GEOTECHNICAL STUDY
FOR THE
PROPOSED NEW RESIDENCE AT
1107 GROVEWOOD LANE
HOUSTON, TEXAS 77018

PREPARED FOR

MR. DREW MCDANIEL
STONE THROW SOLUTIONS
HOUSTON, TEXAS

PREPARED BY

ARM SOIL TESTING LLC
CYPRESS, TEXAS

PROJECT NO: G23-279

April 28, 2023

ARM SOIL TESTING LLC
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April 28, 2023
Project Number: G23-279

Mr. Drew McDaniel
Stone Throw Solutions
448 West 19th Street, #732
Houston, Texas 77008

Reference: GEOTECHNICAL INVESTIGATIONS FOR THE PROPOSED NEW RESIDENCE AT GROVEWOOD LANE IN HOUSTON, TEXAS

Dear Mr. McDaniel:

ARM Soil Testing LLC is pleased to submit the results of the geotechnical exploration study for the above-referenced project. This report briefly presents the findings of the study along with our conclusions and recommendations for the design of the foundation for the proposed new residence at Grovewood Lane in Houston, Texas.

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

Should you have any questions regarding this report, please do not hesitate to email us at info@armsoiltesting.com or call us at (832) 593-7510 at any time.

Respectfully submitted,

ARM SOIL TESTING LLC

Sam Mohammad
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INTRODUCTION

Planning is underway for construction of a new residence at 1107 Grovewood Lane in Houston, Texas. Information on this project was supplied by the client. The project consists of a new residential house. Structural details such as column and wall loads are not known at this time but are not expected to exceed 50 kips and 2.0 kips per foot.

PURPOSE AND SCOPE

A geotechnical study was performed for the purposes of (1) exploring the subsurface conditions of the site (2) evaluating the pertinent engineering properties of the subsurface materials (3) providing recommendations concerning suitable types of foundation systems for support of the planned structure and (4) providing geotechnical construction guidelines.

Analyses of slope stability, bulkhead or any other features at the site is not within the scope of this investigation and, therefore, ARM is not responsible for any problems caused by these features. The settlement analysis was not within the scope of this study.

Narrative descriptions of our findings and recommendations are contained in the body of the report. A Boring Location Plan and the boring logs are included in Plates 1 through 4 of the report.

SUBSURFACE EXPLORATION

Conditions at this site were explored with two (2) borings located approximately as shown on the Location of Borings plan found in the Plate 1 of this report. The borings were drilled to the depths of 20 and 15 feet each below existing site grades on April 20, 2023. After the soil samples were obtained and the borings completed, final groundwater levels were measured in the boreholes and they were backfilled with soil cuttings prior to leaving the site.

Undisturbed and disturbed sampling procedures were performed at selected depths during the field exploration phase to obtain samples for laboratory testing and stratigraphy identification. Three-inch diameter thin-wall tube samplers for cohesive materials and two-inch diameter split samplers for cohensionless soils were utilized to obtain undisturbed samples. Thin-wall tube samples were mechanically extruded in the field, visually classified, labeled according to boring number and depth, then packaged in protective boxes for transport back to the laboratory.

LABORATORY TESTING

Upon completion of drilling operations, the soil samples were transported to the laboratory for testing and further study. The laboratory testing was performed in order to evaluate the strengths, classifications and volume change characteristics of the major soil strata. Atterberg limits tests and minus 200 sieve analyses were performed using selected soil samples to determine the index properties of the subsurface materials. Results of laboratory classification tests, in-situ moisture contents and strength tests are presented on the boring log included in the Appendix of the report.

SITE CONDITIONS

Site Description

The project site is relatively flat. An existing house was located at the project site. Evaluations of the existing house are beyond the scope of this investigation. All trees and root system within the building and pavement area should be removed and the soils compacted as specified in the report.

Soil Stratigraphy

The subsurface conditions present at the boring location are presented on the Log of Borings. A summary of the various strata and their approximate depths and thicknesses which were encountered in the borings are presented on the following TABLE 1. SUMMARY OF SUBSURFACE CONDITIONS. Note that depths on the log and in the following table are referenced from the ground surface, which existed at the time of the field exploration.

