**GEOTECHNICAL INVESTIGATION**
Proposed Remedial Foundations
6000 Teague Road
Houston, Texas

Reported to
CSF Consulting, L.P.
Houston, Texas

Prepared by
A&R Engineering and Testing, Inc.
Houston, Texas

PROJECT NO. : 12S4633

May, 2012

*A&R ENGINEERING and TESTING, INC. • Registration No. F-4123*
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A&R

**A&R ENGINEERING and TESTING, INC.**

*Geotechnical & Material Engineers • Registration No. F-4123*

May 01, 2012

CSF Consulting, L.P.
11210 Steeplecrest Drive, Suite 202
Houston, Texas 77065

Attention: Mr. Cory Walker, P.E.

Reference: Geotechnical Investigation
Proposed Remedial Foundations
6000 Teague Road
Houston, Texas
A&R NO.: 12S4633

Dear Mr. Walker:

A&R Engineering and Testing, Inc. is pleased to submit this report for the above referenced project. This study was authorized by you on April 04, 2012. This report briefly describes the procedures employed in our investigation and presents the conclusions and recommendations of our studies.

We appreciate the opportunity to work with you on this phase of the project. If you have any question concerning this report or require additional information, please contact us.

Very Truly Yours,

STATE OF TEXAS
RASMY M. HASSOUNA
81966
REGISTERED PROFESSIONAL ENGINEER

Russ M. Hassouna, MSCE., P.E.
Principal Engineer

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## INTRODUCTION

**A&R Engineering and Testing, Inc. (A&R)** hereby submits this report of Geotechnical Investigation of subsurface conditions at the site of the Proposed Remedial Foundations located at 6000 Teague Road in Houston, Texas. **A&R's** investigation was authorized by Mr. Cory Walker, P.E. on behalf of CSF Consulting, L.P. on April 04, 2012.

## PURPOSE

The purpose of the Geotechnical Investigation was to determine the subsurface soil conditions on the site of the Proposed Remedial Foundations with particular reference to the design of the foundation for the structure.

## FIELD INVESTIGATION

The field portion of this study was completed on the site located at 6000 Teague Road in Houston, Texas on April 10 and 24, 2012. The subsurface soil conditions were explored by advancing and sampling three (3) soil borings drilled to a depth of twenty (20) feet below existing ground surface. The approximate boring location is shown on the attached Boring Plan, Plate No. 1.

Sample depth, description of soil and soil classification (Based on the Unified Soil Classification System) are presented on the Boring Logs, Plate Nos.2 through 4. Keys to terms and symbols used on the boring logs are shown on Plate No. 5.

The soil borings were of three-inch nominal diameter. Undisturbed samples of the soils were obtained at two (2) foot intervals continuously to a depth of ten (10) feet, and at five (5) foot intervals thereafter. Samples of the soils were obtained by means of three-inch O.D. shelby tube sampler. All undisturbed samples were extruded mechanically from the shelby tubes in the field, wrapped in aluminum foil, and sealed in plastic bags to prevent moisture loss and disturbance. All of the samples were transported to our geotechnical laboratory for examination, testing and analysis.

## LABORATORY TESTING

All field soil samples from the borings were examined and classified by a soils engineer. Laboratory tests were then performed on selected soil samples in order to evaluate and determine the physical and engineering properties of the foundation soils in accordance with the prescribed ASTM standards. Strength properties of the foundation soils were determined by means of Pocket Penetrometer and Unconfined Compression Tests performed on undisturbed samples.

The type and number of laboratory tests performed for this study are:

| DESCRIPTION | NO. OF TESTS |
|---|---|
| Hand Penetrometer Test | 7 |
| Moisture Content Tests | 21 |
| Atterberg Limits | 8 |
| Unconfined Compression Tests | 2 |
| Dry Density Tests | 2 |

The tests noted above were performed to establish the index properties and to aid in the proper classification of the subsurface soils. The test results are shown on the boring logs and are presented on Plate Nos. 2 through 4.

## GENERAL SUBSURFACE CONDITIONS

The site is relatively level with an existing building. The surface soils were moist and firm at the time of our investigation. The specific subsurface stratigraphy as determined by the field exploration, is shown in detail on the boring logs herein. However, the stratigraphy can be generalized as follows:

| Depth (FT.) | DESCRIPTION |
|---|---|
| 0' - 2' | Very Gray and Dark Gray Silty Clay (CL)*. |
| 2' - 8' | Stiff to Very Stiff Gray and Tan Clay to Silty Clay (CH-CL). |
| 8' - 20' | Firm to Very Stiff Light Gray and Tan Clay to Silty Clay (CH-CL). |

* Classification is in accordance with the Unified Soil Classification system.

