Geotechnical Engineering Report

Sherwin Williams Store - Manor
Manor, Texas
May 9, 2022
Terracon Project No. 96225068

Prepared for:
Belterra Partners
Birmingham, Alabama

Prepared by:
Terracon Consultants, Inc.
Austin, Texas

May 9, 2022

Belterra Partners
728 Shades Creek Pkwy, Ste. 130
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Attn: Mr. Scott Smith
P: (205) 968-1701
E: scott@belterrapartners.com

Re: Geotechnical Engineering Report
Sherwin Williams Store - Manor
12937 North FM 973
Manor, Texas
Terracon Project No. 96225068

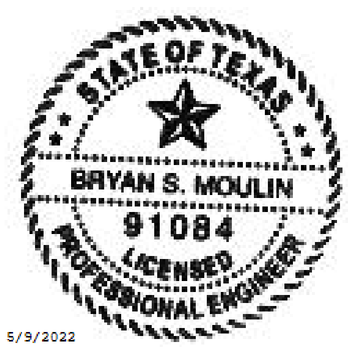
Dear Mr. Smith:

We have completed a subsurface exploration and Geotechnical Engineering evaluation for the above referenced project. This study was performed in general accordance with Terracon Proposal No. P96225068 dated March 4, 2022. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork, subgrade preparation, and the design and construction of foundations, 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.

Rahul Muduganti, E.I.T.
Staff Engineer



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Environmental ■ Facilities ■ Geotechnical ■ Materials

REPORT TOPICS

Note: This report was originally delivered in a web-based format. **Orange 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 ***GeoReport*** logo will bring you back to this page. For more interactive features, please view your project online at client.terracon.com.

ATTACHMENTS

Note: Refer to each individual Attachment for a listing of contents.

Geotechnical Engineering Report

Sherwin Williams Store - Manor
12937 North FM 973
Manor, Texas
Terracon Project No. 96225068
May 9, 2022

INTRODUCTION

This report presents the results of our subsurface exploration and geotechnical engineering services performed for the proposed Sherwin Williams Store - Manor project to be located at 12937 North FM 973 in Manor, Texas. The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil conditions
- Groundwater conditions
- Site preparation and earthwork
- Foundation design and construction
- Floor slab design and construction
- Seismic site classification
- Pavement design and construction

The geotechnical engineering Scope of Services for this project included the advancement of five (5) test borings, designated B-1 through P-3, to depths ranging from approximately 5 to 30 feet below existing site grades.

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

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 is located at 12937 North FM 973 in Manor, Texas. See **Site Location**
Existing Improvements	The project site is currently a vacant lot.
Current Ground Cover	Exposed soils and vegetation

Item	Description
Existing Topography	The project site appears to be sloping down towards north.
Geology	Based on our review of available geologic information and the samples obtained from the test borings, the study area appears to lie within an area characterized by the Navarro and Taylor Groups. The Navarro and Taylor Groups generally consists of highly plastic expansive clay soils ranging in color from gray to yellowish-tan.

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	The project description was provided by Mr. Scott Smith of Belterra Partners via email dated on February 28, 2022.
Proposed Structures	The project includes the construction of the following; ■ 4,500 square feet single-story retail building ■ Private pavement system
Finished Floor Elevation	Unknown at this time but assumed to be ≤ 3 feet from existing grades.
Maximum Loads (Assumed)	Unknown at this time but assumed to be following: ■ Columns: 100 kips maximum ■ Walls: 2 to 4 kips per linear foot (klf) maximum ■ Slabs: 100 to 150 pounds per square foot (psf) maximum
Grading/Slopes	Unknown at this time but assumed to be ≤ 3 feet from existing grades.
Below-Grade Structures	None anticipated.
Free-Standing Retaining Walls	None anticipated.
Pavements	We assume both rigid (concrete) and flexible (asphalt) pavement sections will be considered for the proposed pavement system.

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 site preparation and foundation options. Conditions encountered at each exploration point are indicated on the individual logs. The individual logs can be found in the **Exploration Results** section and the GeoModel can be found in the **Figures** section 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.

Model Layer	Layer Name	General Description
1	**Upper Fat Clay**	Dark brown, stiff to hard
2	**Lower Fat Clay**	Grayish tan to dark brown, stiff to hard

Groundwater

The boreholes were observed while drilling and after completion for the presence and level of groundwater. Groundwater was not observed in the borings while drilling, nor for the short duration the borings could remain open. However, this does not necessarily mean the borings terminated above groundwater as groundwater conditions can (and likely will) vary between the time of the geotechnical investigation and the timeframe of construction activities.

Due to the low permeability of the fat clay 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 level fluctuations occur due to seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the borings were performed. Therefore, groundwater levels during construction or at other times in the life of the structure may be higher or lower than the levels indicated on the boring logs. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

GEOTECHNICAL OVERVIEW

The near-surface fat clay could become problematic with typical earthwork and construction traffic, especially after precipitation events. 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.

The subgrade soils for the floor slabs consist of high plasticity fat clay, therefore extensive subgrade preparation is necessary in order to reduce post-construction movements to about 1-inch. Alternatively, the floor slab may be designed as a structurally suspended slab supported on drilled pier foundations, with void forms underneath the slab and beams. The **Floor Slab** section addresses both slab options.

Expansive fat clay soils are present at this site. 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. Some of these options are discussed in this report such as removal and replacement of expansive soils with select fill or a structural slab supported on drilled pier foundations.

The **Shallow Foundations** section addresses the support of the structure on a monolithic slab-on-grade foundation or spread/strip footing foundations bearing over select fill soils. The **Deep Foundations** section addresses support of the structure on drilled piers bearing into Stratum 2 grayish tan to dark brown fat clay soils. The **Floor Slab** section addresses slab support of the structure.

Asphaltic concrete and portland cement concrete pavement systems are recommended for this site. The **Pavements** section addresses the design of private pavement systems.

The **General Comments** section provides an understanding of the report limitations.

EARTHWORK

Earthwork is anticipated to include clearing and grubbing, excavations, and 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 foundations, floor slabs, and pavements.

Site Preparation

Construction areas should be stripped of all vegetation, loose soils, topsoils and other unsuitable material currently present at the site. We recommend that Terracon be retained to assist in evaluating exposed subgrades during earthwork so that unsuitable materials, if any, are removed at the time of construction.

Proof-Rolling

Once initial subgrade elevations have been achieved (i.e., after cuts but prior to fills), the exposed subgrade in all construction areas (except landscaping) should be carefully and thoroughly proof-rolled with a 20-ton pneumatic roller, fully-loaded dump truck, or similar equipment to detect weak zones in the subgrade. Weak areas detected during proof-rolling should be removed and replaced with soils exhibiting similar classification, moisture content, and density as the adjacent in-situ soils (or flowable fill). Proper site drainage should be maintained during construction so that ponding of surface runoff does not occur and cause construction delays and/or inhibit site access.

Moisture-Conditioned Subgrade

After proof-rolling, and just prior to placement of fill, the exposed soil subgrade in all construction areas (except landscaping) should be evaluated for moisture and density through field density testing. If the moisture and/or density field test results do not meet the moisture and density requirements below, the subgrade should be scarified to a minimum depth of 6 inches, moisture conditioned and compacted as per the fill compaction requirements.

Fill Material Types

Fill required to achieve design grade should be classified as select/structural fill and general fill. Select/structural fill is material used below, and within 5 feet of structures. General fill is material used to achieve grade in paving, landscape, or other general areas (non-structural areas). Earthen materials used for select fill and general fill should meet the following material property requirements:

Fill Type [1]	USCS Classification	Acceptable Specifications
Imported Select/Structural Fill [2,3]	CL, SC, and/or GC	■ TxDOT Item 247, Type A, Grade 3, OR ■ Percent Retained on No. 4 Sieve ≤ 40 percent with 7≤PI≤20 and rocks ≤ 4 inches in maximum dimensions, OR ■ Crushed concrete (TxDOT Item 247, Type D, Grade 3 or better)
Paving Fill and General Fill [4]	CH, CL, SC and/or GC	■ On-Site Soils: Rocks ≤ 4 inches in maximum dimension ■ Imported Soils: PI ≤ 50; Rocks ≤ 4 inches in maximum dimension

1. Structural and 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.
2. As an alternative to the Acceptable Specifications above, a low-plasticity granular material which does not meet these specifications may be used only if approved by Terracon.
3. Based on the laboratory testing performed during this exploration, the excavated Stratum 1 and 2 fat clay soils are not suitable for re-use as select fill. Select fill will need to be imported.
4. Excavated on-site soils, if free of organics, debris, and rocks larger than 4 inches may be considered for re-use as fill in pavement, landscape, or other general areas. Please note that the on-site soils exhibit high to

Fill Type [1]	USCS Classification	Acceptable Specifications
		very high shrink/swell potential. For economic reasons, expansive soils are often used in pavement and/or flatwork areas. The owner should be 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. If paving fill is imported, the PI should not exceed 50.

Fill Compaction Requirements

Recommended compaction and moisture content criteria for engineered fill materials are as follows.

Material Type		Minimum Compaction Requirement (%) [1]	Moisture Content Range (%)	Maximum Loose Lift Thickness (in) [2]
Select/Structural Fill		95 [3]	-3 to +3	8 inches
Moisture Conditioned Building Subgrade	**PI ≤ 25**	95	-3 to +3	
	PI > 25	92	+4 or higher	
Paving Fill, Paving Subgrade and General Fill	**PI ≤ 25**	95	-3 to +3	
	PI > 25	95	Optimum to +4	
Crushed Limestone Base (beneath pavements)		100 [4]	-3 to +3	

1. Per the Standard Proctor Test (ASTM D 698).
2. Fill lift thickness must be reduced (typically 4 to 6 inches) if light compaction equipment is used, as is customary within a few feet of retaining walls and utility trenches.
3. **For fills greater than 5 feet in depth, if any, the compaction should be increased to at least 100 percent of the ASTM D 698 maximum dry unit weight.**
4. Per TEX-113-E.

