Brakes Plus Temple, TX

Geotechnical Engineering Report Revision 1

Temple, Texas

August 16, 2024 | Terracon Project No. AC245058

Prepared for:

Brakes Plus, Inc.
1880 Southpark Dr.
Birmingham, AL 35244

Explore with us

Nationwide

Terracon.com

- Facilities
- Environmental
- Geotechnical
- Materials

800 Paloma Drive, Suite 150
Round Rock, TX 78665
P (512) 628-8600
Terracon.com

August 16, 2024

Brakes Plus, Inc.
1880 Southpark Dr.
Birmingham, AL 35244

Attn: Tyler Hendon
P: (205) 703-7758
E: tyler.hendon@expressoil.com

Re: Geotechnical Engineering Report
Brakes Plus Temple, TX
SEC of Canyon Creek Dr. and S. 31st St.
Temple, Texas
Terracon Project No. AC245058

Dear Mr. Hendon:

We have completed the scope of Geotechnical Engineering services for the above referenced project in general accordance with Terracon Proposal No. PAC245058 dated May 20, 2024. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork, foundations, floor slabs, and pavements for the proposed project.

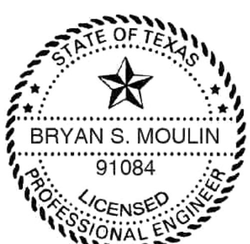
We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report or if we may be of further service, please contact us.

Sincerely,

Terracon Consultants, Inc.
TBPELS Firm Registration TX-F3272

Juan Torres

Juan Torres, E.I.T.
Staff Engineer



08/16/2024

Bryan S. Moulin, P.E.
Senior Principal, Geotechnical Services

Table of Contents

Figures

Attachments

Note: This report was originally delivered in a web-based format. **Blue Bold** text in the report indicates a referenced section heading. The PDF version also includes hyperlinks which direct the reader to that section and clicking on the Terracon logo will bring you back to this page. For more interactive features, please view your project online at client.terracon.com.

Refer to each individual Attachment for a listing of contents.

Introduction

This report presents the results of our subsurface exploration and Geotechnical Engineering services performed for the proposed Brakes Plus automotive shop to be located at SEC of Canyon Creek Dr. and S. 31st St. in Temple, Texas. The purpose of these services was to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil and rock conditions
- Groundwater conditions
- Seismic site classification per IBC
- Site preparation and earthwork
- Foundation design and construction
- Floor slab design and construction
- Recommended pavement thicknesses

The geotechnical engineering Scope of Services for this project included the advancement of test borings, laboratory testing, engineering analysis, and preparation of this report.

Drawings showing the site and boring locations are shown on the Site Location and Exploration Plan, respectively. The results of the laboratory testing performed on soil samples obtained from the site during our field exploration are included on the boring logs and as separate graphs in the Exploration and Laboratory Results section.

Project Description

Our initial understanding of the project was provided in our proposal and was discussed during project planning. A period of collaboration has transpired since the project was initiated, and our final understanding of the project conditions is as follows:

Item	Description
Information Provided	An email request for proposal was provided by Tyler Hendon with Brakes Plus, Inc. on May 09, 2024. The request included a Parcel Map and conceptual site plan drawings of the planned development with proposed boring locations.
Project Description	The project includes the construction of a new Brakes Plus automotive shop with associated pavement areas.

Item	Description
Proposed Structure	The project includes the construction of the following: ■ An approximately 7,690 square foot single story automotive shop with no grease pits ■ Associated parking and driveways areas
Building Construction	Not provided; we anticipate that the building will be constructed using light-gage steel framing with a masonry façade.
Finished Floor Elevation	Finished floor elevation(s) were not provided; boring depths have assumed that finished floor is not more than 2 feet from existing grade. (Please provide information if/when available)
Maximum Loads	Anticipated structural loads were not provided. In the absence of information provided by the design team, we will use the following loads in estimating settlement based on our experience with similar projects. ■ Columns: 200 kips ■ Walls: 2 to 4 kips per linear foot (klf) ■ Slabs: 150 pounds per square foot (psf)
Grading/Slopes	Unknown at this time but anticipated to be ≤ 3 feet from existing grades.
Below-Grade Structures	None Anticipated.
Free-Standing Retaining Walls	None Anticipated.

Item	Description
Pavements	A preferred pavement surfacing was not identified to us during the life of this project. However, asphalt and concrete pavements are common in the Central Texas area for projects of this nature. As mentioned in our proposal, the anticipated ACI traffic categories and daily truck traffic for concrete pavement analyses consisted of: ■ Category A: Car parking areas and access lanes, up to 1 truck per day ■ Category B: Entrance and truck service lanes, up to 10 trucks per day ■ Category E: Garbage or fire truck lanes As mentioned in our proposal, we assumed that the traffic classifications (based on National Asphalt Pavement Association; NAPA designations) for asphaltic pavement analyses would consist of: ■ Class I: Parking stalls for autos and pickup trucks ■ Class II: Traffic consisting of delivery trucks The pavement analysis period typically used in the Central Texas area is 20 years. Please notify us if you desire a different analysis period to be used.
Building Code	2021 IBC

Terracon should be notified if any of the above information is inconsistent with the planned construction, especially the grading limits, as modifications to our recommendations may be necessary.

Site Conditions

The following description of site conditions is derived from our site visit in association with the field exploration and our review of publicly available geologic and topographic maps.

Item	Description
Parcel Information	The project site is an approximately 1.05-acre tract of land located at the SEC of Canyon Creek Dr. and S. 31st St. in Temple, Texas. Latitude/Longitude (approximate): 30.0603 °N, 97.3721 °W See Site Location

Item	Description
Existing Improvements	No existing improvements
Current Ground Cover	Earthen (soils, grass, and weeds), lightly vegetated with trees and/or brush
Existing Topography	A topography plan was not provided to us at this time. Based on Google Earth, existing elevations range from a low elevation of about 620 feet to a high elevation of about 626 feet. The elevations from Google Earth were not applied to our borings, but are presented here for informational purposes only. Google Earth elevations are estimates and should not be used as a substitute for a professional survey.

Geotechnical Characterization

We have developed a general characterization of the subsurface conditions based upon our review of the subsurface exploration, laboratory data, geologic setting and our understanding of the project. This characterization, termed GeoModel, forms the basis of our geotechnical calculations and evaluation of the site. Conditions observed at each exploration point are indicated on the individual logs. The individual logs can be found in the Exploration and Laboratory Results and the GeoModel can be found in the Figures attachment of this report.

As part of our analyses, we identified the following model layers within the subsurface profile. For a more detailed view of the model layer depths at each boring location, refer to the GeoModel. Throughout this report, the terms GeoModel Layer and Stratum are synonymous and used interchangeably.

Model Layer	Layer Name	General Description
1	Surficial Soils	Dark brown to brown, very stiff to hard
2	Lower Clays	Light brown to brown, stiff to hard
3	Limestone (Austin Chalk)	Light brown to gray

Groundwater

The borings were advanced using solid-stem augers that allow short-term groundwater observations to be made while drilling and at completion of drilling. Groundwater seepage was not encountered within the maximum drilling depth at the time of our field exploration.

Groundwater seepage is possible at this site, particularly in the form of seepage traveling along pervious seams/fissures in the soil, along the soil/limestone interface and/or in fissures/fractures in the limestone. Due to the low permeability of the overlying soils encountered in the borings, a relatively long period may be necessary for a groundwater level to develop and stabilize in a borehole. Long term observations in piezometers sealed from the influence of surface water are often required to define groundwater levels in materials of this type. Please contact us if this is desired. Groundwater conditions should be evaluated immediately prior to construction.

Groundwater conditions may change because of seasonal variations in rainfall, construction activities, and other conditions not apparent at the time of drilling, therefore groundwater conditions may be different at the time of construction. The possibility of groundwater should be considered when developing the design and construction plans for the project. Long-term groundwater observations was outside the scope of services for this project.

Seismic Site Class

The seismic design requirements for buildings and other structures are based on Seismic Design Category. Site Classification is required to determine the Seismic Design Category for a structure. The Site Classification is based on the upper 100 feet of the site profile defined by a weighted average value of either shear wave velocity, standard penetration resistance, or undrained shear strength in accordance with Section 20.4 of ASCE 7 and the International Building Code (IBC). Based on the soil/bedrock properties observed at the site and as described on the exploration logs and results, our professional opinion is that a Seismic Site Classification of C may be considered for the project. Subsurface explorations at this site were extended to a maximum depth of 15 feet. The site properties below the boring depth to 100 feet were estimated based on our experience and knowledge of geologic conditions of the general area. Additional deeper borings or geophysical testing may be performed to confirm the conditions below the current boring depth.

Geotechnical Overview

The site appears suitable for the proposed construction based upon geotechnical conditions encountered in the test borings, provided that the recommendations provided in this report are implemented in the design and construction phases of this project.

The subsurface materials generally consisted of high plasticity clays overlying Austin Chalk limestone to the maximum depth of the borings. Groundwater was not encountered within the maximum depths of exploration during and/or at the completion of drilling.

The near surface, very stiff to hard high plasticity fat clay could become problematic with typical earthwork and construction traffic, especially after precipitation events. The effective drainage should be completed early in the construction sequence and maintained after construction to avoid potential issues. Additional site preparation recommendations, including subgrade improvement and fill placement, are provided in the Earthwork section.

Based on our test borings, highly expansive soils that exhibit a potential for volumetric change during moisture variations are present at this site. These subgrade soils may experience expansion and contraction during the life of the structure. Based on existing grades and dry conditions, the soils at this site could exhibit a Potential Vertical Rise (PVR) of up to about 3½ inches, as estimated by the TxDOT Method 124-E.

This report provides recommendations to help mitigate the effects of soil shrinkage and expansion. However, even if these procedures are followed, some movement and (at least minor) cracking in the structure should be anticipated. The severity of cracking and other damage such as uneven floor slabs will probably increase if modification of the site results in excessive wetting or drying of the expansive soils. Eliminating the risk of movement and distress may not be feasible, but it may be possible to further reduce the risk of movement if significantly more expensive measures are used during construction.

The Slab on Grade Foundations section addresses support of the building bearing on select fill or Stratum 2 limestone. The Floor Slabs section addresses slab-on-grade support of the building using overexcavation techniques. The Pavements section addresses the design of pavement systems. The recommendations contained in this report are based upon the results of field and laboratory testing (presented in the Exploration and Laboratory Results), engineering analyses, and our current understanding of the proposed project. The General Comments section provides an understanding of the report limitations.

Earthwork

Earthwork is anticipated to include clearing and grubbing, excavations, and engineered fill placement. The following sections provide recommendations for use in the preparation of specifications for the work. Recommendations include critical quality criteria, as necessary, to render the site in the state considered in our geotechnical engineering evaluation for construction of foundations, floor slabs, pavements, and general site improvements.

Site Preparation

Prior to placing fill, existing vegetation, topsoil, loose soil, and root mats should be removed. Complete stripping of these materials should be performed in the proposed building and pavement areas. Site stripping and excavation operations could loosen limestone rocks/boulders/flags/seams which should either be properly broken down or removed from the site.

Trees are located within or near the footprint of the proposed building, which will require removal at the onset of construction. Tree root systems can remove substantial moisture from surrounding soils. Where trees are removed, the full root ball and all associated dry and desiccated soils should be removed. The soil materials which contain less than 5 percent organics can be reused as engineered fill provided the material is moisture conditioned and properly compacted as recommended in this report.

Tree root systems can remove substantial moisture from surrounding soils increasing additional risk for moisture fluctuations and pavement distress. The affected area from trees is typically related to the lateral extent of a root system. Pavements constructed over or near a tree root system may shrink due to changes in moisture content and result in pavement cracking and settlement. These types of movements often result in longitudinal and/or concentric crack patterns and low spots in the roadway located near trees.