The information in this report summarizes conditions as found on the date the borings were drilled. Free groundwater was encountered at a depth of thirteen (13) feet during the field drilling operation. Long term monitoring of the groundwater level was beyond the scope of this study. It should be noted that the groundwater table may be expected to fluctuate with environmental variations such as frequency and magnitude of rainfall and at the time of year when construction begins.

## EXPANSIVE CLAY

The Atterberg Limit tests indicate that the Liquid Limit of the soils is in the order of 23 to 75 and the Plasticity Index (P.I.) is in the order of 8 to 54. The subsoil would then be described as clays having a moderate to high shrink/swell potential.

## A. UNDERREAMED FOOTINGS

Based on the soil conditions revealed by the field soil test boring, the structure at this site can be supported on a foundation system comprised of drilled and underreamed footings bearing at a depth of fourteen (14) feet below existing grade in the layer of Light Gray and Tan Clay to Silty Clay. The footings may be sized for a net allowable bearing pressure of 3,000 psf for dead load plus sustained live load. The bearing pressure contains a factor of safety of 2.5 and can be increased 25 percent for total load conditions, whichever is critical.

The plinths of underreamed footings should be reinforced with sufficient reinforcing steel to resist the potential tension force induced by swelling soils between the depth of seasonal moisture changes and the final ground surface elevation.

Caving of piers may occur during construction of the drilled piers due to the presence of Silty Clay Materials. In order to minimize the possibility of piers caving during drilled pier construction, the construction contractor should be prepared to use Cased Piers or Straight Sided Shaft Foundations if caving occur. We recommend that the drilling be performed under the supervision of a Geotechnical Engineer.

Experience indicates that underreams can be successfully installed, and based on local practice for performing underream drill piers is to utilize 3.0 to 1.0 for underream to shaft ratio. Should caving occur during belling operations, the shaft diameter may have to be increased, thereby, changing the bell to shaft ratio. If the soil conditions warrant the changing of the shaft diameter, the Structural Engineer of record should be informed about any changes because they may require a change in reinforcing steel or bell diameter. Another alternative, would be to change the typical 45 degree angle of the underream to 60 degree.

The concrete should be placed in a timely manner after drilling to minimize the potential for caving of the foundation soils. No footings should be poured without the prior approval of the Project Engineer, Architect or Owners Representative. Since the exact size and locations of the footings are not known at this time. A detailed settlement analysis was not authorized, nor performed. It is anticipated that the footings designed using the recommended allowable bearing capacity will experience small settlements that will be well within the tolerable limits for the proposed structure. A detailed settlement analysis can be performed, if desired.

## SITE DRAINAGE

It is recommended that site drainage be well developed. Surface water should be directed away from the foundation soils (use a minimum slope of 5% within 10 feet of foundation). No ponding of surface water should be allowed near the structure.

## VEGETATION CONTROL

We recommend trees not to be closer than half the canopy diameter of mature trees from the grade beams, typically a minimum of 20 feet. This will minimize possible foundation settlement caused by the tree root systems.

## INSPECTION DURING CONSTRUCTION

The recommendations are based on the subsoils data in the field exploration and laboratory testing. Due to the geological deposition of the area, variances may occur between boring locations. Therefore, the footing excavations should be inspected under the supervision of a geotechnical engineer to confirm that the bearing soils are similar to those encountered in our field exploration and that the footing areas have been properly prepared. The geotechnical engineer should be immediately notified should any subsoil conditions be uncovered that will alter the conclusions and recommendations contained in this report. Further investigation and supplemental recommendations may be required if such a condition is encountered.

Prior to placement of concrete, the footings should be inspected to monitor that:

(1) The footing bears in the proper bearing strata at the depth recommended in this report.

(2) The footing shaft is to the proper dimensions and reinforcing steel is placed as shown on the structural drawings.

(3) The footings are concentric with the shaft and the shaft has been drilled plumb within specified tolerances.

(4) Excessive cutting, build up of cutting, and any other soft compressible materials have been removed from the bottom of the excavations.