Utility Trench Backfill

Leaking pipes underneath and/or near the foundations will increase the moisture content of the surrounding subgrade soils and will likely result in a PVR greater than 6 inches for these soils. 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. We recommend constructing an effective clay or flowable fill "trench plug" that extends at least 2 feet out from the face of the building exterior. The clay fill/flowable fill should be placed to completely surround the utility line and it should fill the utility trench completely in width and height, with the exception of topsoil at the surface. If clay plug is used, it should be fat clay with a minimum PI of 30 and should be compacted to comply with the water content and compaction recommendations for moisture conditioned building subgrade fill as specified in **Fill Compaction Requirements**. If flowable fill is used, it should be in accordance with TxDOT Item 401.

In the event that the proposed structure is to be designed as structurally suspended slab without building pad preparation, utility lines will be placed in backfilled trenches surrounded by highly expansive clays capable of moving cyclically throughout the year as much as 6 inches. This level of movement can lead to bending, cracking, or separation of utility connections. After surrounding the utility pipe with bedding material, utility trenches should be backfilled with similar soils as the surrounding subsurface (i.e. select fill within the building pad and on-site clays in landscaping and paving areas). In unpaved areas outside of the building, the utility trenches should be capped with a trench cap of fat clays at least 18 inches thick. Joints and connections to the building should be designed by the MEP as flexible connections to tolerate the potential soil movements. If the slab is elevated with a crawl space, the utilities could be hung from the bottom of the slab above the fat clay soils. Hanging utilities will still require flexible connections where they connect into underground portions of the utility.

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.

Effective drainage away from the structure must be provided during construction and maintained through the life of the proposed project. Infiltration of water into excavations should be prevented during construction. It is important that foundation soils are not allowed to become wetted. All grades must provide effective drainage away from the structure during and after construction. The most effective way to achieve this would be to provide concrete aprons (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, particularly those directly abutting the structure. In lieu of providing concrete aprons and if sloping unpaved ground is planned around the structure, then the select fill overbuild (recommended 5 feet beyond the building limits) 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 on-site fat clay soils. The fat clay soils should be compacted and moisture conditioned as per the **Fill Compaction Requirements** section of this report. This procedure is recommended to reduce the possibility of surface runoff infiltrating into the more pervious select fill soils and ponding below the proposed building. We would be glad to discuss other measures (e.g. horizontal or vertical barriers) to reduce moisture infiltration in unpaved areas, if desired. Exposed (unpaved) ground should be sloped at a minimum of 5 percent away from the structure for at least 10 feet beyond the perimeter of the structure. Locally, flatter grades may be necessary to transition ADA access requirement for flatwork.

Roof runoff and surface drainage should be collected and discharged away from the structure to prevent wetting of the foundation soils. Roof gutters should be installed and connected to downspouts and pipes directing roof runoff at least 10 feet away from the structure, 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. In addition, the owner and/or builder should be made aware that placing large bushes and trees adjacent to the structures may cause significant moisture variations in the soils underlying the structures. In general, tree roots can adversely influence the subsurface soil moisture content to a distance of 1 to 1½ times the mature height of the tree and beyond the tree canopy. Watering of vegetation should be performed in a timely and controlled manner and prolonged watering should be 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.

After building construction and landscaping, 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. Water permitted to pond next to the structure can result in greater soil movements than those discussed in this report. Estimated movements described in this report are based on effective drainage for the life of the structure and cannot be relied upon if effective drainage is not maintained.

Earthwork Construction Considerations

Based on our test borings, highly to very highly expansive soils that exhibit a potential for volumetric change during moisture variations are present at this site. These subgrade soils at the surface may experience expansion and contraction due to changes in moisture content. Based on existing grades, the soils at this site could exhibit a Potential Vertical Rise (PVR) of up to about 6 inches, as estimated by the TxDOT Method TEX-124-E.

Excavations, for the proposed structure and utilities, 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 floor slabs. Construction traffic over the completed subgrades should be avoided as much as possible. 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.

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.

Construction Observation and Testing

The earthwork efforts should be documented under the direction of the Geotechnical Engineer. This should include documentation of adequate removal of vegetation and top soil, proof-rolling and mitigation of areas delineated by the proof-roll to require mitigation and density/moisture testing of subgrade and fills. In the event that unanticipated conditions are encountered, the Geotechnical Engineer should be contacted to evaluate the conditions.

Each lift of compacted fill should be tested, evaluated, and reworked as necessary until approved by the Geotechnical Engineer prior to placement of additional lifts. Fill should be tested for density and water content at a frequency of at least one test for every 5,000 square feet per lift of compacted fill in the building areas (with a minimum of 3 tests per lift) and 10,000 square feet per lift in pavement areas. A minimum of one density and water content test should be conducted for every 100 linear feet of compacted utility trench backfill in paving areas.

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 continuity to maintain the Geotechnical Engineer's evaluation of subsurface conditions, including assessing variations and associated design changes.

SHALLOW FOUNDATIONS

If the site has been prepared in accordance with the requirements noted in **Earthwork** and **Floor Slab**, the following design parameters are applicable for shallow foundations.

Design Parameters – Monolithic Slab-On-Grade

A monolithic slab-on-grade foundation system (either conventionally reinforced) would be appropriate to support the proposed structure provided subgrade preparation as described in **Floor Slab** is followed. The slab foundation design parameters presented in the tables below 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 Slab and Beam System Parameters	
Description	**Design Parameter**
Minimum Embedment of Grade Beams below Final Grade [1]	18 inches
Bearing Stratum	Select Fill over Moisture Conditioned Clay
Bearing Pressures (allowable) [2]	Net Dead plus Sustained Live Load – 1,300 psf Net Total Load – 2,000 psf
Subgrade Modulus (k) [3]	100 pci
Approximate Potential Vertical Rise (PVR)	About 1-inch [4,5]

1. Embedment is to reduce surface water migration below the foundation elements and to develop proper end bearing and is not based on structural considerations. The grade beam width and depth should be properly evaluated by the structural engineer. Grade beams may be thickened and widened at interior column locations to serve as spread footings at these concentrated load areas.
2. Grade beams should bear on compacted select fill over moisture conditioned clay.
3. Several design methods use the modulus of subgrade reaction, k, to account for soil properties in design of flat, floor slabs. The modulus of subgrade reaction is a spring constant that depends on the kind of soil, the degree of compaction, and the moisture content. Based on our recommendations provided in **Floor Slab**, the above indicated subgrade modulus can be used for design of a flat, grade-supported floor slab.
4. Differential movements may result from variances in subsurface conditions, loading conditions and construction procedures. We recommend that measures be taken whenever practical to increase the tolerance of the building to post-construction foundation movements. An example of such measures would be to provide frequent control joints for exterior masonry veneers and interior sheetrock walls (particularly near doors and windows) to control cracking across such walls and concentrate movement along the joints.
5. The building subgrade should be properly prepared as described in **Floor Slab**.

BRAB/WRI/PCI Parameters			
Description	**Design Parameter**		
Design Plasticity Index (PI) [1]	BRAB/WRI/PCI	Prepared Subgrade [2]	33
Climatic Rating (C_w)			18
Unconfined Compressive Strength			1.0 tsf
Soil Support Index (C) for BRAB		Prepared Subgrade [2]	0.81

BRAB/WRI/PCI Parameters	
Description	**Design Parameter**

1. The BRAB effective PI is equal to the near surface PI if that PI is greater than all of the PI values in the upper 15 feet. If the near-surface PI is not highest (i.e., after the building pad is prepared), then the effective PI is the weighted average of the upper 15 feet. The WRI/PCI effective PI is always the weighted average of the PI values in the upper 15 feet.
2. The building subgrade should be properly prepared as described in **Floor Slab**.

Design Parameters – Footings

Principal column and wall loads for the proposed structure may also be supported on isolated (spread) and/or continuous (strip) footings, with an independent floor slab. Design parameters for spread/strip footing foundations are provided below.

Description	Design Parameter
Bearing Stratum [1]	Select Fill over Moisture Conditioned Clay
Minimum Embedment Below Final Grade [2]	24 inches
Minimum Footing Dimensions	Spread – 3 feet by 3 feet square Strip – 18 inches wide
Allowable Bearing Pressures [3,4]	Net dead plus sustained live load – 1,300 psf Net allowable total load – 2,000 psf
Approximate Total Movement [5]	1-inch
Estimated Differential Movement [6]	½ to ¾ inch
Nominal (unfactored) Passive Resistance [7]	360 psf per foot of depth against select fill
Coefficient of Sliding Resistance [8]	0.35 on select fill

