Residence at Veteran's Park

Geotechnical Engineering Report

September 4, 2024 | Terracon Project No. 08245155-01

Knoxville, Iowa

Prepared for:

Jones Gillam Renz Architects, Inc.
730 N 9th St
Salina, KS 67401

LICENSED PROFESSIONAL ENGINEER
THEODORE D. BECHTUM
23812
IOWA

I hereby certify that this engineering document was prepared by me or under my direct personal supervision and that I am a duly licensed Professional Engineer under the laws of the State of Iowa.

September 4, 2024

Theodore D. Bechtum, P.E. Date

License Number 23812

My license renewal date is December 31, 2024.

Pages covered by this seal: All pages .

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September 4, 2024

Jones Gillam Renz Architects, Inc.
730 N 9th St
Salina, KS 67401

Attn: Maggie Gillam
P: 785-827-0386
E: mgillam@jgrarchitects.com

Re: Geotechnical Engineering Report
Residence at Veteran's Park
1515 W Pleasant Street
Knoxville, Iowa
Terracon Project No. 08245155-01

Dear Maggie Gillam:

We have completed the scope of Geotechnical Engineering services for the above referenced project in general accordance with Terracon Proposal No. P08245155 dated July 22, 2024. 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 proposed 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

Elle Whitney, E.I.T.
Staff Engineer

Theodore D. Bechtum, P.E.
Department Manager

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Attachments

Note: This report was originally delivered in a web-based format. **Blue Bold** text in the report indicates a referenced section heading. The PDF version also includes hyperlinks which direct the reader to that section and clicking on the Terracon logo will bring you back to this page. For more interactive features, please view your project online at client.terracon.com.

Refer to each individual Attachment for a listing of contents.

Introduction

This report presents the results of our subsurface exploration and Geotechnical Engineering services performed for the proposed apartment building to be located at 1515 W Pleasant Street in Knoxville, Iowa. The purpose of these services was to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil conditions
- Subsurface water conditions
- Estimated seismic site class per IBC
- Site preparation and earthwork
- Foundation design and construction
- Floor slab design and construction
- Lateral earth pressures
- Pavement design and construction
- Frost considerations

The geotechnical engineering Scope of Services for this project included the advancement of nine test borings, laboratory testing, engineering analysis, and preparation of this report.

Drawings showing the site and exploration locations are shown on the Site Location and Exploration Plan, respectively. Results of the laboratory testing performed on samples obtained from the site during our field exploration are included on the boring logs in Exploration and Laboratory Results.

Project Description

Our initial understanding of the project was provided in our proposal and was discussed during project planning. Our final understanding of the project conditions is as follows:

Item	Description
Project Description	The project includes a three-story senior living apartment building to the north of the site. Parking and drive areas with 78 parking stalls are planned to the south of the site.
Proposed Structure	Structures associated with the project include a three-story apartment building (no basement) with a plan footprint of approximately 16,000 square feet.

Item	Description
Building Construction	Not provided; we anticipate the buildings will be supported on a shallow foundation and constructed using wood framing and slab-on-grade construction techniques.
Maximum Loads	We used the following loads in estimating settlement based on our experience with similar projects. ■ Columns: less than 100 kips ■ Walls: 5 to 7 kips per linear foot (klf) ■ Slabs: 100 pounds per square foot (psf)
Finished Floor Elevation / Grading	We understand a grading plan is not currently available. We have considered a finished floor elevation of about 912 feet. We anticipate less than 3 feet of cut or fill will be required to develop final grade in the parking and building area. We understand that slopes are not planned adjacent to the improvement.
Below-Grade Structures	Based on our conversations with JGR, the elevator shaft is anticipated to extend no more than 6 to 7 feet below the ground surface.
Pavements	We anticipate the pavements will be concrete surfaced and will be primarily utilized by passenger vehicles with occasional delivery trucks and trash collection trucks.
Building Code	2018 IBC

Terracon should be notified if any of the above information is inconsistent with the planned construction, especially the grading limits, as modifications to our recommendations may be necessary.

Site Conditions

The following description of site conditions is derived from our site visit in association with the field exploration.

Item	Description
Parcel Information	The project is located at 1515 W Pleasant Street in Knoxville, Iowa. Latitude/Longitude (approximate) < 41.3204°, -93.1162° > See Site Location

Item	Description
Current Ground Cover	Lightly vegetated
Existing Topography	Relatively flat; 1.5 feet of elevation change was observed across the boring locations

Geotechnical Characterization

We have developed a general characterization of the subsurface conditions based on our review of 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 observed at each exploration point are indicated on the individual logs. The individual logs can be found in Exploration and Laboratory Results and the GeoModel can be found in Figures.

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

Model Layer	Layer Name	General Description
1	Existing Fill	Lean and Fat Clay with varying amounts of sand and organics. Wood observed in Boring 5.
2	Loess	Lean with trace amounts of sand. Generally medium stiff to stiff, with occasional soft zones and layers.
3	Paleosol	Lean-to-Fat Clay and Fat Clay with varying amounts of sand. Generally medium stiff to stiff.
4	Glacial Derived Soil	Sandy Lean Clay with trace amounts of gravel. Generally very stiff.
5	Residual Soil	Fat clay. Generally stiff.

Mapping by the Natural Resources Conservation Service (NRCS) indicates the following soil units at this site:

Soil Unit	Map Unit Symbol	Drainage Class	Depth to Water Table (inches)
Macksburg silty clay loam	368	Somewhat poorly drained	12 to 42
Winterset silty clay loam	Y369	Poorly drained	0 to 12

Source: https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx

Select boreholes were observed while drilling for the presence and level of subsurface water. Mapping by the Natural Resources Conservation Service (NRCS) indicates a seasonal high groundwater level as shallow as at the native ground surface. Groundwater conditions may change because of seasonal variations in rainfall, runoff, and other conditions not apparent at the time of drilling. Subsurface water conditions may be different at the time of construction. Long-term groundwater monitoring was outside the Scope of Services for this project.

Seismic Site Class

The seismic design requirements for structures are based on Seismic Design Category. Site Class is required to determine the Seismic Design Category and is based on the upper 100 feet of the site profile defined by a weighted average value of either shear wave velocity, standard penetration resistance, or undrained shear strength in accordance with Section 20.4 of ASCE 7 and the International Building Code (IBC).

Based on the soil properties encountered at the site, as described on the exploration logs and results, it is our professional opinion that a Seismic Site Class D be considered for this project. Subsurface explorations at this site were extended to a maximum depth of 30.5 feet below existing site grades. The site properties below the explored depths to 100 feet were estimated based on our experience and knowledge of geologic conditions of the general area. Additional deeper borings or geophysical testing may be performed to confirm the conditions below the current exploration depths.

Geotechnical Overview

The site appears suitable for the proposed construction based on geotechnical conditions observed in the test borings, provided the recommendations provided in this report are implemented in the design and construction phases of this project.

The subsurface materials generally consisted of clay with varying degrees of plasticity. Existing fill was encountered in the borings to depths of approximately 4 to 5 feet. The depth of existing fill should be anticipated to vary across the site. The existing fill was often observed to have varying degrees of plasticity (i.e., lean and fat clay). Wood was observed in Boring 5.

We understand multiple small structures were previously located at the project site and the structures were previously demolished. Abrupt changes in existing fill constituents and depth should be anticipated due to prior site use and development. We recommend the design team and Owner review information related to previous structures on the site (i.e., presence and depth of basements) to provide additional information related to possible fill depths. The constituents of the existing fill should be anticipated to vary across this site. Borings can often misrepresent the quantity of brick, rubble, concrete, wood, and other unsuitable materials in the soils, and ground penetrating radar or additional test pits would assist in better characterization and discovery of undesirable materials. Debris laden existing fill, buried rubble, concrete, brick, and/or former buried structures could hamper construction. Dedicated efforts to explore and remove these materials prior construction could reduce delays due to obstructions and "unforeseen" conditions.

Below the existing fill, lean clay was observed in the upper portions of the borings to a depth of approximately 9 to 14 feet, and the lean clay was underlain by fat clay. Subsurface water was observed at depths as shallow as 6.5 feet below the ground surface at the time of exploration; however, seasonally shallower water levels are anticipated as discussed in Geotechnical Characterization.

Foundation Support

Based on the conditions encountered and estimated load-settlement relationships, the proposed structures can be supported on conventional continuous or spread footings, provided existing fill is completely removed below foundations. As discussed in Shallow Foundations, due to the lower strength soil, foundations should bear on at least 3 feet of structural fill extending to suitable native soils. The depth of overexcavation could possibly be reduced if the column and wall loads are reduced; however, the existing fill should be completely overexcavated unless documentation for demolition and structural fill placement is provided to Terracon for review and comment.

