GEOTECHNICAL EXPLORATION
PROPOSED TWO-STORY BUILDING
CORAL STREET CAMPUS
1115 CORAL STREET
HOUSTON, TEXAS

REPORT NO. 08-774E

TO

HOUSTON GATEWAY ACADEMY, INC.
HOUSTON, TEXAS

BY

GEOTECH ENGINEERING AND TESTING

SERVICING

TEXAS, LOUISIANA, NEW MEXICO, OKLAHOMA

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JANUARY 2009

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Geotechnical, Environmental, Construction Materials, and Forensic Engineering

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Report No. 08-774E
Report Type: LB/E/D/PL
January 09, 2009

Attention: Mr. Oscar De Los Santos

GEOTECHNICAL EXPLORATION
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CORAL STREET CAMPUS
1115 CORAL STREET
HOUSTON, TEXAS

Gentlemen:

Submitted here are the results of Geotech Engineering and Testing (GET) soils exploration for the proposed two-story building at the above location. This study was authorized by Mr. Richard Garza, CEO on December 17, 2008.

INTRODUCTION

It is planned to construct a two-story building and parking lot at 1115 Coral Street, Houston, Texas. A site vicinity map is presented on Plate 1. The specific project information is as follows:

Structure	Remarks
Building	Two-story, about 60,000 sq. ft, supported on drilled footings. The building will either be Tilt Wall or ICF.
Parking Lot	Concrete subject to auto and bus traffic.

A geotechnical exploration was performed to evaluate the subsoils and groundwater conditions as well as to provide recommendations for design and construction of the building and paving structures.

This report briefly describes the field exploration and laboratory testing followed by our engineering analyses and recommendations. Our recommendations on pavement sections are presented in Appendix A.

FIELD EXPLORATION

At the request of the client, the soil conditions were explored by five (5) soil borings located approximately as shown on Plate 2. The borings' depths and locations were specified by the client. The borings schedule is as follows:

Structure	Boring No.	Depth, ft
Building	B-1 through B-3	20
Parking Lot	B-4 and B-5	5

Soil samples were obtained continuously at each boring location from the ground surface to 5-ft in Borings B-4 and B-5, and continuously to 10-ft and at five-ft intervals thereafter to the completion depth of the borings at 20-ft in Borings B-1 through B-3. The cohesive soils were sampled in general accordance with the ASTM D 1587.

Cohesionless soils were generally sampled with a split-spoon sampler driven in general accordance with the Standard Penetration Test (SPT), ASTM D 1586. This test is conducted by recording the number of blows required for a 140-pound weight falling 30-inches to drive the sampler 12-inches into the soil. Driving resistance for the SPT, expressed as blows per foot of sampler resistance (N), is tabulated on the boring logs.

Soil samples were examined and classified in the field, and cohesive soil strengths were estimated using a calibrated hand penetrometer. This data, together with a classification of the soils encountered and strata limits, is presented on the logs of borings, Plates 3 through 7. A key to the log terms and symbols is given on Plate 8.

The borings were drilled dry, without the aid of drilling fluids to more accurately estimate the depth to groundwater. Water level observations made during and after drilling are indicated at the bottom portion of the individual logs.

LABORATORY TESTS

General

Soil classifications and shear strengths were further evaluated by laboratory tests on representative samples of the major strata. The laboratory tests were performed in general accordance with ASTM Standards. Specially, ASTM D 2487 is used for classification of soils for engineering purpose.

Classification Tests

As an aid to visual soil classifications, physical properties of the soils were evaluated by classification tests. These tests consisted of natural moisture content tests (ASTM D 4643), dry unit weight, percent finer than No. 200 sieve tests (ASTM D1140) and Atterberg limit determinations (ASTM D 4318). Similarity of these properties is indicative of uniform strength and compressibility characteristics for soils of essentially the same geological origin. Results of these tests are tabulated on the boring logs at respective sample depths.

Strength Tests

Undrained shear strengths of the cohesive soils measured in the field were verified by calibrated hand penetrometer, unconfined compressive strength test (ASTM D 2166) and torvane tests. The test results are also presented on the boring logs.

Soil Sample Storage

Soil samples tested or not tested in the laboratory will be stored for a period of seven days subsequent to submittal of this report. The samples will be discarded after this period, unless we are instructed otherwise.

GENERAL SOILS AND DESIGN CONDITIONS

Site Conditions

The project site and the surrounding areas are generally flat and exhibit topographic variation of less than three-ft. Currently, the project site is covered with grass. Our site visit indicated the presence of concrete debris and removed trees stockpiled at portions of the project site. Project site pictures were taken during our field exploration. These pictures are presented on cover page and Plate 9.

Soil Stratigraphy

Subsurface soils appear to be variable across the site. Details of the subsurface conditions at each boring location are presented on the respective boring logs. In general, the soils can be grouped into four (4) major strata with depth limit and characteristics as follows:

Stratum No.	Range of Depth, ft.	Soil Description
I	0 – 0.5	SILTY SAND, light gray, gray, brown, dark brown, with root fibers, moist (SM)*
II	0.3 – 17	FAT CLAY, firm to very stiff, light gray, gray, dark gray, brown, reddish brown, with root fibers to 8', ferrous and calcareous nodules, moist (CH)
III	12 – 17	LEAN CLAY, very stiff, light gray, brown, with ferrous and calcareous nodules, moist (CL)
IV	16 – 25	SILTY SAND, medium dense to dense, brown, wet (SM)

* Classification in accordance with the Unified Soil Classification System (ASTM D 2487).

Design Conditions

Soil properties and how they relate to foundation and pavement design are summarized below:

Stratum No.	Soil Type	PI(s)	SPT	Soil Expansivity	Soil Strength, tsf	Remarks
I	Silty Sand (SM)	–	–	Non-Expansive	–	Moisture Sensitive
II	Fat Clay (CH)	34 – 59	–	Expansive to Highly Expansive	0.46 – 1.50	–
III	Lean Clay (CL)	20	–	Non-Expansive	1.50	–
V	Silty Sand (SM)	–	24 – 32	Non-Expansive	–	–

Legend: PI = Plasticity Index
SPT = Standard Penetration Test

Water-Level Measurements

The soil borings were dry augered to evaluate the presence of perched or free-water conditions. The level where free water was encountered in the open boreholes during the time of our field exploration is shown on the boring log. Our groundwater measurements are as follows:

Boring No.	Groundwater Depth, ft. at the Time of Drilling	Groundwater Depth, ft. after 0.33 Hour Later
B-1 through B-5	Dry	Dry

Fluctuations in groundwater generally occur as a function of seasonal moisture variation, temperature, groundwater withdrawal and future construction activities that may alter the surface drainage and subdrainage characteristics of this site.

An accurate evaluation of the hydrostatic water table in the impermeable clay and low permeability sands/silts requires long term observation of monitoring wells and/or piezometers. It is not possible to accurately predict the pressure and/or level of groundwater that might occur based upon short-term site exploration. The installation of piezometers/monitoring wells was beyond the scope of our study. We recommend that the groundwater level be verified just before construction if any excavations such as construction of drilled footings/underground utilities, etc. are planned.

We recommend that GET be immediately notified if a noticeable change in groundwater occurs from that mentioned in our report. We would be pleased to evaluate the effect of any groundwater changes on our design and construction sections of this report.

FOUNDATION RECOMMENDATIONS

Foundation Type

Foundations for the proposed fire station building should satisfy two independent design criteria. First, the maximum design pressure exerted at the foundation level should not exceed allowable net bearing pressure based on an adequate factor of safety with respect to soil shear strength. Secondly, the magnitude of total and differential settlements or heave under sustained foundation loads must be such that the structure is not damaged or its intended use impaired.

We understand that the proposed structural loads will be supported on drilled footings type foundation. Our recommendations for these foundation types are presented in the following report sections.

Drilled Footings Type Foundation

Allowable Bearing Pressure. Based on the results of field exploration, laboratory testing and bearing capacity theory, allowable loads for drilled footings will be as follows:

Foundation Type	Depth, ft. (1)	Allowable Net Bearing Pressure, psf Dead Load (2)	Allowable Net Bearing Pressure, psf Total Load (Dead + Live)	Allowable Skin Friction Below 10-ft, psf
Drilled Footings:				
Underreams	13	4,000	6,000	200

Notes: 1. With respect to existing natural grade
2. Dead load + sustained live load

Foundations proportioned in accordance with these values will have a factor of safety of 3.0 and 2.0 with respect to shearing failure for dead and total loading, respectively. Footing weight below final grade can be neglected in the determination of design loading.

In order to develop the recommended bearing pressures and to control settlement, the drilled footings must satisfy the following two requirements. First, the maximum drilled footing bell diameter (or shaft diameter, in case of straight shafts) should be limited to one half of drilled footing depth. Secondly, a minimum clearance of one bell diameter (or shaft diameter, in case of straight shafts) should be provided between the drilled footings. If a clearance of one diameter cannot be maintained in every case, the above bearing capacities should be reduced by 20 percent for a clearance between one-half and one bell diameter (or shaft diameter, in case of straight shafts). Drilled footings closer than a clearance of one half of bell diameters (or shaft diameter, in case of straight shafts) are not recommended.

Based on the field and laboratory testing data, it is our opinion that the drilled footings should be designed and constructed as follows:

- The recommended bell to shaft ratio is 3:1.
- In case of borehole sloughing, use a bell to shaft ratio of 2:1.
- Based on our current groundwater observations, the drilled footing excavations will probably not encounter groundwater. Any water inflow must be pumped out, using a sump-pump.
- Drilled footings can probably be installed using a dry method of construction.

We recommend placement of tension steel in the drilled footings to resist uplift loads due to expansive soils. An adhesion value of 0.5 tsf should be applied to the straight shaft portion of the drilled footings for computation of uplift loads.

