Crossroads Center
Preliminary Geotechnical Report

Prepared for

The Crossroads Center
311 Martin Luther King Drive E
Cincinnati, OH 45219

January 4, 2023

Project No. CN230236

CONSULTING SERVICES INCORPORATED
Geotechnical & Materials Engineering | IBC Special Inspection | Material Testing

January 4, 2023

The Crossroads Center
311 Martin Luther King Drive E
Cincinnati, Ohio 45219

Attention: Dr. Roberto Soria

Subject: **Preliminary Geotechnical Report for**
Crossroads Center
2114 Reading Road
Cincinnati, Ohio
CSI Project No. CN230236

Dear Dr. Soria,

Consulting Services Incorporated of Cincinnati (CSI) is pleased to present our preliminary geotechnical report for the Crossroads Center development in Cincinnati, Ohio. We provided our services in general accordance the CSI Proposal 8708, dated September 20, 2023.

Our report represents information provided to us, readily available published data relevant to the site and site area, our observations and subsurface conditions encountered and our opinion of primary geotechnical conditions (discussion and recommendations) affecting site work and foundation design for the project. At the time of this report, borings B-6 and B-7 could not be accessed due to the existing building. Once this building is demolished, CSI should perform the remaining borings to confirm the recommendations provided in this report.

Again, we greatly appreciate the opportunity to provide our services and look forward to working with you and the project team on this (and hopefully) more projects in the future. Please do not hesitate to contact us for questions or comments about the information contained herein.

Cordially,

Nick Koester, P.E.
Project Engineer

STATE OF OHIO
NICHOLAS
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REGISTERED
PROFESSIONAL ENGINEER

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Principal Geotechnical Engineer

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INTRODUCTION

1 SCOPE OF THE GEOTECHNICAL EXPLORATION

As proposed, CSI conducted a geotechnical exploration for the Crossroads Center development located at 2114 Reading Road in Cincinnati, Ohio. Our services included a review of the project information provided, conducting a subsurface exploration that utilized soil borings to obtain samples for modeling the soil conditions at the proposed development, an analysis of data and information obtained, providing foundation recommendations for the site conditions and providing recommendations for site earth work. At the time of our investigation, the existing building on the north end of the property had not yet been demolished and our two (2) planned borings were not able to be completed. In addition, grading and structural plans are in the preliminary stage and have not been provided at the time of this report. Once the building is razed, CSI should perform the remaining borings. CSI should also review the final grading plans and structural details once available. After each of these are complete, this report should be finalized. Recommendations provided herein are subject to change, pending review of the final design documents.

2 SITE AND PROJECT INFORMATION

In preparing for this report, CSI was provided with a site plan named “Site Plan Option 5D” dated August 21, 2023 along with a google maps satellite image showing the proposed site layout.. A summary of the site and project information is summarized in Tables 1 and 2 below.

Table 1: Site Information

Item	Description
Site Location	The site is located at 2114 Reading Road, Cincinnati, Ohio.
Size of Site	Total site area is approximately 1.4 acres.
Surrounding Area	The surrounding area is characterized by residential and commercial developments in all directions.
Existing Conditions	The site is relatively flat with a parking lot between the 2 existing buildings. Additionally the eastern portion of the site is tree-covered and slopes up away from the site. A small retaining wall is present along the western portion of the site at the bottom of the slope, with portions of the retaining wall being concrete and the rest being rock.
Existing/Previous Structures(s)	The site is currently occupied by a building on each of the north and south sides of the property with a parking lot between them. Review of the Sanborn Fire Maps dating to the 1940s as well as historical aerial images indicate that 2 buildings were present on the site in approximately the same location as the current day. However, it was unclear if these were the same structures.
Existing/Previous Utilities	Several utilities such as gas, overhead electric, water, and sewer were marked near near the property.

Table 2: Project Information

Item	Description
Site Layout	See boring location plan in Appendix for details.
Proposed Structure(s)	The proposed construction will consist of a three-story building on the northern portion of the site with associated parking on the southern portion.
Building Construction	While building plans have not been provided, it has been assumed that the structure will be wood-framed with a slab-on-grade bottom floor.
Grading	While no grading plans have been provided, has been assumed that grading will be minimal due to the relatively flat nature of the site.
Finished Floor Elevation	While no finished floor elevation has been provided, it has been assumed to be consistent with the current site elevation of approximately 680 feet.
Maximum Loads	Columns: 20 kips (assumed) Continuous loads: 4 kips per linear foot or less (assumed) Floor Slab: 100 psf or less (assumed)

3 AREA/SITE INFORMATION

3A AREA TOPOGRAPHY / PHYSIOGRAPHY

The site is located within the Outer Bluegrass Region. This area is characterized by Ordovician and Silurian-age dolomites, limestone, and calcareous shales; think pre-Wiconsinan drift on ridges in west; silt-loam colluvium. Figure 1 below shows the location of the site with respect to the regional physiography.

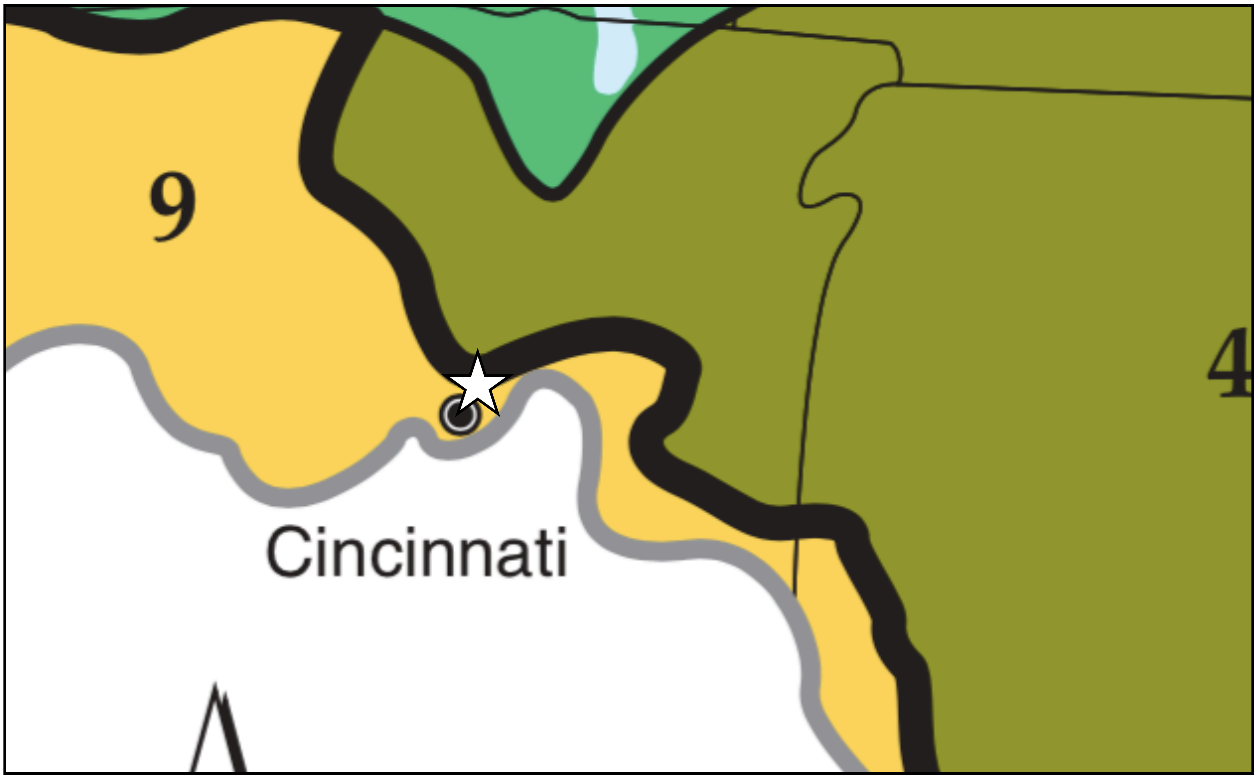


Figure 1: Ohio Physiographic Map (site vicinity shown with star)

3B SITE GEOLOGY

Published surficial geology maps shown in Figure 2 below, indicate that the soils at the site are comprised of less than 10 feet of Illinoian-age glacial till consisting or varying amounts of clay, silt, sand, and rounded gravel. Interbedded shale and limestone bedrock is shown to be present at depths of 10 feet or less below grade.

