Geotechnical Engineering Report

Kansas City, Kansas Community College Housing Building
Kansas City, Kansas
May 1, 2020
Terracon Project No. 02205100

Prepared for:
Kansas City, Kansas Community College
Kansas City, Kansas

Prepared by:
Terracon Consultants, Inc.
Lenexa, Kansas

May 1, 2020

Kansas City, Kansas Community College
7250 State Avenue
Kansas City, Kansas 66112

Attn: Mr. Jeffery Sixta
P: (913) 334-1100
E: jsixta@KCKCC.EDU

Re: Geotechnical Engineering Report
Kansas City, Kansas Community College Housing Building
7250 State Ave
Kansas City, Kansas
Terracon Project No. 02205100

Dear Mr. Sixta:

We have completed a subsurface exploration and geotechnical engineering evaluation for the referenced project. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design and construction of foundations, floor slabs, and pavements for the project.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report or if we may be of further service, please contact us.

Sincerely,
Terracon Consultants, Inc.

Mohamad T. Ibrawish, P.E.
Geotechnical Department Manager
Kansas: 23575

Kole C. Berg, P.E.
Senior Engineer
Kansas: 16720

REPORT TOPICS

Note: This report was originally delivered in a web-based format. For more interactive features, please view your project online at client.terracon.com.

ATTACHMENTS

Note: Refer to each individual Attachment for a listing of contents.

Geotechnical Engineering Report

Kansas City, Kansas Community College Housing Building
7250 State Ave
Kansas City, Kansas
Terracon Project No. 02205100
May 1, 2020

INTRODUCTION

This report presents the results of our subsurface exploration and geotechnical engineering evaluation performed for the proposed Housing Building to be located within the Kansas City, Kansas Community College (KCKCC) campus at 7250 State Ave in Kansas City, Kansas. Six (6) exploratory borings were performed at the site to depths ranging from approximately 20 to 40 feet below existing site grades. This report describes the subsurface conditions encountered at the boring locations, presents the test data, and provides geotechnical recommendations for the following items:

- earthwork
- foundations
- floor slabs
- lateral earth pressures
- seismic site class
- pavements

Maps showing the site and boring locations are shown in the **Site Location and Exploration Plan** section. The results of the laboratory testing performed on soil samples obtained from the site during the field exploration are included on the boring logs in the **Exploration Results** section.

SITE CONDITIONS

The following description of site conditions is derived from our site visit in association with the field exploration and our review of publicly available geologic and topographic maps.

Item	Description
Parcel Information	The project is located at 7250 State Ave in Kansas City, Kansas. Latitude/Longitude: 39.120° N, 94.749° W (approximate)
Existing Improvements	Grass area and trees on the south side of the site
Current Ground Cover	Lightly-vegetated, asphalt paved parking lot on the north
Existing Topography	Generally slopes down from east to west with an elevation difference of 5 to 6 feet

PROJECT DESCRIPTION

Our initial understanding of the project was provided in our proposal email and was discussed during project planning. A period of collaboration has transpired since the project was initiated, and our final understanding of the project conditions is as follows:

Item	Description
Proposed Structure	The project includes a 3-story building with a footprint of about 30,000 square feet. The building will be slab-on-grade (non-basement). The building will have load-bearing masonry walls.
Finished Floor Elevation	The FFE of the structure was not provided. We anticipate the FFE will be within ±3 feet of existing grades.
Maximum Loads	Anticipated structural loads for the new building were not provided. Based on our experience with similar structures, we have considered the following maximum loads: ■ Columns: 250 kips ■ Walls: 5 kips per linear foot ■ Slabs: 100 pounds per square foot
Grading/Slopes	A site grading plan was not provided. We have considered up to 3 feet of cut and of fill will be required to develop final grades.

GEOTECHNICAL CHARACTERIZATION

We have developed a general characterization of the subsurface conditions based on the subsurface exploration, laboratory data, geologic setting and our understanding of the project. This characterization, termed GeoModel, forms the basis of our geotechnical calculations and evaluation of site preparation and foundation options. Conditions encountered at each exploration point are indicated on the individual logs. The individual logs can be found in the **Exploration Results** section and the GeoModel can be found in the **Figures** section of this report.

As part of our analyses, we identified the following model layers within the subsurface profile. For a more detailed view of the model layer depths at each boring location, refer to the GeoModel.

Model Layer	Layer Name	General Description
01	Topsoil	Topsoil
02	Clay	Medium stiff to stiff lean clay and fat clay
03	Bedrock	Limestone

The borings were observed during drilling and shortly after completion of drilling for the presence and level of water. Groundwater was not encountered in the borings at these times. A longer period of time may be required for groundwater to develop and stabilize in a borehole. Longer term observations in piezometers or observation wells, sealed from the influence of surface water, are often required to define groundwater levels.

Groundwater levels may fluctuate due to seasonal variations in the amount of rainfall, runoff, and other factors not evident at the time the borings were performed. “Perched” water could occur above lower permeability soil layers and/or near the soil/bedrock interface, and “trapped” water could be present within existing fill materials. Therefore, groundwater conditions at other times may be different than the conditions encountered in our exploratory borings. The potential for water level fluctuations and perched water should be considered when developing design and construction plans and specifications for the project.

GEOTECHNICAL OVERVIEW

Based on conditions encountered at the boring locations, it appears feasible to support the new building on shallow spread footings bearing on medium stiff to stiff native clay soils and/or engineered fill materials.

Expansive fat clay soils were encountered in all the borings except Boring B-6. These materials have the potential to shrink and swell with seasonal fluctuations in the soil moisture content. We recommend the floor slabs be supported on at least 24 inches of LVC material. In areas that are currently above or less than 2 feet below the planned bottom of floor slab level, native fat clay soils should be undercut to accommodate placement of LVC material. In areas where more than 2 feet of fill will be placed below the bottom-of-floor-slab level, at least the upper 24 inches of new engineered fill should consist of LVC material. Placement of a layer of LVC material below floor slabs, as recommended in this report, will not eliminate all future subgrade volume change and resultant floor slab movements. However, use of an LVC zone should reduce the potential for subgrade volume change. Details regarding the LVC zone are provided in Earthwork. In addition, the limited quantity of lean clay encountered in boring B-6 is not enough to use as LVC on the site, so importing of new fill materials will be needed.

This report provides recommendations to help mitigate the effects of soil shrinkage and expansion. However, even if these procedures are followed, some movement and at least minor cracking in the structure could still occur. The severity of cracking and other cosmetic damage caused by movement of the floor slabs will probably increase if any modification of the site results in excessive wetting or drying of the expansive soils. Eliminating the risk of movement and cosmetic distress may not be feasible, but it may be possible to further reduce the risk of movement if significantly more expensive measures are used during construction. We would be pleased to discuss other construction alternatives with you upon request. The **General Comments** section provides an understanding of the report limitations.

EARTHWORK

Site Preparation

Vegetation, topsoil, and any loose, soft or otherwise unsuitable soils present within the proposed construction areas should be stripped. Based on information obtained at the boring locations, stripping depths on the order of 6 to 8 inches should be anticipated to remove the root zone materials. However, greater stripping depths may be required in areas not explored by the borings. Additional stripping should be expected in drainage swales and other low-lying areas where thicker deposits of organic soils tend to accumulate. Existing trees within proposed construction areas should be thoroughly grubbed to remove all stumps, root balls, and roots larger than ½ inch in diameter. Organic soils removed during site preparation should not be used as fill beneath the proposed new building and pavement areas.