Based on the depth of existing fill observed in the borings, we anticipate removal of existing fill will generally be incidental to excavating to foundation bearing elevation; however, the potential for variation in the depth of existing fill should be considered. Seepage should be anticipated within the excavations, and the contractor should develop a dewatering plan in advance of construction.

Grade Supported Slab and Pavement Support

Support of floor slabs and pavements on or above existing fill materials is discussed in this report. However, even with the recommended construction procedures, an inherent risk remains for the Owner that compressible fill or unsuitable material, within or buried by the fill, will not be discovered. This risk of unforeseen conditions cannot be eliminated without completely removing the existing fill but can be reduced by following the recommendations contained in this report. To take advantage of the cost benefit of not removing the entire amount of undocumented fill, the Owner must be willing to accept the risk of increased differential performance which can result in increased cracking and abrupt differential settlement. Should this risk be acceptable, floor slabs and pavements can be supported above the fill.

Where the owner understands and accepts the risks associated with existing fill, it is our opinion that consideration could be given to supporting the floor slabs on a minimum of 24 inches of new, low plasticity structural fill placed. Pavement sections are normally more tolerant to subgrade volume changes (e.g., settlement, shrinking/swelling) as well as movements due to freeze/thaw action, and a minimum thickness of new, low plasticity structural fill of 12 inches could be considered below pavements.

The exposed subgrade areas beneath this minimum structural fill thickness should be observed, tested, and evaluated for suitability by Terracon according to recommendations of this report. The exposed existing fill to be left in place should be recompacted and proofrolled. Where soft, disturbed, or otherwise unsuitable soils are encountered, improvement will be required. Unstable subgrade areas should be corrected as described in the Soil Stabilization subsection of Earthwork.

Zones of deepened overexcavation and subgrade stabilization should be anticipated due to the potential for encountering rubble and unsuitable material. Overexcavation will be required if any buried foundations, voids, debris, rubble, large particles, or other unsuitable materials are encountered. We would not recommend leaving these materials in place below floor slabs or pavements.

Moderate to High Plasticity Clays

Moderate to high plasticity clays were observed near the existing surface in portions of the site. Slabs supported on moderate to high plasticity soils can experience cycles of upward and downward movement due to water content fluctuations that may result in distortion or cracking of floor slabs and pavements. This report provides recommendations to help reduce the risk of shrink/swell movement.

To reduce the risk of floor slab distress associated with these shrink-swell prone soils, we recommend that these soils are removed if they are encountered within 24 inches of the finished subgrade elevation for floor slabs and if they are encountered within 12 inches of pavements.

Moderate to high plasticity soils are present on this site. This report provides recommendations to help mitigate the effects of soil volume change due to water content fluctuations. However, even if these procedures are followed, some movement and (at least minor) cracking in the structure should be anticipated. The severity of cracking and other damage such as uneven floor slabs could increase if modification of the site results in excessive wetting or drying of the moderate to high plasticity soils. The recommendations are based on our knowledge of the site soil conditions and our experience with similar sites and structures and consider cosmetic distress that this typically considered tolerable. Eliminating the risk of movement and 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. Some of these options are include complete replacement of the moderate to high plasticity existing fill or a structural slab.

Subgrade Stability

The near surface lower strength clay should be anticipated become unstable with typical earthwork and construction traffic, especially after precipitation events. Subgrade stabilization should be anticipated where cuts extend into the native GeoModel Layer 2 soils or where near surface soils are disturbed and exposed to precipitation. The effective drainage should be completed early in the construction sequence and maintained after construction to avoid potential issues. If possible, the grading should be performed during the warmer and drier times of the year. Additional site preparation recommendations, including subgrade improvement and fill placement, are provided in the Earthwork section.

The recommendations contained in this report are based on the results of field and laboratory testing (presented in Exploration and Laboratory Results), engineering analyses, and our current understanding of the proposed project. The General Comments section provides an understanding of the report limitations.

Earthwork

Earthwork is anticipated to include clearing and grubbing, excavations, and structural fill placement. The following sections provide recommendations for use in the preparation of specifications for the work. Recommendations include critical quality criteria, as necessary, to render the site in the state considered in our geotechnical engineering evaluation for foundations, floor slabs, and pavements.

Site Preparation

Site preparation within planned new construction areas should commence with:

- Removal of all existing structures and debris materials from past demolitions (e.g., slabs, footings, walls, utilities, and other remnants of below-grade features).
- Stripping of vegetation, organic soils, root systems, and any unsuitable materials (e.g., debris, desiccated soils, frozen soils, impacted soils scheduled for removal, etc.). Root systems should be satisfactorily grubbed and removed from the planned new construction areas. Soils with greater than 5% organics will need to be removed from construction areas and used as fill in non-structural areas. Terracon should closely evaluate stripping depths during construction.
- Existing fill and moderate to high plasticity soils should be undercut as recommended in this report.

Although no evidence of underground facilities (such as septic tanks, cesspools, basements, and utilities) was observed during the exploration and site reconnaissance, such features could be encountered during construction. If unexpected fills or underground facilities are encountered, such features should be removed, and the excavation thoroughly cleaned prior to backfill placement and/or construction.

Demolition of existing utilities and structures should be performed with close construction observation and testing. Any unsuitable fill or demolition debris should be removed. Demolition contractors should be aware of project requirements for earthwork (e.g., structural fill placement and compaction) so that reworking fill materials placed by demolition contractors is not necessary prior to construction of new structures. Demolition should be observed by Terracon and new structural fill placed in accordance with the recommendations in this report.

Subgrade Preparation

We recommend the floor slab subgrade be undercut a minimum of 24 inches below the bottom of new floor slabs to allow for placement of new low plasticity structural fill. In areas where the existing grade is more than 24 inches below the bottom of new floor slabs, additional undercuts of existing fill materials and/or moderate plasticity clays is not required.

The exposed existing fill materials, left in place below floor slabs, should be further tested and approved by Terracon during initial mass grading operations. We recommend the exposed subgrade be proofrolled to help delineate soft, disturbed, or low-density fill zones along the project alignment. Proofrolling should be accomplished using a fully loaded, tandem axle dump truck or other equipment providing an equivalent subgrade loading (minimum gross weight of 25 tons is recommended for the proofrolling equipment). Unstable areas observed at this time should be undercut to expose stable material and backfilled with low plasticity structural fill, or stabilized as described below.

Following proofrolling, and any additional undercutting, the exposed subgrade should be scarified to a depth of 9 inches, moisture conditioned, and compacted to the density and water content ranges recommended for structural fill.

Soil Stabilization

Methods of subgrade improvement, as described below, could include scarification, moisture conditioning and compaction, removal of unstable materials and replacement with granular fill (with or without geosynthetics), and chemical stabilization. The appropriate method of improvement, if required, would be dependent on factors such as schedule, weather, the size and depth of area to be stabilized, and the nature of the instability. More detailed recommendations can be provided during construction as the need for subgrade stabilization occurs. Performing site grading operations during warm seasons and dry periods would help reduce the amount of subgrade stabilization required, which could include one of the methods outlines below.

- Scarification and Compaction - It may be feasible to scarify, moisture condition, and compact the exposed soils. The success of this procedure would depend primarily on favorable weather and sufficient time to dry the soils. Stable subgrades likely would not be achievable if the thickness of the unstable soil is greater than about 1 foot, if the unstable soil is at or near groundwater levels, or if construction is performed during a period of wet or cool weather when drying is difficult.
- Granular Layer - The use of crushed stone or crushed concrete could be considered to improve subgrade stability. To limit depths of potential undercuts, the use of a geogrid could also be considered after underground work, such as utility construction, is completed. Equipment should not be operated above the

geogrid until one full lift of granular fill is placed above the geogrid. The specifications of the reinforcement product manufacturer should be verified prior to material purchase/delivery and placement at the site.

Further evaluation of the need and recommendations for subgrade stabilization can be provided during construction as the geotechnical conditions are exposed.

Fill Material Types

Fine grained materials (e.g., clays) can be difficult to compact in relatively small areas, and we recommend fine-grained materials are only used where placed with proper equipment during mass grading or in broad excavations.

Moisture conditioning (e.g., wetting or drying) will be necessary to achieve compaction requirements, especially where fine grained materials are used as structural fill for the project.

Reuse of On-Site Soil: Excavated on-site soils meeting the requirements of this report may be selectively reused as low plasticity structural fill. Careful sorting of excavated materials may be needed by the Contractor during construction to ensure marginally unsuitable materials (e.g., moderate to high plasticity soils encountered in Borings 1, 3, 4, and 6 through 9) are not used as low plasticity structural fill. A sample of each material type should be submitted to Terracon for evaluation prior to use on this site.

Fill Material Properties: Fill materials should meet the following material property requirements. Regardless of its source, compacted 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. Material property requirements for structural fill and general fill are noted in the following tables.

Structural fill should be free of deleterious material and should have a maximum particle size of 3 inches.