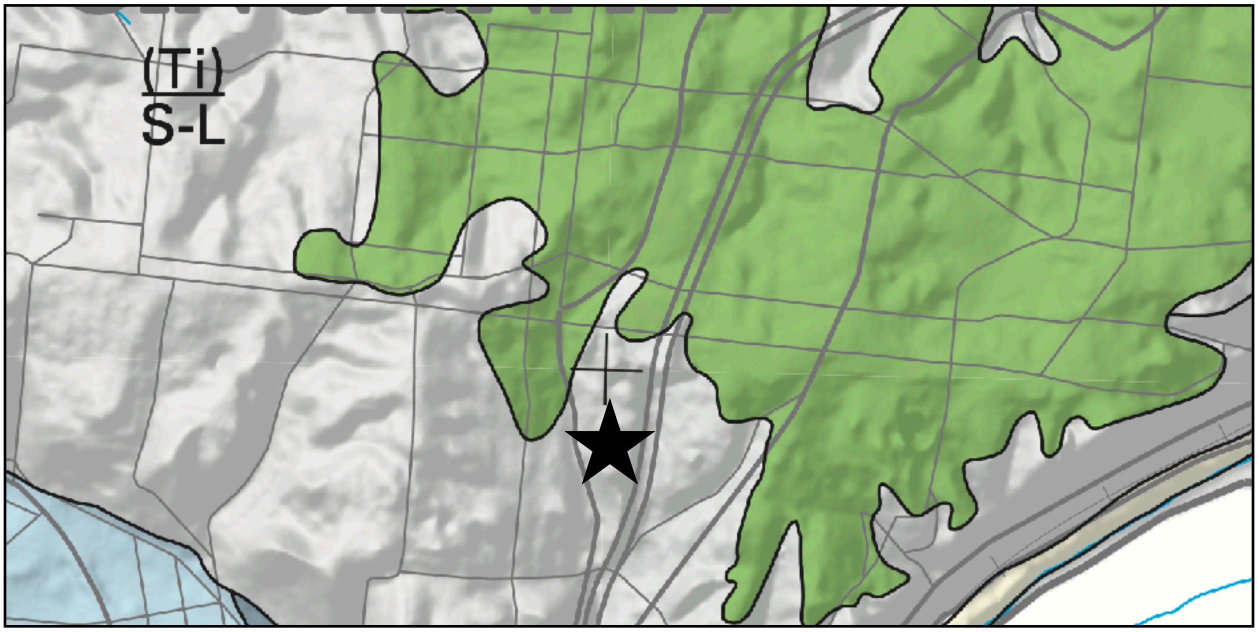


Figure 2: Cincinnati Surficial Geology (site vicinity shown outlined)

A review of bedrock geology as maintained by the Ohio Department of Natural Resources online mapping indicates that the site is underlain with bedrock belonging to the Kope Formation (Ok) and the Miamitown Shale-Fairview Formation (Off). The Kope Formation consists of interbedded shale (75%) and limestone (25%). In general, the limestone and shale within this formation is gray to bluish gray, weathering to a light gray.

Figure 3: Ohio Bedrock Geology (site vicinity shown outlined)

3C PUBLISHED SITE SOIL CONDITIONS

Review of the USDA Soil Survey of Hamilton County (NRCS website), the soils underlying the proposed site consist of the Urban Land (UrUXC) soil series. These soils are typically associated with man made fills or otherwise developed land, which is typical in developed areas of Cincinnati. The Urban land accounts for 100% of the area. While the properties of these soil series may vary greatly depending on many factors, such as previous site use, these soils generally have a depth to water table and depth to restrictive features of greater than 80 inches.

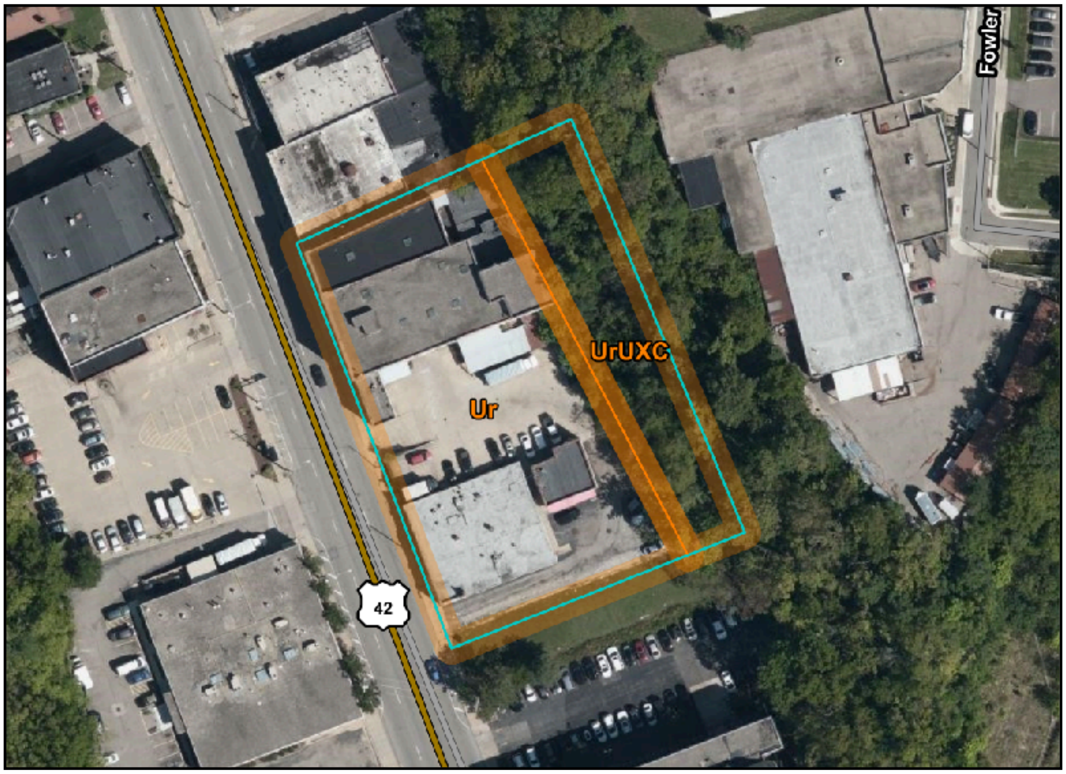


Figure 4: USDA Soil Series Mapping

3D AERIAL PHOTOGRAPHS (GOOGLE EARTH)

Review of historical aerial photography, Figures 4 and 5 below, indicate that the property has not seen any development over the last 30 years. Review of historical aerial images dating back further than available Google imagery, indicate the site was occupied with buildings as far back as the 1940s; however, it is not clear if the current structures are the same as those present earlier.

Figure 4: Google Earth - Dated: 03/31/1994

Figure 6: Google Earth - Dated: 05/30/23

3E HISTORICAL MAPPING

In review of published Sanborn Fire Maps dated 1942, the site appears to have previously had 2 buildings present on the site, roughly matching the locations of the 2 existing buildings. However, it is unclear if the buildings are the same.

Figure 7: Historical Sanborn Mapping (Approximate Location Outlined)

Photo 1: View of existing parking lot

Photo 2: View of existing building.

Photo 3: View of existing building and B-1

Photo 4: View of slope to the east of the site

FINDINGS

5 SUBSURFACE CONDITIONS

CSI performed a total of five (5) borings to explore the subsurface conditions within the proposed development. As mentioned, two (2) of the planned borings could not be performed due to the existing building still being present. In general our borings encountered previously placed fill overlying mixed lacustrine and glacial outwash soils.

5A STRATA INFORMATION

The subsurface conditions encountered at the test boring locations are shown in the Test Boring Logs in the Appendix. This record represents our interpretation of the subsurface conditions based on the field log, visual examination of field samples by an engineer, and tests of the samples collected. The letters in parentheses following the soil descriptions are the soil classifications in general accordance with the Unified Soil Classification System (USCS). It should be noted that dashed stratification lines shown on the soil boring log represent approximate transitions between material types. In-situ stratum changes could occur gradually or at slightly different depths. Boring elevations established using a Real Time Kinematic (RTK) GPS unit.

SURFICIAL COVER

Surficial cover consisted of concrete and asphalt pavement, with the concrete approximately 4 inches thick and the asphalt 2 inches overlaying approximately 3 inches of gravel.

FILL

Previously placed fill material was encountered in each boring immediately underneath the surficial cover to depths ranging from about 3.5 to 6 feet below grade. In general the fill was described to be brown and gray lean to fat clay with varying amounts of sand, roots, and rock fragments. Standard Penetration Testing (SPT) N-Values were reported to range from 5 blows per foot (bpf) to split spoon refusal, indicating a soft to hard consistency. Laboratory testing on representative samples indicate Liquid Limits (LL) of 43 and 52 percent with Plasticity Indices (PI) of 24 and 32 percent, respectively. In-situ moisture contents ranged from 7.4 to 14.8 percent.

RESIDUAL SOILS

Residual soils were encountered underlying the fill in borings B-1 and B-4. The residual soil was described to be brown to gray lean to fat clay with trace roots and sand. SPT N-values ranged from9 to 35 bpf, indicating a stiff to hard consistency. Laboratory testing of a representative sample indicates a LL of 53 percent and a PI of 35 percent. Natural moisture content was recorded at 23.9 percent.

WEATHERED SHALE BEDROCK

Weathered shale bedrock was encountered underlying the fill/residual soils in borings B-1, B-2, and B-5 at depths ranging from 3.5 to 13.5 feet below grade. Additionally, auger refusal was encountered in borings B- and B-2 at depths of 19.3 and 13.9 feet, respectively

For details of subsurface conditions encountered at a particular boring location please refer to the boring logs contained in Appendix A. It should be noted that our borings were drilled and sampled according to the procedures presented in the appendix. The boring locations shown in the appendix should be considered accurate only to the degree implied by the method used.