TABLE 1
SUMMARY OF SUBSURFACE CONDITIONS

	Description	First Encountered (ft)	Bottom of Stratum (ft)
SANDY CLAY (CL)	Firm to very stiff gray to gray and tan to light gray and tan sandy clays	Ground Surface	6
CLAY (CH)	Stiff to very stiff light gray and tan clays	6	16
SAND (SP)	Medium dense light gray sand	16	20

The sandy clays of stratum I are considered moderate clays. The sandy clays are moderate to high plastic with plasticity indices ranging from of 27 to 29. The sandy clays are firm to very stiff in consistency.

The clays of stratum II are considered fat clays. The clays are highly plastic with plasticity indices ranging from of 31 to 39. **These soils are considered expansive** and have very high potential for shrink and swell movements that are usually associated with changes in soil moisture content. The clays are stiff to very stiff in consistency.

The sands of stratum III are medium dense. The Standard Penetration Test (SPT) count is 13 blows per foot.

The above subsurface description is of a generalized nature to highlight the major subsurface stratification features and materials characteristics. The boring logs included in Plates 2 through 4 should be reviewed for specific information at the boring locations. These records include soil /rock descriptions, stratifications, penetration resistances, and locations of the samples and laboratory test data. The stratifications shown on the boring logs represent the conditions only at the actual boring location.

Groundwater Conditions

The borings were monitored at the time of drilling for evidence of groundwater. At the time of drilling, groundwater was encountered at 12 feet and final reading at 10 feet. Excavations for footings may encounter water at some locations. For best results, any standing water should be pumped out and footings poured immediately after the excavation has been made.

Water traveling through the soil (subsurface water) is often unpredictable and may be present at other locations and depths at the site. Due to the seasonal changes in groundwater and the unpredictable nature of groundwater paths, groundwater levels will also fluctuate. Therefore, it is necessary during construction to be aware of groundwater in excavations in order to determine if any changes are necessary in the construction procedures due to the presence of the water.

ANALYSIS AND RECOMMENDATIONS

Suitable Building Foundation

The foundation for the proposed structure must satisfy two independent criteria. First, the maximum design pressure exerted at the foundation level should not exceed the allowable bearing pressure based on an adequate factor of safety with respect to soil shear strength. Secondly, the magnitude of slab-on-grade and foundation movement due to soil volume changes or settlement must be such that structural movement is within tolerable limits. Considering the subsurface conditions encountered at the boring locations, the proposed structure may be supported on drilled and underreamed piers foundation.

Drilled and Underreamed Piers

The structural loads for the proposed new structure may be supported on drilled and underreamed piers. Foundation recommendations are presented as follows:

Foundation Type	Depth, below existing grade (feet)	Allowable Bearing Capacity (psf) Dead Plus Sustained Live Load Factor of Safety = 3	Allowable Bearing Capacity (psf) Total Load Factor of Safety = 2
Drilled and Underreamed Piers	10	2,800	4,200

The drilled piers should not be placed closer than 2.5 diameters of the bell, center to center and the bell/shaft ratio for the piers can be 3:1.

The ultimate capacity of under reamed footings to resist uplift loads can be determined from the following equation provided the ratio of footing depth to bell diameter is greater than 1.5:

$$Q_u = 5.8\ c\ (D^2 - d^2)$$

where: Q_u= ultimate uplift capacity, pounds
c= Average shear strength above the footing grade, pounds per square foot. (use c = 800 PSF)
D= underream diameter, feet.
d= shaft diameter, feet.

A minimum factor of safety of 2.0 is recommended for final design.

The settlement analysis was not within the scope of this study.

Floor Slabs

The surficial soils within the proposed building lines consist of moderate expansive clays. Based on existing soil conditions, the estimated potential vertical rise (PVR) using TEX-124E method is approximately 2.8 inches. Any grade-supported floor slab for this project constructed over expansive clays will incur some level of risk associated with expansion or shrinkage of the moisture-sensitive soils.

A structurally supported floor slab with a six-inch void space would be most suitable floor system for the proposed construction. However, a grade-supported floor system may also used using either of the two options to reduce the PVR to one-inch- (1):

- ♦ Undercut upper 3 feet of existing moderate plasticity expansive clays and replace with compacted low plasticity structural fill or top the existing soils with 3 feet of compacted low plasticity structural fill.

- Excavate the upper 3 feet of existing moderate plasticity clays and thoroughly mix the clays with 6% of lime (dry weight) under proper moisture control. Then place the lime-stabilized clays in 8-inch loose lifts and compact each lift to at least 95% of the maximum dry density as specified by ASTM D-698.

