FOUNDATION ENGINEERING STUDY

For

Proposed Sonic Drive-In

SWQ US Highway 380 & N. Lake Forest Drive
McKinney, Texas

Prepared for:

Mr. Chris Roach
4310 Glencoe Road
Corinth, Texas 76208

Prepared by:

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Texas Registered Engineering Firm F-003653

ATC Project No. NPSDI19001

July 10, 2019

ENVIRONMENTAL • GEOTECHNICAL
BUILDING SCIENCES • MATERIALS TESTING

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July 10, 2019

Mr. Chris Roach
4310 Glencoe Road
Corinth, Texas 76208

Re: FOUNDATION ENGINEERING STUDY
Proposed Sonic Drive-In
SWQ US Highway 380 & N. Lake Forest Drive
McKinney, Texas
ATC Project No. NPSDI19001

Dear Mr. Roach:

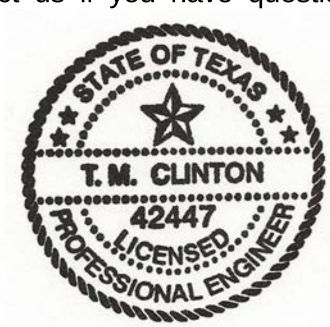
ATC Group Services LLC (ATC) is pleased to present this Foundation Engineering Study for the referenced Sonic Drive-In site.

The attached report describes our exploration procedures, summarizes existing site and subsurface conditions, and presents our geotechnical findings and recommendations.

ATC appreciates this opportunity to provide these services and looks forward to working with you on future projects. Please contact us if you have questions regarding this study or require additional information.

Sincerely,

ATC GROUP SERVICES LLC



07-10-19

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PROPOSED SONIC DRIVE-IN
SWQ US HIGHWAY 380 & N. LAKE FOREST DRIVE
MCKINNEY, TEXAS

1.0 INTRODUCTION

1.1 Project Description

Mr. Chris Roach (hereafter referred to as client) retained ATC to provide geotechnical services for the development of foundation, pavement and site preparation recommendations at a proposed Sonic Drive-In site located in the southwest quadrant of the intersection US Highway 380 and N. Lake Forest Drive in McKinney, Texas. Authorization to provide our services was given by signature of ATC proposal dated May 29, 2019. Drilling of the site was delayed due to frequent heavy rains and wet site conditions.

The site consists of a relatively flat vacant lot. Ground cover generally consisted of grass and weeds. The general arrangement of the proposed development on the site is shown on the Site/Boring Location Plan included in the Appendix.

It is anticipated that the proposed construction will consist of a single-story structure with no basement, patio area with a canopy and drive-in/parking stalls with canopies. Plan area of the new restaurant is approximately 1,608 sf. Details regarding structural loadings were not available at the time of this study. However, it is anticipated that maximum building column, wall and floor loads will not exceed approximately 30 kips, 1 kip/foot and 125 psf, respectively. No unusual loading conditions or settlement restrictions have been specified by the client. It is anticipated that finished floor elevation (FFE) of the proposed restaurant will be established at 593.80 feet, which is estimated to be within approximately 1 foot of the existing grade (ground surface existing at the time of our field exploration). Approximate location and plan area of the proposed structures where obtained from a Site Plan (Sheet C1.10, dated 05/08/19) provided by Sonic Corporation.

Recommendations for Portland Cement Concrete pavement (PCCP) are included in Section 5.0. It is anticipated that traffic in the proposed pavement area will consist primarily of automobile and light truck traffic with an occasional semi-tractor trailer.

If the details of the proposed construction differ from that described herein, ATC should be contacted to evaluate the potential impact on the recommendations provided in this report.

1.2 Purpose and Scope

The purpose of this study has been to develop foundation and pavement design, and subgrade modification recommendations for the project. The scope of services presented in this report has been based upon the information provided by the client. To accomplish its intended purpose, this study has been conducted in the following phases:

1. Drilling of test borings to determine the general subsurface conditions and to obtain samples for testing;
2. Performing laboratory tests on selected samples to determine pertinent engineering properties of the subsurface materials; and,
3. Performing engineering analyses, using the field and laboratory data to develop foundation and pavement design, and subgrade modification recommendations for the proposed development.

Exploration for underlying geologic conditions or evaluation of potential geologic hazards, such as sinkholes, solution cavities, seismic activity, faulting, growth faulting and/or ground subsidence/cracking potential due to groundwater injection/withdrawal, were beyond the scope of this study.

2.0 FIELD EXPLORATION AND TESTING

2.1 Field Exploration

The field exploration was conducted at the site on July 8, 2019. ATC retained the services of an independent contractor to drill the test borings and collect samples for testing. Subsurface conditions beneath the site were explored by advancing 4 test borings to depths of approximately 5 to 20 feet. The test boring locations and depths were established by ATC in consultation with Sonic Corporation. Test borings were located in the field by reference from existing features and by using conventional measuring methods. The accuracy of the test boring locations should only be considered to the level implied by the method used to determine them. Ground surface elevations at the test boring locations were neither surveyed nor furnished. The approximate test boring locations are shown on the Site/Boring Location Plan included in the Appendix.

A truck-mounted rotary drilling rig, using solid flight augers, was used to advance the test borings. Relatively undisturbed samples of the subsurface materials were obtained by hydraulically pushing 3-inch (O.D.) thin-walled (Shelby) tubes into the underlying soils at selected depths in the test borings. Sampling was performed in general accordance with ASTM D1587, entitled *"Standard Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes"*. All samples were extruded from the sampling tubes in the field and tested with a pocket penetrometer for an indication of relative unconfined compressive strength. Representative portions of each sample were selected and sealed in plastic bags to prevent loss of moisture.

Test borings were logged by a representative of the subcontract driller. The Field Boring Logs were reviewed by a geotechnical engineer and edited using the results of laboratory tests performed on selected soil samples from the test borings. The Boring Logs represent the geotechnical engineer's interpretations of the subsurface conditions based on field observations, visual observation of samples and laboratory test results. Lines designating the interface between various strata on the Boring Logs represent the approximate positions of the interface. The in-situ transition between strata may be gradual.

Samples will be retained for 30 days from the date of this report, after which time they will be discarded unless client requests otherwise. Groundwater conditions recorded on the Boring Logs are based on the field observations at the time the exploration was conducted. Upon completion of the drilling operations, boreholes were backfilled with the auger cuttings and the pavement patched with concrete.

2.2 Laboratory Testing

Soil samples were transported to the laboratory where the Field Boring Logs were reviewed and edited by a geotechnical engineer. Soil samples were then selected for geotechnical laboratory testing. Testing included, a dry unit weight determination, Atterberg limits and moisture content tests. All geotechnical testing was conducted in general accordance with the applicable ASTM

Standards. The results of the laboratory tests are provided on the appropriate Boring Logs, which are included in the Appendix. Soil descriptions recorded on the Boring Logs result from field data as well as from laboratory test data.

3.0 SUBSURFACE CONDITIONS

3.1 Subsurface Conditions

Generally, the subsurface materials within the maximum depth explored (20 feet) consist of stiff to hard (undocumented) clay fill underlain by very stiff clays. Fill was observed in the Borings 1 and 2 to depths of approximately 13 feet and 18 feet, respectively. The fill extended to the completion depths of Borings 3 (10 feet) and 4 (5 feet). Fill may extend to greater depths and exist at other locations on the site resulting from previous grading.

Results of Atterberg limits tests follow:

Soil Classification	Plasticity Index (PI)	Degree of Plasticity
Clays	43 to 46	Very High

These soils are highly plastic and are subject to significant shrinking and swelling with changes in moisture content. Adequate precautions should be taken not to allow the on-site soils to become saturated (unstable when wet) or excessively dry.