Lateral Capacity. Drilled footings subjected to lateral loads can be designed on the bases of procedure presented on Plate 10. The following parameters and conditions should be used for this procedure:

1. The zone of seasonal shrinkage and/or thickness of fill, D_S, should be taken as two-feet, unless the surface surrounding the footing is paved, in which case D_S, can be taken as zero.
2. The cohesion, S'_u, may be taken as 0.5 kips per square foot. A factor of safety of 2.0 has been applied to this value.

Uplift Capacity. The ultimate uplift capability of a single drilled footing in clay can be estimated using the following empirical equations:

For L/D values greater than 1.5:

$$Q_u = 5.8S_u (D^2-d^2) + W \qquad (1)$$

For L/D values less than 1.5:

$$Q_u = 2.98S_u^{1/2} (L/D) (D^2 - d^2) + W \qquad (2)$$

Where:
Q_u = Ultimate uplift capacity of a weightless footing, kips
S_u = Cohesion, kips per square foot of shaft surface area
D = Diameter of bell, ft.
L = Depth of base of footing, ft.
d = Shaft diameter, ft.
W = Weight of the footing and the soil directly above it, kips (submerged weight below water table)

Uplift capacity is computed as the smaller of equations (1) or (2) for drilled and underreamed shafts with L/D<1.5.

It is recommended that a cohesion, S_u, of 1.0 ksf be used in Equation (1) and 0.5 ksf in equation (2). Allowable uplift capacity of a footing may be obtained by applying a safety factor of 2.0 for transient loads and 3.0 for sustained loads to be computed value of Q_u. Design groundwater level may be assumed to be at the existing ground surface for these computations.

Floor Slabs Supported on Drilled Footings.

General. The floor slabs may consist of a structural slab with a void space or a slab-on-fill supported on piers. We recommend that the builder and architect/designer discuss foundations and risks with the owner. The proper floor slab system should then be selected by the owner after all risks are discussed.

Structural Slab with Footings. This type of floor slab is highly recommended on sites with expansive soils. We recommend a minimum void space of about six-inches under the floor slabs. In the event that a crawl space is used, we recommend that (a) positive drainage be maintained in the crawl space area at all times, and (b) the area in the crawl space be properly vented.

Slab-on-Fill Foundation Supported on Footings. Expansive soils can cause heave and structural distress of floor slab. Potential movement of expansive soils must be considered to evaluate foundation requirements and subgrade preparation in floor slab areas that are supported at grade.

Vertical movement of expansive foundation soils is commonly referred to in terms of the Potential Vertical Rise (PVR) that can occur due to changes in soil moisture content. Accepted methods of estimating PVR include the use of empirical relationships and the results of laboratory Atterberg limit and moisture content tests. Two different methods for estimation of PVR and the methods to reduce soil movement are presented in the section.

An empirical method for estimating PVR developed by TxDOT-124-E (Ref. 2) is based on soil Atterberg Limit properties and the relationship between in-situ moisture content with the moisture content at the "wet" and "dry" condition. These conditions are considered extreme ranges in moisture content at which the lower bound of soil movement heave due to increase in moisture content form "wet" levels. Conversely, maximum heave can occur when soil moisture increases from "dry" moisture levels. This method uses the maximum percent swell through the entire active depth. The method is considered appropriate for wooded sites.

Another method developed by AASHTO (1993, Ref. 3) is also based on soil Atterberg Limit properties and the relationship between in-situ moisture content with the moisture content at the "wet" and "dry" condition. This method assumes a linear variation of percent swell within the active depth, such that percent swell is a maximum at the ground surface and zero at the bottom of the active depth. This method is considered appropriated for project sites that have been without trees for several years.

Laboratory data show that plasticity characteristics of the clayey soil strata together with the estimated wet and dry moisture contents are as follows:

Stratum No.	Soil Type	Liquid Limit	Plastic Limit	PI	Average Current Moisture Content, %	Moisture Content, % "Wet"	Moisture Content, % "Dry"	Current Moisture Conditions*
II	Fat Clay (CH)	83	24	59	27	41	27	Dry
III	Lean Clay (CL)	37	17	26	18	19.5	17	Dry

* Note: Moisture conditions at the time of drilling

The above moisture values indicate that current moisture contents of clayey soils are approximately at dry conditions.

Using the above soil properties, the PVR estimated by TxDOT-124-E method is in the order of 1.8 to 3.7 inches assuming heave occurs when the soil is at wet and dry moisture levels, respectively. Heave associated with moisture content changes between the present average conditions and wet and dry values are also given on Plate 11. The predicted PVR values are shown on Plate 11 together with the estimated reduction in PVR for placement of select fill under floor slabs.

Using the above soil properties, the PVR estimated by AASHTO method is in the order of 1.3 to 2.8 inches assuming heave occurs when the soil is at wet and dry moisture levels, respectively. Heave associated with moisture content changes between the present average conditions and wet and dry values are also given on Plate 12. The predicted PVR values are shown on Plate 12 together with the estimated reduction in PVR for placement of select fill under floor slabs.

We estimated depth of the active soil zone or depth to which seasonal moisture change occurs at about 10 feet, a value evaluated from the field data, root fibers, laboratory tests results and our experience with soils in the area.

The amount of fill required depends primarily on the tolerable slab heave "PVR". The structural engineer in collaboration with the architect or the owner should discuss the costs and risks involved based on the tolerable PVR and amount of fill required to mitigate the heave based on the graphs on Plates 11 and 12. The current practice indicates a tolerant PVR of about one-inch.

Our site visit indicated that the site is not wooded. Therefore, AASHTO procedure is more appropriated to predict potential heave problems of this site. In order to reduce the potential vertical rise of floor slabs to one-inch, it is suggested that the following measures be planned in the floor slab areas:

1. The surficial silty sand soils may act as a pathway for water to travel under a foundation system. This condition may result in an increase in subsoil moisture contents and subsequent swelling of the underlying expansive soils. This may result in uplift loads on the floor slabs, and subsequent distress to the foundation and structural system. Therefore, we recommend that the surficial silty sand soils be removed from the floor slab areas, and five-ft beyond the building footprint and be replaced with select structural fill in accordance with our "Site Preparation" section. Since current moisture conditions are dry, we recommend a uniform 72-inch thickness under floor slabs of (a) totally imported select fill, or (b) a combination of lime (7% by dry weight) stabilized on-site fat clays (Green Alternative) and imported select fill. This alternative treatment should extend five-ft beyond the building footprint.

   For the proposed outlined above, selected structural fill should be limited to soils with a liquid limit of 40 or less and a plasticity index (PI) between 12 and 20. Bank sand is not a structural fill and should not be used for this purpose.

2. Floor slabs should be provided with a vapor sheeting in order to prevent migration of capillary moisture through the slab. A one- to two-inch bedding layer of leveling sand may be used below the vapor sheeting for leveling purposes only.

3. It is also recommended that floor slab areas should not be structurally connected to interior columns. Isolation joints should be placed between the columns and the slab to ensure that any vertical floor slab movement is not transferred to structural members.

4. We recommend that the upper eight-inches of subgrade soils in the floor slab areas be compacted to at least 95% of standard density (ASTM D 698) at a moisture content between optimum and +3% of optimum.

Void Spaces

Void spaces under the floor slabs are used to provide a void space in between the foundation and the on-site expansive soils. Void spaces should collapse when underlying expansive soils heave; therefore, the load from expansive soil heave will not be transmitted to the foundation system. Some void spaces will not collapse; however, they will allow the expansive soils to heave into them. There is also degradable void spaces (carton form) system. The carton forms degrade as they absorb moisture, leaving void between the foundation system and the expansive soils.

We recommend the use of void spaces under the floor slabs when a structural slab foundation with void is going to be used. Furthermore, a void space of six-inches is recommended.

Additional information regarding specifications and application of void spaces below concrete foundations can be obtained from **Foundation Performance Association Document #FPA-SC-11-0** (Ref. 1).

Foundation Settlement

A detailed settlement analysis was not within the scope of this study. It is anticipated that footings, grade beams and slabs designed using the recommended allowable bearing pressures will experience small settlements that will be within the tolerable limit for the proposed structure.

PAVEMENT SECTIONS

We understand that a rigid paving will be planned for this site. Our field exploration and laboratory testing data indicate that the top soils in the project area consist of silty sand (SM) and fat clay (CH) soils. Our recommendations on pavement section are provided in Appendix A.

OTHER DESIGN CONSIDERATIONS

The potential foundation problems can be reduced by the incorporation of additional design features. Recommended items for consideration are outlined below:

1. Positive drainage should be maintained away from the foundation and pavement areas, both during and after construction.

2. Roof drainage should be collected by a gutter system and downspouts with discharge transmitted by pipe to a storm drainage system or to a paved surface where water can drain away without entering the soil.

3. Sidewalks should be sloped away from the building so that water is drained away from the structure. Water stops, mastic or other means of positive sealing of joints should be used to prevent water intrusion between joints.

4. Parking lots, streets and surface drainage should be sloped away from the building on all sides. Water should not be allowed to pond near the building, pavement or landscape areas.

5. Paving, if possible, should commence at the perimeter of the structural walls to limit moisture content change in floor slab areas.

6. Sand bedding should be specifically prohibited in pavement areas since these more porous soils can allow water inflow which can cause heave and strength loss in the subgrade soils.

7. Backfill for utility lines should consist of low plasticity clays or lime-treated clays. These soils should have a liquid limit of less than 40 and plasticity index (PI) between 12 and 20.

8. Tree roots tend to desiccate the soils. In the event that a tree has been removed prior to building construction, during the useful life of the structure, or if a tree dies, subsoil swelling may occur in the expansive soil areas for several years. Studies (Ref. 4) have shown that this process can take several years in the area where highly expansive clays are present. In this case, the foundation for the structure should be designed for the anticipated maximum heave. Furthermore, the drilled footings, if used, must be placed below the zone of influence of tree roots. In the event that a floating slab foundation is used, we recommend the slab be stiffened to resist the subsoil movements due to the presence of trees. In addition, the area within the tree root zone may have to be chemically stabilized to reduce the potential movements. Alternatively, the site should be left alone for several years so that the moisture regime in the desiccated areas of the soils (where tree roots used to be) becomes equal/stabilized to the surrounding subsoil moisture conditions.