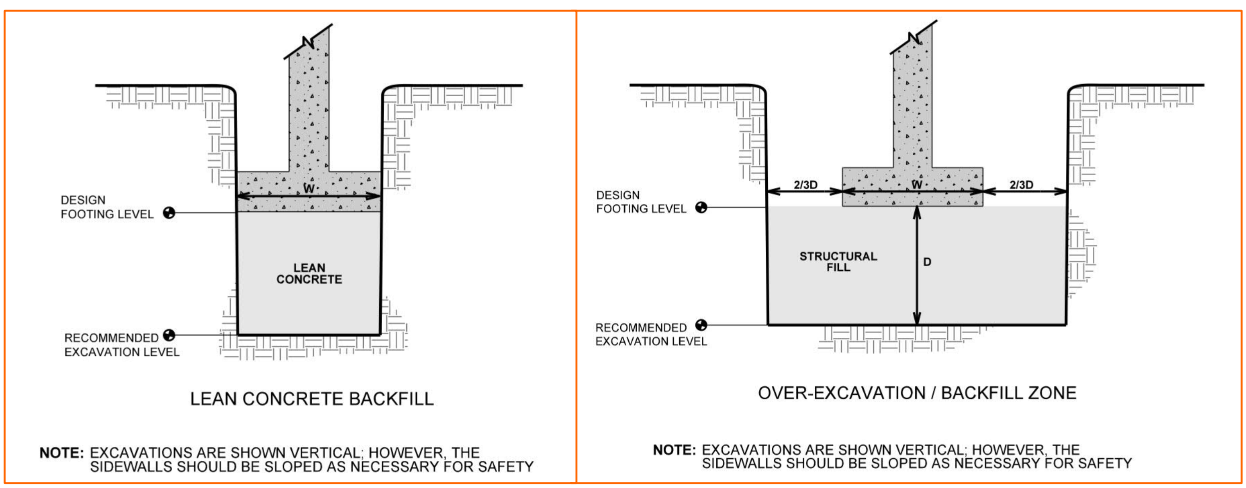
1. Unsuitable or soft soils must be over-excavated and replaced per the recommendations presented in **Earthwork** and the building area should be prepared as per **Floor Slab**.
2. To bear within select fill soils over moisture conditioned clay.
3. Whichever condition yields a larger bearing area.
4. Values provided are for maximum loads noted in **Project Description**.
5. The estimated post-construction settlement of the shallow footings is assuming proper construction practices are followed.
6. Differential settlements may result from variances in subsurface conditions, loading conditions and construction procedures. 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.
7. Passive resistance should be neglected in the first 12 inches below finished grades. Care should be taken to avoid disturbance of the footing bearing area since loose material could increase settlement and

Description	Design Parameter
decrease resistance to lateral loading. If the footing is formed during construction, the open space between the footings and the in-situ soils should be backfilled with concrete. 8. Lateral loads transmitted to the footings will be resisted by a combination of soil-concrete friction on the base of the footings and passive pressure on the side of the footings. We recommend that the allowable frictional resistance be limited to 500 psf.	

Foundation Construction Considerations

Footings/Grade beams 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 footings and the footing excavation be completed with a smooth-mouthed bucket or by hand labor. Debris in the bottom of the excavation should be removed prior to steel reinforcement placement. The foundation excavation should be sloped sufficiently to create internal sumps for runoff collection and removal. If surface runoff water or groundwater seepage in excess of ½-inch accumulates at the bottom of the foundation excavation, it should be collected, removed, and not allowed to adversely affect the quality of the bearing surface.

If unsuitable bearing soils are encountered at the base of the planned footing excavation (such as low strength or disturbed soils), the footing excavations should be deepened to expose suitable bearing materials. The footings could then bear directly on these soils at the lower level, on lean concrete backfill placed in the excavations, or on compacted structural fill backfilled in the excavations and compacted as in **Earthwork**. This is illustrated in the figure below.



Concrete should be placed as soon as possible after excavation to reduce bearing soil disturbance. Soils at bearing level that become disturbed or saturated should be removed prior to placing reinforcing steel and concrete. Adequate water control/dewatering system will aid in minimizing the need for over-excavation and backfill of any soils disturbed by prolonged exposure.

It is important that the foundation subgrade not be disturbed by construction activities (e.g., setting forms and placing reinforcing steel). If disturbance occurs, we recommend that the disturbed soils be removed and that the foundation subgrade be protected with the placement of a lean concrete “mud mat”.

Foundation Construction Observation

The performance of the foundation system for the proposed structure will be highly dependent upon the quality of construction. Thus, we recommend that the foundation construction be monitored by Terracon to identify the proper bearing strata and depths and to help evaluate foundation construction. We would be pleased to develop a plan for foundation observation to be incorporated in the overall quality assurance program.

DEEP FOUNDATIONS

Alternatively, the proposed structure could be supported on drilled piers extending into Stratum 2 tan fat clay soils. Soil design parameters are provided below in the **Drilled and Underreamed Pier Design Summary** table for the design of drilled pier foundations. The values presented for allowable end bearing and side friction include a factor of safety.

Drilled and Underreamed Pier Design Summary		
Description		**Design Parameters**
Bearing Stratum [1]		Minimum 20 feet below FFE into Stratum 2 grayish tan fat clay soils
Minimum Pier Shaft Diameter		18 inches
End Bearing Pressure (net allowable) [2]		Net dead plus sustained live load – 6,000 psf Net total load – 9,000 psf
Side Friction (net allowable) [3]	**Compressive**	700 psf
	Tensile	560 psf
Ratio of Underream Diameter to Shaft Diameter [4]		2:1 to 3:1
Estimated Uplift Force [5,6,7]		30*D for prepared subgrade areas 60*D for unprepared subgrade areas
Minimum Percentage of Steel [5,6,7]		1 percent
Approximate Total Settlement [8,9]		1-inch maximum
Estimated Differential Settlement [8,9]		Approximately ½ to ¾ of total maximum

1. To bear within the Stratum 2 tan fat clay soils. The minimum pier bearing depth should be based on slab FFE.

Drilled and Underreamed Pier Design Summary	
Description	**Design Parameters**

2. Whichever condition yields a larger bearing area.
3. Side friction should be neglected in the upper 10 feet of the pier in contact with soil and lower portion of the pier equal to one underream diameter above the bottom of the pier. Permanently cased pier sections, if any, may not be accounted towards the side friction capacity.
4. In addition to having an adequate bearing area to support compressive loads, the diameter of the underream should be large enough to overcome uplift forces on the pier without causing a local soil failure to the overlying soils. We recommend that the ratio of an underream diameter to shaft diameter be larger than 2:1 to withstand uplift forces due to soil expansion. However, in no case should this ratio exceed 3:1.
5. The amount of reinforcing steel required can be computed by assuming that the dead load of the structure surcharges the pier, the above estimated force acts vertically on the shaft, and the minimum pier depth below FFE is sufficient in withstanding the uplift on the pier itself. The amount of required steel, as calculated by the structural engineer, should extend the entire pier length and in no case should the percentage of steel be less than 1 percent. The equation for uplift force does not include a factor of safety.
6. Uplift force (in kips) is used to calculated pier reinforcing steel. The term "D" is the pier diameter in feet.
7. The recommended minimum embedment depth of the piers below FFE should be sufficient in withstanding soil-related uplift forces. Please note that the uplift force equation given above is intended for calculating the required reinforcing steel and is not intended for calculating pier embedment to overcome soil uplift forces. Additional reinforcing steel may be needed to resist external structural uplift forces.
8. Provided proper construction practices are followed. For adjacent piers, we recommend a minimum edge-to-edge spacing of at least 2 underream diameters (or 3 underream diameters center to center) based on the larger pier diameter of the two adjacent piers. In locations where this minimum spacing criterion cannot be accomplished, Terracon should be contacted to evaluate the locations on a case-by-case basis.
9. Will result from variances in the subsurface conditions, loading conditions and construction procedures, such as cleanliness of the bearing area or flowing water in the shaft.

Drilled Pier Lateral Loading

The following table lists input values for use in LPILE analyses. LPILE will estimate values of k_h and E_{50} based on strength; however, non-default values of k_h should be used where provided. Since deflection or a service limit criterion will most likely control lateral capacity design, no safety/resistance factor is included with the following lateral parameters.

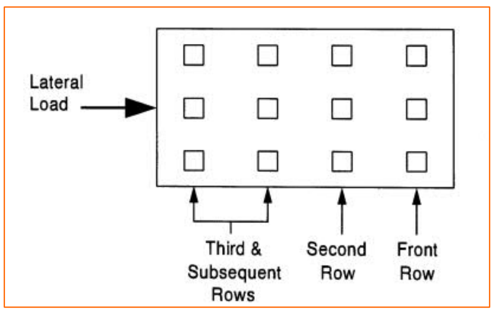
Stratum [1]	L-Pile Soil Model	S_u (psf) [2]	γ (pcf) [2,3]	ε_{50} [2]
1	Stiff Clay w/o Free Water	1,500	115	0.007
2	Stiff Clay w/o Free Water	2,000	120	0.006

1. See **Subsurface Profile** in **Geotechnical Characterization** for more details on Stratigraphy.

Stratum [1]	L-Pile Soil Model	S_u (psf) [2]	γ (pcf) [2,3]	ε_{50} [2]

2. Definition of Terms:
   S_u: Undrained shear strength
   γ: Total unit weight
   ε_{50}: Non-default E50 strain

When piers are used in groups structurally connected together with a large pier cap or mat, the lateral capacities of the piers in the second, third, and subsequent rows of the group should be reduced as compared to the capacity of a single, independent shaft. Guidance for applying p-multiplier factors to the p values in the p-y curves for each row of pier foundations within a pier group are as follows:



- Front row: $P_m = 0.8$;
- Second row: $P_m = 0.4$
- Third and subsequent row: $P_m = 0.3$.

For the case of a single row of piers supporting a laterally loaded grade beam, group action for lateral resistance of piers would need to be considered when spacing is less than three pier diameters (measured center-to-center). However, spacing closer than 3D (where D is the diameter of the pier) is not recommended, due to potential for the installation of a new pier disturbing an adjacent installed pier, likely resulting in axial capacity reduction.

The load capacities provided herein are based on the stresses induced in the supporting soil strata. The structural capacity of the piers should be checked to assure they can safely accommodate the combined stresses induced by axial and lateral forces. Lateral deflections of piers should be evaluated using an appropriate analysis method, and will depend upon the pier's diameter, length, configuration, stiffness and "fixed head" or "free head" condition. We can provide additional analyses and estimates of lateral deflections for specific loading conditions upon request. The load-carrying capacity of piers may be increased by increasing the diameter and/or length.

Drilled Pier Construction Considerations

Drilled pier foundations should be augered and constructed in a continuous matter. Concrete should be placed in the pier excavations following drilling, underreaming, and evaluation for proper bearing stratum, embedment, and cleanliness. The piers should not be allowed to remain open overnight before concrete placement. Surface runoff or groundwater seepage accumulating in the excavation should be pumped out and the condition of the bearing surface should be evaluated immediately prior to placing concrete.