5B GROUNDWATER CONDITIONS

Groundwater was not encountered during drilling, nor at completion within any of our boring locations. In many areas of Greater Cincinnati with similar geology, water conditions that can affect construction and performance of projects is often related to trapped/perched water zones, which can be erratic, but often observed in granular soils. Perched water sources are typically not linked to the more continuous relatively stable groundwater table that typically occurs at greater depths. In addition to perched water surfaces, groundwater may also be encountered at the soil/bedrock interface. Site excavation activities or ground disturbance can expose these features and the resulting seepage can vary greatly. Groundwater issues are also dependent upon recent rainfall activity and surface and subsurface drainage patterns in the area that may change depending on climatic conditions.

6 LABORATORY TESTING

Laboratory tests were performed on selected recovered samples from the borings to provide recommendations for earthwork and to determine index properties of the soils. Details for the test methods and results are shown in the Appendix. Tests performed included:

- 8 Moisture Content Tests
- 2 Grain Size Analyses (-200 Sieve)
- 3 Atterberg Limits Tests

GEOTECHNICAL DISCUSSION AND RECOMMENDATIONS

7 DISCUSSION—GEOTECHNICAL ISSUES

Based on our experience with similar projects and the conditions observed during our subsurface exploration, we believe the site is suitable for the proposed construction, provided the recommendations outlined in this report are followed. The primary geotechnical concerns are:

- **UNDOCUMENTED FILL MATERIALS AND PREVIOUS DEVELOPMENT**
- **COLLAPSIBLE SOILS**
- **DIFFERENTIAL SETTLEMENT**

7A UNDOCUMENTED FILL MATERIALS AND PREVIOUS DEVELOPMENT

As noted above, the property is currently occupied by several buildings which are planned to be demolished. Additionally, fill material was encountered to depths of up to 6 feet below grade. The fill material was highly variable with consistencies varying from soft to hard. Based upon our experience in the area and the time period in which the site has been developed, the fill does not appear to have been placed with engineering controls to observe and test the consistency of the compaction and suitability of the fill material for use in supporting structural foundations. Constructing over these elements does present a risk with total settlement and differential support conditions resulting in unpredictable behavior of the structure.

7B COLLAPSIBLE SOILS

Based upon the composition and consistency of several samples encountered within the borings, collapse of excavation sidewalls is a concern. Soils that are prone to collapse from excavations are often due to poorly compacted fill, granular and silty soils which lack cohesion, poorly consolidated soils, and/or the presence of groundwater. For open-cut excavations, shallowing of the excavation sidewall or the use of trench boxes may be required to maintain stability of the excavations. In using trench boxes, the trench box should rest firmly against the sides of the excavation, otherwise collapse of the ground surrounding trench box could occur resulting in a larger excavation and possible damage to surrounding property.

7C DIFFERENTIAL SUPPORT CONDITIONS

Based on the relatively shallow depth to bedrock encountered on the site, differential support conditions may be a concern. Where foundation excavations encounter both bedrock and soil support conditions, measures must be taken to modify the bearing medium to create more uniform conditions. When foundations are partially supported by compressible material (soil) and more rigid material (rock), differential settlement can occur, often leading to cracking of floor slabs and foundations as well as other aesthetic issues. As mentioned, after the building has been razed, CSI should perform the remaining two (2) borings as they will be relevant in determining the overall conditions at the proposed building location.

8 EARTHWORK

Historically, more change orders (in orders and costs) occur during the earthwork portion of construction than in almost any other part of the project. Further, the site preparation phase of construction always affects the future performance of project structures and pavements. Add into this, the fact that earthwork is the portion of work most influenced by wet weather and unknown conditions and time-wise, this section of the report could be the most important to prevent and minimize delays and costs during construction and for the life of the project.

Please review the geotechnical concerns listed in Section 7 prior to reading the following recommendations. If problems occur and the recommendations do not address or do not adequately remedy, please contact CSI as soon as possible.

8A EXCAVATIONS

Normal earth excavation equipment should be suitable for excavation operations that are associated with the overburden soils. All excavations should comply with OSHA requirements. For below-grade excavations, the fill and residual soils should be classified as an OSHA Type C soil with slope excavations of 1.5H:1V. Shallower excavation slopes are expected to be required in areas where sandy or other non-cohesive soils were encountered. If soil types other than what has been mentioned above are encountered, CSI should be contacted to evaluate stability.

8B SITE PREPARATION (WORK PRIOR TO FILLING)

- The area should be stripped of any topsoil and/or vegetative cover prior to commencing fill operations;
- Areas ready to receive new fill should be proofrolled with a heavily loaded dump truck or similar equipment judged acceptable by the geotechnical engineer.;
- The level of proofroll should be determined by the geotechnical engineer on a case-by-case basis;
- Perform the proofrolling after a suitable period of dry weather to avoid degrading the subgrade;
- Areas which pump, rut, or wave during proofrolling may require undercutting and recompation;
- Backfill of undercut areas should be done in accordance with section 8C;
- Deleterious materials such as topsoil, roots, wood or other materials that will decay should be removed from the site;
- Retain CSI to observe the proofrolling/subgrade evaluation and make recommendations for any unstable or unsuitable conditions encountered - this can save time on the construction schedule and save unnecessary undercutting;
- We recommend that site grading should take place between about late April to early November. Earthwork taking place outside this time period will likely encounter wet conditions and weather conditions that will provide little to no assistance with drying the soils.

8C NEW FILL OPERATIONS (MASS EARTHWORK)

Before new fill construction, representative samples should be obtained of the proposed fill material to determine the moisture-density, classification of the material, and whether the material is suitable to be used as structural fill. After the subgrade has been approved to receive new fill, the fill may commence with the following procedures and guidelines recommended:

- Place cohesive fill (clay) in maximum 8-inch thick loose lifts. Granular soils may be placed in maximum 12 inch loose lifts provided properly sized equipment is used in the compaction process;

- Fill lifts should be compacted to at least 98 percent of the soil's maximum dry density (ASTM D698) in areas beneath structures (buildings, equipment foundations and pavements);
- Non-structural areas (i.e. grassed and/or landscape areas) can utilize a lower compaction requirement of 90 percent. Non-structural areas should be considered 5 feet beyond the limits of structural entities (i.e. building, pavements, sidewalks, etc);
- Maintain the moisture content of compacted fill between minus 2 and plus 2 percent of optimum moisture;
- Maximum particle size of the soil should be limited to half the lift thickness. Equipment should be large enough that any large particles are thoroughly broken up. Large pieces not able to be satisfactorily broken up should be removed from the fill. Excessive construction debris should also be removed;
- Density testing should be performed as a means to verify percent compaction and moisture content of the material as it is being placed and compacted;
- Observation of fill “stability” is also critical, so it is recommended to observe the operation of the filling equipment traversing over the new fill to document movement (similar to proof rolling);
- Density testing should be performed at a rate of at least one per 10,000 square feet per lift with a minimum of 3 tests per lift;
- Soils should not be “over compacted” and construction traffic should be kept to minimum to assure compaction is achieved and that the soil is not allowed to “break down”; and
- Retain a representative of CSI to observe and document fill placement and compaction operations.

8D GENERAL NOTES

- For all earthwork operations, positive surface drainage is prudent to keep water from ponding on the surface and to assist in maintaining surface stability;
- The surface should be sealed prior to expected wet weather. This can usually be accomplished with rubber-tired construction equipment or a steel-drum roller;
- If any soil placement problems occur, CSI should be retained to provide additional recommendations, as needed.

9 SITE DRAINAGE

During construction, water should not be allowed to pond in excavations and fill areas or undercutting will likely be required. During the life of the project, slope the subgrade and other site features so that surface water flows away from the site structures.

For excavations during construction, most free water from the subsurface conditions could likely be removed via sump pumps and open channel flow (if possible) at or near the source of seepage. However, if normal dewatering measures prove insufficient, CSI should be retained to provide recommendations on the issue.

10 FOUNDATIONS

As discussed above, the undocumented fill is not suitable for support of new foundations. New foundations will need to penetrate the fill and bear on the underlying natural soils or weathered shale bedrock. Once a finished floor elevation is available and the remaining two (2) borings are complete, CSI can provide additional comments on proper bearing material; however, it is our opinion that conventional spread footings should be suitable to support the building with a maximum net allowable bearing pressure of at least 3,000 psf. A higher bearing pressure may be available for foundations within the shale, but would need to be evaluated once final design plans are available.

10A GENERAL FOUNDATION RECOMMENDATIONS

Additional design considerations for project foundations are outlined as follows:

- Design all footings with a minimum 18 inches width;
- All exterior footing bottoms should bear at least 30 inches below finished exterior grading for frost protection.
- Interior footings (those not exposed to freezing) may be placed at nominal depths provided they bear on suitable material as recommended in this report;
- Include control joints at suitable intervals in the walls of structures and in areas where changes in support from native soil to fill are anticipated, to help accommodate differential foundation movements.

10B SHALLOW FOUNDATIONS-CONSTRUCTION NOTES

In general, soils tend to lose strength if they become wet. We recommend the foundation subgrades be protected from exposure to water. For foundations construction, we also recommend the following procedures.

- For soils that will remain exposed overnight or for an extended period of time, place a "lean" concrete mudmat (1 to 2 inches) over the bearing areas. Flowable fill concrete or low-strength concrete is suitable for this cover, as conditions allow;
- Foundation bearing conditions should be benched level.
- Areas loosened by excavation operations should be recompacted prior to reinforcing steel placement.

