# Report of Subsurface Exploration
# and Geotechnical Evaluation
# Hard Rock Casino - Proposed Guitar Pick Plaza
Catoosa, Oklahoma
Building & Earth Project No.: OK200253

*Prepared For:*
RK & Associates PLC

*November 11, 2020*

**BUILDING & EARTH**
Geotechnical, Environmental, and Materials Engineers

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November 11, 2020

RK & Associates, PLC
4815 South Harvard Avenue, Suite 290
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Attention: Mr. Rick Kosman, P.E.

Subject: Report of Subsurface Exploration and Geotechnical Evaluation
Hard Rock Casino – Proposed Guitar Pick Plaza
Catoosa, Oklahoma
Building & Earth Project No: OK200253

Dear Mr. Kosman:

Building & Earth Sciences, Inc. has completed the authorized subsurface exploration and geotechnical engineering evaluation for the above referenced project in Catoosa, Oklahoma.

The purpose of this exploration and evaluation was to determine general subsurface conditions at the site and to address applicable geotechnical aspects of the proposed construction and site development. The recommendations in this report are based on a physical reconnaissance of the site and observation and classification of samples obtained from five (5) test borings conducted at the site. Confirmation of the anticipated subsurface conditions during construction is an essential part of geotechnical services.

We appreciate the opportunity to provide consultation services for the proposed project. If you have any questions regarding the information in this report or need any additional information, please call us.

Respectfully Submitted,
**BUILDING & EARTH SCIENCES, INC.**
*Certificate of Authorization, #3975, Expires 6/30/2022*

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## 1.0 PROJECT & SITE DESCRIPTION

The site is located within Cherokee Nation's Hard Rock Hotel and Casino Resort premises at 777 West Cherokee Street in Catoosa, Oklahoma. General information relative to the project site and the proposed development is listed in Table 1. More detailed information and photographs depicting current site conditions are presented on the following pages.

| Development | Detail | Description |
|---|---|---|
| **General Site** | Size (Ac.) | ~0.8 |
| | Existing Development | Casino and hotel facility with parking and access roads |
| | Vegetation | Landscaped areas within the planned development area |
| | Slopes | Relatively flat, with a grade differential of less than 1 to 2 feet. |
| | Drainage | Natural surface drainage, sheet flow across pavements |
| | Cut and Fill | No cuts and fill up to 3.5 feet at planned sign structure location. Western 2/3 of site will receive fill. |
| **Proposed Structures** | No. of Structures | One (1) large guitar-shaped sign |
| | Height | 60-foot tall sign |
| | Gravity Load | 7,700 pounds (provided by sign supplier) |
| | Overturning moment | 124 kip-foot (preliminary estimate by 360 Engineering) |
| | Preferred Foundation | Mat Foundation |
| **Pavements** | Traffic | Not Provided, assumed ESAL capacities |
| | Standard Duty | Rigid – parking areas only |
| | Heavy Duty | Rigid – Fire truck and bus traffic |
| | Crane Path | Rigid – Crane use associated with monument sign only |

**Table 1: Project and Site Description**

***Reference:***

- Conceptual site plans and utility plans
- Preliminary Grading Plan and Profile, prepared by RK & Associates, dated 11/5/2020
- 65' Illuminated D/F Guitar Pylon (Vertical & Tilted), Construction Documents, October 2020, prepared by Yesco

***Notes:***

- If final loading conditions exceed given preliminary loads, Building & Earth must review the proposed structural design and its effects on our recommendations for foundation design.
- Per conversation with Mr. Rick Kosman, P.E., we understand that fill on the order of 3.5 feet is anticipated at the proposed sign structure location. When a grading plan is finalized, Building & Earth should be contracted to review the plan and its effects on our recommendations.
- Through conversation with Mr. Elli Johannsson, P.E. of 360 Engineering, we understand the proposed sign structure will be supported on a mat foundation. Alternate drilled pier recommendations can be provided upon request.

**Figure 1: Google Earth Satellite Image of project site, dated May 2020**

**Figure 2: Photo taken from northeast of the casino building looking southwest**

At the time of our site reconnaissance, underground utilities were not marked within the planned construction area. A provided utility plan indicates the presence of underground utilities within the existing parking area.

## 2.0 SCOPE OF SERVICES

The authorized subsurface exploration was performed on October 21, 2020 in conformance with our proposal OK21128, dated October 15, 2020. Notice to proceed was provided by signing and returning our contract on the same day.

The purpose of the geotechnical exploration was to determine general subsurface conditions at specific boring locations and to gather data on which to base a geotechnical evaluation with respect to the proposed construction. The subsurface exploration for this project consisted of five (5) test borings. The site was drilled using a CME 75 truck mounted drill rig equipped with hollow stem augers and an automatic hammer.

The boring locations were determined in the field by a representative of our staff using a handheld GPS unit. After completion of drilling, boring locations were surveyed by Native Plains Surveying and Mapping, LLC. Boring locations as shown on the Boring Location Plan in the Appendix of this report were provided by Native Plains.

Once boring locations were marked in the field, Ground Penetrating Radar Services (GPRS) scanned an approximate 15-ft radius around each boring for underground utility lines.

Samples recovered during our site investigation were visually classified and specific samples were selected by the project engineer for laboratory analysis, which consisted of:

| Test | ASTM | No. of Tests |
|---|---|---|
| Natural Moisture Content | D2216 | 17 |
| Atterberg Limits | D4318 | 4 |

**Table 2: Scope of Laboratory Tests**

Results of the laboratory analysis are presented on the enclosed Boring Logs and in tabular form in the Appendix of this report. Descriptions of the laboratory tests that were performed are also included in the Appendix.

A supplemental scope of work included coring of asphaltic concrete pavement and estimating the in-place thickness of underlying aggregate base course at select locations within the Circle Road, connecting road to the east of the plaza, and one boring location within the plaza parking lot. This field work was completed on November 6, 2020.

Core locations are shown on the Boring Location Plan in the Appendix of this report. Photographs of the extracted cores are presented in the Appendix and the following table summarizes thickness of asphaltic concrete and aggregate base course for each core location.

| Core No. | Ground Elevation (ft) | Asphalt Thickness (inches) | Aggregate Base Thickness (inches) | Comments |
|---|---|---|---|---|
| C-01 | 643.0 | ~5 ½ | ~7 ½ | ▪ Geogrid at base of aggregate |
| C-02 | 641.5 | ~5 | ~6 ½ | ▪ Geogrid at base of aggregate |
| C-03 | 642.2 | ~5 | <~2 | ▪ Bottom 1" portion of asphalt core broke off during extraction<br>▪ No geogrid at base of aggregate |
| C-04 | 644.4 | ~4 ½ | ~7 | ▪ Bottom ½" portion of asphalt core broke off during extraction<br>▪ Geogrid at base of aggregate |

**Table 3: Summary of Pavement Core and Aggregate Base Thicknesses**

Information gathered from the exploration was evaluated to determine a suitable foundation type for the proposed structure. The information was also evaluated to help determine if any special subgrade preparation procedures will be required during the earthwork phase of the project.

The results of the work are presented within this report that addresses:

- Summary of existing surface conditions.
- A description of the subsurface conditions encountered at the boring locations.
- A description of the groundwater conditions observed in the boreholes during drilling. Long-term monitoring was not included in the scope of this project.
- Presentation of laboratory test results.
- Site preparation considerations including material types to be expected at the site, treatment of any encountered unsuitable soils, excavation considerations, and surface drainage.
- Recommendations to be used for mat foundation design, including appropriate bearing materials, bearing depth, bearing pressure, coefficient of friction, and modulus of subgrade reaction.
- Presentation of expected total and differential settlements.

- Compaction requirements and recommended criteria to establish suitable material for structural backfill.
- Recommended typical minimum rigid pavement sections based on assumed traffic loading conditions.

## 3.0 GEOTECHNICAL SITE CHARACTERIZATION

The following discussion is intended to create a general understanding of the site from a geotechnical engineering perspective. It is not intended to be a discussion of every potential geotechnical issue that may arise, nor to provide every possible interpretation of the conditions identified. The following conditions and subsequent recommendations assume that significant changes in subsurface conditions do not occur between boreholes. However, anomalous conditions can occur due to variations in existing fill, or the geologic conditions at the site, and it will be necessary to evaluate the assumed conditions during site grading and foundation installation.

### 3.1 EXISTING SURFACE CONDITIONS

At the time of our subsurface exploration on October 21, 2020, the current casino and hotel buildings were fully operational. The planned construction area was covered with asphaltic concrete pavement and landscaped areas with grass and topsoil.

The ground surface was covered with asphaltic concrete pavement that was approximately 9 to 10 inches in thickness in borings P-01, P-03, SS-01, and SW-01.

Topsoil with an approximate thickness of 4 inches was encountered in boring P-02. The topsoil conditions reported apply only to the specific boring location. For this report, topsoil is defined as the soil horizon which contains the root mat of the noted vegetation.

### 3.2 SUBSURFACE CONDITIONS

A generalized stratification summary has been prepared using data from the test borings and is presented in the following table. The stratification depicts the general soil/rock conditions and strata types encountered during our field investigation.

| Stratum No. | Typical Thickness | Description | Consistency/ Rock Hardness | Lab Testing Data (5) |
|---|---|---|---|---|
| 1 | 0.4′ to 4.1′ (1) | **Fill Materials:** lean clays (CL) and mixture of lean clays (CL) and some fat clays (CH) and silty clays (CL-ML) with fine roots and sandstone fragments<br>Yellow, brown, reddish brown, gray, olive brown, dark gray, dark brown, olive, and grayish brown | Stiff to very stiff | *Atterberg Limits:*<br>*LL = 30 and 31*<br>*PI = 13 and 14*<br>*Moisture Content Range: 14 to 20%* |
| 2 | 4.5′ to 6′ (2) | **Residuum:** lean clays (CL) and some lean to fat clays (CL-CH) with trace amounts of fine roots, and sandstone fragments<br>Dark brown, olive gray, yellowish brown, gray, yellow, grayish brown, brown, and olive brown | Stiff to very stiff | *Atterberg Limits:*<br>*LL = 33 and 35*<br>*PI = 16 and 18*<br>*Moisture Content Range: 18 to 22%* |
| 3 | 5′ (3) | **Weathered Rock:** clayey shale<br>Light brown and yellowish brown | Soft rock formation | *Moisture Content: 14%* |
| 4 | Termination Layer (4) | **Labette Formation:** Shale, gray | Soft to moderately hard rock | *Moisture Contents: 6 and 7%* |

**Table 4: Stratification Summary**

**Notes:**

1. Boring P-01 terminated within the fill at a depth of about 5 feet below current grades.
2. Borings P-02 and P-03 terminated within the residual clay stratum at a depth of about 5 feet.
3. Encountered in borings SS-01and SW-01 only. Boring SW-01 was terminated within the clayey shale unit at a depth of about 10 feet.
4. Boring SS-01 was terminated within the shale unit at a depth of about 25 feet.
5. For Atterberg Limits: LL = Liquid Limit, PL = Plastic Limit, and PI = Plasticity Index

A subsurface profile has been prepared based on the data obtained at the specific boring locations and is presented in the Appendix. For specific details on the information obtained from individual test borings, please refer to the Boring Logs included in the Appendix. The ground surface elevations at the boring locations indicated in this report were determined and provided by Native Plains Surveying and Mapping, LLC.

### 3.2.1 GROUNDWATER

Groundwater was not encountered in the borings at the time of drilling and they were dry prior to backfilling at the time of our subsurface exploration. Water levels reported are accurate only for the time and date that the borings were drilled. Long term monitoring of the boreholes was not included as part of our subsurface exploration. All borings were backfilled, and pavements patched the same day that they were drilled.