Site Class - Part of the International Building Code (IBC) procedure to evaluate seismic forces requires the evaluation of the Seismic Site Class, which categorizes the site based upon the characteristics of the subsurface profile within the upper 100 feet of the ground surface. To define the Seismic Site Class for this project, we have interpreted the results of our soil test borings drilled within the project site and estimated appropriate soil properties below the base of the test borings to a depth of 100 feet, as permitted by the IBC. Based upon our evaluation, it is our opinion that the subsurface conditions within the site are generally consistent with the characteristics of Site Class D as listed in Chapter 16, Section 1613.2.2 of the 2018 edition of the IBC and as defined in Table 20.3-1, Chapter 20 of ASCE 7.

3.2 Groundwater Observations

During and upon completion of the drilling operations, no groundwater was observed in the test borings. The presence, depth, and quantity of groundwater seepage may fluctuate based on variations in seasonal rainfall, climatic conditions, site surface runoff characteristics, permeability of on-site soils, continuity of pervious materials, irrigation practices, and other factors. These observations do not constitute a long-term groundwater study nor was such an evaluation authorized as a part of the scope of this study. Any changes noted in groundwater levels during the construction process may require a review of the recommendations presented in this report.

3.3 Estimated Soil Movement

The highly plastic clay soils observed at this site can shrink and swell as the soil moisture content fluctuates during seasonal wet and dry cycles. The magnitude of shrinkage and swelling will depend on moisture fluctuations that occur during and after construction. Moisture fluctuations typically occur due to seasonal cycles, but can also be influenced by grading and drainage, landscaping, groundwater conditions, exterior flatwork and the presence of paving. Therefore, the amount of soil movement is difficult to determine due to the many unpredictable variables involved. To estimate the potential vertical soil movement for this site, the Texas Department of Transportation Potential Vertical Rise (PVR) method (TEX-124-E) has been used. Also, the results of the laboratory tests performed on samples obtained from the site, engineering judgment, and experience have been considered. For a full seasonal cycle, the estimated soil PVR is on the order of 5 inches at the ground surface within the proposed building area.

The aforementioned estimated soil movement is based on the observed subsurface conditions and seasonal moisture fluctuations. Actual soil movements will depend on the subsurface moisture fluctuations over the life of the structure. Soil movements may be less than those calculated if moisture variations are minimized after construction. However, soil movements, significantly larger than estimated, could occur due to inadequate site grading, poor drainage, ponding of rainfall, and/or leaky water or sprinkler lines.

The estimated PVR is based on the existing grades (at time of our field exploration) and conditions observed in the test borings drilled for this study. PVR calculations may differ at other locations or times. Site grading will alter the estimated PVR movements. **Proper construction practices, such as those outlined in this report, will tend to reduce potential movements.**

4.0 ANALYSIS AND RECOMMENDATIONS

4.1 Project Information

The site is located in the southwest quadrant of the intersection of US Highway 380 and N. Lake Forest Drive in McKinney, Texas. It is anticipated that the proposed construction will consist of a single-story restaurant with no basement, patio area with a canopy and drive in/parking stalls with canopies. Plan area of the new restaurant is approximately 1,608 sf. Details regarding structural loadings were not available at the time of this study. However, it is anticipated that maximum building column, wall and floor loads will not exceed approximately 30 kips, 1 kip/foot and 125 psf, respectively. No unusual loading conditions or settlement restrictions have been specified by the client. It is anticipated that finished floor elevation (FFE) of the proposed restaurant will be established at 593.80 feet, which is estimated to be within approximately 1 foot of the existing grade (ground surface existing at the time of our field exploration). The general arrangement of the proposed development is shown on the Site/Boring Location Plan included in the Appendix.

ATC has developed foundation and pavement design recommendations on the basis of the previously described project characteristics and subsurface conditions observed in the test borings drilled during the field exploration. After final design plans and specifications are available, a general review by ATC is recommended as a means to check that the evaluations made in preparation of this report are correct, and that earthwork, foundation, pavement and subgrade preparation recommendations are properly interpreted and implemented.

4.2 Grade Supported Foundation/Slab on Expansive Soils

As previously noted, the estimated soil PVR is on the order of 5 inches at the ground surface for a full seasonal moisture cycle. The moisture-induced volume changes associated with the clay soils present at this site could result in significant movement of a shallow, grade supported foundation/slab system.

The potential magnitude of any movement by the subsurface soils is rather indeterminate. It is influenced by the soil properties, overburden pressures, surface drainage, and to a great extent by the in-situ moisture levels at the time of construction. The greatest potential for post-construction movement will occur when the soils are dry prior to construction. We recommend the soils be subjected to wetting prior to concrete placement. Due to the protection against surface evaporation and resulting shrinkage, post-construction movements of slabs-on-grade generally occur as heave. This heave is initiated by moisture increases in the surface expansive soils due to capillary rise from a deeper water level. Shrinkage can also occur along exposed slab or pavement edges, but is often limited to the outer several feet. Shrinkage is also often caused by moisture depletion associated with landscape plantings.

In view of this and the preliminary design information, it is recommended that the proposed restaurant be supported by a conventional reinforced, monolithic grade beam and slab on grade foundation system bearing on a select fill building pad. Building pad preparation and foundation recommendations are provided in Section 4.6.

4.3 Site Preparation

Before proceeding with construction, any old building foundations, concrete flatwork, buried structures, construction debris, vegetation, root systems, topsoil, refuse, sediment in low-lying areas and other deleterious non-soil materials should be stripped/removed from proposed construction areas. The actual stripping depth should be based on field observations with particular attention given to old drainage areas, uneven topography, unexpected fill material areas, and excessively wet soils (if present). The stripped areas should be observed to determine if additional excavation is required to remove weak or otherwise objectionable materials that would adversely affect the fill placement. The stripping should extend at least 5 feet beyond the limits of construction areas.

Pavement & Other Exterior Flatwork Areas – After site stripping and excavation to the required subgrade elevations, the pavement and other exterior flatwork subgrades shall be proofrolled to detect soft spots, which, if they exist shall be reworked. Proofrolling shall be performed using a heavy pneumatic tired roller, loaded dump truck, or similar piece of equipment weighing approximately 25 tons. The proofrolling operations shall be observed by a geotechnical engineer or his representative. The subgrade shall be firm and able to support the construction equipment without displacement. Soft or yielding subgrade shall be corrected and made stable before construction proceeds.

The depth and extent of the undercut operations at the site should be established by a qualified geotechnical engineer during earthwork construction activities. The on-site soils are moisture sensitive and may become unstable when saturated (wet). Generally, more undercutting and delays due to the need for extended drying times can be expected if the grading is performed in the seasonally wet period of the year.

Building Pad Area – The building pad should consist of select fill and be prepared as recommended in Section 4.6.

4.4 Placement and Compaction

The project may include the placement and compaction of a variety of fill materials, including on-site materials, non-expansive select fill and crushed aggregate base material. Typical material requirements and compaction specifications for each of these materials are provided below.

- **On-site Clays in building pad area –** Compact to at least 90 and not greater 95 percent of standard Proctor (ASTM D 698) maximum laboratory dry density at a minimum of 4 percentage points above the optimum moisture content (+4).
- **On-site Clays that are compacted in areas subject to surface loads (but not below structure) or used as backfill –** Compact to at least 93 and not greater 98

percent of standard Proctor (ASTM D 698) maximum laboratory dry density within 1 to 4 percentage points above the optimum moisture content (+1 to +4).