Care should be taken to not disturb the sides and bottom of the excavation during construction. The bottom of the shaft excavation should be free of loose material before concrete placement. Water or loose soil should be removed from the bottom of the drilled shafts prior to placement of the concrete. Concrete should be placed as soon as possible after the foundation excavation is completed, to reduce potential disturbance of the bearing surface.

Concrete should exhibit slump as designated in Structural Engineer’s specifications. A design concrete slump of 6 to 8 inches helps to facilitate removal of casings, if used, and reduces the possibility of concrete arching/honeycombing. Under no circumstance should loose soil be placed in the space between the casing, if used, and the pier sidewalls. The concrete should be placed using a rigid tremie or by the free-fall method provided the concrete falls to its final position through air without striking the sides of the hole, the reinforcing steel cage, or any other obstruction. A drop chute should be used for this free-fall method.

The drilled shaft installation process should be monitored under the direction of the Geotechnical Engineer. The Geotechnical Engineer should document the shaft installation process including soil/rock and groundwater conditions encountered, consistency with expected conditions, and details of the installed shaft.

Grade Beams between Drilled Piers

If a structurally suspended floor slab (without subgrade preparation) is used for the proposed building, grade beams spanning between drilled piers should be protected from the expansive soil movement at this site. A minimum 12-inch void provided below the grade beams should allow the expansive clays to swell without causing distress in the grade beams. The sides of the void should be protected with permanent rigid soil retainers so that the soil will not slough beneath the grade beams and thus fill the void. The above also applies to any individual isolated piers, if any, outside of the building footprint. If these isolated piers are overlain by larger pier caps or grade beams, then those caps/beams should also be protected from the clays by using void forms.

If a grade-supported slab is used, grade beams spanning between drilled piers may be cast at-grade provided the subgrade in the beam areas is prepared as outlined in **Floor Slab**. Grade beams should be designed to span across the drilled pier foundations without subgrade support, due to stress/strain incompatibility between different bearing materials at varying depths.

We recommend that on-site fat clay soils (LL≥50; PI>30) be utilized for backfill adjacent to grade beams/panels at the exterior surface of the structure (to reduce potential infiltration of surface water into the subgrade areas). The exterior backfill should be compacted as outlined in **Earthwork**. On the interior sides of the perimeter grade beams, backfill should consist of properly compacted select fill or flowable fill (TxDOT Item 401), not sand or gravel. Compaction of select fill on the interior sides of beams should be performed by the Earthwork Contractor's personnel and equipment, not by concrete or utility contractors inexperienced with proper soil placements and compaction.

Foundation Construction Observation

The performance of the foundation system for the proposed structure will be highly dependent upon the quality of construction. Thus, we recommend that the foundation installation be monitored by Terracon to identify the proper bearing strata and depths and to help evaluate foundation construction. We would be pleased to develop a plan for foundation monitoring to be incorporated in the overall quality assurance program.

SEISMIC CONSIDERATIONS

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 properties encountered at the site and as described on the exploration logs and results, it is our professional opinion that the **Seismic Site Classification is D**. Subsurface explorations at this site were extended to a maximum depth of 30 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.

FLOOR SLAB

The subgrade soils are comprised of high plasticity clays exhibiting the potential to shrink/swell with changes in water content. However, construction of the floor slab 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 potentially damage the floor slab.

Due to the potential for significant moisture fluctuations of subgrade material beneath the select fill pad, the exposed final subgrade should be prepared as discussed in the first three sub-sections of **Earthwork**.

The most positive way to minimize the potential for foundation distress resulting from volumetric changes would be to suspend the building above the subgrade on drilled pier foundations with a crawl space or void boxes under the slab and beams. An alternative to this foundation type would be to prepare the subgrade to reduce the shrink/swell potential of the near-surface soils and use grade-supported floor slabs as mentioned below. Although subgrade preparation does help to reduce the shrink/swell potential of the subgrade, a degree of risk of subgrade movements (and corresponding foundation distress) remains if grade-supported floor slabs are to be utilized.

Structurally Suspended Floor Slab System

For a structurally suspended floor slab system, we recommend a minimum 18-inch void space be provided beneath the floor slabs and the drilled pier foundation system be designed to carry the additional loads. When void forms are used, special care needs to be taken to avoid potential collapse during concrete placement.

The use of a structurally suspended floor slab in conjunction with drilled piers would eliminate the need for subgrade preparation as discussed in the following section. However, a higher uplift force, as mentioned in **Deep Foundations**, would need to be considered for the drilled pier foundation system.

If the subgrade elevation beneath the floor slab is lower than that of the exterior ground surface in any areas, we recommend that a series of surface drains be placed such that water accumulating in the void space beneath the slab and the subgrade can be properly collected and removed. Sloping the subgrade toward these drains in a manner where water cannot accumulate adjacent to any of the foundation units is recommended. The above can also be accomplished by sloping the subgrade beneath and outside the building to provide positive drainage away from foundation units. In addition, proper ventilation should be provided to reduce the possibility that a high humidity environment could develop in the void space areas.

Any utilities that penetrate into the building subgrade should exhibit flexible connections such that any shrink/swell movements observed in the clays do not damage the utilities. Failure to implement flexible connections can cause damage to the utilities (i.e. bursting pipes). In addition, we recommend that in areas where utilities cross any grade beams, the top of the pipe be at least 6 inches below any void spaces beneath the grade beams.

Grade-Supported Floor Slab System

While the grade-supported floor slab option is not as effective as a structurally suspended floor slab in reducing slab movements, it does represent a compromise between economics and risk of slab distress. If a grade-supported floor slab is utilized, we recommend that the soils immediately below the lowest-level slab be prepared as stated below to reduce the potential for foundation movements associated with volumetric changes of the underlying clay soils due to moisture variation. Grade beams should continue to be designed as mentioned in **Deep Foundations**.

A select fill pad combined with a moisture conditioned clay subgrade may be implemented in order to reduce post-construction shrink/swell movements to approximately 1-inch. The table below provides options for various preparation options depending on the amount of select fill desired below the bottom of the floor slab.

Preparation Option	Select Fill Thickness, feet	Moisture Conditioned Clay Thickness (below select fill), feet	Total Building Pad Thickness, feet
1	9	0.5	9.5
2	8	2	10
3	7	4	11
4 [1]	6	6	12

1. As an example, if option 4 is selected, we recommend that the on-site clay soils be removed to a depth of 12 feet below the bottom of the floor slab. At least 6 feet of the excavated soils should be moisture conditioned as outlined in **Earthwork**. The moisture conditioned clay soils should not be allowed to dry out prior to subsequent lift placements. For option 4, select fill should be placed as outlined in **Earthwork** in order to provide a select fill pad of 6 feet below the floor slab.

The exposed building subgrade should be proof-rolled as discussed in **Earthwork**, prior to placement of the moisture conditioned subgrade. The above subgrade preparation recommendations should be applied to an area extending a minimum of 5 feet outside of building areas including attached walkways, ramps, ATM pads, and any other movement-sensitive 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 flatwork (sidewalk, ramps, etc.) outside of the building area which will be sensitive to movement, 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 buildings resulting from poor drainage), movements in isolated floor slab areas could potentially be in excess of those indicated in this report.

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. Saw-cut control 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.

Although the indicated preparation options are anticipated to reduce cracking in the floor slab, differential movements at entryways may cause difficulty in opening and closing doors. If the floor slab is doweled into the perimeter grade beams to control movement, the resulting soil pressures may cause cracks to develop inside of the dowel bars, adjacent to the exterior walls. However, if the floor is not doweled at these locations, a "trip hazard" could result due to the resulting differential movements at entry ways, and difficulty in opening and closing doors could develop.

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, 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.

Floor Slab Construction Considerations

Design recommendations for floor slabs assume the requirements in **Earthwork** have been followed. Specific attention should be given to positive drainage away from the structure and positive drainage of the subgrade and select fill pad beneath the floor slab.

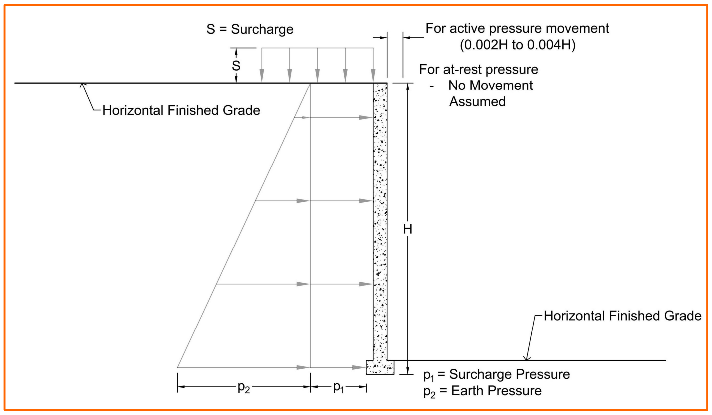
Finished subgrade within and for at least 10 feet beyond the floor slab should be protected from traffic, rutting, or other disturbance and maintained in a relatively moist condition until floor slabs are constructed. If the subgrade should become damaged or desiccated prior to construction of floor 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. Attention should be paid to high traffic areas that were rutted and disturbed earlier, and to areas where backfilled trenches are located.

LATERAL EARTH PRESSURES

Design Parameters

Site retaining walls with unbalanced backfill levels on opposite sides should be designed for earth pressures at least equal to values indicated in the following table. Earth pressures will be influenced by structural design of the walls, conditions of wall restraint, methods of construction and/or compaction and the strength of the materials being restrained. Two wall restraint conditions are shown. Active earth pressure is commonly used for design of free-standing cantilever retaining walls and assumes wall movement. The "at-rest" condition assumes no wall movement and is commonly used for basement walls, loading dock walls, or other walls restrained at the top.

The recommended design lateral earth pressures do not include a factor of safety and do not provide for possible hydrostatic pressure on the walls. The recommendations in this section apply to those walls (i.e., double-formed walls) which are installed in open cut or embankment fill areas such that the backfill extends out from the base at an angle of at least 45 degrees from vertical for the entire height and length of the wall.