Soil Type [1]	USCS Classification	Acceptable Placement (for Structural Fill)
Low Plasticity Cohesive [2, 3]	CL	▪ Maximum liquid limit of 45 and maximum plasticity index of 23 o Below aggregate base for grade supported slabs and pavements o Below foundations if placed during mass grading operations in sufficiently broad excavations o General site grading
Imported Granular	GW, GP, GM, GC, SW, SP, SM, SC	▪ Specific material requirements will need to be satisfied based on the intended use ▪ Below foundations, grade-supported slabs, and pavements

1. Structural should consist of approved materials free of organic matter and debris. Frozen material should not be used, and fill should not be placed on a frozen subgrade. A sample of each material type should be submitted to Terracon for evaluation prior to use on this site.
2. By our definition, low plasticity materials should have a liquid limit of 45 or less and a plasticity index of 23 or less (ASTM D4318).
3. If on-site soils with Liquid Limit greater than 45 or Plasticity Index greater than 23 will be used as structural fill, these materials should not be placed within 24 inches of floor slabs and within 12 inches of pavements. These recommendations for moderate to high plasticity soil apply to on-site soils only and import of moderate to high plasticity soils is not recommended.

Fill Placement and Compaction Requirements

Structural fill should meet the following compaction requirements.

Item	Structural Fill
Maximum Lift Thickness	9 inches or less in loose thickness when heavy, self-propelled compaction equipment is used 4 inches in loose thickness when hand-guided equipment (i.e., jumping jack or plate compactor) is used
Minimum Compaction Requirements [1,2,3]	Cohesive: 95% of maximum Granular: 98% of maximum

Item	Structural Fill
Water Content Range [1]	Cohesive: 0 to +4% of optimum Granular: -3% to +3% of optimum [4]

1. Maximum density and optimum water content as determined by the standard Proctor test (ASTM D 698).
2. Moderate to high plasticity cohesive fill should not be imported to the site. Recommendations do not apply to moderate to high plasticity clay.
3. If the granular material is a coarse sand or gravel, of a uniform size, or has a low fines content, compaction comparison to relative density may be more appropriate. In this case, granular materials should be compacted to at least 70% relative density (ASTM D 4253 and D 4254). Materials not amenable to density testing should be placed and compacted to a stable condition observed by the Geotechnical Engineer or representative.
4. Specifically, the moisture content of the granular material should be at a level to achieve compaction without the granular material bulking during placement or pumping when proofrolled.

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 cohesive fill in non-pavement areas to reduce the infiltration and conveyance of surface water through the trench backfill.

Any soft or unsuitable materials encountered at the bottom of utility trench excavations should be removed and replaced with structural fill or bedding material in accordance with public works specifications for the utility being supported. This recommendation is particularly applicable to utility work requiring grade control and/or in areas where subsequent grade raising could cause settlement in the subgrade supporting the utility.

Utility trenches are a common source of water infiltration and migration. Utility trenches constructed in cohesive soils that penetrate beneath the building should be effectively sealed to restrict water intrusion and flow through the trenches, which could migrate below the building. The trench should provide an effective trench plug that extends at least 5 feet out from the face of the building exterior. The plug material should consist of cementitious flowable fill or low permeability clay. The trench plug material should be placed to surround the utility line. If used, the clay trench plug material should be placed and compacted as recommended in this report. Care should be taken to not damage the in-place utility.

Grading and Drainage

All grades must provide effective drainage away from the building during and after construction and should be maintained throughout the life of the structure. Water retained next to the building can result in soil movements greater than those discussed in this report. Greater movements can result in unacceptable differential floor slab and/or foundation movements, cracked slabs and walls, and roof leaks. The roof should have gutters/drains with downspouts that discharge onto splash blocks at a distance of at least 10 feet from the building.

Exposed ground should be sloped and maintained at a minimum 5% away from the building for at least 10 feet beyond the perimeter of the building. Locally, flatter grades may be necessary to transition ADA access requirements for flatwork. After building construction and landscaping have been completed, final grades should be verified to document effective drainage has been achieved. Grades around the structure should also be periodically inspected and adjusted, as necessary, as part of the structure's maintenance program. Where paving or flatwork abuts the structure, a maintenance program should be established to effectively seal and maintain joints and prevent surface water infiltration.

Planting trees, large shrubs, or other vegetation adjacent to structures supported on shallow foundations and/or with grade-supported slabs is not recommended. Trees and large shrubs can develop extensive root systems that can draw moisture from the subgrade soils, causing them to shrink during dry periods of the year. Drying or desiccation of clay soils below shallow foundations and grade-supported floor slabs can result in settlement of the foundations and slabs.

Earthwork Construction Considerations

Shallow excavations for the proposed structure are anticipated to be accomplished with conventional construction equipment. Upon completion of filling and grading, care should be taken to maintain the subgrade water content prior to construction of grade-supported improvements such as floor slabs and pavements. Construction traffic over the completed subgrades should be avoided. The site should also be graded to prevent ponding of surface water on the prepared subgrades or in excavations. Water collecting over or adjacent to construction areas should be removed. If the subgrade freezes, desiccates, saturates, or is disturbed, the affected material should be removed, or the materials should be scarified, moisture conditioned, and compacted prior to floor slab construction.

The groundwater table could affect overexcavation efforts, especially for overexcavation and replacement of lower strength soils. A temporary dewatering system consisting of sumps with pumps may be necessary to achieve the recommended depth of overexcavation depending on groundwater conditions at the time of construction.

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 and/or state regulations.

Construction site safety is the sole responsibility of the Contractor who controls the means, methods, and sequencing of construction operations. Under no circumstances shall the information provided herein be interpreted to mean Terracon is assuming responsibility for construction site safety or the Contractor's activities; such responsibility shall neither be implied nor inferred.

Excavations or other activities resulting in ground disturbance have the potential to affect adjoining properties and structures. Our Scope of Services does not include review of available final grading information or consider potential temporary grading performed by the Contractor for potential effects such as ground movement beyond the project limits. A preconstruction/ precondition survey should be conducted to document nearby property/infrastructure prior to any site development activity. Excavation or ground disturbance activities adjacent or near property lines should be monitored or instrumented for potential ground movements that could negatively affect adjoining property and/or structures.

Construction Observation and Testing

The earthwork efforts should be observed by Terracon during construction. Observation should include documentation of adequate removal of surficial materials (vegetation, topsoil), partial removal of existing fill materials/moderate to high plasticity clays, assessment of existing fill materials left in place below floor slabs and pavements, delineation of areas requiring subgrade stabilization, as well as proofrolling.

Each lift of compacted fill should be tested, evaluated, and reworked, as necessary, as recommended by Terracon prior to placement of additional lifts. Each lift of fill should be tested for density and water content at a standard frequency. Where not specified by local ordinance, we recommend the following testing frequency:

- One test per lift for every 2,500 square feet of compacted fill in building areas
- One test per lift for every 5,000 square feet in pavement areas
- One test for every 100 linear feet of compacted utility trench backfill and a minimum of one test performed for every 12 vertical inches of compacted backfill

In areas of foundation excavations, the bearing subgrade should be evaluated by Terracon. If unanticipated conditions are observed, Terracon should be given the opportunity to recommend mitigation options.

In addition to the documentation of the essential parameters necessary for construction, the continuation of Terracon's involvement during the construction phase of the project provides the continuity to maintain the Geotechnical Engineer's evaluation of subsurface conditions, including assessing variations and associated design changes.

Shallow Foundations

If the site has been prepared in accordance with the requirements noted in Earthwork, the following design parameters are applicable for shallow foundations.

As discussed in Geotechnical Overview and in this section, existing fill should be completely removed below shallow foundations. Additionally, to help provide uniform support below foundations and help reduce the potential for abrupt variation in bearing conditions, we recommend a minimum overexcavation below all foundations. The depth for this minimum overexcavation is outlined in the table below.