- **Select Fill –** Non-expansive select fill should consist of sandy clay or clayey sand having a plasticity index not less than 5 nor greater than 15, a liquid limit less than 36, no particles greater than 3 inches, a maximum of 70 percent passing #200 sieve and be free of roots or any other organic debris. Organic content should be less than 2 percent. The select fill material used at this site should be compacted to at least 98 percent (100 percent in upper 6 inches of pavement subgrade) of the maximum laboratory dry density as determined by the Standard Proctor test, ASTM D 698. In conjunction with the compacting operations, the select fill material should be brought within plus or minus 2 percentage points of optimum moisture content (-2 to +2). *All grade-raise fill placed beneath the proposed building pad area should meet the requirements of non-expansive select fill.*

- **Crushed Aggregate Base –** Aggregate base placed below pavement should consist of a high quality well-graded material meeting the Texas Department of Transportation (TxDOT) specifications for Flexible Base (Item 247, Type A, Grade 2 or better). The base material should be compacted to a minimum of 98 percent of standard Proctor (ASTM D 698) maximum laboratory dry density within plus or minus 2 percentage points of optimum moisture content (-2 to +2). Recycled crushed concrete or caliche may be used provided it meets these requirements and is approved by the geotechnical engineer.

The moisture content must be maintained until placement of the first fill lift. Fill material, whether non-expansive select fill or moisture conditioned on site soils, should be placed in loose lifts not exceeding 8 inches in uncompacted thickness. The fill material should be uniform with respect to material type and moisture content. Clods and chunks of material should be broken and the fill material mixed as necessary, so that a material of uniform moisture and density is obtained for each lift. Water required to bring the fill material to the proper moisture content should be applied evenly through each layer.

Each lift should be compacted, tested, and approved before another lift is added. As a guide, one field density test per lift for each 5,000 square feet of compacted area is recommended. For small areas or critical areas, the frequency of testing may need to be increased to one test per 2,500 square feet. A minimum of two tests per lift should be required. The purpose of the field density tests is to provide some indication that uniform and adequate compaction and moisture control are being achieved. The actual quality of the fill, as compacted, should be the responsibility of the contractor and satisfactory results from the tests should not be considered as a guarantee of the quality of the contractor's work.

Backfill placed within utility trenches that cross-pavement or building areas should be properly compacted. Numerous parking, drive, sidewalk, and landscape areas have undergone settlement due to soft backfill within utility trenches. Backfill placed in utility trenches or other excavated areas within the building or paved area should be placed in lifts, compacted, and tested in accordance with these earthwork recommendations. Trenches should be opened a sufficient width to safely allow compaction equipment access to the backfill and to safely allow for confirmation testing to occur. Backfill should be placed in horizontal lifts, and if the trench is over 5 feet deep, the side slopes should be benched prior to placing the backfill.

4.5 Site Excavation Characteristics

Finished grades at the site have not been provided. However, we do not anticipate that excavations that exceed the depth of our test borings will be required to develop the site. Rock was not encountered during our field exploration. Therefore, rock excavation is not anticipated. Generally, excavations made at this site can be accomplished using standard excavation equipment, such as large backhoes/excavators equipped with a soil bucket. Depending on design grades (particularly in confined excavations), areas requiring difficult excavation techniques may be necessary if very hard material is encountered. More accurate information regarding the excavation conditions should be evaluated by contractors or other interested parties from test excavations using the equipment that will be used during construction.

During and upon completion of the drilling operations, no groundwater was observed in the test borings. The presence and magnitude of groundwater seepage may fluctuate based on variations in seasonal rainfall, climatic conditions, site surface runoff characteristics, permeability of on-site soils, continuity of pervious materials, irrigation practices, and other factors. Groundwater traveling through the soil is often unpredictable. This could be due to seasonal changes in groundwater and due to the unpredictable nature of groundwater paths. Therefore, it is necessary during construction for the contractor to be observant for groundwater seepage in excavations in order to assess the situation and make necessary changes and/or recommendations.

In accordance with Texas State law, the design and maintenance of all excavation retention systems is the sole responsibility of the Contractor. Attention is drawn to OSHA Standards 29 CFR - 1926 Subpart P for guidance in the design of such systems.

4.6 Monolithic Slab on Grade

The following recommendations are made anticipating that the pavement and/or exterior flatwork will butt against the building foundation (no open spaces for landscaping within 10 ft of the building limits). All joints should be sealed as recommended in section 4.8, Site Drainage and Landscaping. If this is not the case, it may be necessary to modify our design recommendations presented in the following sections.

The proposed restaurant can be supported on a conventional reinforced, monolithic grade beam and slab foundation system. To provide more uniform bearing conditions and help reduce the potential for movement of the foundation, the grade beams should bear on engineered fill having a uniform thickness. The engineered fill should extend **a minimum of 7 feet below the existing grade (ground surface existing at the time of our field exploration)** and a minimum of 3 feet outward beyond the proposed building lines or a minimum of 1 foot beyond sidewalks and other exterior flatwork constructed **adjacent** to the proposed structure (if it is desirable to minimize their movements as well). *Bottom of excavation should be graded so that compacted select fill will have a uniform depth.* All excavations shall conform to applicable OSHA regulations.

Once the required depth is reached and prior to select fill placement, the subgrade shall be scarified to a minimum depth of 12 inches and compacted to at least 90 and not greater 95 percent of the maximum laboratory dry density as determined by ASTM D 698 at a minimum of 4 percentage points above optimum moisture content (+4). Compaction of weak or compressible areas and the excavation base in general, can be aided by mixing a sufficient amount of hydrated lime with the existing subgrade soils to achieve the required compaction. Alternatively, a layer of geotextile, such as Mirafi HP 570 or approved equivalent, can be placed over weak areas. Placement of geotextile should be in accordance with manufacturer's guidelines. Final recommendations should be based on the observations by the geotechnical engineer at the time of construction.

After the bottom of the excavation has been properly compacted, select fill placement should **promptly** commence to prevent drying of the subgrade soils. **Subgrade soils allowed to dry should be moistened with water prior to fill placement.** All select fill placed in the building pad area should be properly compacted and consist of a select material. Compaction and composition of the select fill are described in Section 4.4. Select fill shall have a **minimum uniform thickness of 7 feet**, measured from bottom of granular mat (which is placed directly beneath floor slab) to bottom of excavation.

Earthwork operations should undercut the subgrade around the building perimeter following grade beam construction so that 1 to 2 feet of on-site clay soils may be placed at the ground surface to act as a barrier to surface water infiltration. Where flatwork extends to the building, the barrier can be limited to a thickness of 1 foot. The width of the replacement should be enough to remove the select fill, but should also be no less than 5 feet wide. Failure to provide this could result in potential deep-seated swell. Under no circumstances should a "bath tub effect" be created beneath the floor system.

The sidewalls of the excavation shall not be vertical. Horizontal benches should be a minimum of 1 foot in width or sufficient to allow for adequate compaction along the edge of the prepared building pad.

Estimated Foundation Movements - The above method of improving the existing subsurface conditions should reduce total and differential movements of the slab foundation to less than 1 inch. Actual amount of movement will depend upon loading conditions, moisture content of underlying clay soils at time of concrete and select fill placement, depth of expansive materials, and site drainage during and after construction. Foundation movements may be significantly more than those anticipated if free water is allowed to enter the underlying clay soils from such sources as plumbing leaks and irrigation systems. Careful field observation and testing during subgrade preparation, select fill placement and compaction will also contribute substantially to minimizing foundation movements.

The slab foundation should be designed with exterior and interior (as deemed necessary by the structural engineer) grade beams adequate to provide sufficient rigidity to the foundation system. All grade beams and floor slab should be adequately reinforced with steel to minimize cracking as normal movements occur in the foundation clay soils and weathered shale. **The structural engineer should evaluate configurations and reinforcement requirements for structural loadings, anticipated foundation movements, shrinkage and temperature stresses.**

A net allowable soil bearing pressure of 2,000 pounds per square foot (dead + live loads) can be used for design of grade beams bearing a minimum of 18 inches below lowest adjacent grade on compacted select fill. For seasonal moisture change protection, the exterior grade should be a minimum of 24 inches above the bottoms of all exterior grade beams. Aforementioned bearing value is based on a Factor of Safety of 3 and can be increased by 1/3 for effects of either seismic or wind forces.