The soils within the planned building area should be further undercut as necessary to accommodate placement of the recommended 24-inch thick LVC layer below floor slabs. The undercut areas should extend a minimum of 5 feet laterally outside the building wall lines. Undercutting to facilitate placement of the LVC layer would not be necessary in areas where more than 2 feet of fill will be placed to develop the floor slab subgrade level.

Following initial stripping and any necessary undercutting, the exposed soils should be proofrolled. A Terracon representative should observe the proofrolling. Proofrolling can be accomplished using a loaded tandem-axle dump truck with a gross weight of at least 20 tons, or similarly loaded equipment. Areas that display excessive deflection (pumping) or rutting during proofroll operations should be improved by scarification/compaction or by removal and replacement with engineered fill.

Fill Material Types

A sample of each fill material type should be tested prior to being used on the site. Our professional opinions concerning suitability of fill materials are presented in the following table.

Fill Type [1]	USCS Classification	Acceptable Location for Placement
Low Volume Change (LVC) material	GM [2] or CL (LL<45 and PI<23)	All locations and elevations, except where free-draining material is required

Fill Type [1]	USCS Classification	Acceptable Location for Placement
On-site soils	CH, CL	On-site soils that meet the LVC criteria can be used in locations recommended above for LVC material On-site soils that do not meet the LVC criteria (CH soils, as well as CL soils with LL of 45 or greater and/or PI of 23 or greater) may be can be used as fill in pavement areas and at depths greater than 24 inches below building finished grade
Well-graded granular	GW [3]	Where free-draining material is required

1. Engineered fill should consist of approved materials that are free of organic matter and debris. Frozen material should not be used, and fill should not be placed on a frozen subgrade.
2. KDOT AB-3 or an approved alternate gradation of crushed limestone aggregate.
3. Granular materials with less than 5 percent fines (material passing the #200 sieve), such as ASTM C33 Size No. 57 aggregate or an approved alternate gradation.

Low volume change (LVC) material placed below the building floor slabs can consist of well-graded crushed stone aggregate (e.g., KDOT AB-3). Lean clay soils with a liquid limit less than 45 and plasticity index less than 23 could also be used as LVC material, but these soils would be susceptible to softening and disturbance if they become wetted by surface water and precipitation. A limited amount of lean clay soils that meet the LVC criteria were encountered in Boring B-6, but since these soils were only present to a limited depth in one boring, and LVC soils were not encountered in the other 5 borings. Therefore, it is unlikely that a sufficient quantity of on-site clay soils are available to construct the recommended LVC layer and the extent of earthwork (including selective stockpiling, double-handling, and construction delays to allow confirmation testing of possible LVC soils) required to use on-site LVC soils would be impractical. The use of imported LVC materials should be expected. As an alternative to importing LVC materials, the on-site clay soils could be modified by incorporating Class C fly ash, lime, lime kiln dust (“Code L”) or portland cement to create LVC material. Terracon can provide additional recommendations regarding chemical modification of the on-site soils upon request. If a granular leveling course (such as crushed stone aggregate) is used immediately below the floor slabs, this material can be considered part of the LVC zone.

Fill Compaction Requirements

Item		Description
Lift Thickness (maximum)		9 inches in loose thickness when large, self-propelled compaction equipment is used 4 inches when small, hand-guided equipment (plate or “jumping jack” compactor) is used
Minimum Compaction Requirements [1]		At least 95 percent of the material’s maximum dry density [1]
Moisture Content of Clay Soil	LL<45	-2 to +2 percent of optimum moisture content value [1]
	LL>45	0 to 4 percent above the optimum moisture content value [1]
Moisture Content of Granular Material		Sufficient to achieve compaction without pumping when proofrolled

1. As determined by the standard Proctor test (ASTM D 698)

We recommend that engineered fill be tested for moisture content and compaction during placement. If the results of the in-place density tests indicate the specified moisture or compaction limits have not been met, the area represented by the test should be reworked and retested as required until the specified moisture and compaction requirements are achieved.

Utility Trench Backfill

All trench excavations should be made with sufficient working space to permit construction including backfill placement and compaction. If utility trenches are backfilled with relatively clean granular material, they should be capped with at least 18 inches of clay fill to reduce the infiltration and conveyance of surface water through the trench backfill.

Utility trenches are common sources of water infiltration and migration. All utility trenches that penetrate beneath buildings should be effectively sealed to restrict water intrusion and flow through the trenches that could migrate below the building. We recommend constructing an effective “trench plug” that extends at least 5 feet out from the face of the building exterior. The plug material should consist of clay compacted as recommended in **Earthwork**. The clay fill should be placed to completely surround the utility line and be compacted in accordance with recommendations in this report. Alternatively, flowable fill could be used to construct the trench plug.

Grading and Drainage

During construction, grades should be developed to direct surface water flow away from or around the site. Exposed subgrades should be sloped to provide positive drainage so that saturation of subgrades is avoided. Surface water should not be permitted to accumulate on the site. Final surrounding grades should promote rapid surface drainage away from the structures. Accumulation of water adjacent to the structure could contribute to significant moisture increases in the subgrade soils and subsequent softening/settlement or expansion/heave.

After construction of the structures and pavements have been completed, we recommend verifying final grades to document that effective drainage has been achieved. Grades around the structures should also be periodically inspected and adjusted as necessary, as part of the structure's maintenance program.

Earthwork Construction Considerations

Terracon should be retained during the construction phase of the project to observe earthwork and to perform necessary tests and observations during subgrade preparation, proofrolling, placement and compaction of engineered fill, backfilling of excavations into completed subgrades, and just prior to construction of foundations, slabs, and pavements.

Care should be taken to avoid disturbance of prepared subgrades. Unstable subgrade conditions can develop during general construction operations, particularly if the soils are wetted and/or subjected to repetitive construction traffic. If unstable subgrade conditions develop, stabilization measures will need to be employed. Construction traffic over the completed subgrade should be avoided to the extent practical. If the subgrade becomes frozen, desiccated, saturated, or disturbed, the affected materials should be removed or these materials should be scarified, moisture conditioned, and compacted prior to floor slab construction.

Based on conditions encountered in the borings, significant seepage is generally not expected in excavations for this project (e.g., for footing construction and utility installation). If seepage is encountered in excavations during construction, the contractor is responsible for designing, implementing, and maintaining appropriate dewatering methods to control seepage and facilitate construction. In our experience, dewatering of excavations in clay soils can typically be accomplished using sump pits and pumps.

As a minimum, excavations should be performed in accordance with OSHA 29 CFR, Part 1926, Subpart P, "Excavations" and its appendices, and in accordance with any applicable local, state, and federal safety regulations. The contractor should be aware that slope height, slope inclination, and excavation depth should in no instance exceed those specified by these safety regulations. Flatter slopes than those dictated by these regulations may be required depending upon the soil conditions encountered and other external factors. These regulations are strictly enforced and if they are not followed, the owner, contractor, and/or earthwork and utility subcontractor could be liable and subject to substantial penalties. Under no circumstances should the information provided in this report be interpreted to mean that Terracon is responsible for construction site safety or the contractor's activities. Construction site safety is the sole responsibility of the contractor who shall also be solely responsible for the means, methods, and sequencing of the construction operations.

SHALLOW FOUNDATIONS

Foundation Design Parameters

Based on the conditions encountered at the borings, the building can be supported on shallow footing foundations that bear on a native clay soil and/or engineered fill.