Samples of the subgrade soil and structural fill material should be obtained prior to compaction operations for laboratory moisture/density testing (Proctor Tests). The tests will then provide a basis for evaluating the in-place density requirements during compaction operations. A qualified soil technician should perform sufficient in-place density tests during the filling operations to verify that proper levels of compaction are being attained.

## GENERAL

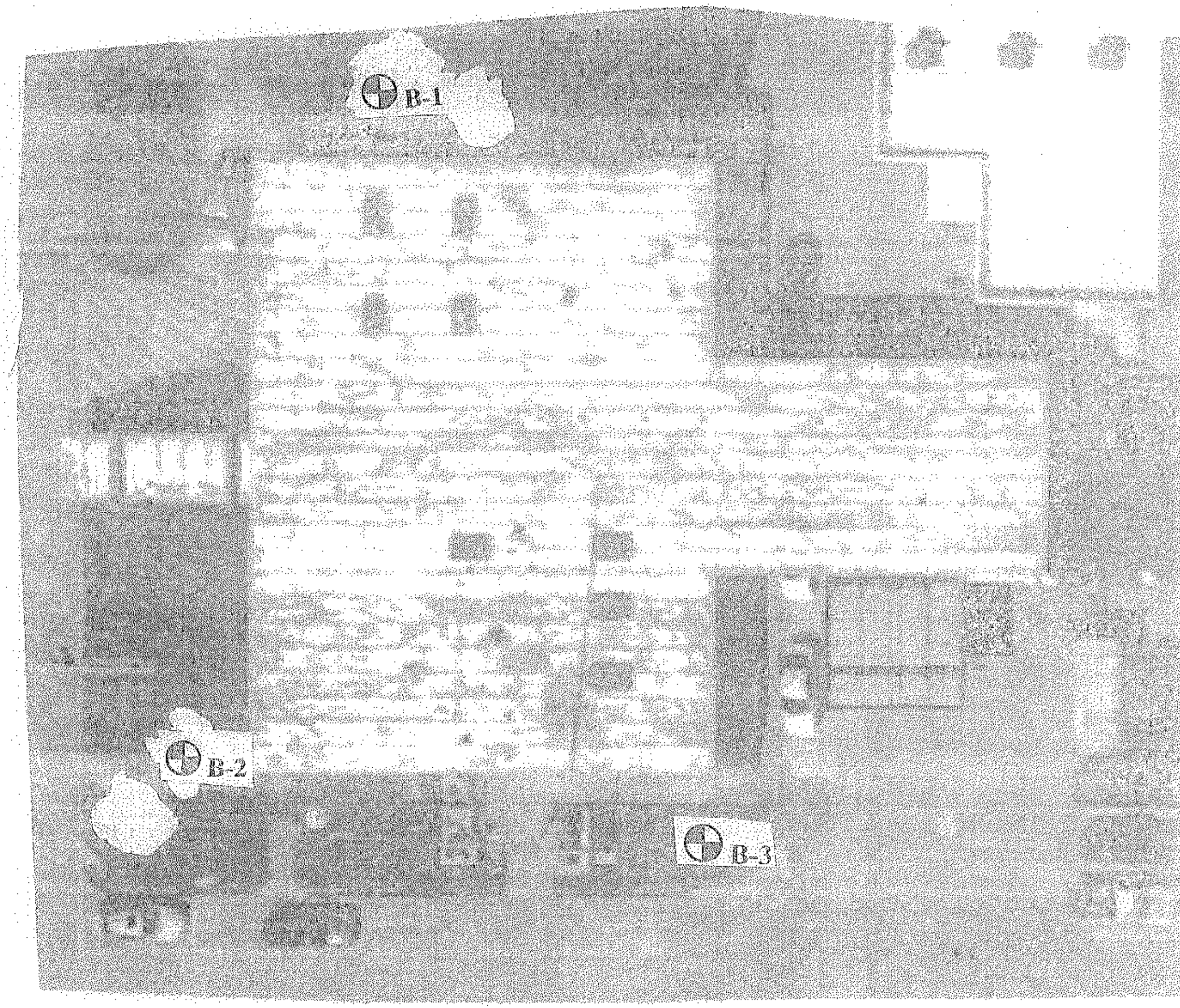
The information and recommendations contained in this report summarized conditions found at the site specified, on the date that the field exploration and soil borings were drilled. The attached boring logs are a true representation of the soils encountered at the specific boring locations on the date of field drilling and represent the stratigraphy as found during the field exploration and drilling of the subject site.