- Loose soil, debris, and excess surface water should be removed from the bearing surface prior to concrete placement.
- Retain the geotechnical engineer to observe all foundation excavations and provide recommendations for treatment of any unsuitable conditions encountered.
- Backfill undercut footings with minimum 1,500 psi ‘leancrete’ or full strength concrete.
- The bearing conditions should be checked by means of portable dynamic cone penetration (DCP) testing at the direction of the geotechnical engineer.
- Even though fill soils placed for foundation support have likely been checked for compaction at the time of placement, these soils may have become wet or lost some level of strength since that time. The areas should be hand probed to check for surface hardness/strength.

11 GRADE SUPPORTED FLOOR SLABS

Given the fill material encountered, constructing a grade-supported slab over the existing fill could result in excessive settlement over time. Due to the generally shallow depth of fill material encountered, if the owner is willing to accept the risk of leaving the fill material in place, it’s our opinion that suitable bearing conditions for the slab can be achieved; however, there is still a risk with leaving the undocumented fill in place. If previously placed fill is left in place, we recommend that the slab sub grade be proofrolled using a fully loaded tandem axle dump truck with a minimum weight of 20 tons to delineate soft or yielding areas. Any soft or loose areas should be undercut at the direction of the geotechnical engineer and backfilled according to the recommendations outlined in the Earthwork sections above.

We recommend a minimum of 4 inches of compacted granular base beneath the slab. The slab should be designed to be structurally independent of any building footings or walls and should be appropriately reinforced to support the proposed loads and control settlement. For design of the slab, a modulus of subgrade reaction (k) of 100 psi/in may be used.

- Provide isolation joints between the slab and columns and along footing supported walls.
- Adequate joint patterns (ACI and ICC guidelines) should be used to permit slab movement due to normal soil settlement, normal subgrade disturbance and material expansion/contraction.
- Keep the crushed stone or gravel moist, but not wet, immediately prior to slab concrete placement to minimize curling of the slab due to differential curing conditions between the top and bottom of the slab.
- *DO NOT allow soils directly below the slab to become overly wet or dry prior to placement of concrete; and*

- Retain CSI to review the actual subgrade conditions prior to slab construction and make recommendations for any unsuitable conditions encountered.

Note: Slab subgrade conditions are also considered earthwork areas and the recommendations contained in the Earthwork section of the report should be followed

12 PAVEMENT SUBGRADE

It is our understanding the the project will also include construction of a passenger vehicle parking lot that we anticipate will be relatively lightly loaded. Similar to grade supported slab sections, pavement areas constructed directly over the fill material could result in pavement distress over time. Based upon review of the provided concept plan, it appears that cuts or fills will be limited in the planned parking area. It is our opinion that the fill material left in place should provide adequate support of the pavement, provided it passes a proofroll. Similar to above, the owner would need to accept the risk with leaving some of the undocumented fill in place. Based upon the blow counts encountered near surface within the proposed pavement areas, it is anticipated that some failures will be observed during proof rolling. It should be anticipated that some undercutting and remediation of the failed areas will be required.

Adequate drainage and slope of the pavement subgrade and pavement section should be provided to promote adequate drainage. Edges of the pavement should be provided a means of water outlet by extending the aggregate base course through to side ditches or providing drain pipes and weep holes at catch basin walls. We recommend under-drains be considered at low points of the pavement to facilitate drainage.

13 SEISMIC RECOMMENDATIONS

The table below provides seismic design parameters for the site in accordance with the 2012/2015 International Building Code (IBC) and the United States Geological Survey (USGS). These parameters have been based upon a Seismic Site Class of a D. Once the remaining 2 borings are complete, the Seismic Site Classification may be improved based on the soil conditions encountered at the remaining borings.Based upon the building use, we have presumed Seismic Risk Category of III or less for the purpose of seismic design.

Table 3: Seismic Design Parameters

Parameter	Value	2012/2015 IBC Reference
Soil Profile Site Class	D	Section 1613.3.2 Site Class Definitions
0.2 Second Spectral Acceleration, S_s	0.144g	Figure 1613.3.1(1)
1.0 Second Spectral Acceleration, S_1	0.078g	Figure 1613.3.1(2)
Site Coefficient, F_a	1.6	Table 1613.3.3(1)
Site Coefficient, F_v	2.4	Table 1613.3.3(2)

14 NOTES ON THE REPORT AND RECOMMENDATIONS

We recommend that this complete report be provided to the various design team members, the contractors and the project Owner. Potential contractors should be informed of this report in the "Instructions to Bidders" section of the bid documents. A geotechnical exploration, such as the one we performed, used five (5) borings to attempt to model the subsurface conditions at the site. Because no exploration contains complete data or a complete model, there is always a possibility that conditions between borings will be different from those at specific boring locations. Thus, it is possible that some subsurface conditions will not be as anticipated by the project team or contractor. If this report is included or referenced in the actual contract documents, it shall be explicitly understood that this report is for informational purposes only. CSI shall not be responsible for the opinions of, or conclusions drawn by others.

It has been our experience that the construction process often disturbs soil conditions and this process, no matter how much experience we use to anticipate construction methodology, is not completely predictable. Therefore, changes or modifications to our recommendations are likely needed due to these possible variances. Experienced CSI geotechnical personnel should be used to observe and document the construction procedures and the conditions encountered. Unanticipated conditions and inadequate procedures should be reported to the design team along with timely recommendations to solve the problems created. We recommend that the Owner retain CSI to provide this service based upon our familiarity with the project, the subsurface conditions and the intent of our recommendations.

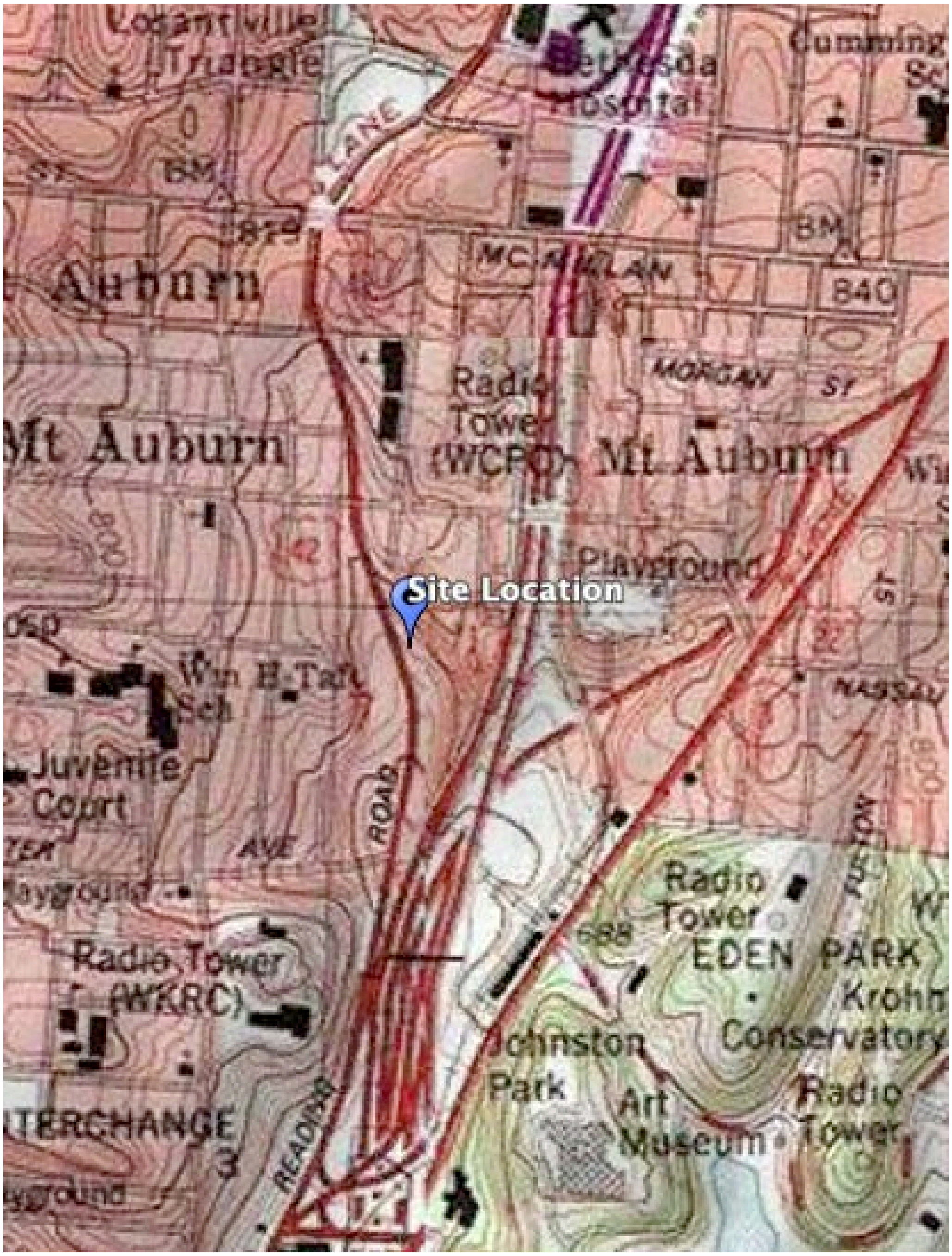
This report is based on the supplied project information, the subsurface conditions observed at the time of the report, and our experience with similar conditions. As such, it cannot be applied to other project sites, types, or combinations thereof. If the Project Information section in this report contains incorrect information or if additional information is available, you should convey the correct or additional information to us and retain us to review our recommendations. Our recommendations may then require modification.