Description	Value
Maximum net allowable bearing pressure [1]	2,000 psf
Minimum embedment below finished grade for frost protection [2]	3 feet
Minimum footing widths	Isolated footings: 30 inches Continuous footings: 16 inches
Estimated total settlement [3]	1 inch or less
Estimated differential settlement [3]	1/2 to 2/3 of the total settlement over a horizontal distance of 50 feet

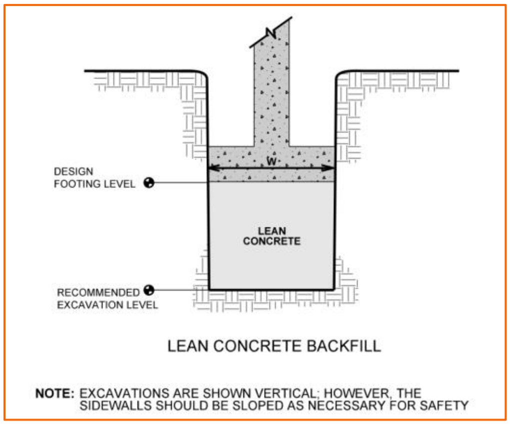
1. The recommended net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the footing base elevation. This pressure assumes that any soft soils or other unsuitable materials, if encountered, will be undercut and replaced with engineered fill.
2. This embedment depth is recommended for perimeter footings and footings beneath unheated areas to provide frost protection and to reduce the effects of seasonal moisture variations in the foundation bearing soils. Interior footings in heated areas may be supported at shallower depths, provided they are not exposed to freezing conditions during construction.
3. The foundation settlement will depend upon the variations within the subsurface soil profile, the structural loading conditions, the embedment depth of the footings, the thickness of engineered fill below the footings, and the quality of the earthwork operations and footing construction.

Foundation Construction Considerations

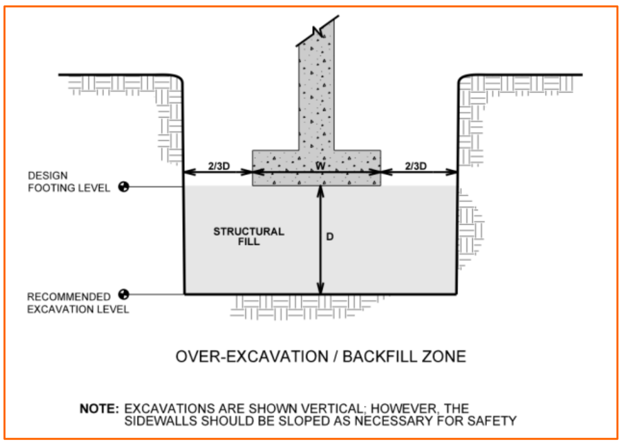
The base of all foundation excavations should be free of water and loose materials prior to placing concrete. Concrete should be placed soon after excavating to reduce bearing soil disturbance. If the soils at the bearing level become excessively dry, disturbed, saturated, or frozen, the affected soil should be removed prior to placing concrete. If the excavations must remain open overnight or for an extended period of time, placement of a lean concrete mud-mat over the bearing soils should be considered.

All footing bearing surfaces should be observed and tested by Terracon. If unsuitable conditions are encountered, footing excavations should be extended deeper to suitable bearing materials.

Footings can bear directly on suitable soils at the lower level or on lean concrete backfill as shown in the following figure.



The footings could also bear on properly compacted backfill extending down to suitable soils as shown in the following figure. Overexcavation for compacted engineered fill placement below footings should extend laterally beyond all edges of the footings at least 8 inches per foot of overexcavation depth below footing elevation. The overexcavation should then be backfilled up to the footing base elevation with well graded granular material (e.g., KDOT AB-3 aggregate or an approved alternate gradation) placed and compacted as recommended in **Earthwork**.



SEISMIC CONSIDERATIONS

Code	Site Class
2012 International Building Code (IBC)	C [1]

1. The 2012 International Building Code (IBC) seismic site class definitions are based on average properties of the subsurface profile to a depth of 100 feet. The exploratory borings terminated within bedrock at a

maximum depth of 20 feet. Our opinion of site class is based on boring data and our knowledge of local geological and geotechnical conditions.

FLOOR SLABS

Floor Slab Design Parameters

Item	Description
Floor Slab Support	At least 24 inches of low volume change (LVC) material
Modulus of Subgrade Reaction	100 pounds per square inch per inch of deflection (psi/in or pci) for point loading conditions
Granular Leveling Course Layer Thickness [1,2]	4 inches (minimum)

1. Well graded crushed stone (e.g., KDOT AB-3 aggregate) or open-graded crushed stone (e.g. ASTM C33, Size No. 57 aggregate) can be used as the leveling course.
2. These granular materials may be considered part of the LVC zone.

Joints should be constructed in slabs at regular intervals as recommended by the American Concrete Institute (ACI) to help control the location of cracks. Joints or any cracks that develop in the floor slab should be sealed with a water-proof, non-extruding compressible compound.

Loads on footings that support structural walls and column loads are typically greater than floor slab loads. Consequently, footings should be expected to settle more than the adjacent floor slabs. The structural engineer should consider the potential for differential movement between foundations and grade-supported floor slabs.

Typically, some increase in the floor slab subgrade moisture content will occur because of gradual accumulation of capillary moisture, which would otherwise evaporate if the floor slab had not been constructed. The use of a vapor retarder should be considered beneath concrete slabs-on-grade that will be covered with wood, tile, carpet or other moisture sensitive or impervious coverings, or when the slab will support equipment sensitive to moisture. When conditions warrant the use of a vapor retarder, the slab designer should refer to ACI 302 and/or ACI 360 for procedures and cautions regarding the use and placement of a vapor retarder.

Floor Slab Construction Considerations

The subgrade should be maintained within the moisture content range recommended for engineered fill until the floor slab is constructed. If the subgrade becomes desiccated prior to construction of the floor slab, the affected material should be removed or the materials should be scarified, moistened, and compacted. Upon completion of grading operations in the building area, care should be taken to maintain the subgrade within the moisture content and density ranges recommended for engineered fill prior to construction of the building floor slab.

On most project sites, the site grading is generally accomplished early in the construction phase. However, as construction proceeds, the subgrade may be disturbed due to utility excavations, construction traffic, desiccation, rainfall etc. As a result, the floor slab subgrade soils may not be suitable for placement of the granular course and/or concrete at the time of building construction, and corrective action may be required.

Terracon should evaluate the condition of the floor slab subgrades immediately prior to placement of the granular leveling course and construction of the slabs. Particular attention should be paid to areas containing backfilled trenches and high traffic areas that were previously disturbed during construction. Where unsuitable conditions are located within the floor slab subgrade soils, the subgrade should be improved by removing and replacing the affected material with properly compacted fill.

PAVEMENTS

Pavement Subgrade Preparation

Pavement subgrades are expected to consist of on-site native clay soils. The pavement subgrades should be proofrolled as recommended in **Earthwork**. If soft or otherwise unsuitable areas are observed, additional over-excavation and replacement will be needed.

Grading and paving are commonly performed by separate contractors and there is often a time lapse between the end of grading operations and the commencement of paving. Subgrades prepared early in the construction process may become disturbed by construction traffic. Non-uniform subgrades often result in poor pavement performance and local failures relatively soon after pavements are constructed. Depending on the paving equipment used by the contractor, measures may be required to improve subgrade strength to greater depths for support of heavily loaded concrete/asphalt trucks.

We recommend the moisture content and density of the subgrade be evaluated and the pavement subgrades be proofrolled (using a loaded tandem-axle dump truck with a minimum gross weight of 20 tons or similarly loaded rubber-tire equipment) within two days prior to commencement of actual paving operations. Areas not in compliance with the required ranges of moisture or density should be scarified, moisture conditioned, and compacted. Particular attention should be paid to high traffic areas that were rutted and disturbed earlier and to areas where backfilled trenches are located. Areas where unsuitable conditions are located should be repaired by removing and replacing the materials with properly compacted fills. The subgrade should be in its finished form at the time of the final review.