Grade Beams

Grade beams used in conjunction with drilled piers should be placed beneath all load bearing walls. Grade beams should be founded at a depth of 24 inches below the final grades and should be designed to support the imposed loads.

Stiffened Slab on-Grade

The stiffened slab on-grade may consist of either post-tensioned slab or conventional slab on-grade. Post-tensioned slab design parameters were obtained from the third edition of the Post-Tensioning Institute Design Manual. The conventional slab on-grade design parameters were based on BRAB design manual entitled "Criteria for Selection and Design of Residential Slabs on Ground".

<u>A minimum of 24 inches of compacted select fill material pad should be used with post-tensioned slab system. All soft area must be excavated and replaced with compacted select fill.</u>

The criteria for the slab-on-grade, in accordance with Post Tensioning Institute (P.T.I.) is given:

Allowable soil bearing capacity	1000 PSF
Weighted average plasticity index (P.I.)	32
Atterberg Limits:	LL = 51 PL = 19 PI = 32
Clay Percent:	60 % (assumed)*
Depth to Constant Suction:	7 ft.
Thornwaite Moisture Index:	Im = 20
Cation Exchange Activity:	CEAc = 0.54
Clay Activity Ratio:	Ac = 0.53
Principal Clay Mineral:	Montmorillonite
Constant Suction Value:	PF = 3.4
Estimated Velocity of Moisture Flow:	c = 0.7 inch/month
Edge Moisture Variation:	em = 8.9 ft. (Center lift) em = 4.8 ft. (Edge lift)
Estimated Differential Swell:	Ym = 1.4 inch (Center lift) Ym = 1.2 inch (Edge lift)

* Clay percent is approximate and assumed based on past experience.

Maintenance Considerations

The site should be graded in such a manner to shed all rainwater away from the structure. Water should not be allowed to pond around the structure. Positive site drainage will reduce the exposure of the on-site clays to a moisture source thus eliminating swelling of the on-site clays.

Due to the presence of clay soils, it is imperative to install a watertight plumbing system. Water leakage due to poor plumbing will have detrimental effects on the performance of the structure.

Roof gutters should be utilized to direct roof runoff away from the structure. Downspouts should not be allowed to discharge near the structure. Downspout extensions should be used to facilitate rapid rainwater drainage away from the structure.

Trees should be planted at a distance equaling the anticipated height of the mature tree. If trees are planted in close proximity to the structure, the roots will extend below the slab area causing distress to the slab. Root barriers should be constructed around the perimeter of the building in the event that trees are located less than the maximum anticipated height of the mature tree. Root barrier should extend at least four feet below grade.

The floor slabs should be provided with a moisture barrier to prevent migration of the capillary moisture through the slab. Six-mill Visqueen can be used. In addition, a two-inch layer of sand can be used for leveling purposes.

Pavement Recommendations

General

We were not provided with traffic type nor with traffic frequency for the drives and parking areas associated with this facility. As a result, we have provided general guidelines for pavement thicknesses.

Flexible asphaltic concrete pavement or rigid Portland cement pavement can be used at this site for automobile traffic use. Pavement subject to light truck traffic can also be rigid or flexible pavement. However, pavement design recommendations presented herein are not applicable for streets or major thoroughfares.

Pavement Sections

The following pavement sections are recommended for the project site. In parking lots and drives servicing only automobile traffic, 5 inches of asphalt concrete should provide adequate service. It is recommended that this be increased to a minimum of 6 inches in main drives and any areas subject to occasional light truck traffic. The section should consist of a 2-inch surface course meeting the requirements of THD Type D with a base course meeting the requirements of THD Type A or B. The coarse aggregate in the surface layer should be crushed limestone rather than gravel.

Portland Cement concrete pavements are recommended in areas subject to any heavy truck traffic such as garbage pickup and/or dumpster trucks and any heavy delivery trucks. We recommend the use of 5 inches of Portland Cement Concrete for general area pavements, which are not subject to truck traffic. A minimum 6-inch thick section is recommended in areas subject to truck traffic. The required thickness will depend on the number of truck passes per day. A minimum 7-inch thick Portland cement pavement thickness is recommended in areas subject to loading of dumpster type garbage trucks. We recommend that the Portland cement concrete in light duty pavement areas should have a minimum 28-day compressive strength of 3,500 pounds per square inch and in heavy duty pavement areas, a 28 day compressive strength of 4,000 psi.