Lateral Earth Pressure Design Parameters				
Backfill Type	Estimated Total Unit Weight, pcf[1]	Lateral Earth Pressure Coefficients[2]		
		At Rest, K_o	Active, K_A	Passive, K_P
Crushed Limestone	135	0.45	0.3	3.5
Clean Sand	120	0.5	0.35	3.0
Clean Gravel	120	0.45	0.3	3.5

1. Compaction should be maintained between 95 and 100 percent of Standard Proctor (ASTM D 698) maximum dry density. Overcompaction can produce lateral earth pressure coefficients in excess of those provided.
2. Coefficients represent nominal (unfactored) values. Appropriate safety factors should be applied.

The above values do not include a hydrostatic or ground-level surcharge component. To prevent hydrostatic pressure build-up, retaining walls should incorporate functional drainage (via free-draining aggregate or manufactured drainage mats) within the backfill zone. The effect of surcharge loads, where applicable, should be incorporated into wall pressure diagrams by adding a uniform horizontal pressure component equal to the applicable lateral earth pressure coefficient times the surcharge load, applied to the full height of the wall.

All retaining walls should be checked against failure due to overturning, sliding and overall slope stability. Such an analysis can only be performed once the dimensions of the wall and cut/fill scenarios are known. For retaining wall bearing capacity design, we recommend the following parameters for footings bearing at least 2 feet below lowest adjacent final grade.

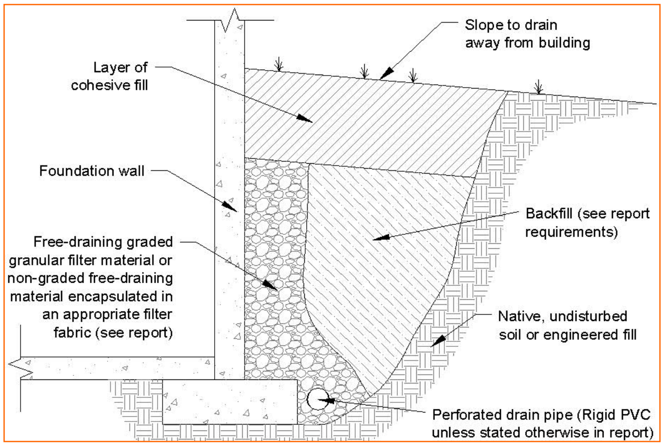
Bearing Material	Coefficient of Sliding Resistance	Maximum Allowable Sliding Resistance, psf	Maximum Footing Bearing Capacity, psf
On-site Fat Clay Soils [1,2]	0.25	300	1,500
Select Fill [3]	0.35	500	2,000

1. There exists a higher movement potential for any retaining walls bearing on the in-situ fat clay soils (up to 6 inches). If lower movement potential is desired, please contact us so that we may provide additional recommendations.
2. Frequent joints should be provided throughout the length of the retaining wall to reduce cracking due to differential movements caused by the shrink/swell movement of the fat clay subgrade.
3. If the subgrade is prepared as recommended in **Floor Slab**, the values for Select Fill may be considered.

We recommend that a “buffer zone” of at least 5 feet wide be applied between pavement areas and retaining walls (with a minimum height of 4 feet or more). This buffer zone should be increased to 10 feet for building areas. These recommended buffer zones are to reduce the potential of distress from any long-term (“creep”) movements of the wall and backfill. Pedestrian sidewalks may be exempted from the above criteria; however, some distress could still be observed in the sidewalks due to movements of the retaining walls and backfill.

Subsurface Drainage for Site Retaining Walls

A perforated rigid plastic drain line installed behind the base of walls and extending below adjacent grade is recommended to prevent hydrostatic loading on the walls. The invert of a drain line around an exterior retaining wall should be placed near foundation bearing level. The drain line should be sloped to provide positive gravity drainage to daylight or to a sump pit and pump. The drain line should be surrounded by clean, free-draining granular material having less than 10 percent passing the No. 8 sieve, such as No. 57 aggregate. The free-draining aggregate should be encapsulated in a filter fabric. The granular fill should extend to within 2 feet of final grade, where it should be capped with compacted cohesive fill to reduce infiltration of surface water into the drain system.



As an alternative to free-draining granular fill, a prefabricated drainage structure may be used. A prefabricated drainage structure is a plastic drainage core or mesh which is covered with filter fabric to prevent soil intrusion and is fastened to the wall prior to placing backfill.

PAVEMENTS

General Pavement Comments

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

Pavement designs 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 the subgrade for pavement design do not account for shrink/swell movements of an expansive clay subgrade, such as the fat clay soils encountered 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.

Lime treatment of the fat clay subgrade is suggested to enhance the workability and support characteristics of the subgrade as well as to provide a barrier to reduce moisture infiltration in the underlying clay subgrade. The lime treatment also helps to reduce the shrink/swell potential of the lime-treated layer. We should note that if lime treatment is planned, we recommend that the subgrade soils be investigated for the presence of sulfates during construction. Excessive concentrations of sulfates in the soils can result in poor performance of lime-treated subgrade.

Based on numerous research studies performed by education institutions, regulatory agencies, and both public and private entities, soils that contain significant amounts of soluble sulfates are not optimal candidates for lime treatment and may result in excessive heave and subsequent distress to the pavements. Soluble sulfate levels of up to 3,000 ppm or less are generally considered to be acceptable for lime treatment. Soluble sulfate levels between 3,000 ppm and 10,000 ppm in clay soils are generally considered to be moderate to high and pose a greater risk to successful traditional lime treatment.

Although lime treatment of the subgrade will likely reduce differential movement and heave in the new pavement system, some differential movement will likely occur. Cracking of the pavement due to differential movements should be expected.

Private Pavement Design Parameters

Design of Asphaltic Concrete (HMAC) private pavements are based on the procedures outlined in the 1993 Guideline for Design of Pavement Structures by the American Association of State Highway and Transportation Officials (AASHTO-1993). Design of Portland Cement Concrete (PCC) private pavements are based upon American Concrete Institute (ACI) 330R-01; Guide for Design and Construction of Concrete Parking Lots.

Detailed traffic loads and frequencies were not available; however we anticipate that traffic will consist primarily of passenger vehicles in the parking areas and passenger vehicles combined with emergency vehicles, occasional garbage trucks, service trucks, and delivery trucks in driveways. If heavier traffic loading is expected or other traffic information is available, Terracon should be provided with the information and allowed to review the pavement sections provided herein. Tabulated below are the assumed traffic frequencies and loads used to design pavement sections for this project.

Pavement Area	Traffic Design Index	Description of Daily Traffic
Parking Areas (Passenger Vehicles Only)	DI-1	Light traffic – (ESALs [1]<5) Passenger cars and pickup trucks, no regular use by heavily loaded two axle trucks or lightly loaded larger vehicles.
Drive-thru lanes and Driveways	DI-2 [2]	Light to medium traffic – (5≤ESALs≤20) Passenger cars and pickup trucks with no more than 50 heavily loaded two-axle trucks or lightly loaded three axle trucks per day. No regular use by heavily loaded trucks with three or more axles.

1. 18-kip equivalent single-axle daily load applications.
2. 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 DI-2 pavements or thicker.

Private Pavement Section Thicknesses

The following tables provides options for HMAC and PCC private pavement sections.

Asphaltic Concrete Design				
Layer	Thickness (inches)			
	DI-1		DI-2	
	Option 1A	Option 1B	Option 2A	Option 2B
Asphaltic Concrete (HMAC)	2.0	2.0	2.5	3.0
Crushed Limestone Base	8.0	10.0	10.0	12.0
Lime Treated Subgrade	8.0	-	8.0	-
Moisture Conditioned Subgrade	-	6.0	-	6.0

Rigid PCC pavements will typically perform better than HMAC pavements in industrial warehouse developments and especially in areas where short-radii turning and braking are expected (i.e. entrance/exit aprons) due to better resistance to rutting and shoving. PCC pavements will perform better in areas subject to large or sustained loads, such as loading docks, dumpster enclosures, and loading/unloading areas.

Portland Cement Concrete Design		
Layer	Thickness (inches)	
	DI-1	DI-2 [1,2]
Reinforced Concrete (PCC)	5	6
Moisture Conditioned Subgrade	6	6

1. For the DI-2 traffic loading conditions, the reinforced concrete thickness may be reduced by ½ inch if the clay subgrade is lime treated to a depth of at least 8 inches instead of moisture conditioned.
2. We recommend that dumpster pad areas be constructed of at least 7-inches of reinforced concrete pavement. The concrete pad areas for the dumpster areas should be designed so that the vehicle wheels of the collection truck are supported on the concrete while the dumpster is being lifted to support the large wheel loading imposed during waste collection. Dumpster areas that are not designed in this manner often experience localized failures due to large wheel loading imposed during waste collection. Reinforced concrete pavements typically result in better performance and less maintenance than flexible pavement systems in these truck areas.

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. As an option, thicker sections could be constructed to decrease future maintenance.

Pavement Materials

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

Item	Value
Hot Mix Asphaltic Concrete (HMAC)	Plant mixed, hot laid Type D (Fine-Grade Surface Course) meeting the specifications in TxDOT Item 340.
Reinforced Portland Cement Concrete (PCC)	28-day flexural strength (third-point loading) ≥ 500 psi, or 28-day compressive strength ≥ 3,500 psi
Crushed Limestone Base [1]	TxDOT Item 247, Type A, Grade 1-2 compacted as outlined in **Earthwork**.
Lime Treated Subgrade [2,3]	Lime treatment as per TxDOT Item 260 is applicable either through dry placement or slurry placement.
Moisture Conditioned Subgrade [4]	As outlined in **Earthwork**.

