Geotechnical Engineering Report

Tudor Road Apartments
Lee's Summit, Missouri
June 10, 2022
Terracon Project No. 02225125

Prepared for:
Cityscape Residential, LLC
Carmel, Indiana

Prepared by:
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June 10, 2022

Cityscape Residential, LLC
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Attn: Mr. Ryan Adams – Vice President
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Re: Geotechnical Engineering Report
Tudor Road Apartments
NE Tudor Road and NW Commerce Drive
Lee's Summit, Missouri
Terracon Project No. 02225125

Dear Mr. Adams:

We have completed a subsurface exploration and geotechnical engineering evaluation for the referenced project. This study was performed in general accordance with Terracon Project No. 02225125, dated May 2, 2022. 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.

STATE OF MISSOURI
KOLE C. BERG
NUMBER PE-2002016417
PROFESSIONAL ENGINEER
6/10/2022

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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

EXPLORATION AND TESTING PROCEDURES
SITE LOCATION AND EXPLORATION PLANS
EXPLORATION RESULTS
SUPPORTING INFORMATION

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

Geotechnical Engineering Report

Tudor Road Apartments

NE Tudor Road and NW Commerce Drive

Lee's Summit, Missouri

Terracon Project No. 02225125

June 10, 2022

INTRODUCTION

This report presents the results of our subsurface exploration and geotechnical engineering evaluation performed for the proposed apartments planned southeast of the intersection of NE Tudor Road and NW Commerce Drive in Lee's Summit, Missouri. 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

Item	Description
Project Location	The project is planned southeast of the intersection of NE Tudor Road and NW Commerce Drive in Lee's Summit, Missouri. Latitude/Longitude: 38.9299° N, 94.3821° W (approximate)
Existing Site Conditions	The project site is currently a vacant lot. A wooded area is located on the south side of the site. Stockpiles of existing fill materials were observed on the north side of the site.
Existing Topography	A topographic site plan was not provided. Based on our review of topography using an online mapping application, site grades slope gradually down to the northwest. Surface elevations range from approximately 992 feet to 1,042 feet.

Item	Description
Geology	The overburden soils at this site are underlain by rock units of the Pennsylvanian Series, Missourian Stage, Kansas City Group in the time stratigraphic unit age classification. Alternating layers of shale, limestone, and sandstone comprise the Kansas City Group. These sedimentary strata were deposited in marine environments which once covered much of western Missouri and eastern Kansas

PROJECT DESCRIPTION

Item	Description
Project Description	The project includes construction of seven apartment buildings, a clubhouse building, swimming pool, and parking lots.
Proposed Buildings	The proposed clubhouse building will be a single-story structure, and the apartment buildings will be four-story structures. Details concerning building construction were not provided. We considered the buildings will be wood-framed structures with grade-supported floor slabs.
Finished Floor Elevation (FFEs)	The FFEs of the structures were not provided. We anticipate the FFEs will be within ±5 feet of existing grades.
Maximum Loads	Anticipated structural loads for the new apartment buildings and clubhouse were not provided. Based on our experience with similar structures, we have considered the following maximum loads: ■ Columns: 200 kips ■ Walls: 5 kips per linear foot ■ Slabs: 100 pounds per square foot
Grading	A site grading plan was not provided. We have considered no more than 5 feet of cut/fill will be required to develop final grades.
Below-Grade Structures	The swimming pool will have below-grade walls and the apartment buildings will have below-grade elevator pit walls. No basement levels or other below-grade structures are planned.
Free-Standing Retaining Walls	Based on site topography, we anticipate retaining walls will be required to develop design grades. We considered any planned retaining walls would be cast-in-place concrete, cantilever-type retaining walls with a maximum height of 5 feet. Analyses and recommendations for taller walls or other wall types (such as large-block gravity walls or mechanically stabilized earth (MSE) walls) are not included in our current scope of services. Please notify us if taller walls or other wall types are planned.

Item	Description
Pavements	New parking lots and drives will be constructed as part of the project. No information regarding anticipated vehicle types, axle loads, or traffic volumes was provided. We anticipate the pavements will be utilized primarily by passenger vehicles (cars, pickup trucks, SUV's) with occasional panel delivery trucks and trash collection trucks.

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 evaluation. Conditions encountered at each boring location are indicated on the individual logs. The individual logs are in the **Exploration Results** section and the GeoModel is in the **Figures** section of this report.

Model Layer	Layer Name	General Description
1	**Existing Fill**	Fat clay with gravel
2	**Residual Clay**	Fat clay and lean to fat clay, medium stiff to very stiff
3	**Bedrock**	Highly to slightly weathered limestone and shale

The borings were observed during drilling and shortly after completion of drilling for the presence and level of water. Groundwater was observed at depths ranging from approximately 6½ feet to 13½ feet in Borings B-8, B-9, and B-10. Groundwater was not encountered in the other 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 or engineered fill materials.

Existing fill materials composed of fat clay were encountered to a depth of approximately 6½ feet at Boring B-8. Stockpiles of existing fill materials were also observed on the north side of the site. Fill could extend to greater depths at the existing stockpiles and in other areas of the site where no borings were performed. Based on field and laboratory test data, it does not appear that the fill was placed with compactive effort. If existing fill is encountered during site grading operations, the existing fill should be overexcavated and replaced with engineered fill that has been placed and compacted as recommended in this report.

Expansive clay soils were encountered at the site. 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 low volume change (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**.

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, excavation, subgrade preparation and placement of engineered fills should conform to recommendations presented in this section. The recommendations presented for design and construction of earth-supported elements including foundations, slabs, and pavements are contingent upon the recommendations outlined in this section being followed. We recommend earthwork on this project be observed and evaluated by Terracon. The evaluation of earthwork should include observation and testing of subgrade preparation, engineered fill, foundation bearing soils, and other geotechnical conditions exposed during the construction of the project.

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 inches should be anticipated to remove the root zone materials. However, greater stripping depths may be required in areas not explored by the borings. Organic soils removed during site preparation should not be used as fill beneath the proposed new building and pavement areas.

Existing trees within proposed construction areas should be thoroughly grubbed to remove all stumps, root balls and roots larger than ½-inch in diameter. Desiccated (excessively dry) clay soils are often present in wooded areas. These desiccated clays have a very high swell potential, so removal of trees and root systems should also include removal of any desiccated clay soils. It may be practical to increase the moisture content of desiccated clay soils for re-use as fill, provided the soils have an organic content of no more than 5 percent.

The soils within the planned building areas 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.

Where fill will be placed on a slope steeper than about 5:1 (Horizontal:Vertical), the slope should be benched prior to fill placement. The benches should have a vertical face height of about 2 to 3 feet and should be cut wide enough to accommodate the compaction equipment. Benching of the slope provides interlocking between the new fill and existing soils and facilitates compaction of the fill.

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
On-site soils	CL/CH, CH (native clay soils and existing fill soils)	Pavement areas and at depths greater than 24 inches below building finished grade Existing fill should be observed, tested and approved by Terracon. Organics, rock/rubble fragments larger than 3 inches, debris, or other unsuitable materials should be removed prior to re-use of the existing fill in engineered fill sections.
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. MoDOT Type 5 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., MoDOT Type 5). 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. Soils that meet the LVC criteria were not encountered in the borings. Therefore, 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 lime 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.

Although general site grading operations for the building and pavement areas are expected to encounter primarily fat clay soils, some deeper excavations (such as for utility installation) may encounter bedrock (shale and/or limestone). Shale and/or limestone fragments excavated from on-site should not be re-used as fill material (including as utility trench backfill) below the building footprint or pavement areas. Although rock materials could be re-used if they are processed by crushing to a relatively small (3-inch minus) maximum particle size, it is likely not economical to set up a rock crushing operation on a project site of this size. In addition, quality control (field testing of moisture content and density) of compacted fill is difficult with rock materials. It would be more practical for this project to export any excavation shale and limestone fragments off-site and replace them with imported crushed stone aggregate or on-site clay, particularly for utility trench backfill.

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.

Bedrock strata were encountered at relatively shallow depths at some of the boring locations. Rock excavation methods may be required for deeper excavations, such as utility trenches, depending upon the depth of excavation and the type of rock encountered. In our experience, highly weathered bedrock strata that can be easily penetrated with a flight auger can typically be excavated using track-hoes with rock teeth or ripper equipped dozers. Excavation of harder bedrock (such as less weathered limestone and shale) will likely require the use of jackhammers or pneumatic breakers. Excavation of rock in confined areas (such as trenches) is usually difficult, even above the level of auger refusal.

SHALLOW FOUNDATIONS

Foundation Design Parameters

Based on the conditions encountered at the borings, the buildings can be supported on shallow footing foundations that bear on stiff, native clay soils and/or engineered fill. If unsuitable conditions are encountered in foundation excavations, the remedial methods described in the **Foundation Construction Considerations** section of this report should be implemented.

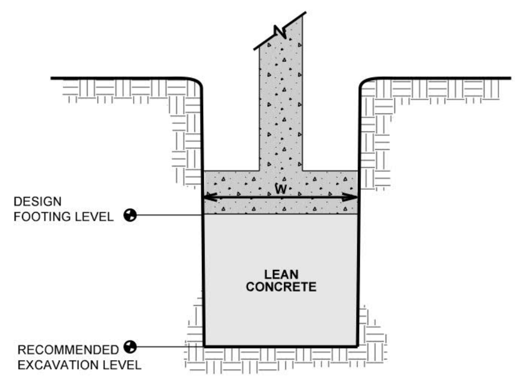
Description	Value
Maximum net allowable bearing pressure [1]	2,500 psf
Minimum embedment below finished grade for frost protection [2]	3 feet
Minimum footing widths	Isolated footings: 30 inches Continuous footings: 16 inches
Estimated total settlement [3]	1 inch or less
Estimated differential settlement [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.

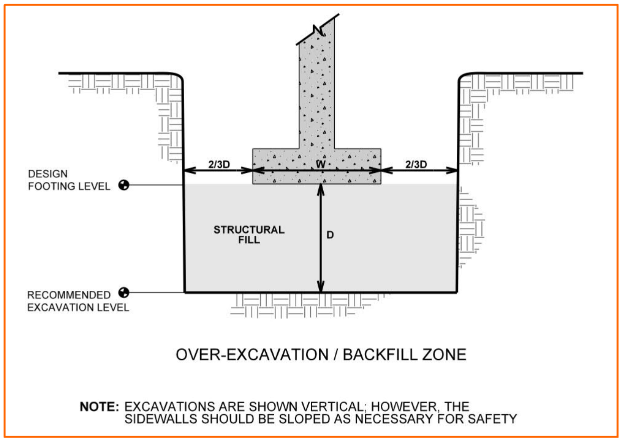
All footing bearing surfaces should be observed and tested by Terracon. If unsuitable conditions are encountered, footing excavations should be extended deeper to suitable bearing materials. Footings can bear directly on suitable soils at the lower level or on lean concrete backfill as shown in the following figure.



LEAN CONCRETE BACKFILL

NOTE: EXCAVATIONS ARE SHOWN VERTICAL; HOWEVER, THE SIDEWALLS SHOULD BE SLOPED AS NECESSARY FOR SAFETY

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., MoDOT Type 5 aggregate or an approved alternate gradation) placed and compacted as recommended in **Earthwork**.



SEISMIC CONSIDERATIONS

Code	Site Class
2018 International Building Code (IBC)	C [1]

1. The 2018 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 shale bedrock at a maximum depth of 15 feet. Our opinion of site class is based on the subsurface conditions encountered at the boring locations 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 or native clay soils and/or engineered fill
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., MoDOT Type 5 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.

SWIMMING POOL

We understand the swimming pool bottom slab, walls, and deck will be constructed using conventional concrete forming and placement techniques. The soils surrounding the swimming pool are expected to consist of native clay soils and/or engineered fill material composed of similar soils.

The swimming pool walls should be designed to resist the at-rest lateral earth pressures provided in the **Lateral Earth Pressures** section. These parameters are based on drainage being provided behind the pool walls to prevent hydrostatic loading on the walls.

A free-draining granular material (e.g., open-graded crushed stone such as ASTM C 33, Size No. 57 aggregate) should be used to backfill a minimum 2-foot zone extending laterally beyond the pool walls. The granular section behind the pool walls should be hydraulically connected to the drainage layer below the pool bottom slab. A geotextile filter fabric (e.g., Mirafi 160N, Contech C60NW, or an approved equivalent) should be placed between the granular material and the adjacent engineered fill soils to help prevent infiltration of fines into the granular material. If the pool walls will be constructed using any method other than conventional formed, cast-in-place concrete, Terracon should be contacted so we can provide supplemental recommendations. In particular, pool walls constructed by spraying of gunite or shotcrete directly on excavation sidewalls would require special geotechnical considerations that are not addressed in this report.

At least 24 inches of LVC material (refer to the **Earthwork** section) should be placed at the base of the pool excavation (below the pool bottom slab). The upper 12 inches of the LVC layer below the pool bottom slab should consist of free-draining granular material (e.g., open-graded crushed stone such as ASTM C 33, Size No. 57 aggregate). A system of collector drains should be constructed at the base of the free-draining granular layer. The drains should outlet to a sump or other suitable outlet where water can be collected and removed.