Excavation

Excavation operations at this site may penetrate through the on-site soils and into the Stratum 3 limestone. Based on the encountered subsurface conditions, our past experience with the Stratum 3 limestone, and the data obtained during our field and laboratory programs, we believe heavy-duty construction equipment, such as a hoe ram, a heavy dozer equipped with a ripper, a rock saw or jack hammer or with rock trenching equipment, is likely suitable for grading, shallow excavations, and utility trench excavations.

Subgrade Preparation

Based on our test borings, highly expansive soils that exhibit a potential for volumetric change during moisture variations are present at this site. These subgrade soils may experience expansion and contraction during the life of the structure. Based on existing grades and dry conditions, the soils at this site could exhibit a Potential Vertical Rise (PVR) of up to about 3½ inches, as estimated by the TxDOT Method 124-E.

Information about existing and proposed grades and FFE for the proposed building has not been provided to Terracon at this time, However, we assume that the planned FFE is within two feet of existing grades. If these assumptions are incorrect, Terracon should be notified to review and modify or verify recommendations in writing.

In order to reduce PVR to about 1-inch, we recommend that the on-site soils be excavated to a depth of 4 feet below existing or finished grades, whichever is deeper. The excavated soil must then be replaced with properly compacted select fill, up to finished grades. All fill within building areas must be select fill. A modulus of subgrade reaction of 100 pci may be used if these recommendations are followed.

The above subgrade preparation recommendations should be applied to an area extending a minimum of 5 feet outside of building areas including attached walkways and any other architectural members. We suggest the use of crushed limestone base in the upper 6 inches of the select fill pad from a standpoint of construction access during wet weather, as well as from a standpoint of floor slab support.

For any movement-sensitive flatwork (sidewalk, ramps, etc.) outside of the building areas, subgrade preparation as discussed above should be considered to reduce differential movements between the flatwork and the adjacent building. If subgrade preparation as given above for building areas is not implemented in the exterior flatwork areas, those areas may be susceptible to post-construction movements in excess of that given above.

The potential movement values indicated are based upon moisture variations in the subgrade due to circumstances such as moisture increases due to rainfall and loss of evapotranspiration. In circumstances where significant water infiltration beneath the floor slab occurs (such as a leaking utility line or water seepage from outside the building resulting from poor drainage), movements in isolated floor slab areas could potentially be in excess of those indicated in this report.

The post-construction performance of the foundation will likely be influenced more by post-construction volumetric changes of the subgrade due to in-situ moisture variations than upon settlement due to foundation loads. Settlement response of select fill supported slabs will be influenced as much by the quality of construction and fill placements as by soil-structure interaction. Therefore, it is essential that the recommendations for foundation construction be strictly followed during the construction phases of the building pad and foundation.

All exposed areas which will receive fill should be scarified to a minimum depth of 6 inches, moisture conditioned as necessary, and compacted per the compaction requirements in this report. The exposed final subgrade in all construction areas (may be omitted in landscaping areas) should be proof rolled (as per TxDOT Item 216) with an adequately loaded vehicle such as a fully-loaded tandem-axle dump truck. The proof rolling should be performed under the observation of the Geotechnical Engineer or representative. Areas excessively deflecting under the proof roll should be delineated and subsequently addressed by the Geotechnical Engineer. Such areas should be scarified a minimum depth of 6 inches and recompacted. Excessively wet or dry material should either be removed, or moisture conditioned and recompacted. Compacted select/structural fill and pavement fill soils should then be placed to the proposed design grade and the moisture content and compaction of subgrade soils should be maintained until foundation, floor slabs, and/or pavement construction.

Based upon the subsurface conditions determined from the geotechnical exploration, subgrade soils exposed during construction are anticipated to be relatively workable; however, the workability of the subgrade may be affected by precipitation, repetitive construction traffic or other factors. If unworkable conditions develop, workability may be improved by scarifying and drying.

Groundwater Control

Although not encountered during our drilling operations, groundwater seepage could be encountered during construction, especially after periods of wet weather. The volume of groundwater seeping/flowing into the excavation will vary based on rainfall patterns before and during construction. Temporary groundwater control during construction would typically consist of perimeter gravel-packed drains sloping toward common sump areas for groundwater collection and removal. Placement of drain laterals within the excavation could be required to remediate isolated water pockets.

Fill Material Types

Engineered fill required to achieve design grade should be classified as select/structural fill or paving/general fill depending on its application. Select/structural fill is material used below and within 5 feet of the structure. Paving/general fill is material used to achieve grade in paving, landscaping, or other general (non-structural) areas.

Reuse of On-Site Soil/Processed Rock: Excavated on-site soil and processed rock may be selectively reused as Paving/General fill. Excavated on-site soil is not suitable for reuse as Select/Structural fill.

Material property requirements for on-site soil for use as paving/general fill and select/structural fill are noted in the table below:

Reuse of On-site Soil/Processed Rock

Property	Paving/General Fill[3,4,5]	Select/Structural Fill[2,3]
Composition	Free of deleterious material	Free of deleterious material
Maximum particle size	4 inches	4 inches
Gradation	Not limited	<40% retained No. 4 sieve
Plasticity	Not limited	7≤PI≤20
GeoModel Layer Potential Suitability[1]	1, 2, 3	2,3

1. Based on subsurface exploration. Actual material suitability should be determined in the field at time of construction. A sample of each material type should be submitted to the Geotechnical Engineer for evaluation prior to use on this site.
2. As an alternative to the Acceptable Specifications above, a low plasticity granular material which does not meet the specifications above may be used only if approved by Terracon.
3. Based on the laboratory testing performed during this exploration, the excavated onsite Stratum 1 fat clay soils are not suitable for re-use as select/structural fill. We do <u>not</u> recommend these soils be considered for re-use as select/structural fill when planning budgets. Stratum 2 lean clays and Stratum 3 excavated limestone may be considered for re-use as select/structural fill if the excavated material is tested and meets the above requirements.
4. It has been our experience that proper processing of excavated limestone often involves processes of breaking down of larger rock with equipment, screening, removal of more highly plastic clay layers, etc. The Contractor’s proposed methods of processing these materials should be reviewed prior to initiation of construction to check that these methods will produce an acceptable select fill material. The relative ease of mining and segregating the materials is unknown at this time.

Reuse of On-site Soil/Processed Rock

Property	Paving/General Fill[3,4,5]	Select/Structural Fill[2,3]

5. The Stratum 1 dark brown fat clay soils exhibit high shrink/swell potential. For economic reasons, expansive soils are often used in pavement and/or flatwork areas. The owner should be made aware that the risk exists for future movements of the subgrade soils which may result in movement and/or cracking of pavement and/or flatwork.

Imported Fill Materials: Imported fill materials should meet the following material property requirements. Regardless of its source, compacted fill should consist of approved materials that are free of organic matter and debris.

Fill Materials

Soil Type [1]	USCS Classification	Acceptable Specifications
Select/Structural Fill [2]	CL, CL-ML ML, SM, SC, GM, GC	■ TxDOT Item 247, Type A, Grade 3 or better, OR ■ Crushed concrete (TxDOT Item 247, Type D, Grade 3 or better, OR ■ Soils with 7≤PI≤20, ≤40% retained on No. 4 sieve, and rocks ≤ 4 inches in maximum dimension
Paving/General Fill	CH, CL, GW, GP, GM, GC, SW, SP, SM, SC	■ Soils with PI ≤35; and rocks ≤ 4 inches in maximum dimension

1. Select/structural and paving/general fill should consist of approved materials free of organic matter and debris. A sample of each material type should be submitted to the Geotechnical Engineer for evaluation prior to use on this site. Additional geotechnical consultation should be provided prior to use of uniformly graded gravel on the site.
2. As an alternative to the Acceptable Specifications above, a low plasticity granular material which does not meet the specifications above may be used only if approved by Terracon.

Fill Placement and Compaction Requirements

Engineered fill should meet the following compaction requirements.

<table>
<tr><th colspan="2">Material Type</th><th>Maximum Lift Thickness</th><th>Minimum Compaction Requirements (%) [1]</th><th>Water Content Range (%) [1]</th></tr>
<tr><td colspan="2">Select/Structural Fill</td><td rowspan="2">≤ 8 inches in loose thickness when heavy, self-propelled compaction equipment is used</td><td>95 [2]</td><td>-3 to +3</td></tr>
<tr><td rowspan="2">Paving Fill, Paving Subgrade, and General Fill</td><td>PI ≤ 25</td><td>95</td><td>-3 to +3</td></tr>
<tr><td>PI > 25</td><td rowspan="2">≤ 6 inches in loose thickness when hand-guided equipment (i.e., jumping jack or plate compactor) is used</td><td>95</td><td>Optimum to +4</td></tr>
<tr><td colspan="2">Crushed Limestone Base (beneath pavements) [3]</td><td>100 [3]</td><td>-3 to +3 [3]</td></tr>
</table>

1. Maximum unit weight and optimum water content as determined by the standard Proctor test (ASTM D 698).
2. For fills thicker than 5 feet, if any, the compaction should be increased to at least 100 percent of the ASTM D 698 maximum dry unit weight.
3. Per TEX-113-E.

Utility Trench Backfill

Any soft or unsuitable materials encountered at the bottom of utility trench excavations should be removed and replaced with select fill (in building/structural areas), general fill (in non-building/structural areas) or bedding material in accordance with public works specifications for the utility to be supported. This recommendation is particularly applicable to utility work requiring grade control and/or in areas where subsequent grade raising could cause settlement in the subgrade supporting the utility. Trench excavation should not be conducted below a downward 1(H):1(V) projection from existing foundations without engineering review of shoring requirements and geotechnical observation during construction.

On-site materials are considered suitable for backfill of utility and pipe trenches in non-building/structural areas from 1 foot above the top of the pipe to the final ground surface, provided the material is free of organic matter and deleterious substances.

Trench backfill should be mechanically placed and compacted as discussed earlier in this report. Compaction of initial lifts should be accomplished with hand-operated tampers or other lightweight compactors. Where trenches are placed in building/structural areas, the backfill should satisfy the engineered select fill requirements discussed in this report. Flooding or jetting for placement and compaction of backfill is not recommended.

For low permeability subgrades, utility trenches are a common source of water infiltration and migration. Utility trenches penetrating beneath the building should be effectively sealed to restrict water intrusion and flow through the trenches, which could migrate below the building. The trench should provide an effective trench plug that extends at least 5 feet from the face of the building exterior. The plug material should consist of cementitious flowable fill or low permeability clay. The trench plug material should be placed to surround the utility line. If used, the clay trench plug material should be placed and compacted to comply with the water content and compaction recommendations for structural fill stated previously in this report. If flowable fill is used, it should be in accordance with TxDOT Item 401.

Grading and Drainage

The performance of the proposed structure will not only be dependent upon the quality of construction, but also upon the stability of the moisture content of the near surface soils. Therefore, we highly recommend that site drainage be developed so that ponding of surface runoff near the structure does not occur. Accumulation of water near the structure may cause significant moisture variations in soils adjacent to the structure, thus increasing the potential for structural distress.