No section or portion of this report (including Appendix information) can be used as a stand alone article to make distinct changes or assumptions. The entire report and Appendix should be used together as one resource. We wish to remind you that our exploration services include storing the soil samples collected and making them available for inspection for 30 days. The soil samples are then discarded unless you request otherwise. Please inform us if you wish to keep any of the obtained samples.

While this report deals with samples of subsurface materials and some comments on water conditions at the site, no assessment of site environmental conditions or the presence of contaminants were performed.

We wish to remind you that our exploration services include storing the soil samples collected and making them available for inspection for 30 days. The samples are then discarded unless you request otherwise. Please inform us if you wish to keep any of the obtained samples.

APPENDIX



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Adapted from Topographic Mapping

FOR ILLUSTRATION PURPOSES ONLY

CSI Cincinnati, LLC
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TITLE: SITE LOCATION PLAN

PROJECT: Crossroads Center
Cincinnati, Ohio

Project No:
CN230236

Drawn By:
NK

Date:
12-19-23

Checked By:
JB

Scale: Not To Scale

Drawing No:
1 of 2

Adapted from Aerial Imagery

FOR ILLUSTRATION PURPOSES ONLY

LEGEND	
B-XX	BORING LOCATIONS

CSI Cincinnati, LLC
11785 Highway Drive Cincinnati, Ohio 45241
513.252.2059 Office|888.792.3121 Fax
www.csiohio.com

TITLE: BORING LOCATION PLAN		Project No: CN230236	Drawn By: NK
PROJECT:	Crossroads Center Cincinnati, Ohio	Date: 12-19-23	Checked By: JB
		Scale: Not To Scale	Drawing No: 2 of 2

This drawing is being furnished for this specific project only. Any party accepting this document does so in confidence and agrees that it shall not be duplicated in whole or in part, nor disclosed to others without the consent of Consulting Services Incorporated of Ohio.

Consulting Services Incorporated
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Geotechnical Boring Information Sheet

Sample Type Symbols	
Splitspoon (SPT)	⊠
Shelby Tube	■
Grab	✋
Rock Core	▯
Auger Cuttings	▮

Surface Symbols	
Topsoil	⁂
Asphalt	■
Concrete	▒
Lean Clay	▨
Fat Clay	▨
Glacial Till	▨
Sandy Clay	▨
Silt	▥
Elastic Silt	▥
Lean Clay to Fat Clay	▨
Gravelly Clay	▨
Sandy Silt	▥
Gravelly Silt	▥
Sand	░
Gravel	○
Fill	▩
Limestone	▤
Sandstone	▤
Shale/Siltstone	☰
Weathered Rock	▥

Samples Strength Descriptors	
Cohesive Soils:	**N**
Very Soft	0-1
Soft	2-4
Firm	5-8
Stiff	9-15
Very Stiff	16-30
Hard	31+
Non-cohesive Soils:	
Very Loose	0-4
Loose	5-10
Firm	11-20
Very Firm	21-30
Dense	30-50
Very Dense	51+

Definitions

SPT-"Splitspoon" or standard penetration test. Blow counts are number of drops required for a 140 lb hammer dropping 30 inches to drive the sampler 6 inches.

N-value is the addition of the last two intervals of the 18-inch sample.

Shelby tubes are often called "undisturbed samples". They are directly pushed into the ground, twisted, allowed to rest for a small period of time and then pulled out of the ground. Tops and bottoms are cleaned and then sealed.

Sample classification is done in general accordance with ASTM D2487 and 2488 using the Unified Soil Classification System (USCS) as a general guide.

Soil moisture descriptions are based on the recovered sample observations. The descriptors are dry, slightly moist, moist, very moist and wet. These are typically based on relative estimates of the moisture condition of a visual estimation of the soils optimum moisture content (EOMC). Dry is almost in a "dusty" condition usually 6 or more percent below EOMC. Slightly moist is from about 6 to 2 percent below EOMC at a point at which the soil color does not readily change with the addition of water. Moist is usually 2 percent below to 2 percent above EOMC and the point at which the soil will tend to begin forming "balls" under some pressure in the hand. Very moist is usually from about 2 percent to 6 percent above EOMC and also the point at which it's often considered "muddy". Wet soil is usually 6 or more percent above EOMC and often contains free water or the soil is in a saturated state.

Silt or Clay is defined at material finer than a standard #200 US sieve (<0.075mm) Sand is defined as material between the size of #200 sieve up to #4 sieve. Gravel is from #4 size sieve material to 3". Cobbles are from 3" to 12". Boulders are over 12".

Rock hardness is classified as follows:

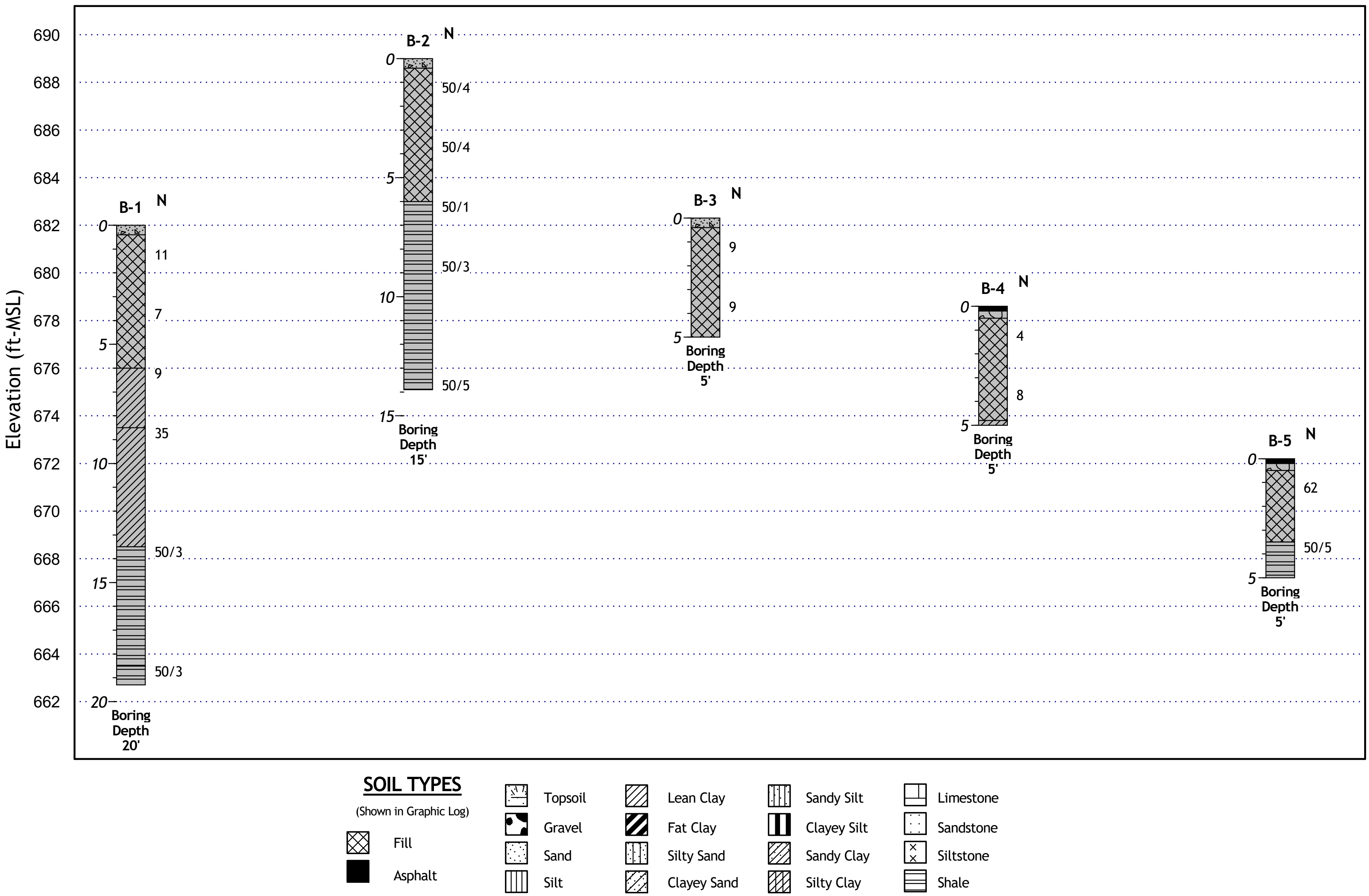
Very Soft:	Easily broken by hand pressure
Soft:	Ends can be broken by hand pressure; easily broken with hammer
Medium:	Ends easily broken with hammer; middle requires moderate blow
Hard:	Ends require moderate hammer blow; middle requires several blows
Very Hard:	Many blows with a hammer required to break core

Rock Quality Designation (RQD) is defined as total combined length of 4" or longer pieces of core divided by the total core run length; defined in percentage.

Water or cave-in observed in borings is at completion of drilling each boring unless otherwise noted.

