

# **TSI LABORATORIES, INC.**

## **GEOTECHNICAL ENGINEERING STUDY**

**Country Reserve Subdivision  
Klesel Rd.  
Schulenburg, TX 78956**



**TSI LABORATORIES, INC.**  
TBPE FIRM REGISTRATION NO: F-9236



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March 14, 2023

Tim Sanders, P.E.  
BEFCO Engineering, Inc.  
c/o Davey Vanicek

Subject: Country Reserve Subdivision  
Klesel Rd.  
Schulenburg, TX 78956

TSI File No.: V-231038

Dear Mr. Sanders,

We are pleased to submit this report of our geotechnical engineering study for the Country Reserve Subdivision located off Klesel Rd. in Schulenburg, TX. The findings and a description of the exploration and testing procedures are presented in the report along with our site preparation recommendations.

We appreciate the opportunity to assist in this phase of the project. Please feel free to contact us, if you have any questions regarding this report or if we may be of further service.

Respectfully submitted,

**TSI Laboratories, Inc.**

A handwritten signature in blue ink that reads "Michael Tater".

Michael Tater, President.



A handwritten signature in blue ink that reads "Daniel Tesfai".

Daniel Tesfai, P.E.

# **GEOTECHNICAL ENGINEERING STUDY**

**Country Reserve Subdivision  
Klesel Rd.  
Schulenburg, TX 78956**

**Prepared For:**

**Mr. Tim Sanders, P.E.  
BEFCO Engineering, Inc.**

**Prepared By:**

**TSI Laboratories, Inc.  
TBPE Firm Registration No.: F-9236**

**Victoria, Texas**

**March 14, 2023**

**TSI Project Number: V-231038**

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## **GEOTECHNICAL ENGINEERING STUDY**

**Country Reserve Subdivision  
Klesel Rd.  
Schulenburg, TX 78956**

### **INTRODUCTION**

#### **Authorization and Scope**

TSI Laboratories, Inc. (TSI) was retained to provide geotechnical study services by Davey Vanicek with Titan Financing Group, LLC on January 24, 2023. The purpose of this study was to determine and evaluate the stratification and engineering properties of the site subsurface soils. TSI will provide geotechnical engineering recommendations and guidelines for use in site preparation, pavement design and related site improvements planned for the Country Reserve Subdivision located off Klesel Rd. in Schulenburg, Texas.

#### **Project Description**

The proposed project involves the construction of a subdivision that will have 750 linear foot of roads.

### **FIELD AND LABORATORY TESTING**

#### **Field Testing**

The site soils were explored by drilling two (2) 10-foot-deep soil test borings within the construction area. Boring locations were determined in the field as indicated by the respective location plan and borings were drilled with respect to the existing grade. Each borehole was advanced using solid stem augers as site conditions dictated. The retrieved samples of the materials encountered were obtained by the appropriate core drilling, split barrel sampling, and with standard penetration testing.

Samples were removed from samplers in the field, visually classified, and appropriately sealed in sample containers to preserve their in-situ moisture contents. Samples were returned to our laboratory in Victoria, Texas.

#### **Laboratory Testing**

The soil samples selected for laboratory testing were examined and visually classified by the sample's representative of the various soil strata encountered. Atterberg limits, moisture contents, sieve analysis and percent fines tests were performed to assist in classifying the soils according to Unified Soil Classification System (ASTM D2487). Proctors and chemical tests were performed to provide additional information on soil properties. The classification and soil test results are presented on the boring logs.

## SUBSURFACE CONDITIONS

The test boring encountered fat clay (CH) soils to the boring termination depths. The site soil has been evaluated by performing various field and laboratory tests on the subsurface samples recovered during the drilling operations. The types of tests conducted on the subsurface samples are listed in the Appendix.

The corresponding log of borings, depicting the stratum soil descriptions, type of sampling used during sample retrieval, laboratory test data, and other field data, is presented in the Appendix at the end of this report. The Key to Boring Log Symbols and Soil Classifications Sheet, which defines the terms and descriptive symbols used on each boring log, is also presented in the Appendix.

### Groundwater

Groundwater was not encountered during drilling operations. It is noted that groundwater levels fluctuate with seasonal climatic variations, such as rainfall, runoff, and other factors. The possibility of groundwater level fluctuations should be considered when developing the design and construction for the project.

### Sulfate Test Results

A sulfate test was performed on sample S23-151, and the result of the test was 206 ppm. The sulfate concentrations indicate the soils at the site are in a low risk level of using lime as a treatment method.

The TxDot Technical Memorandum for treatment of soils containing sulfates with lime indicates the follow risk levels.

Sulfate (ppm)	Risk
< 3,000	Low
3,000 – 5,000	Moderate
5,000 - 8,000	Moderate to High
< 8,000	High

## RECOMMENDATIONS

### Pavement Design

We anticipate that the pavement subgrade will consist of high plasticity, surficial on-site fill soils. We recommend that the top 8-inches of the finished subgrade soils directly beneath the pavement be chemically treated. Chemical treatment will increase the supporting value of the subgrade and decrease the effect of moisture on subgrade soils. These 8-inches of treatment is a required part of the pavement design and is not a part of site and subgrade preparation for wet/soft subgrade conditions.