All grades must provide effective drainage away from the building during and after construction and should be maintained throughout the life of the structure. Water retained next to the building can result in soil movements greater than those discussed in this report. Greater movements can result in unacceptable differential floor slab and/or foundation movements, cracked slabs and walls, and roof leaks. A concrete apron (i.e. concrete sidewalks/pavements directly abutting the building) around the exterior perimeter of the structure for at least 6 feet (1 foot wider than the select fill overbuild). The concrete should be sloped to provide drainage away from the structure and all joints should be sealed. In lieu of concrete aprons, or if sloping unpaved ground is planned around the structure, the select fill overbuild should be excavated to a depth of at least 2 feet below final grades, removed and replaced with a minimum of 2 feet of moisture-conditioned and compacted fat clay soils (USCS CH classification). The fat clay soils should be moisture-conditioned and compacted as per the compaction requirements in this report. We would be glad to discuss other measures (e.g. horizontal or vertical barriers) reduce moisture infiltration in unpaved areas, if desired. The roof should have gutters/drains with downspouts that discharge onto splash blocks at a distance of at least 10 feet from the building or discharged on to positively sloped pavements.

Sprinkler mains and spray heads should preferably be located at least 5 feet away from the structure such that they cannot become a potential source of water directly adjacent to the structure. Placing large bushes and trees adjacent to the structure may cause significant moisture variations in the soils underlying the structure. Tree roots can adversely influence the subsurface soil moisture content. Watering of vegetation should be performed in a timely and controlled manner such that overwatering is avoided. Landscaped irrigation adjacent to the foundation units should be minimized or eliminated. Special care should be taken such that underground utilities do not develop leaks with time.

Exposed ground should be sloped and maintained at a minimum 5% away from the building for at least 10 feet beyond the perimeter of the building. Flatter grades may be necessary to transition ADA access requirements for flatwork. After building construction and landscaping have been completed, final grades should be verified to document effective drainage has been achieved. Grades around the structure should also be periodically inspected and adjusted, as necessary, as part of the structure's maintenance program. Where paving or flatwork abuts the structure, a maintenance program should be established to effectively seal and maintain joints and prevent surface water infiltration.

Earthwork Construction Considerations

Shallow excavations for the proposed structure are anticipated to be accomplished with conventional construction equipment. Upon completion of filling and grading, care should be taken to maintain the subgrade water content prior to construction of grade-supported improvements such as floor slabs and pavements. Construction traffic over the completed subgrades should be avoided. The site should also be graded to prevent ponding of surface water on the prepared subgrades or in excavations. Water collecting over or adjacent to construction areas should be removed. If the subgrade desiccates, saturates, or is disturbed, the affected material should be removed, or the materials should be scarified, moisture conditioned, and recompacted prior to floor slab construction.

Surface runoff could affect overexcavation efforts, especially for overexcavation and replacement of soils. A temporary dewatering system consisting of sumps with pumps may be necessary to achieve the recommended depth of overexcavation depending on groundwater and precipitation conditions at the time of construction. Sump pits should preferably be excavated just outside the select fill pad limits.

As a minimum, excavations should be performed in accordance with OSHA 29 CFR, Part 1926, Subpart P, "Excavations" and its appendices, and in accordance with any applicable local and/or state regulations.

Construction site safety is the sole responsibility of the contractor who controls the means, methods, and sequencing of construction operations. Under no circumstances shall the information provided herein be interpreted to mean Terracon is assuming responsibility for construction site safety or the contractor's activities; such responsibility shall neither be implied nor inferred.

Excavations or other activities resulting in ground disturbance have the potential to affect adjoining properties and structures. Our scope of services does not include review of available final grading information or consider potential temporary grading performed by the contractor for potential effects such as ground movement beyond the project limits. A preconstruction/ precondition survey should be conducted to document nearby property/infrastructure prior to any site development activity. Excavation or ground disturbance activities adjacent or near property lines should be monitored or instrumented for potential ground movements that could negatively affect adjoining property and/or structures.

Construction Observation and Testing

The earthwork efforts should be observed by the Geotechnical Engineer (or others under their direction). Observation should include documentation of adequate removal of surficial materials (vegetation, topsoil, and pavements), as well as proofrolling and mitigation of unsuitable areas delineated by the proofroll.

Each lift of compacted fill should be tested, evaluated, and reworked as necessary, as recommended by the Geotechnical Engineer prior to placement of additional lifts. Each lift of fill should be tested for density and water content at a frequency of at least one test for every 2,500 square feet of compacted fill in the building areas and 5,000 square feet in pavement areas with a minimum of three (3) tests per lift. Where not specified by local ordinance, one density and water content test should be performed for every 100 linear feet of compacted utility trench backfill and a minimum of one test performed for every 12 vertical inches of compacted backfill.

In areas of foundation excavations, the bearing subgrade should be evaluated by the Geotechnical Engineer (or others under their direction). If unanticipated conditions are observed, the Geotechnical Engineer should prescribe mitigation options.

In addition to the documentation of the essential parameters necessary for construction, the continuation of the Geotechnical Engineer into the construction phase of the project provides the opportunity to maintain the Geotechnical Engineer's evaluation of subsurface conditions, including assessing variations and associated design changes.

Shallow Foundations

Principal column and wall loads for the proposed structure may be supported on isolated (spread) and/or continuous (strip) footings bearing on compacted select/structural fill. If the site has been prepared in accordance with the requirements noted in Earthwork, the following design parameters are applicable for shallow foundations.

Design Parameters – Compressive Loads

Item	Description
Maximum Net Allowable Bearing Pressure [1, 2]	2,500 psf - foundations bearing upon select/structural fill
Required Bearing Stratum [3]	Select/structural fill
Minimum Foundation Dimensions	Per IBC 1809.7
Ultimate Passive Resistance[4] (equivalent fluid pressures)	360 pcf – select/structural fill
Ultimate Sliding Resistance [5]	0.35 allowable coefficient of friction – select/structural fill
Minimum Embedment below Finished Grade [6]	24 inches
Estimated Total Settlement from Structural Loads [2,7]	About 1-inch or less
Estimated Differential Settlement [2,7,8]	About ½ to ¾ of total settlement

1. The maximum net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the footing base elevation. Values assume that exterior grades are no steeper than 20% within 10 feet of structure.
2. Values provided are for maximum loads noted in Project Description. Additional geotechnical consultation will be necessary if higher loads are anticipated.
3. Unsuitable or soft soils should be overexcavated and replaced per the recommendations presented in Earthwork.
4. Use of passive earth pressures require the sides of the excavation for the spread footing foundation to be nearly vertical and the concrete placed neat against these vertical faces or that the footing forms be removed and compacted structural fill be placed against the vertical footing face. Assumes no

Item	Description

hydrostatic pressure. Passive resistance should be neglected in the first 12 inches below finished grades. Ultimate (unfactored) values should be reduced by an appropriate factor of safety to compute allowable values.

5. Can be used to compute sliding resistance where foundations are placed on suitable soil/materials. Frictional resistance for granular materials is dependent on the bearing pressure which may vary due to load combinations. Ultimate (unfactored) values should be reduced by an appropriate factor of safety to compute allowable values.
6. Embedment necessary to minimize the effects of seasonal water content variations and potential future disturbance around the perimeter. For sloping ground, maintain depth below the lowest adjacent exterior grade within 5 horizontal feet of the structure.
7. The estimated post-construction settlement of the shallow footings is assuming proper construction practices are followed. The settlement response of the footings will be more dependent upon the quality of construction than upon the response of the subgrade to the foundation loads.
8. Differential settlements are noted for equivalent-loaded foundations and bearing elevation as measured over a span of 50 feet. Differential settlements may result from variances in subsurface conditions, loading conditions, and construction procedures.

Design Parameters – Overturning and Uplift Loads

Shallow foundations subjected to overturning loads should be proportioned such that the resultant eccentricity is maintained in the center-third of the foundation (e.g., e < b/6, where b is the foundation width). This requirement is intended to keep the entire foundation area in compression during the extreme lateral/overturning load event. Foundation oversizing may be required to satisfy this condition.

Uplift resistance of spread footings can be developed from the effective weight of the footing and the overlying soils with consideration to the IBC basic load combinations.

Item	Description
Foundation Unit Weight	As per Structural Engineer
Soil Total Unit Weight[1]	120 pcf
Soil weight included in uplift resistance	Soil included within the prism extending up from the top perimeter of the footing at an angle of 20 degrees from vertical to ground surface

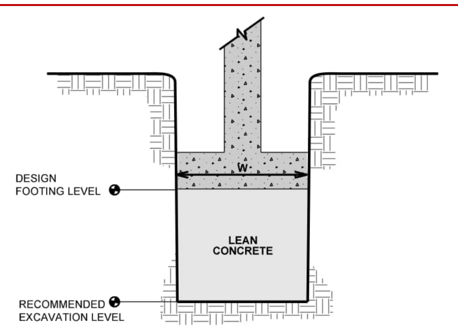
Item	Description

1. The nominal (unfactored) values should be reduced by an appropriate factor of safety to compute allowable values. Soil weight should be ignored in potential zones of disturbance and in areas where erosion control measures are not used, or soil might otherwise be removed.

Foundation Construction Considerations

Footings should be neat excavated, if possible. If neat excavation is not possible, the foundation should be properly formed. If a toothed bucket is used, excavation with this bucket should be stopped approximately 6 inches above final grade of the footing and the footing excavation be completed with a smooth-mouthed bucket or by hand labor. As noted in Earthwork, the footing excavations should be evaluated under the observation of the Geotechnical Engineer. The base of all foundation excavations should be free of water and loose soil, prior to placing concrete. Concrete should be placed soon after excavating to reduce bearing soil disturbance. Care should be taken to prevent wetting or drying of the bearing materials during construction. Excessively wet or dry material or any loose/disturbed material in the bottom of the footing excavations should be removed/reconditioned before foundation concrete is placed.

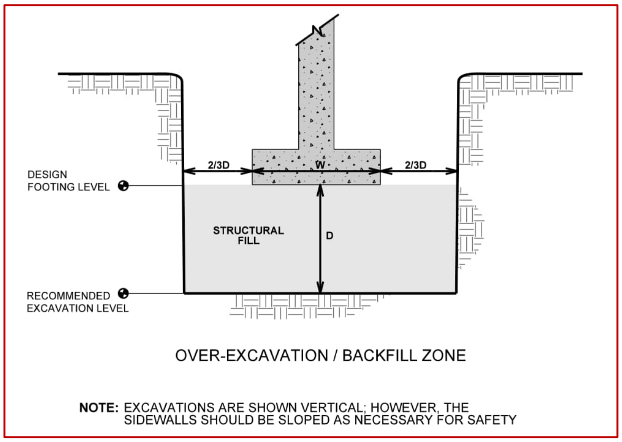
If unsuitable bearing soils are observed at the base of the planned footing excavation, the excavation should be extended deeper to suitable soils, and the footings could bear directly on these soils at the lower level or on lean concrete backfill placed in the excavations. The lean concrete replacement zone is illustrated on the sketch below.



LEAN CONCRETE BACKFILL

NOTE: EXCAVATIONS ARE SHOWN VERTICAL; HOWEVER, THE SIDEWALLS SHOULD BE SLOPED AS NECESSARY FOR SAFETY

Overexcavation for structural fill placement below footings should be conducted as shown below. The overexcavation should be backfilled up to the footing base elevation, with select/structural placed, as recommended in the Earthwork section.



Slab on Grade Foundations

A slab on grade beam foundation may be considered to support the structure at this site. Parameters commonly used to design this type of foundation are provided on the table below. The slab foundation design parameters presented are based on the criteria published by the Building Research Advisory Board (BRAB), the Prestressed Concrete Institute (PCI), and the Wire Reinforcement Institute (WRI). These are essentially empirical design methods and the recommended design parameters are based on our understanding of the proposed project, our interpretation of the information and data collected as a part of this study, our area experience, and the criteria published in the BRAB, PCI, and WRI design manuals.

