Geotechnical Engineering Report

20-Acre Single Family Development

Sherman, Texas

May 31, 2022

D&S ENGINEERING LABS

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B&H Companies, LLC
603 N. Travis Street
Sherman, Texas 75090
Attn: Terrin Bertholf
Phone: 903-267-1573
Email: terrin@elrcommercial.com

GEOTECHNICAL INVESTIGATION
D&S ENGINEERING #G22-2111
20-ACRE SINGLE FAMILY DEVELOPMENT
SHERMAN, TEXAS

Mr. Bertholf,

As requested, D&S Engineering Labs, LLC has completed the Geotechnical Investigation for the above referenced project. This investigation was conducted in accordance with Proposal No. GP22-2111 dated April 18, 2022. Authorization to proceed was received on April 20, 2022.

We appreciate the opportunity to provide professional geotechnical engineering services to you. We are available to discuss any questions which may arise regarding this report. Please do not hesitate to call when we can provide any additional services.

Sincerely,

D&S Engineering Labs, LLC

STATE OF TEXAS
DOUGLAS GREENWOOD
119347
LICENSED
PROFESSIONAL ENGINEER
05/31/22

Ibrahim A. Baayeh, P.E.
Director of Geotechnical Engineering

Douglas Greenwood, P.E.
Senior Geotechnical Engineer

14805 Trinity Boulevard, Fort Worth, TX 76155
Geotechnical 817.529.8464 • Corporate 903.420.0014
www.dsenglabs.com
Texas Engineering Firm Registration # F-12796

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1.0 PROJECT DESCRIPTION

This report presents the results of the geotechnical investigation conducted for a proposed 20-Acre Single Family Development. The site for the proposed development is located northeast of the intersection of Frisco Road and East Graystone Drive in Sherman, Texas. We understand that the new residential subdivision will consist of a total of 93 residential lots, associated residential streets, a common park area, and a stormwater basin on an approximate 20-acre parcel.

At the time of this investigation, the site was generally occupied by short to tall grasses and matured trees. Based upon visual site observations and available topographic maps from the USGS topoview website (ngmdb.usgs.gov), the site appears to generally slope down from the east side of the property towards the southwestern corner with an overall topographic relief of about 20 feet across the project area. Grading plans were not available at the time of this report; therefore, we anticipate that finished grades will be at or near existing ground surface elevations. Recent site conditions are presented in the following photographs:

2.0 PURPOSE AND SCOPE

The purpose of this investigation was to:

- Identify the subsurface stratigraphy and groundwater conditions present at the site.
- Evaluate the physical and engineering properties of the subsurface soil and bedrock strata for use in the geotechnical analyses.
- Provide geotechnical recommendations for use in the design of the proposed residential structures, pavements, and related site work.

The scope of this investigation consisted of:

- Drilling and sampling of a total of fifteen (15) borings. Ten (10) borings (B1 through B10) were advanced to depths of about 10 to 15 feet throughout the proposed footprint of single-family residential properties. Three (3) borings (P1 through P3) were advanced to depths of about 7 to 10 feet below current grades within the proposed pavement areas. Two (2) borings (S1 and S2) were advanced within the proposed stormwater basin to depths of about 15 feet.

- Laboratory testing of selected soil and bedrock samples obtained during the field investigation.

- Preparation of a Geotechnical Report that includes:
    - Evaluation of potential soil heave through Potential Vertical Movement (PVM).
    - Recommendations for the design and construction of the foundations.
    - Recommendations for pavement sections and pavement subgrade stabilization.
    - Recommendations for the proposed stormwater basin.
    - Recommendations for earthwork.

3.0 FIELD AND LABORATORY INVESTIGATION

3.1 General

The borings were advanced using a truck-mounted drilling rig, equipped with continuous flight augers. Undisturbed samples of cohesive soils and weathered limestone bedrock were obtained using 3-inch diameter tube samplers that were advanced into the soils in 1 to 2-foot increments by the continuous thrust of a hydraulic ram located on the drilling equipment. After sample extrusion, an estimate of the material stiffness of each cohesive soil and weathered bedrock sample was obtained in the field using a hand penetrometer.

Subsurface materials were also intermittently tested in-situ using cone penetration tests in order to determine their resistance to penetration. For this test, a 3-inch diameter steel cone is driven by the energy of a 170-pound hammer falling freely from a height of 24 inches and striking an anvil located at the top of the drill string. Depending on the resistance of the soil and bedrock materials, either the number of blows of the hammer required to provide 12 inches of penetration is recorded (as two increments of 6 inches each), or the inches of penetration of the cone resulting from 100 blows of the hammer are recorded (as two increments of 50 blows each).

All samples obtained were extruded in the field, placed in plastic bags to minimize changes in the natural moisture condition, labeled according to the appropriate boring number and depth, and placed in protective cardboard boxes for transportation to the laboratory. The approximate locations of the borings performed at the site are shown on the boring location map that is included in Appendix A. The specific depths, thicknesses and descriptions of the strata encountered are presented on the individual Boring Log illustrations, which are also included in Appendix A. The approximate surface elevations shown on the boring logs were interpolated from USGS topoview website, which provides spot elevation estimates and contours in 10-foot intervals. Strata boundaries shown on the boring logs are approximate.

3.2 Laboratory Testing

Laboratory tests were performed to identify the relevant engineering characteristics of the subsurface materials encountered and to provide data for developing engineering design parameters. The subsurface materials recovered during the field exploration were initially logged in the field by the drill crew and were later described by a Staff Engineer after the samples arrived in the laboratory. These descriptions were later refined by a Geotechnical Engineer based on results of the laboratory tests performed. All recovered soil samples were classified and described in part using the Unified Soil Classification System (USCS) and other accepted procedures. Bedrock strata were described using standard geologic nomenclature.

In order to determine soil characteristics and to aid in classifying the soils, classification testing was performed on selected samples as requested by the Geotechnical Engineer. Classification testing was performed in general accordance with the following ASTM testing standards:

- Moisture Content — ASTM D2216
- Atterberg Limits — ASTM D4318

Additional tests were performed to aid in evaluating strength, volume change characteristics, and chemical properties which consisted of the following:

- Overburden Swell
- Unconfined Compressive Strength of Soil Samples — ASTM D2166
- Soluble Sulfates — TEX-145-E

The results of these tests are presented at the corresponding sample depths on the appropriate Boring Log illustrations. The classification tests are described in more detail in Appendix B (General Description of Procedures).

3.2.1 Overburden Swell Tests

Selected samples of the near-surface cohesive soils were subjected to overburden swell tests. For this test, a sample is placed in a consolidometer and is subjected to the estimated in-situ overburden pressure. The sample is then inundated with water and allowed to swell. Moisture contents are determined both before and after completion of the test. Test results are recorded as the percent swell, with initial and final moisture content.

3.2.2 Unconfined Compression Tests

Unconfined compressive strength testing was performed on selected samples of the cohesive soils and weathered limestone. These tests were performed in general accordance with ASTM D2166. During each test, a cylindrical specimen is subjected to an axial load that is applied at a constant rate of strain until either failure or a large strain (i.e., greater than 15 percent) occurs. Once the test is completed, the unit weight of the sample is determined based on the moisture content.

3.2.3 Soluble Sulfates

Soluble sulfate tests were performed on representative samples obtained. These results are provided in Appendix A (Boring Logs and Supporting Data). Subgrade materials in some areas of Texas have experienced sulfate-induced heave after treatment with calcium-based additives such as lime. In general, a sulfate level less than 3,000 ppm is considered to have an acceptably low potential for sulfate induced heaving. The results of the sulfate tests performed on representative near-surface soil samples from test borings in this study indicate values of about 113 ppm or less, and thus should be considered to pose a minimal risk of sulfate-induced heaving after lime treatment.

4.0 SITE CONDITIONS

4.1 Stratigraphy

Based upon a review of the recovered samples, as well as the Geologic Atlas of Texas, Sherman Sheet, this site is located within the Austin Chalk formation. The Austin Chalk Formation generally consists of non-crystalline limestone of varying argillaceous (clay mineral bearing) content. Residual soils derived from the bedrock are clays that are generally moderately to highly plastic.

At the surface of the site native fat clay soils were present in all fifteen borings conducted for this project. The clay soils present were generally medium stiff to very stiff in consistency, various shades of brown in color, and contained varying amounts of calcareous nodules and limestone fragments throughout. The fat clay soils generally extended to depths of about 0.5 to 6.5 feet below current grades.

Weathered limestone was encountered beneath the residual soils. The weathered limestone strata encountered were very soft to hard in rock hardness classification, various shades of tan and brown in color, and were variably argillaceous (clay mineral bearing). The weathered limestone extended to at least the maximum depths explored of about 10 to 15 feet within the remaining borings.

The upper portions of the tan weathered limestone bedrock strata encountered are differentially weathered, having been leached by percolating waters. The strength of the tan limestone is highly variable with Texas Cone Penetrometer (TCP) test results generally ranging from as hard as 0.5 inches per 100 blows to as soft as 36 blows for 12 inches of penetration.

Difficult drilling and excavation should be anticipated through the tan limestone. Appropriate hard rock excavation equipment will be required. Such heavy equipment should be of a sufficient size and weight to excavate through the hard layers to reach the desired bearing stratum.

The table below, Table 1, shows the depth of the weathered limestone strata.

Table 1: Depth to Weathered Limestone Strata

Boring	Boring Depth (ft)	Depth to Weathered Limestone (ft)
B1	15	5.0
B2	15	1.0
B3	15	1.0
B4	15	6.5
B5	15	0.5
B6	15	2.0
B7	15	1.5
B8	10	0.5
B9	15	1.5
B10	15	2.0
P1	7.5	1.5
P2	10	6.0
P3	10	0.5
S1	15	3.0
S2	15	5.0

4.2 Groundwater

Within Boring S2, groundwater seepage was encountered at a depth of about 7 feet during drilling and was measured at a depth of about 10 feet upon completion of drilling operations. Groundwater seepage was not encountered within the remaining borings either during drilling operations or upon the completion of drilling. It should be noted groundwater levels may fluctuate with seasonal and annual variations in rainfall, and also may vary as a result of development and landscape irrigation. Groundwater is often contained within the joints, fractures and other rock mass defects present in bedrock strata. When intercepted, these defects can produce appreciable amounts of water for a period of time, especially if those defects are extensive and well inter-connected.

5.0 ENGINEERING ANALYSIS

5.1 Estimated Potential Vertical Movement (PVM)

Potential Vertical Movement (PVM) was evaluated utilizing a variety of different methods for predicting movement, as described in Appendix B, and based on our experience and professional opinion. The near-surface soils at this site were generally found to be in a dry to wet moisture condition at the time of our field investigation.

Based on the provided information and the results of this investigation, the soils at the site are estimated to possess a PVM on the order of about 1.5 inches, at the existing grades and soil moisture conditions present at the time of the field investigation. If the near surface soils are allowed to dry appreciably to significant depth prior to or during construction, the PVM will increase. It should be noted the highly to completely weathered limestone when argillaceous can be expansive and has been incorporated into the above values for PVM. Wet, average, dry are relative terms based on moisture content and plasticity.

As grading plans were not available at the time of this investigation, the estimated PVM considers that final grades will be at or near (within about 2 feet) existing grades. Recommended design parameters provided herein should be expected to change should there be significant quantities of cut or fill; therefore, we recommend that this office be permitted to review final grading and design plans prior to construction to confirm and/or revise the conclusions and recommendations provided herein.

6.0 FOUNDATION RECOMMENDATIONS

The near-surface soils present at the site have moderate to high potential for post-construction vertical movement with changes in soil moisture content. If post-construction movements on the order of 1-inch can be tolerated after subgrade preparation is completed in accordance with the recommendations provided herein, it is our opinion that the new buildings may be supported on soil-supported monolithic stiffened slabs incorporating interior and exterior grade beams.