The following design criteria are based on the "Design of Slab-On-Ground Foundations" published by the Wire Reinforcement Institute, Inc. (August 1981) and can be used in design of the slab foundation provided the building pad is prepared according to the recommendations presented in this section:

Climatic Rating, Cw -	20
Effective Plasticity Index, PI -	27

Foundation excavations shall be properly observed by the geotechnical engineer or his representative to confirm that loose, soft or otherwise undesirable materials are removed such that foundation will bear on sound material. Soils exposed in the bases of all satisfactory foundation excavations shall be protected against detrimental change in condition such as rain or excessive drying. Surface runoff shall be directed away from the excavations and not allowed to pond within or near formed foundation excavations. If possible, all concrete for foundations should be placed the same day the excavation is made.

Furthermore, it is recommended that floor slab be supported on at least 4 inches of clean granular material such as sand, sand and gravel, crushed stone or recycled concrete having no more than 5 percent fines passing No. 200 US Standard Sieve. This is to help distribute concentrated loads and equalize moisture conditions beneath slab. If a capillary moisture barrier is desired, the blanket should consist of a free-draining granular material meeting the following gradation, as determined by ASTM D 422:

Sieve Size	Percent Passing
1 in	100
#4	0

In moisture sensitive areas, a vapor barrier consisting of 10 mil polyethylene sheeting should be placed directly above the granular blanket. A 2-inch thick layer of damp, clean sand should be placed directly above the vapor barrier to promote uniform curing of slab concrete and as a vapor barrier puncture protection during construction process. The sand layer should be moistened with water just prior to concrete placement.

4.7 Footings – Drive-In/Parking Stall Canopies

Foundations for the canopies in the drive-in/parking stalls should be designed to support the loads of the canopies and resist uplift and lateral loading conditions. It is recommended that the canopies be supported on spread footings bearing a minimum of 3 feet below lowest adjacent grade within and on the existing clay fill soils or compacted select fill. Footings bearing on these materials may be proportioned for a maximum allowable net soil bearing pressure of 2,000 pounds per square foot (dead + live loads). Aforementioned bearing value is based on a Factor of Safety of 3 and can be increased by 1/3 for effects of either seismic or wind forces. Footings shall have a minimum dimension of 24 inches and shall be earth formed and cast in neat excavations.

Footings may experience up to an estimated 3 inches of vertical movement due to seasonal variations in the moisture content of the underlying clay soils. The canopy structures shall be designed to tolerate the anticipated foundation movement.

It is important that all footings be located so that the least lateral distance between any 2 footings will be at least equal to or greater than the difference in their bearing elevations. This will reduce the pressure overlap of adjacent footings.

Lateral Resistance – Lateral loads against footings may be resisted by friction between bottoms of footings and laterally supporting soils. An allowable shearing resistance of 1,000 pounds per square foot is recommended. Alternately, provided footings are cast neat against the existing fill soils or compacted select fill, an allowable lateral bearing pressure of 200 pounds per square foot per foot of depth can be used with a maximum lateral bearing pressure of 2,000 pounds per square foot. A combination of friction and lateral bearing pressure can be used provided the latter is reduced 1/3.

Uplift Resistance – Uplift resistance of footings can be developed from the weight of the footing, the effective weight of the overlying soils and pavement, and from the effective weight of the structure itself. Soil uplift resistance may be calculated as the weight of the soil prism defined by a diagonal line extending around the perimeter of the foundation, from the top of the foundation, to the ground surface at an angle of 25 degrees from the vertical. The maximum allowable uplift capacity shall be taken as a sum of the weight of soil, plus the weight of the foundation, and structure, divided by an appropriate Factor of Safety. A total unit weight of 105 pcf may be used for compacted backfill above the footings. Backfill should consist of a select material. Compaction and composition of the select backfill are described in Section 4.4.

Care must be exercised during excavation of the footings to minimize disturbance of adjacent materials. Disturbance could significantly reduce the resistance to lateral loads.

All footing excavations shall be observed and evaluated by the geotechnical engineer or his representative immediately prior to placement of foundation concrete. Unsuitable areas identified at this time shall be corrected. Corrective procedures would be dependent upon conditions encountered and may include deepening of foundation elements or undercutting of unsuitable materials and replacement with controlled structural fill or lean concrete.

The base of all footing excavations shall be free of water and loose soil prior to placing concrete. Concrete should be placed as soon as possible after excavating so that excessive drying of bearing materials does not occur. **Subgrade soils allowed to dry should be moistened with water prior to fill placement.** Should the materials at bearing level become excessively dry or saturated, the affected material shall be removed prior to placing concrete.

4.8 Site Drainage and Landscaping

Movement of the slab and footing foundation systems, pavement, sidewalks and other exterior flatwork can be expected because the underlying clay soils are subject to significant shrinking and swelling with changes in moisture content. An important feature of the project is to provide positive drainage away from the structure. If water is permitted to stand next to or below the structure, excessive soil movements (heave), greater than those calculated can occur. This results in cracking of floor slabs, grade beams, interior partitions and doors out of square. Ponding water can result in soil movements exceeding those previously given. A minimum slope of 1½ percent for paved areas and 5 percent for unpaved areas shall be provided, such that the soil slopes away from the building.

A well-designed site drainage plan is of utmost importance and surface drainage shall be provided during construction and maintained throughout the life of the structure. Drainage patterns approved at the time of finish grading should be maintained throughout the life of the building and other structures. It should be understood that altered drainage patterns, landscaping, planters and other improvements, as well as irrigation and variations in seasonal rainfall, all affect subsurface moisture conditions, which in turn could affect pavement, exterior flatwork and structural performance. Consideration should be given to the design and location of gutter downspouts, planting areas, or other features, which may produce moisture concentration adjacent to or beneath the structure or pavement. It is desirable that paving and/or exterior flatwork extend to the building line rather than have planting areas next to the structure. If plantings are desired, consideration should be given to the use of self-contained, watertight planters. Plantings adjacent to buildings in expansive soils can cause heave from over watering or shrinkage due to moisture depletion associated with the vegetation.

Rainwater collected by the gutter system should be transported by pipe to a storm drain or to a paved area. If downspouts discharge next to the structure onto flatwork or paved areas, the area should be watertight in order to eliminate infiltration next to the building. Also, good drainage should be provided in paved areas since the at/and near surface soils are susceptible to pumping if they become saturated (wet). Pumping will contribute significantly to pavement failure.

Care should be taken to prevent the trench backfill for utilities from becoming French drains and piping surface or subsurface water beneath restaurant structure. The use of a two-foot wide clay or flowable fill plug shall be used adjacent to the structure within utility trenches to aid in preventing infiltration of water into the building pad.

Joints next to the structure shall be sealed with a flexible joint sealer to prevent infiltration of surface water. In general, the sealant used should remain plastic and flexible at normal service temperatures. Sealing joints will help minimize the infiltration of surface water into the underlying subgrade soils. Maintenance should include periodic inspection for open joints and cracks and resealing as necessary.

5.0 PAVEMENT

5.1 Design Considerations

Traffic loading information for the proposed pavement was not available at the time of this report submittal. It is anticipated that the parking stalls will be subject to automobile and light truck traffic only and that drives will be subject to both automobile and occasional medium to heavy truck traffic. If the anticipated traffic loading conditions are different than indicated herein, ATC should be contacted since it could impact the recommendations presented in the following sections.