Conventional Method Parameters	Value
Net Allowable Bearing Pressures [1]	2,500 psf
Subgrade Modulus (k)	100 pci
Potential Vertical Rise (PVR)	1 inch
WRI Method Parameters	
Effective Plasticity Index (PI) [2]	20 (Prepared Subgrade)
Climatic Rating (Cw)	17
Soil – Climate Support Index (I_c)	0.95

1. The net allowable bearing pressure provided above includes a Factor of Safety (FS) of at least 3. Based on building pad preparation recommended in this report.
2. The BRAB effective PI is equal to the near surface PI if that PI is greater than the PI values in the upper 15 feet. The WRI/PCI effective PI is the weighted average of the PI values in the upper 15 feet of the soil profile. The upper 5

feet has a weight factor of 3; the depth range from 5 to 10 feet has a weight factor of 2; the depth range of 10 to 15 feet has a weight factor of 1.

We recommend that exterior grade beams (if bearing in select/structural fill) be at least 24 inches below the finished exterior grade. These recommendations are for a proper development of bearing capacity for the continuous beam sections of the foundation system and to reduce the potential for water to migrate beneath the slab foundation. These recommendations are not based on structural considerations. Grade beam depths may need to be greater than recommended herein for structural considerations and should be properly evaluated and designed by the Structural Engineer. The grade beams or slab portions may be thickened and widened to serve as spread footings at concentrated load areas.

For a slab on grade foundation system designed and constructed as recommended in this report, post construction consolidation settlements should be less than 1 inch. Settlement response of a slab on grade foundation is influenced more by the quality of construction than by soil-structure interaction. Therefore, it is essential that the recommendations for foundation construction be strictly followed during the construction phases of the pad and foundation.

The use of a vapor retarder should be considered beneath concrete slabs-on-grade that will be covered with wood, tile, carpet or other moisture sensitive or impervious coverings, or when the slabs will support equipment sensitive to moisture. When conditions warrant the use of a vapor retarder, the slab designer and slab contractor should refer to ACI 302 for procedures and cautions about the use and placement of a vapor retarder.

Floor Slabs

Design parameters for floor slabs assume the requirements for Earthwork have been followed. Specific attention should be given to positive drainage away from the structure and positive drainage of the aggregate base beneath the floor slab.

The subgrade soils are comprised of high plasticity clays exhibiting the potential to swell with increased water content. Construction of the floor slab, combined with the removal of trees, and revising site drainage creates the potential for gradual increased water contents within the clays. Increases in water content will cause the clays to swell and damage the floor slab. To reduce the PVR to about 1 inch, the recommendations provided in this report should be followed.

Floor Slab Design Parameters

Item	Description
Floor Slab Support	Subgrade and select fill building pad compacted to recommendations in Earthwork
Estimated Modulus of Subgrade Reaction [1]	100 pounds per square inch per inch (psi/in) for point loads

1. Modulus of subgrade reaction is an estimated value based upon our experience with the subgrade condition, the requirements noted in Earthwork, and the floor slab support as noted in this table. It is provided for point loads. For large area loads the modulus of subgrade reaction would be lower.

The use of a vapor retarder should be considered beneath concrete slabs on grade covered with wood, tile, carpet, or other moisture sensitive or impervious coverings, when the project includes humidity-controlled areas, or when the slab will support equipment sensitive to moisture. When conditions warrant the use of a vapor retarder, the slab designer should refer to ACI 302 and/or ACI 360 for procedures and cautions regarding the use and placement of a vapor retarder.

Saw-cut contraction joints should be placed in the slab to help control the location and extent of cracking. For additional recommendations, refer to the ACI Design Manual. Joints or cracks should be sealed with a waterproof, non-extruding compressible compound specifically recommended for heavy duty concrete pavement and wet environments.

Where floor slabs are tied to perimeter walls or turn-down slabs to meet structural or other construction objectives, our experience indicates differential movement between the walls and slabs will likely be observed in adjacent slab expansion joints or floor slab cracks beyond the length of the structural dowels. The Structural Engineer should account for potential differential settlement through use of sufficient control joints, appropriate reinforcing or other means.

Floor Slab Construction Considerations

Finished subgrade, within and for at least 10 feet beyond the floor slab, should be protected from traffic, rutting, or other disturbance and maintained in a relatively moist condition until floor slabs are constructed. If the subgrade should become damaged or desiccated prior to construction of floor slabs, the affected material should be removed, and structural fill should be added to replace the resulting excavation. Final conditioning of the finished subgrade should be performed immediately prior to placement of the floor slab support course.

The Geotechnical Engineer should observe the condition of the floor slab subgrades immediately prior to placement of the floor slab support course, reinforcing steel, and concrete. Attention should be paid to high traffic areas that were rutted and disturbed earlier, and to areas where backfilled trenches are located.

Pavements

General Pavement Comments

Recommended minimum pavement thicknesses are provided for the traffic conditions and pavement life conditions as noted in Project Description and in the following sections of this report. A critical aspect of pavement performance is site preparation. Recommended minimum pavement thicknesses noted in this section must be applied to the site which has been prepared as recommended in the Earthwork section.

Recommended minimum pavement thicknesses 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. Support characteristics of subgrade for pavement design do not account for shrink/swell movements of an expansive clay subgrade, such as the on-site soils observed on this project. 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. It is therefore important to minimize moisture changes in the subgrade to reduce shrink/swell movements. Proper site perimeter drainage should be provided so that infiltration of surface water from unpaved areas surrounding the pavement is minimized.

Pavement Section Thicknesses

The following table provides our opinion of minimum thickness for HMAC pavements.

Asphaltic Concrete

Layer	Thickness (inches)			
	Traffic Class I [1]		Traffic Class II [1]	
HMAC [2]	2.0		2.5	
Crushed Limestone Base [2]	7.0	10.0	9.0	12.0
Lime-Treated Subgrade [2]	8.0	---	8.0	---

Asphaltic Concrete

Layer	Thickness (inches)			
	Traffic Class I [1]		Traffic Class II [1]	
Moisture Conditioned Subgrade[2]	---	6.0	---	6.0

1. See Project Description for more specifics regarding traffic assumptions.
2. All materials should meet the current specifications as outlined in Pavement Materials below

The following table provides our opinion of minimum thickness of reinforced PCC pavements.

Portland Cement Reinforced Concrete

Layer	Thickness (inches)					
	Traffic Category A [1]		Traffic Category B [1]		Traffic Category E [1,3]	
Reinforced PCC [2,3]	5.0		6.0	5.5	7.0	6.5
Lime-Treated Subgrade [2]	---	8.0	---	8.0	---	8.0
Moisture Conditioned Subgrade [2]	6.0	---	6.0	---	6.0	---

1. See Project Description for more specifics regarding traffic classifications.
2. All materials should meet the current specifications as outlined in Pavement Materials below.
3. For fire lanes to withstand the occasional HS-20 loading of 32,000 pounds per axle and up to 90,000-pound gross truck weight, use Traffic Category E pavements or thicker.

Areas for parking of heavy vehicles, concentrated turn areas, and start/stop maneuvers could require thicker pavement sections. Edge restraints (i.e., concrete curbs or aggregate shoulders) should be planned along curves and areas of maneuvering vehicles.

PCC pavements will perform better than HMAC pavements in areas where short-radii turning and braking are expected (e.g., entrance/exit aprons) and in areas subject to large or sustained loads (e.g., loadings docks and dumpster enclosures).

Although not required for structural support, a minimum 4-inch-thick base course layer is recommended to help reduce potential for slab curl, shrinkage cracking, and subgrade pumping through joints. Proper joint spacing will also be required to prevent excessive slab curling and shrinkage cracking. Joints should be sealed to prevent entry of foreign material and doweled where necessary for load transfer. PCC pavement details for joint spacing, joint reinforcement, and joint sealing should be prepared in accordance with ACI 330 and ACI 325.

Where practical, we recommend early-entry cutting of crack-control joints in PCC pavements. Cutting of the concrete in its "green" state typically reduces the potential for micro-cracking of the pavements prior to the crack control joints being formed, compared to cutting the joints after the concrete has fully set. Micro-cracking of pavements may lead to crack formation in locations other than the sawed joints, and/or reduction of fatigue life of the pavement.

Pavement Materials

Presented below are our recommended material requirements for the various pavement sections.

Item	Value
Hot Mix Asphaltic Concrete (HMAC) [1]	Plant mixed, hot laid Type D (Fine-Grade Surface Course) meeting the specifications in TxDOT Item 340.
Portland Cement Concrete (PCC)	28-day compressive strength ≥ 3,500 psi
Crushed Limestone Base [2]	TxDOT Item 247, Type A, Grade 1-2 compacted as outlined in Earthwork.
Lime Treated Subgrade [3,4]	If soil subgrade consists of high PI (≥30) with ≤ 15% gravel, lime treatment as per TxDOT Item 260 is applicable either through dry placement or slurry placement.
Moisture Conditioned Subgrade [5]	As outlined in Earthwork.

1. For acceptance and payment evaluation purposes, we recommend the provisions in TxDOT Item 341.
2. Each lift of base should be thoroughly proof-rolled just prior to placement of subsequent lifts and/or asphalt. Particular attention should be paid to areas along curbs, above utility trenches, and adjacent to landscape islands, manholes, and storm drain inlets. Preparation of the base material should extend at least 24 inches beyond curbs or edge of pavements, whichever is greater.

Item	Value

3. We anticipate that approximately 6 to 10 percent hydrated lime will be required to treat the subgrade soils. We suggest 8% lime be used for bidding purposes with add/deduct line items for 1 to 2% above or below the base bid items. Prior to the application of lime to the subgrade, the optimum percentage of lime to be added should be determined based on Plasticity Index (TEX-112-E) and/or pH (ASTM D 6276) laboratory tests conducted on mixtures of the subgrade soils with lime. Subgrade soil samples should be obtained from the pavement areas as the proposed final subgrade elevation. Please note these tests require up to 5 business days to complete.
4. The lime should initially be blended with a mixing device such as a Pulvermixer, sufficient water added, and allowed to cure for at least 48 hours. After curing, mixing should continue until gradation requirements of TxDOT Item 260.4.4 are achieved. The mixture should be moisture adjusted and compacted as outlined in Earthwork. Preparation of the lime-treated subgrade should extend at least 24 inches beyond curbs or edge of pavements, whichever is greater.
5. Subgrade should not dry out or become saturated prior to pavement construction. The pavement subgrade should be thoroughly proof-rolled as outlined in Earthwork. Particular attention should be paid to areas along curbs, above utility trenches, and adjacent to landscape islands, manholes, and storm drain inlets. Preparation of the moisture conditioned subgrade should extend at least 24 inches beyond curbs or edge of pavements, whichever is greater.

Presented below are our recommendations for the construction of the reinforced concrete pavements.

Item	Value
Reinforcing Steel	Category A and B: #3 bars spaced at 18 inches on center in both directions. Category E: #4 bars spaced at 18 inches (or #3 bars spaced at 12 inches) on center in both directions. Rebar should be placed at midpoint of concrete section and supported on chairs prior to concrete placement.
Control (i.e., Contraction) Joint Spacing	In accordance with ACI 330R, control joints should be spaced no greater than 12.5 feet for 5-inch-thick concrete and 15 feet for 6-inch-thick or greater concrete. If sawcut, control joints should be cut within 6 to 12 hours of concrete placement. Sawcut joint should be at least ¼ of the slab thickness.
Expansion (i.e., Isolation) Joint Spacing	ACI 330R indicates that regularly spaced expansion joints may be deleted from concrete pavements, except

Item	Value
	adjacent to structures, manholes, inlets, light poles, etc. Therefore, the installation of expansion joints is optional and should be evaluated by the design/construction team. Expansion joints, if not sealed and maintained can allow infiltration of surface water into the subgrade.
Dowels at Expansion Joints	¾-inch smooth bars, 18 inches in length, with one end treated to slip, spaced at 12 inches on centers at each joint, and placed level at midpoint of concrete section.