## 4.0 SITE DEVELOPMENT CONSIDERATIONS

A final grading plan was not available at the time of this report. Per conversation with Mr. Rick Kosman, we understand that fill on the order of 3.5 feet is anticipated at the proposed sign structure location and that the western 2/3 of the site will receive fill to achieve design grade. ***When a final grading plan is finalized, Building & Earth should be contracted to review the plan and its effects on our recommendations.***

The primary geotechnical concerns for this project are:

- Fill materials comprised of lean clays and some fat clays and silty clays were noted in all borings, extending to depths of about 1.5 to greater than 5 feet.
- Clay fill and underlying residual lean clays exhibited low to medium plasticity characteristics with a low to moderate shrink-swell potential.
- Onsite clay soils are moisture sensitive, prone to losing strength and stability with slight increases in moisture content.
- A clayey shale unit was encountered below the residual clays at a depth of about 8.5 feet in borings SS-01 and SW-01. A harder gray shale unit was encountered below the clayey shale stratum at depth of about 13.5 feet in boring SS-01.

Recommendations addressing the site conditions are presented in the following sections.

### 4.1 INITIAL SITE PREPARATION

All vegetation, roots, trees, topsoil, and any other deleterious materials, should be removed from the proposed construction areas. Approximately 4 inches of topsoil was observed in boring P-02; however, topsoil could extend to greater depths in unexplored areas of the site. For this report, topsoil is defined as the horizon which contains most of the root mat of the noted vegetation.

Grubbing of trees should include removal of the tree stumps and the root systems. Desiccated clay soils may be present in the zone surrounding the trees. Desiccated clay soils should be undercut and replaced with structural fill.

At borings locations P-01, P-03, SS-01, and SW-01, the existing ground surface was covered with asphaltic concrete pavement that was approximately 9 to 10 inches in thickness. Existing pavements should be demolished as part of initial site preparation within proposed construction areas.

A geotechnical engineer should observe stripping, grubbing, and demolition operations to evaluate that all unsuitable materials are removed from locations for proposed construction. Materials disturbed during clearing operations should be stabilized in place or, if necessary, undercut to undisturbed materials and backfilled with properly compacted, approved structural fill.

Existing underground utility lines were noted within the proposed construction area. At the proposed guitar-sign location, all abandoned utility lines should be removed and existing utility lines that will remain in use should be rerouted outside the proposed foundation area. The trench excavations following removal or rerouting of the existing utility lines should be properly backfilled with suitable structural fill.

Within proposed pavement areas, any abandoned utilities should be excavated and removed, or if they remain in-place should be plugged with grout. It should be noted that existing utility lines and their trenches can potentially serve as groundwater conduits, which could result in saturation and softening of surrounding soils or subsurface erosion and subsequent vertical migration of the overlying soils. When existing utility lines are left in-place, thorough evaluation of the backfill material condition is recommended to verify that no unsuitable materials are contained within the trench backfill. Any unsuitable material encountered must be removed full-depth and replaced with properly compacted and approved structural fill.

During site preparation activities, the contractor should identify borrow source materials that will be used as structural fill and provide samples to the testing laboratory so that conformance to the structural fill requirements outlined below and appropriate moisture-density relationship curves can be determined.

### 4.2 MOISTURE SENSITIVE SOILS

Moisture sensitive, lower plasticity lean clays (CL) were encountered across the site. These soils will degrade if allowed to become saturated. Therefore, not allowing water to pond by maintaining positive drainage and temporary dewatering methods (if required) is important to help avoid degradation and softening of the soils.

The contractor should anticipate some difficulty during the earthwork phase of this project if moisture levels are moderate to high during construction. Increased moisture levels will soften the subgrade and the soils may become unstable under the influence of construction traffic. Accordingly, construction during wet weather conditions should be avoided, as this could result in soft and unstable soil conditions that would require ground modification, such as in place stabilization or undercutting.

### 4.3 EVALUATION OF EXPOSED FILL MATERIALS

Following initial site preparation, fill materials are anticipated to be exposed across the proposed construction areas. The fill materials comprised of lean clays and minor fat clays and silty clays, extending to depths ranging from about 1.5 feet to greater than 5 feet below existing grades in the proposed construction area.

Although not encountered in the test borings, the owner and design team need to understand that there is a risk the existing fill may contain soft soils, organics, debris, over-sized rock fragments, or other unsuitable materials that could not be reasonably deduced from the widely-spaced borings.

In addition, the subgrade soils encountered below the asphaltic concrete pavement exhibited stiff to very stiff consistencies. Although not encountered in the borings, in our experience with pavement reconstruction project, soft, unstable, and wet soils may be present below parts of the pavements or in landscape areas where water infiltration may have saturated and softened the soils. Of particular concern are distressed pavement and green scape areas where precipitation and run off may have infiltrated the subgrade.

As a minimum, the exposed fill materials after initial site preparation should be evaluated by means of proofrolling with a tandem-axle, rubber-tired vehicle weighing 20 to 25 tons. The proofrolling will aid in identifying unstable/soft areas, which then would need to be delineated and further evaluated. Evaluation of identified unstable/soft existing fill could include, but not necessarily limited to, test pit excavations and Dynamic Cone Penetration (DCP) testing. Unsuitable fill materials identified during the evaluation must be removed full-depth and replaced with approved structural fill material. Any undercutting should be conducted under the observation of the geotechnical engineer or designated representative.

Following evaluation of fill materials and prior to placement of structural fill, the exposed fill materials within the proposed structure and pavement areas are to be prepared in accordance with *Subgrade Preparation and Evaluation* section of this report.

## 4.4 SUBGRADE PREPARATION AND EVALUATION

Following any necessary undercutting and prior to start of fill placement, we recommend scarifying all exposed subgrade soils to a depth of 8 inches, moisture conditioning them within range of 2 percent below to 2 percent above the material's optimum moisture content, and recompacting the soils to least 95 percent of the material's standard Proctor maximum dry density.

We recommend that the project geotechnical engineer or a qualified representative evaluate the subgrade after the site is prepared. Some unsuitable or unstable areas may be present in unexplored areas of the site. All areas that will require fill or that will support structures should be carefully proofrolled with a fully loaded, tandem-axle dump truck (20- to 25-ton), at the following times.

- After an area has been stripped and undercut as needed, and prior to the placement of any fill.
- After grading an area to the finished subgrade elevation in planned structure and pavement areas.
- After areas have been exposed to any precipitation, and/or have been exposed for more than 48 hours.

Some instability may exist during construction, depending on climatic and other factors immediately preceding and during construction. If any soft or otherwise unsuitable soils are identified during the proofrolling process, they must be undercut or stabilized prior to fill placement or pavement construction. All unsuitable material identified during the construction shall be removed and replaced in accordance with the *Structural Fill* section.

## 4.5 STRUCTURAL FILL

Requirements for structural fill on this project are as follows:

| Soil Type | USCS Classification | Property Requirements | Placement Location |
|---|---|---|---|
| **Imported**<br>Lean Clay, Clayey Sand or Shale | CL, SC | LL<40, 7<PI<20, $\gamma_d$>100 pcf, P200>30%, Maximum 3" particle size in any dimension | **Low Plasticity Structural Fill** to be used for construction within the proposed sign and pavement area |
| **Existing Fill and Residuum**<br>Lean Clays | CL | Same as above for Imported Fill | **May be suitable** for use as lower plasticity structural fill (see note 5) |
| **Residuum**<br>Lean to Fat Clay | CL-CH | Not Applicable | **Not suitable** for use as structural fill in structure and pavement areas |

**Table 5: Structural Fill Requirements**

**Table 5 Notes:**

1. All structural fill should be free of vegetation, topsoil, and any other deleterious materials. The organic content of materials to be used for fill should be less than 3 percent.
2. LL indicates the soil Liquid Limit; PI indicates the soil Plasticity Index; $\gamma_d$ indicates the maximum dry density as defined by the density standard outlined in the table below.
3. Laboratory testing of the soils proposed for fill must be performed in order to verify their conformance with the above recommendations.
4. Representative bulk samples for any onsite and imported offsite materials are to be collected for soil classification and moisture-density relationship determination purposes as part of evaluating suitability for their intended use.
5. It should be noted that some fat clays were noted in the existing fill that may exhibit plasticity characteristics exceeding the plasticity requirements for lower plasticity structural fill; as such, the condition of existing clay fill is to be carefully evaluated during construction when considered for use as lower plasticity fill. Frequent sampling and testing of onsite soils will be required to evaluate the materials suitability for use as structural fill.

Placement requirements for structural fill are as follows:

| Specification | Requirement |
|---|---|
| Lift Thickness | Maximum loose lift thickness of 8 to 12 inches, depending on type of compaction equipment used. |
| Density | Minimum 95% of the standard Proctor maximum density (ASTM D698) |
| Moisture | ±2% of the optimum moisture content as determined by ASTM D698 |
| Density Testing Frequency | **Foundation areas**: One test per 2,500 square feet (SF) per lift with a minimum of three tests performed per lift<br>**Pavement area**: One test per 5,000 SF per lift with a minimum of three tests performed per lift<br>**Utility trenches**: One test per 150 linear feet per lift with a minimum of two tests performed per lift |

**Table 6: Structural Fill Placement Requirements**

## 4.6 EXCAVATION CONSIDERATIONS

All excavations performed at the site should follow OSHA guidelines for temporary excavations. Excavated soils should be stockpiled according to OSHA regulations to limit the potential cave-in of soils.

### 4.6.1 DIFFICULT EXCAVATION

Based on information gathered during our subsurface exploration, we anticipate the existing clay fill, residual clays, and clayey shale can be excavated using a backhoe in good working condition.

A shale unit was encountered at a depth of about 13.5 feet in boring SS-01. A large track hoe with rock teeth will likely be needed to excavate the shale. In confined excavations, a hydraulic hoe ram attachment may be required to advance through the shale unit.

The ability to excavate rock is a function of the material, the equipment used, the skill of the operator, the desired rate of removal and other factors. The contractor should review the borings logs and use their own method to evaluate excavation difficulty.

### 4.7 UTILITY TRENCH BACKFILL

All utility trenches must be backfilled and compacted in the manner specified above for structural fill. It may be necessary to reduce the lift thickness to 4 to 6 inches to achieve compaction using hand-operated equipment.

### 4.8 LANDSCAPING AND DRAINAGE CONSIDERATION

The potential for moisture fluctuations within proposed structure area and pavement subgrades should be lessened to reduce the potential of subgrade movement. Site grading should include positive drainage away from foundations and pavements. Landscaping and irrigation immediately adjacent to the sign structure and pavements should be limited. Trees can develop large root systems which can draw water from subgrade soils, resulting in subsequent shrinkage of the soils. Periodic irrigation of landscaping poses a risk of saturating and softening soils below the foundation and pavements, which could result in foundation settlement and premature pavement failure.

### 4.9 WET WEATHER CONSTRUCTION

Excessive movement of construction equipment across the site during wet weather may result in ruts, which will collect rainwater, prolonging the time required to dry the subgrade soils.

During rainy periods, additional effort will be required to properly prepare the site and establish/maintain an acceptable subgrade. The difficulty will increase in areas where clay or silty soils are exposed at the subgrade elevation. Grading contractors typically postpone grading operations during wet weather to wait for conditions that are more favorable. Contractors can typically disk or aerate the upper soils to promote drying during intermittent periods of favorable weather. When deadlines restrict postponement of grading operations, additional measures such as undercutting and replacing saturated soils or stabilization can be utilized to facilitate placement of additional fill material.

## 5.0 MAT FOUNDATION

Based on the conditions encountered in borings SS-01 and SW-01 and after our site preparation recommendations are implemented, the proposed sign structure can be supported on a mat foundation.

The structural engineer will need to determine the actual mat thickness such as to provide adequate rigidity to the foundation based on the monument sign loads. A modulus of subgrade reaction of 100 pci can be used to aid with design of the mat foundation.

The perimeter of the mat foundation should extend at least 24 inches below finished grades surrounding the proposed sign. Turn down edges can be used to accommodate this recommended bearing depth for mat foundations with a thickness less than 24 inches.

We anticipate that evaluated and approved existing fill materials comprised of stiff to very stiff lean clay soils, and/or new structural fill will be exposed at foundation bearing elevation. **A mat foundation bearing in the anticipated materials can be designed using a maximum net allowable bearing pressure of 2,000 psf for dead loads and sustained live loads. For cyclic live loads (e.g., wind loads), an increased allowable bearing pressure of 2,600 psf may be considered.**

Total settlement of a mat foundation designed and constructed as recommended above is estimated to be less than 1 inch. Differential settlement across the mat foundation is estimated to be less than ½ inch.