Please note that a soil-supported floor slab may experience some vertical movement with changes in soil moisture content. Non-load bearing walls, partitions, and other elements bearing on the floor slab will reflect these movements should they occur. However, with appropriate design, adherence to good construction practices and appropriate post-construction maintenance, these potential movements can be reduced. The majority of the movement is expected to occur within 10 feet of the perimeter of the building, and any walls bearing on the slab in the areas of movement may exhibit distress.

6.1 Stiffened Slab-On-Grade Foundation

A stiffened slab-on-grade foundation may be used for the proposed residences with the soil prepared as described in the Earthwork Recommendations section of this report. A stiffened slab should incorporate interior and exterior grade beams and may be designed as a conventionally reinforced or post-tensioned monolithic slab and beam. Grade beams should be founded a minimum depth of 24 inches below final exterior grade and be designed for an allowable bearing capacity of 2,000 pounds per square foot (psf) when based in reworked soils, and 3,000 pounds per square foot (psf) when based at least 8 inches into competent weathered limestone. We recommend that a representative of the Geotechnical Engineer of Record verify the competency and presence of limestone.

Following removal of the form boards around the exterior grade beams, the exterior perimeter of the grade beams around the structure should be carefully backfilled with on-site clayey soils. The backfill soils should be compacted to at least 95 percent of the maximum dry density for the backfill material as determined by ASTM D698 (standard Proctor method). The backfill should also be placed at a moisture content that is at least two (+≥2%) percentage point above the optimum moisture content, as determined by that same test. This fill should extend to the full depth of the grade beam and extend a minimum distance of two feet away from the perimeter grade beam.

We also recommend placing a moisture barrier, such as plastic sheeting, under the stiffened slab foundation to prevent the infiltration of moisture through the concrete slab.

6.1.1 Wire Reinforcement Institute (WRI) Design Parameters

The following design assumptions may be used for WRI slabs constructed over properly reworked soils as outlined in the Earthwork recommendations section of this report:

- Climatic Rating (Cw): 20
- Weighted Plasticity Index (PI): 34
- Slope Correction Coefficient (Cs): 1.0
- Consolidation Correction coefficient (Co): 1.0
- Effective Plasticity Index (PIe): 34

6.1.2 Post-Tensioning Institute (PTI) Design Parameters

For a slab-on-grade foundation bearing in the on-site reworked soils, the following PTI design parameters presented in Table 2 below are recommended. These parameters are based on the procedures of the *Post-Tensioning Manual 3rd Edition,* our analysis of the data developed during this study, and are modified by our experience and engineering judgment regarding the site conditions and soil types present.

Table 2. PTI Design Parameters

PARAMETER	CENTER LIFT	EDGE LIFT	Depth of Soil Re-Work (feet)
Edge Moisture Variation, e_m	7.2 feet	4.3 feet	4 feet
Estimated Differential Movement, y_m (After soil modification)	-1.4 INCHES (SHRINK)	+1.5 INCHES (SWELL)	

7.0 EARTHWORK RECOMMENDATIONS

Grading plans were not available during the time of this report preparation. We anticipate the finished pad elevation will be achieved by some amount of cut/fill operations. Recommended design parameters provided herein should be expected to change should there be significant quantities of cut or fill; therefore, we recommend that this office be permitted to review final grading and design plans prior to construction to confirm and/or revise the conclusions and recommendations provided herein.

The near surface soils present have moderate to high potential for post-construction vertical movements with changes in subsurface soil moisture conditions. Based on the scope of the project and the conditions encountered onsite, we recommend founding the residential structures on stiffened, slab-on-grade foundations constructed over moisture conditioned, reworked soils. We have the following earthwork recommendations to provide a uniform building pad and limit potential post-construction movements (PVM) to the order of about 1 inch for the proposed residential structures.

7.1 Earthwork for Soil Supported Elements

- Strip the site of all vegetation and remove any remaining organic or deleterious material including root balls, matted roots including all tree stumps. Typically, 6 to 12 inches is sufficient for this purpose.
- After stripping, excavate an additional depth of about 3 feet below existing or finished building pad elevation, whichever is deeper. Stockpile the excavated soil for possible re-use. The excavation should extend at least 3 feet beyond the perimeter of the new structure. If competent, undisturbed limestone is encountered prior to achieving the recommended depth of excavation, the excavation may terminate at the top of the limestone, where present.
- After excavation, the exposed subgrade should be scarified and recompacted to a depth of 12 inches below the finished subgrade elevation. Verified, competent weathered limestone should be left undisturbed and should not be scarified or recompacted. The scarified and reworked soils should be compacted to at least 95 percent of the maximum dry density, as determined by ASTM D698 (standard Proctor), and placed at a moisture content that is at

least two percentage points (≥+2%) above the optimum moisture content, as determined by the same test.

- Within 24 hours of recompacting the reworked excavated exposed subgrade, begin fill operations with the stockpiled on-site soils or imported soils to no higher than 12 inches below the bottom of floor slabs final grade elevation. The on-site fill should be spread across the building pads in a uniform thickness atop the scarified layer as the first and succeeding lifts. The reworked or imported fill soils should be placed in maximum 6-inch compacted lifts, be compacted to at least 95 percent of the maximum dry density as determined by ASTM D698 (standard Proctor), and be placed at a moisture content that is at least 2 percentage points (≥ 2%) above the optimum moisture content, as determined by that same test. Grade raise fill within the building pad areas may be on-site or imported material and should have a Liquid Limit (LL) of 50 or less, a Plasticity Index (PI) of 30 or less, be essentially free of particles more than 4 inches in their longest direction, and have a minimum of 35 percent passing the No. 200 sieve.

- Provide a minimum of 12 inches of select fill on top of the re-worked fill. Select fill should have a Liquid Limit (LL) of less than 35, a Plasticity Index (PI) between 6 and 18 and be essentially free of particles in excess of 4 inches in their longest direction. The select fill should be placed in maximum 6-inch compacted lifts and be compacted to at least 95 percent of the maximum density as determined by ASTM D698, and to a moisture content of optimum or greater as determined by that same test.

- In the instance that competent weathered limestone is encountered directly beneath the grade beams, we recommend about 1 to 2 inches of leveling sand on top of the limestone bedrock to act as a cushion/bond breaker. This will avoid constraint to shrinkage of the concrete that leads to random cracking. Any over breakage greater than 6-inches in depth should be filled with lean concrete, prior to placement of the levelling sand to achieve a level surface.

- The moisture content of the subgrade should be maintained up to the time of concrete placement. Depending on the speed of the earthwork layers, on hot or windy days, sprinkling with water atop the subgrade may be required, to maintain the compaction moisture content.

- Water should not be allowed to pond on the prepared subgrade either during fill placement, or after reaching final subgrade elevation. To that end, the subgrade surfaces should be shaped to shed water to the edges of the respective pads.

- Place a minimum 15-mil thick vapor barrier beneath all floor slabs (Stego or approved equivalent). All seams and penetrations through the barrier should be sealed in accordance with the manufacturer’s requirements.

- Each lift of fill placed should be tested for moisture content and degree of compaction by a testing laboratory at the rate of one (1) test per lift per 3,000 square feet of fill area, with a minimum of one (1) test performed per lift within each building pad, one (1) test per lift per 100 linear feet of grade beam perimeter backfill, and one (1) test per lift per 100 linear feet of utility trench backfill. D&S would be pleased to provide these services in support of this project.

7.2 Additional Considerations

In order to minimize the potential for post-construction vertical movement, consideration should be given to the following:

- Trees or shrubbery with a mature height greater than 6 feet and/or that require excessive amounts of water should not be planted near structures or flatwork.
- Trees should not be planted closer than the mature tree's height from structures or flatwork.
- Water should not be allowed to pond next to the foundations. Rainfall roof runoff should be collected and conveyed to downspouts. Downspouts should be directed to discharge at least 5 feet away from the foundations.
- The moisture content of subgrade soils that are in proximity to the structures should be maintained as close as possible to a consistent level throughout the year. However, we strongly recommend that excessive watering near foundations be avoided.
- Exposed ground should be sloped at a minimum 5 percent away from the building for at least 10 feet beyond the perimeter of the building.

8.0 PAVEMENT RECOMMENDATIONS

8.1 General

The pavement design recommendations provided herein are derived from the subgrade information that was obtained from our geotechnical investigation, design assumptions based on project information, our experience with similar projects in this area, and on the guidelines and recommendations of the American Concrete Pavement Association (ACPA). It is ultimately the responsibility of the Civil Engineer of Record and/or other design professionals who are responsible for pavement design to provide the final pavement design and associated specifications for this project.

We recommend that a treated subgrade be used to provide an adequate and uniform surface for the pavement. As an alternative to a lime treated subgrade, an aggregate base course may be used.

8.2 Behavior Characteristics of Expansive Soils beneath Pavement

Near-surface soils at this site are considered to have low potential for volume change with changes in soil moisture content. The moisture content can be "stabilized", to some degree, in these soils by covering them with an impermeable surface, such as pavement. However, if moisture is introduced by surface or subsurface water, poor drainage, or the addition of excessive irrigation after periods of no moisture, or if moisture is removed by desiccation from vegetation (especially trees), the soils can swell or shrink causing distress to pavements in contact with the soil in the form of cracks.

The edges of pavement and sidewalks are particularly prone to moisture variations; therefore, these areas often experience the most distress (cracking, displacement, etc.). When cracks appear on the surface of the pavement, these openings can allow moisture to enter the pavement subgrade, which can lead to further weakening of the pavement section as well as accelerated failure of the pavement surface.

In order to minimize the potential impacts of expansive soil on paved areas and to improve the long-term performance of the pavement, we have the following recommendations:

- Design a crowned pavement which provides maximum drainage away from the pavement. A minimum slope of 5 percent within the first 5 feet is considered ideal.
- Subgrade treatments intended to reduce the soil's potential for vertical movement or to increase the subgrade stability should extend to at least two (2) feet beyond the back of curbs or edges of pavements.
- Avoid long areas of low-sloping roadway and adjust slopes to provide maximum drainage away from pavement edges.

8.3 Subgrade Strength Characteristics

The anticipated subgrade soils in the proposed paving areas will generally consist of clay soils. However, cuts made to accommodate pavements may reach the weathered limestone strata. We recommend that a California Bearing Ratio (CBR) value of 3 be used for the on-site clay soils in the design with a corresponding resilient modulus of 4,100 psi. We recommend using Modulus of Subgrade reaction (k) of 120 pci for onsite soils prepared in accordance with the recommendations in this report. For compacted lime treated soils and/or compacted aggregate base, we recommend using a resilient modulus of 20,000 psi. Where pavement subgrades are cut into competent weathered limestone bedrock, a CBR value of at least 15 may be used.

8.4 Subgrade Preparation Recommendations

The anticipated subgrade soils will be generally lean and fat clay soils in the proposed paving areas which have poor subgrade characteristics and can become soft and pump with an increase in moisture content. A commonly used method to reduce the potential for pumping, improve the strength properties of the subgrade soils, provide a working platform, and provide a uniform subgrade in this area is to treat the soils with lime or to install an aggregate base layer. The following sections provide recommendations for general pavement subgrade preparations and discuss the subgrade improvement options.

8.4.1 Soil Preparation for Pavements

- Strip the site of all vegetation and remove any remaining organic or deleterious material under the planned paved areas, including all tree stumps and root balls of existing trees. Typically, 6 to 12 inches is sufficient for this purpose.

- Cut as needed to achieve the required pavement subgrade elevation.