Reasonable variations from the subsurface information presented in this report are assumed. If conditions encountered during construction are significantly different than those presented in this report, **A&R** should be notified immediately.

In addition, the construction process may itself alter site soil conditions. Therefore, experienced personnel should observe and document the construction procedures and all conditions encountered. We would welcome the opportunity to discuss our recommendations with you and hope we may have the opportunity to provide any additional studies or services to complete this project.

The following illustrations are attached and complete this report.

| | Plate |
|---|---|
| Location Plan | 1 |
| Boring Logs | 2 through 4 |
| Symbols and Terms Used on Boring Log | 5 |




Approximate Boring Locations

LOCATION
Soil Borings
6000 Teague Road
Houston, Texas

A&R NO. 12S4633

NOT TO SCALE

PLATE NO. 1

# A & R Engineering and Testing, Inc.

GEOTECHNICAL & MATERIALS ENGINEERS

## LOG OF BORING

PROJECT NO.: 12S4633

DRY AUGER: 0 - 20'

DATE OF BORING: 04-10-12

| DEPTH (FT) | SOIL SYMBOL | BLOW PER FT. | SAMPLE | DESCRIPTION OF STRATUM<br>B-1 | MOISTURE % | DRY DENSITY PCF | % PASS # 200 SIEVE | SHEAR STRENGTH (TSF)<br>O PENETROMETER<br>● UNCONFINED<br>0.5 1.0 1.5 | LIQUID LIMIT | PLASTICITY INDEX |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | Medium Dense Gray Clayey Sand | | | | | | |
| 2 | | 14 | X | | 13 | | 48 | | | |
| 3 | | | | Stiff Gray and Tan Clay to Silty Clay | | | | | | |
| 4 | | 13 | X | | 17 | | | | | |
| 5 | | | | | | | | | | |
| 6 | | 13 | X | | 25 | | | | 51 | 30 |
| 7 | | | | | | | | | | |
| 8 | | 8 | X | | 20 | | | | | |
| 9 | | | | Firm to Very Stiff Light Gray and Tan Clay to Silty Clay | | | | | | |
| 10 | | 14 | X | | 17 | | | | 51 | 31 |
| 11 | | | | | | | | | | |
| 12 | | | | | | | | | | |
| 13 | ▼ | | | | | | | | | |
| 14 | | | | | | | | | | |
| 15 | | 7 | X | | 25 | | | | | |
| 16 | | | | | | | | | | |
| 17 | | | | | | | | | | |
| 18 | | | | | | | | | | |
| 19 | | | | | | | | | | |
| 20 | | 18 | X | | 18 | | | | | |

# A & R Engineering and Testing, Inc.

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**LOG OF BORING**

PROJECT NO.: 12S4633

DRY AUGER: 0 - 20'

DATE OF BORING: 04-10-12

| DEPTH (FT) | SOIL SYMBOL | BLOW PER FT. | SAMPLE | DESCRIPTION OF STRATUM B-2 | MOISTURE % | DRY DENSITY PCF | % PASS # 200 SIEVE | SHEAR STRENGTH (TSF) O PENETROMETER ● UNCONFINED 0.5 1.0 1.5 | LIQUID LIMIT | PLASTICITY INDEX |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | Medium Dense Gray Clayey Sand | | | | | | |
| 2 | | 16 | X | | 9 | | | | | |
| 3 | | | | Stiff to Very Stiff Gray and Tan Clay to Silty Clay | | | | | | |
| 4 | | 14 | X | | 24 | | | | 46 | 28 |
| 5 | | | | | | | | | | |
| 6 | | 15 | X | | 20 | | | | | |
| 7 | | | | | | | | | | |
| 8 | | 17 | X | | 19 | | | | 53 | 33 |
| 9 | | | | Firm to Very Stiff Light Gray and Tan Clay to Silty Clay | | | | | | |
| 10 | | 20 | X | | 18 | | | | | |
| 11 | | | | | | | | | | |
| 12 | | | | | | | | | | |
| 13 | ▼ | | | | | | | | | |
| 14 | | | | | | | | | | |
| 15 | | 7 | X | | 16 | | | | 32 | 15 |
| 16 | | | | | | | | | | |
| 17 | | | | | | | | | | |
| 18 | | | | | | | | | | |
| 19 | | | | | | | | | | |
| 20 | | 21 | X | | 17 | | | | | |