   It should be noted that the upheaval in the expansive clays (where trees have been removed or trees have died) occurs predominantly in the areas that poor drainage, excessive irrigation or plumbing/sewer leak is occurring.

9. We recommend that trees should not be planted or left in place (existing trees) closer than half the canopy diameter of mature trees from the grade beams, typically a minimum of 20-feet. Alternatively, root barriers must be placed near the exterior grade beams to minimize tree root movements under the floor slab. This will reduce the risk of possible foundation movement as a result of tree root systems.

10. We recommend that the sprinkler system be placed all around the structure to provide a uniform moisture condition throughout the year. This will reduce fluctuations in subsoil moisture and corresponding movement.

11. Long term performance of structures depends not only on the proper design and construction, but also on the proper foundation maintenance program. A properly designed and constructed structure may still experience distress from vegetation and expansive soils which will undergo volume change when correct drainage is not established or an incorrectly controlled water source, such as plumbing/sewer leaks, excessive irrigation, water ponding near the foundation becomes available. More foundation maintenance information can be found at **Foundation Performance Association Document #FPA-SC-07-0** (Ref. 1).

CONSTRUCTION CONSIDERATIONS

Site Preparation

The project site has the potential for construction problems related to the surficial layer of silty sand soils. These permeable surficial soils are underlain by relatively impermeable clays. Thus, due to poor site drainage, wet season or site geohydrology, water ponds on the clays and creates a "perched water table condition." The surficial silty sand soils become extremely soft when wet, and must be stabilized, aerated, or replaced. Our recommendations for site preparations in the floor slab and pavement areas are summarized below:

1. In general, remove all vegetation, tree roots, organic topsoil, existing foundations, paved areas and any undesirable materials from the construction area. Tree trunks and roots under the floor slabs should be removed to a root size of less than 0.5-inches. We recommend that the stripping depth be evaluated at the time of construction by a soil technician.

2. Any on-site fill soils, encountered in the structure and pavement areas during construction, must have records of successful compaction tests signed by a licensed professional engineer that confirms the use of the fill and record of construction and earthwork testing. These tests must have been performed on all the lifts for the entire thickness of the fill. In the event that no compaction test results are available, the fill soils must be removed, processed and recompacted in accordance with our site preparation recommendations. Excavation should extend at least two-feet beyond the structure and pavement area. Alternatively, the existing fill soils should be tested comprehensively to evaluate the degree of compaction in the fill soils.

3. The subgrade areas should then be proofrolled with a loaded dump truck or similar pneumatic-tired equipment with loads ranging from 25- to 50-tons. The proofrolling serves to compact surficial soils and to detect any soft or loose zones. The proofrolling should be conducted in accordance with TxDOT Standard Specification Item 216. Any soils deflecting excessively under moving loads should be undercut to firm soils and recompacted. Any subgrade stabilization should be conducted after site proofrolling is completed and approved by the geotechnical engineer. The proofrolling operations should be observed by an experienced geotechnician.

4. Scarify the subgrade, add moisture, or dry if necessary, and recompact to 95% of the maximum dry density as determined by ASTM D 698 (Standard Proctor). The moisture content at the time of compaction of subgrade soils should be between optimum and +3% of the Proctor optimum value. We recommend that the degree of compaction and moisture in the subgrade soils be verified by field density tests at the time of construction. We recommend a minimum of four field density tests per lift or one every 2500 square feet of floor slab areas, whichever is greater.

5. Structural fill beneath the building area may consist of off-site inorganic lean clays with a liquid limit of less than 40 and a plasticity index between 12 and 20. Other types of structural fill available locally, and acceptable to the geotechnical engineer, can also be used.

   These soils should be placed in loose lifts not exceeding eight-inches in thickness and compacted to 95 percent of the maximum dry density determined by ASTM D 698 (Standard Proctor). The moisture content of the fill at the time of compaction should be between optimum and +3% of the optimum value. We recommend that the degree of compaction and moisture in the fill soils be verified by field density tests at the time of construction. We recommend that the frequency of density testing be as stated in Item 4.

6. The backfill soils in the trench/underground utility areas and tree root excavation areas should consist of select structural fill, compacted as described in Item 4. In the event of compaction difficulties, the trenches should be backfilled with cement-stabilized sand or other materials approved by the geotechnical engineer. Due to high permeability of sands and potential surface water intrusion, bank sands should not be used as backfill material in the trench/underground utility areas and tree root excavation areas.

7. In cut areas, the soils should be excavated to grade and the surface soils proofrolled and scarified to a minimum depth of six-inches and recompacted to the previously mentioned density and moisture content.

8. The subgrade and fill moisture content and density must be maintained until paving or floor slabs are completed. We recommend that these parameters be verified by field moisture and density tests at the time of construction.

9. In the areas where expansive soils are present, rough grade the site with structural fill soils to insure positive drainage. Due to high permeability of sands, sands should not be used for site grading where expansive soils are present.

10. We recommend that the site and soil conditions used in the structural design of the foundation be verified by the engineer's site visit after all of the earthwork and site preparation has been completed and prior to the concrete placement.

Suitability of On-site Soils for Use as Fill

General. The on-site soils can be used as fill. There are typically three types of fill at a site. These fills can be classified as described in the following sections:

Select Structural Fill. This is the type of fill that can be used under the floor slabs, paving, etc. These soils should consist of lean clays with liquid limit of less than 40 and a plasticity index (PI) between 12 and 20.

Structural Fill. This type does not meet the Atterberg limit requirements for select structural fill. This fill should consist of lean clays or fat clays. They can be used under paving.

General Fill. This type of fill consists of sands and silts. These soils are moisture sensitive and are difficult to compact in a wet condition (they may pump). Their use is not recommended under the floor slabs or pavements. They can be used in the planter areas at least 5-ft away from buildings. They can also be used for site grading outside the buildings and pavement areas.

Use of On-site Soils as Fill. The on-site soils can be used as fill materials as described below:

		Use as Fill			
Stratum No. (1)	Soil Type	Select Structural Fill	Structural Fill	General Fill	Notes
I and IV	Silty Sand (SM)	–	–	✓	2
II	Fat Clay (CH)	–	✓	✓	2, 3
III	Lean Clay (CL)	–	✓	✓	2, 4

Notes: 1. See soil stratigraphy and design conditions sections of this report for strata description.
2. These soils should be free of root organics, etc.
3. These soils, once lime modified (7% by dry weight), can be used as select structural fill.
3. These soils, once lime modified (4% by dry weight), can be used as select structural fill.

Drilled Footings Installations

The drilled footings installations must be in accordance with the American Concrete Institute (ACI) Reference Specifications (Ref. 5) for the construction of drilled piers (ACI 336.1) and commentary (ACI 336.1R-98). Furthermore, it should comply with U.S. Department of Transportation, drilled shafts construction procedures and design methods (Ref. 6).

The drilled footing excavations should be free of loose materials and water prior to concrete placements, and concrete should be poured immediately after drilling the holes.

Due to potential variability of the on-site soils and potential groundwater fluctuations, we recommend that the four corner piers be drilled first to better evaluate the constructability of the depth and bell to shaft ratios recommended herein. Once this information is field verified, all other piers need to be constructed accordingly.

Detailed observations of pier construction should be required by a qualified engineering technician to assure that the piers are (a) founded in the proper bearing Stratum, (b) have the proper depth, (c) have the correct size, and (d) that all loose materials have been removed prior to concrete placement.

Surface Water Drainage

In order to minimize ponding of surface water, site drainage should be established early in project construction so that this condition will be controlled.

Earthwork

General. **Difficult access and workability problems will most likely occur in the surficial silty sand soils due to poor site drainage, wet season, or site geohydrology.** Considering the soils stratigraphy, the construction of this project should be conducted during the dry season to avoid major earthwork problems. In the event the subgrade soils become wet and experience pumping problems, they can be (a) opened up to dry up, (b) removed and replaced with dry cohesive soils or (c) chemically modified or stabilized. These alternatives are discussed in the following report sections.

Subgrade Drying. The on-site wet soils can be opened up so that it would dry up. However, opening up the surficial cohesionless soils for drying purposes may not be practical, due to cyclic rainfall in the Gulf-Coast area.

Removal and Replacement. The surficial cohesionless soils can be removed and replaced with select structural fill. The actual depth of removal and replacement should be evaluated in the field, but it can be whole thickness of surficial cohesionless soils. This procedure will include removal of the surficial cohesionless soils, proofrolling and compacting the subgrade cohesive soils to a minimum of 95 percent standard proctor density (ASTM D 698). The site can then be backfilled with select structural fill, compacted to a minimum of 95 percent of standard proctor density. The proofrolling should be in accordance with the site preparation section of this report. All of the fill soils should be placed and tested in accordance with the site preparation section of this report.

Modification/Stabilization. We recommend that the on-site cohesionless soils be modified (to dry up), using 5 to 10 percent fly ash by dry weight. The fly ash stabilization should be in accordance to Harris County Standard Specification, Item 223. The estimated amount of fly ash per depth of modification are as follows:

Modification Depth, in.	Fly Ash Weight Range, lbs. per Square Yard
6	23 – 45
12	46 – 90
18	69 – 135
24	92 – 180

We recommend that five percent fly ash be used if the surficial soils are relatively moist at the time of application. Higher levels (10 percent) of fly ash should be used if wet and soggy subgrade soils are encountered.