The deck area surrounding the pools should be sloped to allow surface drainage. The pool deck slabs should be constructed on a minimum 24-inch thick layer of LVC material (as discussed in the **Earthwork** section), and the upper 6 inches of the LVC layer should consist free draining aggregate. Subdrains should be installed at regular intervals below the pool deck slabs to collect and remove water from the free draining aggregate layer. Subdrains could consist of 4-inch diameter, perforated plastic pipes encapsulated in filter fabric and placed in shallow trenches at the base of the granular layer. The subdrains should slope to a suitable discharge point. All joints within the pool deck area should be properly sealed and maintained to prevent downward migration of water to the underlying subgrade soils.

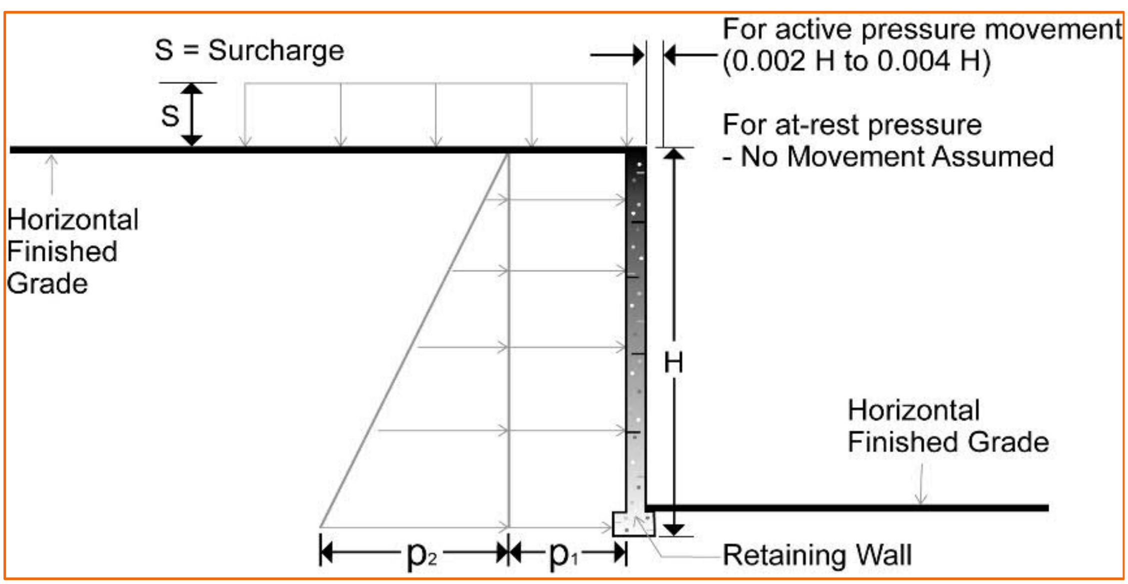
If groundwater levels rise above the bottom of the pool when the pool is empty, uplift loads could be imposed on the pool bottom slab and hydrostatic pressure could be imposed on the pool walls, which could cause heaving, cracking or other damage to the pool bottom slab and walls. We anticipate that the pool design will include pressure relief valves that will allow backflow of groundwater into the empty pool in order to help reduce the potential for hydrostatic loading and subsequent heaving, cracking, or other damage.

Although specific details regarding the pool utilities were not provided to us, in our experience, swimming pools usually include several utility pits/basins (e.g., a pump pit, surge basin, backwash basin and recirculation pump pit). The lateral earth pressure, drainage, and fill placement recommendations provided above for the pool are also applicable to these structures. Permanent drainage systems should be installed at the base of all below grade pits/basins to remove groundwater and help reduce the potential for hydrostatic loading on below grade walls and slabs.

LATERAL EARTH PRESSURES

Lateral Earth Pressure Design Parameters

Below grade swimming pool walls and cast-in-place concrete, cantilever-type retaining walls with unbalanced backfill levels on opposite sides should be designed for earth pressures at least equal to those indicated in the following table. Earth pressures will be influenced by structural design of the walls, conditions of wall restraint, methods of construction, and/or compaction and the strength of materials being restrained. Two wall restraint conditions are shown. Active earth pressure is commonly used for design of free-standing cantilever retaining walls where wall movement is permitted. The at-rest condition considers no wall movement is permitted. The recommended design lateral earth pressures do not include a factor of safety and do not provide for possible hydrostatic pressure on the walls.



Lateral Earth Pressure Parameters

Earth Pressure Conditions	Coefficient for Backfill Type	Equivalent Fluid Unit Weight (pcf)	Surcharge Pressure, p_1 (psf)	Earth Pressure, p_2 (psf)
Active (K_a)	Granular - 0.3 Clay - 0.42	40 50	(0.3)S (0.42)S	(40)H (50)H
At-Rest (K_o)	Granular - 0.47 Clay - 0.60	60 70	(0.47)S (0.60)S	(60)H (70)H
Passive (K_p)	Granular - 3.3 Clay - 2.4	420 290	--- ---	--- ---

<u>Applicable conditions to the above include:</u>

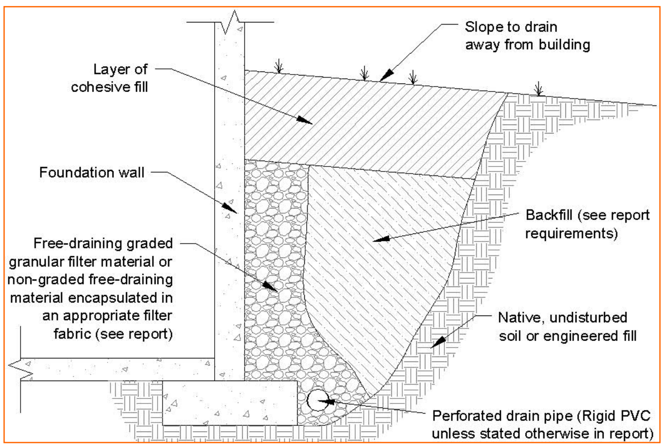
- For active earth pressure, wall must rotate about base, with top lateral movements of about 0.002 H to 0.004 H, where H is wall height
- For passive earth pressure to develop, wall must move horizontally to mobilize resistance
- Uniform surcharge, where S is surcharge pressure
- Clay soil backfill: unit weight = 120 pcf (maximum), and ϕ = 24 degrees (minimum)
- Granular material backfill: unit weight = 130 pcf (maximum), and ϕ = 32 degrees (minimum)
- Horizontal backfill, compacted as recommended in the report
- Loading from heavy compaction equipment not included
- No hydrostatic pressures acting on wall
- No loading from nearby footing or slabs
- No dynamic loading
- No safety factor included in soil parameters
- Ignore passive pressure in frost zone

Backfill placed against structures should consist of granular soils or low plasticity cohesive soils. For the granular values to be valid, the granular backfill must extend out and up from the base of the wall at an angle of at least 45 degrees from vertical for the active and at-rest cases, and at an angle of 60 degrees from vertical for the passive case. To calculate the resistance to sliding, a value of 0.3 should be used as the ultimate coefficient of friction where the footing bears on native clay soils or engineered fill

Gravity walls (e.g., large-block walls) and mechanically stabilized earth (MSE) retaining walls (e.g., geogrid-reinforced backfill with modular block facing) require different design parameters than those provided in this report. If large-block walls or MSE walls will be utilized instead of a reinforced concrete cantilever type walls, the MSE wall designer should review the information from the attached boring logs and develop the parameters required for design of the wall. Terracon's scope of services excludes providing soil parameters, design recommendations, or analyses for large-block walls or MSE walls.

Subsurface Drainage for Below Grade Walls

To prevent hydrostatic pressure on below-grade walls, we recommend drains be installed at the foundation level. Each drain line should be sloped to provide positive gravity drainage and should be surrounded by free-draining granular material graded to prevent the intrusion of fines, or an alternative free-draining granular material encapsulated with suitable filter fabric. At least a 2-foot wide section of free-draining granular fill should be used for backfill above the drain line and adjacent to the wall. The free-draining granular fill should extend to within 2 feet of final grade and should be capped with compacted cohesive fill to minimize infiltration of surface water into the drain system.



As an alternative to free-draining granular fill, a pre-fabricated drainage structure may be used. A pre-fabricated drainage structure is a plastic drainage core or mesh which is covered with filter fabric to prevent soil intrusion, and is fastened to the wall prior to placing backfill.

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	Thicknesses [1]
ACC over aggregate base	2 inches ACC surface 4 inches ACC base 6 inches aggregate base with Geogrid [2] (MoDOT Type 5 or similar)
PCC	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.
2. The City of Lee's Summit has minimum standards for pavement subgrades that include either geogrid reinforcement or chemical stabilization. Our recommended pavement sections include geogrid reinforcement. Chemical stabilization recommendations can be provided upon request.

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.

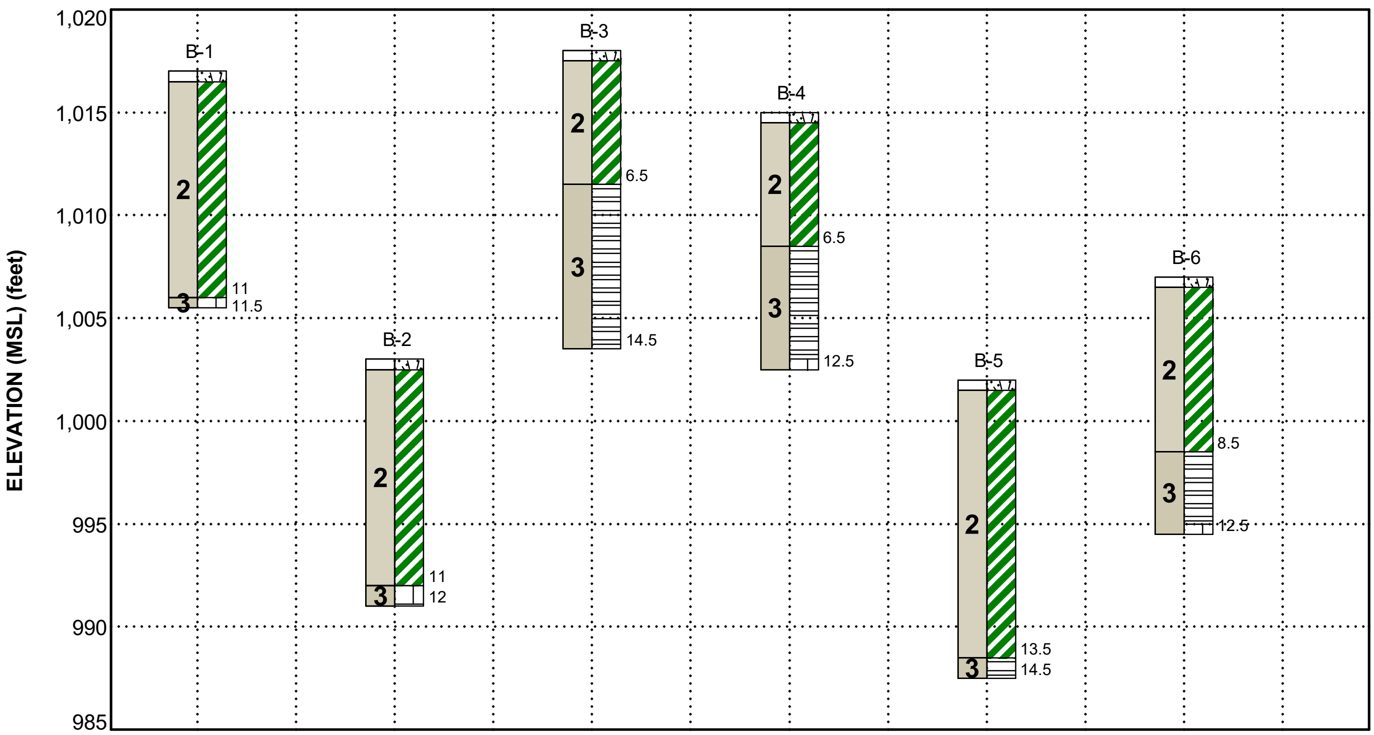
FIGURES

Contents:

GeoModel

GEOMODEL

Tudor Road Apartments ■ Lee's Summit, Missouri
Terracon Project No. 02225125



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	Existing Fill	Fat clay with gravel
2	Residual Clay	Fat clay, medium stiff to very stiff
3	Bedrock	Highly to slightly weathered shale and limestone

LEGEND

Topsoil

Fat Clay

Limestone

Shale

First Water Observation

Groundwater levels are temporal. The levels shown are representative of the date and time of our exploration. Significant changes are possible over time.
Water levels shown are as measured during and/or after drilling. In some cases, boring advancement methods mask the presence/absence of groundwater. See individual logs for details.

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 precision of ±20 feet. Ground surface elevations indicated on the boring logs were interpolated to the nearest foot from the provided topographic site plan. The locations and elevations of the borings should be considered accurate only to the degree implied by the means and methods used to define them.

The borings were drilled with track-mounted and ATV-mounted, rotary drill rigs 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, unconfined compressive strength, and Atterberg limits. 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. Rock core samples and petrographic analysis may indicate other rock types.

SITE LOCATION AND EXPLORATION PLANS

Contents:

Site Location Plan
Exploration Plan (2 pages)

Note: All attachments are one page unless noted above.