Subgrade Stabilization

Based on the results of laboratory testing, the subgrade performance of the on-site soils can be improved by stabilization with hydrated lime. Stabilization is recommended below both pavement systems. It is estimated that the near surface expansive clayey soils below the future pavements will require 6 percent hydrated lime by dry unit weight. This assumes soil properties of the subgrade soils will be similar to the soils existing in the areas where the borings were drilled. The stabilized clays should be compacted to a minimum of ninety-five (95) percent of the maximum density in a moisture content range of -1% to +4% of the soil/lime mixture's optimum moisture content as determined by ASTM D-698.

A minimum stabilized subgrade depth of 6 inches is recommended below the bottom of the proposed pavement. We recommend that the depth of stabilized subgrade be increased to 8-inch for heavy traffic areas. It is to be noted that the actual amount of lime required be determined after stripping of the subgrade.

The prepared subgrade should be protected and moist cured or sealed with a bituminous material until the pavement materials are placed. Finished pavement subgrade areas should be graded at all times to prevent ponding and infiltration of excessive moisture on or adjacent to the pavement subgrade surface.

It is recommended to extend the pavement stabilization five feet beyond the perimeter of the pavement in order to preclude edge failure. It is also highly recommended to maintain positive drainage away from the pavement throughout the life of the pavement.

Hot Mixed Asphaltic Concrete (HMAC)

All hot mix asphaltic concrete used on this project for new construction shall comply in all respects to Item 340 of the current edition of the Texas Department of Highways and Public Transportation's Standard Specifications (TSDHPT) except as modified for this project. The paving mixture for the wearing surface for new pavement for this project is recommended to be a Fine Graded Surface Course (Type D). The paving mixture for the HMAC base course for this project should be a coarse graded or fine graded Base Course (Type A or Type B). The coarse aggregate in the surface layer should be a crushed limestone rather than gravel.

Portland Cement (Rigid) Concrete

The Portland cement concrete (PCC) used on this project should comply in all respects with Item 360 of the current edition of the TSDHPT Standard Specifications except as may be modified for this project. Type I cement is recommended for use in the concrete pavement.

The concrete in light duty pavement areas should have a minimum 28 day compressive strength of 3,500 pounds per square inch and in heavy duty pavement areas, a 28 day compressive strength of 4,000 psi is recommended. Assuming a nominal maximum aggregate size of 1 to 1 1/2 inches, it is recommended that the concrete have entrained air of 5 percent (±1%) with a maximum water cement ratio of 0.50.

Portland cement concrete pavement types for standard or heavy duty traffic pavements in this area are generally jointed reinforced concrete pavements (JRCP). Due to construction over swelling clays, unreinforced pavement is not recommended. Reinforcing steel and joint systems for the pavement should be properly designed.

CONSTRUCTION GUIDELINES

Site Preparation

Soft soils should be removed until firm soil is reached. The soft soils can be aerated and placed back in eight-inch loose lifts and compacted to 95% as specified by ASTM D-698. Tree stumps, tree roots, old slabs, old foundations and existing pavements should be removed from the structure area. If the tree stumps and roots are left in place, settlement and termite infestation may occur. Once a root system is removed, a void is created in the subsoil. It is recommended to fill these voids with structural fill or cement-stabilized sand and compact to 95% as specified by ASTM D-698.

Any low-lying areas including ravines, ditches, swamps, etc. should be filled with structural fill and placed in eight-inch lifts. Each lift should be compacted to 95% of the maximum dry density as specified by ASTM D-698.

The exposed subgrade should be scarified to a minimum depth of six (6) inches in the driveway and slab areas. The subgrade should then be compacted to 95% of the maximum density as determined by the Standard Moisture Density Relationship (ASTM D-698). In the event that the upper six (6) inches cannot be compacted due to excessive moisture, we recommend that these soils be excavated and removed or chemically stabilized to provide a firm base for fill placement. Proof rolling should be performed using a heavy tired loaded truck or pneumatic rubber-tired weighting about 15 to 20 tons equipment.