Opinions of Minimum Pavement Thickness

Pavement thickness depends upon many factors including but not limited to:

- applied wheel/axle loads and number of repetitions
- subgrade and pavement material characteristics
- climate conditions
- site and pavement drainage

Specific information regarding anticipated vehicle types, axle loads and traffic volumes was not provided at the time of this report. The "Parking Lots" pavement section considers 4-tire, 2-axle personal vehicle traffic only (cars, vans, pickups and SUVs). The "Drives" pavement section considers personal vehicle traffic and a maximum of ten delivery trucks/trash collection trucks per week. Our recommendations for full depth asphaltic cement concrete (ACC) pavement, ACC pavement over aggregate base, and Portland cement concrete (PCC) pavement sections are outlined in the following table.

Pavement Type	Parking Lots	Drives
Full depth ACC	2 inches ACC surface 4 inches ACC base	2 inches ACC surface 6 inches ACC base
ACC over aggregate base	2 inches ACC surface 2 inches ACC base 6 inches aggregate base (KDOT AB-3 or similar)	2 inches ACC surface 4 inches ACC base 6 inches aggregate base (KDOT AB-3 or similar)
PCC	5 inches PCC 4 inches open graded rock (ASTM C33 Size No. 57 aggregate or similar)	6 inches PCC 4 inches open graded rock (ASTM C33 Size No. 57 aggregate or similar)

1. For trash container pads, we recommend a PCC pavement section be used consisting of 7 inches (minimum) of PCC over 4 inches (minimum) of open graded rock (ASTM C33 Size No. 57 aggregate or similar) on a compacted soil subgrade. The trash container pad should be large enough to support the container and the tipping axle of the collection truck.

PCC pavements will perform better than ACC in areas where short-radii turning and braking are expected (i.e., entrance/exit aprons) due to better resistance to rutting and shoving. In addition, PCC pavement will perform better in areas subject to heavy static loads.

Construction traffic on the pavements was not considered in developing our opinions of minimum pavement thickness. If the pavements will be subject to construction equipment/vehicles, the pavement sections should be revised to consider the additional loading.

Pavements and subgrades will be subject to freeze-thaw cycles and seasonal fluctuations in moisture content. Pavement thickness design methods are intended to provide adequate thickness of structural materials over a particular subgrade such that wheel loads are reduced to a level that the subgrade can support. The subgrade support parameters for pavement thickness design do not account for shrink/swell movements of a subgrade constructed of expansive clay soils. Therefore, the pavement may be adequate from a structural standpoint, yet still experience cracking and deformation due to shrink/swell related movement of the subgrade.

The pavement sections provided above consider that the subgrade soils will not experience significant increases in moisture content. Paved areas should be sloped to provide rapid drainage of surface water and to drain water away from the pavement edges. Pavements should be designed so water does not accumulate on or adjacent to the pavement, since this could saturate and soften the subgrade soils and subsequently accelerate pavement deterioration.

Periodic maintenance of the pavements will be required. Cracks should be sealed, and areas exhibiting distress should be repaired promptly to help prevent further deterioration. Even with periodic maintenance, some movement and related cracking may still occur and repairs may be required.

GENERAL COMMENTS

Our analysis and opinions are based upon our understanding of the project, the geotechnical conditions in the area, and the data obtained from our site exploration. Natural variations will occur between boring locations or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. Terracon should be retained to provide observation and testing services during pertinent construction phases. If variations appear, we can provide further evaluation and supplemental recommendations. If variations are noted in the absence of our observation and testing services on-site, we should be immediately notified so that we can provide evaluation and supplemental recommendations.

Our scope of services does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

Our services and any correspondence or collaboration through this system are intended for the sole benefit and exclusive use of our client for specific application to the project discussed and are accomplished in accordance with generally accepted geotechnical engineering practices with no third-party beneficiaries intended. Any third-party access to services or correspondence is solely for information purposes to support the services provided by Terracon to our client.

Reliance upon the services and any work product is limited to our client, and is not intended for third parties. Any use or reliance of the provided information by third parties is done solely at their own risk. No warranties, either express or implied, are intended or made.

Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly impact excavation cost. Any parties charged with estimating excavation costs should seek their own site characterization for specific purposes to obtain the specific level of detail necessary for costing. Site safety, cost estimating, excavation support, and dewatering requirements/design are the responsibility of others. If changes in the nature, design, or location of the project are planned, our conclusions and recommendations shall not be considered valid unless we review the changes and either verify or modify our conclusions in writing.

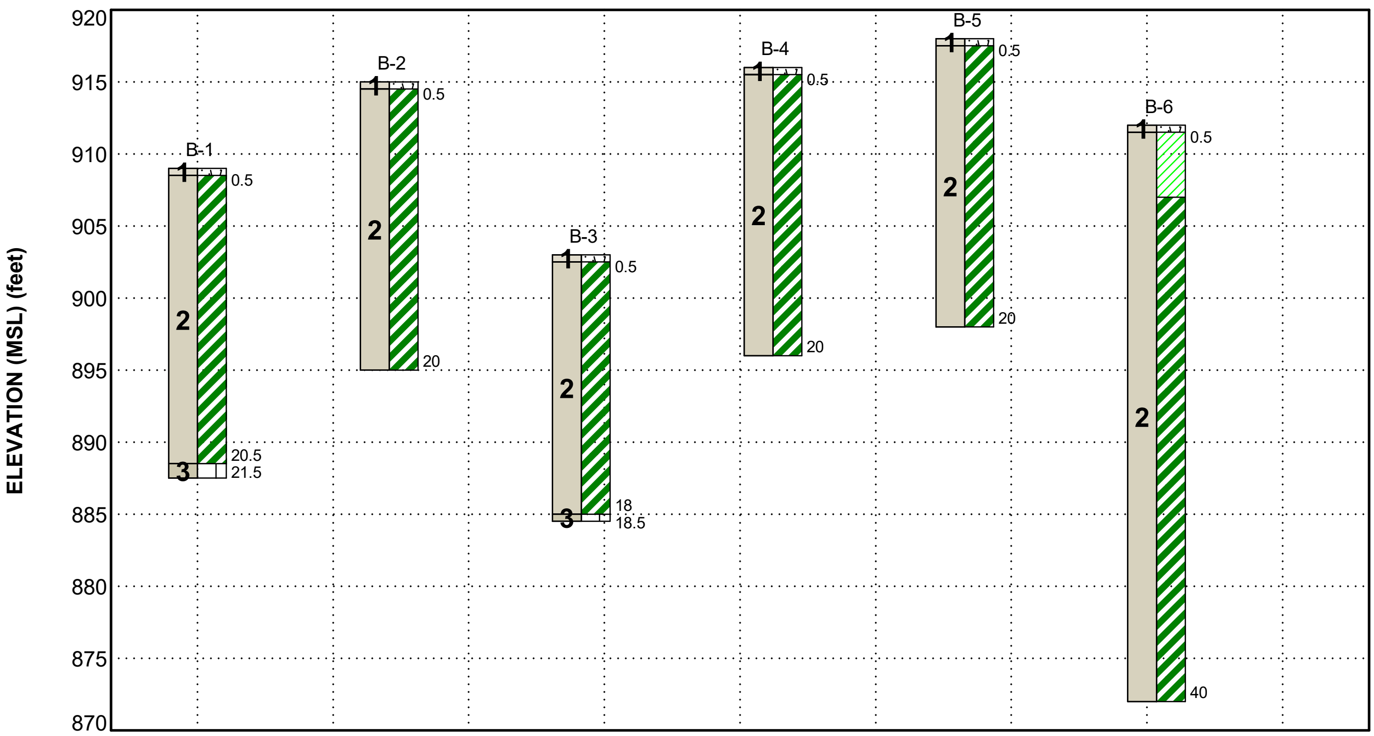
FIGURES

Contents:

GEOMODEL

Housing Building KCKCC ■ Kansas City, KS

Terracon Project No. 02205100



This is not a cross section. This is intended to display the Geotechnical Model only. See individual logs for more detailed conditions.