SITE LOCATION

Tudor Road Apartments ■ Lee's Summit, Missouri
June 10, 2022 ■ Terracon Project No. 02225125

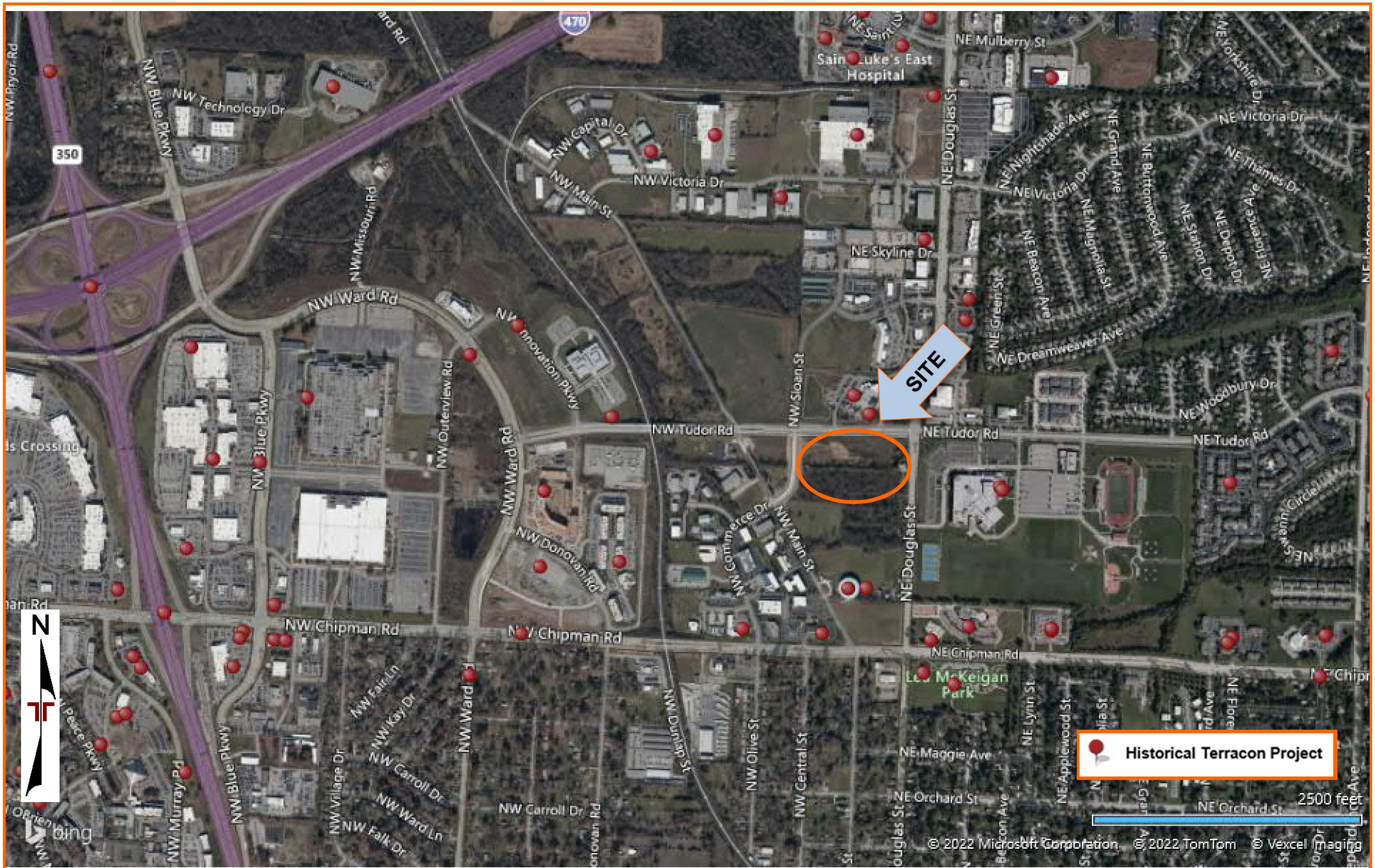


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

EXPLORATION PLAN

Tudor Road Apartments ■ Lee's Summit, Missouri

June 10, 2022 ■ Terracon Project No. 02225125

Terracon GeoReport

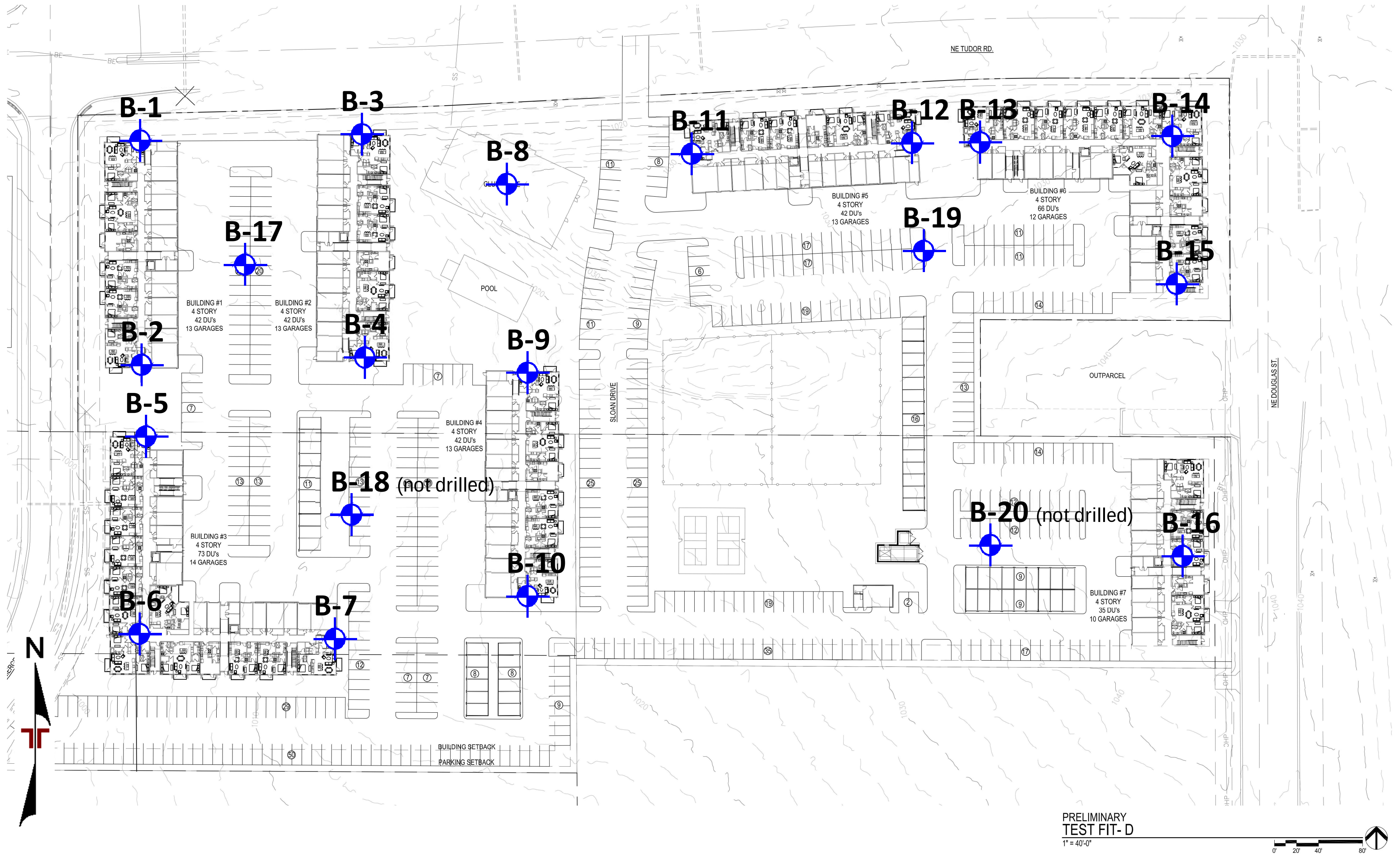


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

EXPLORATION PLAN

Tudor Road Apartments ■ Lee's Summit, Missouri
June 10, 2022 ■ Terracon Project No. 02225125

Terracon GeoReport

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-20)
Atterberg Limits
Unconfined Compressive Strength (8 pages)

Note: All attachments are one page unless noted above.

BORING LOG NO. B-1

PROJECT: Tudor Road Apartments

CLIENT: Cityscape Residential, LLC
Carmel, Indiana

SITE: NE Tudor Road and NW Commerce Drdive
Lee's Summit, Missouri

LOCATION See Exploration Plan

Latitude: 38.9305° Longitude: -94.3832°

Approximate Surface Elev.: 1017 (Ft.) +/-

MODEL LAYER	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
	0.5	**6" ROOT ZONE**	1016.5+/-									
2		**FAT CLAY (CH)**, brown and gray, stiff to very stiff				Split spoon	12	3-4-4 N=8		31.0		71-25-46
						Shelby tube	18		4290	25.9	100	
		shaley below 6.5 feet		5		Split spoon	12	4-6-7 N=13		24.7		
						Split spoon	12	4-7-8 N=15		20.0		
	11.0		1006+/-	10								
3	11.5	**LIMESTONE**, gray, highly weathered	1005.5+/-									
		Auger Refusal at 11.5 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 were interpolated from a topographic site plan.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
15620 W 113th St
Lenexa, KS

Boring Started: 05-16-2022	Boring Completed: 05-16-2022
Drill Rig: 850X	Driller: DB
Project No.: 02225125	

BORING LOG NO. B-2

PROJECT: Tudor Road Apartments

CLIENT: Cityscape Residential, LLC Carmel, Indiana

SITE: NE Tudor Road and NW Commerce Drdive Lee's Summit, Missouri

LOCATION See Exploration Plan

Latitude: 38.9299° Longitude: -94.3832°

Approximate Surface Elev.: 1003 (Ft.) +/-

MODEL LAYER	DEPTH	DESCRIPTION	ELEVATION (Ft.)
	0.5	**6" ROOT ZONE**	1002.5+/-
2	11.0	**FAT CLAY (CH)**, brown and gray, medium stiff to stiff	992+/-
3	12.0	**LIMESTONE**, gray, highly weathered	991+/-
		Auger Refusal at 12 Feet	

DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
		X	12	2-3-4 N=7		28.8		
		X	12	2-3-5 N=8		25.9		
5								
		X	12	3-3-5 N=8		26.7		
		X	12	3-5-3 N=8		24.2		
10								

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 were interpolated from a topographic site plan

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
15620 W 113th St
Lenexa, KS

Boring Started: 05-17-2022	Boring Completed: 05-17-2022
Drill Rig: 850X	Driller: DB
Project No.: 02225125	

BORING LOG NO. B-3

PROJECT: Tudor Road Apartments

CLIENT: Cityscape Residential, LLC
Carmel, Indiana

SITE: NE Tudor Road and NW Commerce Drdive
Lee's Summit, Missouri

LOCATION See Exploration Plan

Latitude: 38.9304° Longitude: -94.3825°

Approximate Surface Elev.: 1018 (Ft.) +/-

MODEL LAYER	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
	0.5	**6" ROOT ZONE**	1017.5+/-									
2		**FAT CLAY (CH)**, brown, stiff										
						Split spoon	12	3-4-4 N=8		28.3		
						Shelby tube	12		3590	30.3	96	
	6.5		1011.5+/-	5								
3		**SHALE**, light brown, highly to moderately weathered										
						Split spoon	12	3-4-7 N=11		33.7		
						Split spoon	12	4-10-19 N=29		19.7		
				10								
	14.5		1003.5+/-			Split spoon	10	10-50/5"		18.2		
		Boring Terminated at 14.5 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 were interpolated from a topographic site plan

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
15620 W 113th St
Lenexa, KS

Boring Started: 05-16-2022	Boring Completed: 05-16-2022
Drill Rig: 850X	Driller: DB
Project No.: 02225125	

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 02225125 TUDOR ROAD APARTM.GPJ TERRACON_DATATEMPLATE.GDT 6/9/22

BORING LOG NO. B-4

PROJECT: Tudor Road Apartments

CLIENT: Cityscape Residential, LLC
Carmel, Indiana

SITE: NE Tudor Road and NW Commerce Drdive
Lee's Summit, Missouri

LOCATION See Exploration Plan

Latitude: 38.9299° Longitude: -94.3825°

Approximate Surface Elev.: 1015 (Ft.) +/-

MODEL LAYER	DEPTH	DESCRIPTION	ELEVATION (Ft.)
	0.5	**6" ROOT ZONE**	1014.5+/-
2	6.5	**FAT CLAY (CH)**, brown and gray, medium stiff to stiff	1008.5+/-
3	12.0	**SHALE**, light brown and gray, highly to moderately weathered	1003+/-
	12.5	**LIMESTONE**, gray, slightly weathered	1002.5+/-

Auger Refusal at 12.5 Feet

DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
1.5–3		X	12	2-2-3 N=5		26.8		68-18-50
3.5–5		X	12	3-3-5 N=8		27.4		
6.5–8		X	12	9-16-23 N=39		16.6		
8.5–10		X	12	15-35-50 N=85		12.7		

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 were interpolated from a topographic site plan.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
15620 W 113th St
Lenexa, KS

Boring Started: 05-17-2022	Boring Completed: 05-17-2022
Drill Rig: 850X	Driller: DB
Project No.: 02225125	