Due to the noted presence of existing fill, we recommend further evaluation of bearing materials exposed in the bottom of the mat foundation excavation. Evaluation of the bearing materials should include hand auger borings and dynamic cone penetration (DCP) testing to a depth at least 5 feet below the bearing elevation. DCP testing will aid with verification of the in-place bearing capacity of the bearing materials at the time of construction. The geotechnical engineer should be consulted when unsuitable conditions are encountered during foundation excavation.

Where soils are encountered that do not meet the design bearing capacity, foundation excavations must be undercut to underlying soils that meet design bearing capacity. The foundation should then be brought back up to design bearing elevation with properly compacted and approved structural fill (placed in loose lifts of no more than 6 inches thick and compacted to at least 95 percent of the standard Proctor maximum dry density) or controlled low-strength material (CLSM, Section 701.19 of Oklahoma Department of Transportation Standard Specifications, 2019).

## 5.1 UPLIFT RESISTANCE

Uplift resistance of the mat foundation supporting the sign can be developed from the weight of the foundation, the effective weight of overlying soils, 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 (see Figure 3).

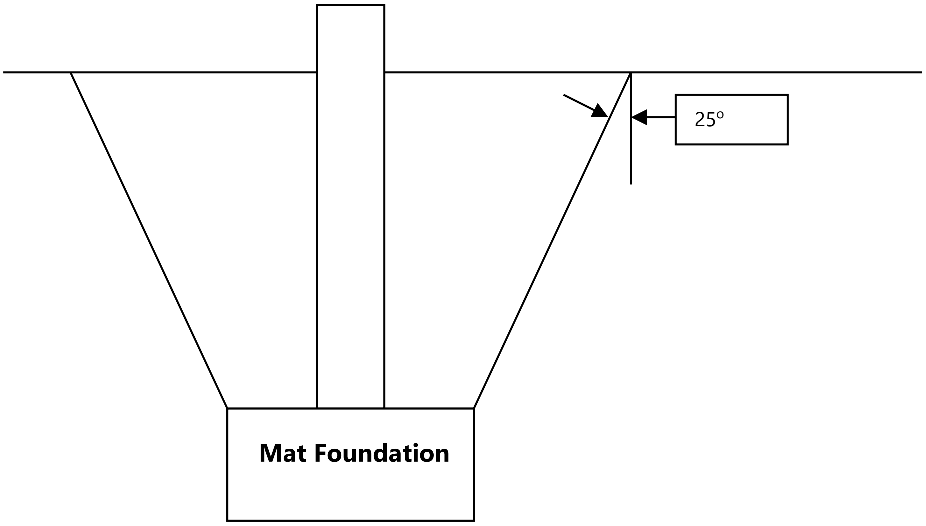


**Figure 3: Soil uplift resistance sketch**

The maximum uplift capacity should be taken as the sum of the weight of the soil, plus the weight of the foundation, divided by an appropriate factor of safety. A total unit weight of 110 pounds per cubic foot (pcf) can be used for well-compacted structural fill that has been placed over the mat foundation.

## 5.2 SHEAR RESISTANCE

Bearing material friction at the base of the mat foundation may be used to resist shear. A coefficient of friction of 0.35 can be used for a mat foundation bearing on stiff to very stiff existing clay fill or new structural fill.

The use of passive earth pressure from soils against the edge of the mat foundation is not recommended for a bearing depth of 2 feet. For foundations extending to depths greater than 2 feet, an equivalent fluid unit weight of 250 pcf can be used for that portion of the circumference of the mat foundation in direct contact with the anticipated bearing materials.

### 5.3 GENERAL SHALLOW FOUNDATION CONSIDERATIONS

The following items should be considered during the preparation of construction documents and foundation installation:

- The geotechnical engineer of record should observe the exposed foundation bearing surfaces prior to concrete placement to verify that the conditions anticipated during the subsurface exploration are encountered.
- All bearing surfaces must be free of soft or loose soil and debris prior to placing concrete.
- The bottom surface of the mat foundation should be level.
- Concrete should be placed the same day the excavations are completed and bearing materials verified by the engineer. If the excavations are left open for an extended period, or if the bearing surfaces are disturbed after the initial observation, then the bearing surfaces should be re-evaluated prior to concrete placement.
- Water should not be allowed to pond in foundation excavations prior to concrete placement or above the concrete after the foundation is completed.
- Wherever possible, the foundation concrete should be placed “neat”, using the sides of the excavations as forms. Where this is not possible, the excavations created by forming the foundations must be backfilled with suitable structural fill and properly compacted.
- Grades around the structure should be sloped to drain away from the foundation.

## 6.0 PAVEMENT CONSIDERATIONS

Mr. Rick Kosman informed us that the proposed new parking area, circle road, and designated crane use area within the parking lot will be constructed using Portland cement concrete.

Specific traffic information was not provided. For pavement design purposes, we have assumed proposed pavements will be subjected to passenger cars, pick-up trucks, and occasional light delivery box trucks (e.g., FedEx and UPS vehicles) with 18-kip Equivalent Single Axle Loads (ESALs) of 85,000. Heavy-duty pavement for the circle road may be subjected to fire truck and bus traffic with estimated ESAL of 500,000.

We also understand that a heavy-duty reinforced rigid pavement section will be constructed for crane use associated with installation and maintenance of proposed sign structure within the proposed parking lot.

In addition, we have assumed the following design parameters:

| Design Criteria | Value |
|---|---|
| Design life (Years) | 20 |
| Terminal Serviceability | 2.0 |
| Reliability | 85% |
| Initial Serviceability | 4.5 |
| Standard Deviation | 0.35 |

**Table 7: Assumed Rigid Pavement Design Parameters**

All subgrade, base and pavement construction operations should meet minimum requirements of the Oklahoma Department of Transportation (ODOT), Standard Specifications for Highway Construction, dated 2019. The applicable sections of the specifications are identified as follows:

| Material | Specification Section |
|---|---|
| Portland Cement Concrete Pavement | 414 & 701 |
| Mineral Aggregate Base Materials | 303 & 703.01 |

**Table 8: ODOT Specification Sections**

The following rigid pavement sections are based on the design parameters presented above. We assume a modulus of subgrade reaction (k) of 100 pci for evaluated and approved existing lean clay fill and new structural fill. We assumed a concrete elastic modulus (Ec) of 3.6 X $10^6$ psi, and a concrete modulus of rupture (S'c) of 600 psi.

| Minimum Recommended Thickness (in) | | | Material |
|---|---|---|---|
| Standard Duty Parking Lot (1) | Heavy Duty Circle Road (2) | Designated Crane Use Within Parking Lot (3) | |
| 5.0 | 7.0 | 6.0 | Portland Cement Concrete, $f'_c$=4,000 psi |
| 4.0 | 6.0 | 6.0 | Crushed Aggregate (ODOT Type "A") |

**Table 9: Rigid Pavement Recommendations**

**Notes:**

1. Unreinforced, plain concrete.
2. Use doweled construction joints for load transfer between concrete panels. Access drive approaches into the parking lot are to be constructed with a heavy-duty pavement section.
3. Concrete panels reinforced with No. 4 reinforcing steel, placed 18 inches on center both ways.
4. Aggregate to be compacted to at least 98 percent of the standard Proctor maximum dry density.

Concrete should be protected against moisture loss, rapid temperature fluctuations, and construction traffic for several days after placement. All pavements should be sloped for positive drainage. We suggest that a curing compound be applied after the concrete has been finished.

Although not referenced in the ODOT specifications, based on our experience with project sites in this region and anticipated traffic loads, we recommend Portland cement concrete should have a minimum 28-day compressive strength of 4,000 psi, maximum slump of 4 inches, and air content of 5 to 7 percent.

A jointing plan should be developed to control cracking and help preclude surficial migration of water into the subgrade. Additionally, joints should be sealed to further preclude surficial moisture migration into subgrade soils.

All pavements should be sloped, approximately ¼ inch per foot, to provide rapid surface drainage. Water allowed to pond on or adjacent to the pavement could saturate the subgrade and cause premature deterioration of the pavements as a result of loss of strength and stability. Periodic maintenance of the pavement should be anticipated. This should include sealing of cracks and joints and maintaining proper surface drainage to avoid ponding of water on or near the pavement areas

## 7.0 CONSTRUCTION MONITORING

Field verification of site conditions is an essential part of the services provided by the geotechnical consultant. In order to confirm our recommendations, it will be necessary for Building & Earth personnel to make periodic visits to the site during site grading. Typical construction monitoring services are listed below.

- Periodic observations and consultations by a member of our engineering staff during site development
- Proofroll observations of subgrades
- Continuous monitoring during structural fill placement
- Field density tests during structural fill placement
- Observation and verification of the bearing surfaces exposed after foundation excavation
- Reinforcing steel inspections
- Molding and testing of concrete cylinders

## 8.0 CLOSING AND LIMITATIONS

This report was prepared for RK & Associates, PLC., for specific application to the subject project located in Catoosa, Oklahoma. The information in this report is not transferable. This report should not be used for a different development on the same property without first being evaluated by the engineer.

The recommendations in this report were based on the information obtained from our field exploration and laboratory analysis. The data collected is representative of the locations tested. Variations are likely to occur at other locations throughout the site. Engineering judgment was applied in regards to conditions between borings. It will be necessary to confirm the anticipated subsurface conditions during construction.

This report has been prepared in accordance with generally accepted standards of geotechnical engineering practice. No other warranty is expressed or implied. In the event that changes are made, or anticipated to be made, to the nature, design, or location of the project as outlined in this report, Building & Earth must be informed of the changes and given the opportunity to either verify or modify the conclusions of this report in writing, or the recommendations of this report will no longer be valid.

The scope of services for this project did not include any environmental assessment of the site or identification of pollutants or hazardous materials or conditions. If the owner is concerned about environmental issues Building & Earth would be happy to provide an additional scope of services to address those concerns.

This report is intended for use during design and preparation of specifications and may not address all conditions at the site during construction. Contractors reviewing this information should acknowledge that this document is for design information only.

An article published by the Geoprofessional Business Association (GBA), titled *Important Information About Your Geotechnical Report*, has been included in the Appendix. We encourage all individuals to become familiar with the article to help manage risk.

# Appendix Table of Contents

# GEOTECHNICAL INVESTIGATION METHODOLOGIES

The subsurface exploration, which is the basis of the recommendations of this report, has been performed in accordance with industry standards. Detailed methodologies employed in the investigation are presented in the following sections.

## *DRILLING PROCEDURES – STANDARD PENETRATION TEST (ASTM D1586)*

At each boring location, soil samples were obtained at standard sampling intervals with a split-spoon sampler. The borehole was first advanced to the sample depth by augering and the sampling tools were placed in the open hole. The sampler was then driven 18 inches into the ground with a 140-pound automatic hammer free-falling 30 inches. The number of blows required to drive the sampler each 6-inch increment was recorded. The initial increment is considered the "seating" blows, where the sampler penetrates loose or disturbed soil in the bottom of the borehole.

The blows required to penetrate the final two (2) increments are added together and are referred to as the Standard Penetration Test (SPT) N-value. The N-value, when properly evaluated, gives an indication of the soil's strength and ability to support structural loads. Many factors can affect the SPT N-value, so this result cannot be used exclusively to evaluate soil conditions.

The SPT testing was performed using a drill rig equipped with an automatic hammer. Automatic hammers mechanically control the height of the hammer drop, and doing so, deliver higher energy efficiency (90 to 99 % efficiency) than manual hammers (60 % efficiency) which are dropped using a manually operated rope and cathead system. Because historic data correlations were developed based on use of a manual hammer, it is necessary to adjust the N-values obtained using an automatic hammer to make these correlations valid. Therefore, an energy correction factor of 1.3 was applied to the recorded field N-values from the automatic hammer for the purpose of our evaluation. The N-values discussed or mentioned in this report and shown on the boring logs are recorded field values.

Samples retrieved from the boring locations were labeled and stored in plastic bags at the jobsite before being transported to our laboratory for analysis. The project engineer prepared Boring Logs summarizing the subsurface conditions at the boring locations.