Pavement Drainage

On most projects, rough site grading is accomplished relatively early in the construction phase. Fills are placed and compacted in a uniform manner. However, as construction proceeds, excavations are made into these areas, dry weather may desiccate some areas, rainfall and surface water saturates some areas, heavy traffic from concrete and other delivery vehicles disturbs the subgrade, and many surface irregularities are filled in with loose soils to temporarily improve subgrade conditions. As a result, the pavement subgrade should be carefully evaluated as the time for pavement construction approaches. This is particularly important in and around utility trench cuts. All pavement areas should be moisture conditioned and properly compacted to the recommendations in this report immediately prior to paving. Thorough proof-rolling of pavement areas should be performed no more than 36 hours prior to surface paving. Proof-rolling should be repeated if the site received rainfall prior to paving. Any problematic areas should be reworked and compacted at that time.

Openings in pavements, such as landscaped islands, are sources for water infiltration into surrounding pavement systems. Water can collect in the islands and migrate into the surrounding subgrade soils thereby degrading support of the pavement. Islands with raised concrete curbs, irrigated foliage, and low permeability near-surface soils are particular areas of concern. The civil design for the pavements with these conditions should include features to restrict or to collect and discharge excess water from the islands. Examples of features are self-contained planters, edge drains connected to the storm water collection system, longitudinal subdrains, or other suitable outlet, and impermeable barriers preventing lateral migration of water such as a cutoff wall installed to a depth below the pavement structure.

Pavements should be sloped to provide rapid drainage of surface water. Water allowed to pond on or adjacent to the pavements could saturate the subgrade and contribute to premature pavement deterioration. In addition, the pavement subgrade should be graded to provide positive drainage within the granular base section. Appropriate sub-drainage or connection to a suitable daylight outlet should be provided to remove water from the granular subbase.

Pavement Maintenance

The pavement sections represent minimum recommended thicknesses and, as such, periodic upkeep should be anticipated. Preventive maintenance should be planned and provided for through an on-going pavement management program. Maintenance activities are intended to slow the rate of pavement deterioration and to preserve the pavement investment. Pavement care consists of both localized (e.g., crack and joint sealing and patching) and global maintenance (e.g., surface sealing). Additional engineering consultation is recommended to determine the type and extent of a cost-effective program. Even with periodic maintenance, some movements and related cracking may still occur, and repairs may be required.

Pavement performance is affected by its surroundings. In addition to providing preventive maintenance, the civil engineer should consider the following recommendations in the design and layout of pavements:

- Final grade adjacent to paved areas should slope down from the edges at a minimum 2%.
- Subgrade and pavement surfaces should have a minimum 2% slope to promote proper surface drainage.
- Install pavement drainage systems (i.e., French drains) surrounding areas anticipated for frequent wetting.
- Install joint sealant and seal cracks immediately.
- Seal all landscaped areas in or adjacent to pavements to reduce moisture migration to subgrade soils.
- Place compacted, low permeability backfill against the exterior side of curb and gutter.
- Construct curb, gutter and/or sidewalk directly on clay subgrade soils rather than on unbound granular base course materials.

General Comments

Our analysis and opinions are based upon our understanding of the project, the geotechnical conditions in the area, and the data obtained from our site exploration. Variations will occur between exploration point locations or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. Terracon should be retained as the Geotechnical Engineer, where noted in this report, to provide observation and testing services during pertinent construction phases. If variations appear, we can provide further evaluation and supplemental recommendations. If variations are noted in the absence of our observation and testing services on-site, we should be immediately notified so that we can provide evaluation and supplemental recommendations.

Our Scope of Services does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, 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.

Our services and any correspondence are intended for the sole benefit and exclusive use of our client for specific application to the project discussed and are accomplished in accordance with generally accepted geotechnical engineering practices with no third-party beneficiaries intended. Any third-party access to services or correspondence is solely for information purposes to support the services provided by Terracon to our client. Reliance upon the services and any work product is limited to our client and is not intended for third parties. Any use or reliance of the provided information by third parties is done solely at their own risk. No warranties, either express or implied, are intended or made.

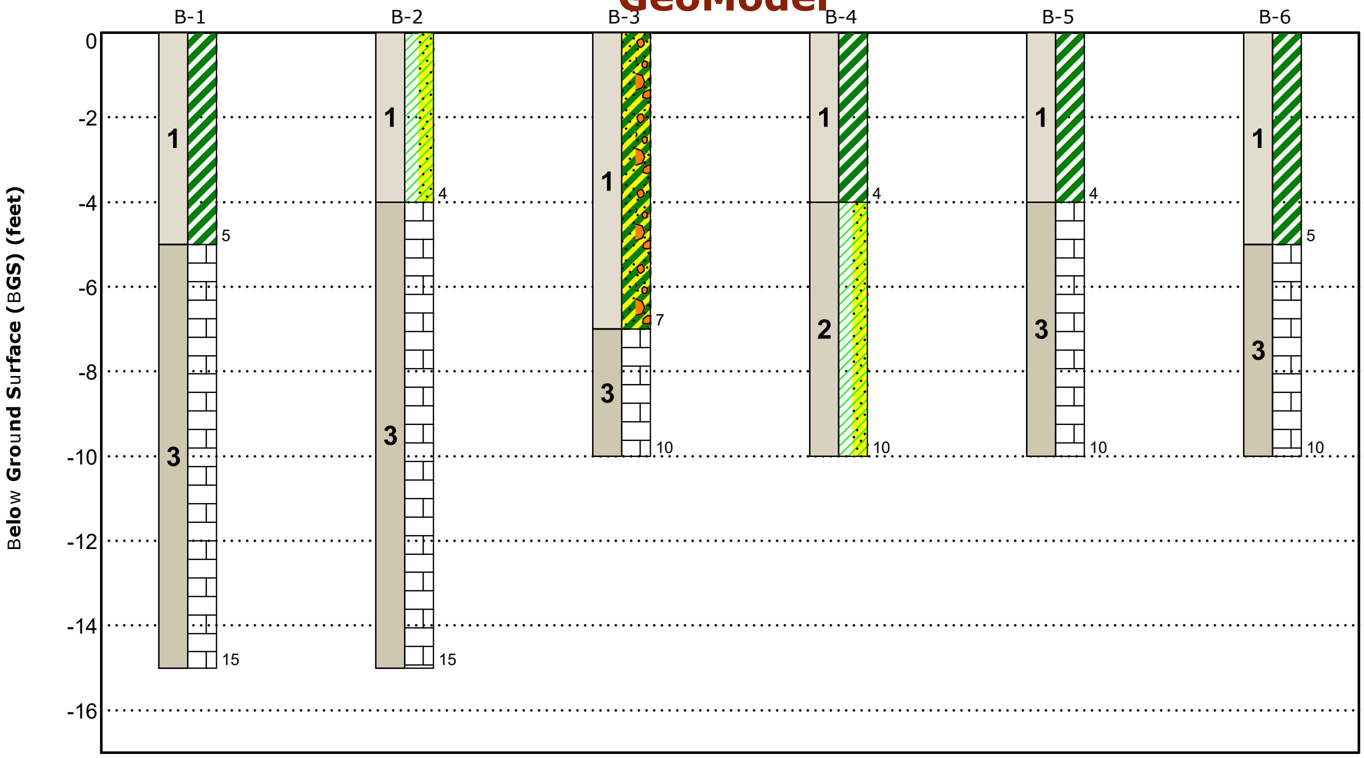
Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly effect excavation cost. Any parties charged with estimating excavation costs should seek their own site characterization for specific purposes to obtain the specific level of detail necessary for costing. Site safety and cost estimating including excavation support and dewatering requirements/design are the responsibility of others. Construction and site development have the potential to affect adjacent properties. Such impacts can include damages due to vibration, modification of groundwater/surface water flow during construction, foundation movement due to undermining or subsidence from excavation, as well as noise or air quality concerns. Evaluation of these items on nearby properties are commonly associated with contractor means and methods and are not addressed in this report. The owner and contractor should consider a preconstruction/precondition survey of surrounding development. If changes in the nature, design, or location of the project are planned, our conclusions and recommendations shall not be considered valid unless we review the changes and either verify or modify our conclusions in writing.

Figures

Contents:

800 Paloma Dr Ste 160
Round Rock, TX

GeoModel



This is not a cross section. This is intended to display the Geotechnical Model only. See individual logs for more detailed conditions.

Model Layer	Layer Name	General Description	Legend
1	SURFICIAL SOILS	DARK BROWN TO BROWN, VERY STIFF TO HARD	Fat Clay; Limestone; Lean Clay with Sand; Sandy Fat Clay with Gravel
2	LOWER CLAY	LIGHT BROWN TO BROWN, STIFF TO HARD	
3	LIMESTONE (AUSTIN CHALK)	LIGHT BROWN TO GRAY	

NOTES:
Layering shown on this figure has been developed by the geotechnical engineer for purposes of modeling the subsurface conditions as required for the subsequent geotechnical engineering for this project.
Numbers adjacent to soil column indicate depth below ground surface.

Attachments

Exploration and Testing Procedures

Field Exploration

Number of Borings	Approximate Boring Depth (feet)	Location
2	15	Building area
4	10	Parking/driveway area

Boring Layout and Elevations: Terracon personnel provided the boring layout using handheld GPS equipment (estimated horizontal accuracy of about ±10 feet) and referencing existing site features. If elevations and a more precise boring layout are desired, we recommend borings be professionally surveyed.

Subsurface Exploration Procedures: Our drilling subcontractor advanced the borings with a truck-mounted, rotary drill rig using continuous flight augers (solid stem). Samples were obtained at approximately two-foot intervals in the upper 10 feet of each boring and at intervals of 5 feet thereafter (unless bedrock was encountered). Soil sampling was performed using Shelby tube samplers and/or split-barrel sampling procedures. The split-barrel samplers were driven in accordance with the standard test method for standard penetration test (SPT) and split-barrel sampling of soils. Bedrock was sampled with split-barrel-sampling spoons. For safety purposes, all borings were backfilled with auger cuttings after their completion.

Our exploration team/drilling subcontractor observed and recorded groundwater levels during drilling and sampling. Groundwater was not observed during our field investigation.

The sampling depths, penetration distances, and other sampling information was recorded on the field boring logs. The samples were placed in appropriate containers and taken to our soil laboratory for testing and classification by a Geotechnical Engineer. Our exploration team prepared field boring logs as part of the drilling operations. These field logs included visual classifications of the materials observed during drilling and our interpretation of the subsurface conditions between samples. Final boring logs were prepared from the field logs. The final boring logs represent the Geotechnical Engineer's interpretation of the field logs and include modifications based on observations and tests of the samples in our laboratory.

Laboratory Testing

The project engineer reviewed the field data and assigned laboratory tests. The laboratory testing program included the following types of tests:

- Moisture Content
- Dry Unit Weight
- Grain Size Distribution
- Atterberg Limits
- Unconfined Compression

The laboratory testing program often included examination of soil samples by an engineer. Based on the results of our field and laboratory programs, we described and classified the soil samples in accordance with the Unified Soil Classification System.

Rock classification was conducted using locally accepted practices for engineering purposes; petrographic analysis may reveal other rock types. Rock core samples typically provide an improved specimen for this classification. Boring log rock classification was determined using the Description of Rock Properties.

Site Location and Exploration Plans

Contents:

Note: All attachments are one page unless noted above.