BORING LOG NO. B-5

PROJECT: Tudor Road Apartments

CLIENT: Cityscape Residential, LLC
Carmel, Indiana

SITE: NE Tudor Road and NW Commerce Drdive
Lee's Summit, Missouri

LOCATION See Exploration Plan

Latitude: 38.9297° Longitude: -94.3832°

Approximate Surface Elev.: 1002 (Ft.) +/-

MODEL LAYER	DEPTH	DESCRIPTION	ELEVATION (Ft.)
	0.5	**6" ROOT ZONE**	1001.5+/-
2	13.5	**FAT CLAY (CH)**, brown and gray, medium stiff to stiff	988.5+/-
3	14.5	**SHALE**, gray, highly weathered	987.5+/-
		Boring Terminated at 14.5 Feet	

RECOVERY (In.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
12	2-3-3 N=6		29.1		
12		3790	26.3	99	
12	2-4-6 N=10		23.8		
12	2-4-5 N=9		26.4		
8	28-50/3"		10.0		

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 were interpolated from a topographic site plan

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
15620 W 113th St
Lenexa, KS

Boring Started: 05-17-2022	Boring Completed: 05-17-2022
Drill Rig: 850X	Driller: DB
Project No.: 02225125	

BORING LOG NO. B-6

PROJECT: Tudor Road Apartments

CLIENT: Cityscape Residential, LLC Carmel, Indiana

SITE: NE Tudor Road and NW Commerce Drdive Lee's Summit, Missouri

LOCATION See Exploration Plan

Latitude: 38.9292° Longitude: -94.3832°

Approximate Surface Elev.: 1007 (Ft.) +/-

MODEL LAYER	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
	0.5	**6" ROOT ZONE**	1006.5+/-									
2		**FAT CLAY (CH)**, brown, stiff				X	8	3-4-4 N=8		27.7		
						X	12	3-4-5 N=9		22.3		
				5								
						X	12	5-5-8 N=13		27.1		
	8.5		998.5+/-									
3		**SHALE**, sandy, light brown, highly weathered				X	6	50/6"		10.8		
				10								
	12.0		995+/-									
	12.5	**LIMESTONE**, gray, highly weathered	994.5+/-									
		Auger Refusal at 12.5 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 were interpolated from a topographic site plan

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
15620 W 113th St
Lenexa, KS

Boring Started: 05-27-2022	Boring Completed: 05-27-2022
Drill Rig: 550X	Driller: DB
Project No.: 02225125	

BORING LOG NO. B-7

PROJECT: Tudor Road Apartments

CLIENT: Cityscape Residential, LLC
Carmel, Indiana

SITE: NE Tudor Road and NW Commerce Drdive
Lee's Summit, Missouri

LOCATION See Exploration Plan

Latitude: 38.9292° Longitude: -94.3826°

Approximate Surface Elev.: 1011 (Ft.) +/-

MODEL LAYER	DEPTH	DESCRIPTION	ELEVATION (Ft.)
	0.5	**6" ROOT ZONE**	1010.5+/-
2	6.5	**FAT CLAY (CH)**, brown, medium stiff to stiff	1004.5+/-
3	14.5	**SHALE**, light brown, highly to moderately weathered	996.5+/-
		Boring Terminated at 14.5 Feet	

SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
Split spoon	12	2-3-4 N=7		27.8		
Shelby tube	9		3770	27.9	94	
Split spoon	12	3-13-18 N=31		20.5		
Split spoon	10	22-50/6"		12.2		
Split spoon	6	42-50/3"		9.4		

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 were interpolated from a topographic site plan.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
15620 W 113th St
Lenexa, KS

Boring Started: 05-27-2002	Boring Completed: 05-27-2022
Drill Rig: 550X	Driller: DB
Project No.: 02225125	

BORING LOG NO. B-8

PROJECT: Tudor Road Apartments

CLIENT: Cityscape Residential, LLC
Carmel, Indiana

SITE: NE Tudor Road and NW Commerce Drdive
Lee's Summit, Missouri

LOCATION See Exploration Plan

Latitude: 38.9303° Longitude: -94.3820°

Approximate Surface Elev.: 1029 (Ft.) +/-

MODEL LAYER	DEPTH	MATERIAL DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
	0.5	**6" ROOT ZONE**	1028.5+/-									
1		**FILL - FAT CLAY**, trace gravel, brown and gray				X	12	2-1-2 N=3		31.7		
						X	12	2-4-5 N=9		27.8		
				5								
	6.5		1022.5+/-									
2		**FAT CLAY (CH)**, brown, stiff				X	12	3-4-5 N=9		28.5		
						X	12	3-3-5 N=8		27.9		
				10								
	13.5		1015.5+/-		▽							
3		**SHALE**, gray, highly weathered				X	10	30-6-11 N=17		20.9		
	15.0		1014+/-	15								
		Boring Terminated at 15 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 were interpolated from a topographic site plan

Notes:

WATER LEVEL OBSERVATIONS

▽ *13.5 feet while drilling*

Terracon
15620 W 113th St
Lenexa, KS

Boring Started: 05-16-2022	Boring Completed: 05-16-2022
Drill Rig: 850X	Driller: DB
Project No.: 02225125	

BORING LOG NO. B-9

PROJECT: Tudor Road Apartments

CLIENT: Cityscape Residential, LLC
Carmel, Indiana

SITE: NE Tudor Road and NW Commerce Drdive
Lee's Summit, Missouri

LOCATION See Exploration Plan

Latitude: 38.9298° Longitude: -94.3820°

Approximate Surface Elev.: 1019 (Ft.) +/-

MODEL LAYER	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
	0.5	**6" ROOT ZONE**	1018.5+/-									
2		**FAT CLAY (CH)**, brown, stiff				Split spoon	12	2-3-5 N=8		27.4		60-24-36
						Shelby tube	10		3700	24.6	100	
				5	▽							
	7.0		1012+/-									
3		**LIMESTONE**, gray, highly weathered				Split spoon	11	10-50/5"		50.3		
	8.5		1010.5+/-									
		at 8.5 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 were interpolated from a topographic site plan

Notes:

WATER LEVEL OBSERVATIONS

▽ *6.5 feet while drilling*

Terracon
15620 W 113th St
Lenexa, KS

Boring Started: 05-16-2022	Boring Completed: 05-16-2022
Drill Rig: 850X	Driller: DB
Project No.: 02225125	

BORING LOG NO. B-10

PROJECT: Tudor Road Apartments

CLIENT: Cityscape Residential, LLC
Carmel, Indiana

SITE: NE Tudor Road and NW Commerce Drdive
Lee's Summit, Missouri

LOCATION See Exploration Plan

Latitude: 38.9293° Longitude: -94.3820°

Approximate Surface Elev.: 1020 (Ft.) +/-

MODEL LAYER	GRAPHIC LOG	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
		0.5	**6" ROOT ZONE**	1019.5+/-									
2			**FAT CLAY (CH)**, brown, stiff				X	10	2-3-5 N=8		30.9		
							X	12	2-4-5 N=9		26.3		
					5								
							X	12	3-3-5 N=8		35.2		
						▽							
		9.0		1011+/-			X	10	5-50/6"		70.7		
3			**LIMESTONE**, gray, highly weathered										
		10.0		1010+/-	10								
			Auger Refusal at 10 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 were interpolated from a topographic site plan

Notes:

WATER LEVEL OBSERVATIONS

▽ *8.5 feet while drilling*

Terracon
15620 W 113th St
Lenexa, KS

Boring Started: 05-27-2002	Boring Completed: 05-27-2022
Drill Rig: 550X	Driller: DB
Project No.: 02225125	

BORING LOG NO. B-11

PROJECT: Tudor Road Apartments

CLIENT: Cityscape Residential, LLC
Carmel, Indiana

SITE: NE Tudor Road and NW Commerce Drdive
Lee's Summit, Missouri

LOCATION See Exploration Plan

Latitude: 38.9304° Longitude: -94.3814°

Approximate Surface Elev.: 1029 (Ft.) +/-

MODEL LAYER	GRAPHIC LOG	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
		0.5	**6" ROOT ZONE**	1028.5+/-									
2			**FAT CLAY (CH)**, brown and gray, medium stiff to stiff					12	2-3-3 N=6		29.5		60-24-36
								11		3220	30.9	91	
					5								
								12	2-3-4 N=7		28.8		
								12	2-3-3 N=6		47.5		
					10								
		13.5		1015.5+/-									
3			**SHALE**, gray, highly weathered					12	15-19-12 N=31		15.7		
		15.0		1014+/-	15								
			Boring Terminated at 15 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 were interpolated from a topographic site plan

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
15620 W 113th St
Lenexa, KS

Boring Started: 05-16-2022	Boring Completed: 05-16-2022
Drill Rig: 850X	Driller: DB
Project No.: 02225125	

BORING LOG NO. B-12

PROJECT: Tudor Road Apartments

CLIENT: Cityscape Residential, LLC
Carmel, Indiana

SITE: NE Tudor Road and NW Commerce Drdive
Lee's Summit, Missouri

LOCATION See Exploration Plan

Latitude: 38.9304° Longitude: -94.3807°

Approximate Surface Elev.: 1033 (Ft.) +/-

MODEL LAYER	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
	0.5	**6" ROOT ZONE**	1032.5+/-									
2		**FAT CLAY (CH)**, brown and gray, stiff										
						X	12	3-3-5 N=8		30.6		
						X	12	2-4-4 N=8		22.7		
				5								
						X	12	3-4-4 N=8		26.3		
		medium stiff at 8.5 feet				X	12	3-3-4 N=7		26.9		
	11.0		1022+/-	10								
3	11.5	**LIMESTONE**, gray, highly weathered	1021.5+/-									
		Auger Refusal at 11.5 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 were interpolated from a topographic site plan

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
15620 W 113th St
Lenexa, KS

Boring Started: 05-16-2022	Boring Completed: 05-16-2022
Drill Rig: 850X	Driller: DB
Project No.: 02225125	

BORING LOG NO. B-13

PROJECT: Tudor Road Apartments

CLIENT: Cityscape Residential, LLC
Carmel, Indiana

SITE: NE Tudor Road and NW Commerce Drdive
Lee's Summit, Missouri

LOCATION See Exploration Plan

Latitude: 38.9304° Longitude: -94.3805°

Approximate Surface Elev.: 1033 (Ft.) +/-

MODEL LAYER	GRAPHIC LOG	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
		0.5	**6" ROOT ZONE**	1032.5+/-									
2			**FAT CLAY (CH)**, brown and gray, medium stiff to stiff				Split spoon	12	2-3-4 N=7		28.8		
2			very stiff at 3 feet				Shelby tube	13		4880	23.0	102	
2					5								
2							Split spoon	12	3-4-4 N=8		30.0		
2							Split spoon	12	2-3-5 N=8		25.2		
2		13.5		1019.5+/-	10								
			SHALE, gray, highly weathered				Split spoon	12	7-9-15 N=24		20.0		
		15.0		1018+/-	15								
			Boring Terminated at 15 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 were interpolated from a topographic site plan

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
15620 W 113th St
Lenexa, KS

Boring Started: 05-16-2022	Boring Completed: 05-16-2022
Drill Rig: 850X	Driller: DB
Project No.: 02225125	

BORING LOG NO. B-14

PROJECT: Tudor Road Apartments

CLIENT: Cityscape Residential, LLC
Carmel, Indiana

SITE: NE Tudor Road and NW Commerce Drdive
Lee's Summit, Missouri

LOCATION See Exploration Plan

Latitude: 38.9304° Longitude: -94.3799°

Approximate Surface Elev.: 1030 (Ft.) +/-

MODEL LAYER	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
	0.5	**6" ROOT ZONE**	1029.5+/-									
2		**FAT CLAY (CH)**, brown and gray, medium stiff to stiff				X	12	2-3-4 N=7		30.5		
						X	12	2-3-4 N=7		22.3		
				5								
						X	12	3-3-5 N=8		35.4		
						X	12	3-5-5 N=10		24.6		
				10								
	13.5		1016.5+/-									
3	15.0	**SHALE**, gray, highly weathered	1015+/-			X	12	14-22-30 N=52		16.3		
		Boring Terminated at 15 Feet		15								

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 were interpolated from a topographic site plan

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
15620 W 113th St
Lenexa, KS

Boring Started: 05-16-2022	Boring Completed: 05-16-2022
Drill Rig: 850X	Driller: DB
Project No.: 02225125	

BORING LOG NO. B-15

PROJECT: Tudor Road Apartments

CLIENT: Cityscape Residential, LLC
Carmel, Indiana

SITE: NE Tudor Road and NW Commerce Drdive
Lee's Summit, Missouri

LOCATION See Exploration Plan

Latitude: 38.9300° Longitude: -94.3799°

Approximate Surface Elev.: 1037 (Ft.) +/-

MODEL LAYER	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
	0.5	**6" ROOT ZONE**	1036.5+/-									
2		**LEAN TO FAT CLAY (CL/CH)**, brown and gray, stiff					8	4-4-4 N=8		23.8		48-22-26
	3.0		1034+/-									
		FAT CLAY (CH), brown and gray, very stiff					15		5340	27.3	98	
				5								
		stiff at 6.5 feet					12	3-5-6 N=11		25.2		
		medium stiff at 8.5 feet					12	2-3-3 N=6		31.4		
				10								
		stiff at 13.5 feet					12	2-3-7 N=10		35.8		
	15.0		1022+/-	15								
		Boring Terminated at 15 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 were interpolated from a topographic site plan

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
15620 W 113th St
Lenexa, KS