Design Parameters – Compressive Loads

Item	Description
Maximum Net Allowable Bearing Pressure [1, 2]	1,500 psf
Required Bearing Stratum [3]	Structural fill extending to native soils (minimum of 3 feet of structural fill)
Minimum Foundation Dimensions	Wall footing: 18 inches Column footing: 30 inches
Ultimate Passive Resistance[4] (equivalent fluid pressures)	285 pcf (cohesive backfill) 360 pcf (granular backfill)
Sliding Resistance [5]	On suitable bearing material: 0.32
Minimum Embedment below Finished Grade [6]	42 inches
Estimated Total Settlement from Structural Loads [2, 7]	Less than about 1 inch
Estimated Differential Settlement [2, 7, 8]	About 2/3 of total settlement

Item	Description

1. The maximum net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the footing base elevation. Values consider that exterior grades are no steeper than 20% within 10 feet of structure.
2. Values provided are for maximum loads noted in Project Description. Additional geotechnical consultation will be necessary if higher loads are anticipated.
3. Unsuitable or soft soils should be overexcavated and replaced per the recommendations presented in Earthwork.
4. Use of passive earth pressures require the sides of the excavation for the spread footing foundation to be nearly vertical and the concrete placed neat against these vertical faces or that footing forms be removed and compacted structural fill be placed against the vertical footing face. Passive resistance in the upper 3½ feet of the soil profile in exterior locations should be neglected due to frost effects. Does not consider hydrostatic pressure.
5. Can be used to compute sliding resistance where foundations are placed on suitable soil/materials. Frictional resistance is dependent on the bearing pressure which may vary due to load combinations.
6. Embedment is necessary to minimize the effects of frost and/or seasonal water content variations. For sloping ground, maintain depth below the lowest adjacent exterior grade within 5 horizontal feet of the structure. Minimum embedment for exterior footings applies to perimeter footings. Where interior footings will not be subject to freezing weather and large moisture fluctuations during or after construction, the minimum embedment below top of slab could be reduced to 1½ feet.
7. Foundation settlements will depend on the variation within the subsurface soil profile, the structural loading conditions, the embedment depth of the footings, the thickness of the structural fill, and the quality of earthwork operations.
8. Differential settlements are noted for equivalent-loaded foundations and bearing elevation as measured over a span of 50 feet.

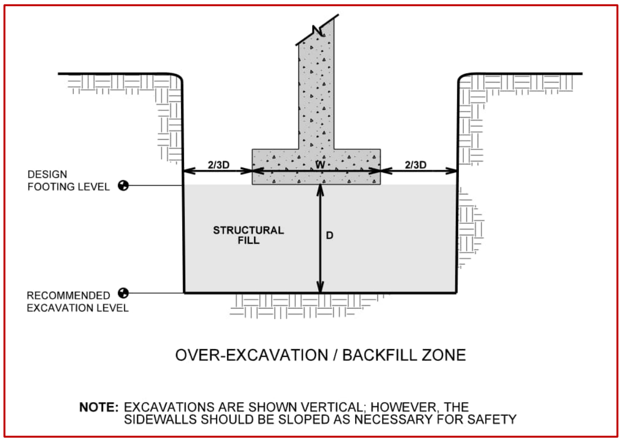
Foundation Construction Considerations

As noted in Earthwork, the footing excavations should be evaluated by Terracon during construction. The base of all foundation excavations should be free of water and loose soil, prior to placing concrete. Concrete should be placed soon after excavating to reduce bearing soil disturbance. Care should be taken to prevent wetting or drying and freezing of the bearing materials during construction. Excessively wet or dry material, frozen, or any loose/disturbed material in the bottom of the footing excavations should be removed/reconditioned before foundation concrete is placed.

Sensitive soils are anticipated at the base of the excavation and construction of a working surface consisting of either crushed stone or a lean concrete mud mat may be required prior to the placement of reinforcing steel and construction of foundations.

Existing fill is anticipated at the base of the planned footings and the existing fill should be completely overexcavated. A minimum overexcavation below footings is recommended as outlined in the above table. Terracon should evaluate the materials exposed at the base of the overexcavation.

Overexcavation for structural fill placement below footings should be conducted as shown below. The overexcavation should be backfilled up to the footing base elevation, with granular structural fill, placed as recommended in the Earthwork section.



Floor Slabs

Design parameters for floor slabs consider the requirements for Earthwork have been followed. Specific attention should be given to positive drainage away from the structure and positive drainage of the aggregate base layer beneath the floor slab.

The subgrade soils are comprised of moderate to high plasticity clays exhibiting the potential to swell with increased water content. Construction of the floor slab, combined with revising site drainage creates the potential for gradual increased water contents within the clays. Increases in water content will cause the clays to swell and potentially damage the floor slab. To reduce the swell potential, at least the upper 24 inches of subgrade soils below the floor slab (including the floor slab granular base) should be an approved low plasticity structural fill material.

Existing fill materials were observed at the site to depths of 4 to 5 feet below existing grades. Any existing fill left in place below the bottom of the low plasticity structural fill zone should be further evaluated by Terracon for suitability during construction, provided the Owner understands and accepts the risks associated with supporting the structure on existing fill materials as discussed in Geotechnical Overview.

Floor Slab Design Parameters

Item	Description
Floor Slab Support[1]	Minimum 6 inches of free draining granular base meeting material specifications of ACI 302 (e.g., Iowa DOT granular subbase, Section 4121) At least 24 inches of newly placed, low plasticity structural fill materials should be present below the floor slab Subgrade compacted to recommendations in Earthwork
Estimated Modulus of Subgrade Reaction [2]	100 pounds per square inch per inch (psi/in) for point loads

1. Floor slabs should be structurally independent of building footings or walls to reduce the possibility of floor slab cracking caused by differential movements between the slab and foundation.
2. Modulus of subgrade reaction is an estimated value based on our experience with the subgrade condition, the requirements noted in Earthwork, and the floor slab support as noted in this table. It is provided for point loads. For large area loads the modulus of subgrade reaction would be lower.

The use of a vapor retarder should be considered beneath concrete slabs on grade covered with wood, tile, carpet, or other moisture sensitive or impervious coverings, when the project includes humidity-controlled areas, 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.

Saw-cut contraction joints should be placed in the slab to help control the location and extent of cracking. For additional recommendations, refer to the ACI Design Manual. Joints or cracks should be sealed with a waterproof, non-extruding compressible compound specifically recommended for heavy duty concrete pavement and wet environments.

Where floor slabs are tied to perimeter walls or turn-down slabs to meet structural or other construction objectives, our experience indicates differential movement between the walls and slabs will likely be observed in adjacent slab expansion joints or floor slab cracks beyond the length of the structural dowels. The Structural Engineer should account for potential differential settlement through use of sufficient control joints, appropriate reinforcing or other means.

Settlement of floor slabs supported on existing fill materials cannot be accurately predicted but could be larger than normal and result in some cracking. Mitigation measures, as noted in Earthwork, are critical to the performance of floor slabs. In addition to the mitigation measures, the floor slab can be stiffened by adding steel reinforcement, grade beams, and/or post-tensioned elements.

Exterior Slabs and Frost Considerations

The soils on this site are frost susceptible, and small amounts of water can affect the performance of the slabs on-grade and pavements. Exterior slabs should be anticipated to heave during winter months. If frost action needs to be reduced in critical areas, we recommend the use of non-frost susceptible (NFS) fill or structural slabs (for instance, structural stoops in front of building doors). Placement of NFS material in large areas may not be feasible; however, the following recommendations are provided to help reduce potential frost heave:

- Provide surface drainage away from the building and slabs, and toward the site drainage system.
- Install drains around the perimeter of the building, stoops, below exterior slabs and pavements, and connect them to the site drainage system.
- Grade clayey subgrades so groundwater potentially perched in overlying fill or aggregate base, slope toward a site drainage system.
- Place NFS fill as backfill beneath slabs and pavements critical to the project.
- Place a 3 horizontal to 1 vertical (3H:1V) transition zone between NFS fill and other soils.

Floor Slab Construction Considerations

Finished subgrade, within and for at least 10 feet beyond the floor slab, should be protected from traffic, rutting, or other disturbance and maintained in a relatively moist condition until floor slabs are constructed. If the subgrade should become damaged or desiccated prior to construction of floor slabs, the affected material should be removed, and structural fill should be added to replace the resulting excavation. Final conditioning of the finished subgrade should be performed immediately prior to placement of the floor slab support course.

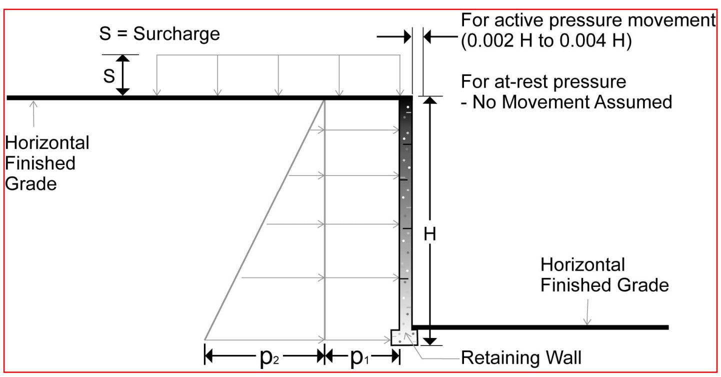
Terracon should observe the condition of the floor slab subgrades immediately prior to placement of the floor slab granular base, reinforcing steel, and concrete. Attention should be paid to high traffic areas that were rutted and disturbed earlier, and to areas where backfilled trenches are located.

Care will be necessary to avoid contaminating the floor slab granular base with soil prior to floor slab placement. We recommend the floor slab granular base be placed only immediately prior to slab concrete placement.