For highly plastic subgrade soils, a rigid pavement section is typically recommended. The highly plastic clays observed on the site exhibit poor subgrade characteristics. Expansive clays exhibit low strengths when wet and are likely to pump when exposed to vehicle traffic. Therefore, providing a non-pumping subgrade is recommended to improve its strength, and to provide a working platform for construction. Lime is commonly used to treat expansive clay soils and provide a non-pumping subgrade.

5.2 Pavement Subgrade Preparation

As previously mentioned, the high plasticity clays found on this site are typically low strength materials and can pump when wet. Clay soils in this region are commonly improved by treatment with hydrated lime. The treated soil subgrade will provide:

- A working platform for construction equipment, particularly during wet weather
- A uniform, stable, and long-lasting layer that is stiffer than the natural soil upon which to support additional pavement layers
- A reduction in the plasticity and expansiveness of the treated layer
- A non-pumping base for the support of rigid pavements
- Impermeable layer

Of these bulleted items, perhaps the most important is the creating of a working platform. The working platform allows not only for work to proceed during inclement weather, but also creates a platform that is more tolerant of construction activities, allowing for quality construction for the overlying pavement.

If lime is selected, an application rate of 6 to 7 percent of lime (by dry unit weight of soil) is recommended, which corresponds to approximately 22 to 26 pounds (based on a soil dry unit weight of 81 pounds per cubic feet & 6 inches of lime treated subgrade) of lime per square yard of exposed subgrade) for estimating purposes. Higher lime percentages may be necessary to attain the desired results.

Samples of the actual pavement soils should be tested during construction to determine the suitable lime application rate. The plasticity index (PI) of the lime-soil mixture should not exceed 15.

The lime-treated subgrade should extend a minimum of 12 inches outside the curb line. This will improve the support for the edge of the pavement and also lessen the "edge effect" associated with shrinkage during dry periods. The use of sand or select fill as a leveling course below pavement in expansive clay areas should be prevented as these porous soils can allow water inflow between the pavement and subgrade, facilitating heave and strength loss within the subgrade soil.

The lime treated pavement subgrade should be compacted to a minimum of 95 percent of the maximum laboratory dry density as determined by the standard Proctor (ASTM D 698) test at a moisture content ranging from optimum to 3 percentage points above optimum. The moisture content and density of the completed subgrade section must be maintained until the paving is complete. Uniform support of the pavement is critical for satisfactory performance of the pavement. As in normal pavement construction, the treated subgrade should be constructed upon an undisturbed or compacted subgrade. Utility trench backfill that lies within the roadway or other questionable subgrade areas must be properly compacted before treatment of the pavement subgrade soils. Fill or backfill areas should be proofrolled to verify that soft or yielding subgrade areas have been compacted to satisfactory conditions (refer to the Section 4.3 for detailed proofrolling recommendations). The untreated subgrade should be left in an undisturbed condition if possible. In the event that it is undercut or disturbed, the soil subgrade below the lime treated subgrade should be compacted as recommended in Section 4.4.

5.3 Portland Cement Concrete Pavement (PCCP)

The following PCCP pavement recommendations are made expecting that the pavement subgrade will consist primarily of highly plastic clays. Typical pavement sections for PCCP are presented in the following Table 1:

Table 1 - PCCP (Rigid) Sections

Pavement Type	Pavement Section		
	Parking Areas	Main Drive Lanes	Fire Lanes, Drive-Thru Lanes and Dumpster Pad/Approach
Portland Cement Concrete	5 inches	6 inches	7 inches
Lime Treated Subgrade or Crushed Aggregate Base	6 inches	6 inches	6 inches

The following pavement materials are based on the Texas Department of Transportation (TxDOT) Standard Specifications (2014 Edition). Related material composition and compaction requirements of the aggregate base material are provided in the preceding Section 4.4.

1. **Portland Cement Concrete –** TxDOT Item 360 - Concrete should have a minimum flexural strength of 600 psi at 28 days; that corresponds to roughly 3,600-psi compressive strength. Concrete should be steel reinforced and include joints to control the formation of temperature and shrinkage related cracks. Concrete should include air entrainment to increase the resistance to temperature effects. As a general guide, the air entrainment should vary from 5 to 7 percent (total air volume).

2. **Lime Treated Subgrade –** TxDOT Item 260. Apply hydrated lime at an application rate of approximately 6 to 7 percent (by dry unit weight of soil) or approximately 22 to 26 pounds (based on a soil dry unit weight of 81 pounds per cubic feet) of lime per square yard for the 6-inch compacted thickness. Higher lime percentages may be necessary to attain the desired results. Samples of the lime-treated pavement subgrade soils should be tested during construction to determine the suitable lime application rate. In all areas where hydrated lime is used to treat the subgrade soils, routine Atterberg limit tests should be performed on representative samples of the soil-lime mixture during placement so that the Plasticity Index (PI) of the mixture does not exceed 15. *Allow lime treated subgrade to cure a minimum of 5 days prior to placing concrete pavement.*

3. **Crushed Aggregate Base (CAB) –** TxDOT Item 247, Type A, Grade 2 or better CAB, as described in Section 4.4, can be used as an alternative to lime treatment of the pavement subgrade. Recycled crushed concrete may also be used provided it meets these requirements. Prior to placement of the CAB, the upper 12 inches of the pavement subgrade should be compacted as recommended in Section 4.4.

The pavement should be placed directly on the lime treated subgrade or crushed aggregate base. A granular subbase consisting of a clean sand layer should not be placed between the pavement and the lime treated subgrade or crushed aggregate base material.

If the preference is not to treat the clay pavement subgrade soils with lime or utilize an crushed aggregate base, then the lime treated subgrade or crushed aggregate base could be omitted if:

- the minimum Portland cement concrete pavement thicknesses recommended in Table 1 of Section 5.3 are each increased by a minimum of 1 inch;
- the minimum 28-day compressive strength is increased to 4,000 psi;
- the upper 12 inches of the pavement subgrade is compacted to a minimum of 93 and not more than 98 percent of standard Proctor (ASTM D 698) maximum laboratory dry density at 1 to 4 percentage points (+1 to +4) above optimum moisture content; and,
- the steel reinforcing consists of #4 bars spaced 18 inches on center each way.

Compaction of the subgrade should extend a minimum of 2 feet beyond the outer edges of pavement or curbs. **Following compaction, the subgrade should be protected and maintained in a moist condition until the pavement is placed.**

5.4 Pavement Considerations

Pavement design methods are intended to provide an adequate thickness of structural materials over a particular subgrade, such that wheel loads are distributed to a level, which the subgrade can support. The support characteristics of the subgrade do not account directly for shrink and swell movements of an expansive soil subgrade. Thus, the pavement may be adequate from a structural standpoint, yet still experience cracking and deformation due to shrink/swell movements of the subgrade. Portland cement concrete (rigid) pavements generally perform better than asphaltic concrete (flexible) pavements in these situations.

It is therefore, important to minimize moisture changes in the subgrade to reduce shrink/swell movements and pumping. All pavements shall be sloped to provide rapid surface drainage. Water should not be allowed to pond on or adjacent to the pavement.

The aforementioned pavement design recommendations are subject to successful completion of site and subgrade preparation and structural fill placement as recommended in this report. Imported soils used in paved areas should meet the criteria outlined in Section 4.4.

The compaction, quality, and gradation of the aggregate base (TXDOT Item 247) will directly affect the quality and life of the pavement section. Consequently, we recommend a minimum compaction of 98 percent of standard Proctor (ASTM D 698) maximum laboratory dry density with plus or minus 2 percentage points of optimum moisture content (-2 to +2). The aggregate base should extend a minimum of 12 inches beyond the curb line, where possible. This will improve the support for the edge of the pavement and also lessen the "edge effect" associated with shrinkage during dry periods.