Boring Started: 05-16-2022	Boring Completed: 05-16-2022
Drill Rig: 850X	Driller: DB
Project No.: 02225125	

BORING LOG NO. B-16

PROJECT: Tudor Road Apartments

CLIENT: Cityscape Residential, LLC
Carmel, Indiana

SITE: NE Tudor Road and NW Commerce Drdive
Lee's Summit, Missouri

LOCATION See Exploration Plan

Latitude: 38.9293° Longitude: -94.3799°

Approximate Surface Elev.: 1042 (Ft.) +/-

MODEL LAYER	GRAPHIC LOG	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
		0.5	**6" ROOT ZONE**	1041.5+/-									
2			**FAT CLAY (CH)**, brown, stiff				X	12	3-5-5 N=10		26.7		
			medium stiff at 3.5 feet				X	10	2-3-4 N=7		25.0		
					5								
		8.5		1033.5+/-			X	12	3-4-5 N=9		23.9		
3			**SHALE**, light brown, highly weathered				X	12	3-5-15 N=20		16.5		
					10								
		15.0		1027+/-	15		X	12	5-9-13 N=22		21.8		
			Boring Terminated at 15 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 were interpolated from a topographic site plan

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
15620 W 113th St
Lenexa, KS

Boring Started: 05-27-2002	Boring Completed: 05-27-2022
Drill Rig: 550X	Driller: DB
Project No.: 02225125	

BORING LOG NO. B-17

PROJECT: Tudor Road Apartments

CLIENT: Cityscape Residential, LLC
Carmel, Indiana

SITE: NE Tudor Road and NW Commerce Drdive
Lee's Summit, Missouri

LOCATION See Exploration Plan

Latitude: 38.9301° Longitude: -94.3828°

Approximate Surface Elev.: 1010 (Ft.) +/-

MODEL LAYER	GRAPHIC LOG	DEPTH	DESCRIPTION	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
		0.5	**6" ROOT ZONE**	1009.5+/-									
2			**FAT CLAY (CH)**, brown, medium stiff to stiff										
							X	12	3-3-3 N=6		28.8		
							X	12	3-4-5 N=9		25.4		
		5.0		1005+/-	5								
			Boring Terminated at 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 were interpolated from a topographic site plan

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
15620 W 113th St
Lenexa, KS

Boring Started: 05-17-2022	Boring Completed: 05-17-2022
Drill Rig: 850X	Driller: DB
Project No.: 02225125	

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 02225125 TUDOR ROAD APARTM.GPJ TERRACON_DATATEMPLATE.GDT 6/9/22

BORING LOG NO. B-18

PROJECT: Tudor Road Apartments

CLIENT: Cityscape Residential, LLC
Carmel, Indiana

SITE: NE Tudor Road and NW Commerce Drdive
Lee's Summit, Missouri

MODEL LAYER	GRAPHIC LOG	LOCATION See Exploration Plan Latitude: 38.9295° Longitude: -94.3825° DEPTH ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
		THIS BORING WAS DELETED FROM THE SUBSURFACE EXPLORATION									

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

Advancement Method:

Abandonment Method:

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.

Notes:

WATER LEVEL OBSERVATIONS

Terracon
15620 W 113th St
Lenexa, KS

Boring Started:	Boring Completed:
Drill Rig:	Driller:
Project No.: 02225125	

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 02225125 TUDOR ROAD APARTM.GPJ TERRACON_DATATEMPLATE.GDT 6/9/22

BORING LOG NO. B-19

PROJECT: Tudor Road Apartments

CLIENT: Cityscape Residential, LLC
Carmel, Indiana

SITE: NE Tudor Road and NW Commerce Drdive
Lee's Summit, Missouri

LOCATION See Exploration Plan

Latitude: 38.9301° Longitude: -94.3807°

Approximate Surface Elev.: 1030 (Ft.) +/-

MODEL LAYER	GRAPHIC LOG	DEPTH	ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
		0.5 **6" ROOT ZONE**	1029.5+/-									
2		**FAT CLAY (CH)**, brown, medium stiff										
						X	12	2-3-4 N=7		31.4		
						X	12	2-3-4 N=7		25.0		
		5.0	1025+/-	5								

Boring Terminated at 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 were interpolated from a topographic site plan

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

Terracon
15620 W 113th St
Lenexa, KS

Boring Started: 05-16-2022	Boring Completed: 05-16-2022
Drill Rig: 850X	Driller: DB
Project No.: 02225125	

BORING LOG NO. B-20

PROJECT: Tudor Road Apartments	**CLIENT: Cityscape Residential, LLC** **Carmel, Indiana**
SITE: NE Tudor Road and NW Commerce Drdive **Lee's Summit, Missouri**	

MODEL LAYER	GRAPHIC LOG	LOCATION See Exploration Plan Latitude: 38.9294° Longitude: -94.3805° DEPTH ELEVATION (Ft.)	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	UNCONFINED COMPRESSIVE STRENGTH (psf)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
		THIS BORING WAS DELETED FROM THE SUBSURFACE EXPLORATION									

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

Advancement Method:

Abandonment Method:

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.

Notes:

WATER LEVEL OBSERVATIONS

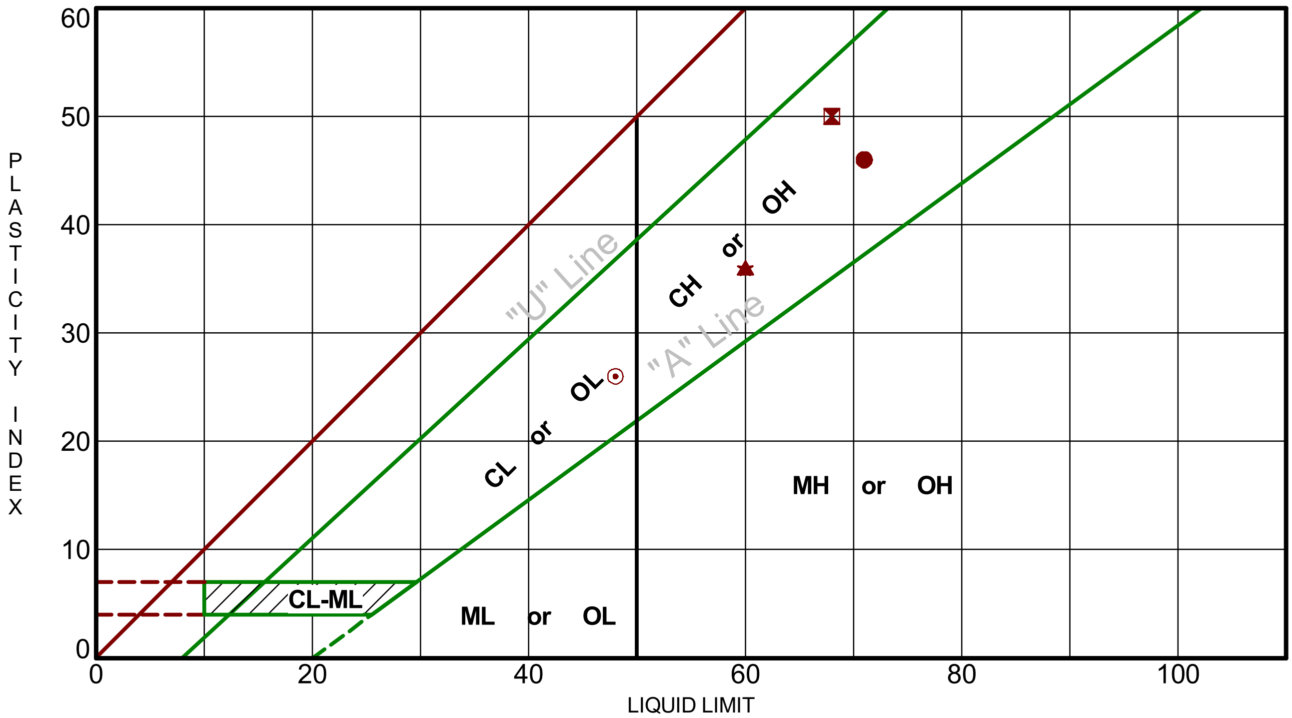
Terracon
15620 W 113th St
Lenexa, KS

Boring Started:	Boring Completed:
Drill Rig:	Driller:
Project No.: 02225125	

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL 02225125 TUDOR ROAD APARTM.GPJ TERRACON_DATATEMPLATE.GDT 6/9/22

ATTERBERG LIMITS RESULTS

ASTM D4318



	Boring ID	Depth (Ft)	LL	PL	PI	Fines	USCS	Description
●	B-1	1.5 - 3	71	25	46			
⧗	B-4	1.5 - 3	68	18	50			
▲	B-9	1.5 - 3	60	24	36			
★	B-11	1.5 - 3	60	24	36			
⊙	B-15	1.5 - 3	48	22	26			