Site Location

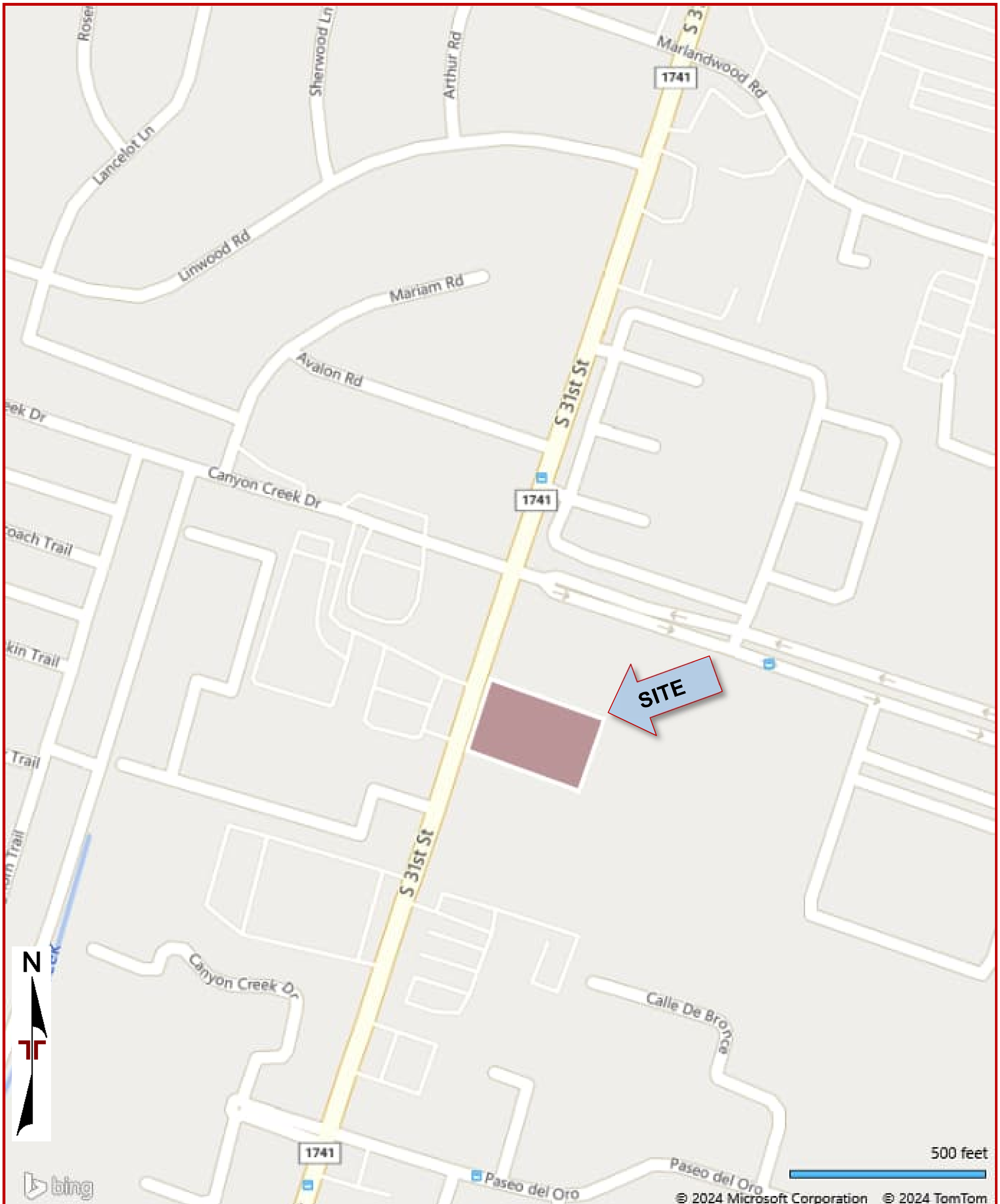


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

Exploration Plan

Exploration Plan

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

Exploration and Laboratory Results

Contents:

Note: All attachments are one page unless noted above.

Terracon
800 Paloma Dr Ste 160
Round Rock, TX

Boring Log No. B-1

Location: See Exploration Plan

Latitude: 31.0602° Longitude: -97.3725°

Model Layer	Depth (Ft.) / Description	Elevation: 0 (Ft.) +/-	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Strength Test: Test Type	Strength Test: Compressive Strength (tsf)	Strength Test: Strain (%)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
1	**FAT CLAY (CH)**, dark brown, hard					4.5+ tsf (HP)				30.1			92
						4.5+ tsf (HP)	UC	4.09	6.4	17.1	102		
	5.0 -with limestone fragments below 4.5 feet	-5	5			31-50/3"				10.7		80-24-56	
3	**AUSTIN CHALK**, light brown to gray, with lean clay seams/layers					50/2"				14.0			
						50/1"				13.4			
			10										
	15.0	-15	15			50/2"				10.8			
	Boring Terminated at 15 Feet												

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).
See Supporting Information for explanation of symbols and abbreviations.
Elevation Reference: Elevations were not determined.

Notes

Water Level Observations
Groundwater not encountered

Advancement Method
Dry Augered

Abandonment Method
Boring backfilled with Auger Cuttings and/or Bentonite

Drill Rig
CME55

Hammer Type
Automatic

Driller
Mid-Tex Testing

Logged by
Mid-Tex Testing

Boring Started
06-24-2024

Boring Completed
06-24-2024

Terracon
800 Paloma Dr Ste 160
Round Rock, TX

Boring Log No. B-2

Location: See Exploration Plan

Latitude: 31.0600° Longitude: -97.3721°

Model Layer	Graphic Log	Depth (Ft.) / Elevation: 0 (Ft.) +/-	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Strength Test: Test Type	Strength Test: Compressive Strength (tsf)	Strength Test: Strain (%)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
1		**LEAN CLAY WITH SAND (CL)**, dark brown, medium stiff to hard				4.5+ tsf (HP)				27.7			
						4.5+ tsf (HP)	UC	0.57	5.2	20.8	103	38-22-16	83
		4.0 / -4											
3		**AUSTIN CHALK**, light brown, with lean clay seams/layers				50/6"				12.7			
			5										
						50/6"				9.6			
						50/2"				12.1			
			10										
						50/2"				12.3			
		15.0 / -15	15										
		Boring Terminated at 15 Feet											

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).
See Supporting Information for explanation of symbols and abbreviations.
Elevation Reference: Elevations were not determined.

Water Level Observations
Groundwater not encountered

Drill Rig
CME55

Hammer Type
Automatic

Driller
Mid-Tex Testing

Notes

Advancement Method
Dry Augered

Abandonment Method
Boring backfilled with Auger Cuttings and/or Bentonite

Logged by
Mid-Tex Testing

Boring Started
06-24-2024

Boring Completed
06-24-2024

Terracon
800 Paloma Dr Ste 160
Round Rock, TX

Boring Log No. B-3

Location: See Exploration Plan

Latitude: 31.0601° Longitude: -97.3719°

Depth (Ft.) Elevation: 0 (Ft.) +/-

Model Layer	Graphic Log	Material Description	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Strength Test: Test Type	Strength Test: Compressive Strength (tsf)	Strength Test: Strain (%)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
1		**SANDY FAT CLAY WITH GRAVEL (CH)**, dark brown, hard				4.5+ tsf (HP)				25.2			
						4.5+ tsf (HP)				16.6		51-22-29	69
			5			13-21-22 N=43				15.7			
		7.0 -with increasing limestone fragments below 6.5 feet -7				12-32-50/1"				17.2			
3		**AUSTIN CHALK**, light brown, with lean clay seams/layers											
						50/5"				13.6			
		10.0 -10	10										
		Boring Terminated at 10 Feet											

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).
See Supporting Information for explanation of symbols and abbreviations.
Elevation Reference: Elevations were not determined.

Water Level Observations
Groundwater not encountered

Drill Rig
CME55

Hammer Type
Automatic

Driller
Mid-Tex Testing

Notes

Advancement Method
Dry Augered

Abandonment Method
Boring backfilled with Auger Cuttings and/or Bentonite

Logged by
Mid-Tex Testing

Boring Started
06-24-2024

Boring Completed
06-24-2024

Terracon
800 Paloma Dr Ste 160
Round Rock, TX

Boring Log No. B-4

Location: See Exploration Plan

Latitude: 31.0602° Longitude: -97.3722°

Depth (Ft.) Elevation: 0 (Ft.) +/-

Model Layer	Graphic Log	Description	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Strength Test: Test Type	Strength Test: Compressive Strength (tsf)	Strength Test: Strain (%)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
1		**FAT CLAY (CH)**, dark brown, hard				4.5+ tsf (HP)				29.9			
						4.5+ tsf (HP)				26.9			
		4.0 -4											
2		**LEAN CLAY WITH SAND (CL)**, light brown to brown, stiff to very stiff	5			1.0 tsf (HP)				19.6		31-20-11	79
						1.5 tsf (HP)				23.7			
						1.5 tsf (HP)	UC	2.52	2.1	24.1	98		
		10.0 -10	10										
		Boring Terminated at 10 Feet											

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).
See Supporting Information for explanation of symbols and abbreviations.
Elevation Reference: Elevations were not determined.

Water Level Observations
Groundwater not encountered

Drill Rig
CME55

Hammer Type
Automatic

Driller
Mid-Tex Testing

Notes

Advancement Method
Dry Augered

Abandonment Method
Boring backfilled with Auger Cuttings and/or Bentonite

Logged by
Mid-Tex Testing

Boring Started
06-24-2024

Boring Completed
06-24-2024

Terracon
800 Paloma Dr Ste 160
Round Rock, TX

Boring Log No. B-5

Location: See Exploration Plan

Latitude: 31.0604° Longitude: -97.3726°

Model Layer	Graphic Log	Depth (Ft.) / Description / Elevation: 0 (Ft.) +/-	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Strength Test: Test Type	Strength Test: Compressive Strength (tsf)	Strength Test: Strain (%)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
1		**FAT CLAY (CH)**, dark brown, very stiff to hard				4.5+ tsf (HP)				26.7			
						4.0 tsf (HP)				27.9		86-23-63	93
		4.0 / -4											
3		**AUSTIN CHALK**, light brown, with lean clay seams/layers				31-50/1"				11.8			
			5			50/6"				18.9			
						50/4"				13.4			
		10.0 / -10	10										
		Boring Terminated at 10 Feet											

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).
See Supporting Information for explanation of symbols and abbreviations.
Elevation Reference: Elevations were not determined.

Water Level Observations
Groundwater not encountered

Drill Rig
CME55

Hammer Type
Automatic

Driller
Mid-Tex Testing

Notes

Advancement Method
Dry Augered

Abandonment Method
Boring backfilled with Auger Cuttings and/or Bentonite

Logged by
Mid-Tex Testing

Boring Started
06-24-2024

Boring Completed
06-24-2024

Terracon
800 Paloma Dr Ste 160
Round Rock, TX

Boring Log No. B-6

Location: See Exploration Plan

Latitude: 31.0602° Longitude: -97.3727°

Model Layer	Depth (Ft.)	Description (Elevation: 0 (Ft.) +/-)	Elev.	Depth (Ft.)	Water Level Observations	Sample Type	Field Test Results	Test Type	Compressive Strength (tsf)	Strain (%)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI	Percent Fines
1		**FAT CLAY (CH)**, dark brown, hard					4.5+ tsf (HP)				27.2		88-25-63	95
							4.5+ tsf (HP)				28.6			
							21-50/6"				11.6			
	5.0	-with limestone fragments below 4.5 feet	-5	5										
3		**AUSTIN CHALK**, light brown, with lean clay seams/layers					50/2"				12.5			
							50/2"				13.0			
	10.0		-10	10										
		Boring Terminated at 10 Feet												

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).
See Supporting Information for explanation of symbols and abbreviations.
Elevation Reference: Elevations were not determined.