We anticipate that the on-site soils should react well with lime applied at a rate of about 5 to 6%. These percentages are typically equivalent to about thirty (30) and thirty-five (35) pounds of lime per square yard per 8-inch treated depth. These treatment percentages are given as application by dry weight. The actual amount of lime should be determined at the time of construction by the use of lime determination tests.

Once the subgrade is properly prepared both flexible pavement systems (consisting of asphalt and base material) and reinforced concrete pavement systems may be considered for this project.

Listed below are pavement component thicknesses, which may be used as a guide for pavement systems at the site for the traffic classifications stated herein. The sections we are recommending are equivalent to Fayette County standards. These systems were derived based on general characterization of the subgrade. Specific testing (such as CBR tests, resilient modulus tests, etc.) was not performed for this project to evaluate the support characteristics of the subgrade.

Rigid Pavement	Light duty Thickness	Heavy duty Thickness
Reinforced Concrete	6.0"	8.0"
Treated Subgrade	8.0"	8.0"

Flexible Pavement	Light duty Thickness	Heavy duty Thickness
Asphaltic Concrete	2.0"	2.5"
Base Material	8.0"	10.0"
Treated Subgrade	8.0"	8.0"

The pavement design engineer should consider these and other similar situations when planning and designing pavement areas. Presented below are our recommended material requirements for the various pavement sections.

Reinforced Concrete Pavement – The Portland cement concrete mix should have a minimum 28-day compressive strength of 4,000 psi.

Reinforcing Steel – Reinforcing steel should consist of #3 bars at 12-inches or #4 bars at 18-inches for light duty and #4 bars spaced at 18-inches on centers in both directions for heavy duty.

Control Joint Spacing – control joints should be spaced at about thirty (30) times the thickness of the concrete pavement and a maximum control joint spacing of 15-foot. Sawcut control joints should be cut within six (6) to twelve (12) hours of concrete placement.

Dowels at Expansion Joints – The dowels at expansion joints, if the joints are provided, should be 3/4-inch diameter, 14-inches long with 6-inch embedment for light duty and 7/8-inch diameter, 14-inches long with 6-inch embedment for heavy duty.

Hot Mix Asphaltic Concrete Surface Course – The asphaltic concrete surface course should be plant mixed, hot laid Type D (Fine Graded Surface Course) meeting the specifications requirements in TxDOT 2014 Standard Specifications Item 340. Specific criteria for the job

specifications should include compaction to within an air void range of 5 to 9% calculated using the maximum theoretical gravity mix measured by TxDOT Tex-227-F. The asphalt cement content by percent of total mixture weight should be within  $\pm 0.5\%$  asphalt cement from the job mix design.

Two course surface treatment shall be in accordance with specifications requirements in TxDOT 2014 Standard Specifications Item 316. The rates for the first and second course asphalt must be 0.3 gallons per square yard. The aggregate size for the first and second course is 5/8 and 3/8 river rock respectively at 16 pounds per square yard. The first course shall be rolled with six-ton roller. The remaining roller for the first and second course shall be done with a medium pneumatic roller. The second course surface treatment shall be applied the same day or immediately after the placement of the first course.

Base Material – Base material should be composed of crushed limestone or crushed concrete meeting the requirements of TxDOT 2014 Standard Specifications Item 247, Type A, B, or D, Grade 1. The base material should be compacted to at least 95% of the Modified Effort (ASTM D1557) maximum dry density at a moisture content within 2% of the optimum moisture content.

Treated Subgrade – The on-site surficial subgrade soils should be treated with lime in accordance with the TxDOT 2014 Standard Specifications Item 260. We recommend that 5 to 6% lime by dry weight be used for estimating and planning. The actual quantity of the lime should be determined at the time of construction based on laboratory, Atterberg-Lime Series, testing conducted using bulk samples of the subgrade soils. The pulverization, mixing and curing of the lime treated subgrade is of particular importance in these plastic clays. The lime used should be lime or commercial lime slurry conforming to TxDOT 2014 Standard Specifications Item 260. The subgrade should be compacted to a minimum of 95% of the Standard Effort (ASTM D698) maximum dry density within 2% of the optimum moisture content. Preferably, traffic should be kept off the treated subgrade for seven (7) days to facilitate curing of the soil - chemical mixture. In addition, the subgrade is not suitable for heavy construction traffic prior to paving.

On most project sites, the site grading is accomplished relatively early in the construction phase. As construction proceeds, rainfall and surface water saturates in some areas, heavy traffic from concrete trucks and other delivery vehicles disturbs the subgrade. As a result, the pavement subgrades, initially prepared early in the project, should be carefully evaluated as the time for pavement construction approaches.

We recommend the moisture content and density of the top 8-inches of the subgrade be evaluated and the pavement subgrades be proof rolled two (2) days prior to commencement of actual paving operations. Areas not in compliance with the required ranges of moisture or density should be moisture conditioned and recompact. Particular attention should be paid to high traffic areas that were rutted and disturbed earlier and to areas where backfilled trenches are located. Areas where unsuitable conditions are located should be repaired by removing and replacing the materials with properly compacted fills.