PROJECT: Tudor Road Apartments

SITE: NE Tudor Road and NW Commerce Drdive
Lee's Summit, Missouri

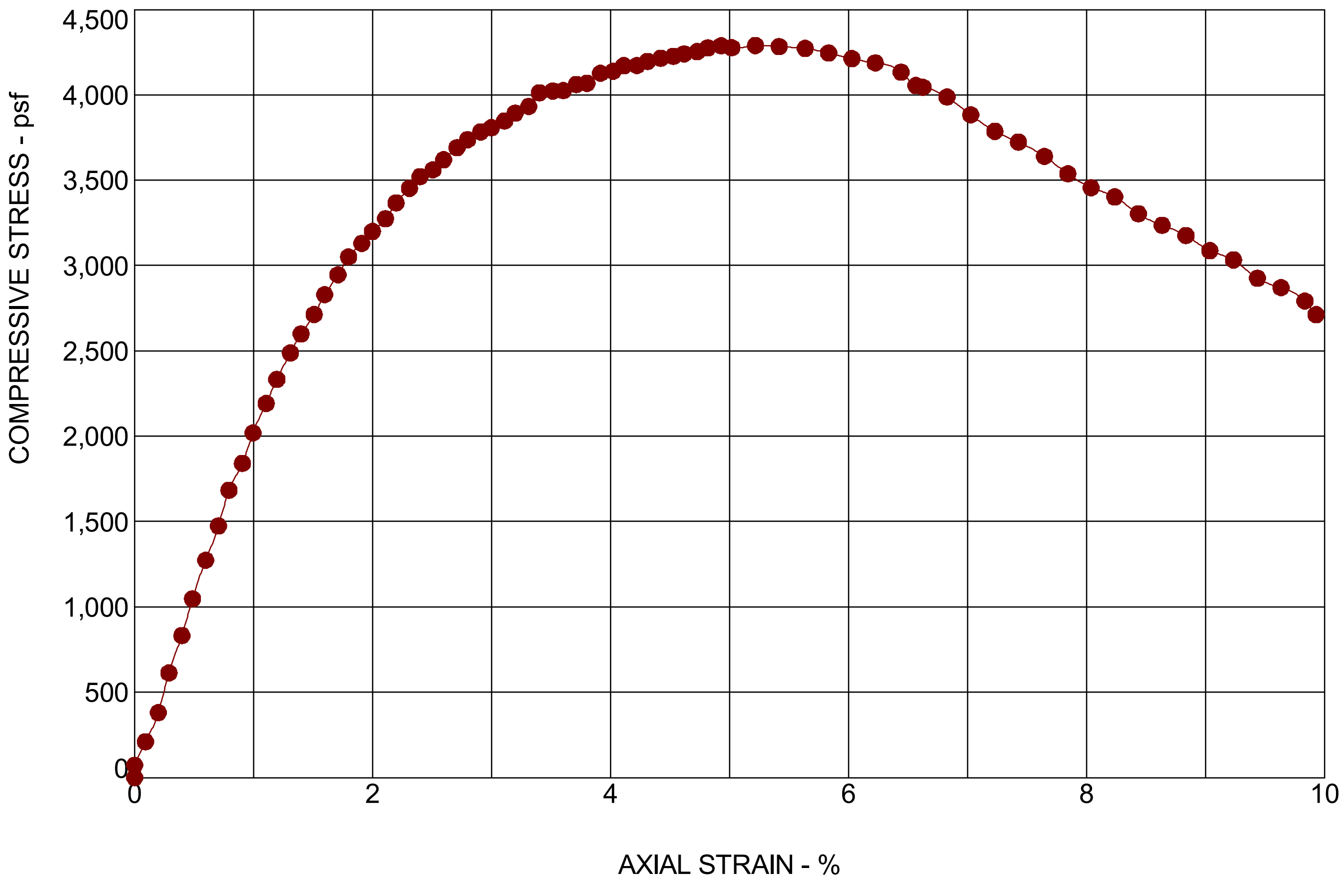
Terracon
15620 W 113th St
Lenexa, KS

PROJECT NUMBER: 02225125

CLIENT: Cityscape Residential, LLC
Carmel, Indiana

UNCONFINED COMPRESSION TEST

ASTM D2166



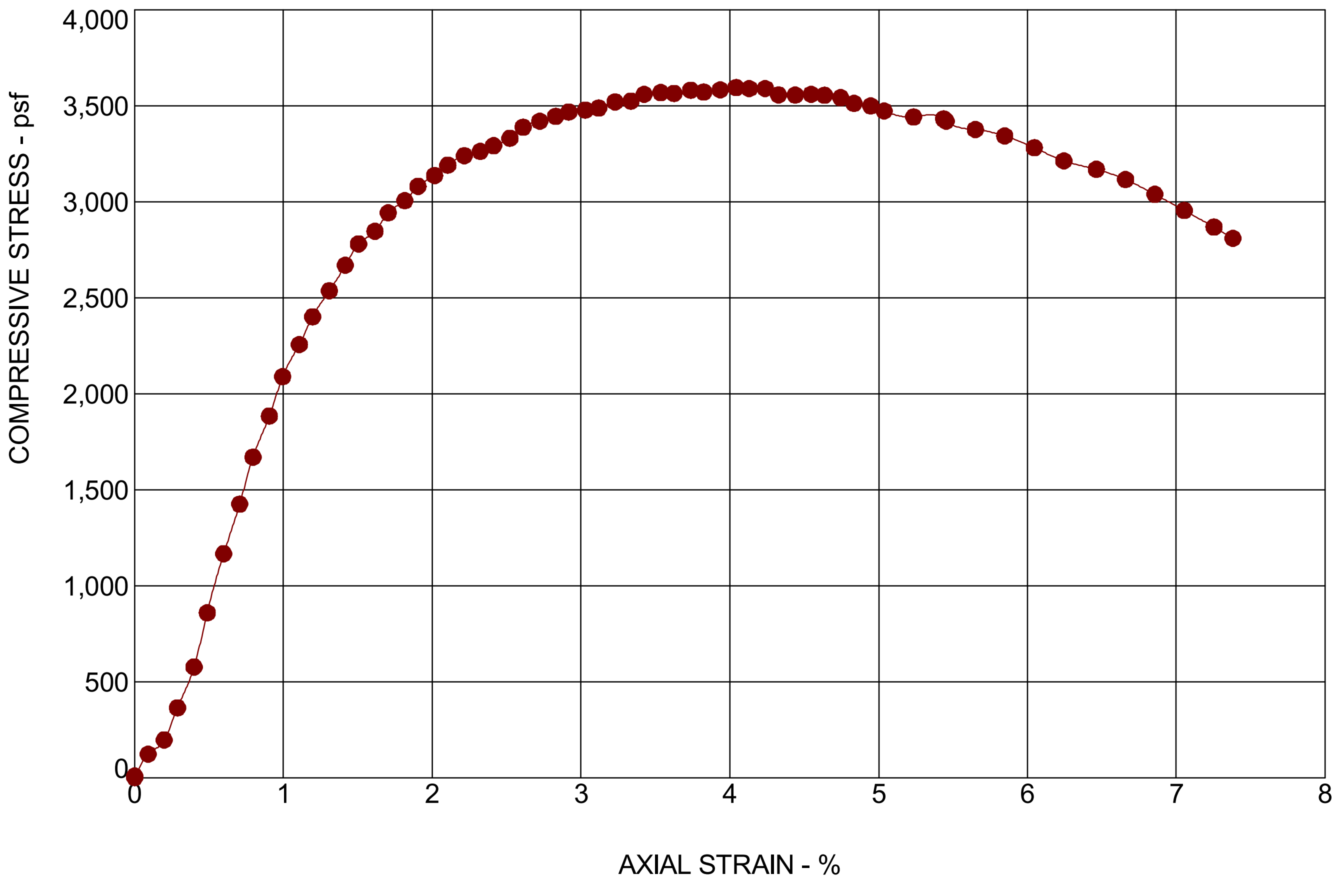
SPECIMEN FAILURE PHOTOGRAPH	SPECIMEN TEST DATA		
	Moisture Content:	%	25.9
	Dry Density:	pcf	100
	Diameter:	in.	2.80
	Height:	in.	5.81
	Height / Diameter Ratio:		2.08
	Calculated Saturation:	%	
	Calculated Void Ratio:		
	Assumed Specific Gravity:		
	Failure Strain:	%	5.22
	Unconfined Compressive Strength	(psf)	4289
	Undrained Shear Strength:	(psf)	2144
	Strain Rate:	in/min	0.1158
	Remarks:		

SAMPLE TYPE: Shelby Tube	SAMPLE LOCATION: B-1 @ 3 - 5 feet			
DESCRIPTION:	LL	PL	PI	Percent < #200 Sieve

PROJECT: Tudor Road Apartments	Terracon 15620 W 113th St Lenexa, KS	PROJECT NUMBER: 02225125
SITE: NE Tudor Road and NW Commerce Drdive Lee's Summit, Missouri		CLIENT: Cityscape Residential, LLC Carmel, Indiana

UNCONFINED COMPRESSION TEST

ASTM D2166



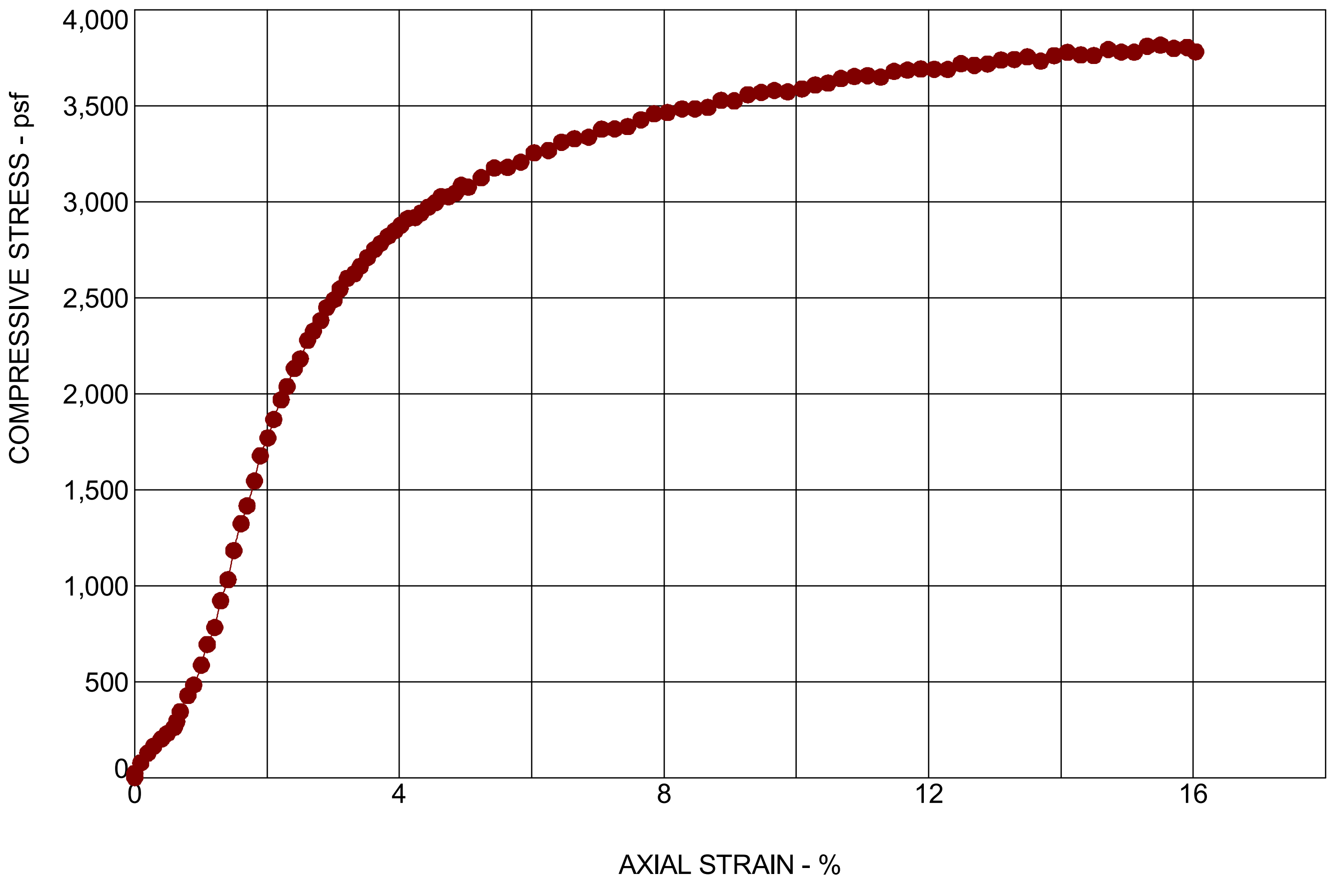
SPECIMEN FAILURE PHOTOGRAPH	SPECIMEN TEST DATA		
	Moisture Content:	%	30.3
	Dry Density:	pcf	96
	Diameter:	in.	2.84
	Height:	in.	5.88
	Height / Diameter Ratio:		2.07
	Calculated Saturation:	%	
	Calculated Void Ratio:		
	Assumed Specific Gravity:		
	Failure Strain:	%	4.04
	Unconfined Compressive Strength	(psf)	3594
	Undrained Shear Strength:	(psf)	1797
	Strain Rate:	in/min	0.1173
	Remarks:		

SAMPLE TYPE: Shelby Tube	SAMPLE LOCATION: B-3 @ 3 - 5 feet			
DESCRIPTION:	LL	PL	PI	Percent < #200 Sieve

PROJECT: Tudor Road Apartments	Terracon 15620 W 113th St Lenexa, KS	PROJECT NUMBER: 02225125
SITE: NE Tudor Road and NW Commerce Drdive Lee's Summit, Missouri		CLIENT: Cityscape Residential, LLC Carmel, Indiana

UNCONFINED COMPRESSION TEST

ASTM D2166



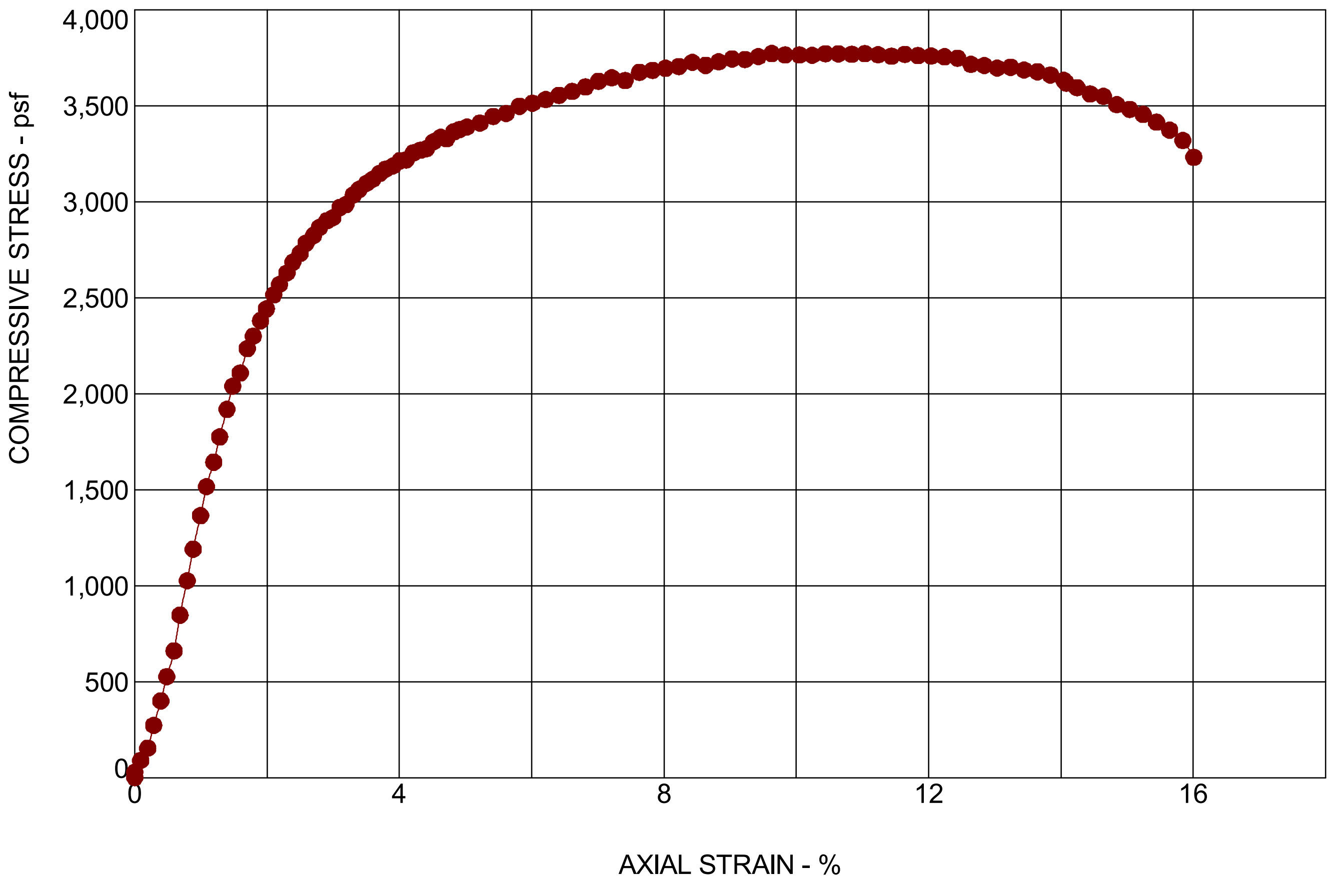
SPECIMEN FAILURE PHOTOGRAPH	SPECIMEN TEST DATA		
	Moisture Content:	%	26.3
	Dry Density:	pcf	99
	Diameter:	in.	2.81
	Height:	in.	5.76
	Height / Diameter Ratio:		2.05
	Calculated Saturation:	%	
	Calculated Void Ratio:		
	Assumed Specific Gravity:		
	Failure Strain:	%	14.72
	Unconfined Compressive Strength	(psf)	3792
	Undrained Shear Strength:	(psf)	1896
	Strain Rate:	in/min	0.1151
	Remarks:		