Water Level Observations
Groundwater not encountered

Drill Rig
CME55

Hammer Type
Automatic

Driller
Mid-Tex Testing

Notes

Advancement Method
Dry Augered

Abandonment Method
Boring backfilled with Auger Cuttings and/or Bentonite

Logged by
Mid-Tex Testing

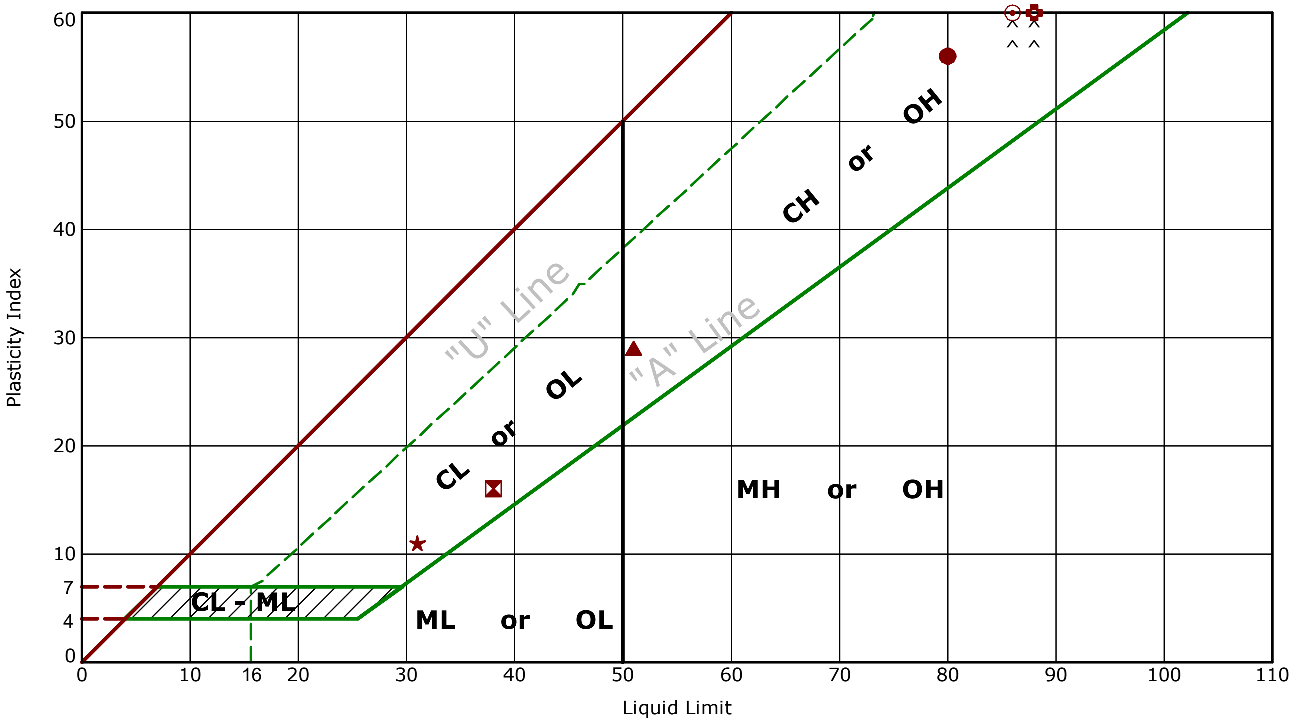
Boring Started
06-24-2024

Boring Completed
06-24-2024

800 Paloma Dr Ste 160
Round Rock, TX

Atterberg Limit Results

ASTM D4318

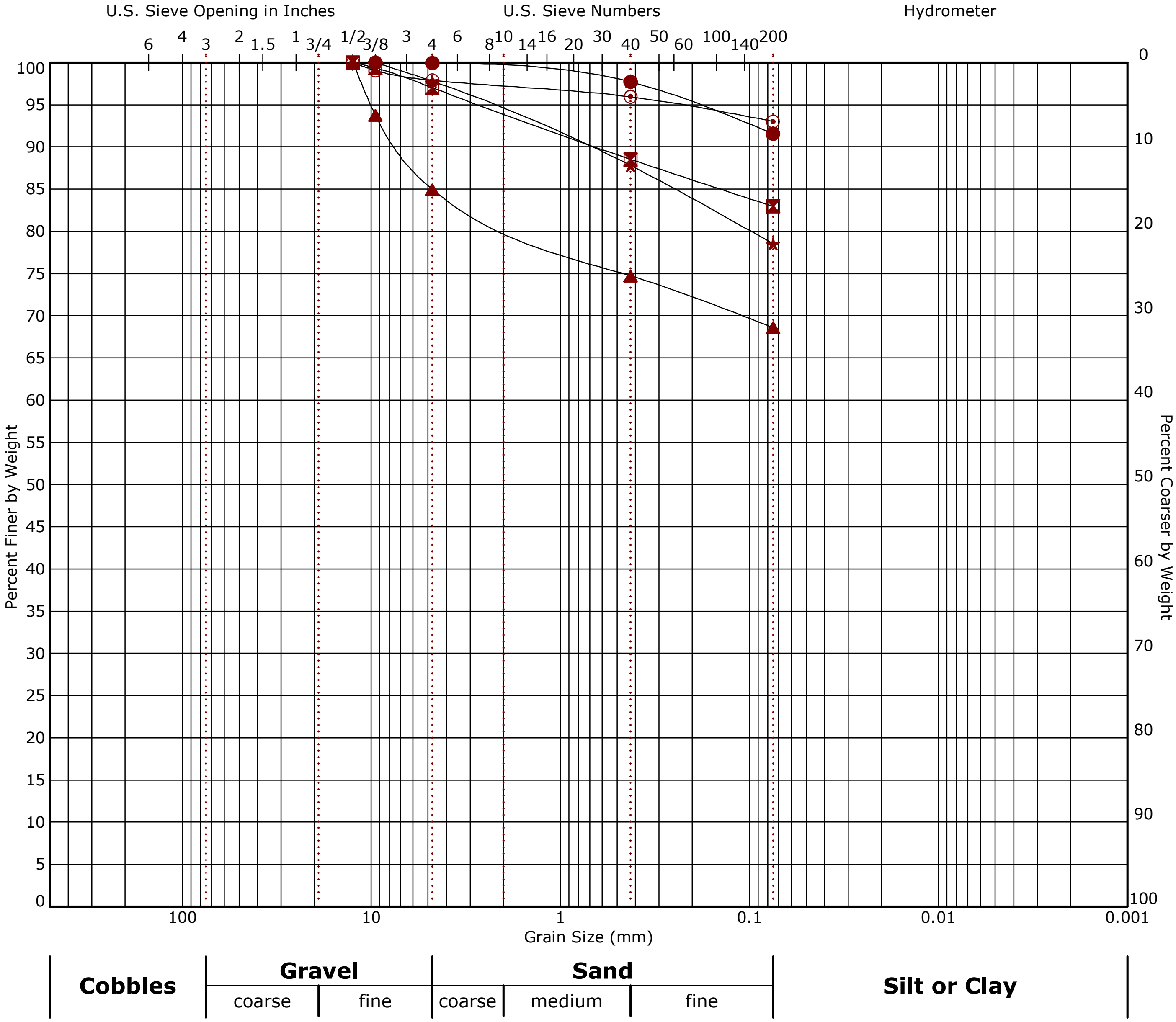


	Boring ID	Depth (Ft)	LL	PL	PI	Fines	USCS	Description
●	B-1	4 - 4.8	80	24	56			
⊠	B-2	2 - 4	38	22	16	83.0	CL	LEAN CLAY with SAND
▲	B-3	2 - 4	51	22	29	68.6	CH	SANDY FAT CLAY with GRAVEL
★	B-4	4 - 6	31	20	11	78.5	CL	LEAN CLAY with SAND
⊙	B-5	2 - 4	86	23	63	93.0	CH	FAT CLAY
✚	B-6	0 - 2	88	25	63	94.6	CH	FAT CLAY

Terracon
800 Paloma Dr Ste 160
Round Rock, TX

Grain Size Distribution

ASTM D422 / ASTM C136 / AASHTO T27



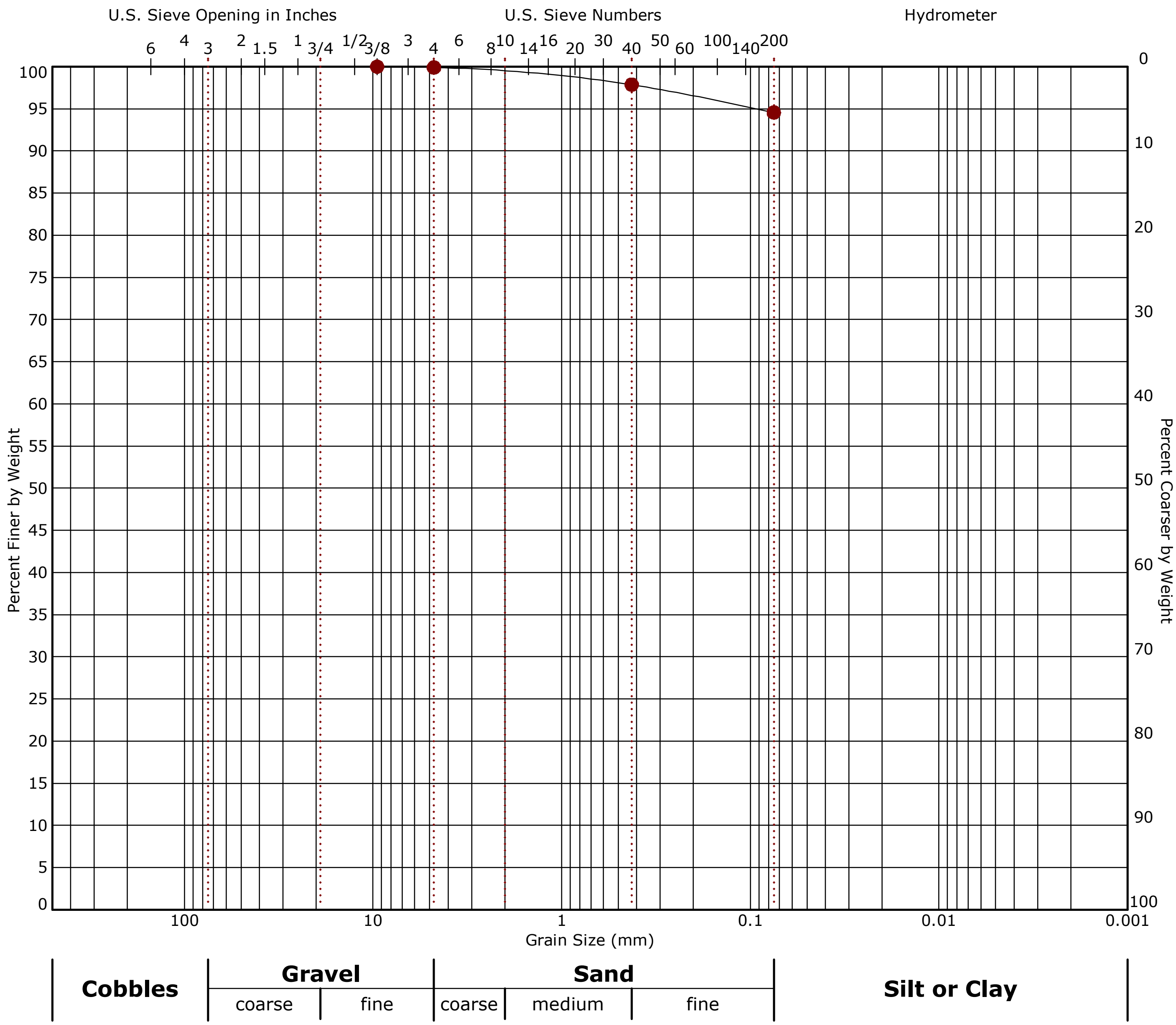
Boring ID	Depth (Ft)	Description	USCS	LL	PL	PI	Cc	Cu
● B-1	0 - 2							
⧗ B-2	2 - 4	LEAN CLAY with SAND	CL	38	22	16		
▲ B-3	2 - 4	SANDY FAT CLAY with GRAVEL	CH	51	22	29		
★ B-4	4 - 6	LEAN CLAY with SAND	CL	31	20	11		
⊙ B-5	2 - 4	FAT CLAY	CH	86	23	63		