The asphaltic surface shall meet the requirements of the current TxDOT 2014 Specification Item 340 for Dense Graded Hot Mix Asphalt (small quantity) for projects with total production of less

than 5,000 tons and TxDOT 2014 Specifications Item 341 Dense Graded Hot Mix Asphalt for projects with total production of 5,000 tons or greater. The hot mix asphaltic surface will be compacted to between 3.0 and 8.5% in place air voids in conformance with the specification. It is recommended that the testing required by this specification be performed during production. The target design laboratory density should be 97% of the maximum theoretical density for from Rice Test.

Prior to compaction the following gradation requirement must be met:

<b>Minimum Passing Percentage</b>		
<b>Sieve</b>	<b>Base</b>	<b>Subgrade</b>
1 $\frac{3}{4}$	100 %	100 %
$\frac{3}{4}$	85 %	85 %
#4	-	60 %

The pavement design methods described above are intended to provide structural sections with adequate thickness over a particular subgrade such that wheel loads are reduced to a level the subgrade can support. The support characteristics of the subgrade for pavement design do not account for shrink/swell movements of an expansive clay subgrade. Thus, the pavement may be adequate from a structural standpoint, yet still experience cracking and deformation due to shrink/swell related movement of the subgrade. Post-construction subgrade movements and some cracking of pavements are not uncommon for clayey subgrade conditions such as those observed at this site. Minimizing moisture changes in the subgrade is important to reduce shrink/swell movements. Although lime treatment will help to reduce such movement/cracking this movement/cracking cannot be economically eliminated.

Related civil design factors such as subgrade drainage, shoulder support, cross-sectional configurations, surface elevations and environmental factors which will significantly affect the service life must be included in the preparation of the construction drawings and specifications. Normal periodic maintenance will be required.

Long-term pavement performance will be dependent upon several factors, including maintaining subgrade moisture levels and providing for preventive maintenance. The following recommendations should be implemented to help promote long-term pavement performance.

- Site grading should be designed to drain away from the pavements, preferably at a minimum grade of 2%.
- The subgrade and the pavement surface should be designed to promote proper surface drainage, preferably at a minimum grade of 2%.
- Joint sealant should be installed, and cracks should be sealed immediately.
- Curbs should be extended into the treated subgrade for a depth of at least 4-inches to help prevent moisture migration into the subgrade soils beneath the pavement section.
- Compacted, low permeability clayey backfill should be placed against the exterior side of the curb and gutter.

Preventive maintenance should be planned and provided for the pavements at this site. Preventive maintenance activities are intended to slow the rate of pavement deterioration and consist of both localized maintenance (e.g., crack, and joint sealing and patching) and global maintenance (e.g., surface sealing). Prior to implementing any maintenance, additional engineering observations are recommended to evaluate the type and extent of preventive maintenance needed.

### **Rolling Pattern**

A minimum compaction temperature of 175°F (80°C) is the cutoff point, because after this point, the mat temperature is so low that compaction possibilities decrease rapidly. In some cases, the material is too hot to be properly compacted. This is noticeable from the instability of the material under the roller. It is essential that the first pass be made as soon as possible so that the temperature relationships mentioned above will be maintained. The greatest part of compaction is attained with the first breakdown pass. To eliminate or minimize compactor marks the final finishing passes may have to be delayed until the mat cools to the proper temperature.

### **Weather Limitations**

Adverse weather conditions would affect the quality of the asphaltic concrete pavement. These include, but are not limited to the following:

1. Frozen subgrade as evident by the fact that a shaded surface thermometer reads 32°F or less, or the subgrade is excessively hard- the entrapped water has turned to ice.
2. For thin lifts temperature requirements such as 80°F.
3. Muddy subgrade due to the material being too wet.
4. Standing water on the subgrade (this can usually be remedied by using pumps and/or an air hose).
5. A light rain is sometimes OK as long the mat does not cool down too quickly.

## GENERAL REMARKS

TSI should be retained to review the final design plans and specifications so comments can be made regarding interpretation and implementation of our geotechnical recommendations in the design and specifications. TSI also should be retained to provide testing and observation during excavation, grading, foundation, and construction phases of the project.

The analysis and recommendations presented in this report are based upon the data obtained from the borings performed at the indicated locations and from other information discussed in this report. This report does not reflect variations that may occur between borings, across the site, or due to the modifying effects of weather. The nature and extent of such variations may not become evident until during or after construction. If variations appear, we should be immediately notified so that further evaluation and supplemental recommendations can be provided.

The scope of services for this project does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, and bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials, or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

For any excavation construction activities at this site, all Occupational Safety and Health Administration (OSHA) guidelines and directives should be followed by the Contractor during construction to insure a safe working environment. In regard to worker safety, OSHA Safety and Health Standards require the protection of workers from excavation instability in trench situations.

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either expressed or implied, are intended or made. Site safety, excavation support, and dewatering requirements are the responsibility of others. In the event that changes in the nature, design, or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless TSI reviews the changes and either verifies or modifies the conclusions of this report in writing.

