engineers, Inc.	PROJECT DATE:	8/22/2023		
PROJECT ADDRESS:	2205 Gardenia Dr., Austin, TX, 78727	FIELD WORK DATE:	6/19/2023		

DEPTH (FT)	SAMPLE TYPE	SYMBOL	SPT FIELD DATA: N (blows per ft) STRENGTH (TSF) Texas Cone Penetrometer	SOIL DESCRIPTION	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	MOISTURE CONTENT (%)	MOISTURE CONTENT (%) 10 20 30 40 50 60 70 80
0–1	SS		1-2-1 (N=3)	*Gravelly CLAY (CH): very pale brown*				
1–4	ST			*medium*				
4–5	SS		2-2-3 (N=5)	*CLAY (CH): reddish yellow, medium*				
5–8	ST			*w/ white streaks*				
8–14	ST			*CLAY (CH): dark grey/yellowish red*				
14–15	SS		8-7-10 (N=17)	*...very stiff*				
15–30								

OBS: HORIZONTAL LINES REPRESENT APPROXIMATE BOUNDARY OF EACH STRATUM AT THE LOCATION OF FIELD BORING

KEY TO SYMBOLS

SS SPLIT SPOON SAMPLER
ST SHELBY TUBE SAMPLER
A AUGER SAMPLE
SPT STANDARD PENETRATION TEST
WL WATER LEVEL
▽ APPROXIMATE GROUND WATER LEVEL
◇ MOISTURE CONTENT (%)

LIST OF ABBREVIATIONS

NP: NON-PLASTIC

MAJOR DIVISIONS			GROUP SYMBOLS	TYPICAL NAMES
COARSE GRAINED SOILS More than 50% retained on No.200 Sieve	**GRAVELS** *50% or more of coarse fraction retained on No.4 Sieve*	CLEAN GRAVELS	**GW**	*Well-graded Gravels, Gravel-Sand mixtures, Little or no fines.*
			GP	*Poorly-graded gravels, Gravel-Sand mixtures, Little or no fines.*
		GRAVELS WITH FINES	**GM**	*Silty Gravels, Gravel-Sand-Silt Mixtures*
			GC	*Clayey Gravels, Gravel-Sand-Clay Mixtures*
	SANDS *More than 50% of coarse fraction passes No.4 Sieve*	CLEAN SANDS	**SW**	*Well-Graded Sands, Gravelly Sands, Little or no fines*
			SP	*Poorly Graded Sands, Gravely Sands, little or no fines*
		SANDS WITH FINES	**SM**	*Silty Sands, Sand-Silt Mixtures*
			SC	*Clayey Sands, Sand-Clay Mixtures*
FINE GRAINED SOILS 50% or more passes No.200 Sieve	**SILTS AND CLAYS** *Liquid Limit (LL) 50% or Less*		**ML**	*Inorganic Silts, Very Fine Sands, Rock Flour, Silty or Clayey Fine Sands or Clayey Silts with Slight Plasticity*
			CL	*Inorganic Clays of Low to Medium plasticity, Gravely Clays, Sandy Clays, Silty Clays, Lean Clays*
			OL	*Organic Silts and Organic Silty Clays of Low Plasticity*
	SILTS AND CLAYS *Liquid Limit (LL) greater than 50%*		**MH**	*Inorganic Silts*
			CH	*Inorganic Clays of High Plasticity, Fat Clays*
			OH	*Organic Clays of Medium to High Plasticity, Organic Silts*
HIGHLY ORGANIC SOILS			**PT**	*Peat, muck and other highly organic soils*

GW	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{D_{30}^2}{D_{10} \times D_{60}}$ between 1 and 3;	
GP	Not meeting all the criteria for GW	
GM	Atterberg Limits below "A" line or PI less than 4	Atterberg Limits above "A" line or PI between 4 and 7 are borderline cases requiring use of dual symbols
GC	Atterberg Limits above "A" line or PI greater than 7	
SW	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{D_{30}^2}{D_{10} \times D_{60}}$ between 1 and 3;	
SP	Not meeting all the criteria for SW	
SM	Atterberg Limits below "A" line or PI less than 4	Atterberg Limits in shaded zone with PI between 4 and 7 are borderline cases requiring use of dual symbols
SC	Atterberg Limits above "A" line or PI greater than 7	

Determine percentages of sand and gravel from grain size curve. Depending on percentage of fines (fraction smaller than No. 200 Sieve Size), coarse-grained soils are classified as follows:
Less than 5 percent .... GW, GP, SW, SP
More than 12 percent .... GM, GC, SM, SC
Between 5 and 12 percent .... Dual Symbols (e.g.: SM-SP)

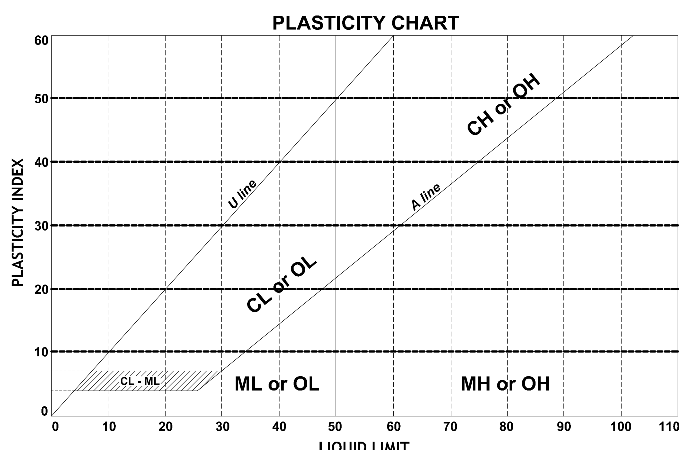
Cu: Coefficient of Uniformity Cc: Coefficient of Gradation/Curvature

GRAIN SIZE TERMINOLOGY

MAJOR COMPONENTS	PARTICLE SIZE
BOULDERS	> 12IN
COBBLES	3 IN TO 12 IN
GRAVEL	#4 SIEVE TO 3 IN
SAND	#200 SIEVE TO #4 SIEVE
SILT OR CLAY	PASSING #200 SIEVE

PLASTICITY DESCRIPTION

NON-PLASTIC	PI = 0
LOW	1<PI<20
MEDIUM	20<PI<30
HIGH	PI>30



RELATIVE DENSITY

N (BLOWS PER FT)	SANDS AND GRAVELS
0-4	VERY LOOSE
4-10	LOOSE
10-30	MEDIUM
30-50	DENSE
> 50	VERY DENSE

CONSISTENCY

N (BLOWS PER FT)	SILT AND CLAYS
< 2	VERY SOFT
2 - 4	SOFT
4 - 8	MEDIUM
8 - 15	STIFF
15 - 30	VERY STIFF
> 30	HARD

SEC SOLUTIONS