The subgrade soils should be removed to a depth of 24-inches (or more) below existing grade. These soils should be stockpiled. The soils below a depth of 24-inches should be modified to a depth of 12-inches. These soils should be compacted to a minimum of 95 percent of standard proctor density (ASTM D 698). The stockpiled soils should then be modified and replaced in six-inch lifts and compacted to 95 percent of maximum dry density as determined by ASTM D 698 at moisture contents within ±2 percent of optimum.

Due to poor drainage and the depth of the cohesionless soils, the depth of stabilization may be as deep as depth of cohesionless soils. A test section can be implemented for this purpose. The subgrade soils should be modified in six-inch lifts and compacted within four hours of mixing and placement. All of the subgrade soils should be compacted to a minimum of 95 percent of the standard proctor density at the moisture content with optimum. The degree of compaction for the lifts, below a depth of 24-inches can be relaxed to 90 percent of maximum dry density to ease the construction procedures.

The subcontractor who will be doing the subgrade modification or stabilization should be experienced with stabilization procedures and methods. Furthermore, all of the earthwork at this project should be monitored by our geotechnician to assured compliance with the project specifications. Once the subgrade is constructed, the soils at the top of subgrade should be slicked and the subgrade needs to be crowned such that the all surface water would drain away. No low areas should be left within the subgrade areas, since these areas would hold water and destroy the subgrade structure.

Provided the site work is performed during dry weather and/or project schedules permit aeration of wet soils, the subgrade will be suitable for floor slab and pavement support.

Construction Surveillance

Construction surveillance and quality control tests should be planned to verify materials and placement in accordance with the specifications. The recommendations presented in this report were based on a discrete number of soil test borings. Soil type and properties may vary across the site. As a part of quality control, if this condition is noted during the construction, we can then evaluate and revise the design and construction to minimize construction delays and cost overruns. We recommend the following quality control procedures be followed by a qualified engineer or technician during the construction of the facility:

- Observe the site stripping and proofrolling.
- Verify the type, depth and amount of stabilizer.
- Verify the compaction of subgrade soils.
- Evaluate the quality of fill and monitor the fill compaction for all lifts.
- Monitor and test the foundation excavations for strength, cleanness, depth, size, etc.
- Observe the foundation make-up prior to concrete placement.
- Monitor concrete placement, conduct slump tests and make concrete cylinders.
- Conduct after pour observations, including post-tensioned slab cable stress monitoring, if used.
- Conduct after construction site visit to evaluate the site landscaping, drainage and the presence of trees near the structure.

It is the responsibility of the client to notify GET of when each phase of the construction is taking place so that proper quality control and procedures are implemented. More information regarding construction quality control can be found at the **Foundation Performance Association Document #FPA-SC-10-1** (Ref. 1).

RECOMMENDED ADDITIONAL STUDIES

We recommend the following additional studies be conducted:

1. This report has been based on assumed conditions/characteristics of the proposed development where specific information was not available. It is recommended that the architect, civil engineer and structural engineer along with any other design professionals involved in this project carefully review these assumptions to ensure they are consistent with the actual planned development. When discrepancies exist, they should be brought to our attention to ensure they do not affect the conclusions and recommendations provided herein. We recommend that GET be retained to review the plans and specifications to ensure that the geotechnical related conclusions and recommendations provided herein have been correctly interpreted as intended.

2. Conduct a site characterization study. This study will include the following:

    - Phase I Geologic Fault Study to look for geologic faults at or near the site.
    - Phase I Environmental Site Assessment Study to evaluate the risk of contamination at the site.
    - Review previous aerial photos of the project site.
    - Review site topography.
    - Conduct a site visit to look for drainage features, slopes, seeps, trees and other vegetation; fence lines, ponds, stock tanks; areas of fill, etc.

3. We recommend obtaining baseline micro-elevations of the floor slabs after floor covering is installed. This information will be valuable in the event of future foundation movements.

STANDARD OF CARE

The recommendations described herein were conducted in a manner consistent with the level of care and skill ordinarily exercised by members of the geotechnical engineering profession practicing contemporaneously under similar conditions in the locality of the project. No other warranty or guarantee, expressed or implied, is made other than the work was performed in a proper and workmanlike manner.

REPORT DISTRIBUTION

This report was prepared for the sole and exclusive use by our client, based on specific and limited objectives. All reports, boring logs, field data, laboratory test results, maps and other documents prepared by GET as instruments of service shall remain the property of GET. Reuse of these documents is not permitted without written approval by GET. GET assumes no responsibility or obligation for the unauthorized use of this report by other parties and for purposes beyond the stated project objectives and work limitations.

We appreciate the opportunity to assist you on this project. Please call if there should be any questions.

Very truly yours,

GEOTECH ENGINEERING AND TESTING

Weihua (Harry) Wang
Project Engineer

STATE OF TEXAS
YOUNGAN CHUNG
100317
LICENSED
PROFESSIONAL ENGINEER

1-09-2009

Youngan (Andrew) Chung, P.E.
Engineering Manager

HW/AC/ch

Copies Submitted: (3)

ILLUSTRATIONS

REFERENCES

1. Committee Papers from Foundation Performance Association (FPA), see FPA Website: http://www.foundationperformance.org/committee_papers.html

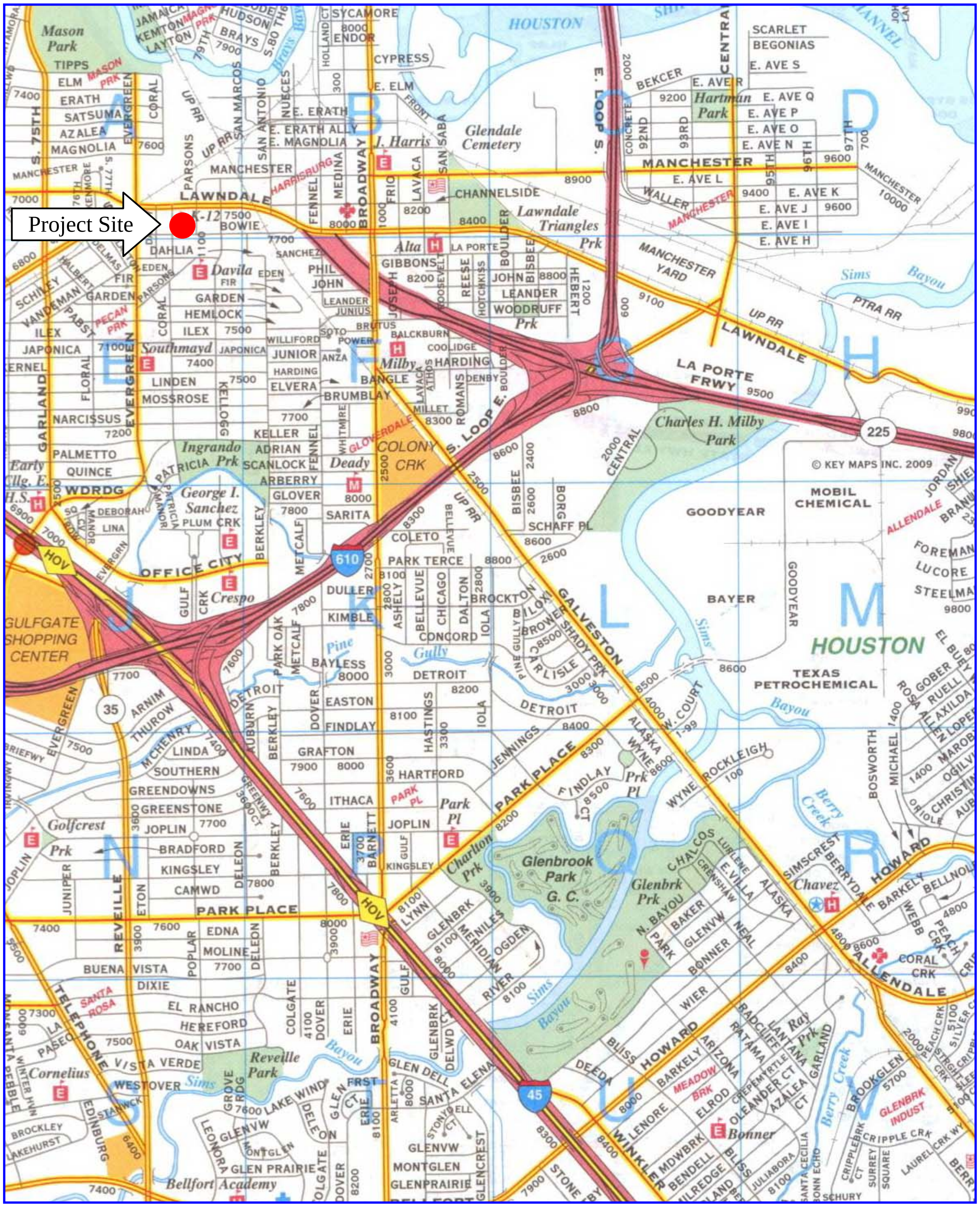
2. "Method for Determining the Potential Vertical Rise, PVR," State Department of Highways and Public Transportation, Test Method Tex 124-E, Austin, Texas.

3. "AASHTO Guide for Design of Pavement Structures", American Association of State Highway and Transportation Officials, Washington, D.C, 1993.

4. "Design of Foundations with Trees in Mind", Presented at the ASCE Texas Section Meeting, 1997.

5. "Reference Specifications for the Construction of Drilled Piers (ACI 336.1) and Commentary (ACI 336.1R)", American Concrete Institute, Farmington Hills, Michigan.

6. "Drilled Shafts: Construction Procedures and Design Methods", U.S. Department of Transportation, Federal Highway Administration, Volumes I and II, August 1999.