SAMPLE TYPE: Shelby Tube	SAMPLE LOCATION: B-5 @ 3 - 5 feet			
DESCRIPTION:	LL	PL	PI	Percent < #200 Sieve

PROJECT: Tudor Road Apartments	Terracon 15620 W 113th St Lenexa, KS	PROJECT NUMBER: 02225125
SITE: NE Tudor Road and NW Commerce Drdive Lee's Summit, Missouri		CLIENT: Cityscape Residential, LLC Carmel, Indiana

UNCONFINED COMPRESSION TEST

ASTM D2166



SPECIMEN FAILURE PHOTOGRAPH	SPECIMEN TEST DATA		
	Moisture Content:	%	27.9
	Dry Density:	pcf	94
	Diameter:	in.	2.84
	Height:	in.	5.73
	Height / Diameter Ratio:		2.02
	Calculated Saturation:	%	
	Calculated Void Ratio:		
	Assumed Specific Gravity:		
	Failure Strain:	%	9.63
	Unconfined Compressive Strength	(psf)	3771
	Undrained Shear Strength:	(psf)	1885
	Strain Rate:	in/min	0.1147
	Remarks:		

SAMPLE TYPE: Shelby Tube	SAMPLE LOCATION: B-7 @ 3 - 5 feet			
DESCRIPTION:	LL	PL	PI	Percent < #200 Sieve

PROJECT: Tudor Road Apartments

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Lee's Summit, Missouri

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Lenexa, KS

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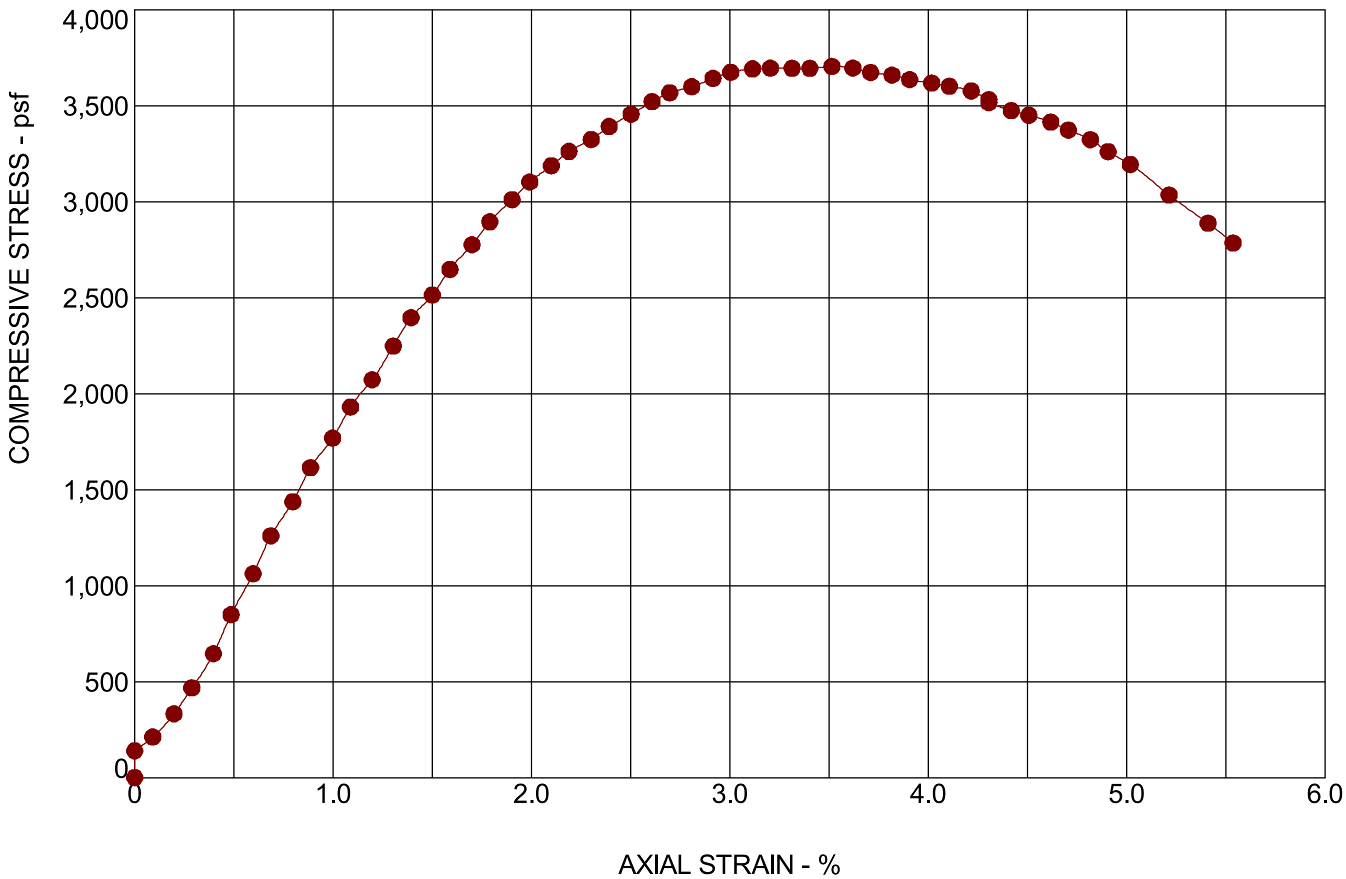
CLIENT: Cityscape Residential, LLC
Carmel, Indiana

UNCONFINED COMPRESSION TEST

ASTM D2166



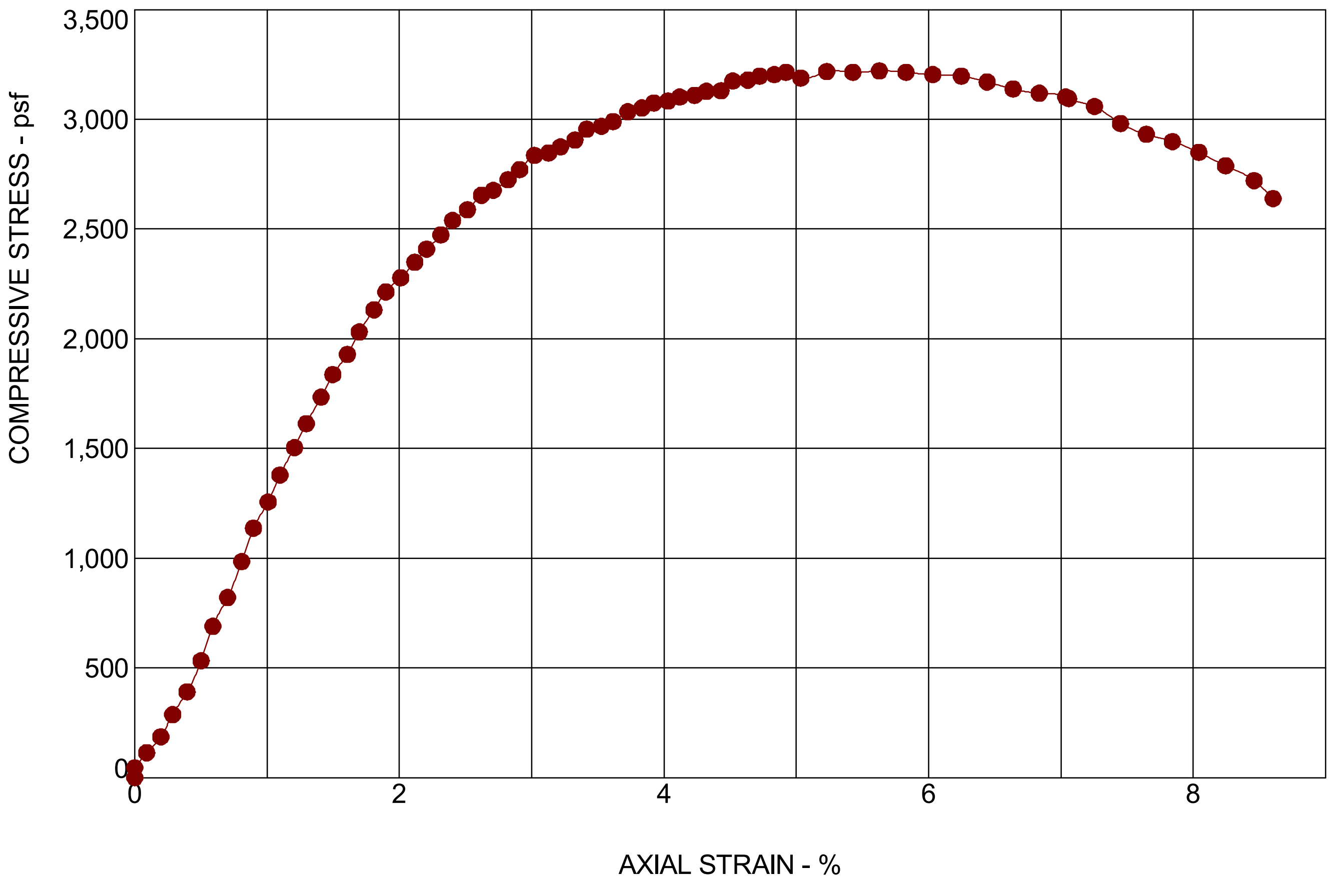
SPECIMEN FAILURE PHOTOGRAPH	SPECIMEN TEST DATA		
	Moisture Content:	%	24.6
	Dry Density:	pcf	100
	Diameter:	in.	2.82
	Height:	in.	5.81
	Height / Diameter Ratio:		2.06
	Calculated Saturation:	%	
	Calculated Void Ratio:		
	Assumed Specific Gravity:		
	Failure Strain:	%	3.51
	Unconfined Compressive Strength	(psf)	3704
	Undrained Shear Strength:	(psf)	1852
	Strain Rate:	in/min	0.1163
	Remarks:		

SAMPLE TYPE: Shelby Tube	SAMPLE LOCATION: B-9 @ 3 - 5 feet			
DESCRIPTION:	LL	PL	PI	Percent < #200 Sieve

PROJECT: Tudor Road Apartments	Terracon 15620 W 113th St Lenexa, KS	PROJECT NUMBER: 02225125
SITE: NE Tudor Road and NW Commerce Drdive Lee's Summit, Missouri		CLIENT: Cityscape Residential, LLC Carmel, Indiana

UNCONFINED COMPRESSION TEST

ASTM D2166



SPECIMEN FAILURE PHOTOGRAPH	SPECIMEN TEST DATA		
	Moisture Content:	%	30.9
	Dry Density:	pcf	91
	Diameter:	in.	2.83
	Height:	in.	5.15
	Height / Diameter Ratio:		1.82
	Calculated Saturation:	%	
	Calculated Void Ratio:		
	Assumed Specific Gravity:		
	Failure Strain:	%	5.63
	Unconfined Compressive Strength	(psf)	3220
	Undrained Shear Strength:	(psf)	1610
	Strain Rate:	in/min	0.1031
	Remarks:		

SAMPLE TYPE: Shelby Tube | SAMPLE LOCATION: B-11 @ 3 - 5 feet

DESCRIPTION:	LL	PL	PI	Percent < #200 Sieve

PROJECT: Tudor Road Apartments

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15620 W 113th St
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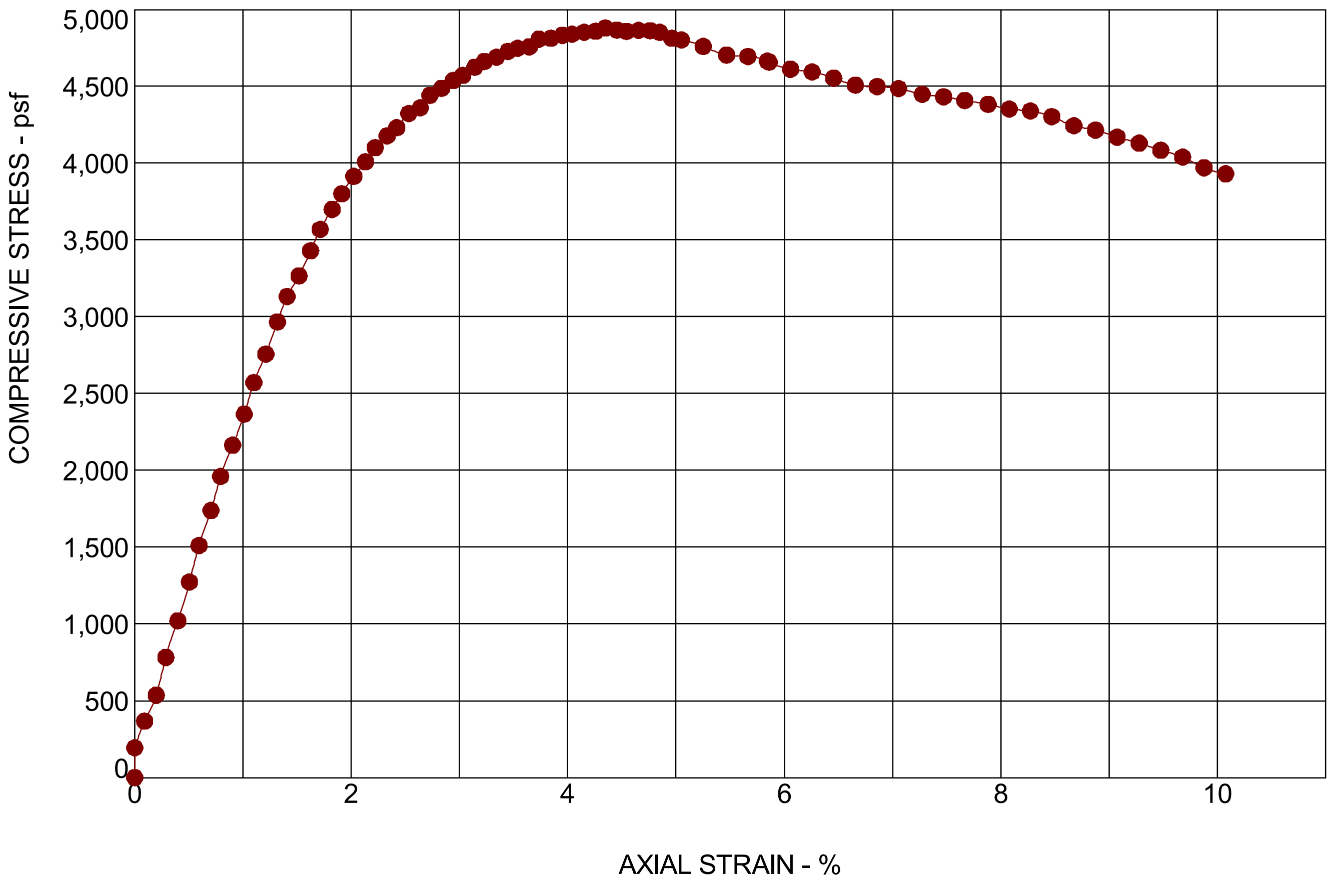
Carmel, Indiana