- After stripping and performing necessary cuts, the exposed subgrade should be proof rolled. Proof rolling should consist of rolling the entire pavement subgrade with a heavily loaded, tandem-axle dump truck weighing at least 25 tons or other approved equipment capable of applying similar loading conditions. Any soft, wet, or weak soils that are observed to rut or pump excessively during proof rolling should be removed and replaced with well-compacted, on-site clayey material as outlined below. The proof rolling operation should be performed under the observation of a qualified geotechnical engineer or representative.

- After proof rolling, exposed clay subgrade surfaces should be scarified and reworked to a depth of 12 inches. The soils should then be recompacted to a minimum of 95 percent of the maximum dry density obtained in accordance with ASTM D698 (standard Proctor), and to a moisture content that is at least two (2) percentage points above the material's optimum moisture content, as determined by the same test (≥+2%).

- If competent limestone is present at finished subgrade elevation, the limestone will not require proof rolling and should not be scarified. If proof rolling, scarification, and recompaction of the subgrade is not to be conducted due to the presence of limestone, we recommend that a competent representative of the Geotechnical Engineer of Record verify the competency and presence of limestone.

- Fill may be derived from on-site or may be imported. The fill should be placed in maximum 8-inch compacted lifts, compacted to at least 95 percent of the maximum dry density, as determined by ASTM D698 (standard Proctor), and be placed at a moisture content that is at least two (2) percentage points above the optimum moisture content, as determined by the same test. Prior to compaction, each lift of fill should first be processed throughout its thickness to break up and reduce clod sizes and blended to achieve a material of uniform density and moisture content. Once blended, compaction should be performed with a heavy tamping foot roller. Once compacted, if the surface of the embankment is too smooth, it may not bond properly with the succeeding layer. If this occurs, the surface of the compacted lift should be roughened and loosened by dicing before the succeeding layer is placed.

- Water required to bring the fill material to the proper moisture content should be applied evenly through each layer. Any layers that become significantly altered by weather conditions should be reprocessed in order to meet project criteria. On hot or windy days, the use of water spraying methods may be required in order to keep each lift moist prior to placement of the subsequent lift. Furthermore, the subsurface soils should be kept moist prior to placing the pavement by water sprinkling or spraying methods.

- Fill materials should be placed on a properly prepared subgrade as outlined above. The combined excavation, placement, and spreading operation should be performed in such a manner as to obtain blending of the material, and to assure that, once compacted, the materials, will have the most practicable degree of compaction and stability. Materials obtained from on-site must be mixed and not segregated.

- Soil imported from off-site sources should be tested for compliance with the recommendations herein and approved by the project geotechnical engineer prior to being used as fill. Imported materials shall consist of lean clays (maximum Plasticity Index of 30) that are essentially free of organic materials and particles larger than 4 inches in their maximum dimension.

- Treat the subgrade soils with lime or place aggregate base in accordance with the recommendations outlined in subsequent sections.

- In the instance that limestone is encountered directly beneath the pavement, lime stabilization or aggregate base course may not be required. We recommend about 1 to 2 inches of leveling sand atop the limestone bedrock to act as a cushion/bond breaker. This will avoid constraint to shrinkage of the concrete that leads to random cracking.

- Once lime treatment is performed or aggregate base has been placed, water should not be allowed to pond on the treated surface. To that end, the pavement subgrade surface should be shaped in a way that will allow water to shed from one or more edges of the prepared subgrade.

- Field density and moisture content testing should be performed at the rate of one test per lift per 100 linear feet of roadway.

8.4.2 Lime Treatment

Once the subgrade is prepared, we have the following recommendations for preparation of the lime-treated subgrade:

- Treat the prepared subgrade using an estimated six (6) percent hydrated lime by dry weight measure of the subgrade soil (approximately 27 pounds per square yard for 6-inch treatment depths). However, the final amount of lime used should be determined once subgrade preparation is nearly complete. The amount of lime used should be sufficient to reduce the Plasticity Index of the soil to 15 or below (Atterberg Lime series) or to increase pH of the soil-lime mixture to 12.4 (pH series). To account for construction and site variation, an additional 1 to 2 percent lime may be added to these test quantities. The area of lime treated subgrade should extend a minimum of 2 feet beyond the back of roadway curbs or edges.

- In the instance that competent weathered limestone is encountered directly beneath the pavements, lime stabilization will not be necessary. We recommend about 1 to 2 inches of levelling sand on top of the weathered limestone to act as a cushion/bond breaker. This will avoid constraint to shrinkage of the concrete that leads to random cracking. Any over breakage greater than 6-inches should be filled with lean concrete prior to placing the leveling sand.

- Hydrated lime should be applied such that mixing operations can be completed during the same working day. The hydrated lime should be placed by the slurry method, meaning that the hydrated lime should be mixed with water in trucks or in tanks and applied as a thin water suspension or slurry. The distributor truck or tank should be equipped with an agitator, which will maintain the lime and water in a uniform mixture. The material and hydrated lime should be thoroughly mixed by a rotary mixer or other device to obtain a homogeneous, friable mixture of material and lime that is free from clods and left to cure from one to four days.

- We have found that a curing period of 48 to 72 hours is adequate. During the curing period, the material should be kept moist. After the required curing time, the material should be uniformly mixed using a rotary mixer capable of reducing the size of the particles so that, when all non-slaking aggregates retained on a no. 4 sieve are removed, the remainder of the material shall meet the following requirements when tested dry by laboratory sieves:

- Minimum passing 1-3/4" sieve: 100%
- Minimum passing No. 4 sieve: 60%

- After sufficiently re-mixed, the soil and lime mixture should be compacted to a minimum of 95 percent of Standard Proctor (ASTM D698) and to a moisture content that is at or above optimum moisture, as determined by the same test.

- During the interval of time between application and mixing, the hydrated lime should not be exposed to the open air for a period exceeding six hours.

- To reduce the potential for subgrade soil moisture changes at the edges of pavements, the lime treated subgrade should extend a minimum of 2 feet past the back of the roadway curbs.

- Field density and moisture content testing should be performed at the rate of one (1) test per lift per 100 linear feet of roadway.

8.4.3 Aggregate Base

As an alternative to lime treatment, aggregate base may be placed over the prepared subgrade in accordance with the following recommendations prior to placing the pavement.

- After proof rolling, scarification, and recompaction of the clay subgrade are completed and any grade raise fill has been placed, install the recommended thickness of aggregate base for concrete pavements. The area of aggregate base should extend a minimum of 24-inches beyond the back of roadway curbs or edges of pavement.

- Aggregate base should be TxDOT Type A or D and meeting the gradation, durability, and plasticity requirements of TxDOT Item 247 Grade 1-2 or better. Aggregate base material should be uniformly compacted to a minimum of 95% of the maximum standard Proctor dry density (ASTM D 698) and placed at a moisture content that is sufficient to achieve density.

- Field density and moisture content testing should be performed at the rate of one (1) test per lift per 100 linear feet of roadway.

8.5 Rigid Pavement

We recommend that reinforced Rigid Portland Cement Concrete for this site have a minimum thickness of 6 inches for the residential roadways over 6 inches of lime treated subgrade or aggregate base course. The following concrete mix design recommendations are as follows:

- Recommended minimum design compressive strength: 3,500 psi.
- 15 to 20 percent fly ash may be used with the approval of the Civil Engineer of record
- Curing compound should be applied within one hour of finishing operations

8.6 Pavement Joints and Cutting

The performance of concrete pavement depends to a large degree on the design, construction, and long-term maintenance of concrete joints. The following recommendations and observations are offered for consideration by the Civil Engineer and/or pavement Designer-of-Record.

The concrete pavements should have adequately spaced contraction joints to control shrinkage cracking. Past experience indicates that reinforced concrete pavements with sealed contraction joints on a 12 to 15-foot spacing, cut to a depth of one-quarter to one-third of the pavement thickness, have generally exhibited less uncontrolled post-construction cracking than pavements with wider spacing. The contraction joint pattern should divide the pavement into panels that are approximately square where the panel length should not exceed 25 percent more than the panel width. Saw cut, post placement formed contraction joints should be saw cut as soon as the concrete can support the saw cutting equipment and personnel and before shrinkage cracks appear, on the order of 4 to 6 hours after concrete placement.

The recommendations provided herein in regard to expansion joints for jointed reinforced concrete pavement (JRCP) are derived from our experience and on the guidelines and recommendations of the American Concrete Institute (ACI), Federal Highway Administration (FHWA) and Texas Department of Transportation (TXDOT). The following recommendations and observations are offered for consideration by the Civil Engineer and/or pavement Designer-of-Record who are responsible to seal the final pavement plans and associated specifications for the project:

- An expansion joint is provided to allow for thermal expansion of the concrete pavement in order to prevent spalling at the joints. Where provided the joint is full pavement depth with dowel bars at the mid-section of the joint. It can be argued that the closely spaced contraction joints allow for this potential thermal expansion and therefore there is no requirement for expansion joints within the interior of the parking lot. This has the benefit of strengthening the contraction joints and not allowing the joints to open up causing premature failure of the joint sealant. Isolation joints however should be provided at the edges of the pavement where the pavement abuts a structural element. However, due to the potential for excessive thermal expansion caused by high temperatures encountered in the DFW Metroplex it can also be argued to provide expansion joints with maximum spacing on the order of 60 to 600 feet depending on the author.

- Isolation joints should be used wherever the pavement will abut a structural element subject to a different magnitude of movement, e.g., existing pavement or manholes.

- In order to minimize the potential differential movement across the pavement areas, all joints including contraction, isolation and construction joints should be sealed to minimize the potential for infiltration of surface water. Rubberized asphalt, silicone or other suitable flexible sealant may be used to seal the joints. Maintenance should include periodic inspection of these joints and resealed, as necessary.

8.7 Pavement Reinforcing Steel

For a 6-inch-thick concrete pavement section, we recommend No. 3 bars spaced at 18-inches on-center. Reinforcement requirements may increase depending on specific traffic loading and design life parameters.

9.0 STORMWATER BASIN RECOMMENDATIONS

Borings S1 and S2 were drilled within the general area of the proposed stormwater basin. The onsite fat clays present, or imported clay materials, may be used as liner material. In either case, the liner materials must be well-compacted during installation. The liner materials should consist of clay materials having a Plasticity Index of at least 25 and be cleaned of all debris and rock fragments that may be present. Sand bearing clay soils should not be used as liner materials.

We recommend that the bottom of the excavation be scarified and reworked to a minimum depth of 12 inches and be compacted to at least 100 percent of the maximum dry density, as determined by ASTM D698 (standard Proctor) and placed at a moisture content that is at least the optimum moisture content, as determined by the same test. If competent, undisturbed limestone is present at the base of the excavation, it should be left undisturbed and should not be scarified or reworked.

Cut slopes should be gentle and preferably should not exceed 4 horizontal to 1 vertical (4H: 1V).

10.0 OTHER CONSTRUCTION

10.1 Utility and Service Lines

Backfill for utility lines should consist of on-site material and should be placed in accordance with the following recommendations. The on-site fill soil should be placed in maximum 6-inch compacted lifts, compacted to a minimum of 95 percent of the maximum dry density, as determined by ASTM D698 (standard Proctor), and placed at a moisture content that is at least the optimum moisture content, as determined by that same test. It is not uncommon to realize some settlement along the trench backfill. We also recommend that the utility trenches be visually inspected during the excavation process to ensure that undesirable fill that was not detected by the test borings does not exist at the site. This office should be notified immediately if any such fill is detected.

Utility lines connected to the structure may experience differential movement in response to changing moisture conditions in expansive soil. These movements may result in damage to the lines, especially at connections. Flexible connections may be considered to account for potential differential movement between the building and utilities.