Lateral Earth Pressures

Design Parameters

Structures with unbalanced backfill levels on opposite sides should be designed for earth pressures at least equal to values 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 the materials being restrained. The "at-rest" condition assumes no wall movement and is commonly used for basement walls, loading dock walls, or other walls restrained at the top. 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 Design Parameters

Earth Pressure Condition	Coefficient for Backfill Type [1]	Surcharge Pressure [2] p_1 (psf)	Equivalent Fluid Pressures (psf) [3,4,5]	
			Drained [6]	Undrained [6]
At-Rest (Ko)	Granular - 0.50 Cohesive - 0.59	(0.50)S (0.59)S	(60)H (70)H	(90)H (100)H

Lateral Earth Pressure Design Parameters

Earth Pressure Condition	Coefficient for Backfill Type [1]	Surcharge Pressure [2] p_1 (psf)	Equivalent Fluid Pressures (psf) [3,4,5]	
			Drained [6]	Undrained [6]

1. Uniform, horizontal backfill, with a maximum unit weight of 120 pcf. Fat clay or other expansive soils should not be used as backfill behind a wall.
2. Uniform surcharge, where S is surcharge pressure.
3. Loading from heavy compaction equipment is not included.
4. No factor of safety included in these values. H value is used for at-rest pressure computations and is the distance from the top of the wall.
5. Uniform, final graded backfill, compacted following the recommendations in Earthwork.
6. To achieve "Drained" conditions, follow guidelines in Subsurface Drainage for Below-Grade Walls below. "Undrained" conditions are recommended when drainage behind walls is not incorporated into the design or where walls will be submerged during heavy rain and/or flooding events.

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 case.

Footings, floor slabs or other loads bearing on backfill behind walls may have a significant influence on the lateral earth pressure. Placing footings within wall backfill and in the zone of active soil influence on the wall should be avoided unless structural analyses indicate the wall can safely withstand the increased pressure.

The lateral earth pressure recommendations given in this section are applicable to the design of rigid retaining walls subject to slight rotation, such as cantilever, or gravity type concrete walls. These recommendations are not applicable to the design of modular block - geogrid reinforced backfill walls (also termed MSE walls). Recommendations covering these types of wall systems are beyond the Scope of Services for this project. However, we would be pleased to develop a proposal for evaluation and design of such wall systems on request.

The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project. If groundwater levels rise above the bottom of an below grade structure, uplift loads could be imposed on the bottom slab and hydrostatic pressure could be imposed on the walls, which could cause heaving, cracking or other damage to the bottom slab and walls. We anticipate the designs will include measures to reduce hydrostatic loading for the below grade structures, such as pressure relief valves that will allow backflow of groundwater into empty structures or exterior pumping systems.

Subsurface Drainage for Below-Grade Walls

To reduce hydrostatic loading behind unbalanced walls, we recommend a drainage system be installed along the walls and extend to the foundation of the below grade walls. The wall drain system should be designed according to the following table.

Item	Description
Below grade wall subdrain pipe	▪ Perforated rigid plastic drain line with a minimum 4-inch diameter. ▪ Pipe perforations should be appropriately sized to prevent free-draining granular material from entering the subdrain pipe. ▪ Pipe invert should be at least 42 inches below proposed exterior grade or at the foundation of the wall, whichever is greatest. ▪ Subdrain lines should be sloped to provide positive gravity drainage to daylight or to a reliable discharge point (e.g., storm sewer, sump pit and pump, etc.) [2] ▪ Pipes should be embedded in at least 6 inches of wall drainage backfill material.
Wall drainage backfill [1]	▪ A minimum 2-ft wide section of coarse-grained (granular) fill located above the drain line and adjacent to the walls, consisting of either: ▪ IaDOT porous backfill (Section 4131), or ▪ free-draining coarse-grained material encapsulated with non-woven geotextile filter fabric ▪ The coarse-grained fill should be capped to reduce infiltration of surface water into the subdrain system.

1. As an alternate 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.

If walls must resist combined hydrostatic and lateral earth pressures, then combined hydrostatic and lateral earth pressures should be calculated using the "Undrained" values in the *Lateral Earth Pressure Design Parameters* table above. Water stops and other wall waterproofing measures should also be considered if subdrainage systems are not included in the design.

Pavements

General Pavement Comments

Pavement designs are provided for the traffic conditions and pavement design conditions as noted in Project Description and in the following sections of this report. A critical aspect of pavement performance is site preparation. Pavement designs noted in this section must be applied to the site which has been prepared as recommended in the Earthwork section.

We anticipate the pavement subgrade will consist of a minimum of 12 low plasticity structural fill. We expect the pavement subgrade materials will be placed and compacted following the recommendations in the Earthwork section. Pavement design methods are intended to provide structural sections with adequate thickness over a particular subgrade such that wheel loads are reduced to a level the subgrade can support.

Support characteristics of the subgrade for pavement design do not account for frost heave or shrink/swell movements of an expansive clay subgrade, such as soils observed on this project. Thus, the pavement may be adequate from a structural standpoint, yet still experience cracking and deformation due to frost heave or shrink/swell related movement of the subgrade.

Pavement Section Thicknesses

We anticipate traffic to consist primarily of personal vehicles; however, occasional delivery and garbage trucks are anticipated along the proposed drives. Traffic classifications are provided in the following tables and should be reviewed and approved by the design team and owner prior to commencement of pavement operations.

The following table provides our opinion of minimum thicknesses for portland cement concrete (PCC) pavements generally based on ACI 330-21 "Commercial Concrete Parking Lots and Site Paving Design and Construction - Guide", based on our understanding of anticipated traffic types and volumes.

- American Concrete Institute (ACI) ACI 330-21 – Commercial Concrete Parking Lots and Site Paving Design and Construction – Guide
  - Traffic category A (Light Duty / car parking areas),
  - Traffic category B (Moderate Duty / drive lanes for normal vehicle traffic)
  - Traffic category E (Heavy Duty / refuse collection, fire vehicles)

The traffic considerations for Light Duty pavement sections are based on light passenger vehicle (gross weight less than 4 tons) traffic only, and only occasional light truck traffic such as snow removal pick-up trucks. As part of the layout design for the project, we recommend the designer use signs and preventative structures to restrict truck traffic from entering these areas. Traffic classifications and estimates should be reviewed and approved by the design team and owner prior to commencement of pavement operations.

Opinions of pavement thicknesses are based on the subsurface conditions encountered in the borings, general characterization of the subgrade, and our experience on similar projects, and consider that the subgrade is proofrolled, tested and evaluated as recommended in this report. The thickness of pavements for these scenarios should be in accordance with local city or county ordinances.

As a minimum, we suggest the following typical pavement sections be considered.

Pavement Area(s)	PCC over Granular Base [1, 2, 3] (inches)
Light Duty / Personal vehicle parking areas	5 over 4
Moderate Duty / Drive lanes	6 over 4
Entrance aprons, areas subject to truck traffic, and trash container pads[4]	7 over 4

1. All material should meet the current Iowa DOT Standard Specifications for Highway and Bridge Construction.
2. Pavements should be provided with subdrains and a permeable granular base in accordance with section Pavement Drainage. Considers the subgrade is sloped to promote drainage and is prepared in accordance with section Earthwork.
3. PCC pavement concrete should have a 28-day compressive strength of at least 4,000 psi.
4. The trash container pads should be large enough to support the container and the tipping axle of the collection truck.

For the PCC pavement sections given above, the granular base layer is recommended to help reduce the potential for slab curl, shrinkage cracking, and subgrade pumping through joints. Proper joint spacing will be required to prevent excessive slab curling and shrinkage cracking. Joints should be sealed to prevent entry of foreign material and doweled where necessary for load transfer. PCC pavement details for joint spacing, joint reinforcement, and joint sealing should be prepared in accordance with ACI 330 and ACI 325.

Where practical, we recommend early-entry cutting of crack-control joints in PCC pavements. Cutting of the concrete in its "green" state typically reduces the potential for micro-cracking of the pavements prior to the crack control joints being formed, compared to cutting the joints after the concrete has fully set. Micro-cracking of pavements may lead to crack formation in locations other than the sawed joints, and/or reduction of the service period of the pavement.

Pavement Drainage

Pavements should be sloped to provide rapid drainage of surface water. Water allowed to pond on or adjacent to the pavements could saturate the subgrade and contribute to premature pavement deterioration.

Openings in pavements, such as decorative landscaped areas, are sources for water infiltration into surrounding pavement systems. Water can collect in the islands and migrate into the surrounding subgrade soils thereby degrading support of the pavement. Islands with raised concrete curbs, irrigated foliage, and low permeability near-surface soils are particular areas of concern. The civil design for the pavements with these conditions should include features to restrict or collect and discharge excess water from the islands. Examples of features are edge drains connected to the stormwater collection system, longitudinal subdrains, or other suitable outlets and impermeable barriers preventing lateral migration of water such as a cutoff wall installed to a depth below the pavement structure.

