GEOTECHNICAL STUDY
PROPOSED COMMERCIAL BUILDING
17211 IH 45
HOUSTON, TEXAS

TGC REPORT NO. 711303

DECEMBER 22, 2017

PREPARED FOR

STEWART CONSULTING SERVICES
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PREPARED BY

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HOUSTON, TEXAS

Date: December 22, 2017

Job No: 711303

Stewart Consulting Services
P. O. Box 82
Humble, Texas 77347-0082

Attention: Mr. Bob Stewart

Reference: Geotechnical Study
Proposed Commercial Building
17211 IH 45
Houston, Texas

Dear Mr. Stewart:

Texas Geotechnical Consultants, LLC (TGC), is pleased to submit this report for the geotechnical investigation at the above referenced location. Our findings, analysis and recommendations are submitted herein.

It has been a pleasure working with you on this project and look forward to working with you on your future projects. Should you have any questions regarding this report, please call us at (281) 407-6335.

TEXAS GEOTECHNICAL CONSULTANTS, LLC.

TBPE FIRM NO. F-14495

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1.0 INTRODUCTION

This investigation was authorized by Mr. Bob Stewart of Stewart Consulting Services., with the acceptance of our proposal GP17-1141 dated November 30, 2017. Project details were provided to TGC by Mr. Stewart. It is planned to build a new commercial building at 17211 IH 45, Houston, Texas. The building will be approximately 7500 square feet in size and will be 1 storied. In addition, there will be parking and drives. Asphalt or concrete pavement may be used. Although the building column or wall loading information is not currently known to us, it is anticipated that the maximum column loads will be less than 100 kips and the maximum wall loads will be less than 2 kips/feet. This report includes results of the field investigation, laboratory testing, geotechnical engineering analysis and recommendations for the design and construction of proposed building and associated parking and drives.

2.0 PROJECT SCOPE

The purpose of this geotechnical investigation was to explore the subsurface and ground water conditions at the site, perform laboratory tests on the sampled soils and develop geotechnical engineering recommendations for the design and construction of the proposed new building and paving.

Our scope of services included the following:

- Drilling (2) soil borings to a depth of 20 feet each and two (2) soil borings to a depth of 5 feet each.
- Observation of ground water conditions in the borings at the time of drilling.
- Obtaining samples at select depths for performing laboratory tests.
- Performing select laboratory tests on selected soil samples for determining the soils moisture, strength and expansion potential.
- Develop a log of borings by incorporating the field and laboratory data.
- Performing geotechnical engineering analysis and developing foundation design and construction recommendations for the project.

Our scope of work did not include any environmental assessment of the site or the determination of groundwater at or around the site. Any information regarding odors in soil samples, soil colors, textures, etc., on the logs of borings or in the report are given for informational purposes only. A geologic fault study to evaluate the potential of surface faulting at this site was also beyond the scope of this study.

3.0 SITE CONDITIONS

The project site is currently vacant. The site is relatively flat with a topographic variation of less than 3 feet. The site drainage appears to be adequate. Asphalt paving was observed at the site.

4.0 FIELD EXPLORATION

At the request of the client, the soil conditions were explored by two (2) soil borings drilled to a completion depth of twenty (20) feet each and two (2) soil borings drilled to a completion depth of five (5) feet each. Boring locations as drilled for this geotechnical exploration are approximately shown in Plate 1. Undisturbed samples were obtained continuously at the boring location to a depth of ten (10) feet and then at five (5) feet intervals thereafter.

Dry auger drilling methods were generally adopted to drill the soil borings to more accurately observe the depth of groundwater. All soil samples were examined, classified and logged in the field. Cohesive soil strengths were estimated in the field using a hand penetrometer. Standard penetration tests (SPT) were performed in the granular soils.

5.0 LABORATORY TESTING

In addition to the field exploration, supplemental laboratory testing was performed to verify field information and obtain additional pertinent engineering characteristics of the soils. Samples obtained from the field were again examined and classified in the lab. Additional testing was performed on selected samples to determine the moisture, shear strength, sieve 200 and atterberg limits of the soils. The results of laboratory tests are presented on the borings logs in Plates 2 through 5 of this report. Soil samples obtained during testing will be stored for a period of 14 calender days subsequent to the submittal of this report. Unless requested otherwise in writing, the soil samples will be discarded.

6.0 SOIL STRATIGRAPHY

Based on the soil boring and the results of the field and laboratory test data, a generalized soil profile is presented below. The depths delineating the interface between soil strata are approximate.

Table 1: Generalized Soil Profile – Soil Borings

Stratum No.	*Starting Depth, feet*	*Ending Depth, feet*	*Soil Description*
I	0	2	Fill: Fat Clay (CH), firm, brown, with ferrous nodules and sand pockets; in boring B-1.
II	0	2	Possible Fill: Clayey Sand (SC), brown; in borings B-2 through B-4
III	2	12	Lean Clay (CL), stiff to hard, brown, light gray and reddish brown, with ferrous nodules.
IV	12	20	Clayey Sand (SC), medium dense, light gray.