Utility excavations should be sloped so that water within excavations will flow to a low point away from the active construction where it can be removed before backfilling. Compaction of bedding material should not be water jetted. Compacted backfill above the utilities should be on-site clays to limit the percolation of surface water. Utility trenches extending under structures should include fat clay or concrete cut-off collars at the perimeter/edge to prevent the transmission of water along trench lines.

10.2 Exterior Flatwork

Concrete flatwork should include high tensile steel reinforcement to reduce the formation and size of cracks. Flatwork should also include frequent and regularly spaced expansion/control joints and dowels to limit vertical offsets between neighboring flatwork slabs. Structure entrances should either be part of the structure or designed to tolerate vertical movement without inhibiting access. The moisture content of the subgrade should be maintained up to the time of concrete placement. If subgrade soils are allowed to dry below the levels recommended herein, additional moisture conditioning of the soils may be required. These recommendations are intended to reduce possible distress to exterior flatwork but will not prevent movement and/or vertical offsets between slabs.

10.3 Surface Drainage

Proper drainage is critical to the performance and condition of building foundations, pavements, and flatwork. Positive surface drainage should be provided that directs surface water away from the buildings and flatwork. We recommend that the exterior grades should slope away from foundations at the rate of ten (10) percent in the first ten (10) feet. This is equivalent to a fall of one foot in the first 10 feet away from the foundation. As drainage will be slow with shallow limestone consideration be given for a drainage trench (French drain) be provided around the building exiting into the street. The slopes should direct water away from the structure, and these grades should be maintained throughout construction and the life of the structure.

The location of gutter downspouts, and other features, should be designed such that these items will not create moisture concentrations at or beneath the structure or flatwork. Downspouts should discharge well away from the structure and should not be allowed to erode surface soil.

Moisture related issues can be positively addressed by constructing continuous exterior flatwork that extends to the building line. Where this occurs, the joints created at the interface of the flatwork and building line should be sealed with a flexible joint sealer to prevent the infiltration of water. Open cracks that may develop in the flatwork should also be sealed. The joint and any cracks that develop should be resealed as they become apparent and should be part of a periodic inspection and maintenance program.

10.4 Landscaping

Landscaping against and around the exterior of the structures can adversely affect subgrade moisture resulting in localized differential movements if not properly maintained. If used, landscaping should be kept as far away from the foundations as possible, and positive drainage away from the structures should be designed, constructed, and maintained. Landscaping elements (such as edging) should not prohibit or slow the drainage of water that could result in water ponding next to foundations or edges of flatwork. When feasible, irrigation lines and heads should not be placed in close proximity to the foundation to prevent the collection of water near the foundation or flatwork, particularly in the event of leaking lines or sprinkler heads.

Trees (if planned) should not be placed in proximity to the structure or movement sensitive flatwork, as trees are known to cause localized soil shrinkage due to desiccation of the soil by the root system, possibly leading to differential movements of the structure in excess of those anticipated herein. The desiccation zone varies by tree, but trees should not be planted closer to structures than the mature tree height, and in no case, should the drip-line of the mature tree extend closer than 10-feet of rooflines. To the extent practical, it is recommended that trees scheduled for removal (where required) in the vicinity of the proposed structure and pavements be removed as far in advance of slab construction as possible, ideally by several months or longer. This will tend to restore a more favorable soil moisture equilibrium which will, in turn, tend to minimize the potential for greater than anticipated post-construction ground movements. A moist but not overly wet soil condition should be maintained at all times in all landscaped areas near the building after construction to minimize soil volume changes caused by changing soil moisture conditions.

10.5 Site Grading

Expansive clay cut and fill slopes should be gentle and preferably should not exceed 4 horizontal to 1 vertical (4H:1V).

Excess water ponding on and beside roadways, sidewalks, and ground-supported slabs can cause unacceptable heave of these structures. To reduce this potential heave, good surface drainage should be established. In addition, final grades in the vicinity of structures, pavements, and flatwork should provide for positive drainage away from these elements.

10.6 Excavations and Excavation Difficulties

The upper portions of the tan weathered limestone bedrock strata encountered are differentially weathered, having been leached by percolating waters. The strength of the tan limestone is highly variable with Texas Cone Penetrometer (TCP) test results generally ranging as hard as 0.5 inches per 100 blows to as soft as 36 blows for 12 inches of penetration.

Excavations into limestone bedrock during site grading, utility and foundation construction may require the use of special construction equipment to facilitate. Such heavy equipment should be of a sufficient size and weight to excavate through the hard layers to reach the desired bearing stratum. Excavators equipped with rock-buckets may be adequate for smaller areas or narrower trenches. Larger excavations in the area have utilized large dozer equipment outfitted with a single-tooth ripper to loosen the rock; however, where natural rock joints, fractures and other mass defects are present, this method can result in large over-breakage. Wheel-cutters or hoe-ram equipment types are sometimes used to facilitate neat cuts where over-breakage is a concern. Other types of excavation equipment may safely and efficiently produce an equal or better result.

Excavations greater than 5 feet in height/depth should be in accordance with OSHA 29CFR 1926, Subpart P. Temporary construction slopes should incorporate excavation protection systems or should be sloped back. Where the excavation does not extend close to building lines, these areas may be laid back. Where space allows, temporary slopes should be sloped at 1.5 horizontal to 1 vertical (1.5H:1V) or flatter. Excavations in weathered limestone can often be excavated as steep as ½ to ¾ H:1V, whereas the fresh gray limestone can often be excavated near vertical. The contractor's competent person should verify in situ conditions as the excavation proceeds.

Where excavation slopes greater than five (5) feet in height cannot be laid back, these areas will require installation of a temporary retention system or shoring to protect the existing construction, restrain the subsurface soils and maintain the integrity of the excavation. We recommend that monitoring points be established around the retention system and that these locations be monitored during and after the excavation activities to confirm the integrity of the retention system.

The slopes and temporary retention system should be verified by and designed by the contractor's engineer and should not be surcharged by traffic, construction equipment, or permanent structures. The slopes and temporary retention system should be adequately maintained and periodically inspected to ensure the safety of the excavation and surrounding property.

11.0 LIMITATIONS

The professional geotechnical engineering services performed for this project, the findings obtained, and the recommendations prepared were accomplished in accordance with currently accepted geotechnical engineering principles and practices.

Variations in the subsurface conditions are noted at the specific boring locations for this study. As such, all users of this report should be aware that differences in depths and thicknesses of strata encountered can vary between the boring locations. Statements in the report as to subsurface conditions across the site are extrapolated from the data obtained at the specific boring locations. The number and spacing of the exploration borings were chosen to obtain geotechnical information for the design and construction of residential streets and single-family residential foundations. If there are any conditions differing significantly from those described herein, D&S should be notified to re-evaluate the recommendations contained in this report.

Recommendations contained herein are not considered applicable for an indefinite period of time. Our office must be contacted to reevaluate the contents of this report if construction does not begin within a one-year period after completion of this report.

The scope of services provided herein does not include an environmental assessment of the site or investigation for the presence or absence of hazardous materials in the soil, surface water, or groundwater.

All contractors referring to this geotechnical report should draw their own conclusions regarding excavations, construction, etc. for bidding purposes. D&S is not responsible for conclusions, opinions or recommendations made by others based on these data. The report is intended to guide preparation of project specifications and should not be used as a substitute for the project specifications.

Recommendations provided in this report are based on our understanding of information provided by the Client to us regarding the scope of work for this project. If the Client notes any differences, our office should be contacted immediately since this may materially alter the recommendations.

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

APPENDIX A - BORING LOGS AND SUPPORTING DATA

BORING LOCATIONS ARE INTENDED FOR GRAPHICAL REFERENCE ONLY

D&S ENGINEERING LABS

N.T.S.

PLAN OF BORINGS

20-ACRE SINGLE FAMILY DEVELOPMENT

SHERMAN TEXAS

SHEET NO.

G1

DATE DRILLED

May 10 - 12, 2021

BORING LOCATIONS ARE INTENDED FOR GRAPHICAL REFERENCE ONLY

D&S ENGINEERING LABS

N.T.S.

PLAN OF BORINGS

20-ACRE SINGLE FAMILY DEVELOPMENT

SHERMAN

TEXAS

SHEET NO.

G2

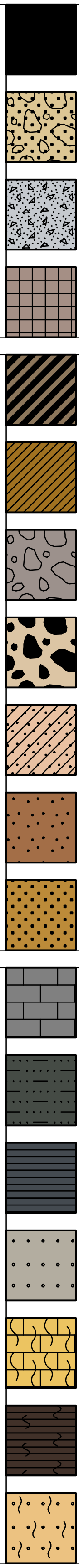
DATE DRILLED

May 10 - 12, 2021

D&S ENGINEERING LABS

KEY TO SYMBOLS AND TERMS

LITHOLOGIC SYMBOLS



ARTIFICIAL
- Asphalt
- Aggregate Base
- Concrete
- Fill

SOIL
- CH: High Plasticity Clay
- CL: Low Plasticity Clay
- GP: Poorly-graded Gravel
- GW: Well-graded Gravel
- SC: Clayey Sand
- SP: Poorly-graded Sand
- SW: Well-graded Sand

ROCK
- Limestone
- Mudstone
- Shale
- Sandstone
- Weathered Limestone
- Weathered Shale
- Weathered Sandstone

CONSISTENCY OF SOILS

CONSISTENCY: FINE GRAINED SOILS		
Consistency	SPT (# blows/ft)	UCS (tsf)
Very Soft	0 - 2	< 0.25
Soft	3 - 4	0.25 - 0.5
Medium Stiff	5 - 8	0.5 - 1.0
Stiff	9 - 15	1.0 - 2.0
Very Stiff	16 - 30	2.0 - 4.0
Hard	> 30	> 4.0

CONDITION OF SOILS

CONDITION: COARSE GRAINED SOILS			
Condition	SPT (# blows/ft)	TCP (#blows/ft)	Relative Density (%)
Very Loose	0 - 4	< 8	0 - 15
Loose	5 - 10	8 - 20	15 - 35
Medium Dense	11 - 30	20 - 60	35 - 65
Dense	31 - 50	60 - 100	65 - 85
Very Dense	> 50	> 100	85 - 100

SECONDARY COMPONENTS

QUANTITY DESCRIPTORS	
Trace	< 5% of sample
Few	5% to 10%
Little	10% to 25%
Some	25% to 35%
With	> 35%

RELATIVE HARDNESS OF ROCK MASS

Designation	Description
Very Soft	Can be carved with a knife. Can be excavated readily with point of pick. Pieces 1" or more in thickness can be broken by finger pressure. Readily scratched with fingernail.
Soft	Can be gouged or grooved readily with knife or pick point. Can be excavated in chips to pieces several inches in size by moderate blows with the pick point. Small, thin pieces can be broken by finger pressure.
Medium Hard	Can be grooved or gouged 1/4" deep by firm pressure on knife or pick point. Can be excavated in small chips to pieces about 1" maximum size by hard blows with the point of a pick.
Moderately Hard	Can be scratched with knife or pick. Gouges or grooves 1/4" deep can be excavated by hard blow of the point of a pick. Hand specimens can be detached by a moderate blow.
Hard	Can be scratched with knife or pick only with difficulty. Hard blow of hammer required to detach a hand specimen.
Very Hard	Cannot be scratched with knife or sharp pick. Breaking of hand specimens requires several hard blows from a hammer or pick.