1. 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 18 inches behind curbs.
2. We anticipate 7% lime be used for bidding purposes with add/deduct line items for 1 to 2% lime 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 at the proposed final subgrade elevation. Please note that these tests require up to 5 business days to complete.
3. 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 are achieved. The mixture should then be moisture adjusted and compacted as outlined in Earthwork. Preparation of the lime-treated subgrade should extend at least 18 inches behind curbs.
4. 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 18 inches behind curbs.

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

Item	Value
Reinforcing Steel	DI-1 and DI-2: #3 bars spaced at 18 inches on center in both directions. Dumpster Pad Areas: #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 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. This is especially applicable for islands with raised concrete curbs, irrigated foliage, and low permeability near-surface soils. 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 sufficiently to provide positive drainage within the granular base section.

Pavement Maintenance

The pavement sections represent minimum recommended thicknesses and, as such, periodic maintenance should be anticipated. Therefore, 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. Maintenance consists of both localized maintenance (e.g. crack and joint sealing and patching) and global maintenance (e.g. surface sealing). Preventive maintenance is usually the priority when implementing a pavement maintenance program. Additional engineering observation 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 perimeter 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 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. Natural 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 or collaboration through this system 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.

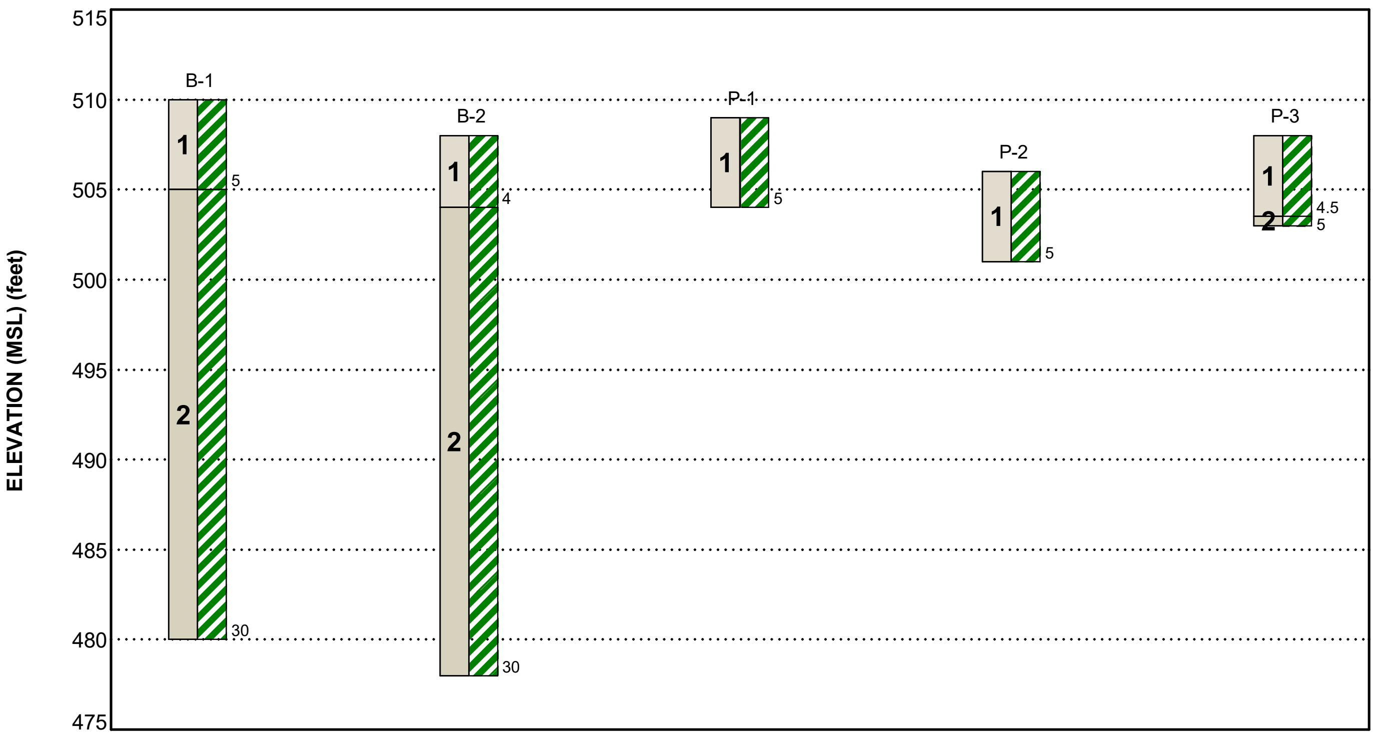
Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly impact excavation 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. 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:

GEOMODEL

Sherwin Williams Retail Store ■ Manor, TX
Terracon Project No. 96225068



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
1	Upper Fat Clay	Dark brown, Fat clay, stiff to hard
2	Lower Fat Clay	Grayish tan to dark brown, Fat clay, stiff to hard

LEGEND

Fat Clay

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

Location	Number of Borings	Boring Depth (feet)
Building Area	2	30
Pavement Area	3	5

Boring Layout and Elevations: Terracon personnel provided the boring layout. Coordinates were obtained with a handheld GPS unit (estimated horizontal accuracy of about ±10 feet) and approximate elevations were obtained by interpolation from Google Earth. If elevations and a more precise boring layout are desired, we recommend borings be surveyed following completion of fieldwork.

Subsurface Exploration Procedures: We advanced the borings with a truck-mounted rotary drill rig using continuous flight augers. Five samples were obtained in the upper 10 feet of each boring and at intervals of 5 feet thereafter. Soil sampling was performed using thin-wall tube (shelby tubes) sampling procedure. We observed and recorded groundwater levels during drilling and sampling. For safety purposes, all borings were backfilled with auger cuttings after their completion.

The sampling depths, penetration distances, and other sampling information were 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 encountered 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 to understand the engineering properties of the various soil strata, as necessary, for this project. Procedural standards noted below are for reference to methodology in general. In some cases, variations to methods were applied because of local practice or professional judgment. Standards noted below include reference to other, related standards. Such references are not necessarily applicable to describe the specific test performed.

- ASTM D2216 Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

- ASTM D4318 Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
- ASTM D422 Standard Test Method for Particle-Size Analysis of Soils
- TEX-620-J Determining Chloride and Sulfate Content in Soil

The laboratory testing program often included examination of soil samples by an engineer. Based on the material's texture and plasticity, we described and classified the soil samples in accordance with the Unified Soil Classification System.

SITE LOCATION AND EXPLORATION PLANS

Contents:

Note: All attachments are one page unless noted above.

SITE LOCATION

Sherwin Williams Store - Manor ■ Manor, Texas
May 9, 2022 ■ Terracon Project No. 96225068

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

MAP PROVIDED BY MICROSOFT BING MAPS

EXPLORATION PLAN

Sherwin Williams Store - Manor ■ Manor, Texas

May 9, 2022 ■ Terracon Project No. 96225068

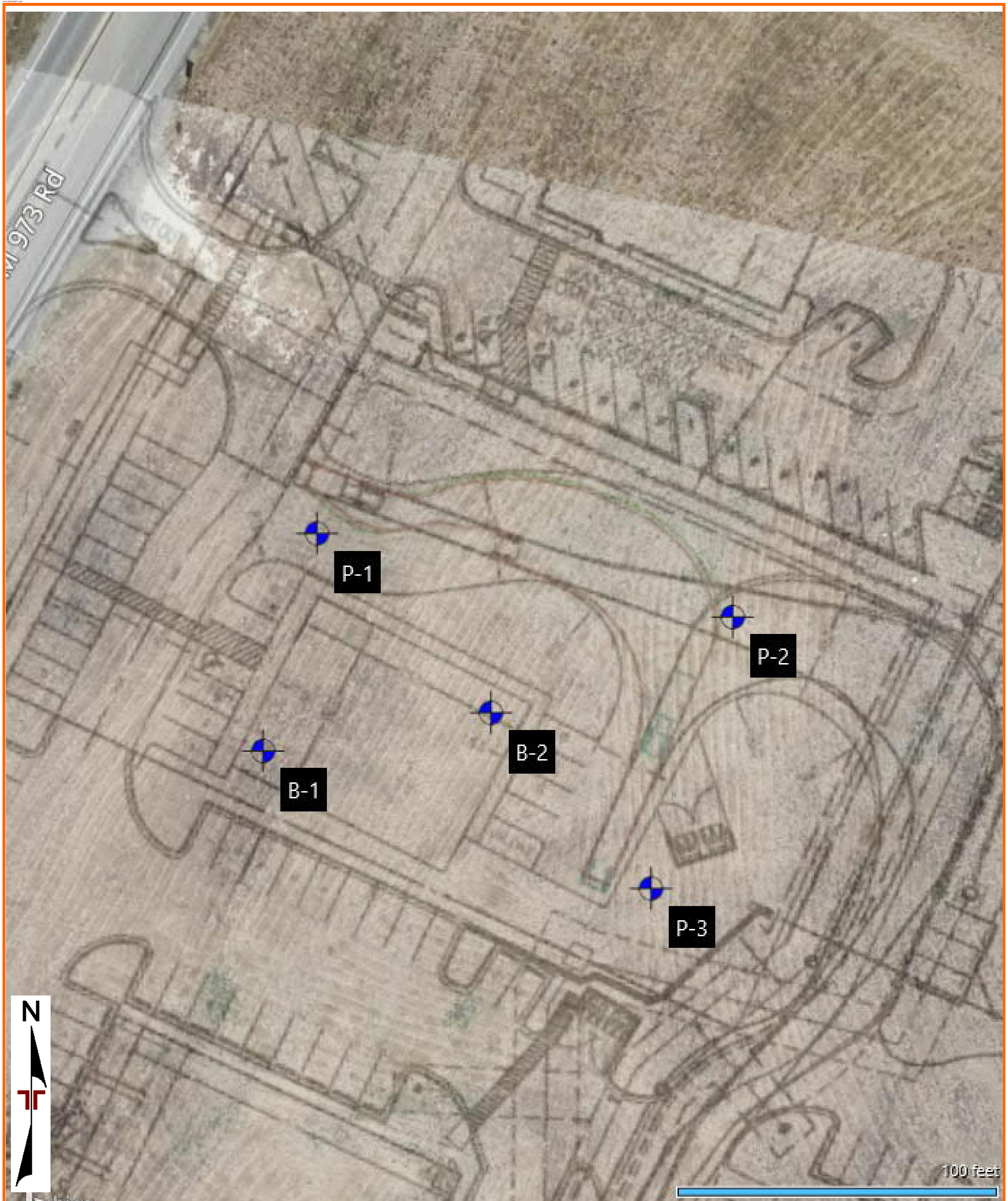


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

EXPLORATION RESULTS

Contents:

Note: All attachments are one page unless noted above.