The fill soils should extend at least five feet beyond the perimeter of the structure. In addition, the floor slab should be placed as soon as possible after the building pad is prepared. If the building pad is left exposed to rainfall, perched groundwater conditions may develop which will undermine the integrity of the floor slab. All trenches (water, cable, electrical) should be properly backfilled and compacted to 95% of the maximum dry densities. Sand or permeable materials should not be used as backfill. Improperly backfilled and improperly compacted trench, if left exposed will also be another source for perched groundwater conditions. In general perched water tends to be trapped within the fill. The trapped groundwater tends to soften the subgrade. Positive drainage should be maintained across the entire building pad.

A qualified soil technician should monitor all earthwork operations. Field density tests should be conducted on each lift using a nuclear density gauge. The gauge should be calibrated every day. Prior to field density tests, a 50-pound sample from the subgrade soils should be obtained. A similar sample should be obtained from the fill soils. A Standard Moisture Density Relationship (ASTM D-698) should be performed on each sample in order to obtain an optimum moisture content and a maximum dry density. The field density tests should be compared to these results every time the soils are tested in the field.

The above recommendations are applicable to slabs, driveways, pavements and any structures that are supported directly on-grade.

Vegetation Control

Existing Trees

Existing tree roots absorb moisture from their surrounding soils. This results in formation of pockets of isolated dry soils around the tree roots with a moisture content significantly lower than the soil moisture contents away from these roots. When the trees are cut, the roots die and stop absorbing moisture from their surrounding soils. With time and seasonal rainfall as well as by capillary action, these dry pockets of soils will undergo increases in moisture content and as a result heave. If the tree is cut and a building or paving is immediately constructed on it, then these isolated areas of dry soils will have more than the soils at other areas of the building/paving or site. This will result in differential heaving under the structure of pavement. Where large trees are cut and building built over it, the slab should be stiffened to resist the higher differential heave. Alternatively, a safer option would be to structurally support the building slab on deeper footings with a void space larger than the anticipated maximum heave of the drier soils. Positive drainage should be developed and maintained all around the building at all times.

New Trees

New trees should be avoided near the building slab especially larger trees. No tree should be planted closer than 20 feet or half the canopy diameter of fully matured trees. Alternatively, root barriers may be used to prevent the migration of tree roots underneath the buildings. Use of large shrubs should be avoided immediately adjacent to the building slab.

Low Swell Potential Structural Fill

Low swell potential select fill should consist of cohesive soils free of organics or other deleterious materials and should have a plasticity index not less than 10 or more than 20. Sandy clays are recommended for use.

The low swell potential select fill should be cleaned and free of organic matter or other deleterious material. The fill should be placed in maximum 8-inch loose lifts and compacted to a minimum of 95 percent of the maximum dry density as determined by ASTM D 698 (Standard Proctor). The moisture content at the time of compaction should be +/-2% of the optimum value as defined by ASTM D 698. The referenced moisture content and density should be maintained until construction is complete.

Drainage

Roof drainage should be collected by a system of gutters and down spouts and transmitted to a paved surface where water can drain rapidly away from the structure. Sidewalks, parking areas, building access drives, and the general ground surface should be sloped so that water will drain away from the structure. Water should not be allowed to pond near the building foundations.

Footing Construction

Concrete should be placed in underreamed piers immediately following drilling and inspection. Significant seepage into excavations from groundwater is anticipated if excavations remain too long. If water collects in excess of 1-inch depth at the bottom of the footing excavations, it should be pumped out prior to concrete placement or the concrete should be tremied in place. We recommend that footing installations be monitored by the testing laboratory.

Groundwater Control

In general, the highest groundwater level during construction should be at least three (3) feet below the bottom of the excavation to ensure excavation stability. Presence of groundwater above the excavation depths may require de-watering. However, it is the contractor's responsibility to select the proper de-watering systems for the proposed constructions.