# A & R Engineering and Testing, Inc.

GEOTECHNICAL & MATERIALS ENGINEERS

**LOG OF BORING**

PROJECT NO.: 12S4633

DRY AUGER: 0 - 20'

DATE OF BORING: 04-24-12

B-3

| DEPTH (FT) | SOIL SYMBOL | BLOW PER FT. | SAMPLE | DESCRIPTION OF STRATUM | MOISTURE % | DRY DENSITY PCF | % PASS # 200 SIEVE | SHEAR STRENGTH (TSF) O PENETROMETER ● UNCONFINED (0.5 1.0 1.5) | LIQUID LIMIT | PLASTICITY INDEX |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | Stiff Gray and Dark Gray Silty Clay | | | | | | |
| 2 | | | | | 18 | | | O | 23 | 8 |
| 3 | | | | Very Stiff Gray and Tan Clay | | | | | | |
| 4 | | | | | 16 | 97 | | ● O | | |
| 5 | | | | | | | | | | |
| 6 | | | | | 19 | | | O | 75 | 54 |
| 7 | | | | | | | | | | |
| 8 | | | | | 20 | | | O | | |
| 9 | | | | Very Stiff Light Gray and Tan Clay to Silty Clay | | | | | | |
| 10 | | | | | 20 | | | O | 57 | 39 |
| 11 | | | | | | | | | | |
| 12 | | | | | | | | | | |
| 13 | ▼ | | | | | | | | | |
| 14 | | | | | | | | | | |
| 15 | | | | | 15 | 107 | | ● O | | |
| 16 | | | | | | | | | | |
| 17 | | | | | | | | | | |
| 18 | | | | | | | | | | |
| 19 | | | | | | | | | | |
| 20 | | | | | 13 | | | O | | |

**PLATE NO.: 4**

## KEY TO SOIL CLASSIFICATION AND SYMBOLS

### SOIL TYPES

- Gravel (GW, GP, GM, GC)
- Sand (SW, SP)
- Silty Sand (SM)
- Clayey Sand (SC)
- Clayey Silt (ML)
- Silt (ML)
- Sandy Silt (ML)
- Silty or Sandy Clay (CL)
- Clay (CH)

### CONSISTENCY OF COHESIVE SOILS

| Description | Shear Strength-KSF | Penetration Resistance Blows / Ft |
|---|---|---|
| Very Soft | Less than 0.25 | 0 - 2 |
| Soft | 0.25 - 0.50 | 2 - 4 |
| Firm | 0.50 - 1.00 | 4 - 8 |
| Stiff | 1.00 - 2.00 | 8 - 15 |
| VeryStiff | 2.00 - 4.00 | 15 - 30 |
| Hard | Greater than 4.00 | > 30 |

### RELATIVE DENSITY OF COHESIONLESS SOIL

| Description | Penetration Resistance Blows / Ft | Relative Density . % |
|---|---|---|
| Very Loose | 0 - 4 | 0 - 15 |
| Loose | 4 - 10 | 15 - 35 |
| Medium Dense | 10 - 30 | 35 - 65 |
| Dense | 30 - 50 | 65 - 85 |
| Very Dense | > 50 | 85 -100 |

### SOIL STRUCTURE

| | |
|---|---|
| CALCAREOUS NODULES | - Nodules of Calcium Carbonate |
| FERROUS NODULES | - Nodules of Ferrous Material |
| SLICKENSIDED | - Having inclined planes of weakness that are slick and glossy |
| BLOCKY | - Having inclined planes of weakness that are frequent and rectangular in pattern |
| LAMINATED | - Composed of thin layers of varying soil type and texture |
| FISSURED | - Containing shrinkage cracks frequently filled with fine sand |
| INTERBEDDED | - Composed of alternate layers of different soil types |

### SAMPLE SYMBOLS

Shelby Tube Sample

Standard Penetration Test

Auger or Wash Sample

No Recovery

### GROUNDWATER

▽ (24 hr) - Water level after drilling (time increment after drilling)

▼ - Free water observed during drilling

### FAILURE DESCRIPTION (COMPRESSION TEST)

B - Bulge
S - Shear
M/S - Multiple Shear

SLS - Failure surface occuring along slickensided plane
SAS - Failure surface occuring along or in sand seam
SS - Failure surface occuring in or along other secondary structure such as calcareous pockets

**PLATE NO.: 5**

A&R

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