SITE VICINITY MAP

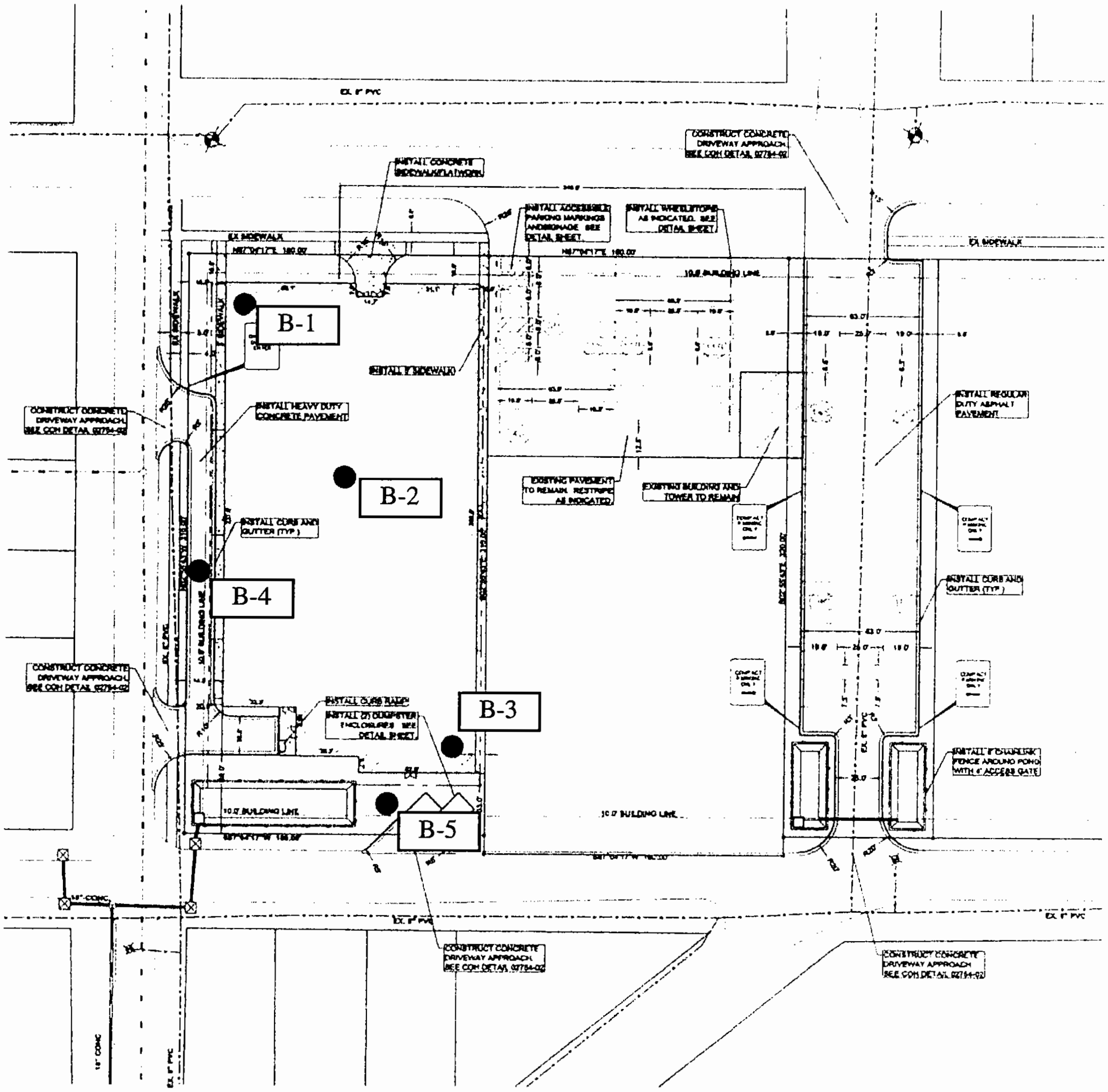
PROJECT: Two-Story Building at 1115 Coral Street
Houston, Texas

SCALE: NOT TO SCALE

DATE: JANUARY 2009

REPORT NO.: 08-774E

NORTH



PLAN OF BORINGS (boring dimensions and locations are approximate)

PROJECT: Two-Story Building at 1115 Coral Street
Houston, Texas

SCALE: NOT TO SCALE

DATE: JANUARY 2009

REPORT NO.: 08-774E

NORTH

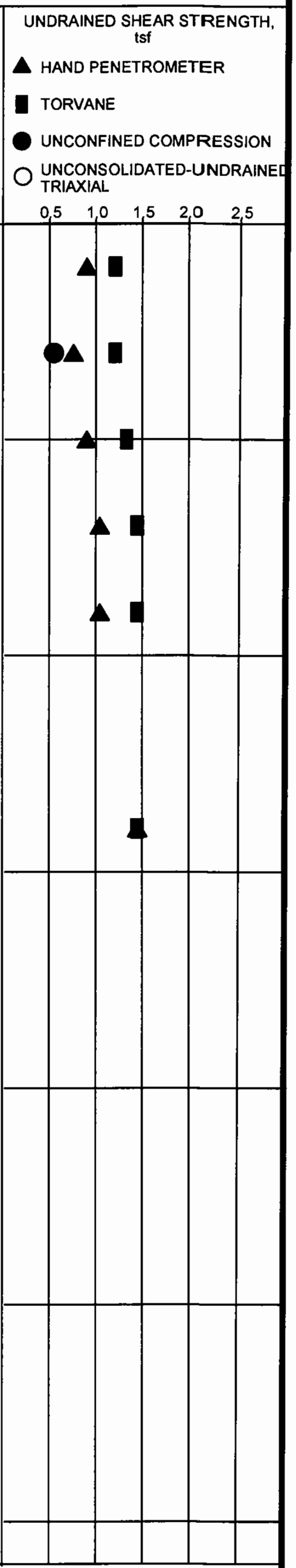
LOG OF BORING NO. B-1

Sheet 1 of 1

Geotech Engineering and Testing
800 Victoria Drive
Houston, Texas 77022
Phone: 713-699-4000 Fax: 713-699-9200

PROJECT: Two-Story Building at 1115 Coral Street
LOCATION: Houston, Texas
PROJECT NO.: 08-774E STATION NO.:
DATE: 1-5-08 COMPLETION DEPTH: 25.0 ft.

DEPTH, ft	SPT N-VALUE blows per foot	OVM, ppm	DESCRIPTION	NATURAL MOISTURE CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX, %	PERCENT PASSING NO. 200 SIEVE	SUCTION (pF)	DRY UNIT WEIGHT, pcf	PERCENT COMPACTION	PASSING/FAILING (P/F)
			ELEVATION: Existing Grade									
0			SILTY SAND (SM), brown, with root fibers, moist									
			FAT CLAY (CH), stiff, dark gray, with root fibers to 6', moist									
				29	67	21	46			94		
5			- gray, light gray, brown, with ferrous and calcareous nodules 4' to 10'									
			- very stiff 6' to 10'									
				35	64	21	43					
10												
			LEAN CLAY (CL), very stiff, light gray, brown, with calcareous nodules, moist									
15			SILTY SAND (SM), dense, light gray, moist									
	32											
20			- medium dense, brown 23' to 25'									
	24											
25												
30												



WATER OBSERVATIONS:
NO FREE WATER ENCOUNTERED DURING DRILLING

DRY AUGER: 0 TO 25 ft.
WET ROTARY: ____ TO ____ ft.

DRILLED BY: GET
LOGGED BY: Greg

OVM2 08-774E.GPJ OVM.GDT 1/9/09

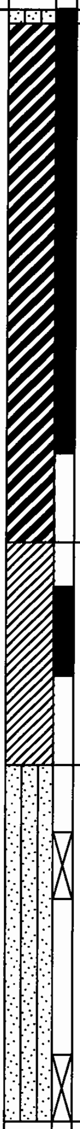
LOG OF BORING NO. B-2

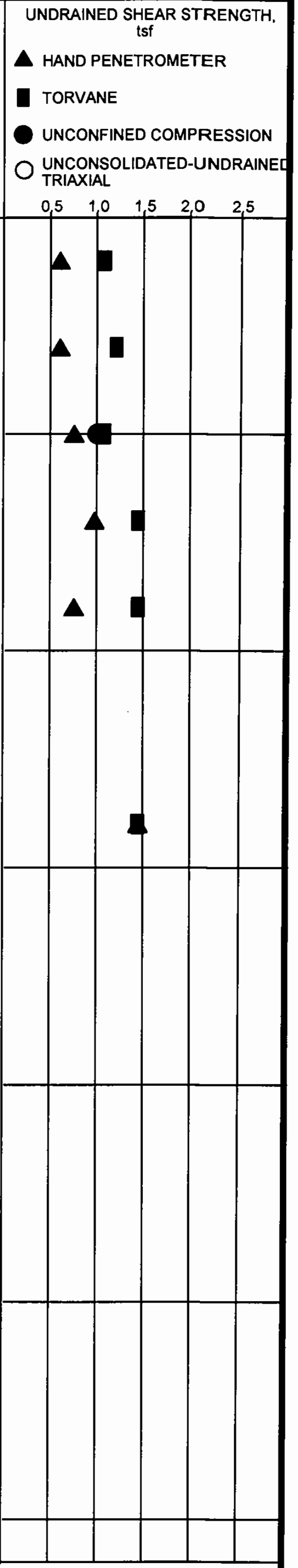
Sheet 1 of 1

Geotech Engineering and Testing
800 Victoria Drive
Houston, Texas 77022
Phone: 713-699-4000 Fax: 713-699-9200

PROJECT: Two-Story Building at 1115 Coral Street
LOCATION: Houston, Texas
PROJECT NO.: 08-774E STATION NO.:
DATE: 1-5-08 COMPLETION DEPTH: 25.0 ft.