BORING LOG NO. B-1

PROJECT: Sherwin Williams Retail Store

CLIENT: Belterra Partners LLC Birmingham, AL

SITE: 12937 N FM 973 Manor, TX

LOCATION See Exploration Plan

Latitude: 30.3474° Longitude: -97.5393°

Approximate Surface Elev.: 510 (Ft.) +/-

MODEL LAYER	DEPTH	DESCRIPTION	ELEVATION (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, stiff to very stiff					4.0 tsf				21.3		53-18-35	
		with sand from 2 to 4 feet					2.0 tsf				24.2		75-20-55	82
2	5.0	**FAT CLAY (CH)**, grayish tan, stiff to hard	505+/-	5			1.5 tsf							
							3.5 tsf							
							3.5 tsf				18.2			
				10										
							4.5 tsf	UC	0.67	1.2	25.8	95		
				15										
							4.5 tsf							
				20										
							4.5 tsf	UC	5.06	10.4	22.3	99	86-26-60	
				25										
		dark brown from 28 to 30 feet					17-13-24 N=37							
	30.0	***Boring Terminated at 30 Feet***	480+/-	30										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Continuous Flight Auger

Abandonment Method:
Boring backfilled with Auger Cuttings and/or Bentonite

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.

Elevations were interpolated from Google Earth

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
5307 Industrial Oaks Blvd Ste 160
Austin, TX

Boring Started: 04-13-2022	Boring Completed: 04-13-2022
Drill Rig: CME 45	Driller: Austin Geo-Logic
Project No.: 96225068	

BORING LOG NO. B-2

PROJECT: Sherwin Williams Retail Store

CLIENT: Belterra Partners LLC
Birmingham, AL

SITE: 12937 N FM 973
Manor, TX

LOCATION See Exploration Plan

Latitude: 30.3475° Longitude: -97.5390°

Approximate Surface Elev.: 508 (Ft.) +/-

MODEL LAYER	GRAPHIC LOG	DEPTH / DESCRIPTION / ELEVATION (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				19.5		74-18-56	85
						2.5 tsf				23.9		56-19-37	
		4.0 — 504+/-											
2		**FAT CLAY (CH)**, grayish tan, very stiff to hard	5			2.5 tsf				17.2		50-14-36	
						2.25 tsf							
						4.0 tsf							
			10										
						4.5+ tsf							
			15										
						4.5+ tsf							
			20										
						4.5+ tsf	UC	4.18	7.4	23.1	100		
			25										
		dark brown from 28 to 30 feet				4.5+ tsf	UC	1.32	8.7	23.5	94		
		30.0 — 478+/-	30										
		Boring Terminated at 30 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Continuous Flight Auger

Abandonment Method:
Boring backfilled with Auger Cuttings and/or Bentonite

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.

Elevations were interpolated from Google Earth

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
5307 Industrial Oaks Blvd Ste 160
Austin, TX

Boring Started: 04-13-2022	Boring Completed: 04-13-2022
Drill Rig: CME 45	Driller: Austin Geo-Logic
Project No.: 96225068	

BORING LOG NO. P-1

PROJECT: Sherwin Williams Retail Store

CLIENT: Belterra Partners LLC
Birmingham, AL

SITE: 12937 N FM 973
Manor, TX

LOCATION See Exploration Plan

Latitude: 30.3476° Longitude: -97.5392°

Approximate Surface Elev.: 509 (Ft.) +/-

MODEL LAYER	GRAPHIC LOG	DEPTH / ELEVATION (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, stiff to very stiff				3.75 tsf							
						2.0 tsf							
		5.0 504+/-	5			1.75 tsf							
		Boring Terminated at 5 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Continuous Flight Auger

Abandonment Method:
Boring backfilled with Auger Cuttings and/or Bentonite

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.

Elevations were interpolated from Google Earth

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
5307 Industrial Oaks Blvd Ste 160
Austin, TX

Boring Started: 04-13-2022	Boring Completed: 04-13-2022
Drill Rig: CME 45	Driller: Austin Geo-Logic
Project No.: 96225068	

BORING LOG NO. P-2

PROJECT: Sherwin Williams Retail Store

CLIENT: Belterra Partners LLC
Birmingham, AL

SITE: 12937 N FM 973
Manor, TX

LOCATION See Exploration Plan

Latitude: 30.3475° Longitude: -97.5388°

Approximate Surface Elev.: 506 (Ft.) +/-

MODEL LAYER	GRAPHIC LOG	DEPTH / ELEVATION (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				21.6		84-24-60	
						2.0 tsf							
		5.0 / 501+/-	5			2.0 tsf							
		Boring Terminated at 5 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Continuous Flight Auger

Abandonment Method:
Boring backfilled with Auger Cuttings and/or Bentonite

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.

Elevations were interpolated from Google Earth

Notes:

WATER LEVEL OBSERVATIONS

No free water observed

Terracon
5307 Industrial Oaks Blvd Ste 160
Austin, TX

Boring Started: 04-13-2022	Boring Completed: 04-13-2022
Drill Rig: CME 45	Driller: Austin Geo-Logic
Project No.: 96225068	

BORING LOG NO. P-3

PROJECT: Sherwin Williams Retail Store

**CLIENT: Belterra Partners LLC
Birmingham, AL**

**SITE: 12937 N FM 973
Manor, TX**

LOCATION See Exploration Plan

Latitude: 30.3473° Longitude: -97.5389°

Approximate Surface Elev.: 508 (Ft.) +/-

MODEL LAYER	GRAPHIC LOG	DEPTH	DESCRIPTION	ELEVATION (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, stiff to very stiff					2.0 tsf							
								1.5 tsf							
		4.5		503.5+/-				3.0 tsf							
2		5.0	**FAT CLAY (CH)**, grayish tan, very stiff	503+/-	5										
			Boring Terminated at 5 Feet												

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Continuous Flight Auger

Abandonment Method:
Boring backfilled with Auger Cuttings and/or Bentonite

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.

Elevations were interpolated from Google Earth

Notes:

WATER LEVEL OBSERVATIONS

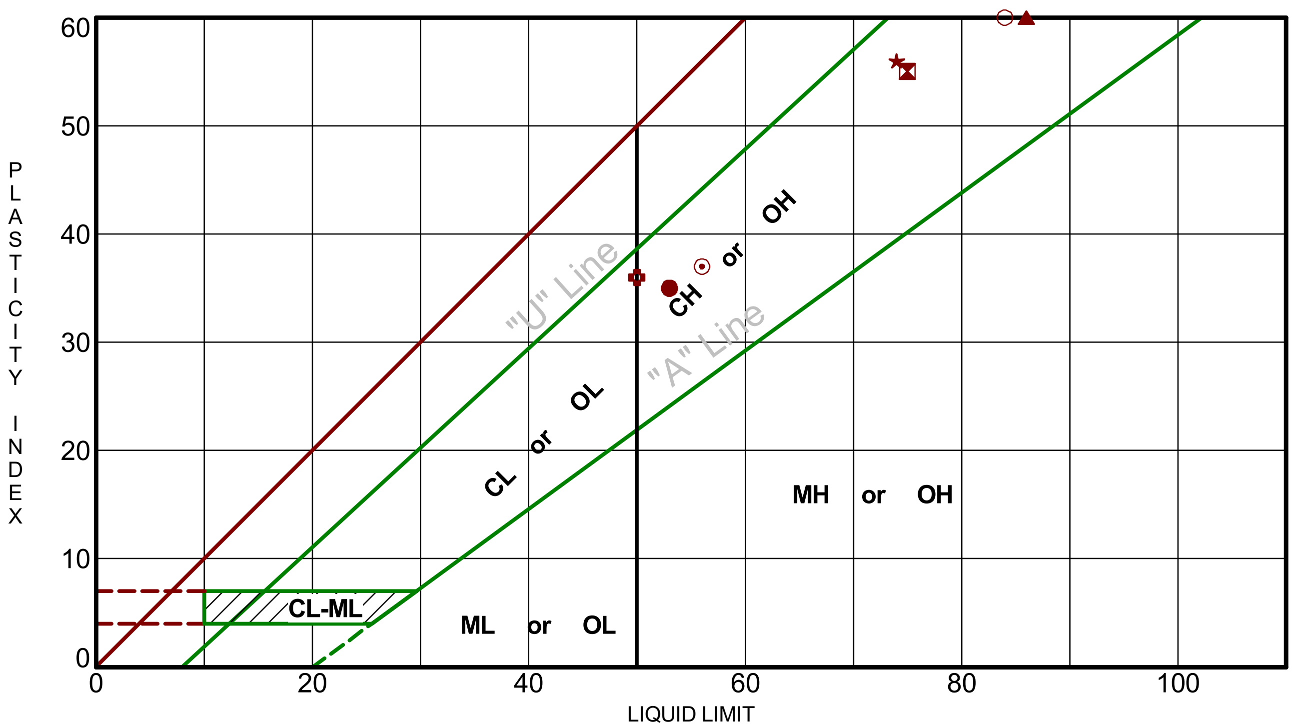
No free water observed

Terracon
5307 Industrial Oaks Blvd Ste 160
Austin, TX

Boring Started: 04-13-2022	Boring Completed: 04-13-2022
Drill Rig: CME 45	Driller: Austin Geo-Logic
Project No.: 96225068	