## APPENDIX

Boring Locations Map

Logs of Boring

Laboratory Test Results

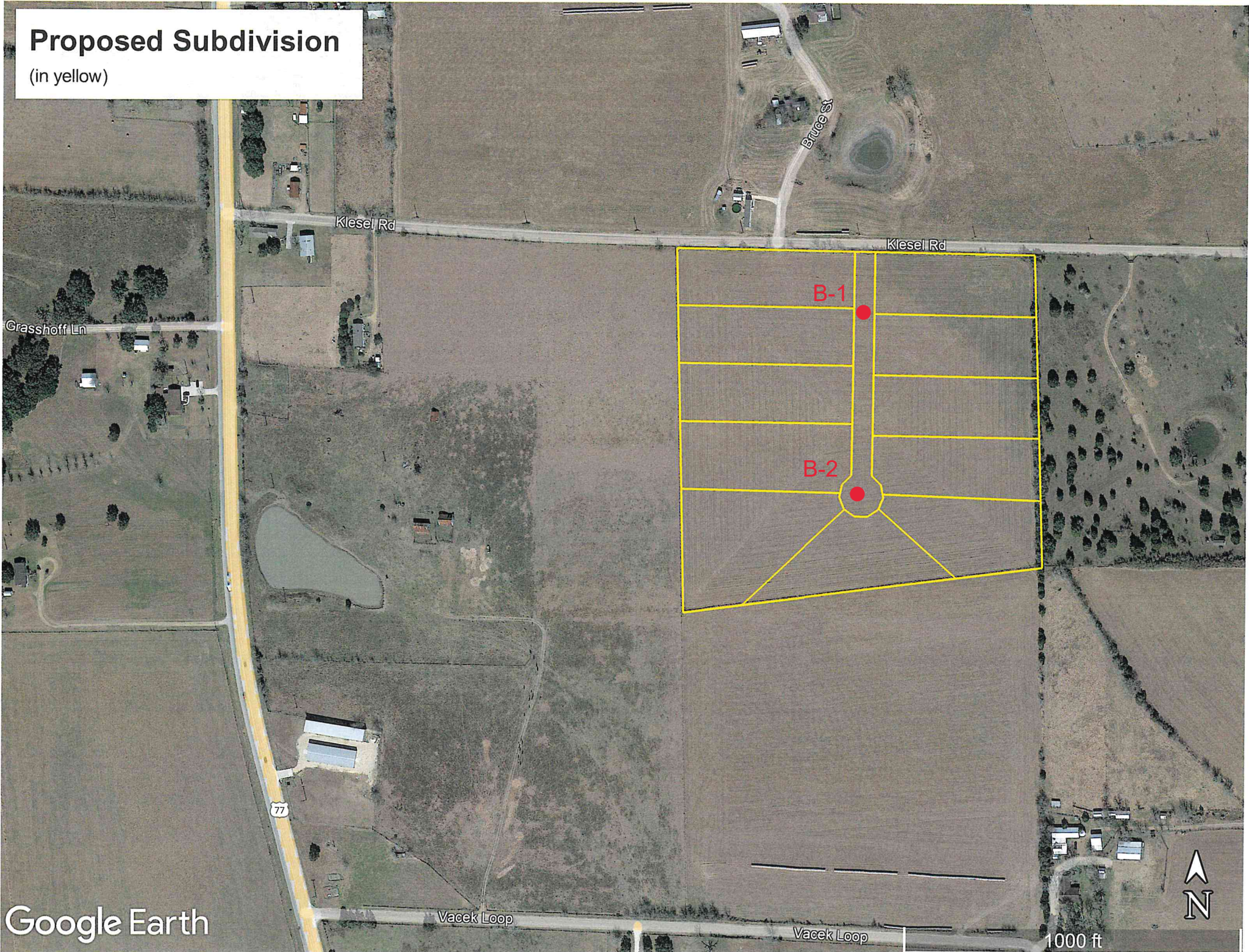
Symbols and Terms Used on Boring Logs

Field and Laboratory Testing Procedures

Important Information About  
Geotechnical Engineering Report

# Proposed Subdivision

(in yellow)



# Log of Boring

**PROJECT:** Country Reserve Subdivision  
Schulenburg, TX 78956

**BORING NO.:** B-1  
**PROJECT NO.:** V-231038  
**DATE:** 02/03/23  
**SURFACE ELEV.:** N/A  
**LAB. NO.:** L-001

**CLIENT:** BEFCO Engineering, Inc.

FIELD DATA		LABORATORY DATA						DRILLING METHOD(S) : Dry Auger 0-10.0'					
DEPTH (FEET)	SAMPLE	SOIL TYPE	N : BLOWS/FT T : INCH/100 BLOWS P : TONS/SQ. FT. R : PERCENT RQD : RATIO	MOISTURE CONT. %	DRY DENSITY pounds/ft. 3	Atterberg Limits %			MINUS No. 200 SIEVE (%)	COMPRESSIVE STRENGTH (tsf)	FAILURE STRAIN %	GROUNDWATER INFORMATION:	
						Liquid Limit	Plastic Limit	Plasticity Index				Groundwater was not encountered.	
												DESCRIPTION OF STRATUM	
0												FAT CLAY - very dark gray (CH)	
5				24		75	26	49	89			- with sand, dark brown (CH) (Cementitious sands)	
10												Boring terminated at 10.0'	
15													
20													
25													
30													
35													