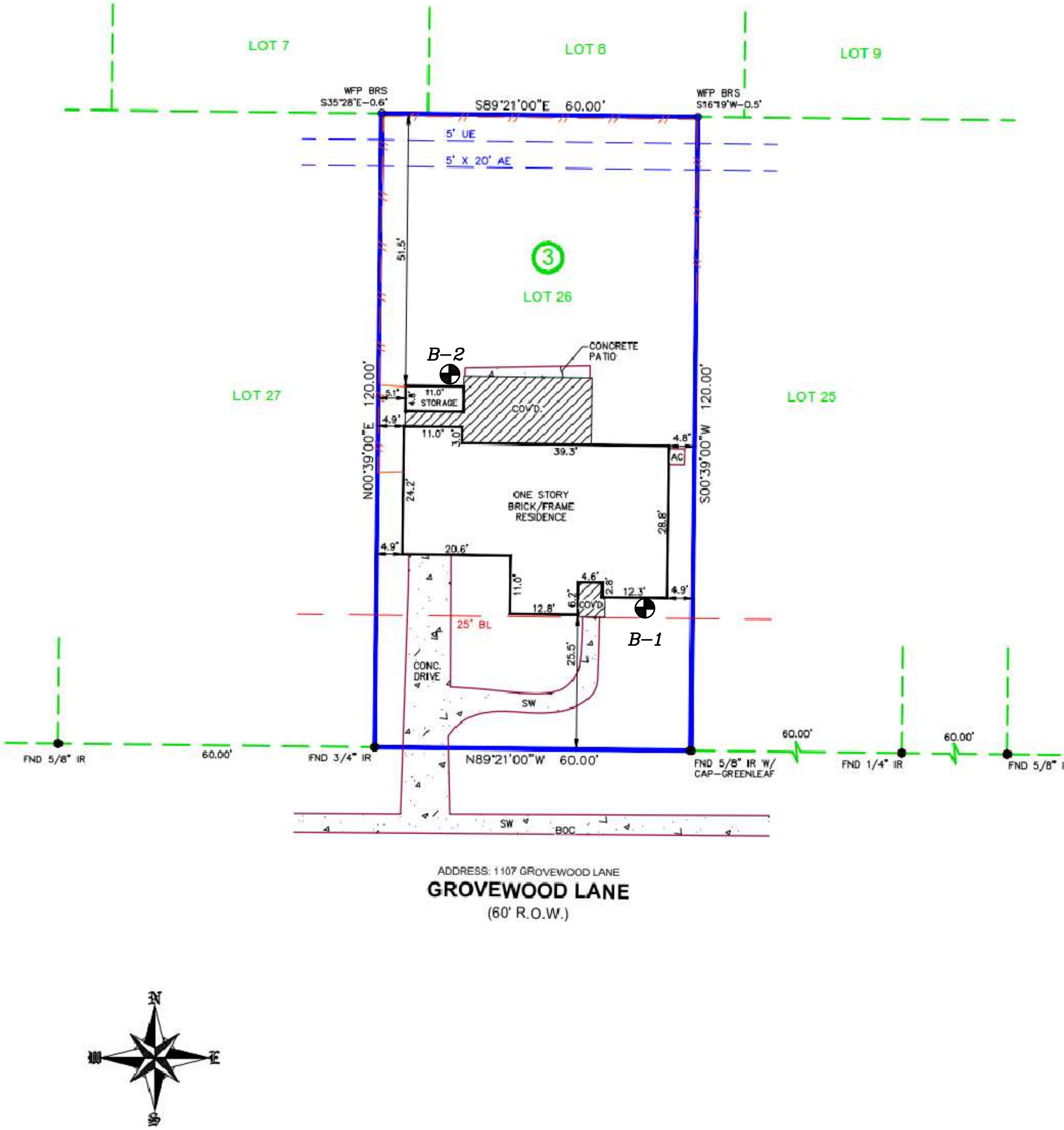
LIMITATIONS

The conclusions reached in this report are based on the conditions at the boring location. In any subsurface exploration, it is necessary to assume that the subsoil conditions between exploratory borings do not change significantly. Therefore, careful observations must be made during excavation to detect significant deviations from conditions encountered in the test borings. If such deviations are detected, this office should be contacted immediately.

In the event that any changes in the nature, design or location of the structures are planned, the conclusions and recommendations contained in this report shall not be considered valid unless the changes are reviewed and conclusions of this report are modified and verified in writing.

We have conducted this geotechnical study using the standard of care and diligence normally practiced by recognized engineering firms now performing services of a similar nature under similar circumstances. Unless specifically stated otherwise, any environmental or contaminant assessment efforts are beyond the scope of work for this report. We intend for this report, including all illustrations, to be used in its entirety. If this report is made available to potential contractors, it should be for information only and not as a warranty of subsurface conditions.

This report has been prepared for the specific application to the proposed new residence at 1107 Grovewood Lane in Houston, Texas.