UNCONFINED COMPRESSION TEST

ASTM D2166



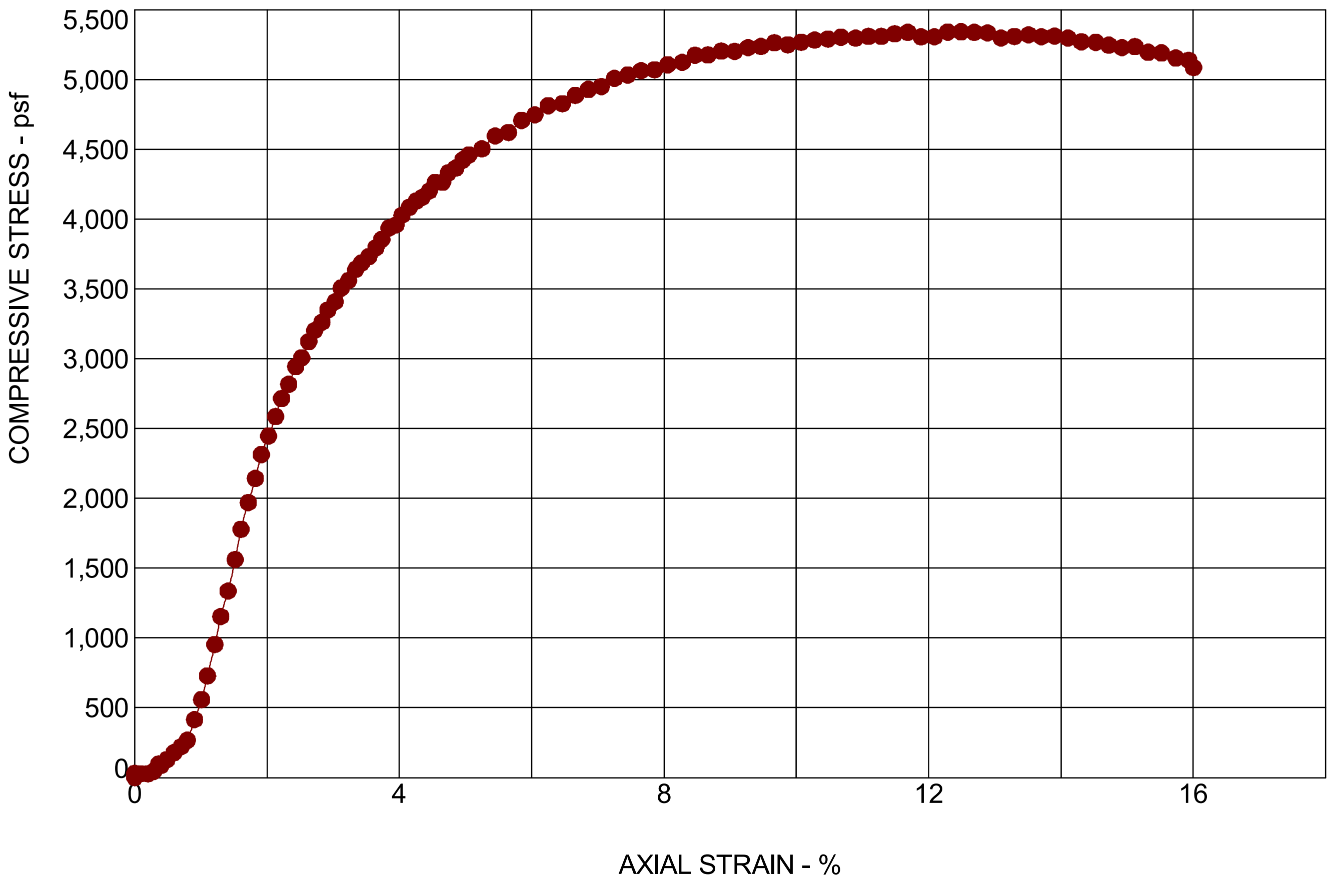
SPECIMEN FAILURE PHOTOGRAPH	SPECIMEN TEST DATA		
	Moisture Content:	%	23.0
	Dry Density:	pcf	102
	Diameter:	in.	2.82
	Height:	in.	5.85
	Height / Diameter Ratio:		2.07
	Calculated Saturation:	%	
	Calculated Void Ratio:		
	Assumed Specific Gravity:		
	Failure Strain:	%	4.35
	Unconfined Compressive Strength	(psf)	4879
	Undrained Shear Strength:	(psf)	2440
	Strain Rate:	in/min	0.1171
	Remarks:		

SAMPLE TYPE: Shelby Tube	SAMPLE LOCATION: B-13 @ 3 - 5 feet			
DESCRIPTION:	LL	PL	PI	Percent < #200 Sieve

PROJECT: Tudor Road Apartments	Terracon 15620 W 113th St Lenexa, KS	PROJECT NUMBER: 02225125
SITE: NE Tudor Road and NW Commerce Drdive Lee's Summit, Missouri		CLIENT: Cityscape Residential, LLC Carmel, Indiana

UNCONFINED COMPRESSION TEST

ASTM D2166



SPECIMEN FAILURE PHOTOGRAPH	SPECIMEN TEST DATA		
	Moisture Content:	%	27.3
	Dry Density:	pcf	98
	Diameter:	in.	2.74
	Height:	in.	5.75
	Height / Diameter Ratio:		2.10
	Calculated Saturation:	%	
	Calculated Void Ratio:		
	Assumed Specific Gravity:		
	Failure Strain:	%	12.49
	Unconfined Compressive Strength	(psf)	5341
	Undrained Shear Strength:	(psf)	2670
	Strain Rate:	in/min	0.1148
	Remarks:		

SAMPLE TYPE: Shelby Tube	SAMPLE LOCATION: B-15 @ 3 - 5 feet			
DESCRIPTION:	LL	PL	PI	Percent < #200 Sieve

PROJECT: Tudor Road Apartments

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15620 W 113th St
Lenexa, KS

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CLIENT: Cityscape Residential, LLC
Carmel, Indiana

SUPPORTING INFORMATION

Contents:

General Notes
Unified Soil Classification System
Description of Rock Properties

Note: All attachments are one page unless noted above.

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

Tudor Road Apartments ■ Lee's Summit, Missouri

Terracon Project No. 02225125

Terracon GeoReport

SAMPLING	WATER LEVEL	FIELD TESTS
Shelby Tube; Split Spoon	**Water Initially Encountered** **Water Level After a Specified Period of Time** **Water Level After a Specified Period of Time** **Cave In Encountered** 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.	**N** **Standard Penetration Test Resistance (Blows/Ft.)** **(HP)** **Hand Penetrometer** **(T)** **Torvane** **(DCP)** **Dynamic Cone Penetrometer** **UC** **Unconfined Compressive Strength** **(PID)** **Photo-Ionization Detector** **(OVA)** **Organic Vapor Analyzer**

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification as noted on the soil boring logs is based Unified Soil Classification System. Where sufficient laboratory data exist to classify the soils consistent with ASTM D2487 "Classification of Soils for Engineering Purposes" this procedure is used. ASTM D2488 "Description and Identification of Soils (Visual-Manual Procedure)" is also used to classify the soils, particularly where insufficient laboratory data exist to classify the soils in accordance with ASTM D2487. In addition to USCS classification, coarse grained soils are classified on the basis of their in-place relative density, and fine-grained soils are classified on the basis of their consistency. See "Strength Terms" table below for details. The ASTM standards noted above are for reference to methodology in general. In some cases, variations to methods are applied as a result of local practice or professional judgment.

LOCATION AND ELEVATION NOTES

Exploration point locations as shown on the Exploration Plan and as noted on the soil boring logs in the form of Latitude and Longitude are approximate. See Exploration and Testing Procedures in the report for the methods used to locate the exploration points for this project. 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		
Descriptive Term (Density)	**Standard Penetration or N-Value Blows/Ft.**	**Descriptive Term (Consistency)**	**Unconfined Compressive Strength Qu, (psf)**	**Standard Penetration or N-Value Blows/Ft.**
Very Loose	0 - 3	Very Soft	less than 500	0 - 1
Loose	4 - 9	Soft	500 to 1,000	2 - 4
Medium Dense	10 - 29	Medium Stiff	1,000 to 2,000	4 - 8
Dense	30 - 50	Stiff	2,000 to 4,000	8 - 15
Very Dense	> 50	Very Stiff	4,000 to 8,000	15 - 30
		Hard	> 8,000	> 30

RELEVANCE OF SOIL BORING LOG

The soil boring logs contained within this document are intended for application to the project as described in this document. Use of these soil boring logs for any other purpose may not be appropriate.

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]	$Cu \geq 4$ and $1 \leq Cc \leq 3$ [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]	$Cu \geq 6$ and $1 \leq Cc \leq 3$ [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	< 0.75	OL	Organic clay [K, L, M, N]
			Liquid limit - not dried			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	< 0.75	OH	Organic clay [K, L, M, P]
			Liquid limit - not dried			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] $Cu = D_{60}/D_{10}$ $\quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains $\geq$ 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 $\geq$ 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 $\geq$ 30% plus No. 200 predominantly sand, add “sandy” to group name.

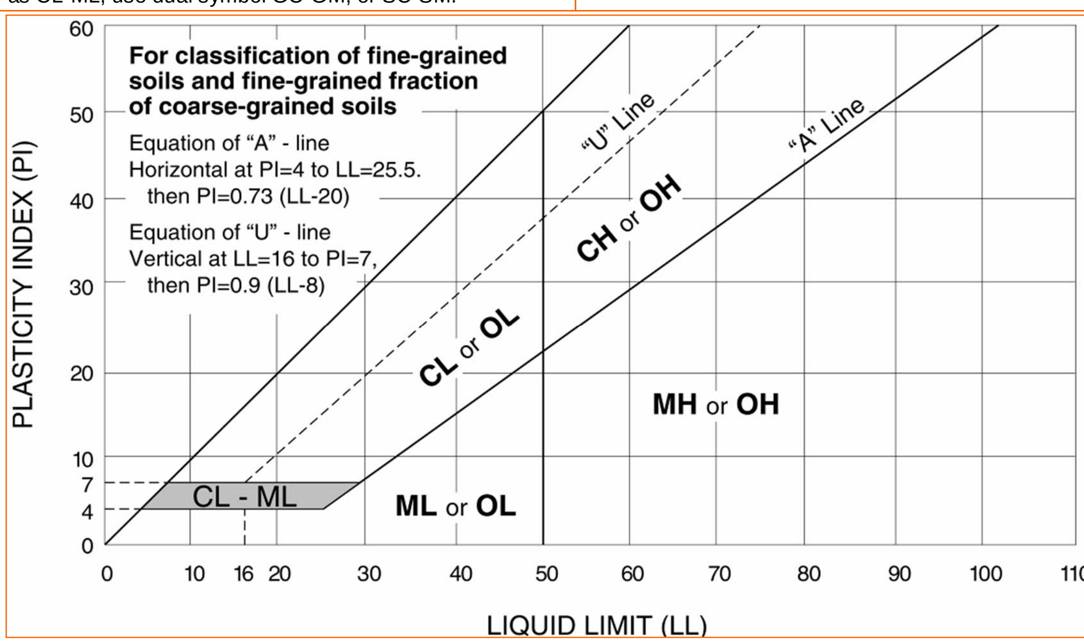
[M] If soil contains $\geq$ 30% plus No. 200, predominantly gravel, add “gravelly” to group name.

[N] $PI \geq 4$ 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