- Steel Tube Sample
- Split Spoon Sample
- Disturbed Sample

**REMARKS:**

**TS<sub>1</sub>**  
Laboratories, Inc.

# Log of Boring

**PROJECT:** Country Reserve Subdivision  
Schulenburg, TX 78956

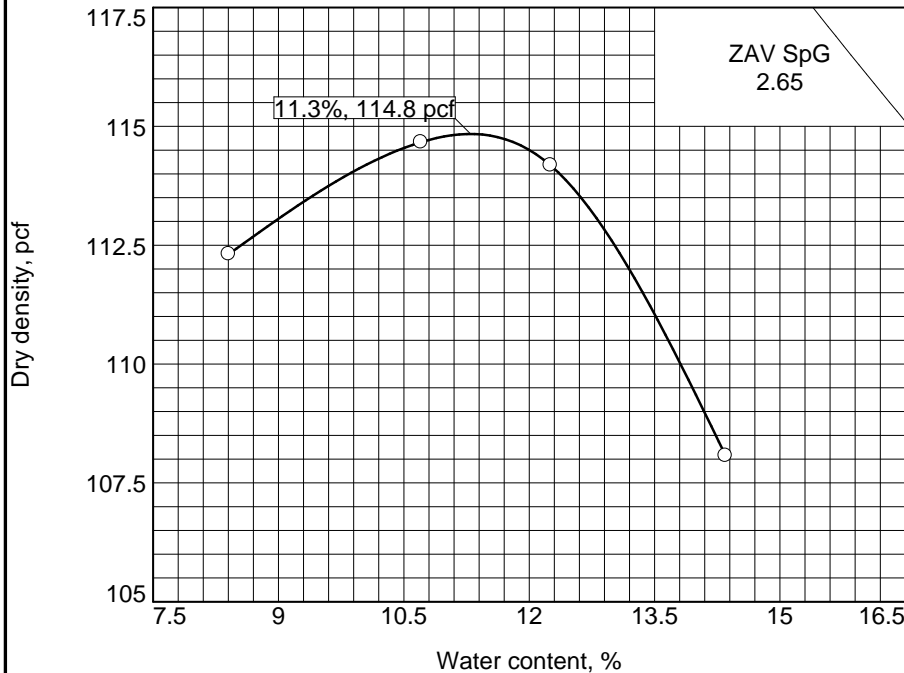
**BORING NO.:** B-2  
**PROJECT NO.:** V-231038  
**DATE:** 02/03/23  
**SURFACE ELEV.:** N/A  
**LAB. NO.:** L-001

**CLIENT:** BEFCO Engineering, Inc.

FIELD DATA		LABORATORY DATA						DRILLING METHOD(S) : Dry Auger 0-10.0'					
DEPTH (FEET)	SAMPLE	SOIL TYPE	N : BLOWS/FT T : INCH/100 BLOWS P : TONS/SQ. FT. R : PERCENT RQD : RATIO	MOISTURE CONT. %	DRY DENSITY pounds/ft. 3	Atterberg Limits %			MINUS No. 200 SIEVE (%)	COMPRESSIVE STRENGTH (tsf)	FAILURE STRAIN %	GROUNDWATER INFORMATION:	
						Liquid Limit	Plastic Limit	Plasticity Index				Groundwater was not encountered.	
												DESCRIPTION OF STRATUM	
0												FAT CLAY- very dark gray (CH)	
5				35		80	28	52	90			- with sand, dark brown (CH)	
10				15		51	19	32	83			Boring terminated at 10.0'	
15													
20													
25													
30													
35													
				<b>REMARKS:</b>								<div style="text-align: center;">  Steel Tube Sample   Split Spoon Sample   Disturbed Sample                 </div> <div style="text-align: right; font-weight: bold; font-size: 1.2em;">                     TS<sub>1</sub>                      Laboratories, Inc.                 </div>	

# MOISTURE-DENSITY TEST REPORT

**Curve No.**  
**S23-152**



**Test Specification:**  
ASTM D 698-12 Method A Standard

**Preparation Method**           Dry            
**Hammer Wt.**           5.5 lb.            
**Hammer Drop**           12 in.            
**Number of Layers**           three            
**Blows per Layer**           25            
**Mold Size**           0.03333 cu. ft.            
**Test Performed on Material**  
**Passing**           #4           **Sieve**  
**NM**            **LL**           15           **PI**           0            
**Sp.G. (ASTM D 854)**           2.65            
**%>#4**            **%<No.200**             
**USCS**            **AASHTO**             
**Date Sampled**           2/7/2023            
**Date Tested**           2/8/2023            
**Tested By**           PJ & DG          

### TESTING DATA

	1	2	3	4	5	6
<b>WM + WS</b>	8.48	8.65	8.69	8.54		
<b>WM</b>	4.42	4.42	4.42	4.42		
<b>WW + T #1</b>	796.5	800.0	811.8	798.0		
<b>WD + T #1</b>	768.4	764.8	771.2	753.0		
<b>TARE #1</b>	434.1	436.0	439.9	439.4		
<b>WW + T #2</b>						
<b>WD + T #2</b>						
<b>TARE #2</b>						
<b>MOISTURE</b>	8.4	10.7	12.3	14.3		
<b>DRY DENSITY</b>	112.3	114.7	114.2	108.1		

### TEST RESULTS

Maximum dry density = 114.8 pcf  
 Optimum moisture = 11.3 %

**Project No.** V-231038    **Client:** BEFCO Engineering, Inc.  
**Project:** Country Reserve Subdivision  
 Schulenburg, TX 78956  
 ○ **Sample Number:** S23-152

### Material Description

Reddish Brown Silty Sand w/organics

#### Remarks:

Sampled and received by TSI.