SITE PLAN	*A.R.M. SOIL TESTING* *17240 HUFFMEISTER ROAD, SUITE 102* *CYPRESS, TEXAS*	
PROPOSED NEW RESIDENCE *1107 GROVEWOOD LANE* *HOUSTON, TEXAS*	*SCALE: N.T.S.*	*DRAWN BY: OA*
	PROJECT NO.: G23-279	*PLATE NO. 1*

LOG OF BORING B- 1

PROJECT NAME: PROPOSED NEW RESIDENCE	PROJECT NUMBER: G23-279
PROJECT LOCATION: 1107 GROVEWOOD LANE IN HOUSTON, TEXAS	DATE DRILLED: 4/20/2023

Type of Boring: Auger

Boring Location: See Plan of Borings

Surface Elevation: Existing

DEPTH, FT.	STANDARD PENETRATION TEST	POCKET PENETROMETER (tsf)	UNCONFINED COMP. (tsf)	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	LIQUID LIMIT (%)	PLASTIC LIMIT	PLASTICITY INDEX	#200 SIEVE (%)	MATERIAL DESCRIPTION	GROUP SYMBOL
0.0–6.0										Firm gray **SANDY CLAY**	CL
		1.50		19							
2.0		3.00	1.45	16	120	47	18	29		.. very stiff gray and tan below 2 feet	
4.0		3.50		14						.. light gray and tan below 4 feet	
6.0–16.0										Stiff light gray and tan **CLAY**	CH
		2.50		24							
8.0		2.00	1.10	26	104	57	20	37			
10.0											
12.0		2.00	1.00	25	107	50	19	31			
15.0											
16.0–20.0										Medium dense light gray **SAND**	SP
	13			15					6		
20.0										Boring Was Terminated at 20 feet	

Water Level Measurements:

Initial Reading: 12'

Final Reading: 10'

Drilled by: JM Drilling

Driller: Jeff

LOG OF BORING B- 2

PROJECT NAME: PROPOSED NEW RESIDENCE	PROJECT NUMBER: G23-279
PROJECT LOCATION: 1107 GROVEWOOD LANE IN HOUSTON, TEXAS	DATE DRILLED: 4/20/2023

Type of Boring: Auger
Boring Location: See Plan of Borings
Surface Elevation: Existing

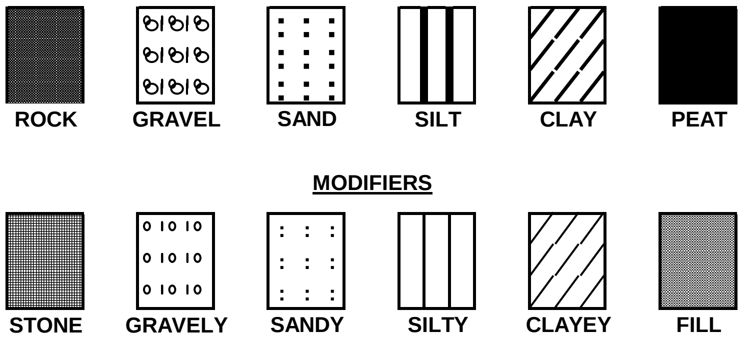
DEPTH, FT.	SAMPLE TYPE	STANDARD PENETRATION TEST	LEGEND	POCKET PENETROMETER (tsf)	UNCONFINED COMP. (tsf)	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	LIQUID LIMIT (%)	PLASTIC LIMIT	PLASTICITY INDEX	#200 SIEVE (%)	MATERIAL DESCRIPTION	GROUP SYMBOL
												Stiff gray **SANDY CLAY**	CL
				2.25		18							
2.0													
				2.50	1.30	17	118	45	18	27		.. light gray and tan below 2 feet	
4.0													
				3.00		16						.. very stiff below 4 feet	
6.0												Very stiff light gray and tan **CLAY**	CH
				3.50	1.70	23	108	55	20	35			
8.0													
				3.00		24							
10.0													
12.0													
				2.50	1.30	27	102	59	20	39		.. stiff below 13 feet	
15.0												Boring Was Terminated at 15 feet	
20.0													

Water Level Measurements:
Initial Reading: 12'
Final Reading: 10'