# BORING LOG DESCRIPTION

Building & Earth Sciences, Inc. used the gINT software program to prepare the attached boring logs. The gINT program provides the flexibility to custom design the boring logs to include the pertinent information from the subsurface exploration and results of our laboratory analysis. The soil and laboratory information included on our logs is summarized below:

## *DEPTH AND ELEVATION*

The depth below the ground surface and the corresponding elevation are shown in the first two columns.

## *SAMPLE TYPE*

The method used to collect the sample is shown. The typical sampling methods include Split Spoon Sampling, Shelby Tube Sampling, Grab Samples, and Rock Core. A key is provided at the bottom of the log showing the graphic symbol for each sample type.

## *SAMPLE NUMBER*

Each sample collected is numbered sequentially.

## *BLOWS PER INCREMENT, REC%, RQD%*

When Standard Split Spoon sampling is used, the blows required to drive the sampler each 6-inch increment are recorded and shown in column 5. When rock core is obtained the recovery ration (REC%) and Rock Quality Designation (RQD%) is recorded.

## *SOIL DATA*

Column 6 is a graphic representation of four different soil parameters. Each of the parameters use the same graph, however, the values of the graph subdivisions vary with each parameter. Each parameter presented on column 6 is summarized below:

- N-value- The Standard Penetration Test N-value, obtained by adding the number of blows required to drive the sampler the final 12 inches, is recorded . The graph labels range from 0 to 50.
- Qu – Unconfined Compressive Strength estimate from the Pocket Penetrometer test in tons per square foot (tsf). The graph labels range from 0 to 5 tsf.
- Atterberg Limits – The Atterberg Limits are plotted with the plastic limit to the left, and liquid limit to the right, connected by a horizontal line. The difference in the plastic and liquid limits is referred to as the Plasticity Index. The Atterberg Limits test results are also included in the Remarks column on the far right of the boring log. The Atterberg Limits graph labels range from 0 to 100%.
- Moisture – The Natural Moisture Content of the soil sample as determined in our laboratory.

### *SOIL DESCRIPTION*

The soil description prepared in accordance with ASTM D2488, Visual Description of Soil Samples. The Munsel Color chart is used to determine the soil color. Strata changes are indicated by a solid line, with the depth of the change indicated on the left side of the line and the elevation of the change indicated on the right side of the line. If subtle changes within a soil type occur, a broken line is used. The Boring Termination or Auger Refusal depth is shown as a solid line at the bottom of the boring.

### *GRAPHIC*

The graphic representation of the soil type is shown. The graphic used for each soil type is related to the Unified Soil Classification chart. A chart showing the graphic associated with each soil classification is included.

### *REMARKS*

Remarks regarding borehole observations, and additional information regarding the laboratory results and groundwater observations.

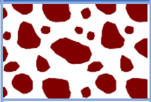
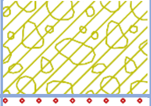
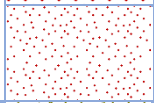
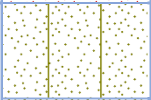
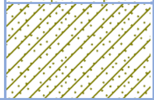
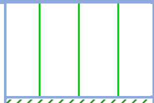
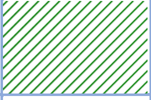
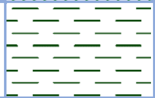
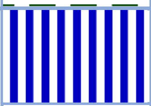
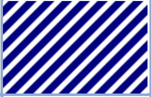
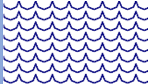
| ***Major Divisions*** | | | ***Symbols*** | | ***Group Name & Typical Description*** |
|---|---|---|---|---|---|
| | | | ***Lithology*** | ***Group*** | |
| ***Coarse Grained Soils***<br>*More than 50% of material is larger than No. 200 sieve size* | ***Gravel and Gravelly Soils***<br>*More than 50% of coarse fraction is larger than No. 4 sieve* | ***Clean Gravels***<br>*(Less than 5% fines)* |  | ***GW*** | *Well-graded gravels, gravel – sand mixtures, little or no fines* |
| | | |  | ***GP*** | *Poorly-graded gravels, gravel – sand mixtures, little or no fines* |
| | | ***Gravels with Fines***<br>*(More than 12% fines)* |  | ***GM*** | *Silty gravels, gravel – sand – silt mixtures* |
| | | |  | ***GC*** | *Clayey gravels, gravel – sand – clay mixtures* |
| | ***Sand and Sandy Soils***<br>*More than 50% of coarse fraction is smaller than No. 4 sieve* | ***Clean Sands***<br>*(Less than 5% fines)* |  | ***SW*** | *Well-graded sands, gravelly sands, little or no fines* |
| | | |  | ***SP*** | *Poorly-graded sands, gravelly sands, little or no fines* |
| | | ***Sands with Fines***<br>*(More than 12% fines)* |  | ***SM*** | *Silty sands, sand – silt mixtures* |
| | | |  | ***SC*** | *Clayey sands, sand – clay mixtures* |
| ***Fine Grained Soils***<br>*More than 50% of material is smaller than No. 200 sieve size* | ***Silts and Clays***<br>*Liquid Limit less than 50* | ***Inorganic*** |  | ***ML*** | *Inorganic silts and very find sands, rock flour, silty or clayey fine sands or clayey silt with slight plasticity* |
| | | |  | ***CL*** | *Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays* |
| | | ***Organic*** |  | ***OL*** | *Organic silts and organic silty clays of low plasticity* |
| | ***Silts and Clays***<br>*Liquid Limit greater than 50* | ***Inorganic*** |  | ***MH*** | *Inorganic silts, micaceous or diatomaceous fine sand, or silty soils* |
| | | |  | ***CH*** | *Inorganic clays of high plasticity* |
| | | ***Organic*** |  | ***OH*** | *Organic clays of medium to high plasticity, organic silts* |
| ***Highly Organic Soils*** | | |  | ***PT*** | *Peat, humus, swamp soils with high organic contents* |

**Table 1: Soil Classification Chart (based on ASTM D2487)**

# SOIL CLASSIFICATION METHODOLOGY

Building & Earth Sciences classifies soil in general accordance with the Unified Soil Classification System (USCS) presented in ASTM D2487. Table 1 and Figure 1 exemplify the general guidance of the USCS. Soil consistencies and relative densities are presented in general accordance with Terzaghi, Peck, & Mesri's (1996) method, as shown on Table 2, when quantitative field and/or laboratory data is available. Table 2 includes Consistency and Relative Density correlations with N-values obtained using either a manual hammer (60 percent efficiency) or automatic hammer (90 percent efficiency). The *Blows Per Increment* and *SPT N-values* displayed on the boring logs are the unaltered values measured in the field. When field and/or laboratory data is not available, we may classify soil in general accordance with the Visual Manual Procedure presented in ASTM D2488.

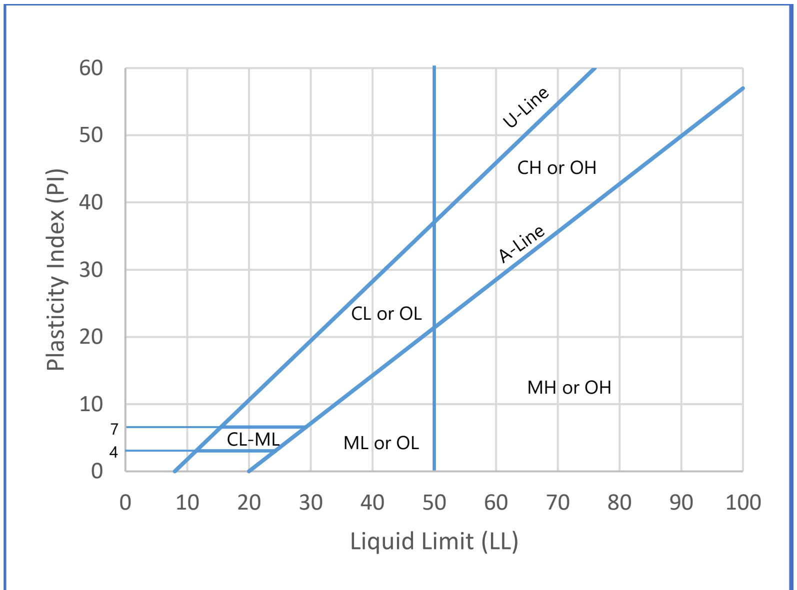


**Figure 1: Plasticity Chart (based on ASTM D2487)**

| **Non-cohesive: Coarse-Grained Soil** | | | **Cohesive: Fine-Grained Soil** | | | |
|---|---|---|---|---|---|---|
| **SPT Penetration (blows/foot)** | | **Relative Density** | **SPT Penetration (blows/foot)** | | **Consistency** | **Estimated Range of Unconfined Compressive Strength (tsf)** |
| Automatic Hammer* | Manual Hammer | | Automatic Hammer* | Manual Hammer | | |
| | | | < 2 | < 2 | Very Soft | < 0.25 |
| 0 - 3 | 0 - 4 | Very Loose | 2 - 3 | 2 - 4 | Soft | 0.25 – 0.50 |
| 3 - 8 | 4 - 10 | Loose | 3 - 6 | 4 - 8 | Medium Stiff | 0.50 – 1.00 |
| 8 - 23 | 10 - 30 | Medium Dense | 6 - 12 | 8 - 15 | Stiff | 1.00 – 2.00 |
| 23 - 38 | 30 - 50 | Dense | 12 - 23 | 15 - 30 | Very Stiff | 2.00 – 4.00 |
| > 38 | > 50 | Very Dense | > 23 | > 30 | Hard | > 4.00 |

**Table 2: Soil Consistency and Relative Density (based on Terzaghi, Peck & Mesri, 1996)**

* - Modified based on 80% hammer efficiency

# KEY TO LOGS

| | | | |
|---|---|---|---|
| ☒ | Standard Penetration Test ASTM D1586 or AASHTO T-206 | ▼ | Dynamic Cone Penetrometer (Sower DCP) ASTM STP-399 |
| ■ | Shelby Tube Sampler ASTM D1587 | ○ | No Sample Recovery |
| ▥ | Rock Core Sample ASTM D2113 | ▽ | Groundwater at Time of Drilling |
| ■ | Auger Cuttings | ▼ | Groundwater as Indicated |

**Table 1: Symbol Legend**

| Soil | Particle Size | U.S. Standard |
|---|---|---|
| **Boulders** | Larger than 300 mm | N.A. |
| **Cobbles** | 300 mm to 75 mm | N.A. |
| **Gravel** | 75 mm to 4.75 mm | 3-inch to #4 sieve |
| Coarse | 75 mm to 19 mm | 3-inch to ¾-inch sieve |
| Fine | 19 mm to 4.75 mm | ¾-inch to #4 sieve |
| **Sand** | 4.75 mm to 0.075 mm | #4 to #200 Sieve |
| Coarse | 4.75 mm to 2 mm | #4 to #10 Sieve |
| Medium | 2 mm to 0.425 mm | #10 to #40 Sieve |
| Fine | 0.425 mm to 0.075 mm | #40 to #200 Sieve |
| **Fines** | Less than 0.075 mm | Passing #200 Sieve |
| Silt | Less than 5 µm | N.A. |
| Clay | Less than 2 µm | N.A. |

**Table 2: Standard Sieve Sizes**

| | | | |
|---|---|---|---|
| N-Value<br>☐ | Standard Penetration Test Resistance calculated using ASTM D1586 or AASHTO T-206. Calculated as sum of original, field recorded values. | Atterberg Limits<br>├─┤<br>PL LL | A measure of a soil's plasticity characteristics in general accordance with ASTM D4318. The soil Plasticity Index (PI) is representative of this characteristic and is bracketed by the Liquid Limit (LL) and the Plastic Limit (PL). |
| Qu<br>▲ | Unconfined compressive strength, typically estimated from a pocket penetrometer. Results are presented in tons per square foot (tsf). | % Moisture<br>● | Percent natural moisture content in general accordance with ASTM D2216. |

**Table 3: Soil Data**

| | |
|---|---|
| Hollow Stem Auger | Flights on the outside of the shaft advance soil cuttings to the surface. The hollow stem allows sampling through the middle of the auger flights. |
| Mud Rotary / Wash Bore | A cutting head advances the boring and discharges a drilling fluid to support the borehole and circulate cuttings to the surface. |
| Solid Flight Auger | Flights on the outside bring soil cuttings to the surface. Solid stem requires removal from borehole during sampling. |
| Hand Auger | Cylindrical bucket (typically 3-inch diameter and 8 inches long) attached to a metal rod and turned by human force. |