Due to frost-susceptible soils and the possibility of shallow and/or perched groundwater, consideration should be given to installing a pavement subdrain system to control subgrade moisture, improve stability, and improve long-term pavement performance.

We recommend free-draining granular material be placed beneath the pavements. The use of a free draining granular base will also reduce the potential for frost action. We recommend pavement subgrades be crowned at least 2% to promote the flow of water towards the subdrains, and to reduce the potential for ponding of water on the subgrade. The design recommendations for the subdrains are provided in the following table:

Subdrain Design Recommendations

Item	Value
Free Draining Granular Base Thickness below Pavement	4 inches of material meeting the specifications for Iowa DOT granular subbase (Section 4121), modified subbase (Section 4123), or special backfill (Section 4132)
Minimum Drainpipe Diameter	4 inches

Subdrain Design Recommendations

Item	Value
Drain Trench Width	16 inches or greater to provide minimum 6-inch annulus of free-draining granular material around drainpipe
Invert Depth below Subgrade Elevation	42 inches
Maximum Drainpipe Spacing	50 feet
Subdrain Trench Backfill Material	Iowa DOT porous backfill (Section 4131) or a free-draining granular material encapsulated with non-woven geotextile filter fabric (Contech C60NW or equivalent).

The subdrains should be hydraulically connected to the free-draining granular base layer. Subdrains should be sloped to provide positive gravity drainage to reliable discharge points such as a stormwater detention basin. Periodic maintenance of subdrains is required for long-term proper performance.

Pavement Maintenance

The pavement sections represent minimum recommended thicknesses and, as such, periodic upkeep should be anticipated. Preventive maintenance should be planned and provided for through an on-going pavement management program. Maintenance activities are intended to slow the rate of pavement deterioration and to preserve the pavement investment. Pavement care consists of both localized (e.g., crack and joint sealing and patching) and global maintenance (e.g., surface sealing). Additional engineering consultation is recommended to determine the type and extent of a cost-effective program. Even with periodic maintenance, some movements and related cracking may still occur, and repairs will be required.

General Comments

Our analysis and opinions are based on our understanding of the project, the geotechnical conditions in the area, and the data obtained from our site exploration. Variations will occur between exploration point 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 during construction, where noted in this report, 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 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 on 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.

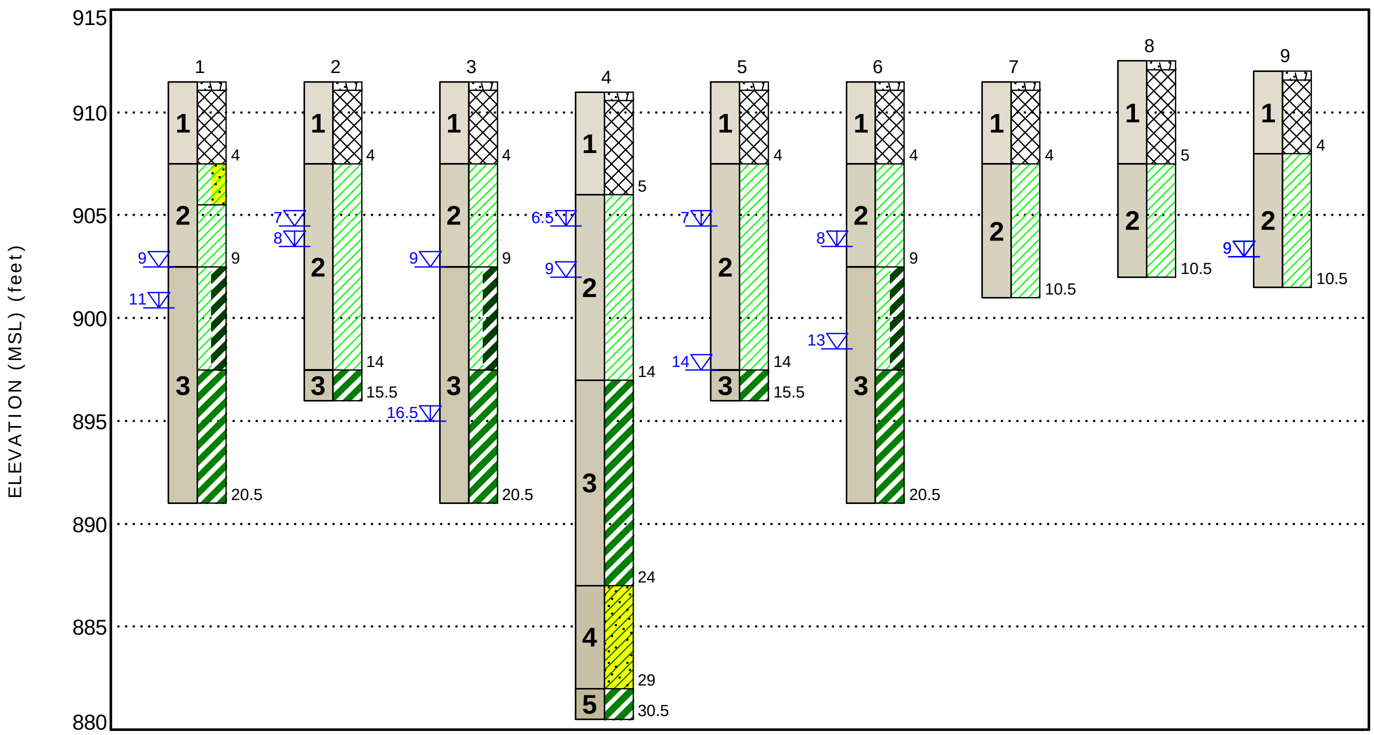
Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly impact excavation 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 and cost estimating including excavation support and dewatering requirements/design are the responsibility of others. Construction and site development have the potential to affect adjacent properties. Such impacts can include damages due to vibration, modification of groundwater/surface water flow during construction, foundation movement due to undermining or subsidence from excavation, as well as noise or air quality concerns. Evaluation of these items on nearby properties are commonly associated with Contractor means and methods and are not addressed in this report. The Owner and Contractor should consider a preconstruction/precondition survey of surrounding development. 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:

Terracon
600 SW 7th St, Ste M
Des Moines, IA

GeoModel



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	Lean and Fat Clay with varying amounts of sand and organics. Wood observed in Boring 5.
2	Loess	Lean with trace amounts of sand. Generally medium stiff to stiff, with occasional soft zones and layers.
3	Palesol	Lean-to-Fat Clay and Fat Clay with varying amounts of sand. Generally medium stiff to stiff.
4	Glacial Derived Soil	Sandy Lean Clay with trace amounts of gravel. Generally very stiff.
5	Residual Soil	Fat Clay. Generally stiff.

Legend

- Topsoil
- Fill
- Lean Clay with Sand
- Lean Clay
- Lean Clay/Fat Clay
- Fat Clay
- Sandy Lean Clay

First Water Observation
Second 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

Boring ID	Approximate Boring Depth (feet)	Location
B-1, B-3, B-6	20.5	Building area
B-2, B-5	15.5	
B-4	30.5	
B-7 through B-9	10.5	Parking/driveway area

Boring Layout and Elevations: Terracon personnel provided the boring layout using handheld GPS equipment and referencing existing site features.

Approximate ground surface elevations were obtained by the drill crew using a level and grade rod referenced to a manhole southeast of the intersection of West Pleasant Street and Freedom Way with provided elevation of 911.30 feet. The ground surface elevations indicated on the logs are approximate and have been rounded to the nearest half foot.

The locations and elevations of the borings are considered accurate only to the degree implied by the means and methods used to define them. If elevations and a more precise boring layout are desired, we recommend borings be surveyed.

Subsurface Exploration Procedures: We advanced the borings with an ATV-mounted rotary drill rig using continuous flight augers (solid stem and/or hollow stem, as necessary, depending on soil conditions). Samples were obtained from the borings 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 was pushed hydraulically into the soil to obtain a relatively undisturbed sample. In the split-barrel sampling procedure, a standard 2-inch outer diameter split-barrel sampling spoon was 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.

We observed the boreholes while drilling and at the completion of drilling for the presence of subsurface water. The subsurface water levels are shown on the attached boring logs. For safety purposes, all borings were backfilled with auger cuttings after their completion.

The sampling depths, penetration distances, and other sampling information was recorded on the field boring logs. The samples were placed in appropriate containers and taken to our soil laboratory for testing and classification. Our exploration team prepared field boring logs as part of the drilling operations. These field logs included visual classifications of the materials observed during drilling and our interpretation of the subsurface conditions between samples. Final boring logs were prepared from the field logs. The final boring logs represent the Geotechnical Engineer's interpretation of the field logs and include modifications based on observations and tests of the samples in our laboratory.