Model Layer	Layer Name	General Description
1	**Topsoil**	Topsoil
2	**Clay**	Medium stiff to stiff, lean clay and fat clay
3	**Bedrock**	Limestone

LEGEND

Topsoil

Lean Clay

Fat Clay

Limestone

NOTES:

Layering shown on this figure has been developed by the geotechnical engineer for purposes of modeling the subsurface conditions as required for the subsequent geotechnical engineering for this project. Numbers adjacent to soil column indicate depth below ground surface.

ATTACHMENTS

EXPLORATION AND TESTING PROCEDURES

Field Exploration

The borings were located in the field by Terracon personnel using a hand-held GPS unit with a horizontal accuracy of ±20 feet. Ground surface elevations indicated on the boring logs were obtained from Google Earth.

The borings were drilled with a track-mounted, rotary drill rig using solid-stem, continuous flight augers to advance the boreholes. Samples of the soil encountered in the borings were obtained using thin-walled tube and split-barrel sampling procedures. In the thin-walled tube sampling procedure, a thin-walled, seamless steel tube with a sharp cutting edge is pushed hydraulically into the soil to obtain a relatively undisturbed sample. In the split-barrel sampling procedure, a standard 2-inch outside diameter split-barrel sampling spoon is driven into the ground by a 140-pound automatic hammer falling a distance of 30 inches. The number of blows required to advance the sampling spoon the last 12 inches of a normal 18-inch penetration is recorded as the Standard Penetration Test (SPT) resistance value. The SPT resistance values, also referred to as N-values, are indicated on the boring logs at the test depths.

The samples were tagged for identification, sealed to reduce moisture loss, and taken to our laboratory for further examination, testing, and classification. The drill crew backfilled the borings with auger cuttings after completion of drilling/sampling and prior to leaving the site.

The drill crew prepared a field log of each boring to record data including visual classifications of the materials encountered during drilling as well as the driller's interpretation of the subsurface conditions between samples. The final boring logs included with this report represent the engineer's interpretation of the subsurface conditions at the borings based on field and laboratory data and observation of the samples.

Laboratory Testing

Representative soil samples were tested in the laboratory to measure their natural water content, dry unit weight, and Atterberg limits. A pocket penetrometer was used to estimate the consistency of selected cohesive samples. The test results are provided on the boring logs included in **Exploration Results**.

The soil samples were classified in the laboratory based on visual observation, texture, plasticity, and the laboratory testing described above. The soil descriptions presented on the boring logs are in accordance with the enclosed General Notes and Unified Soil Classification System (USCS). The estimated USCS group symbols for native soils are shown on the boring logs, and a brief description of the USCS is included in this report.

The bedrock materials encountered in the borings were described in accordance with the appended Description of Rock Properties on the basis of drilling characteristics and visual classification of disturbed auger cuttings. Petrographic analysis and rock core may indicate other rock types.

SITE LOCATION AND EXPLORATION PLANS

Contents:

Note: All attachments are one page unless noted above.

SITE LOCATION

Kansas City, Kansas Community College Housing Building ■ Kansas City, Kansas
May 1, 2020 ■ Terracon Project No. 02205100

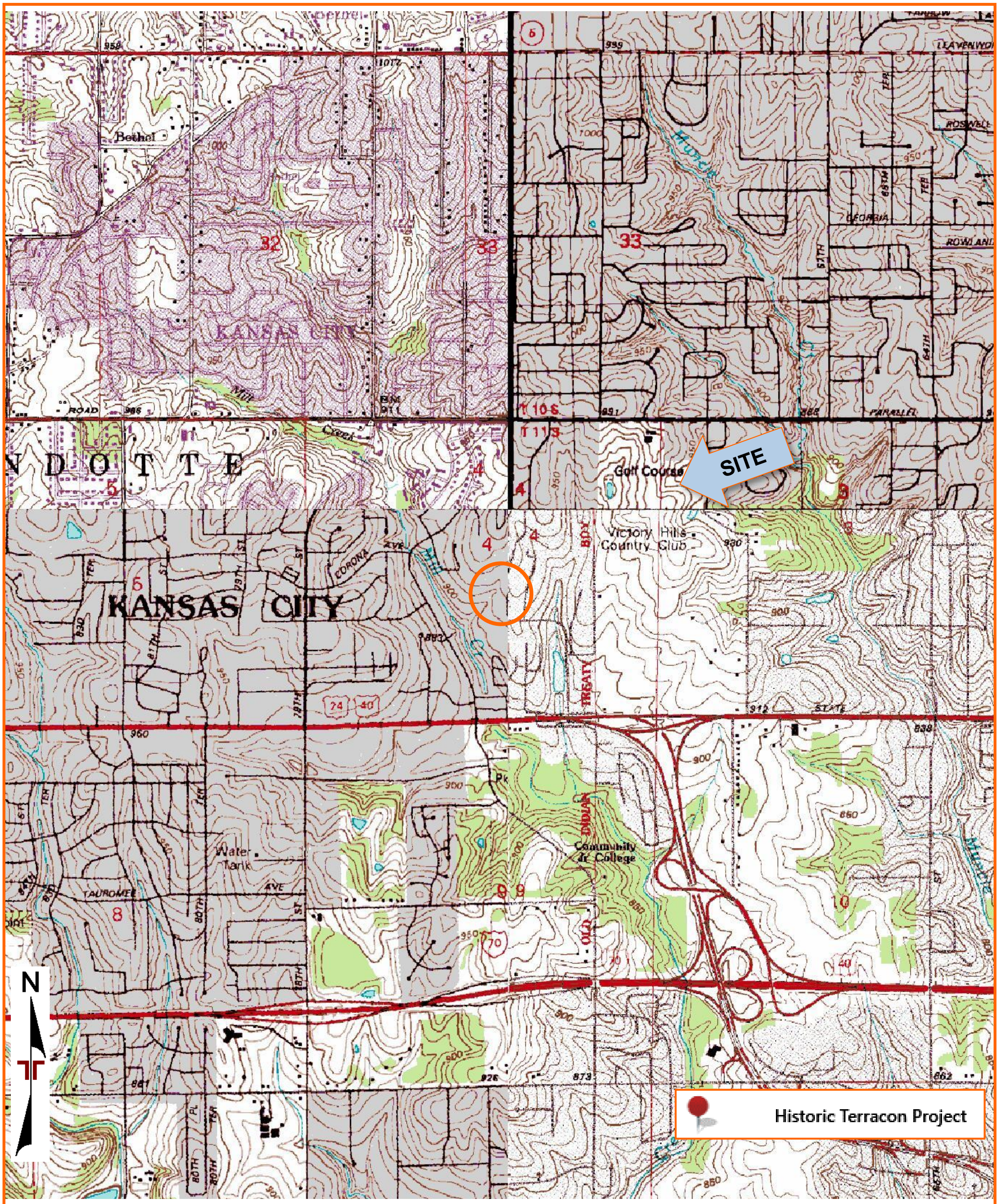


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

EXPLORATION PLAN

Kansas City, Kansas Community College Housing Building ■ Kansas City, Kansas
May 1, 2020 ■ Terracon Project No. 02205100