**Table 4: Soil Drilling Methods**

| Descriptor | Meaning |
|---|---|
| Trace | Likely less than 5% |
| Few | 5 to 10% |
| Little | 15 to 25% |
| Some | 30 to 45% |
| Mostly | 50 to 100% |

**Table 5: Descriptors**

| | |
|---|---|
| **Manual Hammer** | The operator tightens and loosens the rope around a rotating drum assembly to lift and drop a sliding, 140-pound hammer falling 30 inches. |
| **Automatic Trip Hammer** | An automatic mechanism is used to lift and drop a sliding, 140-pound hammer falling 30 inches. |
| **Dynamic Cone Penetrometer (Sower DCP) ASTM STP-399** | Uses a 15-pound steel mass falling 20 inches to strike an anvil and cause penetration of a 1.5-inch diameter cone seated in the bottom of a hand augered borehole. The blows required to drive the embedded cone a depth of 1-3/4 inches have been correlated by others to N-values derived from the Standard Penetration Test (SPT). |

**Table 6: Sampling Methods**

| | |
|---|---|
| **Non-plastic** | A 1/8-inch thread cannot be rolled at any water content. |
| **Low** | The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit. |
| **Medium** | The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be re-rolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit. |
| **High** | It takes considerable time rolling and kneading to reach the plastic limit. The thread can be re-rolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit. |

**Table 7: Plasticity**

| | |
|---|---|
| **Dry** | Absence of moisture, dusty, dry to the touch. |
| **Moist** | Damp but no visible water. |
| **Wet** | Visible free water, usually soil is below water table. |

**Table 8: Moisture Condition**

| | |
|---|---|
| **Stratified** | Alternating layers of varying material or color with layers at least ½ inch thick. |
| **Laminated** | Alternating layers of varying material or color with layers less than ¼ inch thick. |
| **Fissured** | Breaks along definite planes of fracture with little resistance to fracturing. |
| **Slickensides** | Fracture planes appear polished or glossy, sometimes striated. |
| **Blocky** | Cohesive soil that can be broken down into small angular lumps which resist further breakdown. |
| **Lensed** | Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay. |
| **Homogeneous** | Same color and appearance throughout. |

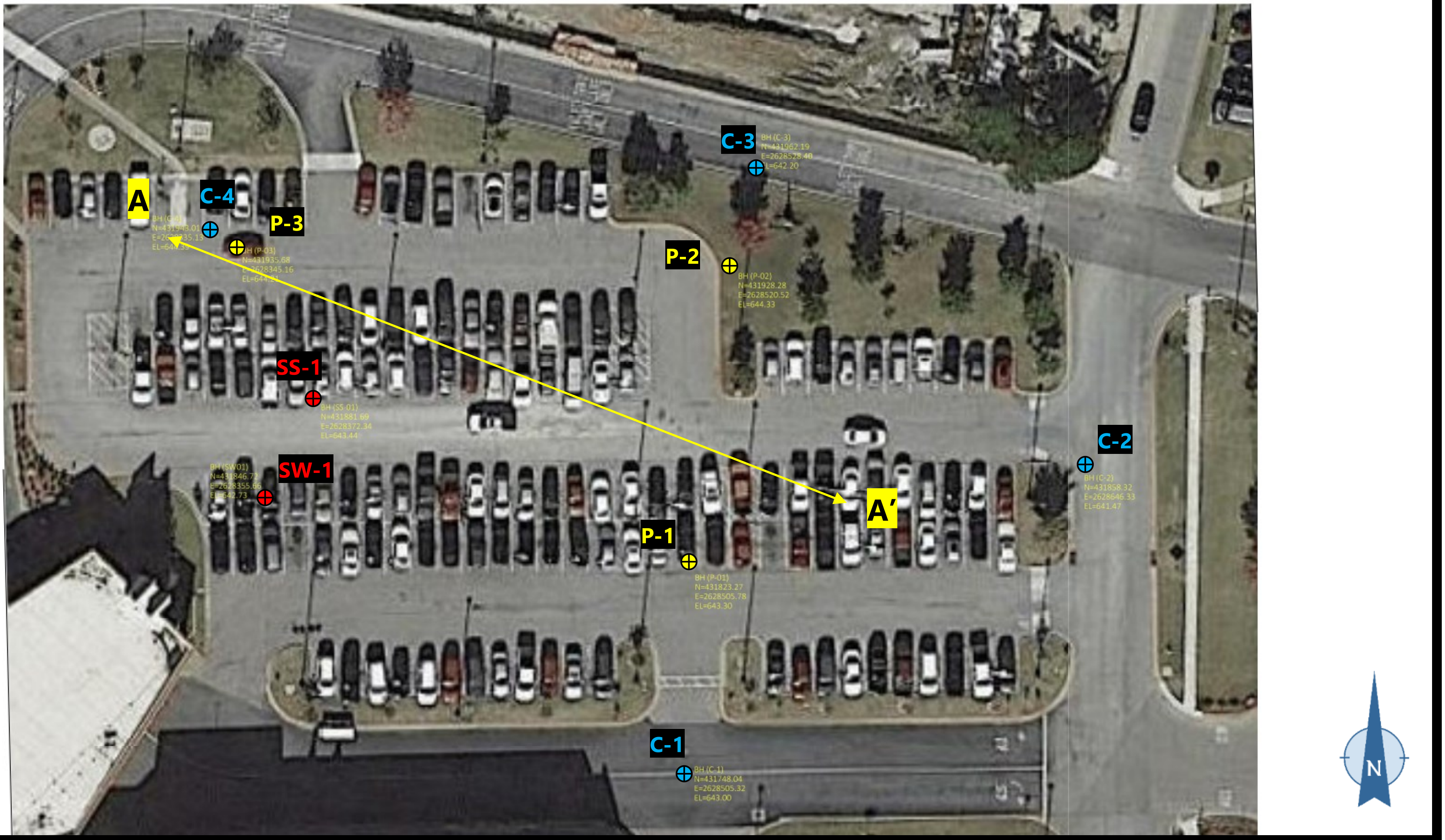
**Table 9: Structure**

# KEY TO HATCHES

| Hatch | Description | Hatch | Description | Hatch | Description |
|---|---|---|---|---|---|
| ▨ | ***GW*** *- Well-graded gravels, gravel – sand mixtures, little or no fines* | ■ | *Asphalt* | ▨ | *Clay with Gravel* |
| ▨ | ***GP*** *- Poorly-graded gravels, gravel – sand mixtures, little or no fines* | ▨ | *Aggregate Base* | ▨ | *Sand with Gravel* |
| ▨ | ***GM*** *- Silty gravels, gravel – sand – silt mixtures* | ▨ | *Topsoil* | ▨ | *Silt with Gravel* |
| ▨ | ***GC*** *- Clayey gravels, gravel – sand – clay mixtures* | ▨ | *Concrete* | ▨ | *Gravel with Sand* |
| ▨ | ***SW*** *- Well-graded sands, gravelly sands, little or no fines* | ▨ | *Coal* | ▨ | *Gravel with Clay* |
| ▨ | ***SP*** *- Poorly-graded sands, gravelly sands, little or no fines* | ▨ | ***CL-ML*** *- Silty Clay* | ▨ | *Gravel with Silt* |
| ▨ | ***SM*** *- Silty sands, sand – silt mixtures* | ▨ | *Sandy Clay* | ▨ | *Limestone* |
| ▨ | ***SC*** *- Clayey sands, sand – clay mixtures* | ▨ | *Clayey Chert* | ▨ | *Chalk* |
| ▨ | ***ML*** *- Inorganic silts and very find sands, rock flour, silty or clayey fine sands or clayey silt with slight plasticity* | ▨ | *Low and High Plasticity Clay* | ▨ | *Siltstone* |
| ▨ | ***CL*** *- Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays* | ▨ | *Low Plasticity Silt and Clay* | ▨ | *Till* |
| ▨ | ***OL*** *- Organic silts and organic silty clays of low plasticity* | ▨ | *High Plasticity Silt and Clay* | ▨ | *Sandy Clay with Cobbles and Boulders* |
| ▨ | ***MH*** *- Inorganic silts, micaceous or diatomaceous fine sand, or silty soils* | ▨ | *Fill* | ▨ | *Sandstone with Shale* |
| ▨ | ***CH*** *- Inorganic clays of high plasticity* | ▨ | *Weathered Rock* | ▨ | *Coral* |
| ▨ | ***OH*** *- Organic clays of medium to high plasticity, organic silts* | ▨ | *Sandstone* | ▨ | *Boulders and Cobbles* |
| ▨ | ***PT*** *- Peat, humus, swamp soils with high organic contents* | ▨ | *Shale* | ▨ | *Soil and Weathered Rock* |

**Table 1: Key to Hatches Used for Boring Logs and Soil Profiles**

# BORING LOCATION PLAN



**REFERENCE USED TO PRODUCE THIS DRAWING:**

Satellite Imagery as provided by RK & Associates, PLC

# BORING LOCATION PLAN

**DATE: 10/21/2020**

**PROJECT NO.**

OK200253

**PROJECT NAME / LOCATION:**

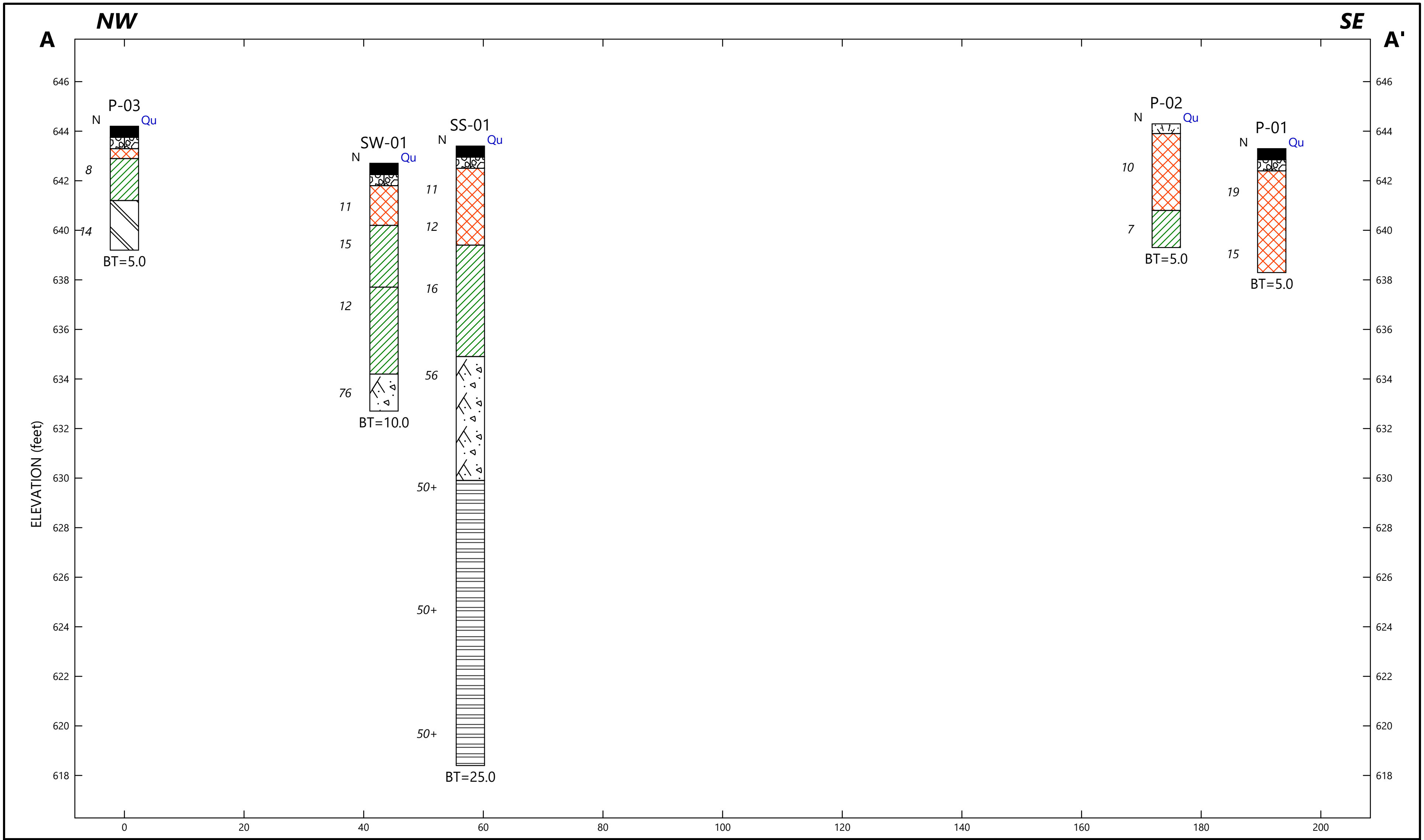
Hard Rock Casino – Proposed
Guitar Pick Plaza
Catoosa, OK