WEATHERING OF ROCK MASS

Designation	Description
Fresh	No visible sign of weathering
Slightly weathered	Penetrative weathering on open discontinuity surfaces, but only slight weathering of rock material
Moderately weathered	Weathering extends throughout rock mass, but the rock material is not friable
Highly weathered	Weathering extends throughout rock mass, and the rock material is partly friable
Completely weathered	Rock is wholly decomposed and in a friable condition but the rock texture and structure are preserved
Residual Soil	A soil material with the original texture, structure, and mineralogy of the rock completely destroyed

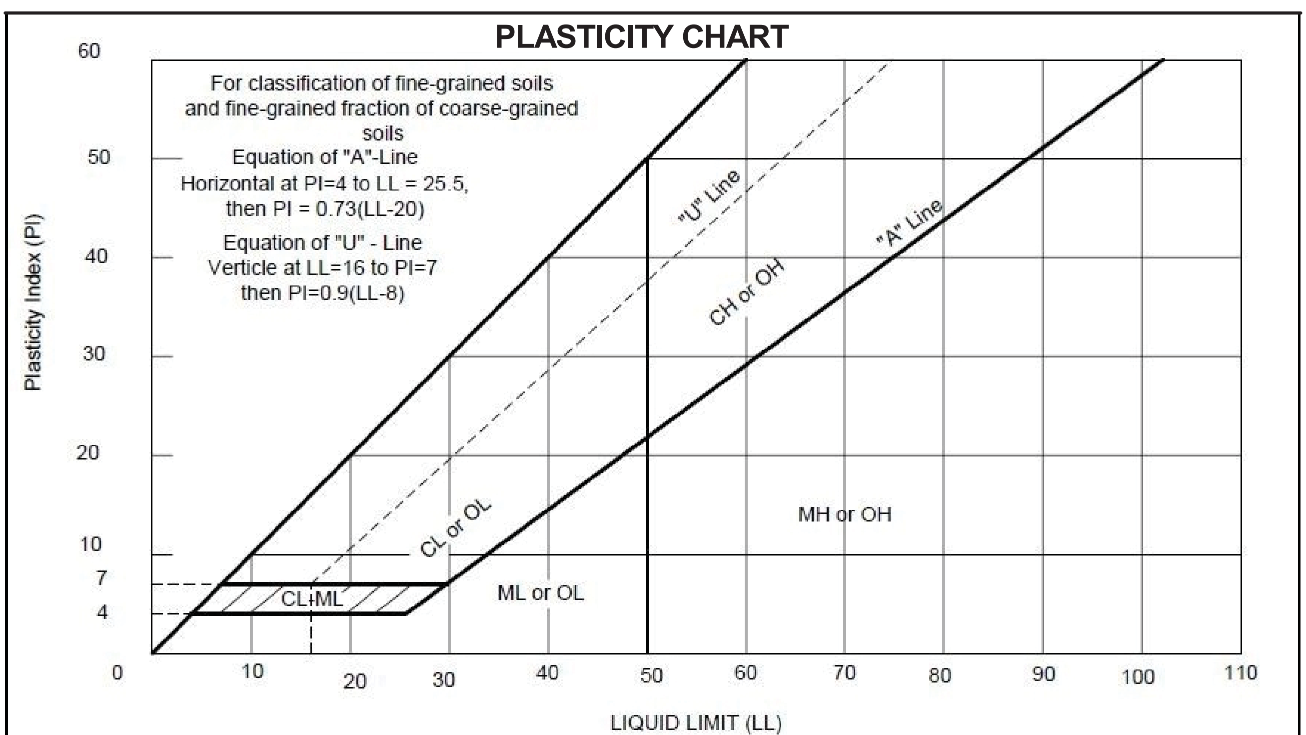
UNIFIED SOIL CLASSIFICATION SYSTEM

ADAPTED FROM ASTM D 2487

D&S ENGINEERING LABS

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS				GROUP SYMBOL	GROUP NAME
COARSE GRAINED SOILS MORE THAN 50% OF MATERIAL IS RETAINED ON THE NO. 200 SIEVE	GRAVELS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LESS THAN 5% FINES)	$Cu \geq 4 \text{ and } 1 \leq Cc \leq 3$	**GW**	WELL-GRADED GRAVEL
			$Cu < 4 \text{ and/or } [Cc < 1 \text{ or } Cc > 3]$	**GP**	POORLY-GRADED GRAVEL
		GRAVELS WITH FINES (MORE THAN 12% FINES)	Fines classify as ML or MH	**GM**	SILTY GRAVEL
			Fines classify as CL or CH	**GC**	CLAYEY GRAVEL
	SANDS MORE THAN 50% OF COARSE FRACTION PASSING THE NO. 4 SIEVE	CLEAN SANDS (LESS THAN 5% FINES)	$Cu \geq 6 \text{ and } 1 \leq Cc \leq 3$	**SW**	WELL-GRADED SAND
			$Cu < 6 \text{ and/or } [Cc < 1 \text{ or } Cc > 3]$	**SP**	POORLY-GRADED SAND
		SANDS WITH FINES (MORE THAN 12% FINES)	Fines classify as ML or MH	**SM**	SILTY SAND
			Fines classify as CL or CH	**SC**	CLAYEY SAND
FINE GRAINED SOILS MORE THAN 50% OF MATERIAL PASSES THROUGH 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
			PI < 4 or plots below "A" line	**ML**	SILT
		ORGANIC	$\frac{\text{Liquid limit} - \text{oven dried}}{\text{Liquid limit} - \text{not dried}} < 0.75$	**OL**	ORGANIC CLAY ORGANIC SILT
	SILTS AND CLAYS LIQUID LIMIT GREATER THAN 50	INORGANIC	PI plots on or above "A" line	**CH**	FAT CLAY
			PI plots below "A" line	**MH**	ELASTIC SILT
		ORGANIC	$\frac{\text{Liquid limit} - \text{oven dried}}{\text{Liquid limit} - \text{not dried}} < 0.75$	**OH**	ORGANIC CLAY ORGANIC SILT
HIGHLY ORGANIC SOILS	PRIMARILY ORGANIC MATTER, DARK IN COLOR, AND ORGANIC ODOR			**PT**	PEAT



BORING LOG

D&S ENGINEERING LABS

PROJECT: 20-Acre Single Family Development
CLIENT: B&H Companies, LLC
PROJECT NUMBER: G22-2111
START DATE: 5/11/2022 FINISH DATE: 5/11/2022
LOGGED BY: Dalton Hubbard (D&S)
LOCATION: Sherman, Texas
GPS COORDINATES: N33.672456, W96.585062
GROUND ELEVATION: Approx. 804 feet
DRILL METHOD: Cont. Flight Auger
DRILLED BY: Markevian Smith (D&S)

Legend:
- S-Shelby Tube
- N-Standard Penetration
- T-Texas Cone Penetration
- C-Core
- B-Bag Sample
- - Water Encountered

Depth (ft)	Sample Type	Hand Pen. (tsf) or SPT or TCP	Material Description	REC (%) RQD (%)	MC (%)	LL (%)	PL (%)	PI	Passing #200 Sieve (%)	Total Suction (pF)	Clay (%)	Swell (%)	DUW (pcf)	Unconf. Compr. Str (ksf)
0	S	2.0	**FAT CLAY (CH);** medium stiff to stiff; dark brown; trace to few calcareous nodules		26.5									
	S	1.5			36.0									
	S	1.5												
	S	1.5			33.6	67	26	41				0.1	81.2	
5	S	1.5	5.0 ft		34.4									
	T	17, 19	**LIMESTONE;** highly to completely weathered; very soft; tan, light brown; highly argillaceous (799.0 ft)											
	S	1.75			23.7								9.9	9.2
	S	4.5+												
	S	4.5+	9.0 ft											
10	T	50=3.25", 50=2.0"	**LIMESTONE;** slightly to moderately weathered; moderately hard to hard; tan, light brown; highly argillaceous (795.0 ft)											
15	T	50=1.5", 50=0.75"	15.2 ft											
			End of boring at 15.2' (788.8 ft)											

Notes:
-dry during drilling
-dry upon completion

Depth scale: 0, 5, 10, 15, 20, 25, 30, 35

BORING LOG

B2

D&S ENGINEERING LABS

PROJECT: 20-Acre Single Family Development
CLIENT: B&H Companies, LLC
PROJECT NUMBER: G22-2111
START DATE: 5/11/2022 FINISH DATE: 5/11/2022
LOGGED BY: Dalton Hubbard (D&S)

LOCATION: Sherman, Texas
GPS COORDINATES: N33.671737, W96.585559
GROUND ELEVATION: Approx. 812 feet
DRILL METHOD: Cont. Flight Auger
DRILLED BY: Markevian Smith (D&S)

Legend:
- S-Shelby Tube
- N-Standard Penetration
- T-Texas Cone Penetration
- C-Core
- B-Bag Sample
- ▽ - Water Encountered

Depth (ft)	Sample Type	Hand Pen. (tsf) or SPT or TCP	Graphic Log	Material Description	REC (%) RQD (%)	MC (%)	Atterberg Limits LL (%)	PL (%)	PI	Passing #200 Sieve (%)	Total Suction (pF)	Clay (%)	Swell (%)	DUW (pcf)	Unconf. Compr. Str (ksf)
0	S	4.5+		**FAT CLAY (CH);** very stiff; dark brown; trace to few calcareous nodules (1.0 ft, 811.0 ft)		31.7	63	32	31						
	S	3.25		**LIMESTONE;** highly to completely weathered; very soft; tan, light brown; highly argillaceous (3.5 ft, 808.5 ft)		30.6									
	S	4.5+				20.9									
	S	4.5+		**LIMESTONE;** slightly to moderately weathered; moderately hard to hard; tan, light brown; highly argillaceous											
5	T	50=3.25", 50=1.75"													
10	T	50=2.0", 50=1.5"													
15	T	50=1.75", 50=1.0"		(15.2 ft)											
				End of boring at 15.2' (796.8 ft)											
20															
25															
30															
35															

Notes:
-dry during drilling
-dry upon completion

BORING LOG

D&S ENGINEERING LABS

PROJECT: 20-Acre Single Family Development
CLIENT: B&H Companies, LLC
PROJECT NUMBER: G22-2111
START DATE: 5/11/2022 FINISH DATE: 5/11/2022
LOGGED BY: Dalton Hubbard (D&S)

LOCATION: Sherman, Texas
GPS COORDINATES: N33.672452, W96.586051
GROUND ELEVATION: Approx. 813 feet
DRILL METHOD: Cont. Flight Auger
DRILLED BY: Markevian Smith (D&S)

Legend:
- S-Shelby Tube
- N-Standard Penetration
- T-Texas Cone Penetration
- C-Core
- B-Bag Sample
- Water Encountered

Depth (ft)	Sample Type	Hand Pen. (tsf) or SPT or TCP	Graphic Log	Material Description	REC (%) RQD (%)	MC (%)	Atterberg Limits LL (%)	PL (%)	PI	Passing #200 Sieve (%)	Total Suction (pF)	Clay (%)	Swell (%)	DUW (pcf)	Unconf. Compr. Str (ksf)
0	S	1.5		**FAT CLAY (CH);** very stiff; dark brown; trace to few calcareous nodules (1.0 ft, 812.0 ft)		34.9									
	S	2.25				31.3	67	28	39						
	S	4.5+		**LIMESTONE;** highly to completely weathered; very soft; tan, light brown; highly argillaceous (3.5 ft, 809.5 ft)		21.2									
	S	4.5+		**LIMESTONE;** slightly to moderately weathered; moderately hard to hard; tan, light brown; highly argillaceous		15.8									
5	T	50=2.75", 50=1.0"													
10	T	50=1.75", 50=1.25"													
15	T	50=1.75", 50=1.0"		(15.2 ft, 797.8 ft) End of boring at 15.2'											