The fill fat clay (CH) of stratum I are expansive with a plasticity index (PI) of about 33. The possible fill clayey sand (SC) of stratum II can be moisture sensitive and difficult to compact in a wet condition (they may pump). The lean clay (CL) soils to stratum III are non- to moderately expansive with plasticity indices (PI's) ranging from 8 to 23. These fat clay (CH) will experience high shrink/swell movements with changes in moisture contents. The lean clay (CL) soils are expected to experience a low to moderate shrink/swell potential with changes in moisture contents. The non expansive (PI<20) lean clays are suitable for use as select fill material. The expansive fat clay (CH) soils and moderately expansive (PI>20) lean clays (CL) are not suitable for use as select fill material in their present condition. These soils once lime stabilized (6% and 5% by dry weight, respectively) should be suitable for use as select fill material. However, these soils in their present conditions and free of debris, organics and other unsuitable materials may be used as random fill material.

A more detailed stratigraphy is presented on logs of borings B-1 (Plate 2) through B-4 (Plate 5). Definition of terms and key to symbols used in the boring log is presented on Plate 6.

7.0 GROUNDWATER INFORMATION

The soil borings were dry augered to observe the presence of any perched water or ground water. The levels where perched or groundwater were encountered in the borings at the time of our field exploration are shown on the respective boring logs. Groundwater was not encountered during drilling at any of the boring locations.

It should also be noted that fluctuations in groundwater levels generally occur as a function of seasonal rainfall variations, groundwater removal, temperatures, topography, surface and subdrainage features around the site. It should be noted that a detailed hydrogeological investigation of the proposed project area is beyond the scope of this investigation.

An accurate evaluation of the groundwater in the low permeability clays and silt require long term observations in monitoring wells or piezometers. Their installation was not in our scope of work. Groundwater levels should be verified prior to starting any excavations that may be affected by it such as utilities, drilled piers, etc. TGC should be contacted if any significant change is observed in the groundwater then that mentioned in this report. We can then evaluate the effect of any groundwater changes on the design or construction recommendations given in this report.

8.0 POTENTIAL VERTICAL RISE

The upper stratum of soil at this site consists of low to moderate plasticity lean clays and a thin layer of expansive fill fat clay. These lean clay soils have a low to moderate potential for expansion and shrinkage with increases and decreases in moisture content. The fat clay have a high potential for expansion and shrinkage.

Based on Test Method TEX-124-E by the Texas State Department of Highways and Public Transportation, Materials and Tests Division, the soil conditions at this site has a potential vertical rise (PVR) of about 1.0 inch.

9.0 FOUNDATION RECOMMENDATIONS

Foundations for the structures should satisfy three separate design requirements as mentioned here. 1) The maximum foundation loads should not exceed the allowable bearing pressures given in the report. 2) The total and differential settlements under sustained loads should not exceed the settlement tolerance limit of the structure. 3) The total and differential heaving should not exceed the movement tolerance limit of the structure.

The foundation for the building may consist of slab supported on drilled piers or a floating slab foundation. Our recommendations for these foundation types are given below.

9.1 DRILLED PIERS

Drilled piers with underreams (bell) may be used for the building foundation. Drilled piers may be founded at the depth of 9 feet and designed for an allowable bearing pressure of 3000 psf for dead plus sustained live loads and 4500 psf for total loads. The given values include a factor of safety of 3 and 2, respectively.

An underream to shaft ratio of 3 to 1 may be used for the drilled piers. Seams, pockets or layers of silt or sands or the presence of slickensides in the clay stratum may cause the underream to slough. In the event of underream sloughing, the ratio should be reduced to 2 to 1 by increasing the shaft diameter. If sloughing still continues then straight sided shafts may have to be used. In this event the diameter of the straight shaft must be made equal to the diameter of the designed underream to obtain the same compressive capacity.

Based on the groundwater readings, groundwater is not likely to be encountered during drilled pier excavations. However, it should be noted that fluctuations in groundwater level occurs as a result of seasonal rainfall variations, temperature, drainage changes, etc. In the event that groundwater is encountered, all standing water in the drilled pier excavations should be pumped out and the drilled pier concrete poured as soon as possible after the completion of the excavation.

The uplift capacity of drilled and underreamed piers may be taken as:

$$Qu = 0.785 * Nu * C * (D^2 - d^2)$$

Here: Qu = Ultimate Uplift Capacity in tons (or kips or pounds)

Nu = Dimensionless factor = 3.5 * (H/D) $\leq$ 9

C = Undrained cohesion in tsf (or ksf or psf) – use 0.5 tsf for design purposes

D = Diameter of underream, feet

d = Diameter of shaft, feet

H = Depth of pier, feet

A factor of safety of 2.0 for transient and wind loads and 3.0 for sustained loads is recommended for the uplift capacity.