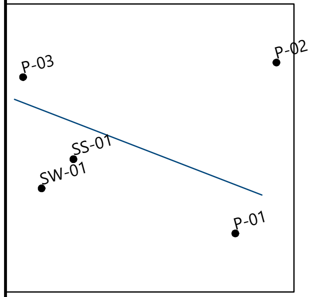
**SCALE:**

As Shown

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

# SUBSURFACE PROFILE





Site Map Scale 1 inch equals 145 feet

## Key to Hatches

■ Asphalt

▨ Aggregate Base Material

▨ Fill

▨ Topsoil

▨ USCS Low Plasticity Clay

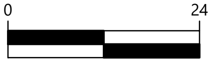
▨ USCS Low to High Plasticity Clay

▨ Weathered Rock

▤ Shale

## Legend

BT=Boring Termination, TPT=Test Pit Terminated
AR=Auger Refusal, ER=Excavation Refusal
N=Standard Penetration Test N-Value
Qu=Unconfined compressive strength estimate from pocket penetrometer test (tsf)
▽ Water Level Reading at time of drilling.
▼ Water Level Reading after drilling.



Horizontal Scale (feet)
Vertical Exaggeration: 4x

## Building & Earth Sciences, Inc.

1403 South 70th East Avenue, Tulsa, OK 74112

Hard Rock Casino - Proposed Guitar Pick Plaza
Catoosa, OK

**A-A': Subsurface Profile**

| | | |
|---|---|---|
| PROJECT NO: OK200253 | PLATE NO: A-1 | DATE: 11/11/20 |

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

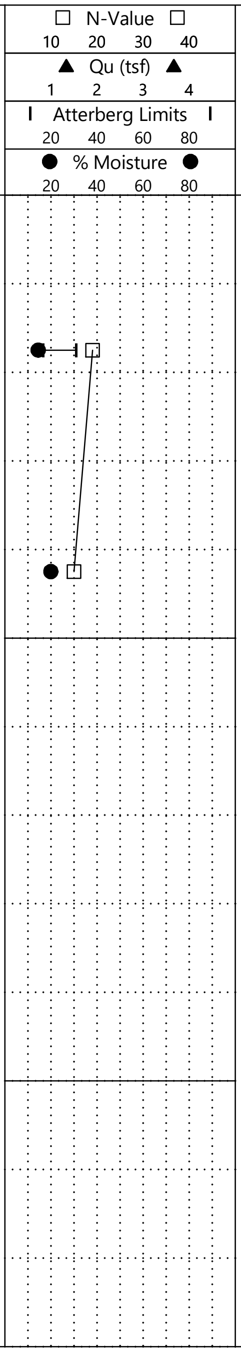
# BORING LOGS

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

1403 South 70th East Avenue
Tulsa, OK 74112
Office: (918) 439-9005

# LOG OF BORING
## Designation: P-01
Sheet 1 of 1

PROJECT NAME: Hard Rock Casino - Proposed Guitar Pick Plaza
PROJECT NUMBER: OK200253
DRILLING METHOD: Hollow Stem Auger
EQUIPMENT USED: CME 75
HAMMER TYPE: Automatic
BORING LOCATION: SE Access Drive
LOCATION: Catoosa, OK
DATE DRILLED: 10/21/20
WEATHER: Clear
ELEVATION: 643.3
DRILL CREW: Mohawk
LOGGED BY: Timothy Wilkie



| DEPTH (ft) | ELEVATION (ft) | SAMPLE TYPE | SAMPLE NO. | BLOWS PER INCREMENT | LAB DATA | SOIL DESCRIPTION | GRAPHIC | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 0.5 | 642.9 | | | | | ASPHALT | ■ | |
| 0.9 | 642.4 | | | | | AGGREGATE BASE | ▒ | |
| | | ☒ | 1 | 7<br>12<br>7 | Sample 1<br>LL: 31<br>PL: 17<br>PI: 14<br>M: 14.5% | MIXTURE of LEAN CLAY (CL) and some FAT CLAY (CH): very stiff, yellow, brown, reddish brown, gray, low to medium plasticity, moist, with gravel and sandstone fragments, (POSSIBLE FILL) | ▨ | |
| | 640 | ☒ | 2 | 5<br>7<br>8 | Sample 2<br>M: 19.9% | dark brown, dark gray | ▨ | |
| 5.0 | 638.3 | | | | | Boring Terminated at 5 feet. | | |
| | 635 | | | | | | | |
| 10 | | | | | | | | Groundwater not encountered at time of drilling.<br>Borehole backfilled on date drilled unless otherwise noted.<br>Consistency/Relative Density based on correction factor for Automatic hammer. |

SAMPLE TYPE ☒ Split Spoon

**N-VALUE** STANDARD PENETRATION RESISTANCE (AASHTO T-206)
**% MOISTURE** PERCENT NATURAL MOISTURE CONTENT
∇ GROUNDWATER LEVEL IN THE BOREHOLE AT TIME OF DRILLING
▼ STABILIZED GROUNDWATER LEVEL
**REC** RECOVERY
**RQD** ROCK QUALITY DESIGNATION
**UD** UNDISTURBED
**Qu** POCKET PENETROMETER UNCONFINED COMPRESSIVE STRENGTH
**LL:** LIQUID LIMIT
**PL:** PLASTIC LIMIT
**PI:** PLASTICITY INDEX
**M:** NATURAL MOISTURE CONTENT
**F:** PERCENT PASSING NO. 200 SIEVE

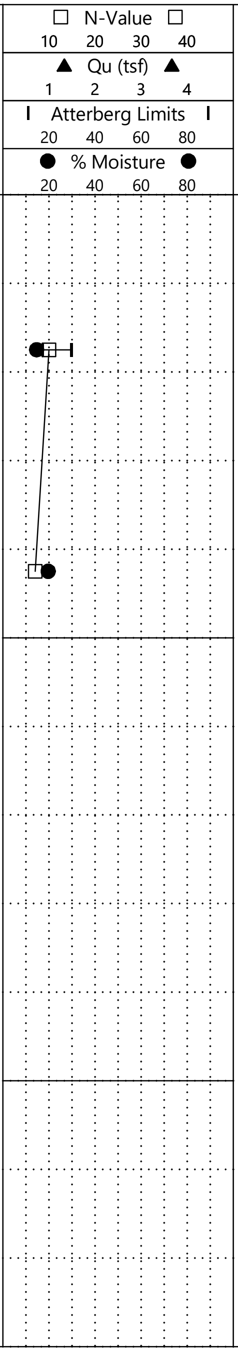
**BUILDING & EARTH**
Geotechnical, Environmental, and Materials Engineers

# LOG OF BORING
## Designation: P-02
Sheet 1 of 1

1403 South 70th East Avenue
Tulsa, OK 74112
Office: (918) 439-9005

PROJECT NAME: Hard Rock Casino - Proposed Guitar Pick Plaza
PROJECT NUMBER: OK200253
DRILLING METHOD: Hollow Stem Auger
EQUIPMENT USED: CME 75
HAMMER TYPE: Automatic
BORING LOCATION: NE Access Drive
LOCATION: Catoosa, OK
DATE DRILLED: 10/21/20
WEATHER: Clear
ELEVATION: 644.3
DRILL CREW: Mohawk
LOGGED BY: Timothy Wilkie

| DEPTH (ft) | ELEVATION (ft) | SAMPLE TYPE | SAMPLE NO. | BLOWS PER INCREMENT | LAB DATA | SOIL DESCRIPTION | GRAPHIC | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 0.4 | 643.9 | | | | | TOPSOIL: 4" | | |
| 3.5 | 640.8 | ☒ | 1 | 6<br>4<br>6 | Sample 1<br>LL: 30<br>PL: 17<br>PI: 13<br>M: 14.6% | LEAN CLAY (CL): stiff, yellow, dark brown, reddish brown, olive, low plasticity, moist, with gravel and sandstone fragments, (FILL) | | |
| 5.0 | 639.3 | ☒ | 2 | 3<br>3<br>4 | Sample 2<br>M: 19.7% | LEAN CLAY (CL): stiff, brown, olive brown, low plasticity, moist to wet, (RESIDUAL) | | |
| | | | | | | Boring Terminated at 5 feet. | | Groundwater not encountered at time of drilling.<br>Borehole backfilled on date drilled unless otherwise noted.<br>Consistency/Relative Density based on correction factor for Automatic hammer. |



SAMPLE TYPE ☒ Split Spoon

| | | | | | |
|---|---|---|---|---|---|
| **N-VALUE** | STANDARD PENETRATION RESISTANCE (AASHTO T-206) | **REC** | RECOVERY | **LL:** | LIQUID LIMIT |
| **% MOISTURE** | PERCENT NATURAL MOISTURE CONTENT | **RQD** | ROCK QUALITY DESIGNATION | **PL:** | PLASTIC LIMIT |
| ▽ | GROUNDWATER LEVEL IN THE BOREHOLE AT TIME OF DRILLING | **UD** | UNDISTURBED | **PI:** | PLASTICITY INDEX |
| ▼ | STABILIZED GROUNDWATER LEVEL | **Qu** | POCKET PENETROMETER UNCONFINED COMPRESSIVE STRENGTH | | |

**M:** NATURAL MOISTURE CONTENT
**F:** PERCENT PASSING NO. 200 SIEVE

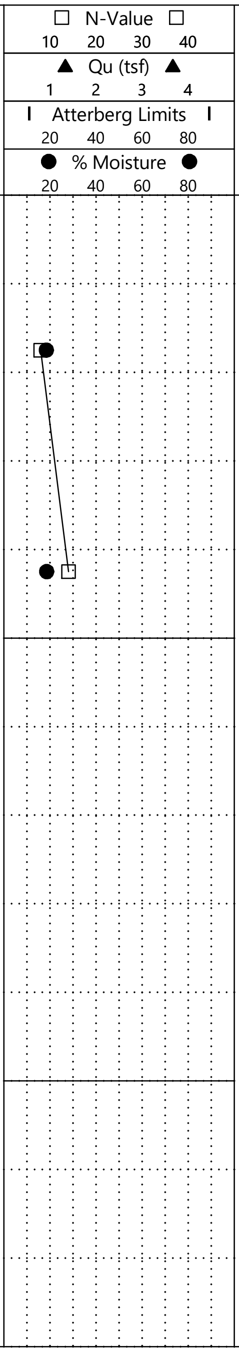
# LOG OF BORING

## Designation: P-03

Sheet 1 of 1

PROJECT NAME: Hard Rock Casino - Proposed Guitar Pick Plaza
PROJECT NUMBER: OK200253
DRILLING METHOD: Hollow Stem Auger
EQUIPMENT USED: CME 75
HAMMER TYPE: Automatic
BORING LOCATION: Proposed Parking - NW Corner

LOCATION: Catoosa, OK
DATE DRILLED: 10/21/20
WEATHER: Clear
ELEVATION: 644.2
DRILL CREW: Mohawk
LOGGED BY: Timothy Wilkie



| DEPTH (ft) | SOIL DESCRIPTION | ELEVATION (ft) | GRAPHIC |
|---|---|---|---|
| 0.5 | ASPHALT | 643.8 | ■ |
| 0.9 | AGGREGATE BASE | 643.3 | |
| 1.3 | LEAN CLAY (CL): stiff, olive brown, yellow, brown, gray, medium plasticity, moist, (FILL) | 642.9 | ▨ |
| 3.0 | LEAN CLAY (CL): stiff, dark brown, gray brown, medium plasticity, moist, with fine roots, (RESIDUAL) | 641.2 | ▨ |
| 5.0 | LEAN TO FAT CLAY (CL-CH): very stiff, yellow, gray, yellowish brown, medium to high plasticity, moist, with sandstone fragments, (RESIDUAL) | 639.2 | ▨ |

Boring Terminated at 5 feet.

| SAMPLE TYPE | SAMPLE NO. | BLOWS PER INCREMENT | LAB DATA |
|---|---|---|---|
| ☒ | 1 | 3<br>4<br>4 | Sample 1<br>M: 18.4% |
| ☒ | 2 | 3<br>7<br>7 | Sample 2<br>M: 18.6% |

DEPTH (ft): 5, 10
ELEVATION (ft): 640, 635

REMARKS:
Groundwater not encountered at time of drilling.
Borehole backfilled on date drilled unless otherwise noted.
Consistency/Relative Density based on correction factor for Automatic hammer.