Notes:
-dry during drilling
-dry upon completion

BORING LOG

D&S ENGINEERING LABS

PROJECT: 20-Acre Single Family Development
CLIENT: B&H Companies, LLC
PROJECT NUMBER: G22-2111
START DATE: 5/11/2022 FINISH DATE: 5/11/2022
LOGGED BY: Dalton Hubbard (D&S)

LOCATION: Sherman, Texas
GPS COORDINATES: N33.671735, W96.586533
GROUND ELEVATION: Approx. 804 feet
DRILL METHOD: Cont. Flight Auger
DRILLED BY: Markevian Smith (D&S)

Legend:
- S-Shelby Tube
- N-Standard Penetration
- T-Texas Cone Penetration
- C-Core
- B-Bag Sample
- Water Encountered

Sample Type	Hand Pen. (tsf) or SPT or TCP	Description	REC (%) RQD (%)	MC (%)	Atterberg Limits LL (%)	PL (%)	PI	Passing #200 Sieve (%)	Total Suction (pF)	Clay (%)	Swell (%)	DUW (pcf)	Unconf. Compr. Str (ksf)
S	0.75	**FAT CLAY (CH);** very stiff; dark brown; trace to few calcareous nodules		37.8									
S	1.25			36.4	67	26	41						
S	1.25			35.4									
T	8, 18	6.5 ft / 797.5 ft											
S	4.5+	**LIMESTONE;** highly to completely weathered; very soft; tan, light brown; highly argillaceous		22.2	46	25	21					10.8	5.7
S	4.5+	10.0 ft / 794.0 ft		23.1									
T	50=3.0", 50=2.0"	**LIMESTONE;** slightly to moderately weathered; moderately hard to hard; tan, light brown; highly argillaceous											
T	50=1.25", 50=0.5"	15.2 ft / 788.8 ft											

End of boring at 15.2'

Notes:
-dry during drilling
-dry upon completion

BORING LOG

D&S ENGINEERING LABS

PROJECT: 20-Acre Single Family Development
CLIENT: B&H Companies, LLC
PROJECT NUMBER: G22-2111
START DATE: 5/10/2022 FINISH DATE: 5/10/2022
LOGGED BY: Dalton Hubbard (D&S)

LOCATION: Sherman, Texas
GPS COORDINATES: N33.673148, W96.586091
GROUND ELEVATION: Approx. 813 feet
DRILL METHOD: Cont. Flight Auger
DRILLED BY: Markevian Smith (D&S)

Legend:
- S-Shelby Tube
- N-Standard Penetration
- T-Texas Cone Penetration
- C-Core
- B-Bag Sample
- Water Encountered

Depth (ft)	Sample Type	Hand Pen. (tsf) or SPT or TCP	Material Description	REC (%) RQD (%)	MC (%)	LL (%)	PL (%)	PI	Passing #200 Sieve (%)	Total Suction (pF)	Clay (%)	Swell (%)	DUW (pcf)	Unconf. Compr. Str (ksf)
0	S	4.5+	**FAT CLAY (CH);** very stiff; dark brown; trace to few calcareous nodules (0.5 ft, 812.5 ft)		19.1	34	20	14						
	S	4.5+	**LIMESTONE;** highly to completely weathered; very soft to soft; tan, light brown; highly argillaceous		15.4									
	S	4.5+			18.9	40	22	18				0.1	100.9	
	S	4.5+			20.7									
5	S	4.5+												
	T	50=5.0", 50=5.0"	(7.0 ft)											
			LIMESTONE; moderately to highly weathered; moderately hard; tan, light brown; highly argillaceous (806.0 ft)											
10	T	50=3.0", 50=1.0"												
15	T	50=3.0", 50=1.0"	(15.3 ft, 797.7 ft) End of boring at 15.3'											

Notes:
-dry during drilling
-dry upon completion

BORING LOG

D&S ENGINEERING LABS

PROJECT: 20-Acre Single Family Development
CLIENT: B&H Companies, LLC
PROJECT NUMBER: G22-2111
START DATE: 5/12/2022 FINISH DATE: 5/12/2022
LOGGED BY: Dalton Hubbard (D&S)
LOCATION: Sherman, Texas
GPS COORDINATES: N33.673892, W96.585123
GROUND ELEVATION: Approx. 813 feet
DRILL METHOD: Cont. Flight Auger
DRILLED BY: Markevian Smith (D&S)

Legend:
- S-Shelby Tube
- N-Standard Penetration
- T-Texas Cone Penetration
- C-Core
- B-Bag Sample
- ∇ - Water Encountered

Depth (ft)	Sample Type	Hand Pen. (tsf) or SPT or TCP	Graphic Log	Material Description	REC (%) RQD (%)	MC (%)	Atterberg Limits LL (%)	PL (%)	PI	Passing #200 Sieve (%)	Total Suction (pF)	Clay (%)	Swell (%)	DUW (pcf)	Unconf. Compr. Str (ksf)
0	S	3.0		**FAT CLAY (CH);** very stiff; dark brown; trace to few calcareous nodules		34.4									
	S	3.5		2.0 ft / 811.0 ft		34.2	76	34	42				0.5	78.3	
	S	4.5+		**LIMESTONE;** highly to completely weathered; very soft; tan, light brown; highly argillaceous		31.0									
	S	4.5+		4.0 ft / 809.0 ft		25.8	47	25	22						
5	T	50=1.5", 50=0.5"		**LIMESTONE;** moderately to highly weathered; medium hard to hard; tan, light brown; highly argillaceous											
10	T	50=1.75", 50=0.75"													
15	T	50=2.5", 50=1.0"		15.3 ft / 797.7 ft											
				End of boring at 15.3'											

Notes:
-dry during drilling
-dry upon completion

Depth scale: 0, 5, 10, 15, 20, 25, 30, 35

BORING LOG

D&S ENGINEERING LABS

PROJECT: 20-Acre Single Family Development
CLIENT: B&H Companies, LLC
PROJECT NUMBER: G22-2111
START DATE: 5/10/2022 FINISH DATE: 5/10/2022
LOGGED BY: Dalton Hubbard (D&S)
LOCATION: Sherman, Texas
GPS COORDINATES: N33.673963, W96.586102
GROUND ELEVATION: Approx. 817 feet
DRILL METHOD: Cont. Flight Auger
DRILLED BY: Markevian Smith (D&S)

Legend: S-Shelby Tube; N-Standard Penetration; T-Texas Cone Penetration; C-Core; B-Bag Sample; ▽ - Water Encountered

Depth (ft)	Sample Type	Hand Pen. (tsf) or SPT or TCP	Material Description	REC (%) RQD (%)	MC (%)	LL (%)	PL (%)	PI	Passing #200 Sieve (%)	Total Suction (pF)	Clay (%)	Swell (%)	DUW (pcf)	Unconf. Compr. Str (ksf)
0	S	3.5	**FAT CLAY (CH);** very stiff; dark brown; trace to few calcareous nodules		28.1									
	S	3.75	1.5 ft / 815.5 ft		24.1	48	22	26				0.4	92.4	
	S	4.5+	**LIMESTONE;** highly to completely weathered; very soft; tan, light brown; highly argillaceous		22.9									
	S	4.5+			25.3									
	S	4.5+			29.4									
5	T	38, 50												
	S	4.5+	6.5 ft / 810.5 ft											
			LIMESTONE; slightly to moderately weathered; moderately hard to hard; tan, light brown; highly argillaceous											
10	T	50=3.5", 50=1.0"												
15	T	50=0.5", 50=0"	15.1 ft / 801.9 ft End of boring at 15.1'											
20														
25														
30														
35														

Notes:
-dry during drilling
-dry upon completion

BORING LOG

PROJECT: 20-Acre Single Family Development
CLIENT: B&H Companies, LLC
PROJECT NUMBER: G22-2111
START DATE: 5/12/2022 FINISH DATE: 5/12/2022
LOGGED BY: Dalton Hubbard (D&S)

LOCATION: Sherman, Texas
GPS COORDINATES: N33.673793, W96.587075
GROUND ELEVATION: Approx. 814 feet
DRILL METHOD: Cont. Flight Auger
DRILLED BY: Markevian Smith (D&S)

Legend:
- S-Shelby Tube
- N-Standard Penetration
- T-Texas Cone Penetration
- C-Core
- B-Bag Sample
- Water Encountered

Depth (ft)	Sample Type	Hand Pen. (tsf) or SPT or TCP	Description	Depth / Elev.	REC (%) RQD (%)	MC (%)	LL (%)	PL (%)	PI	Passing #200 Sieve (%)	Total Suction (pF)	Clay (%)	Swell (%)	DUW (pcf)	Unconf. Compr. Str (ksf)
0	S	4.5+	**FAT CLAY (CH);** very stiff; dark brown; trace to few calcareous nodules	0.5 ft / 813.5 ft		26.8	63	32	31						
	T	50=2.5", 50=1.0"	**LIMESTONE;** highly to completely weathered; very soft; tan, light brown; highly argillaceous	1.5 ft / 812.5 ft											
5	T	50=2.25", 50=0.75"	**LIMESTONE;** moderately to highly weathered; medium to moderately hard; tan, light brown; highly argillaceous												
10	T	50=1.75", 50=1.0"	End of boring at 10.2'	10.2 ft / 803.8 ft											

Notes:
-dry during drilling
-dry upon completion

BORING LOG

D&S ENGINEERING LABS

PROJECT: 20-Acre Single Family Development
LOCATION: Sherman, Texas
CLIENT: B&H Companies, LLC
GPS COORDINATES: N33.673080, W96.586990
PROJECT NUMBER: G22-2111
GROUND ELEVATION: Approx. 810 feet
START DATE: 5/10/2022 FINISH DATE: 5/10/2022
DRILL METHOD: Cont. Flight Auger
LOGGED BY: Dalton Hubbard (D&S)
DRILLED BY: Markevian Smith (D&S)

Legend:
- S-Shelby Tube
- N-Standard Penetration
- T-Texas Cone Penetration
- C-Core
- B-Bag Sample
- Water Encountered

Sample Type	Hand Pen. (tsf) or SPT or TCP	Material Description	REC (%) RQD (%)	MC (%)	LL (%)	PL (%)	PI	Passing #200 Sieve (%)	Total Suction (pF)	Clay (%)	Swell (%)	DUW (pcf)	Unconf. Compr. Str (ksf)
S	3.75	**FAT CLAY (CH);** very stiff; dark brown; trace to few calcareous nodules (to 1.5 ft, 808.5 ft)		28.1	58	27	31						
S	4.5+	**LIMESTONE;** highly to completely weathered; very soft; tan, light brown; highly argillaceous		22.2									
S	4.5+												
S	4.5+			24.7	53	29	24				0.0	91.3	
S	4.5+			26.9								99.2	3.3
T	25, 20												
S	4.5+	(to 8.0 ft, 802.0 ft)		19.0									
T	50=5.0", 50=4.0"	**LIMESTONE;** moderately to highly weathered; soft to medium hard; tan, light brown; highly argillaceous											
T	50=4.0", 50=1.0"	(to 15.4 ft, 794.6 ft)											

End of boring at 15.4'

Notes:
-dry during drilling
-dry upon completion

BORING LOG

B10

D&S ENGINEERING LABS

PROJECT: 20-Acre Single Family Development
CLIENT: B&H Companies, LLC
PROJECT NUMBER: G22-2111
START DATE: 5/12/2022 FINISH DATE: 5/12/2022
LOGGED BY: Dalton Hubbard (D&S)
LOCATION: Sherman, Texas
GPS COORDINATES: N33.673172, W96.585101
GROUND ELEVATION: Approx. 816 feet
DRILL METHOD: Cont. Flight Auger
DRILLED BY: Markevian Smith (D&S)