**Checked by:** Daniel Tesfai  
**Title:** PE

**Lab Report No.**







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# KEY TO SYMBOLS

Symbol Description

## Strata symbols

	Low plasticity clay
	High plasticity clay
	Poorly graded clayey silty sand
	Clayey sand

## Soil Samplers

	Steel Tube Sample
	Split Spoon Sample
	Disturbed Sample

Consistency of Sands & Gravels	
Consistency	Penetration Resistance (N)* Blows Per Foot
Very Loose	0 – 4
Loose	4 – 10
Medium Dense	10 – 30
Dense	30 – 50
Very Dense	Over 50

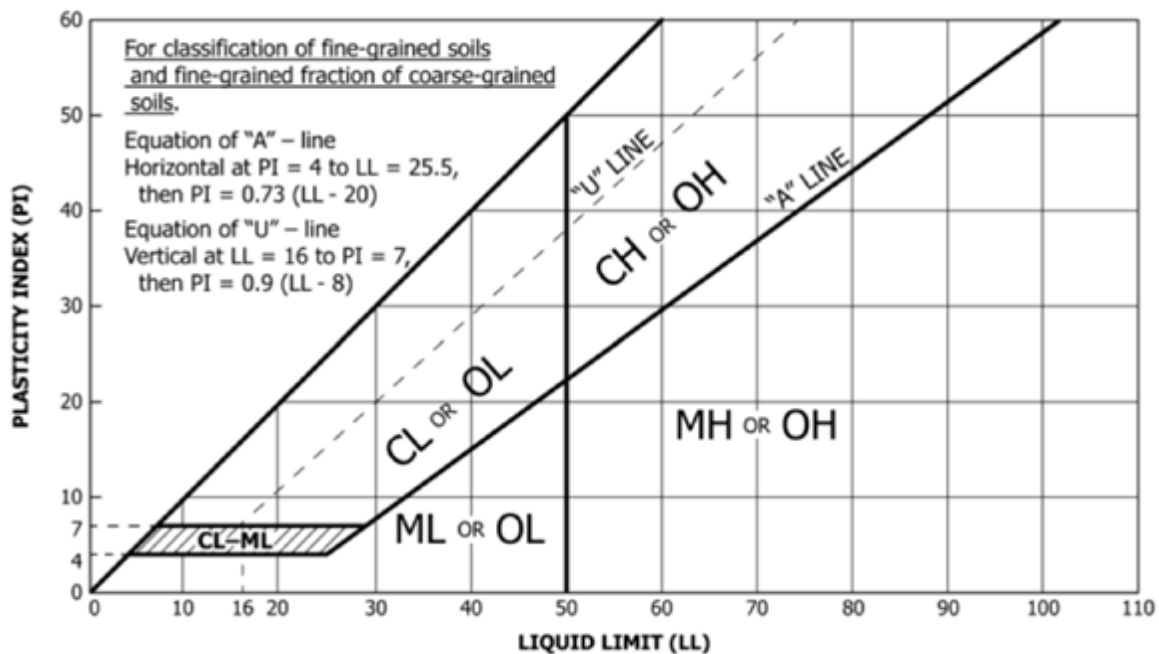
Consistency/Strength of Clays & Silty Clays		
Consistency	Undrained Shear Strength, tsf	Pocket Penetrometer (p)
Very Soft	Less than 0.125	0 – 0.5
Soft	0.125 – 0.25	0.5 – 1.0
Firm	0.25 – 0.50	1.0 – 1.75
Stiff	0.50 – 1.0	1.75 – 3.5
Very Stiff	1.0 – 2.0	3.5 – 4.5
Hard	Over 2.0	Over 4.5

\*N=Number of Blows from 140 lb. hammer falling 30" to drive a 1-3/8" Id. split barrel sample (ASTM D-1586)

### Soil Grain Analysis US Standard Sieves

6"		3"		3/4"		#4		#10			#40		#200		
Boulders	Cobbles	Gravel				Sand						Silt	Clay		
		Coarse		Fine		Coarse		Medium		Fine					
152		76.2		19.1		4.76		2.0		0.420		0.074		0.002	

### Soil Grain Size in Millimeters ASTM D-2488



**FIELD AND LABORATORY TESTING PROCEDURES  
(TEST PROCEDURES ARE PRESENTED FOR INFORMATIONAL PURPOSES)**

**FIELD TESTING**

**A. Boring Procedure Between Samples**

The borehole is extended downward, between samples, by continuous flight, hollow or solid stem augers or by rotary drilling techniques using bentonite drilling fluid or water.

**B. Penetration Test and Split-Barrel Sampling of Soils  
ASTM D-1586**

This sampling method consists of driving a 2-inch outside diameter split barrel sampler using a 140 pound hammer freely falling through a distance of 30 inches. The sampler is first seated 6 inches into the material to be sampled and then driven an additional 12 inches. The number of blows required to drive the sampler the final 12 inches is known as the Standard Penetration Resistance. Recovered samples are first classified as to color and texture by the driller. Later, in the laboratory, the driller's field classification is reviewed by the soils engineer who examines each sample.