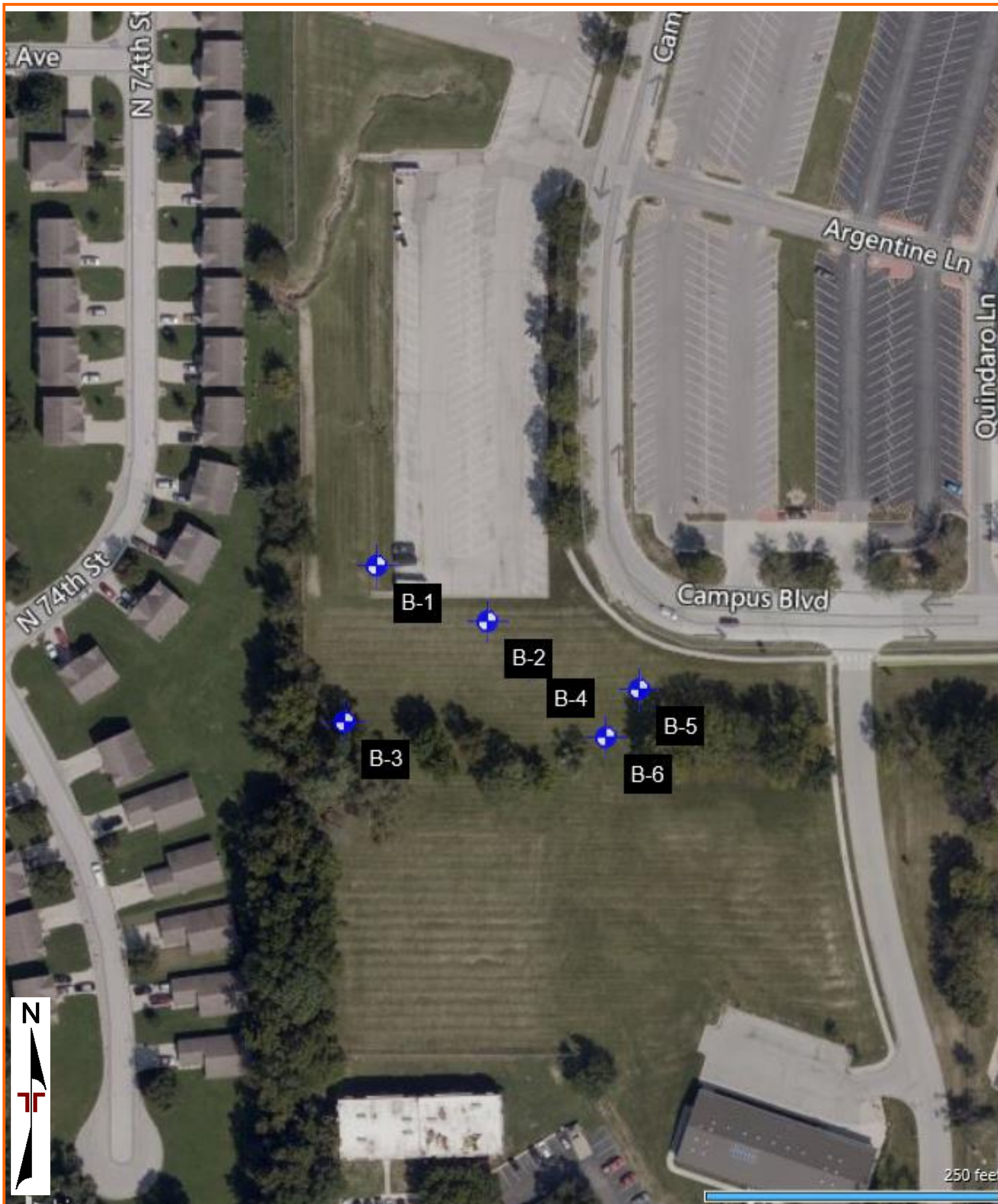


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

EXPLORATION RESULTS

Contents:

Boring Logs (B-1 through B-6)

Note: All attachments are one page unless noted above.

BORING LOG NO. B-1

PROJECT: Housing Building KCKCC

**CLIENT: Kansas City Kansas Community College
Kansas City, KS**

**SITE: 7250 State Ave
Kansas City, KS**

LOCATION See Exploration Plan

Latitude: 39.1207° Longitude: -94.751°

Surface Elev.: 909 (Ft.)

MODEL LAYER	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	SAMPLE TYPE	FIELD TEST RESULTS	TEST TYPE	COMPRESSIVE STRENGTH (psf)	STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
1	0.5		908.5									
2		**FAT CLAY (CH)**, brown, medium stiff to stiff										
					Split spoon	3-3-4 N=7				31		54-22-32
					Shelby tube		UC	3030	10.2	30	96	
				5								
					Split spoon	1-2-5 N=7				29		
					Split spoon	1-2-3 N=5				26		
				10								
					Split spoon	2-5-6 N=11				26		
				15								
					Split spoon	4-5-5 N=10				26		
	20.5		888.5	20								
3	21.5	**LIMESTONE**, gray, highly weathered	887.5									
		Boring Terminated at 21.5 Feet										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Solid-stem flight augers

Abandonment Method:
Boring backfilled with Auger Cuttings and/or Bentonite

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevations obtained from GoogleEarth

Notes:

WATER LEVEL OBSERVATIONS

Terracon
15620 W 113th St
Lenexa, KS

Boring Started: 04-17-2020	Boring Completed: 04-17-2020
Drill Rig: 754	Driller: JW
Project No.: 02205100	

BORING LOG NO. B-2

PROJECT: Housing Building KCKCC

CLIENT: Kansas City Kansas Community College, Kansas City, KS

SITE: 7250 State Ave, Kansas City, KS

LOCATION See Exploration Plan

Latitude: 39.1206° Longitude: -94.7507°

Surface Elev.: 915 (Ft.)

MODEL LAYER	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	TEST TYPE	COMPRESSIVE STRENGTH (psf)	STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
1	0.5		914.5										
2		**FAT CLAY (CH)**, brown, medium stiff to very stiff				Split spoon	3-5-6 N=11				20		
						Shelby tube					25	99	
						Split spoon	1-2-2 N=4				30		
						Split spoon	2-2-2 N=4				29		
						Split spoon	2-4-4 N=8				23		
	20.0		895	20		Split spoon	6-9-11 N=20				22		

Boring Terminated at 20 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Solid-stem flight augers

Abandonment Method:
Boring backfilled with Auger Cuttings and/or Bentonite

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevations obtained from GoogleEarth

Notes:

WATER LEVEL OBSERVATIONS

Terracon
15620 W 113th St
Lenexa, KS

Boring Started: 04-17-2020	Boring Completed: 04-17-2020
Drill Rig: 754	Driller: JW
Project No.: 02205100	

BORING LOG NO. B-3

PROJECT: Housing Building KCKCC

CLIENT: Kansas City Kansas Community College Kansas City, KS

SITE: 7250 State Ave Kansas City, KS

LOCATION See Exploration Plan

Latitude: 39.1203° Longitude: -94.7511°

Surface Elev.: 903 (Ft.)