Legend:
- S-Shelby Tube
- N-Standard Penetration
- T-Texas Cone Penetration
- C-Core
- B-Bag Sample
- ▽ - Water Encountered

Depth (ft)	Sample Type	Hand Pen. (tsf) or SPT or TCP	Material Description	REC (%) RQD (%)	MC (%)	Atterberg Limits LL (%)	Atterberg Limits PL (%)	Atterberg Limits PI	Passing #200 Sieve (%)	Total Suction (pF)	Clay (%)	Swell (%)	DUW (pcf)	Unconf. Compr. Str (ksf)
0	S	4.5+	**FAT CLAY (CH);** very stiff; dark brown; trace to few calcareous nodules		32.1									
	S	4.5+			25.2	58	25	33				0.2	88.3	
2.0	S	4.5+	**LIMESTONE;** highly to completely weathered; very soft; tan, light brown; highly argillaceous (2.0 ft / 814.0 ft)		17.6									
4.0			**LIMESTONE;** moderately to highly weathered; soft to medium hard; tan, light brown; highly argillaceous (4.0 ft / 812.0 ft)											
5	T	50=5.0", 50=1.25"												
10	T	50=2.0", 50=0.75"												
15	T	50=3.5", 50=3.25"	15.5 ft / 800.5 ft											

End of boring at 15.5'

Notes:
-dry during drilling
-dry upon completion

BORING LOG

D&S ENGINEERING LABS

PROJECT: 20-Acre Single Family Development
CLIENT: B&H Companies, LLC
PROJECT NUMBER: G22-2111
START DATE: 5/10/2022 FINISH DATE: 5/10/2022
LOGGED BY: Dalton Hubbard (D&S)
LOCATION: Sherman, Texas
GPS COORDINATES: N33.672122, W96.586295
GROUND ELEVATION: Approx. 812 feet
DRILL METHOD: Cont. Push
DRILLED BY: Markevian Smith (D&S)

Legend:
- S-Shelby Tube
- N-Standard Penetration
- T-Texas Cone Penetration
- C-Core
- B-Bag Sample
- Water Encountered

Depth (ft)	Sample Type	Hand Pen. (tsf) or SPT or TCP	Graphic Log	Material Description	REC (%) RQD (%)	MC (%)	Atterberg Limits LL (%)	PL (%)	PI	Passing #200 Sieve (%)	Total Suction (pF)	Clay (%)	Swell (%)	DUW (pcf)	Unconf. Compr. Str (ksf)
0	S	3.5		**FAT CLAY (CH);** very stiff; dark brown; trace to few calcareous nodules (1.5 ft, 810.5 ft)		28.8	68	31	37						
	S	4.5+		**LIMESTONE;** highly to completely weathered; very soft; tan, light brown; highly argillaceous		25.5									
	S	4.5+				25.1									
	S	4.5+				19.0									
5	S	4.5+				17.6									
	S	4.5+													
	S	4.5+													
	T	30, 50		(7.5 ft, 804.5 ft)											

End of boring at 7.5' (804.5 ft)

Notes:
-dry during drilling
-dry upon completion

Depth scale: 0, 5, 10, 15, 20, 25, 30, 35

BORING LOG

P2

D&S ENGINEERING LABS

PROJECT: 20-Acre Single Family Development
CLIENT: B&H Companies, LLC
PROJECT NUMBER: G22-2111
START DATE: 5/11/2022 FINISH DATE: 5/11/2022
LOGGED BY: Dalton Hubbard (D&S)

LOCATION: Sherman, Texas
GPS COORDINATES: N33.673425, W96.586769
GROUND ELEVATION: Approx. 804 feet
DRILL METHOD: Cont. Push
DRILLED BY: Markevian Smith (D&S)

Legend:
- S-Shelby Tube
- N-Standard Penetration
- T-Texas Cone Penetration
- C-Core
- B-Bag Sample
- Water Encountered

Depth (ft)	Sample Type	Hand Pen. (tsf) or SPT or TCP	Description	REC (%) RQD (%)	MC (%)	Atterberg Limits LL (%)	PL (%)	PI	Passing #200 Sieve (%)	Total Suction (pF)	Clay (%)	Swell (%)	DUW (pcf)	Unconf. Compr. Str (ksf)
0–6.0	S	2.25	**FAT CLAY (CH);** medium stiff to stiff; dark brown; trace to few calcareous nodules		30.0									
	S	2.0			31.1									
	S	1.75			27.7	63	28	35						
5	S	1.75												
	S	4.5+	6.0 ft		28.0									
6.0–10.0			**LIMESTONE;** highly to completely weathered; very soft; tan, light brown; highly argillaceous (798.0 ft)											
	S	4.5+												
10	S	2.0	10.0 ft											
			End of boring at 10.0' (794.0 ft)											

Notes:
-dry during drilling
-dry upon completion

BORING LOG

D&S ENGINEERING LABS

PROJECT: 20-Acre Single Family Development
CLIENT: B&H Companies, LLC
PROJECT NUMBER: G22-2111
START DATE: 5/12/2022 FINISH DATE: 5/12/2022
LOGGED BY: Dalton Hubbard (D&S)

LOCATION: Sherman, Texas
GPS COORDINATES: N33.672819, W96.585327
GROUND ELEVATION: Approx. 814 feet
DRILL METHOD: Cont. Flight Auger
DRILLED BY: Markevian Smith (D&S)

Legend:
- S-Shelby Tube
- N-Standard Penetration
- T-Texas Cone Penetration
- C-Core
- B-Bag Sample
- Water Encountered

Depth (ft)	Sample Type	Hand Pen. (tsf) or SPT or TCP	Graphic Log	Material Description	REC (%) RQD (%)	MC (%)	Atterberg Limits LL (%)	PL (%)	PI	Passing #200 Sieve (%)	Total Suction (pF)	Clay (%)	Swell (%)	DUW (pcf)	Unconf. Compr. Str (ksf)
0	S	3.0		**FAT CLAY (CH);** stiff to very stiff; dark brown; trace to few calcareous nodules (0.5 ft, 813.5 ft)		27.3	60	27	33						
	S	4.5+				34.7									
	T	50=4.0", 50=1.5"		**LIMESTONE;** highly to completely weathered; very soft; tan, light brown; highly argillaceous (2.0 ft, 812.0 ft)											
5	T	50=3.25", 50=1.5"		**LIMESTONE;** slightly to moderately weathered; medium hard to hard; tan, light brown; highly argillaceous											
10	T	50=1.0", 50=0.5"		(10.1 ft, 803.9 ft) End of boring at 10.1'											
15															
20															
25															
30															
35															

Notes:
-dry during drilling
-dry upon completion

BORING LOG

D&S ENGINEERING LABS

PROJECT: 20-Acre Single Family Development
CLIENT: B&H Companies, LLC
PROJECT NUMBER: G22-2111
START DATE: 5/10/2022 FINISH DATE: 5/10/2022
LOGGED BY: Dalton Hubbard (D&S)
LOCATION: Sherman, Texas
GPS COORDINATES: N33.672475, W96.586961
GROUND ELEVATION: Approx. 804 feet
DRILL METHOD: Cont. Flight Auger
DRILLED BY: Markevian Smith (D&S)

Legend:
- S-Shelby Tube
- N-Standard Penetration
- T-Texas Cone Penetration
- C-Core
- B-Bag Sample
- ▽ - Water Encountered

Depth (ft)	Sample Type	Hand Pen. (tsf) or SPT or TCP	Graphic Log	Material Description	REC (%) RQD (%)	MC (%)	LL (%)	PL (%)	PI	Passing #200 Sieve (%)	Total Suction (pF)	Clay (%)	Swell (%)	DUW (pcf)	Unconf. Compr. Str (ksf)
0	S	2.5		**FAT CLAY (CH);** very stiff; dark brown; trace to few calcareous nodules		37.5									
	S	2.75													
	S	3.0		3.0 ft		26.1	63	26	37						
	S	4.5+		**LIMESTONE;** highly to completely weathered; very soft; tan, light brown; highly argillaceous (801.0 ft)											
5	S	4.5+				26.6									
	S	4.5+													
	S	4.5+				26.8									
	S	4.5+													
	S	4.5+		8.5 ft		21.1									
10				**LIMESTONE;** slightly to moderately weathered; medium to moderately hard; tan, light brown; highly argillaceous (795.5 ft)											
	T	50=3.0", 50=2.0"													
15	T	50=1.5", 50=1.0"		15.2 ft											
				End of boring at 15.2' (788.8 ft)											

Notes:
-dry during drilling
-dry upon completion

D&S ENGINEERING LABS

BORING LOG

S2

PROJECT: 20-Acre Single Family Development
CLIENT: B&H Companies, LLC
PROJECT NUMBER: G22-2111
START DATE: 5/10/2022 FINISH DATE: 5/10/2022
LOGGED BY: Dalton Hubbard (D&S)
LOCATION: Sherman, Texas
GPS COORDINATES: N33.671787, W96.587872
GROUND ELEVATION: Approx. 796 feet
DRILL METHOD: Cont. Flight Auger
DRILLED BY: Markevian Smith (D&S)

Legend:
- S-Shelby Tube
- N-Standard Penetration
- T-Texas Cone Penetration
- C-Core
- B-Bag Sample
- Water Encountered

Depth (ft)	Sample Type	Hand Pen. (tsf) or SPT or TCP	Description	REC (%) RQD (%)	MC (%)	LL (%)	PL (%)	PI	Passing #200 Sieve (%)	Total Suction (pF)	Clay (%)	Swell (%)	DUW (pcf)	Unconf. Compr. Str (ksf)
0	S	2.0	**FAT CLAY (CH);** very stiff; dark brown; trace to few calcareous nodules		29.7									
	S	2.0												
	S	2.0			38.8	73	32	41						
	S	2.0			37.1									
5	S	1.75	5.0 ft		33.9									
	S	4.5+	**LIMESTONE;** highly to completely weathered; very soft; tan, light brown; highly argillaceous (791.0 ft)											
	S	4.5+			21.2									
	S	4.5+	8.0 ft											
			LIMESTONE; moderately to highly weathered; soft to medium hard; tan, light brown; highly argillaceous (788.0 ft)											
10	T (water encountered)	50=3.0", 50=2.0"												
15	T (water encountered)	50=6.0", 50=3.5"	15.8 ft											
			End of boring at 15.8' (780.2 ft)											

Notes:
-seepage at 7 feet during drilling
-water at 10 feet upon completion

SOLUBLE SULFATE CONTENT RESULTS

TEX 145-E

D&S ENGINEERING LABS

PROJECT: 20-Acre Single Family Development | PROJECT NUMBER: G22-2111

CLIENT: B&H Companies, LLC | LOCATION: Sherman, Texas

Boring Number:	Depth (feet):	Soil Description	Soluble Sulfate Content (ppm)
B3	0-1	**FAT CLAY (CH);** very stiff; dark brown; trace to few calcareous nodules	100
P1	0-1	**FAT CLAY (CH);** very stiff; dark brown; trace to few calcareous nodules	<100
P2	0-1	**FAT CLAY (CH);** very stiff; dark brown; trace to few calcareous nodules	<100
P3	0-1	**FAT CLAY (CH);** very stiff; dark brown; trace to few calcareous nodules	113

SWELL TEST RESULTS

D&S ENGINEERING LABS

PROJECT: 20-Acre Single Family Development

CLIENT: B&H Companies, LLC

PROJECT NUMBER: G22-2111

LOCATION: Sherman, Texas

Boring Number	Depth feet	Initial Moisture Content, %	Final Moisture Content, %	Applied Pressure, psf	Vertical Swell, %
B1	3-4	33.6	38.0	390	0.1
B10	1-2	25.2	29.5	130	0.2
B5	2-3	18.9	23.0	260	0.1
B6	1-2	34.2	38.0	129	0.5
B7	1-2	24.1	28.3	129	0.4
B9	3-4	24.7	30.1	394	0.0

APPENDIX B - GENERAL DESCRIPTION OF PROCEDURES

ANALYTICAL METHODS TO PREDICT MOVEMENT

CLASSIFICATION TESTS

Classification testing is perhaps the most basic, yet fundamental tool available for predicting potential movements of clay soils. Classification testing typically consists of moisture content, Atterberg Limits, and Grain-size distribution determinations. From these results a general assessment of a soil's propensity for volume change with changes in soil moisture content can be made.