Strata lengths shown on borings represents a rough estimate. Transition may be more abrupt or gradual. Soil borings are representative of that estimated location at that time and are based on recovered samples. Conditions may be different between borings and between sample intervals. Boring information is not to be considered stand alone but should be taken in context with comments and information in the geotechnical report and the means by which the borings are logged, sampled and drilled.

CSI STRATIGRAPHY (GINT 7) PROPOSED CROSSROADS CENTER BUILDING.GPJ GINT STD US LAB.GDT 12/18/23



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Proposed Crossroads
Center Building
CN230236

BORING PROFILE

Fig. 1

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TEST BORING LOG

CLIENT **The Cross Roads Center**
PROJECT NAME **Proposed Crossroads Center Building**
PROJECT LOCATION **2114 Reading Road, Cincinnati, OH**

BORING # **B-1**
JOB # **CN230236**
LOGGED BY **CG**
APPROVED BY **NK**

DRILLING and SAMPLING INFORMATION

Date Started	11/14/2023	Contractor	CSI
Date Completed	11/14/2023	Boring Size	4 in.
Drill Rig	B-57	Boring Method	SFA
Weather	Sunny 50s	Hammer Type	Automatic

SOIL CLASSIFICATION / TEST DATA

Elev. (ft)	Depth Scale	Water Level	SURFACE ELEVATION: 682.0	Sample No.	Sample Type	Sample Graphics	Recovery (in)	Standard Penetration Test Blows per 6" [N-Value] blows/foot	Qu-tsf Unconfined (Pocket Pen.) Compressive Strength	Moisture Content %	Liquid Limit (LL)	Plasticity Index (PI)	Percent Passing #200 Sieve	Remarks
			CONCRETE - 4 INCHES											
680	2		Brown, gray to olive gray LEAN CLAY (CL) with trace sand, roots, rounded gravel, and limestone fragments [Fill] - moist, stiff	1	SS	☒	5	4-6-5 [*11*]	1.75	23.1				
678	4			2	SS	☒	4	3-3-4 [*7*]	2	24.0				
676	6		Brown and gray mottled LEAN CLAY (CL) with trace sand and trace roots [Residuum] - moist, stiff	3	SS	☒	18	3-4-5 [*9*]	3.25	23.9	53	35	96	
674	8		Light brown LEAN CLAY (CL) with trace sand [Residuum] - moist, hard	4	SS	☒	18	8-15-20 [*35*]	4.5					
672	10													
670	12													
668	14		Grayish brown highly weathered SHALE - very soft	5	SS	☒	6	18-50/3- [*50/3*]						
666	16													
664	18													
			Gray highly weathered SHALE - very soft Auger refusal at 19.3' Boring terminated	6	SS	☒	6	24-50/3- [*50/3*]						
662	20													
660	22													
658	24													

Depth to Groundwater

● Noted on Drilling Tools _______ ft.
▽ At Completion _______ ft.
▼ After ________ hours _______ ft.
☒ Cave Depth ________ ft.

Sample Type

SPT- Standard Penetration Test
SS- Split Spoon
ST- Shelby Tube
RC- Rock Core
CU- Auger Cuttings

Boring Method

HSA- Hollow Stem Augers
CFA- Continuous Flight Augers
MD- Mud Drilling

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TEST BORING LOG

CLIENT **The Cross Roads Center**
PROJECT NAME **Proposed Crossroads Center Building**
PROJECT LOCATION **2114 Reading Road, Cincinnati, OH**

BORING # **B-2**
JOB # **CN230236**
LOGGED BY **CG**
APPROVED BY **NK**

DRILLING and SAMPLING INFORMATION

Date Started	11/14/2023	Contractor	CSI
Date Completed	11/14/2023	Boring Size	4 in.
Drill Rig	B-57	Boring Method	SFA
Weather	Sunny 50s	Hammer Type	Automatic

			SOIL CLASSIFICATION	TEST DATA										
Elev. (ft)	Depth Scale	Water Level	SURFACE ELEVATION: 689.0	Sample No.	Sample Type	Sample Graphics	Recovery (in)	Standard Penetration Test Blows per 6" [*N-Value*] *blows/foot*	Qu-tsf Unconfined (Pocket Pen.) Compressive Strength	Moisture Content %	Liquid Limit (LL)	Plasticity Index (PI)	Percent Passing #200 Sieve	Remarks
688			CONCRETE - 4 INCHES Brown LEAN CLAY (CL) with sand and rock fragments [Fill] - moist to dry, dense	1	SS	☒	4	50/4-- [*50/4*]						
	2													
686														
	4			2	SS	☒	4	50/4-- [*50/4*]		7.4			60	
684														
	6		Gray highly weathered SHALE - very soft to soft	3	SS	☒	5	20-50/1- [*50/1*]						
682														
	8													
680				4	SS	☒	0	50/3-- [*50/3*]						
	10													
678														
	12													
676														
	14			5	SS	☒	4	50/5-- [*50/5*]						
674			Auger refusal at 13.9' Boring terminated											
	16													
672														
	18													
670														
	20													
668														
	22													
666														
	24													

Depth to Groundwater
- Noted on Drilling Tools ________ ft.
- At Completion ________ ft.
- After ________ hours ________ ft.
- Cave Depth ________ ft.

Sample Type
- SPT- Standard Penetration Test
- SS- Split Spoon
- ST- Shelby Tube
- RC- Rock Core
- CU- Auger Cuttings

Boring Method
- HSA- Hollow Stem Augers
- CFA- Continuous Flight Augers
- MD- Mud Drilling

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TEST BORING LOG

CLIENT **The Cross Roads Center**
PROJECT NAME **Proposed Crossroads Center Building**
PROJECT LOCATION **2114 Reading Road, Cincinnati, OH**

BORING # **B-3**
JOB # **CN230236**
LOGGED BY **CG**
APPROVED BY **NK**

DRILLING and SAMPLING INFORMATION

Date Started	**11/14/2023**	Contractor	**CSI**
Date Completed	**11/14/2023**	Boring Size	**4** in.
Drill Rig	**B-57**	Boring Method	**SFA**
Weather	**Sunny 50s**	Hammer Type	**Automatic**

SOIL CLASSIFICATION / TEST DATA

Elev. (ft)	Depth Scale	Water Level	SURFACE ELEVATION: 682.3	Sample No.	Sample Type	Sample Graphics	Recovery (in)	Standard Penetration Test Blows per 6" [N-Value] blows/foot	Qu-tsf Unconfined (Pocket Pen.) Compressive Strength	Moisture Content %	Liquid Limit (LL)	Plasticity Index (PI)	Percent Passing #200 Sieve	Remarks
682			CONCRETE - 4 INCHES											
680	2		Brown and gray becoming light brown mottled FAT CLAY (CH) with trace sand, roots, and rock fragments [Fill] - moist, stiff	1	SS	☒	14	6-5-4 [9]	2	23.2	52	32		
678	4			2	SS	☒	12	2-5-4 [9]	1.5	23.4				
676	6		Boring terminated at 5.0' No refusal											
674	8													
672	10													
670	12													
668	14													
666	16													
664	18													
662	20													
660	22													
658	24													

Depth to Groundwater
● Noted on Drilling Tools ________ ft.
∇ At Completion ________ ft.
▼ After ________ hours ________ ft.
Cave Depth ________ ft.

Sample Type
SPT- Standard Penetration Test
SS- Split Spoon
ST- Shelby Tube
RC- Rock Core
CU- Auger Cuttings

Boring Method
HSA- Hollow Stem Augers
CFA- Continuous Flight Augers
MD- Mud Drilling

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TEST BORING LOG

CLIENT **The Cross Roads Center**

PROJECT NAME **Proposed Crossroads Center Building**

PROJECT LOCATION **2114 Reading Road, Cincinnati, OH**

BORING # **B-4**

JOB # **CN230236**

LOGGED BY **CG**

APPROVED BY **NK**

DRILLING and SAMPLING INFORMATION

Date Started **11/14/2023**

Date Completed **11/14/2023**

Drill Rig **B-57**

Weather **Sunny 50s**

Contractor **CSI**

Boring Size **4** in.

Boring Method **SFA**

Hammer Type **Automatic**

TEST DATA

Elev. (ft)	Depth Scale	Water Level	SOIL CLASSIFICATION SURFACE ELEVATION: 678.6	Sample No.	Sample Type	Sample Graphics	Recovery (in)	Standard Penetration Test Blows per 6" [N-Value] blows/foot	Qu-tsf Unconfined (Pocket Pen.) Compressive Strength	Moisture Content %	Liquid Limit (LL)	Plasticity Index (PI)	Percent Passing #200 Sieve	Remarks
678			ASPHALT - 2 INCHES											
			GRAVEL - 3 INCHES											
676	2		Brown and gray FAT CLAY (CH) with trace sand and rock fragments [Fill] - moist, soft to firm	1	SS	☒	18	3-2-2 [4]	1.5	24.8	43	24		
674	4			2	SS	☒	14	2-3-5 [8]	3.5	16.7				
			Light brown LEAN CLAY (CL) with trace sand [Residuum] - moist, firm											
672	6		Boring terminated at 5.0'											
			No refusal											
670	8													
668	10													
666	12													
664	14													
662	16													
660	18													
658	20													
656	22													
654	24													

Depth to Groundwater

- ● Noted on Drilling Tools ________ ft.
- ▽ At Completion ________ ft.
- ▼ After ________ hours ________ ft.
- ▨ Cave Depth ________ ft.