MODEL LAYER	DEPTH	ELEVATION (Ft.)	DESCRIPTION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (psf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
1	0.5	902.5											
2			**FAT CLAY (CH)**, brown, medium stiff to stiff				2-3-5 N=8				29		56-20-36
								UC	2699	11.8	29	94	
				5			2-4-5 N=9				25		
				10			1-2-4 N=6				24		
				15			3-5-8 N=13				21		
	18.0	885											
3	18.5	884.5	**LIMESTONE**, highly weathered				50/0"						

Boring Terminated at 18.5 Feet

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Solid-stem flight augers

Abandonment Method:
Boring backfilled with Auger Cuttings and/or Bentonite

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevations obtained from GoogleEarth

Notes:

WATER LEVEL OBSERVATIONS

Terracon
15620 W 113th St
Lenexa, KS

Boring Started: 04-17-2020	Boring Completed: 04-17-2020
Drill Rig: 754	Driller: JW
Project No.: 02205100	

BORING LOG NO. B-4

PROJECT: Housing Building KCKCC

CLIENT: Kansas City Kansas Community College
Kansas City, KS

SITE: 7250 State Ave
Kansas City, KS

LOCATION See Exploration Plan

Latitude: 39.1205° Longitude: -94.7505°

Surface Elev.: 916 (Ft.)

MODEL LAYER	DEPTH	DESCRIPTION	ELEVATION (Ft.)
1	0.5	(topsoil)	915.5
2	20.0	**FAT CLAY (CH)**, brown gray, medium stiff to very stiff	896
		Boring Terminated at 20 Feet	

DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (psf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
~1.5–3		Split spoon	2-4-5 N=9				22		
~3–5		Shelby tube		UC	5670	11.9	22	102	
~6–7.5		Split spoon	1-2-3 N=5				29		
~8.5–10		Split spoon	2-3-3 N=6				30		
~13.5–15		Split spoon	2-3-3 N=6				23		
~18.5–20		Split spoon	4-5-8 N=13				24		

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Solid-stem flight augers

Abandonment Method:
Boring backfilled with Auger Cuttings and/or Bentonite

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevations obtained from GoogleEarth

Notes:

WATER LEVEL OBSERVATIONS

Terracon
15620 W 113th St
Lenexa, KS

Boring Started: 04-17-2020	Boring Completed: 04-17-2020
Drill Rig: 754	Driller: JW
Project No.: 02205100	

BORING LOG NO. B-5

PROJECT: Housing Building KCKCC

CLIENT: Kansas City Kansas Community College
Kansas City, KS

SITE: 7250 State Ave
Kansas City, KS

LOCATION See Exploration Plan

Latitude: 39.1204° Longitude: -94.7502°

Surface Elev.: 918 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH / DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (psf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
1		0.5	917.5										
2		**FAT CLAY (CH)**, brown gray, medium stiff to very stiff					1-2-4 N=6				30		
								UC	3237	10.1	26	94	
				5									
							1-3-5 N=8				29		
							1-3-6 N=9				27		
				10									
							2-4-4 N=8				23		
				15									
							3-3-7 N=10				19		
		20.0	898	20									
		Boring Terminated at 20 Feet											

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Solid-stem flight augers

Abandonment Method:
Boring backfilled with Auger Cuttings and/or Bentonite

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevations obtained from GoogleEarth

Notes:

WATER LEVEL OBSERVATIONS

Terracon
15620 W 113th St
Lenexa, KS

Boring Started: 04-17-2020	Boring Completed: 04-17-2020
Drill Rig: 754	Driller: JW
Project No.: 02205100	

BORING LOG NO. B-6

PROJECT: Housing Building KCKCC

CLIENT: Kansas City Kansas Community College Kansas City, KS

SITE: 7250 State Ave Kansas City, KS

LOCATION See Exploration Plan

Latitude: 39.1203° Longitude: -94.7503°

Surface Elev.: 912 (Ft.)

MODEL LAYER	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	COMPRESSIVE STRENGTH (psf)	STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
1	0.5	**TOPSOIL**	911.5										
		LEAN CLAY (CL), brown, medium stiff to stiff				Split spoon	1-2-4 N=6				25		38-19-19
						Shelby tube		UC	6789	8.3	19	105	
2	5.0	**FAT CLAY (CH)**, sandy, brown gray, stiff	907	5									
						Split spoon	3-4-5 N=9				25		
				10		Split spoon	3-4-6 N=10				26		
				15		Split spoon	2-4-6 N=10				24		
				20		Split spoon	6-9-14 N=23				16		
				25		Split spoon	3-5-7 N=12				19		

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Solid-stem flight augers

Abandonment Method:
Boring backfilled with Auger Cuttings and/or Bentonite

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Elevations obtained from GoogleEarth

Notes:

WATER LEVEL OBSERVATIONS

Terracon
15620 W 113th St
Lenexa, KS

Boring Started: 04-17-2020	Boring Completed: 04-17-2020
Drill Rig: 754	Driller: JW
Project No.: 02205100	

BORING LOG NO. B-6

PROJECT: Housing Building KCKCC

**CLIENT: Kansas City Kansas Community College
Kansas City, KS**

**SITE: 7250 State Ave
Kansas City, KS**

LOCATION See Exploration Plan

Latitude: 39.1203° Longitude: -94.7503°

Surface Elev.: 912 (Ft.)

MODEL LAYER	GRAPHIC LOG	DEPTH / DESCRIPTION / ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (psf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
2		**FAT CLAY (CH)**, sandy, brown gray, stiff *(continued)*										
			30		X	1-3-6 N=9				25		
			35		X	2-2-3 N=5				8		
		40.0 ... 872	40		X	3-6-9 N=15				18		
		Boring Terminated at 40 Feet										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Solid-stem flight augers

Abandonment Method:
Boring backfilled with Auger Cuttings and/or Bentonite

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

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Terracon
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Boring Started: 04-17-2020	Boring Completed: 04-17-2020
Drill Rig: 754	Driller: JW
Project No.: 02205100	

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING

Shelby Tube

WATER LEVEL

- **Water Initially Encountered**
- **Water Level After a Specified Period of Time**
- **Water Level After a Specified Period of Time**

Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.

FIELD TESTS

N	**Standard Penetration Test Resistance (Blows/Ft.)**
(HP)	**Hand Penetrometer**
(T)	**Torvane**
(DCP)	**Dynamic Cone Penetrometer**
(PID)	**Photo-Ionization Detector**
(OVA)	**Organic Vapor Analyzer**

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

LOCATION AND ELEVATION NOTES

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

STRENGTH TERMS

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance		**CONSISTENCY OF FINE-GRAINED SOILS** (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance			**BEDROCK**	
Descriptive Term (Density)	**Standard Penetration or N-Value Blows/Ft.**	**Descriptive Term (Consistency)**	**Unconfined Compressive Strength Qu, (tsf)**	**Standard Penetration or N-Value Blows/Ft.**	**Standard Penetration or N-Value Blows/Ft.**	**Descriptive Term (Consistency)**
Very Loose	0 - 3	Very Soft	less than 0.25	0 - 1	< 20	Weathered
Loose	4 - 9	Soft	0.25 to 0.50	2 - 4	20 - 29	Firm
Medium Dense	10 - 29	Medium-Stiff	0.50 to 1.00	4 - 8	30 - 49	Medium Hard
Dense	30 - 50	Stiff	1.00 to 2.00	8 - 15	50 - 79	Hard
Very Dense	> 50	Very Stiff	2.00 to 4.00	15 - 30	>79	Very Hard
		Hard	> 4.00	> 30		

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 15
With	15 - 29
Modifier	> 30

GRAIN SIZE TERMINOLOGY

Major Component of Sample	Particle Size
Boulders	Over 12 in. (300 mm)
Cobbles	12 in. to 3 in. (300mm to 75mm)
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm
Silt or Clay	Passing #200 sieve (0.075mm)