Since paving and grading are typically performed by separate contractors, a time lapse generally occurs between the end of grading operations and the commencement of paving. Disturbance, desiccation, and/or wetting of the subgrade prior to completion of paving can result in deterioration of the previously compacted subgrade. A non-uniform subgrade can result in poor pavement performance and local failures relatively soon after pavements are constructed. Where applicable, we recommend the pavement subgrade be proofrolled (see Section 4.3), and the moisture content and density of the top 6 inches (12 inches if the subgrade soils are not treated with lime) of the subgrade be checked within two days prior to commencement of actual paving operations. If any significant event, such as precipitation, occurs after proofrolling, the subgrade shall be reviewed by qualified personnel immediately prior to placing the pavement. The subgrade shall be in its finished form at the time of the final review.

A soils engineering technician working under the direction of a geotechnical engineer should observe compaction of the subgrade and perform soil density tests to confirm that the subgrade has been properly compacted in accordance with the recommendations presented herein. In addition, all paving materials and paving operations should meet applicable specifications of TXDOT or the local governing agency.

Utility trench backfill that lies within paved and other flatwork areas must be properly compacted. Fill or backfill areas should be proofrolled to verify that soft or yielding subgrade areas have been properly compacted (refer to Section 4.3 for detailed proofrolling recommendations).

It is important to minimize moisture changes in the pavement subgrade. The pavement and adjacent areas should be well drained. Regular maintenance should be performed on cracks in the pavement surface to prevent water passing through to the subgrade.

All joints including sawed joints should be properly cleaned and sealed as soon as possible to avoid infiltration of water, small gravel, etc. Either cold-poured or hot-poured sealing material may be used. Backing should be provided to hold the isolation joint sealant in place. Manufacturers' instructions for mixing and installing the joint materials should be followed.

It is recommended that the concrete pavement be reinforced with No. 3 or larger bars supported on appropriate chairs and placed on a minimum of approximately 24-inch (18-inch for pavement thickness greater than 5 inches) centers in each direction. *If lime treatment of the subgrade or crushed aggregate base are omitted, then the concrete pavement should be reinforced with No. 4 or larger bars supported on appropriate chairs and placed on a minimum of 18-inch centers each way.* Additional reinforcing consisting of #5 bars should be included around openings for manholes, drains, planters, etc. Contraction joints should not be placed greater than 20 feet on center each way (OCEW). The perimeter of the pavements should have a stiffening curb section to reduce the potential for distress due to heavy wheel loads near the edge of the pavements and to provide channelized drainage.

Periodic maintenance of all of the pavement should be anticipated. This should include sealing of all cracks and joints and by maintaining proper surface drainage to avoid ponding of water on or near the pavement areas. Even with these precautions, some movements and related cracking may still occur, requiring additional maintenance.

6.0 BASIS FOR RECOMMENDATIONS

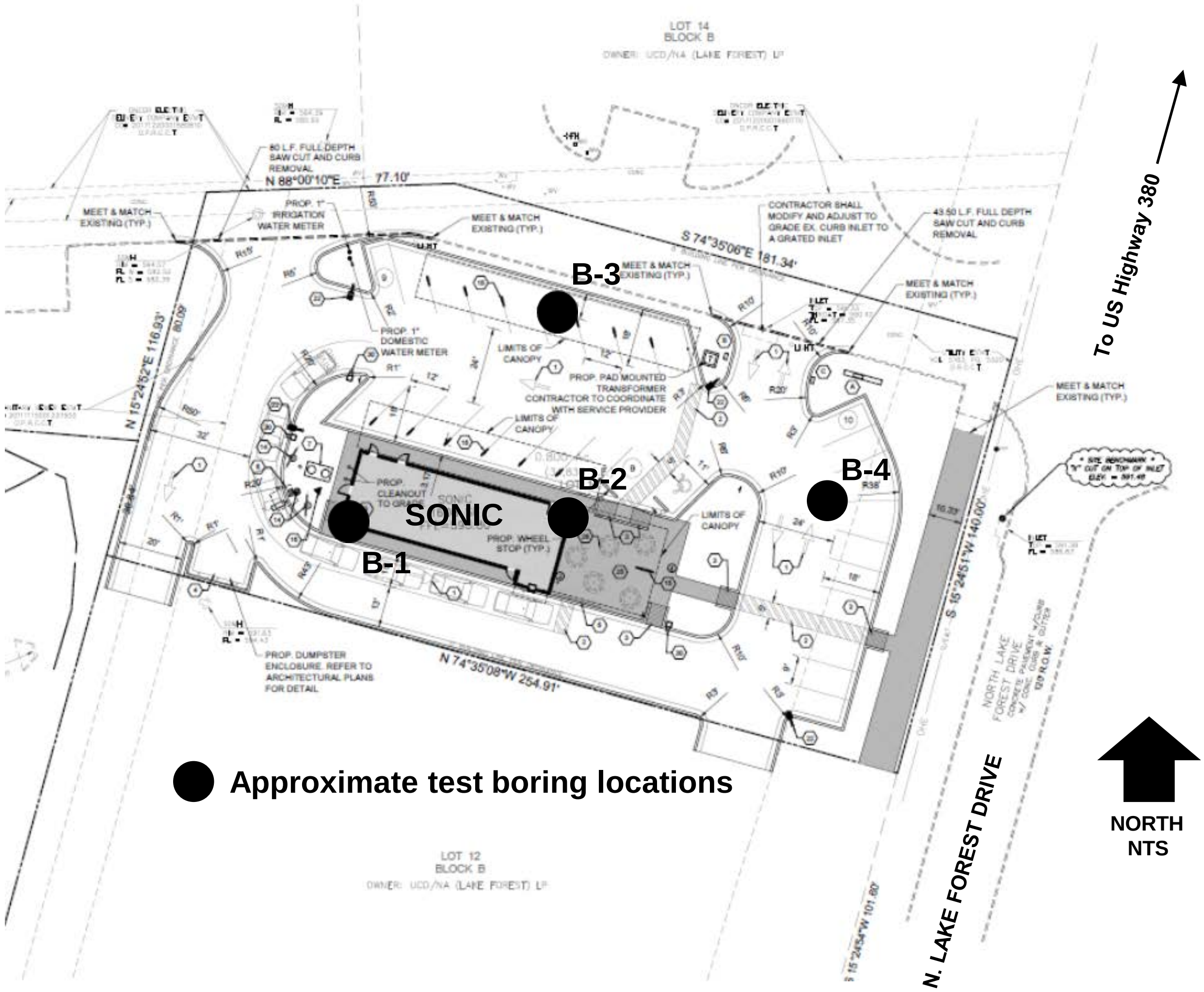
ATC's professional services have been performed, findings obtained, and recommendations prepared in accordance with generally accepted geotechnical engineering principles and practices. ATC is not responsible for the conclusions, opinions, or recommendations made by others based upon this data.

The scope of our services was intended to evaluate soil conditions within the primary influence of the proposed structure and does not include an evaluation of potential deep soil conditions. Analyses and recommendations submitted in this report are based upon the data obtained from the soil test borings performed at the locations indicated. Regardless of the thoroughness of a geotechnical exploration, there is always a possibility that conditions between test borings will be different from those at specific test boring locations and that conditions will not be as anticipated by the designers or contractors. In addition, the construction process itself may alter soil conditions.

If any subsoil variations become evident during the course of this project, a re-evaluation of the recommendations contained in this report will be necessary after ATC has had an opportunity to observe the characteristics of the conditions encountered. The applicability of this report should also be reviewed in the event that significant changes occur in the design, nature, or location of the proposed construction.