Sample Type

SPT- Standard Penetration Test
SS- Split Spoon
ST- Shelby Tube
RC- Rock Core
CU- Auger Cuttings

Boring Method

HSA- Hollow Stem Augers
CFA- Continuous Flight Augers
MD- Mud Drilling

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TEST BORING LOG

CLIENT **The Cross Roads Center**
PROJECT NAME **Proposed Crossroads Center Building**
PROJECT LOCATION **2114 Reading Road, Cincinnati, OH**

BORING # **B-5**
JOB # **CN230236**
LOGGED BY **CG**
APPROVED BY **NK**

DRILLING and SAMPLING INFORMATION

Date Started	**11/14/2023**	Contractor	**CSI**
Date Completed	**11/14/2023**	Boring Size	**4** in.
Drill Rig	**B-57**	Boring Method	**SFA**
Weather	**Sunny 50s**	Hammer Type	**Automatic**

SOIL CLASSIFICATION / TEST DATA

Elev. (ft)	Depth Scale	Water Level	SURFACE ELEVATION: 672.2	Sample No.	Sample Type	Sample Graphics	Recovery (in)	Standard Penetration Test Blows per 6" [*N-Value*] *blows/foot*	Qu-tsf Unconfined (Pocket Pen.) Compressive Strength	Moisture Content %	Liquid Limit (LL)	Plasticity Index (PI)	Percent Passing #200 Sieve	Remarks
672			ASPHALT - 2 INCHES											
			GRAVEL - 3 INCHES											
670	2		Brown and gray LEAN CLAY (CL) with limestone fragments, shale fragments, and trace sand [Fill] - moist, hard	1	SS	☒	12	17-16-46 [*62*]	2					
668	4		Gray highly weathered SHALE - very soft	2	SS	☒	17	17-20- [**50/5**] [*50/5*]						
			Boring terminated at 5.0' Splitspoon refusal											

Depth to Groundwater
- ● Noted on Drilling Tools ________ ft.
- ⊻ At Completion ________ ft.
- ▼ After ________ hours ________ ft.
- ▨ Cave Depth ________ ft.

Sample Type
- SPT- Standard Penetration Test
- SS- Split Spoon
- ST- Shelby Tube
- RC- Rock Core
- CU- Auger Cuttings

Boring Method
- HSA- Hollow Stem Augers
- CFA- Continuous Flight Augers
- MD- Mud Drilling

FIELD TESTING PROCEDURES

Field Operations: The general field procedures employed by CSI are summarized in ASTM D 420 which is entitled "Investigating and Sampling Soils and Rocks for Engineering Purposes." This recommended practice lists recognized methods for determining soil and rock distribution and ground water conditions. These methods include geophysical and in situ methods as well as borings.

Borings are drilled to obtain subsurface samples using one of several alternate techniques depending upon the subsurface conditions. These techniques are:

a. Continuous 2-1/2 or 3-1/4 inch I.D. hollow stem augers;

b. Wash borings using roller cone or drag bits (mud or water);

c. Continuous flight augers (ASTM D 1425).

These drilling methods are not capable of penetrating through material designated as "refusal materials." Refusal, thus indicated, may result from hard cemented soil, soft weathered rock, coarse gravel or boulders, thin rock seams, or the upper surface of sound continuous rock. Core drilling procedures are required to determine the character and continuity of refusal materials.

The subsurface conditions encountered during drilling are reported on a field test boring record by the chief driller. The record contains information concerning the boring method, samples attempted and recovered, indications of the presence of various materials such as coarse gravel, cobbles, etc., and observations between samples. Therefore, these boring records contain both factual and interpretive information. The field boring records are on file in our office.

The soil and rock samples plus the field boring records are reviewed by a geotechnical engineer. The engineer classifies the soils in general accordance with the procedures outlined in ASTM D 2488 and prepares the final boring records which are the basis for all evaluations and recommendations.

The final boring records represent our interpretation of the contents of the field records based on the results of the engineering examinations and tests of the field samples. These records depict subsurface conditions at the specific locations and at the particular time when drilled. Soil conditions at other locations may differ from conditions occurring at these boring locations. Also, the passage of time may result in a change in the subsurface soil and ground water conditions at these boring locations. The lines designating the interface between soil or refusal materials on the records and on profiles represent approximate boundaries. The transition between materials may be gradual. The final boring records are included with this report.

The detailed data collection methods using during this study are discussed on the following pages.

Soil Test Borings: Soil test borings were made at the site at locations shown on the attached Boring Plan. Soil sampling and penetration testing were performed in accordance with ASTM D 1586.

The borings were made by mechanically twisting a hollow stem steel auger into the soil. At regular intervals, the drilling tools were removed and soil samples obtained with a standard 1.4 inch I.D., 2 inch O.D., split tube sampler. The sampler was first seated 6 inches to penetrate any loose cuttings, then driven an additional foot with blows of a 140-pound hammer falling 30 inches. The number of hammer blows required to drive the sampler the final foot was recorded and is designated the "penetration resistance". The penetration resistance, when properly evaluated, is an index to the soil strength and foundation supporting capability.

Representative portions of the soil samples, thus obtained, were placed in glass jars and transported to the laboratory. In the laboratory, the samples were examined to verify the driller's field classifications. Test Boring Records are attached which graphically show the soil descriptions and penetration resistances.

Core Drilling: Refusal materials are materials that cannot be penetrated with the soil drilling methods employed. Refusal, thus indicated, may result from hard cemented soil, soft weathered rock, coarse gravel or boulders, thin rock seams or the upper surface of sound continuous rock. Core drilling procedures are required to determine the character and continuity of refusal materials.

Prior to coring, casing is set in the drilled hole through the overburden soils, if necessary, to keep the hole from caving. Refusal materials are then cored according to ASTM D 2113 using a diamond-studded bit fastened to the end of a hollow double tube core barrel. This device is rotated at high speeds, and the cuttings are brought to the surface by circulating water. Core samples of the material penetrated are protected and retained in the swivel-mounted inner tube. Upon completion of each drill run, the core barrel is brought to the surface, the core recovered is measured, the samples are removed and the core is placed in boxes for storage.

The core samples are returned to our laboratory where the refusal material is identified and the percent core recovery and rock quality designation is determined by a soils engineer or geologist. The percent core recovery is the ratio of the sample length obtained to the depth drilled, expressed as a percent. The rock quality designation (RQD) is obtained by summing up the length of core recovered, including only the pieces of core which are four inches or longer, and dividing by the total length drilled. The percent core recovery and RQD are related to soundness and continuity of the refusal material. Refusal material descriptions, recoveries, and RQDs are shown on the "Test Boring Records".

Hand Auger Borings and Dynamic Cone Penetration Testing: Hand auger borings are performed manually by CSI field personnel. This consists of manually twisting hand auger tools into the subsurface and extracting “grab” or baggie samples at intervals determined by the project engineer. At the sample intervals, dynamic cone penetration (DCP) testing is performed. This testing involves the manual raising and dropping of a 20 pound hammer, 18 inches. This “driver” head drives a solid-1¾ inch diameter cone into the ground. DCP “counts” are the number of drops it takes for the hammer to drive three 1¾ inch increments, recorded as X-Y-Z values.

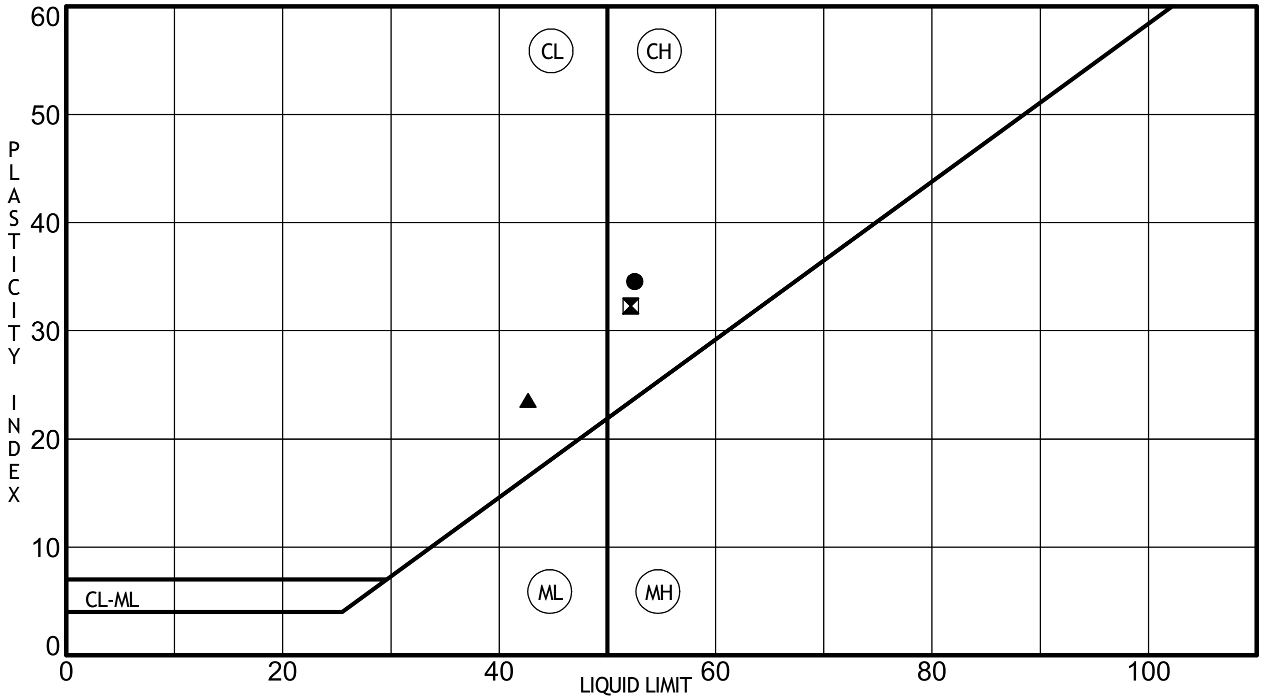
Test Pits: Test pits are excavated by the equipment available, often a backhoe or trackhoe. The dimensions of the test pits are based on the equipment used and the power capacity of the equipment. Samples are taken from the spoils of typical buckets of the excavator and sealed in jars or “Ziplock” baggies. Dynamic Cone Penetration or hand probe testing is often performed in the upper few feet as OSHA standards allow. Refusal is deemed as the lack of advancement of the equipment with reasonable to full machine effort.