The lateral capacity of drilled piers may be calculated using passive resistance of soils. An allowable passive resistance of 1000 psf may be taken for design purposes in cohesive soils. The passive resistance in the top 2 feet should be neglected for design purposes. The lateral capacity may also be analyzed using computer programs such as LPile Plus. A horizontal modulus of subgrade reaction, k, of 300 pci may be taken for design purposes in lean clay soils or compacted fill.

The minimum clear spacing of 3 underream diameters center to center is recommended. If the spacing between the two underreams is less than 3, then stress concentrations will occur between the two piers. Use of lower allowable bearing pressures may be required. TGC should be contacted if the spacing is significantly closer from that recommended above.

9.1.1 Floor Slabs Supported on Drilled Piers

Since the surficial soils are generally low in plasticity and the PVR is about 1.0 inch, the floor slabs may be supported on grade. However, the surface fill fat clay (CH) and possible fill clayey sand (SC) soils should be excavated and replaced with select fill as outlined in the "site preparation" section of the report. The subgrade soils must be properly compacted as outlined in the "site preparation" section. Positive drainage should be developed and maintained all around the building at all times.

9.2 FLOATING SLAB FOUNDATION

A floating slab foundation at this site may be an engineered post-tensioned slab (Ref. 1) or ribbed & reinforced (conventionally reinforced) slab (Ref. 2) with a perimeter footing and interior thickened sections. The fill fat clay (CH) and possible fill clayey sand (SC) must be excavated and replaced with select fill inaccordance with the "site preparation" section of the report.

Minimum Grade Beam Depth Below Final Grade: 12 inches (in compacted select fill soils)

Grade Beam Allowable Bearing Pressure (in compacted select fill soils)

Total Loads	: 2250 psf			
Dead + Sustained Live Loads	: 1500 psf			
Atterberg Limits	: LL=36;		PL=16;	PI=20
Thornwaite Moisture Index	: Im	=	18	
Constant Suction Value	: PF	=	3.45	
Edge Moisture Variation	: em	=	9.0	ft.(Center lift)
	: em	=	6.0	ft. (Edge lift)
Estimated Differential Swell	: Ym	=	0.8	inch (Center lift)
	: Ym	=	0.7	inch (Edge lift)
Support Index	: C	=	0.8	

9.3 FOUNDATION SETTLEMENT

A detailed settlement analysis was not within the scope of our work. It is anticipated that foundations designed based on the allowable bearing pressures and other recommendations as given in this report will experience settlements which should be within the allowable limits of the proposed structure.

10.0 SITE PREPARATION

The site has a potential for development of a condition called "perched water" due to the presence of surface sands underlained by relatively impermeable clays. The surface sands are firm when dry but may become extremely soft when wet and may have to be chemically stabilized, aerated or replaced with select fill. The following system of construction procedures is recommended:

1. In general remove all surface organics, organic topsoil, roots, existing foundations and paving and all unsuitable materials from all structure areas.
2. Proof roll the subgrade with a loaded dump truck, scraper or similar pneumatic-tired equipment to detect any wet, soft, or pumping areas. Soils deflecting excessively during proofrolling should be undercut to firm soils and recompacted. Treat the wet or pumping soils with drying or stabilizing agents as necessary or remove and replace them with a suitable fill material. Any existing fill material should have records of passing densities for all lifts or should be excavated, reprocessed and recompacted as below.
3. Scarify the subgrade, add moisture or dry as necessary and compact the subgrade to a minimum of ninety-five (95) percent of its maximum dry density as determined by the Standard Proctor Compaction Test (ASTM D 698). The moisture content should be plus or minus 2 percent of the optimum moisture.
4. Structural fill material within the structure area should be a silty or sandy clay (CL) having a plasticity index (P.I.) of ten (10) to twenty (20) and a liquid limit of 25 or more. Fill materials should be placed in six (6) to eight (8) inch loose lifts and compacted at plus or minus 2 percent of optimum moisture content to ninety-five (95) percent of their maximum dry density as determined by the Standard Proctor Compaction Test.
5. Establish positive site drainage. Install storm drainage structures if required.

6. The backfill soils in the utility trenches may consist of select fill mentioned in Item 4. In the event of compaction difficulties, cement sand may be used as backfill material. Due to the high permeability and potential for surface water intrusion from these soils to under the building slab, bank sand should not be used as backfill material for the utility trenches.
7. The subgrade and fill moisture content and density must be maintained until the placement of floor slabs or pavement. Verification of this should be done prior to slab or pavement placement. Scheduling of the building slab pour as soon as possible after the subgrade and fill compaction would help in minimizing moisture and density changes due to drying, wetting or disturbance of these soils.