SAMPLE TYPE ☒ Split Spoon

**N-VALUE** STANDARD PENETRATION RESISTANCE (AASHTO T-206)
**% MOISTURE** PERCENT NATURAL MOISTURE CONTENT
∇ GROUNDWATER LEVEL IN THE BOREHOLE AT TIME OF DRILLING
▼ STABILIZED GROUNDWATER LEVEL
**REC** RECOVERY
**RQD** ROCK QUALITY DESIGNATION
**UD** UNDISTURBED
**Qu** POCKET PENETROMETER UNCONFINED COMPRESSIVE STRENGTH
**LL:** LIQUID LIMIT
**PL:** PLASTIC LIMIT
**PI:** PLASTICITY INDEX
**M:** NATURAL MOISTURE CONTENT
**F:** PERCENT PASSING NO. 200 SIEVE

# LOG OF BORING

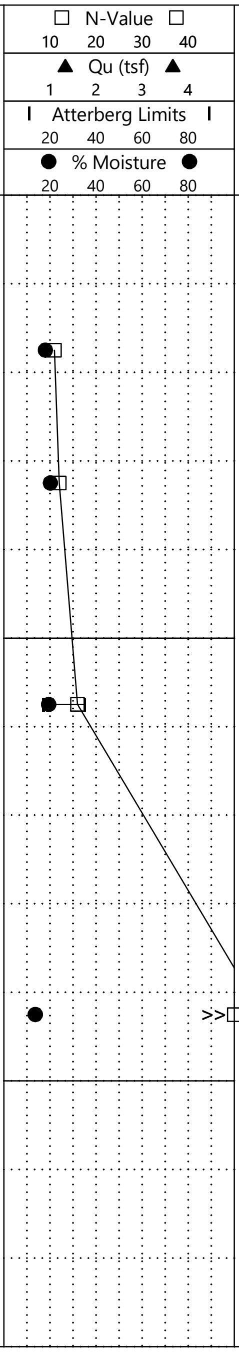
## Designation: SS-01

Sheet 1 of 2

1403 South 70th East Avenue
Tulsa, OK 74112
Office: (918) 439-9005

PROJECT NAME: Hard Rock Casino - Proposed Guitar Pick Plaza
PROJECT NUMBER: OK200253
DRILLING METHOD: Hollow Stem Auger
EQUIPMENT USED: CME 75
HAMMER TYPE: Automatic
BORING LOCATION: Proposed Sign Structure Area

LOCATION: Catoosa, OK
DATE DRILLED: 10/21/20
WEATHER: Clear
ELEVATION: 643.4
DRILL CREW: Mohawk
LOGGED BY: Timothy Wilkie



| DEPTH (ft) | ELEVATION (ft) | SAMPLE TYPE | SAMPLE NO. | BLOWS PER INCREMENT | LAB DATA |
|---|---|---|---|---|---|
| | | ☒ | 1 | 3<br>4<br>7 | Sample 1<br>M: 18.0% |
| | 640 | ☒ | 2 | 4<br>5<br>7 | Sample 2<br>M: 20.2% |
| 5 | | ☒ | 3 | 3<br>7<br>9 | Sample 3<br>LL: 35<br>PL: 17<br>PI: 18<br>M: 19.5% |
| | 635 | ☒ | 4 | 10<br>22<br>34 | Sample 4<br>M: 13.6% |
| 10 | | | | | |

| | SOIL DESCRIPTION | | GRAPHIC | REMARKS |
|---|---|---|---|---|
| 0.5 | ASPHALT | 643.0 | | |
| 0.9 | AGGREGATE BASE | 642.5 | | |
| 4.0 | MIXTURE of LEAN CLAY (CL) and some FAT CLAY (CH): stiff, dark brown, olive, medium plasticity, moist, with roots, (FILL)<br>stiff to very stiff, with dark brown silty clay layers | 639.4 | | |
| 8.5 | LEAN CLAY (CL): very stiff, yellow-brown, gray, medium plasticity, moist, with sandstone fragments, (RESIDUAL) | 634.9 | | |
| | CLAYEY SHALE: soft, light brown, yellow-brown, gray, with ferrous staining, (WEATHERED ROCK) | | | |

SAMPLE TYPE ☒ Split Spoon

**N-VALUE** STANDARD PENETRATION RESISTANCE (AASHTO T-206)
**% MOISTURE** PERCENT NATURAL MOISTURE CONTENT
∇ GROUNDWATER LEVEL IN THE BOREHOLE AT TIME OF DRILLING
▼ STABILIZED GROUNDWATER LEVEL

**REC** RECOVERY
**RQD** ROCK QUALITY DESIGNATION
**UD** UNDISTURBED
**Qu** POCKET PENETROMETER UNCONFINED COMPRESSIVE STRENGTH

**LL:** LIQUID LIMIT
**PL:** PLASTIC LIMIT
**PI:** PLASTICITY INDEX

**M:** NATURAL MOISTURE CONTENT
**F:** PERCENT PASSING NO. 200 SIEVE

**BUILDING & EARTH**
Geotechnical, Environmental, and Materials Engineers

# LOG OF BORING

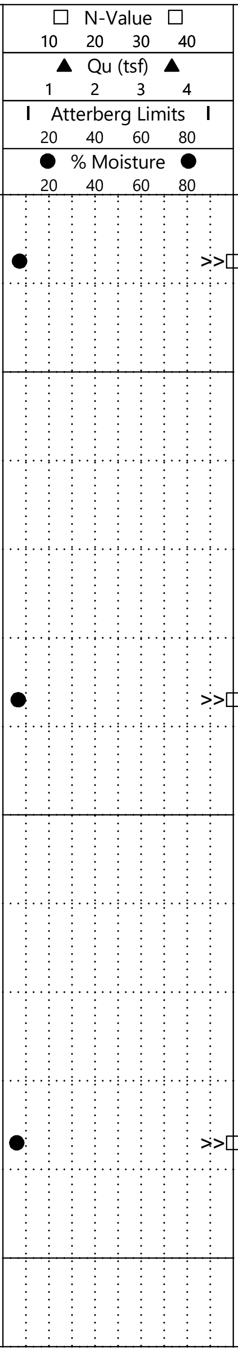
## Designation: SS-01

Sheet 2 of 2

1403 South 70th East Avenue
Tulsa, OK 74112
Office: (918) 439-9005

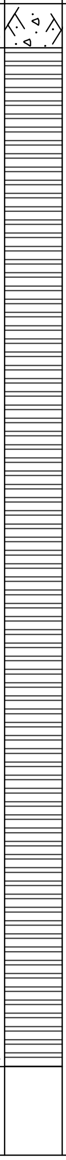
PROJECT NAME: Hard Rock Casino - Proposed Guitar Pick Plaza
PROJECT NUMBER: OK200253
DRILLING METHOD: Hollow Stem Auger
EQUIPMENT USED: CME 75
HAMMER TYPE: Automatic
BORING LOCATION: Proposed Sign Structure Area

LOCATION: Catoosa, OK
DATE DRILLED: 10/21/20
WEATHER: Clear
ELEVATION: 643.4
DRILL CREW: Mohawk
LOGGED BY: Timothy Wilkie



| DEPTH (ft) | ELEVATION (ft) | SAMPLE TYPE | SAMPLE NO. | BLOWS PER INCREMENT | LAB DATA | SOIL DESCRIPTION | REMARKS |
|---|---|---|---|---|---|---|---|
|  | 630 |  |  |  |  | 13.5 629.9 |  |
|  |  | ☒ | 5 | 50/5.75" | Sample 5<br>M: 7.2% | SHALE: soft to moderately hard, gray, (LABETTE FORMATION) |  |
| 15 |  |  |  |  |  |  |  |
|  | 625 | ☒ | 6 | 50/4" | Sample 6<br>M: 6.7% |  |  |
| 20 |  |  |  |  |  |  |  |
|  | 620 | ☒ | 7 | 50/4" | Sample 7<br>M: 6.0% |  | Groundwater not encountered at time of drilling.<br>Borehole backfilled on date drilled unless otherwise noted.<br>Consistency/Relative Density based on correction factor for Automatic hammer. |
| 25 |  |  |  |  |  | 25.0 618.4<br>Boring Terminated at 25 feet. |  |

GRAPHIC



SAMPLE TYPE ☒ Split Spoon

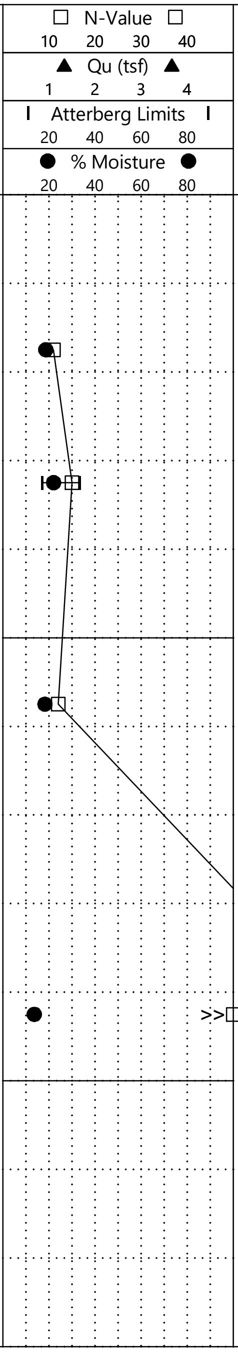
**N-VALUE** STANDARD PENETRATION RESISTANCE (AASHTO T-206)
**% MOISTURE** PERCENT NATURAL MOISTURE CONTENT
▽ GROUNDWATER LEVEL IN THE BOREHOLE AT TIME OF DRILLING
▼ STABILIZED GROUNDWATER LEVEL
**REC** RECOVERY
**RQD** ROCK QUALITY DESIGNATION
**UD** UNDISTURBED
**Qu** POCKET PENETROMETER UNCONFINED COMPRESSIVE STRENGTH
**LL:** LIQUID LIMIT
**PL:** PLASTIC LIMIT
**PI:** PLASTICITY INDEX
**M:** NATURAL MOISTURE CONTENT
**F:** PERCENT PASSING NO. 200 SIEVE

BUILDING & EARTH
Geotechnical, Environmental, and Materials Engineers

# LOG OF BORING
## Designation: SW-01
Sheet 1 of 1

1403 South 70th East Avenue
Tulsa, OK 74112
Office: (918) 439-9005

PROJECT NAME: Hard Rock Casino - Proposed Guitar Pick Plaza
PROJECT NUMBER: OK200253
DRILLING METHOD: Hollow Stem Auger
EQUIPMENT USED: CME 75
HAMMER TYPE: Automatic
BORING LOCATION: Proposed Screen Wall Area
LOCATION: Catoosa, OK
DATE DRILLED: 10/21/20
WEATHER: Clear
ELEVATION: 642.7
DRILL CREW: Mohawk
LOGGED BY: Timothy Wilkie



| DEPTH (ft) | ELEVATION (ft) | SAMPLE TYPE | SAMPLE NO. | BLOWS PER INCREMENT | LAB DATA | SOIL DESCRIPTION | GRAPHIC | REMARKS |
|---|---|---|---|---|---|---|---|---|
| 0.5 | 642.3 | | | | | ASPHALT | | |
| 0.9 | 641.8 | | | | | AGGREGATE BASE | | |
| 2.5 | 640.2 | ☒ | 1 | 7<br>6<br>5 | Sample 1<br>M: 18.6% | MIXTURE of LEAN CLAY (CL) and some FAT CLAY (CH): stiff, yellow, brown, gray, medium plasticity, moist, with sandstone fragments, (FILL) | | |
| 5.0 | 637.7 | ☒ | 2 | 3<br>7<br>8 | Sample 2<br>LL: 33<br>PL: 17<br>PI: 16<br>M: 22.0% | LEAN CLAY (CL): very stiff, dark brown, olive gray, medium plasticity, moist, with fine roots, (RESIDUAL) | | |
| 8.5 | 634.2 | ☒ | 3 | 5<br>7<br>5 | Sample 3<br>M: 18.2% | LEAN CLAY (CL): stiff to very stiff, dark brown, low to medium plasticity, moist, (RESIDUAL) | | |
| 10.0 | 632.7 | ☒ | 4 | 14<br>28<br>48 | Sample 4<br>M: 13.6% | CLAYEY SHALE: soft, light brown, yellow, gray, (WEATHERED ROCK) | | |
| | | | | | | Boring Terminated at 10 feet. | | Groundwater not encountered at time of drilling.<br>Borehole backfilled on date drilled unless otherwise noted.<br>Consistency/Relative Density based on correction factor for Automatic hammer. |

Depth scale: 5, 10. Elevation scale: 640, 635, 630.