RELATIVE PROPORTIONS OF FINES

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 5
With	5 - 12
Modifier	> 12

PLASTICITY DESCRIPTION

Term	Plasticity Index
Non-plastic	0
Low	1 - 10
Medium	11 - 30
High	> 30

Terracon

UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]				Soil Classification	
				Group Symbol	**Group Name** [B]
Coarse-Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	Cu ≥ 4 and 1 ≤ Cc ≤ 3 [E]	GW	Well-graded gravel [F]
			Cu < 4 and/or [Cc<1 or Cc>3.0] [E]	GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH	GM	Silty gravel [F, G, H]
			Fines classify as CL or CH	GC	Clayey gravel [F, G, H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	Cu ≥ 6 and 1 ≤ Cc ≤ 3 [E]	SW	Well-graded sand [I]
			Cu < 6 and/or [Cc<1 or Cc>3.0] [E]	SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH	SM	Silty sand [G, H, I]
			Fines classify as CL or CH	SC	Clayey sand [G, H, I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	PI > 7 and plots on or above "A" line [J]	CL	Lean clay [K, L, M]
			PI < 4 or plots below "A" line [J]	ML	Silt [K, L, M]
		Organic:	Liquid limit - oven dried / Liquid limit - not dried < 0.75	OL	Organic clay [K, L, M, N]
					Organic silt [K, L, M, O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above "A" line	CH	Fat clay [K, L, M]
			PI plots below "A" line	MH	Elastic Silt [K, L, M]
		Organic:	Liquid limit - oven dried / Liquid limit - not dried < 0.75	OH	Organic clay [K, L, M, P]
					Organic silt [K, L, M, Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor			PT	Peat

[A] Based on the material passing the 3-inch (75-mm) sieve.

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay.

[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥ 15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.

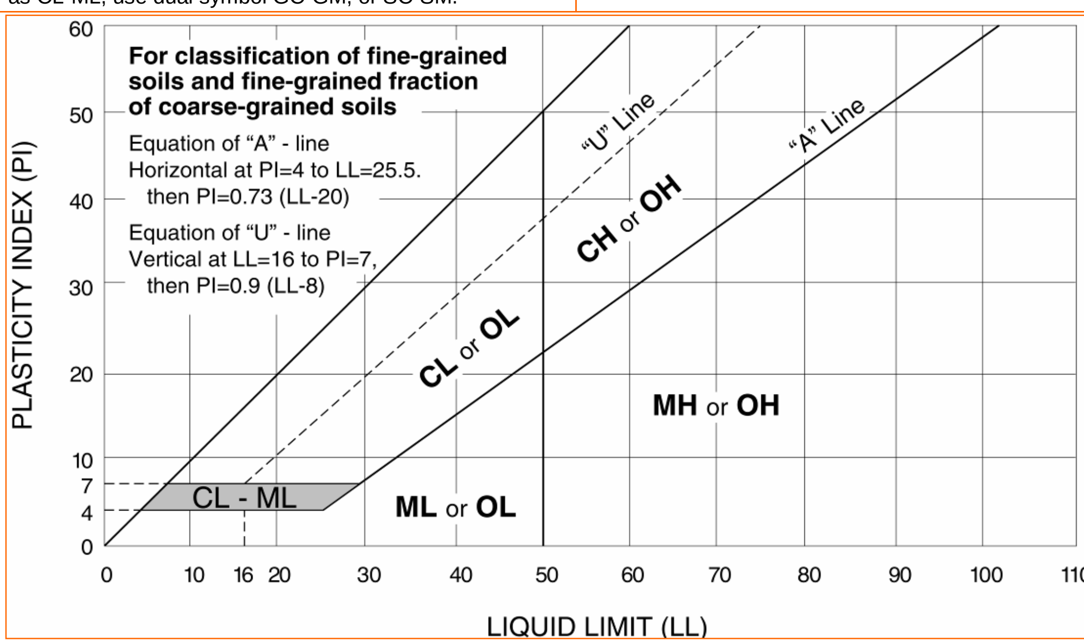
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] PI ≥ 4 and plots on or above "A" line.

[O] PI < 4 or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.



DESCRIPTION OF ROCK PROPERTIES

WEATHERING	
Term	**Description**
Unweathered	No visible sign of rock material weathering, perhaps slight discoloration on major discontinuity surfaces.
Slightly weathered	Discoloration indicates weathering of rock material and discontinuity surfaces. All the rock material may be discolored by weathering and may be somewhat weaker externally than in its fresh condition.
Moderately weathered	Less than half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discolored rock is present either as a continuous framework or as corestones.
Highly weathered	More than half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discolored rock is present either as a discontinuous framework or as corestones.
Completely weathered	All rock material is decomposed and/or disintegrated to soil. The original mass structure is still largely intact.
Residual soil	All rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume, but the soil has not been significantly transported.

STRENGTH OR HARDNESS		
Description	**Field Identification**	**Uniaxial Compressive Strength, psi (MPa)**
Extremely weak	Indented by thumbnail	40-150 (0.3-1)
Very weak	Crumbles under firm blows with point of geological hammer, can be peeled by a pocket knife	150-700 (1-5)
Weak rock	Can be peeled by a pocket knife with difficulty, shallow indentations made by firm blow with point of geological hammer	700-4,000 (5-30)
Medium strong	Cannot be scraped or peeled with a pocket knife, specimen can be fractured with single firm blow of geological hammer	4,000-7,000 (30-50)
Strong rock	Specimen requires more than one blow of geological hammer to fracture it	7,000-15,000 (50-100)
Very strong	Specimen requires many blows of geological hammer to fracture it	15,000-36,000 (100-250)
Extremely strong	Specimen can only be chipped with geological hammer	>36,000 (>250)

DISCONTINUITY DESCRIPTION			
Fracture Spacing (Joints, Faults, Other Fractures)		**Bedding Spacing (May Include Foliation or Banding)**	
Description	**Spacing**	**Description**	**Spacing**
Extremely close	< ¾ in (<19 mm)	**Laminated**	< ½ in (<12 mm)
Very close	¾ in – 2-1/2 in (19 - 60 mm)	**Very thin**	½ in – 2 in (12 – 50 mm)
Close	2-1/2 in – 8 in (60 – 200 mm)	**Thin**	2 in – 1 ft. (50 – 300 mm)
Moderate	8 in – 2 ft. (200 – 600 mm)	**Medium**	1 ft. – 3 ft. (300 – 900 mm)
Wide	2 ft. – 6 ft. (600 mm – 2.0 m)	**Thick**	3 ft. – 10 ft. (900 mm – 3 m)
Very Wide	6 ft. – 20 ft. (2.0 – 6 m)	**Massive**	> 10 ft. (3 m)

Discontinuity Orientation (Angle): Measure the angle of discontinuity relative to a plane perpendicular to the longitudinal axis of the core. (For most cases, the core axis is vertical; therefore, the plane perpendicular to the core axis is horizontal.) For example, a horizontal bedding plane would have a 0-degree angle.

ROCK QUALITY DESIGNATION (RQD) [1]	
Description	**RQD Value (%)**
Very Poor	0 - 25
Poor	25 – 50
Fair	50 – 75
Good	75 – 90
Excellent	90 - 100

1. The combined length of all sound and intact core segments equal to or greater than 4 inches in length, expressed as a percentage of the total core run length.

Reference: U.S. Department of Transportation, Federal Highway Administration, Publication No FHWA-NHI-10-034, December 2009 Technical Manual for Design and Construction of Road Tunnels – Civil Elements