DEPTH, ft	SPT N-VALUE blows per foot	OVM, ppm	DESCRIPTION	NATURAL MOISTURE CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX, %	PERCENT PASSING NO. 200 SIEVE	SUCTION (pF)	DRY UNIT WEIGHT, pcf	PERCENT COMPACTION	PASSING/FAILING (P/F)
			ELEVATION: Existing Grade									
0			SILTY SAND (SM), gray, light gray, brown, with root fibers, moist									
			FAT CLAY (CH), stiff, gray, with root fibers 8', moist									
			- very stiff 4' to 8'									
5				27	83	24	59			97		
			- light gray, brown, reddish brown, with ferrous nodules 6' to 10'									
			LEAN CLAY (CL), very stiff, light gray, brown, with ferrous and calcareous nodules, moist									
				18	37	17	20					
			SILTY SAND (SM), medium dense, brown, moist									
	30											
	25											





WATER OBSERVATIONS:
NO FREE WATER ENCOUNTERED DURING DRILLING

DRY AUGER: 0 TO 25 ft.
WET ROTARY: ____ TO ____ ft.

DRILLED BY: GET
LOGGED BY: Greg

OVM2 08-774E.GPJ OVM.GDT 1/9/09

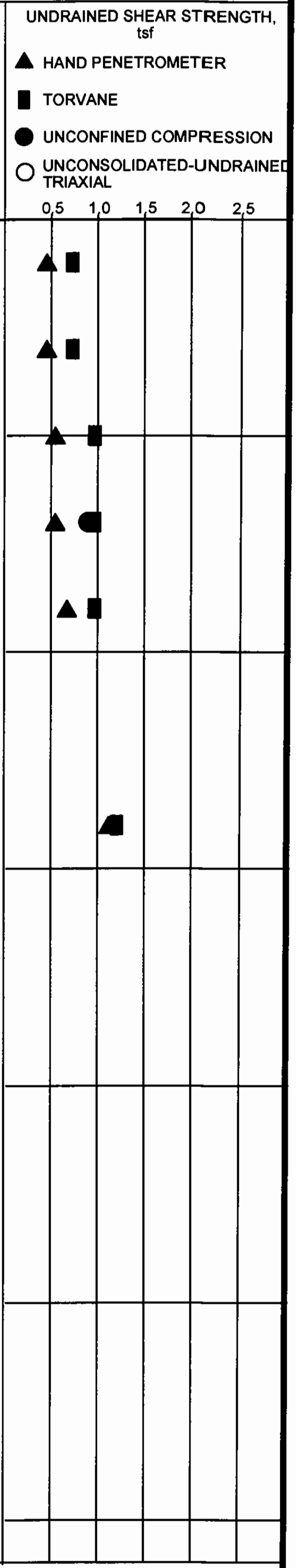
LOG OF BORING NO. B-3

Sheet 1 of 1

Geotech Engineering and Testing
800 Victoria Drive
Houston, Texas 77022
Phone: 713-699-4000 Fax: 713-699-9200

PROJECT: Two-Story Building at 1115 Coral Street
LOCATION: Houston, Texas
PROJECT NO.: 08-774E STATION NO.:
DATE: 1-5-08 COMPLETION DEPTH: 25.0 ft.

DEPTH, ft	SPT N-VALUE blows per foot	OVM, ppm	SYMBOL	SAMPLES	DESCRIPTION	NATURAL MOISTURE CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX, %	PERCENT PASSING NO. 200 SIEVE	SUCTION (pF)	DRY UNIT WEIGHT, pcf	PERCENT COMPACTION	PASSING/FAILING (P/F)
					ELEVATION: Existing Grade									
					SILTY SAND (SM), dark brown, dark gray, with root fibers, moist									
					FAT CLAY (CH), firm, dark gray, with root fibers to 8', moist	25	53	19	34					
					- stiff, gray, brown, reddish brown 4' to 10'									
						28	71	22	49			99		
					- very stiff, light gray, dark gray, with calcareous nodules 13' to 15'									
					SILTY SAND (SM), medium dense, gray, reddish brown, moist									
	30					26				14				
					- brown 23' to 25'									
	25													



WATER OBSERVATIONS:
NO FREE WATER ENCOUNTERED DURING DRILLING

DRY AUGER: 0 TO 25 ft.
WET ROTARY: ____ TO ____ ft.

DRILLED BY: GET
LOGGED BY: Greg

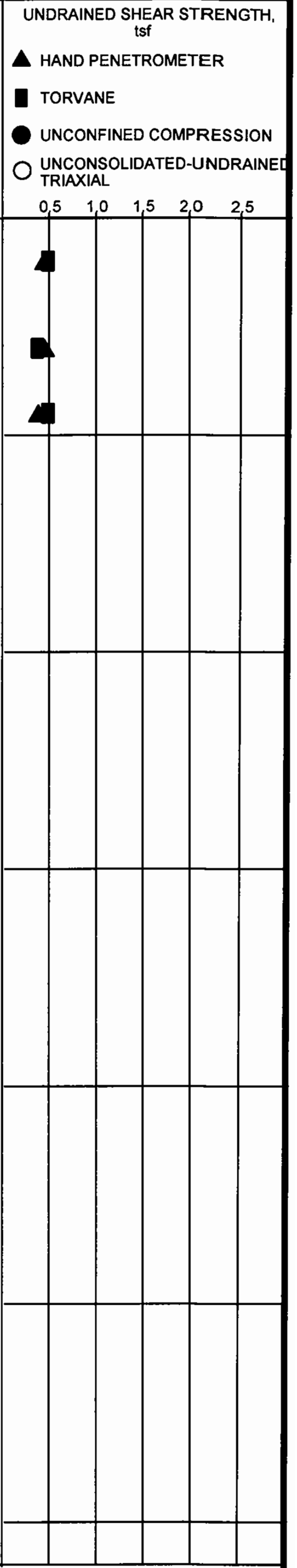
LOG OF BORING NO. B-4

Sheet 1 of 1

Geotech Engineering and Testing
800 Victoria Drive
Houston, Texas 77022
Phone: 713-699-4000 Fax: 713-699-9200

PROJECT: Two-Story Building at 1115 Coral Street
LOCATION: Houston, Texas
PROJECT NO.: 08-774E STATION NO.:
DATE: 1-5-08 COMPLETION DEPTH: 5.0 ft.

DEPTH, ft	SPT N-VALUE blows per foot	OVM, ppm	SYMBOL	SAMPLES	DESCRIPTION	NATURAL MOISTURE CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX, %	PERCENT PASSING NO. 200 SIEVE	SUCTION (pF)	DRY UNIT WEIGHT, pcf	PERCENT COMPACTION	PASSING/FAILING (P/F)
					ELEVATION: Existing Grade									
0					SILTY SAND (SM), brown, with root fibers, moist									
					FAT CLAY (CH), firm, dark gray, dark brown, with root fibers, moist - dark gray 2' to 5'	22	64	21	43					
5														
10														
15														
20														
25														
30														



WATER OBSERVATIONS:
NO FREE WATER ENCOUNTERED DURING DRILLING

DRY AUGER: 0 TO 5 ft.
WET ROTARY: ____ TO ____ ft.

DRILLED BY: GET
LOGGED BY: Greg

LOG OF BORING NO. B-5

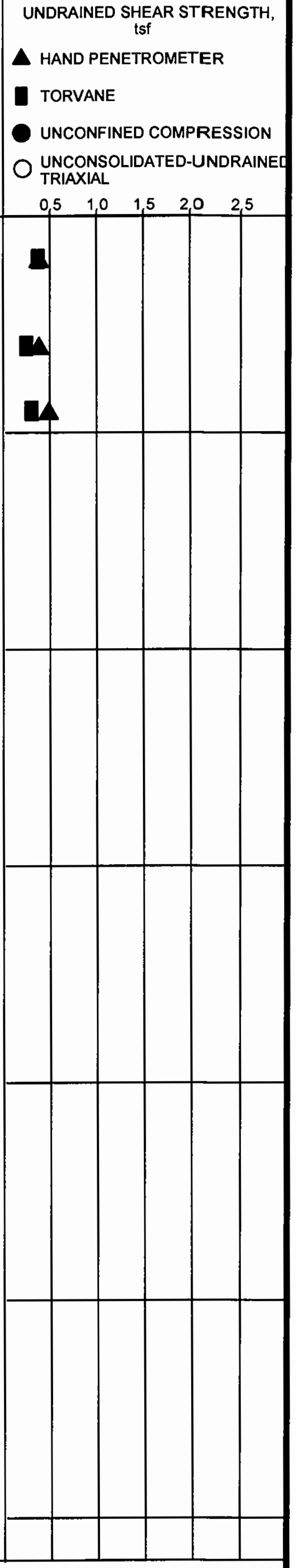
Sheet 1 of 1

Geotech Engineering and Testing
800 Victoria Drive
Houston, Texas 77022
Phone: 713-699-4000 Fax: 713-699-9200

PROJECT: Two-Story Building at 1115 Coral Street
LOCATION: Houston, Texas
PROJECT NO.: 08-774E STATION NO.:
DATE: 1-5-08 COMPLETION DEPTH: 5.0 ft.

ELEVATION: Existing Grade

DEPTH, ft	SPT N-VALUE blows per foot	OVM, ppm	SYMBOL	SAMPLES	DESCRIPTION	NATURAL MOISTURE CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	PLASTICITY INDEX, %	PERCENT PASSING NO. 200 SIEVE	SUCTION (pF)	DRY UNIT WEIGHT, pcf	PERCENT COMPACTION	PASSING/FAILING (P/F)
0					SILTY SAND (SM), brown, with root fibers, moist									
					FAT CLAY (CH), firm, gray, brown, with root fibers, moist	30	81	24	57			82		
5														
10														
15														
20														
25														
30														



WATER OBSERVATIONS:
NO FREE WATER ENCOUNTERED DURING DRILLING

DRY AUGER: 0 TO 5 ft.
WET ROTARY: ____ TO ____ ft.