Water Level Readings: Water table readings are normally taken in conjunction with borings and are recorded on the "Test Boring Records". These readings indicate the approximate location of the hydrostatic water table at the time of our field investigation. Where impervious soils are encountered (clayey soils) the amount of water seepage into the boring is small, and it is generally not possible to establish the location of the hydrostatic water table through water level readings. The ground water table may also be dependent upon the amount of precipitation at the site during a particular period of time. Fluctuations in the water table should be expected with variations in precipitation, surface run-off, evaporation and other factors.

The time of boring water level reported on the boring records is determined by field crews as the drilling tools are advanced. The time of boring water level is detected by changes in the drilling rate, soil samples obtained, etc. Additional water table readings are generally obtained at least 24 hours after the borings are completed. The time lag of at least 24 hours is used to permit stabilization of the ground water table which has been disrupted by the drilling operations. The readings are taken by dropping a weighted line down the boring or using an electrical probe to detect the water level surface.

Occasionally the borings will cave-in, preventing water level readings from being obtained or trapping drilling water above the caved-in zone. The cave-in depth is also measured and recorded on the boring records.

Liquid and Plastic Limits Test Report



	Boring	Depth (ft)	LL	PL	PI	Water Content	% < #40	% < #200	USCS	Description
●	B-1	6.0	53	18	35	23.9		96		FAT CLAY(CH)
⧗	B-3	1.0	52	20	32	23.2				
▲	B-4	1.0	43	19	24	24.8				

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PROJECT INFORMATION

Client: The Cross Roads Center
Project Name: Proposed Crossroads Center Building
Project Number: CN230236
Project Location: 2114 Reading Road, Cincinnati, OH

Summary of Laboratory Results

Sheet 1 of 1

Borehole	Depth	Sample Type	Liquid Limit	Plastic Limit	Plasticity Index	Classification	Water Content (%)	Unconfined Compressive Strength (tsf)	Dry Density (pcf)	Wet Density (pcf)	Max. Dry Density (pcf)	Opt. Water Content (%)	CBR	Swell (%)	RQD	Percent Recovery	Percent Finer (No. 200)
B-1	1.0	SS					23.1										
B-1	3.5	SS					24.0										
B-1	6.0	SS	53	18	35	FAT CLAY(CH)	23.9										96
B-2	3.5	SS					7.4										60
B-3	1.0	SS	52	20	32		23.2										
B-3	3.5	SS					23.4										
B-4	1.0	SS	43	19	24		24.8										
B-4	3.5	SS					16.7										

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SS - Split Spoon Sample
GRAB - Bulk Grab Sample

PROJECT INFORMATION

Client: The Cross Roads Center
Project Name: Proposed Crossroads Center Building
Project Number: CN230236
Project Location: 2114 Reading Road, Cincinnati, OH

LABORATORY TESTING PROCEDURES

Soil Classification: Soil classifications provide a general guide to the engineering properties of various soil types and enable the engineer to apply past experience to current problems. In our investigations, samples obtained during drilling operations are examined in our laboratory and visually classified by an engineer. The soils are classified according to consistency (based on number of blows from standard penetration tests), color and texture. These classification descriptions are included on our "Test Boring Records."

The classification system discussed above is primarily qualitative and for detailed soil classification two laboratory tests are necessary: grain size tests and plasticity tests. Using these test results the soil can be classified according to the AASHTO or Unified Classification Systems (ASTM D 2487). Each of these classification systems and the in-place physical soil properties provides an index for estimating the soil's behavior. The soil classification and physical properties obtained are presented in this report.

Rock Classification: Rock classifications provide a general guide to the engineering properties of various rock types and enable the engineer to apply past experience to current situations. In our explorations, rock core samples obtained during drilling operations are examined in our laboratory and visually classified by an engineer. The rock cores are classified according to relative hardness and RQD (see Guide to Rock Classification Terminology), color, and texture. These classification descriptions are included on our Test Boring Records.

Atterberg Limits: Portions of the samples are taken for Atterberg Limits testing to determine the plasticity characteristics of the soil. The plasticity index (PI) is the range of moisture content over which the soil deforms as a plastic material. It is bracketed by the liquid limit (LL) and the plastic limit (PL). The liquid limit is the moisture content at which the soil becomes sufficiently "wet" to flow as a heavy viscous fluid. The plastic limit is the lowest moisture content at which the soil is sufficiently plastic to be manually rolled into tiny threads. The liquid limit and plastic limit are determined in accordance with ASTM D 4318.

Moisture Content: The Moisture Content is determined according to ASTM D 2216.

Percent Finer Than 200 Sieve: Selected samples of soils are washed through a number 200 sieve to determine the percentage of material less than 0.074 mm in diameter.

Rock Strength Tests: To obtain strength data for rock materials encountered, unconfined compression tests are performed on selected samples. In the unconfined compression test, a cylindrical portion of the rock core is subjected to increasing axial load until it fails. The pressure required to produce failure is recorded, corrected for the length to diameter ratio of the core and reported.

Compaction Tests: Compaction tests are run on representative soil samples to determine the dry density obtained by a uniform compactive effort at varying moisture contents. The results of the test are used to determine the moisture content and unit weight desired in the field for similar soils. Proper field compaction is necessary to decrease future settlements, increase the shear strength of the soil and decrease the permeability of the soil.

The two most commonly used compaction tests are the Standard Proctor test and the Modified Proctor test. They are performed in accordance with ASTM D 698 and D 1557, respectively. Generally, the Standard Proctor compaction test is run on samples from building or parking areas where small compaction equipment is anticipated. The Modified compaction test is generally performed for heavy structures, highways, and other areas where large compaction equipment is expected. In both tests a representative soil sample is placed in a mold and compacted with a compaction hammer. Both tests have three alternate methods.

Test	Method	Hammer Wt./Fall	Mold Diam.	Run on Material Finer Than	No. of Layers	No. of Blows/ Layer
Standard D 698	A	5.5 lb./12"	4"	No. 4 sieve	3	25
	B	5.5 lb./12"	4"	3/8" sieve	3	25
	C	5.5 lb./12"	6"	3/4" sieve	3	56

Test	Method	Hammer Wt./Fall	Mold Diam.	Run on Material Finer Than	No. of Layers	No. of Blows/ Layer
Modified D 1557	A	10 lb./18"	4"	No. 4 sieve	5	25
	B	10 lb./18"	4"	3/8" sieve	5	25
	C	10 lb./18"	6"	3/4" sieve	5	56

The moisture content and unit weight of each compacted sample is determined. Usually 4 to 5 such tests are run at different moisture contents. Test results are presented in the form of a dry unit weight versus moisture content curve. The compaction method used and any deviations from the recommended procedures are noted in this report.

Laboratory California Bearing Ratio Tests: The California Bearing Ratio, generally abbreviated to CBR, is a punching shear test and is a comparative measure of the shearing resistance of a soil. It provides data that is a semi-empirical index of the strength and deflection characteristics of a soil. The CBR is used with empirical curves to design pavement structures.

A laboratory CBR test is performed according to ASTM D 1883. The results of the compaction tests are utilized in compacting the test sample to the desired density and moisture content for the laboratory California Bearing Ratio test. A representative sample is compacted to a specified density at a specified moisture content. The test is performed on a 6-inch diameter, 4.58-inch-thick disc of compacted soil that is confined in a cylindrical steel mold. The sample is compacted in accordance with Method C of ASTM D 698 or D 1557.

CBR tests may be run on the compacted samples in either soaked or unsoaked conditions. During testing, a piston approximately 2 inches in diameter is forced into the soil sample at the rate of 0.05 inch per minute to a depth of 0.5 inch to determine the resistance to penetration. The CBR is the percentage of the load it takes to penetrate the soil to a 0.1 inch depth compared to the load it takes to penetrate a standard crushed stone to the same depth. Test results are typically shown graphically.