ATTERBERG LIMITS RESULTS

ASTM D4318



Boring ID		Depth (Ft)	LL	PL	PI	Fines	USCS	Description
●	B-1	0 - 2	53	18	35			
⊠	B-1	2 - 4	75	20	55	81.8	CH	FAT CLAY with SAND
▲	B-1	23 - 25	86	26	60			
★	B-2	0 - 2	74	18	56	85.4	CH	FAT CLAY
⊙	B-2	2 - 4	56	19	37			
✿	B-2	4 - 6	50	14	36			
○	P-2	0 - 2	84	24	60			

PROJECT: Sherwin Williams Retail Store

SITE: 12937 N FM 973
Manor, TX

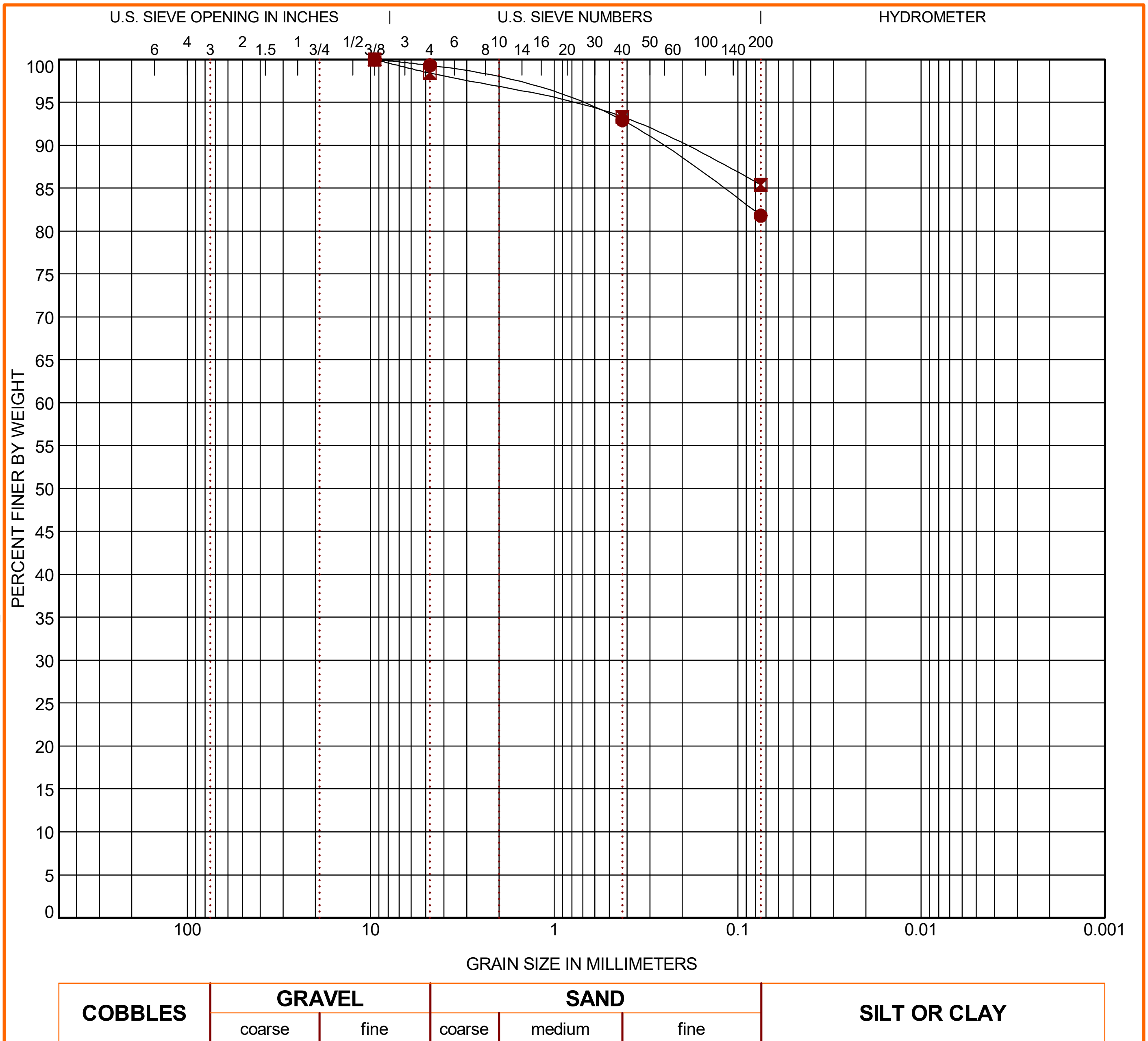
Terracon
5307 Industrial Oaks Blvd Ste 160
Austin, TX

PROJECT NUMBER: 96225068

CLIENT: Belterra Partners LLC
Birmingham, AL

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



Boring ID		Depth (Ft)	USCS Classification	WC (%)	LL	PL	PI	Cc	Cu
●	B-1	2 - 4	FAT CLAY with SAND (CH)	24.2	75	20	55		
⊠	B-2	0 - 2	FAT CLAY (CH)	19.5	74	18	56		

Boring ID		Depth (Ft)	D_{100}	D_{60}	D_{30}	D_{10}	%Cobbles	%Gravel	%Sand	%Silt	%Fines	%Clay
●	B-1	2 - 4	9.5				0.0	0.7	17.5		81.8	
⊠	B-2	0 - 2	9.5				0.0	1.6	13.0		85.4	

PROJECT: Sherwin Williams Retail Store

SITE: 12937 N FM 973
Manor, TX

Terracon
5307 Industrial Oaks Blvd Ste 160
Austin, TX

PROJECT NUMBER: 96225068

CLIENT: Belterra Partners LLC
Birmingham, AL

DHL Analytical, Inc.

Date: *05-May-22*

CLIENT:	Terracon	**Client Sample ID:**	B-1 (0-2)
Project:	Sherwin Williams	**Lab ID:**	2204289-01
Project No:	96225068	**Collection Date:**	04/26/22 11:00 AM
Lab Order:	2204289	**Matrix:**	SOIL

Analyses	Result	MDL	RL	Qual	Units	DF	Date Analyzed
CHLORIDE AND SULFATE CONTENT IN SOIL		**TEX620J**					Analyst: **BM**
Chloride	63.2	38.1	47.6	N	ppm-dry	10	05/04/22 06:27 PM
Sulfate	165	19.0	47.6	N	ppm-dry	10	05/04/22 06:27 PM

Qualifiers:				
	*	Value exceeds TCLP Maximum Concentration Level	C	Sample Result or QC discussed in the Case Narrative
	DF	Dilution Factor	E	TPH pattern not Gas or Diesel Range Pattern
	J	Analyte detected between MDL and RL	MDL	Method Detection Limit
	ND	Not Detected at the Method Detection Limit	RL	Reporting Limit
	S	Spike Recovery outside control limits	N	Parameter not NELAP certified

DHL Analytical, Inc.

Date: *05-May-22*

CLIENT:	Terracon	**Client Sample ID:**	B-2 (2-4)
Project:	Sherwin Williams	**Lab ID:**	2204289-02
Project No:	96225068	**Collection Date:**	04/26/22 11:00 AM
Lab Order:	2204289	**Matrix:**	SOIL

Analyses	Result	MDL	RL	Qual	Units	DF	Date Analyzed
CHLORIDE AND SULFATE CONTENT IN SOIL		**TEX620J**					Analyst: **BM**
Chloride	<39.6	39.6	49.5	N	ppm-dry	10	05/04/22 08:21 PM
Sulfate	268	19.8	49.5	N	ppm-dry	10	05/04/22 08:21 PM

Qualifiers:				
	*	Value exceeds TCLP Maximum Concentration Level	C	Sample Result or QC discussed in the Case Narrative
	DF	Dilution Factor	E	TPH pattern not Gas or Diesel Range Pattern
	J	Analyte detected between MDL and RL	MDL	Method Detection Limit
	ND	Not Detected at the Method Detection Limit	RL	Reporting Limit
	S	Spike Recovery outside control limits	N	Parameter not NELAP certified

SUPPORTING INFORMATION

Contents:

Note: All attachments are one page unless noted above.

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

Sherwin Williams Retail Store ■ Manor, TX

Terracon Project No. 96225068

Terracon GeoReport

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		
Descriptive Term (Density)	**Standard Penetration or N-Value Blows/Ft.**	**Descriptive Term (Consistency)**	**Unconfined Compressive Strength Qu, (tsf)**	**Standard Penetration or N-Value Blows/Ft.**
Very Loose	0 - 3	Very Soft	less than 0.25	0 - 1
Loose	4 - 9	Soft	0.25 to 0.50	2 - 4
Medium Dense	10 - 29	Medium Stiff	0.50 to 1.00	4 - 8
Dense	30 - 50	Stiff	1.00 to 2.00	8 - 15
Very Dense	> 50	Very Stiff	2.00 to 4.00	15 - 30
		Hard	> 4.00	> 30

RELEVANCE OF SOIL BORING LOG

The soil boring logs contained within this document are intended for application to the project as described in this document. Use of these soil boring logs for any other purpose may not be appropriate.

UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]				Soil Classification: Group Symbol	Soil Classification: 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 on or above “A” line	CL	Lean clay [K, L, M]
			PI < 4 or plots below “A” line [J]	ML	Silt [K, L, M]
		Organic:	Liquid limit - oven dried / Liquid limit - 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:	Liquid limit - oven dried / Liquid limit - 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] $Cu = D_{60}/D_{10}$ $\quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains $\geq$ 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 $\geq$ 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 $\geq$ 30% plus No. 200 predominantly sand, add “sandy” to group name.

[M] If soil contains $\geq$ 30% plus No. 200, predominantly gravel, add “gravelly” to group name.

[N] PI $\geq$ 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.