DRILLED BY: GET
LOGGED BY: Greg

OVM2 08-774E.GPJ OVM.GDT 1/9/09

KEY TO LOG TERMS AND SYMBOLS

UNIFIED SOIL CLASSIFICATIONS

Symbol		Material Descriptions
GW	▩	WELL GRADED-GRAVELS, GRAVEL-SAND MIXTURES LITTLE OR NO FINES
GP	▢	POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
GM	▥	SILTY GRAVELS, GRAVEL-SAND SILT MIXTURES
GC	▨	CLAY GRAVELS, GRAVEL-SAND CLAY MIXTURES
SW	▦	WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
SP	░	POORLY GRADED SANDS, OR GRAVELLY SANDS, LITTLE OR NO FINES
SM	▤	SILTY SANDS, SAND-SILT MIXTURES a
SC	▨	CLAYEY SANDS, SAND-SILT MIXTURES b
ML	▥	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
CL	▨	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
OL	☰	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
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 MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
PT	▢	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENT
	⊠	FILL SOILS

TERMS CHARACTERIZING SOIL STRUCTURE

Slickensided	-	Having incline planes of weakness that are slick and glossy in appearance.
Fissured	-	Containing shrinkage cracks frequently filled with fine sand or silt: usually vertical.
Laminated	-	Composed of thin layers of varying colors and soil sample texture.
Interbedded	-	Composed of alternate layers of different soil types.
Calcareous	-	Containing appreciable quantities of calcium carbonate.
Well Graded	-	Having wide range in grain sizes and substantial amounts of all intermediate particle sizes.
Poorly Graded	-	Predominantly of one grain size, or having a range of sizes with some intermediate sizes missing.
Pocket	-	Inclusion of material of different texture that is smaller than the diameter of the sample.
Parting	-	Inclusion less than ⅛-inch thick extending through the sample.
Seam	-	Inclusion ⅛- to 3-inches thick extending through the sample.
Layer	-	Inclusion greater than 3-inches thick extending through the sample.
Interlayered	-	Soils sample composed of alternating layers of different soil types.
Intermixed	-	Soil samples composed of pockets of different soil type and layered or laminated structure is not evident.

COARSE GRAINED SOILS (major portion retained on No. 200 Sieve): Includes (1) clean gravels and sands, and (2) silty or clayey gravels and sands. Conditions rated according to standard penetration test (SPT)* as performed in the field.

Descriptive Terms	Blows Per Foot*
Very Loose	0 – 4
Loose	5 – 10
Medium Dense	11 – 30
Dense	31 – 50
Very Dense	over 50

* 140 pound weight having a free fall of 30-inches

SOIL SAMPLERS

■ SHELBY TUBE SAMPLER

☒ STANDARD PENETRATION TEST

◨ AUGER SAMPLING

FINE GRAINED SOILS (major portion passing No. 200 Sieve): Include (1) inorganic or organic silts and clays, (2) gravelly, sandy, or silty clays, and (3) clayey silts. Consistency is rated according to shearing strength as indicated by hand penetrometer readings or by unconfined compression tests.

Descriptive Term	Undrained Shear Strength Ton/Sq. Ft.
Very Soft	Less than 0.13
Soft	0.13 to 0.25
Firm	0.25 to 0.50
Stiff	0.50 to 1.00
Very Stiff	1.00 to 2.00
Hard	2.00 or higher

NOTE: Slickensided and fissured clays may have lower unconfined compressive strengths than shown above because of weakness or cracks in the soil. The consistency ratings of such soils are based on hand penetrometer readings.

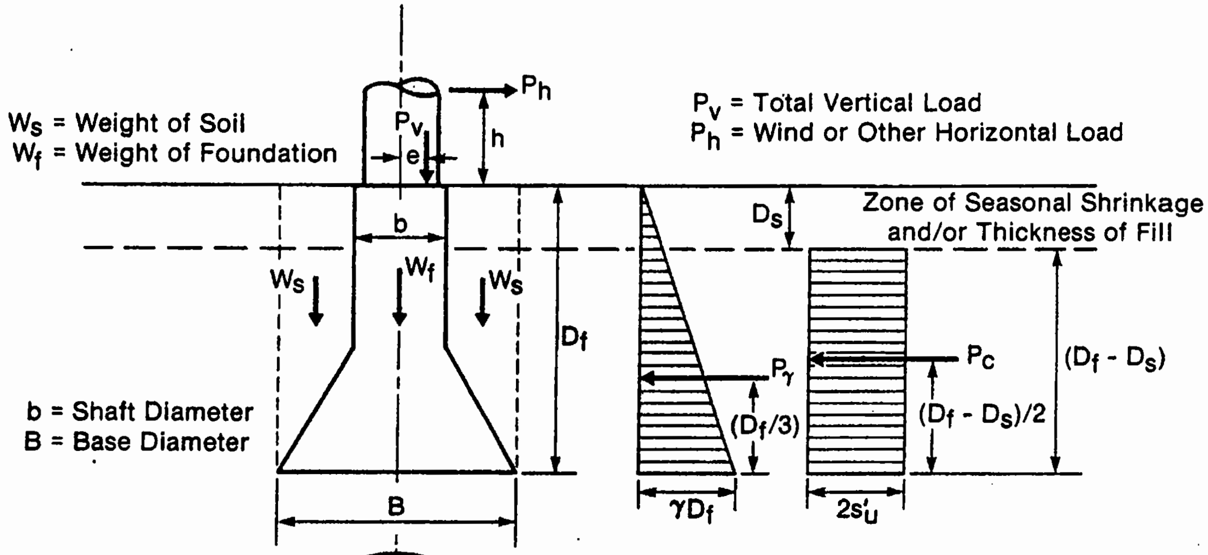
TERMS CHARACTERIZING ROCK PROPERTIES

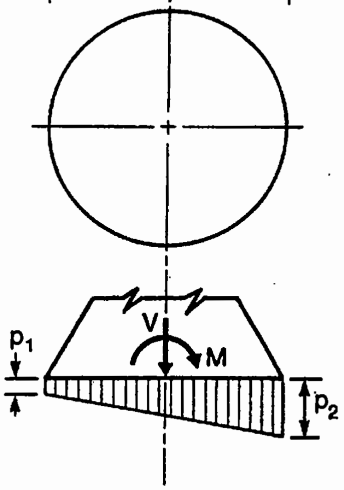
VERY SOFT OR PLASTIC	Can be remolded in hand: corresponds in consistency up to very stiff in soils.
SOFT	Can be scratched with fingernail.
MODERATELY HARD	Can be scratched easily with knife; cannot be scratched with fingernail.
	Difficult to scratch with knife.
VERY HARD	Cannot be scratched with knife.
POORLY CEMENTED OR FRIABLE	Easily crumbled.
CEMENTED	Bounded Together by chemically precipitated materials.
UNWEATHERED	Rock in its natural state before being exposed to atmospheric agents.
SLIGHTLY WEATHERED	Noted predominantly by color change with no disintegrated zones.
WEATHERED	Complete color change with zones of slightly decomposed rock.
EXTREMELY WEATHERED	Complete color change with consistency, texture, and general appearance or soil.

PROJECT PICTURE

Report No. 08-774E

Note: The above picture(s) indicate a snap shot of the project and the surroundings. We request that the client review the picture(s) and make sure that they represent the project area. We must be contacted immediately if any discrepancy exists.





FOR FOOTINGS IN CLAYS :

$P_\gamma = (\gamma/2)\ (D_f)^2\ b$

γ = Effective Unit Weight of Soil

$P_c = 2s'_u\ (D_f - D_s)\ b$

$s'_u = s_u/\text{F.S.}$

s_u = Undrained Shear Strength of Soil

F.S. = Factor of Safety

AT BASE OF FOOTING :

(1) Applied Vertical Load ;

$V = P_v + W_f + W_s$

(2) Applied Overturning Moment ;

$M_o = P_v\ e + P_h\ (h + D_f)$

(3) Resisting Moment from Lateral Earth Pressure ;

$M_r = P_\gamma\ (D_f/3) + P_c\ [(D_f - D_s)/2]$

M_r cannot be greater than M_o

(4) Net Moment Resisted by Base ;

$M = M_o - M_r$

(5) Soil Pressures ;