Boring ID	Depth (Ft)	D_{100}	D_{60}	D_{30}	D_{10}	%Cobbles	%Gravel	%Sand	%Fines	%Silt	%Clay
● B-1	0 - 2	9.5				0.0	0.1	8.4	91.6		
⧗ B-2	2 - 4	12.5				0.0	3.0	14.0	83.0		
▲ B-3	2 - 4	12.5				0.0	15.0	16.4	68.6		
★ B-4	4 - 6	9.5				0.0	2.2	19.3	78.5		
⊙ B-5	2 - 4	12.5				0.0	2.1	4.9	93.0		

Terracon
800 Paloma Dr Ste 160
Round Rock, TX

Grain Size Distribution

ASTM D422 / ASTM C136 / AASHTO T27



	Boring ID	Depth (Ft)	Description	USCS	LL	PL	PI	Cc	Cu
●	B-6	0 - 2	FAT CLAY	CH	88	25	63		

	Boring ID	Depth (Ft)	D_{100}	D_{60}	D_{30}	D_{10}	%Cobbles	%Gravel	%Sand	%Fines	%Silt	%Clay
●	B-6	0 - 2	9.5				0.0	0.1	5.3	94.6		

Supporting Information

Contents:

Note: All attachments are one page unless noted above.

Terracon
800 Paloma Dr Ste 160
Round Rock, TX

General Notes

Sampling	Water Level	Field Tests
Shelby Tube Standard Penetration Test	Water Initially Encountered Water Level After a Specified Period of Time Water Level After a Specified Period of Time Cave In Encountered Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.	N Standard Penetration Test Resistance (Blows/Ft.) (HP) Hand Penetrometer (T) Torvane (DCP) Dynamic Cone Penetrometer UC Unconfined Compressive Strength (PID) Photo-Ionization Detector (OVA) Organic Vapor Analyzer

Descriptive Soil Classification

Soil classification as noted on the soil boring logs is based Unified Soil Classification System. Where sufficient laboratory data exist to classify the soils consistent with ASTM D2487 "Classification of Soils for Engineering Purposes" this procedure is used. ASTM D2488 "Description and Identification of Soils (Visual-Manual Procedure)" is also used to classify the soils, particularly where insufficient laboratory data exist to classify the soils in accordance with ASTM D2487. In addition to USCS classification, coarse grained soils are classified on the basis of their in-place relative density, and fine-grained soils are classified on the basis of their consistency. See "Strength Terms" table below for details. The ASTM standards noted above are for reference to methodology in general. In some cases, variations to methods are applied as a result of local practice or professional judgment.

Location And Elevation Notes

Exploration point locations as shown on the Exploration Plan and as noted on the soil boring logs in the form of Latitude and Longitude are approximate. See Exploration and Testing Procedures in the report for the methods used to locate the exploration points for this project. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

Strength Terms

Relative Density of Coarse-Grained Soils (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance		**Consistency of Fine-Grained Soils** (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance			**Bedrock**	
Relative Density	**Standard Penetration or N-Value (Blows/Ft.)**	**Consistency**	**Unconfined Compressive Strength Qu (tsf)**	**Standard Penetration or N-Value (Blows/Ft.)**	**Standard Penetration or N-Value (Blows/Ft.)**	**Consistency**
Very Loose	0 - 3	Very Soft	less than 0.25	0 - 1	< 20	Weathered
Loose	4 - 9	Soft	0.25 to 0.50	2 - 4	20 - 29	Firm
Medium Dense	10 - 29	Medium Stiff	0.50 to 1.00	4 - 8	30 - 49	Medium Hard
Dense	30 - 50	Stiff	1.00 to 2.00	8 - 15	50 - 79	Hard
Very Dense	> 50	Very Stiff	2.00 to 4.00	15 - 30	>79	Very Hard
		Hard	> 4.00	> 30		

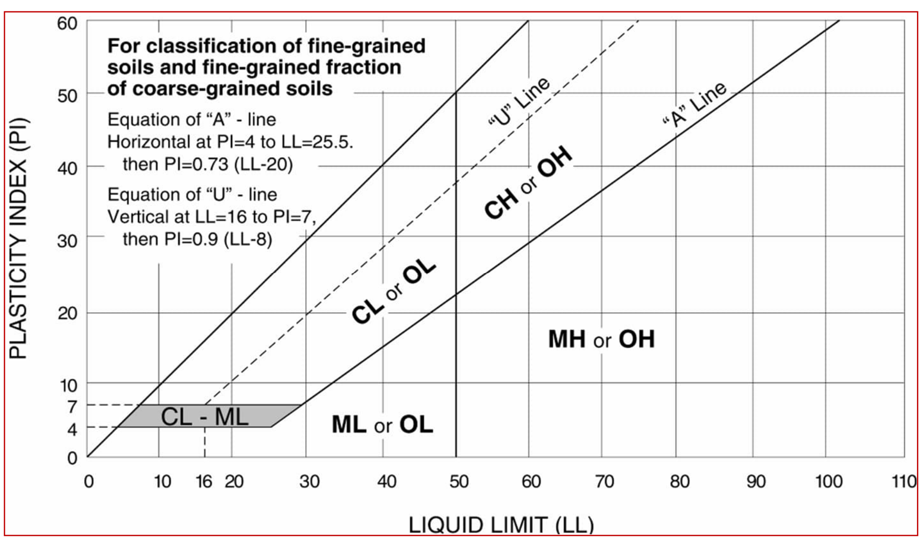
Relevance of Exploration and Laboratory Test Results

Exploration/field results and/or laboratory test data contained within this document are intended for application to the project as described in this document. Use of such exploration/field results and/or laboratory test data should not be used independently of this document.

Unified Soil Classification System

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]				Soil Classification	
				Group Symbol	Group Name [B]
Coarse-Grained Soils: More than 50% retained on No. 200 sieve	Gravels: More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels: Less than 5% fines [C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$ [E]	GW	Well-graded gravel [F]
			$Cu < 4$ and/or $[Cc < 1$ or $Cc > 3.0]$ [E]	GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH	GM	Silty gravel [F, G, H]
			Fines classify as CL or CH	GC	Clayey gravel [F, G, H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	Clean Sands: Less than 5% fines [D]	$Cu \geq 6$ and $1 \leq Cc \leq 3$ [E]	SW	Well-graded sand [I]
			$Cu < 6$ and/or $[Cc < 1$ or $Cc > 3.0]$ [E]	SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH	SM	Silty sand [G, H, I]
			Fines classify as CL or CH	SC	Clayey sand [G, H, I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	Silts and Clays: Liquid limit less than 50	Inorganic:	PI > 7 and plots above "A" line [J]	CL	Lean clay [K, L, M]
			PI < 4 or plots below "A" line [J]	ML	Silt [K, L, M]
		Organic:	$\frac{LL\ oven\ dried}{LL\ not\ dried} < 0.75$	OL	Organic clay [K, L, M, N]
					Organic silt [K, L, M, O]
	Silts and Clays: Liquid limit 50 or more	Inorganic:	PI plots on or above "A" line	CH	Fat clay [K, L, M]
			PI plots below "A" line	MH	Elastic silt [K, L, M]
		Organic:	$\frac{LL\ oven\ dried}{LL\ not\ dried} < 0.75$	OH	Organic clay [K, L, M, P]
					Organic silt [K, L, M, Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor			PT	Peat

[A] Based on the material passing the 3-inch (75-mm) sieve.
[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.
[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.
[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay.
[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$
[F] If soil contains ≥ 15% sand, add "with sand" to group name.
[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.
[H] If fines are organic, add "with organic fines" to group name.
[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.
[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.
[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.
[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.
[N] PI ≥ 4 and plots on or above "A" line.
[O] PI < 4 or plots below "A" line.
[P] PI plots on or above "A" line.
[Q] PI plots below "A" line.



Rock Classification Notes

WEATHERING	
Term	Description
Fresh	Mineral crystals appear bright; show no discoloration. Features show little or no staining on surfaces. Discoloration does not extend into intact rock.
Slightly weathered	Rock generally fresh except along fractures. Some fractures stained and discoloration may extend <0.5 inches into rock.
Moderately weathered	Significant portions of rock are dull and discolored. Rock may be significantly weaker than in fresh state near fractures. Soil zones of limited extent may occur along some fractures.
Highly weathered	Rock dull and discolored throughout. Majority of rock mass is significantly weaker and has decomposed and/or disintegrated; isolated zones of stronger rock and/or soil may occur throughout.
Completely weathered	All rock material is decomposed and/or disintegrated to soil. The rock mass or fabric is still evident and largely intact. Isolated zones of stronger rock may occur locally.

STRENGTH OR HARDNESS		
Description	Field Identification	Uniaxial Compressive Strength, psi
Extremely strong	Can only be chipped with geological hammer. Rock rings on hammer blows. Cannot be scratched with a sharp pick. Hand specimens require several hard hammer blows to break.	>36,000
Very strong	Several blows of a geological hammer to fracture. Cannot be scratched with a 20d common steel nail. Can be scratched with a geologist's pick only with difficulty.	15,000-36,000
Strong	More than one blow of a geological hammer needed to fracture. Can be scratched with a 20d nail or geologist's pick. Gouges or grooves to ¼ inch deep can be excavated by a hard blow of a geologist's pick. Hand specimens can be detached by a moderate blow.	7,500-15,000
Medium strong	One blow of geological hammer needed to fracture. Can be distinctly scratched with 20d nail. Can be grooved or gouged 1/16 in. deep by firm pressure with a geologist's pick point. Can be fractured with single firm blow of geological hammer. Can be excavated in small chips (about 1-in. maximum size) by hard blows of the point of a geologist's pick;	3,500-7,500
Weak	Shallow indent by firm blow with geological hammer point. Can be gouged or grooved readily with geologist's pick point. Can be excavated in pieces several inches in size by moderate blows of a pick point. Small thin pieces can be broken by finger pressure.	700-3,500
Very weak	Crumbles under firm blow with geological hammer point. Can be excavated readily with the point of a geologist's pick. Pieces 1-in. or more in thickness can be broken with finger pressure. Can be scratched readily by fingernail.	150-700

DISCONTINUITY DESCRIPTION			
Fracture Spacing (Joints, Faults, Other Fractures)		Bedding Spacing (May Include Foliation or Banding)	
Description	Spacing	Description	Spacing
Intensely fractured	< 2.5 inches	Laminated	< ½-inch
Highly fractured	2.5 – 8 inches	Very thin	½ – 2 inches
Moderately fractured	8 inches to 2 feet	Thin	2 inches – 1 foot
Slightly fractured	2 to 6.5 feet	Medium	1 – 3 feet
Very slightly fractured	> 6.5 feet	Thick	3 – 10 feet
		Massive	> 10 feet

ROCK QUALITY DESIGNATION (RQD) [1]	
Description	RQD Value (%)
Very Poor	0 - 25
Poor	25 – 50
Fair	50 – 75
Good	75 – 90
Excellent	90 - 100

1. The combined length of all sound and intact core segments equal to or greater than 4 inches in length, expressed as a percentage of the total core run length.