Moisture Content

By studying the moisture content of the soils at varying depths and comparing them with the results of Atterberg Limits, one can estimate a rough order of magnitude of potential soil movement at various moisture contents, as well as movements with moisture changes. These tests are typically performed in accordance with ASTM D2216.

Atterberg Limits

Atterberg limits determine the liquid limit (LL), plastic limit (PL), and plasticity index (PI) of a soil. The liquid limit is the moisture content at which a soil begins to behave as a viscous fluid. The plastic limit is the moisture content at which a soil becomes workable like putty, and at which a clay soil begins to crumble when rolled into a thin thread (1/8" diameter). The PI is the numerical difference between the moisture constants at the liquid limit and the plastic limit. This test is typically performed in accordance with ASTM D4318.

Clay mineralogy and the particle size influence the Atterberg Limits values, with certain minerals (e.g., montmorillonite) and smaller particle sizes having higher PI values, and therefore higher movement potential.

A soil with a PI below about 15 to 18 is considered to be generally stable and should not experience significant movement with changes in moisture content. Soils with a PI above about 30 to 35 are considered to be highly active and may exhibit considerable movement with changes in moisture content.

Fat clays with very high liquid limits, weakly cemented sandy clays, or silty clays are examples of soils in which it can be difficult to predict movement from classification testing alone.

Grain-size Distribution

The simplest grain-size distribution test involves washing a soil specimen over the No. 200 mesh sieve with an opening size of 0.075 mm (ASTM D1140). This particle size has been defined by the engineering community as the demarcation between coarse-grained and fine-grained soils. Particles smaller than this size can be further distinguished between silt-size and clay-size particles by use of a Hydrometer test (ASTM D422). A more complete grain-size distribution test that uses sieves to relative amount of particles according is the Sieve Gradation Analysis of Soils (ASTM D6913). Once the characteristics of the soil are determined through classification testing, a number of movement prediction techniques are available to predict the potential movement of the soils. Some of these are discussed in general below.

TEXAS DEPARTMENT OF TRANSPORTATION METHOD 124-E

The Texas Department of Transportation (TxDOT) has developed a generally simplistic method to predict movements for highways based on the plasticity index of the soil. The TxDOT method is empirical and is based on the Atterberg limits and moisture content of the subsurface soil. This method generally assumes three different initial moisture conditions: dry, “as-is”, and wet. Computation of each over an assumed depth of seasonal moisture variation (usually about 15 feet or less) provides an estimate of potential movement at each initial condition. This method requires a number of additional assumptions to develop a potential movement estimate. As such, the predicted movements generally possess large uncertainties when applied to the analysis of conditions under building slabs and foundations. In our opinion, estimates derived by this method should not be used alone in determination of potential movement.

SWELL TESTS

Swell tests can lead to more accurate site-specific predictions of potential vertical movement by measuring actual swell volumes at in situ initial moisture contents. One-dimensional swell tests are almost always performed for this measurement. Though swell is a three-dimensional process, the one-dimensional test provides greatly improved potential vertical movement estimates than other methods alone, particularly when the results are “weighted” with respect to depth, putting more emphasis on the swell characteristics closer to the surface and less on values at depth.

POTENTIAL VERTICAL MOVEMENT

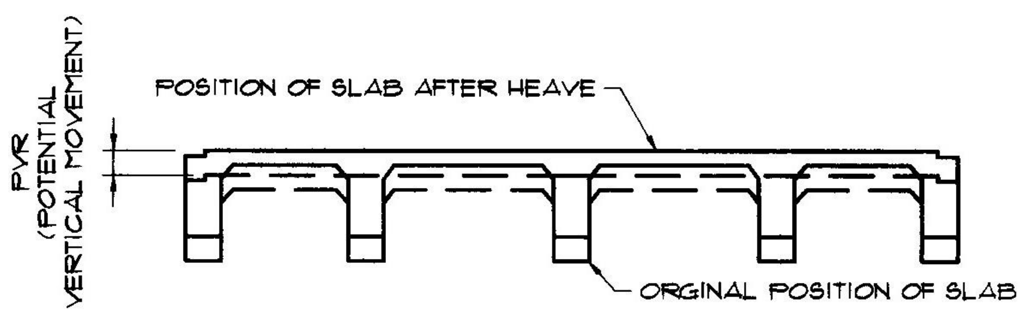
A general index for movement is known as the Potential Vertical Rise (PVR). The actual term PVR refers to the TxDOT Method 124-E mentioned above. For the purpose of this report the term Potential Vertical Movement (PVM) will be used since PVM estimates are derived using multiple analytical techniques, not just TxDOT methods.

It should be noted that all slabs and foundations constructed on clay or clayey soils have at least some risk of potential vertical movement due to changes in soil moisture contents. To eliminate that risk, slabs, and foundation elements (e.g., grade beams) should be designed as structural elements physically separated by some distance from the subgrade soils (usually 6 to 12 inches).

In some cases, a floor slab with movements as little as 1/4 of an inch may result in damage to interior walls, such as cracking in sheet rock or masonry walls, or separation of floor tiles. However, these cracks are often minor, and most people consider them 'livable'. In other cases, movement of one inch may cause significant damage, inconvenience, or even create a hazard (trip hazard or others).

Vertical movement of clay soils under slab on grade foundations due to soil moisture changes can result from a variety of causes, including poor site grading and drainage, improperly prepared subgrade, trees, and large shrubbery located too close to structures, utility leaks or breaks, poor subgrade maintenance such as inadequate or excessive irrigation, or other causes. A sampling of more common moisture control procedures to reduce the potential for movement due to these causes is presented in Appendix B.

PVM is generally considered to be a measurement of the change in height of a foundation from the elevation it was originally placed. Experience and generally accepted practice suggest that if the PVM of a site is less than one inch, the associated differential movement will be minor and acceptable to most people.



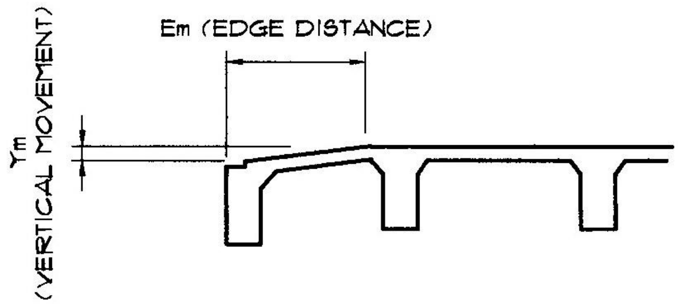
POTENTIAL VERTICAL RISE

SETTLEMENT

Settlement is a measure of a downward movement due to consolidation of soil. This can occur from improperly placed fill (uncompacted or under-compacted), loose native soil, or from large amounts of unconfined sandy material. Properly compacted fill may settle approximately 1 percent of its depth, particularly when fill depths exceed 10 feet.

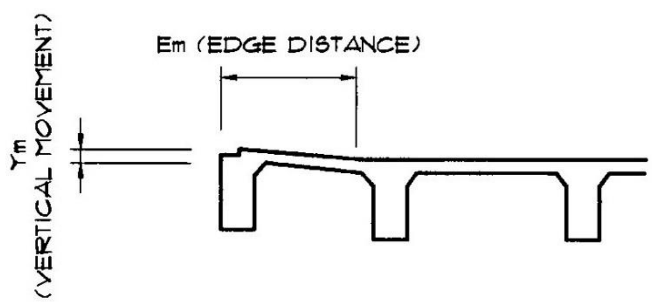
EDGE AND CENTER LIFT MOVEMENT (y_m)

The Post-Tensioning Institute (PTI) has developed a parameter of movement defined as the differential movement (y_m) estimated using the change in soil surface elevation in two locations separated by a distance e_m within which the differential movement will occur; e_m being measured from the exterior of a building to some distance toward the interior. All calculations for this report are based on the modified PTI procedure in addition to our judgment as necessary for specific site conditions. The minimum movements given in the PTI are for climatic conditions only and have been modified somewhat to account for site conditions which may increase the actual parameters.



CENTER LIFT PARAMETERS

"Center lift" occurs when the center, or some portion of the center of the building, is higher than the exterior. This can occur when the soil around the exterior shrinks, or the soil under the center of the building swells, or a combination of both occurs.



EDGE LIFT PARAMETERS

"Edge lift" occurs when the edge, or some portion of the exterior of the building, is higher than the center. This can occur when the soil around the exterior swells. It is not uncommon to have both the center lift and the edge lift phenomena occurring on the same building, in different areas.

SPECIAL COMMENTARY ON CONCRETE AND EARTHWORK

RESTRAINT TO SHRINKAGE CRACKS

One of the characteristics of concrete is that during the curing process shrinkage occurs and if there are any restraints to prevent the concrete from shrinking, cracks can form. In a typical slab on grade or structurally suspended foundation there will be cracks due to interior beams and piers that restrict shrinkage. This restriction is called Restraint to Shrinkage (RTS). In post tensioned slabs, the post tensioning strands are slack when installed and must be stressed at a later time. The best procedure is to stress the cables approximately 30% within one to two days of placing the concrete. Then the cables are stressed fully when the concrete reaches greater strength, usually in 7 days. During this time before the cables are stressed fully, the concrete may crack more than conventionally reinforced slabs. When the cables are stressed, some of the cracks will pull together. These RTS cracks do not normally adversely affect the overall performance of the foundation. It should be noted that for exposed floors, especially those that will be painted, stained, or stamped, these cracks may be aesthetically unacceptable. Any tile which is applied directly to concrete or over a mortar bed over concrete has a high probability of minor cracks occurring in the tile due to RTS. It is recommended if tile is used to install expansion joints in appropriate locations to minimize these cracks.

UTILITY TRENCH EXCAVATION

Trench excavation for utilities should be sloped or braced in the interest of safety. Attention is drawn to OSHA Safety and Health Standards (29 CFR 1926/1910), Subpart P, regarding trench excavations greater than 5 feet in depth.

FIELD SUPERVISION AND DENSITY TESTING

Field density and moisture content determinations should be made on each lift of fill at a frequency of one (1) test per lift per 3,000 square feet of building pad area, with a minimum of one (1) test per lift per building pad, one (1) test per lift per 100 linear feet of grade beam perimeter backfill, one (1) test per lift per 100 linear feet of utility trench backfill, and one (1) test per lift per 100 linear feet of roadway subgrade and base. Supervision by the field technician and the project engineer is required. Some adjustments in the test frequencies may be required based upon the general fill types and soil conditions at the time of fill placement.

It is recommended that all site and subgrade preparation, proof rolling, and pavement construction be monitored by a qualified engineering firm. Density tests should be performed to verify proper compaction and moisture content of any earthwork. Inspection should be performed prior to and during concrete placement operations. D&S would be pleased to assist you on this project.

14805 Trinity Boulevard, Fort Worth, Texas 76155
Geotechnical 817.529.8464   Corporate 903.420.0014
www.dsenglabs.com
Texas Engineering Firm Registration # F-12796
Oklahoma Engineering Firm Certificate of Authorization CA 7181

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