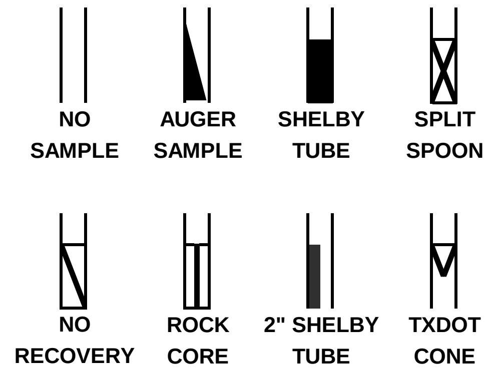
Drilled by: JM Drilling
Driller: Jeff

KEY TO LOG TERMS AND SYMBOLS

SOIL TYPE



SAMPLER TYPE



UNIFIED SOIL CLASSIFICATION SYSTEM - ASTM D 2487

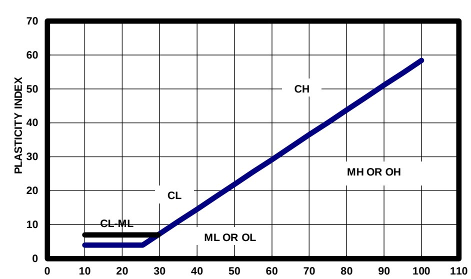
MAJOR DIVISIONS			LETTER SYMBOL	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS LESS THAN 50% PASSING NO. 200 SIEVE	GRAVEL & GRAVELY SOILS LESS THAN 50% PASSING NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES	GW	WELL GRADED GRAVELS, GRAVEL-SAND MIXTURES WITH LITTLE OR NO FINES
			GP	POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES WITH LITTLE OR NO FINES
		W/ APPRECIATE-BLE FINES	GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES
			GC	CLAYEY GRAVELS,GRAVEL-SAND-CLAY MIXTURES
	SANDS MORE THAN 50% PASSING NO. 4 SIEVE	CLEAN SANDS LITTLE FINES	SW	WELL GRADED SAND, GRAVELY SAND (LITTLE FINES)
			SP	POORLY GRADED SANDS, GRAVELY SAND (L.FINES)
		SANDS WITH APPREA. FINES	SM	SILTY SANDS, SAND-SILT MIXTURES
			SC	CLAYEY SANDS,SAND-CLAY MIXTURES
FINE GRAINED SOILS LESS THAN 50% PASSING NO. 200 SIEVE	SILTS AND CLAYS LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS & VERY FINE SANDS,ROCK FLOUR SILTY OR CLAYEY FINE SANDS OR CLAYEY SILT W/PI
			CL	INORGANIC CLAY OF LOW TO MEDIUM PI LEAN CLAY GRAVELY CLAYS, SANDY CLAYS, SILTY CLAYS
			OL	ORGANIC SILTS & ORGANIC SILTY CLAYS OF LOW PI
	SILTS AND CLAYS LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS, ELASTIC SILTS
			CH	INORGANIC CLAYS OF HIGH PLASTICITY FAT CLAYS
			OH	ORGANIC CLAYS OF MED TO HIGH PI, ORGANIC SILT
HIGHLY ORGANIC SOIL			PT	PEAT AND OTHER HIGHLY ORGANIC SOILS
UNCLASSIFIED FILL MATERIALS			ARTIFICIALLY DEPOSITED AND OTHER UNCLASSIFIED SOILS FILL MATERIALS	

CONSISTENCY OF COHESIVE SOILS

CONSISTENCY	UNCONIFINED COMP. STRENGTH IN TSF
VERY SOFT	0 TO 0.25
SOFT	0.25 TO 0.5
FIRM	0.5 TO 1.5
STIFF	1.75 TO 2.75
VERY STIFF	3.0 TO 4.5
HARD	4.5+

RELATIVE DENSITY - GRANULAR SOILS

CONSISTENCY	N-VALUE (BLOWS PER FT)
VERY LOOSE	0-4
LOOSE	4-9
MEDIUM DENSE	10-29
DENSE	30-49
VERY DENSE	> 50 OR 50+



CLASSIFICATION OF GRANULAR SOILS

U.S. STANDARD SIEVE SIZE(S)

6" 3" 3/4" 4 10 40 200

BOUL- -DERS	COBBLES	GRAVEL		SAND			SILT OR CLAY	CLAY
		COARSE	FINE	COARSE	MEDIUM	FINE		

152 76.2 19.1 4.76 2.0 0.42 0.074 0.002

GRAIN SIZE IN MM