Laboratory Testing

The project engineer reviewed the field data and assigned laboratory tests. The laboratory testing program included the following types of tests:

- Water Content
- Unit Weight
- Unconfined Compression
- Atterberg Limits

Based on the results of our field and laboratory programs, we described and classified the soil samples in general accordance with the Unified Soil Classification System.

Site Location and Exploration Plan

Contents:

Note: All attachments are one page unless noted above.

Site Location

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES MAP PROVIDED BY MICROSOFT BING MAPS

Boring Locations

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

MAP PROVIDED BY MICROSOFT BING MAPS

Exploration and Laboratory Results

Contents:

Note: All attachments are one page unless noted above.

Terracon
600 SW 7th St, Ste M
Des Moines, IA

Boring Log No. 1

Location: See Exploration Plan

Latitude: 41.3206° Longitude: -93.1167°

Depth (Ft.) Elevation: 911.5 (Ft.) +/-

Model Layer	Graphic Log	Depth (Ft.) / Description / Elevation	Depth (Ft.)	Water Level Observations	Sample Type	Recovery (In.)	Field Test Results	SAMPLE ID	Unconfined Compressive Strength (psf)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI
1		0.4 Approx. 2 Inch Root Zone 911.08										
		FILL - LEAN CLAY, trace sand and organics, dark brown										
		FILL - FAT CLAY, trace sand, dark gray				9	2-3-3 N=6	1		28.8		58-24-34
		4.0 907.5										
2		LEAN CLAY (CL), with sand, dark gray, very stiff	5			18		2	4850	24.6	99	
		6.0 905.5										
		LEAN CLAY (CL), trace sand, brown gray, soft				18	2-2-1 N=3 2000 (HP)	3		27.5		
		9.0 902.5		▽ (9')								
3		LEAN CLAY (CL/CH), trace sand, light gray, stiff	10	▽ (11')		24		4	2310	28.3	96	
		14.0 897.5										
		FAT CLAY (CH), trace sand, gray, medium stiff	15			17	2-3-3 N=6 2500 (HP)	5		30.4		
			20			16	2-3-3 N=6	6		25.2		
		20.5 891										

Boring Terminated at 20.5 Feet

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.

Elevation Reference: Elevations were measured in the field using an engineer's level and grade rod.

Notes

Water Level Observations
- ▽ 9' Observed While Sampling
- ▽ 11' Observed Shortly After Boring

Advancement Method
Power Auger

Abandonment Method
Boring backfilled with soil cuttings upon completion.

Drill Rig
709

Hammer Type
Automatic

Driller
SA

Logged by
AL

Boring Started
08-12-2024

Boring Completed
08-12-2024

Terracon
600 SW 7th St, Ste M
Des Moines, IA

Boring Log No. 2

Location: See Exploration Plan

Latitude: 41.3204° Longitude: -93.1166°

Depth (Ft.) Elevation: 911.5 (Ft.) +/-

Model Layer	Depth (Ft.) / Elev.	Material Description	Water Level Observations	Sample Type	Recovery (In.)	Field Test Results	SAMPLE ID	Unconfined Compressive Strength (psf)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI
1	0.4 / 911.08	Approx. 2 Inch Root Zone									
1		FILL - LEAN CLAY, trace sand and organics, dark brown									
1	4.0 / 907.5	FILL - LEAN CLAY, with sand, trace gravel, dark brown with brown		Shelby tube	20		1	1250	24.8	99	
2		LEAN CLAY (CL), trace sand, brown gray, medium stiff to soft		Split spoon	14	2-2-2 N=4 2000 (HP)	2		32.3		
2			7' ▽ / 8' ▽	Split spoon	18	2-1-2 N=3 1000 (HP)	3		27.0		
2	14.0 / 897.5			Split spoon	16	2-2-2 N=4	4		26.7		
3	15.5 / 896	FAT CLAY (CH), trace sand, gray, medium stiff		Split spoon	15	2-3-3 N=6	5		27.8		

Boring Terminated at 15.5 Feet

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.

Elevation Reference: Elevations were measured in the field using an engineer's level and grade rod.

Water Level Observations
▽ 7' Observed While Sampling
▽ 8' Observed Shortly After Boring

Drill Rig
709

Hammer Type
Automatic

Driller
SA

Notes

Advancement Method
Power Auger

Abandonment Method
Boring backfilled with soil cuttings upon completion.

Logged by
AL

Boring Started
08-12-2024

Boring Completed
08-12-2024

Terracon
600 SW 7th St, Ste M
Des Moines, IA

Boring Log No. 3

Location: See Exploration Plan

Latitude: 41.3204° Longitude: -93.1163°

Depth (Ft.) Elevation: 911.5 (Ft.) +/-

Model Layer	Graphic Log	Description	Depth (Ft.)	Water Level Observations	Sample Type	Recovery (In.)	Field Test Results	SAMPLE ID	Unconfined Compressive Strength (psf)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI
1		0.4 Approx. 2 Inch Root Zone 911.08										
		FILL - LEAN CLAY, trace sand and organics, dark brown										
		FILL - LEAN TO FAT CLAY, trace sand, dark brown and gray			Split spoon	10	2-2-3 N=5	1		31.6		
		4.0 907.5										
2		LEAN CLAY (CL), trace sand, brown gray, stiff to medium stiff	5		Shelby tube	22		2	2030	29.2	95	45-23-22
					Split spoon	18	2-2-3 N=5	3		25.1		
		9.0 902.5		▽								
3		LEAN TO FAT CLAY (CL/CH), trace sand, light gray, stiff	10		Shelby tube	24		4	2570	28.0	97	
		14.0 897.5										
		FAT CLAY (CH), trace sand, gray, medium stiff	15		Split spoon	17	2-3-3 N=6	5		29.4		
				▽								
		20.5 891	20		Split spoon	17	2-3-3 N=6	6		24.1		
		Boring Terminated at 20.5 Feet										

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.

Elevation Reference: Elevations were measured in the field using an engineer's level and grade rod.

Water Level Observations
▽ 9' Observed While Sampling
▽ 16.5' Observed Shortly After Boring

Drill Rig
709

Hammer Type
Automatic

Driller
SA

Notes

Advancement Method
Power Auger

Abandonment Method
Boring backfilled with soil cuttings upon completion.

Logged by
AL

Boring Started
08-12-2024

Boring Completed
08-12-2024

Terracon
600 SW 7th St, Ste M
Des Moines, IA

Boring Log No. 4

Location: See Exploration Plan

Latitude: 41.3205° Longitude: -93.1161°

Model Layer	Depth (Ft.)	Material Description	Elevation: 911.0 (Ft.) +/-	Sample Depth (Ft.)	Water Level Observations	Sample Type	Recovery (In.)	Field Test Results	SAMPLE ID	Unconfined Compressive Strength (psf)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI
1	0.4	Approx. 2 Inch Root Zone	910.58										
	5.0	FILL - LEAN CLAY, trace sand and organics, dark brown; FILL - LEAN TO FAT CLAY, trace sand, dark brown with brown	906	2.5		Split spoon	14	3-3-4 N=7	1		25.7		
2		LEAN CLAY (CL), trace sand, brown gray, medium stiff		5		Shelby tube	21		2	1820	32.9	93	
				7.5	6.5'	Split spoon	16	2-2-3 N=5	3		22.8		
	14.0		897	10	9'	Shelby tube	24		4	1050	28.7	94	
3		FAT CLAY (CH), trace sand, gray, medium stiff		15		Split spoon	16	2-3-3 N=6	5		30.1		
	24.0		887	20		Split spoon	17	2-3-4 N=7	6		25.5		
4	29.0	SANDY LEAN CLAY (CL), trace gravel, brown with gray, very stiff	882	25		Shelby tube	24		7	4150	20.2	107	
5	30.5	FAT CLAY (CH), gray and gray brown, stiff, Residual soil	880.5	30		Split spoon	14	3-4-5 N=9 4000 (HP)	8		30.6		

Boring Terminated at 30.5 Feet

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.

Elevation Reference: Elevations were measured in the field using an engineer's level and grade rod.

Water Level Observations
- 9' Observed While Sampling
- 6.5' Observed Shortly After Boring

Drill Rig
709

Hammer Type
Automatic

Driller
SA

Logged by
AL

Boring Started
08-12-2024

Boring Completed
08-12-2024

Notes

Advancement Method
Power Auger

Abandonment Method
Boring backfilled with soil cuttings upon completion.