Recommendations provided herein are based in part upon project information provided to ATC and they apply only to the specific project and site discussed in this report. If the project information is incorrect or if additional information is available, the correct or additional information should be conveyed to ATC for review. ATC's recommendations may then be modified, if necessary. Experienced geotechnical personnel should observe and document the construction procedures used and the conditions encountered. Unanticipated conditions and inadequate procedures should be reported to the design team. ATC further recommends that ATC is retained to provide these services based upon our familiarity with the project, the subsurface conditions, and the intent of the recommendations and design criteria.

APPENDIX



Site/Boring Location Plan
Sonic Drive-In - McKinney, TX
ATC Project No. NPSDI19001
July 2019

ENVIRONMENTAL • GEOTECHNICAL
BUILDING SCIENCES • MATERIALS TESTING

BORING LOG

ATC

Client:	Mr. Chris Roach	Boring #: 1 (Building)
Project:	Sonic Drive-In	Project #: NPSDI19001
Location:	McKinney, Texas	Drawn By: TMC

DRILLING & SAMPLING INFORMATION

Date Started:	07-08-19	Hammer Wt., lb:	
Date Completed:	07-08-19	Hammer Drop, in:	
Driller:	Total Depth	Split Sampler OD, in:	
Logger:	FM	Rock Core Dia., in:	
Boring Method:	CFA	Shelby Tube OD, in:	3

DESCRIPTION	FIELD & LABORATORY DATA										
Surface Elevation -	Depth Scale	Smpl. No.	Smpl. Type	N Bl/Ft	Qp TSF	- #200 %	Mc %	LL	PL	PI	Dd PCF
CLAY: dark brown & light brown, stiff to hard w/sand & gravel, trace organic matter - ***Fill***		1	ST		1.5						
		2	ST		2.7						
	5	3	ST		3.0						
- - w/occasional limestone fragments		4	ST		2.7						
		5	ST		4.0						
	10										
CLAY: dark brown, very stiff		6	ST		3.0						
	15										
- - brown		7	ST		2.5						
End of Test Boring at 20 feet	20										
	25										

SAMPLE
BS-BAG SAMPLE
ST-SHELBY TUBE
SS-SPLIT SAMPLER
RC-ROCK CORE

GROUNDWATER (GW)
∇ AT COMPLETION DRY FT
⊻ AFTER HR FT
∨ ENCOUNTERED DURING DRILLING DRY FT

BORING METHOD
AR-AIR ROTARY
CFA-CONTINUOUS FLIGHT AUGERS
HSA-HOLLOW STEM AUGERS
RW-ROTARY WASH

BORING LOG

Client: Mr. Chris Roach		Boring #: 2 (Building)
Project: Sonic Drive-In		Project #: NPSDI19001
Location: McKinney, Texas		Drawn By: TMC

DRILLING & SAMPLING INFORMATION

Date Started: 07-08-19	Hammer Wt., lb:
Date Completed: 07-08-19	Hammer Drop, in:
Driller: Total Depth	Split Sampler OD, in:
Logger: FM	Rock Core Dia., in:
Boring Method: CFA	Shelby Tube OD, in: 3

DESCRIPTION	FIELD & LABORATORY DATA										
Surface Elevation -	Depth Scale	Smpl. No.	Smpl. Type	N Bl/Ft	Qp TSF	- #200 %	Mc %	LL	PL	PI	Dd PCF
CLAY: dark brown & light brown, stiff to hard w/sand & gravel, trace organic matter - ***Fill***		1	ST		2.0		27				81
		2	ST		2.5		27	60	17	43	
	5	3	ST		2.5		27				
- - w/occasional limestone fragments		4	ST		3.7		28				
		5	ST		3.5		21	64	18	46	
	10										
- - brown & dark brown		6	ST		3.5		24				
	15										
CLAY: brown, tan & light gray, very stiff w/calcareous nodules & lenses		7	ST		2.5		25				
	20										
End of Test Boring at 20 feet											
	25										

SAMPLE
BS-BAG SAMPLE
ST-SHELBY TUBE
SS-SPLIT SAMPLER
RC-ROCK CORE

GROUNDWATER (GW)
∇ AT COMPLETION DRY FT
⊻ AFTER HR FT
∨ ENCOUNTERED DURING DRILLING DRY FT

BORING METHOD
AR-AIR ROTARY
CFA-CONTINUOUS FLIGHT AUGERS
HSA-HOLLOW STEM AUGERS
RW-ROTARY WASH

BORING LOG

ATC

Client:	Mr. Chris Roach	Boring #:	3 (Canopy)
Project:	Sonic Drive-In	Project #:	NPSDI19001
Location:	McKinney, Texas	Drawn By:	TMC

DRILLING & SAMPLING INFORMATION

Date Started:	07-08-19	Hammer Wt., lb:	
Date Completed:	07-08-19	Hammer Drop, in:	
Driller:	Total Depth	Split Sampler OD, in:	
Logger:	FM	Rock Core Dia., in:	
Boring Method:	CFA	Shelby Tube OD, in:	3

DESCRIPTION	FIELD & LABORATORY DATA										
Surface Elevation -	Depth Scale	Smpl. No.	Smpl. Type	N Bl/Ft	Qp TSF	- #200 %	Mc %	LL	PL	PI	Dd PCF
CLAY: dark brown & light brown, stiff to hard w/sand & gravel, trace organic matter - ***Fill***		1	ST		1.0						
		2	ST		4.0						
	5	3	ST		3.7						
- - w/occasional limestone fragments		4	ST		2.5						
		5	ST		2.5						
End of Test Boring at 10 feet.	10										
	15										
	20										
	25										

SAMPLE
BS-BAG SAMPLE
ST-SHELBY TUBE
SS-SPLIT SAMPLER
RC-ROCK CORE

GROUNDWATER (GW)
∇ AT COMPLETION DRY FT
⊻ AFTER HR FT
∨ ENCOUNTERED DURING DRILLING DRY FT

BORING METHOD
AR-AIR ROTARY
CFA-CONTINUOUS FLIGHT AUGERS
HSA-HOLLOW STEM AUGERS
RW-ROTARY WASH

BORING LOG

Client:	Mr. Chris Roach	Boring #:	4 (Pavement)
Project:	Sonic Drive-In	Project #:	NPSDI19001
Location:	McKinney, Texas	Drawn By:	TMC

DRILLING & SAMPLING INFORMATION

Date Started:	07-08-19	Hammer Wt., lb:	
Date Completed:	07-08-19	Hammer Drop, in:	
Driller:	Total Depth	Split Sampler OD, in:	
Logger:	FM	Rock Core Dia., in:	
Boring Method:	CFA	Shelby Tube OD, in:	3

DESCRIPTION	FIELD & LABORATORY DATA										
Surface Elevation -	Depth Scale	Smpl. No.	Smpl. Type	N Bl/Ft	Qp TSF	- #200 %	Mc %	LL	PL	PI	Dd PCF
CLAY: dark brown & light brown, stiff to hard w/sand & gravel, trace organic matter - ***Fill***		1	ST		1.5		32	61	17	44	77
		2	ST		3.2						
		3	ST		3.5						
	-- 5										
End of Test Boring at 5 feet.											
	--10										
	--15										
	--20										
	--25										

SAMPLE
BS-BAG SAMPLE
ST-SHELBY TUBE
SS-SPLIT SAMPLER
RC-ROCK CORE

GROUNDWATER (GW)
∇ AT COMPLETION DRY FT
∇ AFTER HR FT
∇ ENCOUNTERED DURING DRILLING DRY FT

BORING METHOD
AR-AIR ROTARY
CFA-CONTINUOUS FLIGHT AUGERS
HSA-HOLLOW STEM AUGERS
RW-ROTARY WASH

KEY TO SOIL SYMBOLS AND CLASSIFICATIONS

The abbreviations commonly used on each "Boring Log", as seen on the figures and in the text of the report, are as follows:

I. SOIL DESCRIPTION

(a) Cohesionless Soils

Relative Density	N, BLOWS/FT
Very Loose	0 to 4
Loose	5 to 10
Compact	11 to 30
Dense	31 to 50
Very Dense	Over 50

(b) Cohesive Soils

Consistency	Qu, TSF
Very Soft	Less than O.25
Soft	0.25 to 0.50
Firm	0.50 to 1.00
Stiff	1.00 to 2.00
Very Stiff	2.00 to 4.00
Hard	Over 4.00

II. PLASTICITY

Degree of Plasticity	Plasticity Index
None to Slight	0 - 4
Slight	5 - 10
Medium	11 - 30
High to Very High	Over 30

III. RELATIVE PROPORTIONS

Descriptive Term	Percent
Trace	1 - 10
Little	11 - 20
Some	21 - 35
And	36 - 50

IV. PARTICLE SIZE IDENTIFICATION

Boulders:	8 in diameter or more
Cobbles:	3 in to 8 in diameter
Gravel:	Coarse - 3/4 in to 3 in
	Fine - 5.0 mm to 3/4 in
Sand:	Coarse - 2.0 mm to 5.0 mm
	Medium - 0.4 mm to 2.0 mm
	Fine - 0.07 mm to 0.4 mm
Silt:	- 0.002 mm to 0.07 mm
Clay:	- less than 0.002 mm

V. SOIL PROPERTY SYMBOLS

N:	Standard Penetration Resistance: Number of blows by a 140 lb hammer dropped 30 in, required to drive a 2 in OD split spoon sampler 1 ft
Qu:	Unconfined Compressive Strength, TSF
Qp:	Pocket Penetrometer Unconfined Compressive Strength, TSF
Dd:	Natural Dry Unit Weight, PCF
∇:	Apparent Groundwater Level at Time Noted
Mc:	Moisture or Water Content, %
LL:	Liquid Limit
PL:	Plastic Limit
PI:	Plasticity Index
LI:	Liquidity Index (Mc-PL/PI)
e:	Void Ratio
Gs:	Specific Gravity of Solid Particles
k:	Coefficient of Permeability
i:	Hydraulic Gradient
q:	Rate of Discharge
h:	Hydraulic Gradient
TSF:	Tons per Square Foot
PSF:	Pounds per Square Foot
KSF:	Kips per Square Foot
PCF:	Pounds per Cubic Foot

VI. DRILLING/EXCAVATING AND SAMPLING SYMBOLS

AR:	Air Rotary
CFA:	Continuous Flight Auger
HSA:	Hollow Stem Auger
RW:	Rotary Wash
BH:	Backhoe
AU:	Auger Sample
BS:	Bag Sample
RC:	Rock Core
SS:	Split-Spoon, 1-3/8 in ID, 2 in OD, Except as Noted
ST:	Shelby Tube, 3 in OD, Except as Noted
WS:	Wash Sample
OD:	Outside Diameter
ID:	Inside Diameter
TxC:	Texas Department of Transportation Cone Penetrometer Test
RQD:	Rock Quality Designation
CR:	Core Recovery, %
TS:	Tube Sample, 1.5 in or 2.5 in OD
RS:	Ring Sample, 2.5 in OD

NOTE: SOILS ARE CLASSIFIED IN GENERAL ACCORDANCE WITH THE UNIFIED SOIL CLASSIFICATION SYSTEM

Important Information about This

Geotechnical-Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

Geotechnical Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical-engineering study conducted for a civil engineer may not fulfill the needs of a constructor — a construction contractor — or even another civil engineer. Because each geotechnical- engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client. No one except you should rely on this geotechnical-engineering report without first conferring with the geotechnical engineer who prepared it. *And no one — not even you* — should apply this report for any purpose or project except the one originally contemplated.

Read the Full Report

Serious problems have occurred because those relying on a geotechnical-engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

Geotechnical Engineers Base Each Report on a Unique Set of Project-Specific Factors

Geotechnical engineers consider many unique, project-specific factors when establishing the scope of a study. Typical factors include: the client's goals, objectives, and risk-management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, do not rely on a geotechnical-engineering report that was:

- not prepared for you;
- not prepared for your project;
- not prepared for the specific site explored; or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical-engineering report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light-industrial plant to a refrigerated warehouse;
- the elevation, configuration, location, orientation, or weight of the proposed structure;
- the composition of the design team; or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes—even minor ones—and request an assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

Subsurface Conditions Can Change

A geotechnical-engineering report is based on conditions that existed at the time the geotechnical engineer performed the study. *Do not rely on a geotechnical-engineering report whose adequacy may have been affected by*: the passage of time; man-made events, such as construction on or adjacent to the site; or natural events, such as floods, droughts, earthquakes, or groundwater fluctuations. *Contact the geotechnical engineer before applying this report to determine if it is still reliable.* A minor amount of additional testing or analysis could prevent major problems.

Most Geotechnical Findings Are Professional Opinions

Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ — sometimes significantly — from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide geotechnical-construction observation is the most effective method of managing the risks associated with unanticipated conditions.

A Report's Recommendations Are Not Final

Do not overrely on the confirmation-dependent recommendations included in your report. *Confirmation-dependent recommendations are not final,* because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations *only* by observing actual subsurface conditions revealed during construction. *The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's confirmation-dependent recommendations if that engineer does not perform the geotechnical-construction observation required to confirm the recommendations' applicability.*

A Geotechnical-Engineering Report Is Subject to Misinterpretation

Other design-team members' misinterpretation of geotechnical-engineering reports has resulted in costly problems. Confront that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Constructors can also misinterpret a geotechnical-engineering report. Confront that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing geotechnical construction observation.

Do Not Redraw the Engineer's Logs

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical-engineering report should *never* be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, *but recognize that separating logs from the report can elevate risk.*

Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make constructors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give constructors the complete geotechnical-engineering report, *but* preface it with a clearly written letter of transmittal. In that letter, advise constructors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. *Be sure constructors have sufficient time* to perform additional study. Only then might you be in a position to give constructors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

Read Responsibility Provisions Closely

Some clients, design professionals, and constructors fail to recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce the risk of such outcomes, geotechnical engineers commonly include a variety of explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Environmental Concerns Are Not Covered

The equipment, techniques, and personnel used to perform an *environmental* study differ significantly from those used to perform a *geotechnical* study. For that reason, a geotechnical-engineering report does not usually relate any environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated environmental problems have led to numerous project failures.* If you have not yet obtained your own environmental information, ask your geotechnical consultant for risk-management guidance. *Do not rely on an environmental report prepared for someone else.*

Obtain Professional Assistance To Deal with Mold

Diverse strategies can be applied during building design, construction, operation, and maintenance to prevent significant amounts of mold from growing on indoor surfaces. To be effective, all such strategies should be devised for the *express purpose* of mold prevention, integrated into a comprehensive plan, and executed with diligent oversight by a professional mold-prevention consultant. Because just a small amount of water or moisture can lead to the development of severe mold infestations, many mold- prevention strategies focus on keeping building surfaces dry. While groundwater, water infiltration, and similar issues may have been addressed as part of the geotechnical- engineering study whose findings are conveyed in this report, the geotechnical engineer in charge of this project is not a mold prevention consultant; *none of the services performed in connection with the geotechnical engineer's study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not of itself be sufficient to prevent mold from growing in or on the structure involved.*

Rely, on Your GBC-Member Geotechnical Engineer for Additional Assistance

Membership in the Geotechnical Business Council of the Geoprofessional Business Association exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project. Confer with you GBC-Member geotechnical engineer for more information.

GBC GEOTECHNICAL BUSINESS COUNCIL of the Geoprofessional Business Association

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