**C. Thin-Walled Tube Geotechnical Sampling  
ASTM D-1587**

This method consists of pushing thin walled steel tubes, usually 3 inches in diameter, into the soils to be sampled using hydraulic or other means. Cohesive soils are usually to be sampled in this manner and relatively undisturbed samples are recovered.

**D. Soil Investigation and Sampling by Auger Borings  
ASTM D-1452**

This method consists of augering a hole and removing representative soil samples from the auger flight or bit at 5 foot depth intervals or with each change in substrata. Disturbed samples are obtained and this method is, therefore, limited to situations where it is satisfactory to determine the approximate subsurface profile.

**E. Diamond Core Drilling for Site Investigation  
ASTM D-2113**

This method consists of advancing a hole into hard strata by rotating a single or double tube core barrel equipped with a cutting bit. Diamond, tungsten carbide, or other cutting agents may be used for the bit. Wash water is used to remove the cuttings and cool the bit. Normally, a 2 inch outside diameter by 1-3/8 inch inside diameter (NX) coring bit is used unless otherwise noted. The rock or hard material recovered within the core barrel is examined in the field and in the laboratory and the cores are stored in partitioned boxes. The core recovery is the length of the material recovered and is expressed as a percentage of the total distance penetrated.

**F. Visual – Manual Soil Classification Procedure  
ASTM D-2488**

This procedure is a visual – manual soil classification methodology for the description of soil for engineering purposes when precise soils classification is not required.

**LABORATORY TESTING**

**A. Atterberg Limits: Liquid Limit, Plastic Limit and Plasticity Index of Soils  
ASTM D-4318, TEX 104-E, 105-E and 106-E**

Atterberg Limits determine the soil's plasticity characteristics. The soil's Plasticity Index (PI) is representative of this characteristic and is the difference between the Liquid Limit (LL) and the Plastic Limit (PL). The LL is the moisture content at which the soil will flow as a heavy viscous fluid. The PL is the moisture content at which the soil begins to lose its plasticity. The test results are presented on the boring logs adjacent to the appropriate sampling information.

**B. Particle Size Analysis of Soils  
ASTM D-422 and TEX 110-E**

Grain size analysis tests are performed to determine the particle size and distribution of the samples tested. The grain size distribution of the soils coarser than the Standard Number 200 sieve is determined by passing the sampled through a standard set of nested sieves.

**C. Laboratory Determination of Water (Moisture) Content of Soil and Rock  
ASTM D-2216 and TEX 103-E**

The moisture content of soil is defined as the ratio, expressed as a percentage, of the weight of water in a given soil mass to the weight of solid particles. It is determined by measuring the wet and oven dry weights of a soil sample. The test results are presented on the boring logs.

**D. Unconfined Compressive Strength of Cohesive Soil  
ASTM D-2166**

The unconfined compressive strength of soil is determined by placing a section of an undisturbed sample into a loading frame and applying an axial load until the sample fails in shear. The test results are presented on the boring logs adjacent to the appropriate sampling information.

**E. California Bearing Ratio (CBR) of Lab Compacted Soils  
ASTM D-1883**

The CBR test is performed by compacting soil in a 6 inch diameter mold at the desired density, soaking the sample for four days under a surcharge load approximating the pavement weight and then testing the soils in punching shear. A 2 inch diameter piston is forced into the soil to determine the resistance to penetration. The CBR is the ratio of the actual load required to produce 0.1 inches of penetration to that producing the same penetration in a standard crushed stone.

**F. Swell Test  
ASTM D-4546**

The swell test is performed by confining a 1 inch thick specimen in a 2-1/2 inch diameter stainless steel ring and loading the specimen to the approximate overburden pressure. The test specimen is then inundated with distilled water and allowed to swell for 48 hours. The volumetric swell is measured as a percentage of the total volume and is converted mathematically to linear swell.

**G. Compaction Tests  
ASTM D-698, D-1557, TEX 113-E or 114-E**

The compaction test is performed by compacting soil in a steel mold at varying moisture contents. Layers are compacted using a hammer weight and number of blows per layer which vary with the different test procedures. ASTM D-698, D-1557, TEX 113-E and 114-E. The data is plotted and the maximum weight and optimum moisture content is determined.

**H. Classification of Soils for Engineering Purposes  
Unified Soil Classification System, D-2487**

This standard describes a system for classifying mineral and organo-mineral soils for engineering purposes based on laboratory determination of particle-size characteristics, liquid limit, and plasticity index and shall be used when precise classification is required.

## RECOMMENDED SPECIFICATIONS FOR PLACEMENT OF SELECT FILL

**1. General**

The soils engineer shall be the owners representative to control the placement of compacted fill. The soils engineer shall approve the subgrade preparation, the fill materials, the method of placement and compaction, and shall give written approval of the completed fill.

**2. Preparation of Existing Ground**

All topsoil, plants and other organic material shall be removed. The exposed surface shall be scarified, moistened if necessary, and compacted in the manner specified for subsequent layers of fill.

**3. Select Fill Material**

Fill shall have a liquid limit of less than 35 and a Plasticity Index between 8 and 18. The fill shall contain no organic material or other perishable material, and no stones larger than 6 inches. Fill material shall be approved by the soils engineer.