Terracon
600 SW 7th St, Ste M
Des Moines, IA

Boring Log No. 5

Location: See Exploration Plan

Latitude: 41.3205° Longitude: -93.1159°

Depth (Ft.) Elevation: 911.5 (Ft.) +/-

Model Layer	Depth (Ft.)	Material Description	Elevation	Water Level Observations	Sample Type	Recovery (In.)	Field Test Results	SAMPLE ID	Unconfined Compressive Strength (psf)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI
1	0.4	Approx. 2 Inch Root Zone	911.08									
		FILL - LEAN CLAY, trace sand and organics, dark brown										
		FILL - LEAN CLAY, wood, trace sand, dark brown and gray Large wood fragment observed in Sample 1				8		1		26.8	67	
	4.0		907.5									
2		LEAN CLAY (CL), trace sand, brown gray, medium stiff				16	1-2-2 N=4 1000 (HP)	2		32.4		
				▽ (7')		16	2-2-2 N=4 2000 (HP)	3		26.7		
						18	2-2-2 N=4 2000 (HP)	4		27.3		
	14.0		897.5	▽ (14')								
3		FAT CLAY (CH), trace sand, gray, medium stiff				15	2-3-3 N=6	5				
	15.5		896									

Boring Terminated at 15.5 Feet

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.

Elevation Reference: Elevations were measured in the field using an engineer's level and grade rod.

Water Level Observations
▽ 14' Observed While Sampling
▽ 7' Observed Shortly After Boring

Drill Rig
709

Hammer Type
Automatic

Driller
SA

Notes

Advancement Method
Power Auger

Abandonment Method
Boring backfilled with soil cuttings upon completion.

Logged by
AL

Boring Started
08-12-2024

Boring Completed
08-12-2024

Terracon
600 SW 7th St, Ste M
Des Moines, IA

Boring Log No. 6

Location: See Exploration Plan

Latitude: 41.3205° Longitude: -93.1158°

Depth (Ft.) Elevation: 911.5 (Ft.) +/-

Model Layer	Depth (Ft.)	Material Description	Elevation (Ft.)
1	0.4	Approx. 2 Inch Root Zone	911.08
1		FILL - LEAN CLAY, trace sand and organics, dark brown	
1	4.0	FILL - LEAN TO FAT CLAY, with sand, dark brown with brown	907.5
2	9.0	LEAN CLAY (CL), trace sand, brown gray, stiff to medium stiff	902.5
3	14.0	LEAN TO FAT CLAY (CL/CH), trace sand, light gray, stiff	897.5
3	20.5	FAT CLAY (CH), trace sand, gray, medium stiff	891

Boring Terminated at 20.5 Feet

Recovery (In.)	Field Test Results	SAMPLE ID	Unconfined Compressive Strength (psf)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI
12	1-2-2 N=4	1		25.2		
15		2	2520	27.6	94	
17	1-2-2 N=4 2000 (HP)	3		28.7		
24		4	2470	28.2	95	
17	3-3-3 N=6	5		26.1		
18	2-3-4 N=7	6		25.1		

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.

Elevation Reference: Elevations were measured in the field using an engineer's level and grade rod.

Notes

Water Level Observations
- 13' Observed While Drilling
- 8' Observed Shortly After Boring

Advancement Method
Power Auger

Abandonment Method
Boring backfilled with soil cuttings upon completion.

Drill Rig
709

Hammer Type
Automatic

Driller
SA

Logged by
AL

Boring Started
08-12-2024

Boring Completed
08-12-2024

Residence at Veteran's Park
1515 W Pleasant St | Knoxville, Iowa
Terracon Project No. 08245155

Terracon
600 SW 7th St, Ste M
Des Moines, IA

Boring Log No. 7

Location: See Exploration Plan

Latitude: 41.3203° Longitude: -93.1159°

Depth (Ft.) Elevation: 911.5 (Ft.) +/-

Model Layer	Graphic Log	Depth (Ft.) / Description / Elevation	Water Level Observations	Sample Type	Recovery (In.)	Field Test Results	SAMPLE ID	Unconfined Compressive Strength (psf)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI
1		0.4 Approx. 2 Inch Root Zone 911.08									
		FILL - LEAN CLAY, trace sand and organics, dark brown									
		FILL - LEAN TO FAT CLAY, with sand, brown gray with dark gray		X	11	2-3-3 N=6	1		29.8		
		4.0 907.5									
2		LEAN CLAY (CL), trace sand, brown gray, medium stiff		X	12	2-2-2 N=4	2		29.8		
				X	18	2-2-2 N=4	3		26.2		
		10.5 901		X	17	2-3-3 N=6	4		24.7		

Boring Terminated at 10.5 Feet

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.

Elevation Reference: Elevations were measured in the field using an engineer's level and grade rod.

Water Level Observations
None Observed While Drilling
None Observed Shortly After Boring

Notes

Advancement Method
Power Auger

Abandonment Method
Boring backfilled with soil cuttings upon completion.

Drill Rig
709

Hammer Type
Automatic

Driller
SA

Logged by
AL

Boring Started
08-12-2024

Boring Completed
08-12-2024

Terracon
600 SW 7th St, Ste M
Des Moines, IA

Boring Log No. 8

Location: See Exploration Plan

Latitude: 41.3201° Longitude: -93.1163°

Elevation: 912.5 (Ft.) +/-

Model Layer	Depth (Ft.)	Material Description	Elevation	Sample Depth (Ft.)	Water Level Observations	Sample Type	Recovery (In.)	Field Test Results	SAMPLE ID	Unconfined Compressive Strength (psf)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI
1	0.4	Approx. 2 Inch Root Zone	912.08										
		FILL - LEAN CLAY, trace sand and organics, dark brown											
		FILL - LEAN TO FAT CLAY, with sand, trace organics, brown gray and dark brown				Split spoon	10	2-3-3 N=6	1		29.4		
	5.0		907.5	5		Split spoon	12	2-2-2 N=4 2000 (HP)	2		30.7		
2		LEAN CLAY (CL), trace sand, brown gray, medium stiff				Split spoon	17	2-3-3 N=6	3		27.3		
	10.5		902	10		Split spoon	16	2-2-2 N=4	4		27.9		

Boring Terminated at 10.5 Feet

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.

Elevation Reference: Elevations were measured in the field using an engineer's level and grade rod.

Water Level Observations
None Observed While Drilling
None Observed Shortly After Boring

Notes

Advancement Method
Power Auger

Abandonment Method
Boring backfilled with soil cuttings upon completion.

Drill Rig
709

Hammer Type
Automatic

Driller
SA

Logged by
AL

Boring Started
08-12-2024

Boring Completed
08-12-2024

Terracon
600 SW 7th St, Ste M
Des Moines, IA

Boring Log No. 9

Location: See Exploration Plan

Latitude: 41.3202° Longitude: -93.1167°

Depth (Ft.) Elevation: 912.0 (Ft.) +/-

Model Layer	Graphic Log	Depth (Ft.) / Description / Elevation	Depth (Ft.)	Water Level Observations	Sample Type	Recovery (In.)	Field Test Results	SAMPLE ID	Unconfined Compressive Strength (psf)	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits LL-PL-PI
1		0.4 Approx. 2 Inch Root Zone 911.58										
		FILL - LEAN CLAY, trace sand and organics, dark brown										
		FILL - LEAN TO FAT CLAY, with sand, dark gray			X	11	2-3-2 N=5 2000 (HP)	1		28.2		
		4.0 908										
2		LEAN CLAY (CL), trace sand, brown gray, medium stiff	5		X	14	2-3-2 N=5 2000 (HP)	2		27.9		
					X	12	2-3-3 N=6 1000 (HP)	3		33.7		
				▽								
		10.5 901.5	10		X	18	2-3-3 N=6	4		26.4		
		Boring Terminated at 10.5 Feet										

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.

Elevation Reference: Elevations were measured in the field using an engineer's level and grade rod.

Water Level Observations
▽ 9' Observed While Sampling
▽ 9' Observed Shortly After Boring

Drill Rig
709

Hammer Type
Automatic

Driller
SA

Notes

Advancement Method
Power Auger

Abandonment Method
Boring backfilled with soil cuttings upon completion.

Logged by
AL

Boring Started
08-12-2024

Boring Completed
08-12-2024

Supporting Information

Contents:

Note: All attachments are one page unless noted above.

Terracon
600 SW 7th St, Ste M
Des Moines, IA

General Notes

Sampling	Water Level	Field Tests
Shelby Tube; Standard Penetration Test	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		
Relative Density	**Standard Penetration or N-Value (Blows/Ft.)**	**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 Exploration and Laboratory Test Results

Exploration/field results and/or laboratory test data contained within this document are intended for application to the project as described in this document. Use of such exploration/field results and/or laboratory test data should not be used independently of this document.

Unified Soil Classification System

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

[A] Based on the material passing the 3-inch (75-mm) sieve.
[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.
[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.
[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay.
[E] $Cu = D_{60}/D_{10}$ $Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$
[F] If soil contains ≥ 15% sand, add "with sand" to group name.
[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.
[H] If fines are organic, add "with organic fines" to group name.
[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.
[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.
[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.
[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.
[N] PI ≥ 4 and plots on or above "A" line.
[O] PI < 4 or plots below "A" line.
[P] PI plots on or above "A" line.
[Q] PI plots below "A" line.