SAMPLE TYPE ☒ Split Spoon

**N-VALUE** STANDARD PENETRATION RESISTANCE (AASHTO T-206)
**% MOISTURE** PERCENT NATURAL MOISTURE CONTENT
▽ GROUNDWATER LEVEL IN THE BOREHOLE AT TIME OF DRILLING
▼ STABILIZED GROUNDWATER LEVEL
**REC** RECOVERY
**RQD** ROCK QUALITY DESIGNATION
**UD** UNDISTURBED
**Qu** POCKET PENETROMETER UNCONFINED COMPRESSIVE STRENGTH
**LL:** LIQUID LIMIT
**PL:** PLASTIC LIMIT
**PI:** PLASTICITY INDEX
**M:** NATURAL MOISTURE CONTENT
**F:** PERCENT PASSING NO. 200 SIEVE

# PAVEMENT CORE PHOTOGRAPHS

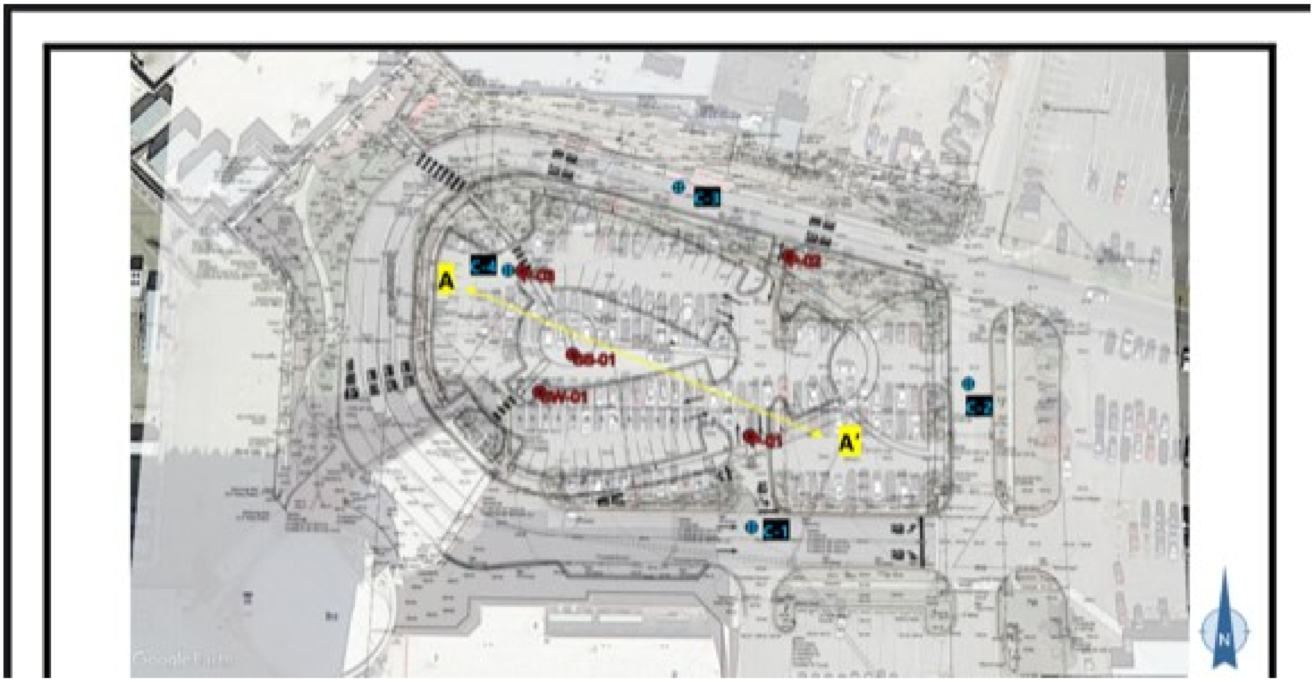


Fig. 1 – Overall Coring Plan

Fig. 2 – C-1 Core Sample 5 ½" Asphalt Depth

Fig. 3 – C-1: Confirm 5 ½” Asphalt Depth.

**A total of approximately 7 ½ “of Agg base below asphalt.**

Fig. 4 – C-2: Approximately 5” of Asphalt.

Fig. 5 – C-2: Confirm 5" Asphalt Depth.

Fig. 6 – C-2: Approximately 6 ½" of Agg Base.

Fig. 7 – C-3: 4” Core with ~1” Left in Hole. (~5” Asphalt Thickness)

Fig. 8 – C-3: < 2” of Agg Base and 5” of Asphalt.

**Fig. 9 – C-4: 4 ½" of Asphalt (~1/2" of Sample Left in Hole)**

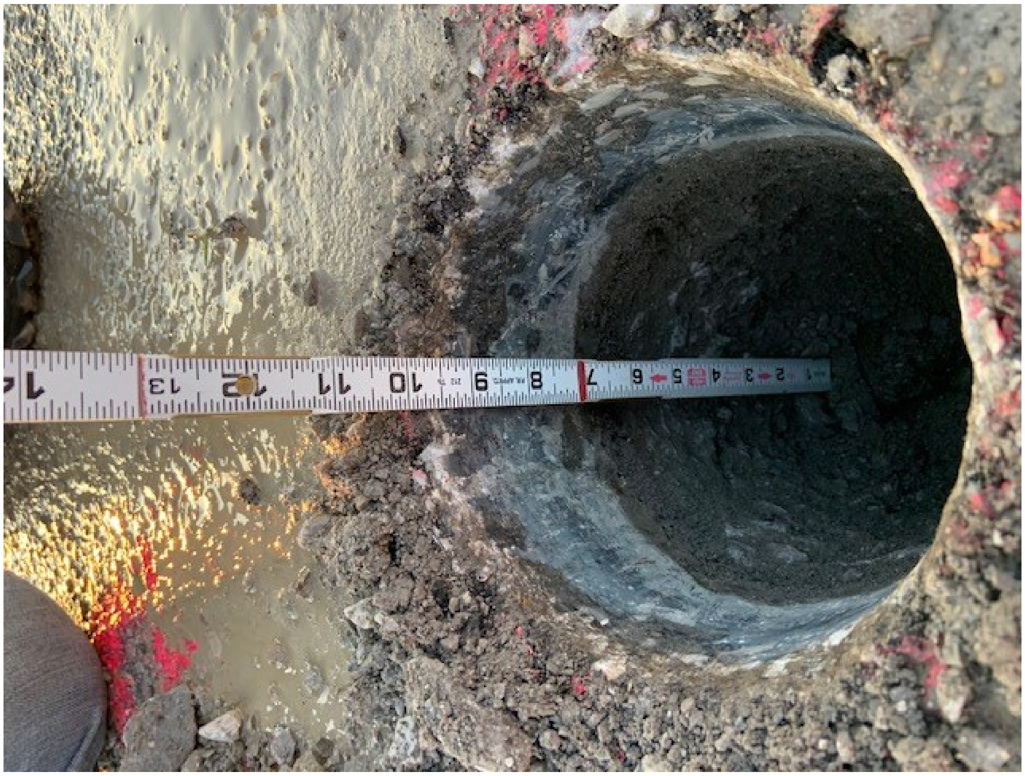


**Fig. 10 – C-4: Approximately 7" of Agg Base Below Asphalt.**

# LABORATORY TEST PROCEDURES

A brief description of the laboratory tests performed is provided in the following sections.

## *DESCRIPTION OF SOILS (VISUAL-MANUAL PROCEDURE) (ASTM D2488)*

The soil samples were visually examined by our engineer and soil descriptions were provided. Representative samples were then selected and tested in accordance with the aforementioned laboratory-testing program to determine soil classifications and engineering properties. This data was used to correlate our visual descriptions with the Unified Soil Classification System (USCS).

## *NATURAL MOISTURE CONTENT (ASTM D2216)*

Natural moisture contents (M%) were determined on selected samples. The natural moisture content is the ratio, expressed as a percentage, of the weight of water in a given amount of soil to the weight of solid particles.

## *ATTERBERG LIMITS (ASTM D4318)*

The Atterberg Limits test was performed to evaluate the soil's plasticity characteristics. The soil Plasticity Index (PI) is representative of this characteristic and is bracketed by the Liquid Limit (LL) and the Plastic Limit (PL). The Liquid Limit is the moisture content at which the soil will flow as a heavy viscous fluid. The Plastic Limit is the moisture content at which the soil is between "plastic" and the semi-solid stage. The Plasticity Index (PI = LL - PL) is a frequently used indicator for a soil's potential for volume change. Typically, a soil's potential for volume change increases with higher plasticity indices.

## *LABORATORY TEST RESULTS*

The results of the laboratory testing are presented in the following tables.

| BORING NO. | DEPTH | MOISTURE CONTENT (%) | LIQUID LIMIT | PLASTIC LIMIT | PLASTICITY INDEX | % PASSING #200 SIEVE | CLASSIFICATION |
|---|---|---|---|---|---|---|---|
| P-01 | 1.0 - 2.5 | 14.5 | 31 | 17 | 14 | | |
| P-01 | 3.5 - 5.0 | 19.9 | | | | | |
| P-02 | 1.0 - 2.5 | 14.6 | 30 | 17 | 13 | | |
| P-02 | 3.5 - 5.0 | 19.7 | | | | | |
| P-03 | 1.0 - 2.5 | 18.4 | | | | | |
| P-03 | 3.5 - 5.0 | 18.6 | | | | | |
| SS-01 | 1.0 - 2.5 | 18.0 | | | | | |
| SS-01 | 2.5 - 4.0 | 20.2 | | | | | |
| SS-01 | 5.0 - 6.5 | 19.5 | 35 | 17 | 18 | | |
| SS-01 | 8.5 - 10.0 | 13.6 | | | | | |
| SS-01 | 13.5 - 14.0 | 7.2 | | | | | |
| SS-01 | 18.5 - 18.9 | 6.7 | | | | | |
| SS-01 | 23.5 - 23.9 | 6.0 | | | | | |
| SW-01 | 1.0 - 2.5 | 18.6 | | | | | |
| SW-01 | 2.5 - 4.0 | 22.0 | 33 | 17 | 16 | | |
| SW-01 | 5.0 - 6.5 | 18.2 | | | | | |
| SW-01 | 8.5 - 10.0 | 13.6 | | | | | |
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**TABLE L-1: General Soil Classification Test Results**

*Soils with a Liquid Limit (LL) greater than 50 and Plasticity Index (PI) greater than 25 usually exhibit significant volume change with varying moisture content and are considered to be highly plastic*

# 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
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