$p_1 = (4V/\pi B^2) - (32M/\pi B^3)$

$p_2 = (4V/\pi B^2) + (32M/\pi B^3)$

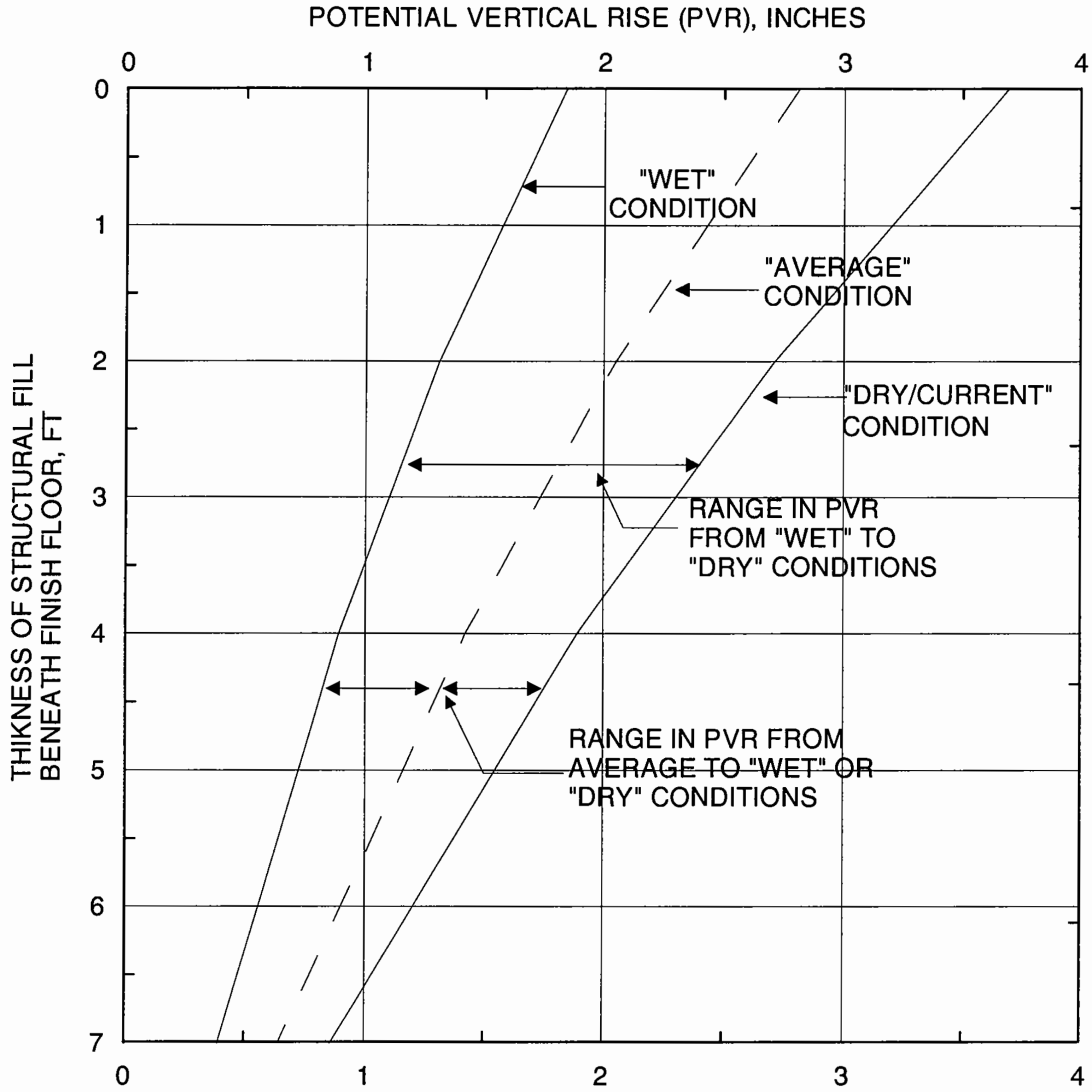
(6) Maximum Pressure, p_2, should not exceed Allowable Gross Bearing Pressure, q_{ga} ; where :

$q_{ga} = q_{na} + \gamma D_f$

q_{na} = Allowable Net Bearing Pressure

DESIGN EQUATIONS FOR ECCENTRICALLY LOADED DRILLED AND UNDERREAMED FOOTINGS

POTENTIAL VERTICAL RISE
OF FOUNDATION SOILS
TxDOT-124-E METHOD



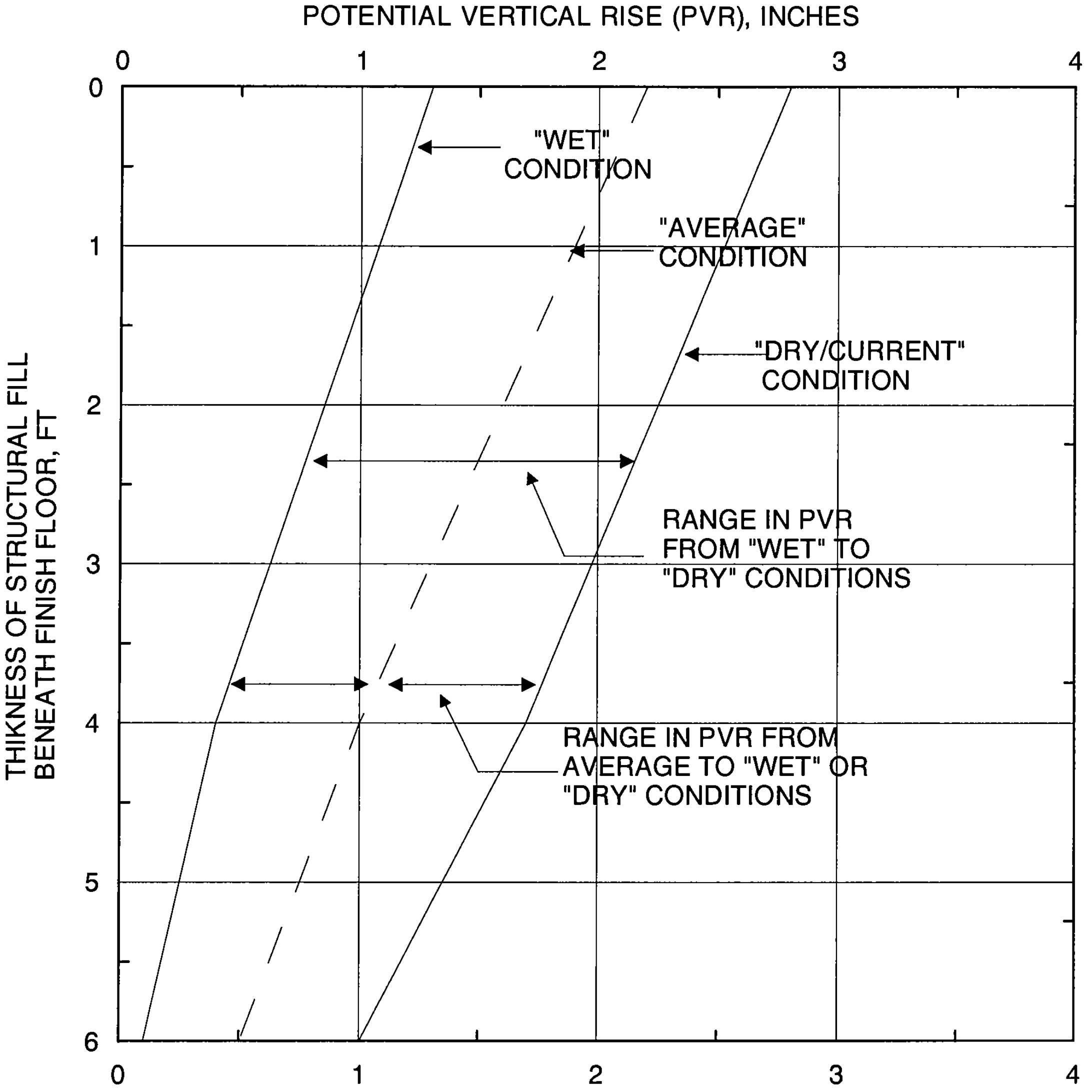
NOTE:

1. Zone of moisture content change (Active Zone) thickness was assumed to be 10-ft.
2. Wet condition Moisture Content = 0.47 LL + 2, lower-bond envelope, after/during prolonged raining condition.

   Dry Condition Moisture Content = 0.22 LL + 9, upper-bond envelope, after/during prolonged drought.
3. Existing moisture in the field during the our field exploration. Present moisture contents are near average to dry conditions.
4. Structural fill should consist of sandy clays or silty clays (lean clay) with liquid limit (LL) less than 40 and plasticity index (PI) between 12 and 20.
5. Criteria based on TxDOT-124-E Method for calculating Potential Vertical Rise(PVR) (Ref. 2).
6. General practice is to limit the PVR to one-inch or less.

Report No. 08-774E

POTENTIAL VERTICAL RISE
OF FOUNDATION SOILS
AASHTO METHOD



NOTE:

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   Dry Condition Moisture Content = 0.22 LL + 9, upper-bond envelope, after/during prolonged drought.
3. Existing moisture in the field during the our field exploration. Present moisture contents are near average to dry conditions.
4. Structural fill should consist of sandy clays or silty clays (lean clay) with liquid limit (LL) less than 40 and plasticity index (PI) between 12 and 20.
5. Criteria based on AASHTO Method for calculating Potential Vertical Rise(PVR) (Ref. 3).
6. General practice is to limit the PVR to one-inch or less.

APPENDIX A

Pavement Sections

APPENDIX A

PAVEMENT SECTIONS

The laboratory data indicates that the upper subsoils are classified as silty sand (SM) and fat clay (CH) soils by the Unified Soil Classification System. These soils have subgrade moduli, k, ranging from 100 to 140 pci and CBR values ranging from 3 to 5.

Based on the subgrade soil properties, the recommended pavement thickness for rigid paving is given on Table I.

Detailed traffic analysis was not conducted to evaluate the pavement sections in this report. We recommend that additional studies be conducted to evaluate the proposed pavement traffic loading. This information can be used to evaluate the required pavement sections. Adequate site drainage is essential to pavement performance in accordance with design criteria.

It should be noted that our recommendations on subgrade stabilization assume that final paving grade will be at the top of existing subgrade. Alternative subgrade stabilization recommendations will be required if the final subgrade is different from the one assumed in this report.

TABLE I

Rigid Pavement (Protected Corner)		Auto or Bus Traffic, in	Service Drive or Heavy Truck Traffic, in
Surface:	Concrete Pavement	5	7
Subgrade:	Lime-Fly Ash Stabilized Subgrade (TxDOT Specification Item 265, Notes 1 and 2) Compact to 95% of Maximum Standard Proctor Density (ASTM D 698) at a moisture content between optimum and +3% of optimum.	6	6

Concrete flexural strength should be at least 500 psi at 7 days. This corresponds to a compressive strength of 3000 psi at 28 days. The paving for the auto traffic should be reinforced with #4 bars at 18-inches on centers each. The paving for the heavy truck traffic should be reinforced with #5 bars at 15-inches center-to-center each way. Suggested longitudinal and transverse joint spacing for concrete paving is 15-feet. The expansion joint spacing is approximately 80-feet. Steel used for reinforcements should be grade 60.

NOTES:

1. Reference Texas Department of Transportation Specifications (TxDOT)

2. Use 2% lime and 8% fly-ash by dry weight to stabilize the upper soils. This results in application rates of 9 and 36 pounds per square yard per six-inches of compacted thickness for lime and fly-ash, respectively.