**4. Placing Select Fill**

Fill materials shall be placed in horizontal layers not exceeding 8 inches thickness after compaction. Successive loads of material shall be dumped so as to secure even distribution, avoiding the formation of layers of lenses of dissimilar materials. The contractor shall route hill hauling equipment to distribute travel evenly over the fill area.

**5. Compaction of Select Fill**

- a. **Moisture Control:** The moisture content of the fill material shall be distributed uniformly throughout each layer of the material. The allowable range of moisture content during compaction shall be within plus two (+2) and minus two (-2) percentage points of the optimum moisture content. The contractor may be directed to add necessary moisture to the material either in the borrow area or upon the fill surface or to dry the material, as directed by the soils engineer. The drying of cohesive soils between lifts to moisture contents less than 70% of optimum before the placement of subsequent lifts shall be avoided or the fill reworked at the proper moisture content.
- b. **Compaction:** The material in each layer shall be compacted to obtain proper densities. Compaction by the hauling equipment alone will not be considered sufficient. Structural fills, including pavement subgrade, subbase, and base, shall be compacted to densities equivalent to the percentages of the Standard Proctor (ASTM D-698) or Modified Proctor (ASTM D-1557) maximum dry density listed in the table below. The Texas Department of Highways and Public Transportation Method TEX 113-E or TEX 114-E compaction test, which varies the compactive effort with soil type, may be substituted for the Standard or Modified Proctor methods and percentages listed in the table below.

Area	PERCENT COMPACTION	
	Fine Grained Soils ASTM D-698 (Standard) or TEX 114-E	Coarse Grained Soils ASTM D-1557 (Modified) or TEX 113-E
Within five (5) feet of building lines, under footings, floor slabs, slab-on-grade foundation and structures attached to the building (i.e. walls, patios, steps)	95	95+
More than five (5) feet beyond building lines, under walks, and fill area to be landscaped	90	90
Pavement subgrade and subbase, including lime treated soils	95	95+

Soils classified as coarse grained soils are those with more than 50%, by weight, retained on the No. 200 Standard Sieve.

**6. Comparison Testing**

Field density tests for the determination of the compaction of the fill shall be performed by TSI Laboratories, Inc. in accordance with recognized procedures for making such tests. A representative number of tests shall be made in each compacted lift at locations selected by the soils engineer or his/her representative. For general structural and paving fills, we suggest one test per 3,000 square feet per lift with a minimum of three tests per lift.

## **IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL ENGINEERING REPORT**

The following observations and suggestions are provided to help you better utilize your geotechnical engineering report and to reduce construction problems and delays related to the soil and groundwater conditions.

### **REPORT IS BASED UPON SPECIFIC SITE AND PROJECT**

A geotechnical report is based on a subsurface exploration conducted on a specific site and planned using specific project information. The project information typically includes structure size and configuration, type of construction, and general location on the site. Limitations, such as existing buildings or utilities, specific foundation requirements for structures, budget limitations, and the level of risk assumed by the client may affect the scope of the exploration.

Since the report applies to a specific structure and site, the geotechnical report should not be used in the following circumstances unless the geotechnical engineer has reviewed the changes and concurs in the use of the report.

- When the nature of the proposed structure is changed, such as an office building instead of a warehouse or parking garage, or a refrigerated warehouse instead of one which is not refrigerated
- When the size, configuration, or floor elevations is changed
- When the location of the structure on the site is changed
- When there is a change of ownership

### **FINDINGS ARE PROFESSIONAL ESTIMATES**

The actual subsurface conditions are determined only at the boring locations and only at the time the samples are taken. The information is extrapolated by the geotechnical engineer who then renders professional opinions regarding the characteristics of the subsurface materials, the behavior of the soils during construction, and appropriate foundation designs. No exploration, however complete, can be assured of sampling the entire range of soil conditions. The soils may vary between or beyond the borings and stratum transitions may be more gradual or more abrupt, and all types of soils and rock existing on the site may not be found in the borings. The geotechnical engineer is often retained during construction to evaluate variances and recommend solutions to problems encountered on the site.

### **SUBSURFACE CONDITIONS CAN CHANGE**

Grading operations on or close to the site, floods, groundwater fluctuations, utility construction, and utility leaks are among the events that can change the subsurface conditions. The geotechnical engineer should be kept apprised of such events.

### **GEOTECHNICAL SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES AND PERSONS**

A geotechnical report may have been made to evaluate foundation alternatives only, for preliminary site evaluation, or for other limited purposes. The exploration may also have been limited by the direction of the client, budget limitations, or the level of risk assumed by the client. Therefore, no one other than the original client should use the report for its intended purpose or other purposes without conferring with the geotechnical engineer.

### **GEOTECHNICAL REPORTS ARE SUBJECT TO MISINTERPRETATION**

Geotechnical reports are based on the project information available at the time the report was made and the judgment and opinions of the geotechnical engineer. This specialized information is subject to misinterpretation by other design professionals, contractors and owners. The geotechnical engineer should be retained during the design process to interpret the recommendations and review the adequacy of the plans and specifications relative to geotechnical issues. The boring logs should not be separated from the geotechnical report, but, rather the entire report should be made available to the contractors and others needing this information.