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**REPORT OF GEOTECHNICAL
EXPLORATION AND REVIEW**

**PROPOSED SOCCER FIELD CONCESSIONS
BUILDING**

**LAZELLE STREET
STURGIS, SOUTH DAKOTA**

AET No. 17-03158

Date:

October 31, 2017

Prepared for:

**City of Sturgis
1040 Harley Davidson Way
Sturgis, South Dakota 57785**

www.amengtest.com





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October 31, 2017

City of Sturgis
1040 Harley Davidson Way
Sturgis, South Dakota 57785

Attn: Ms. Liz Wunderlich, PE
lwunderlich@strugisgov.com

RE: Geotechnical Exploration and Review
Proposed Soccer Field Concessions Building
Lazelle Street
Sturgis, South Dakota
Report No.17-03158

Dear Ms. Wunderlich:

American Engineering Testing, Inc. (AET) is pleased to present the results of our subsurface exploration program and geotechnical engineering review for the proposed concessions building to be constructed adjacent to the soccer fields off Lazelle Street in Sturgis, South Dakota. These services were performed according to our proposal to you dated September 28, 2017 and the written authorization to proceed by Daniel Ainslie on September 29, 2017. We are submitting one electronic copy of the report to you.

Within the limitations of scope, budget, and schedule, our services have been conducted according to generally accepted geotechnical engineering practices at this time and location. Other than this, no warranty, either expressed or implied, is intended. Important information regarding risk management and proper use of this report is given in the Appendix entitled "Geotechnical Report Limitations and Guidelines for Use".

Please contact me if you have any questions about the report. I can also be contacted for arranging construction observation and testing services during the earthwork phase.

Sincerely,
American Engineering Testing, Inc.

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Page i

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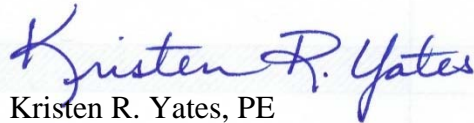
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TABLE OF CONTENTS

Transmittal Letter.....	i
Signature Page	ii
1.0 INTRODUCTION	1
2.0 SCOPE OF SERVICES	1
3.0 PROJECT INFORMATION.....	1
4.0 SUBSURFACE EXPLORATION AND TESTING	2
4.1 Field Exploration Program	2
4.2 Laboratory Testing	2
5.0 SITE CONDITIONS.....	2
5.1 Surface Observations.....	2
5.2 Subsurface Soils/Geology.....	2
5.3 Groundwater	3
6.0 RECOMMENDATIONS	3
6.1 Discussion.....	3
6.2 Site Preparation.....	3
6.3 Foundation Recommendations	4
6.4 Concrete Floor Slabs.....	5
6.5 Backfill Considerations	5
7.0 CONSTRUCTION CONSIDERATIONS	6
7.1 Potential Difficulties.....	6
8.2 Runoff Water in Excavation	6
8.3 Disturbance of Soils.....	6
8.4 Excavation Backsloping	7
8.5 Observation and Testing.....	7
9.0 LIMITATIONS.....	7

STANDARD SHEETS - Excavation and Refilling for Structural Support
 Freezing Weather Effects on Building Construction
 Floor Slab Moisture/Vapor Protection

APPENDIX A – Geotechnical Field Exploration and Testing
 Boring Log Notes
 Unified Soil Classification System
 Site Location Map
 Boring Location Map
 Subsurface Boring Logs
 Sieve Analysis Results

APPENDIX B – Geotechnical Report Limitations and Guidelines for Use

1.0 INTRODUCTION

We understand the City of Sturgis is proposing the construction of a new concessions building adjacent to the existing soccer fields off Lazelle Street in Sturgis, South Dakota. To assist with the planning and design, you have authorized American Engineering Testing, Inc. (AET) to conduct a subsurface exploration program at the site, conduct soil laboratory testing, and perform a geotechnical engineering review for the project. This report presents the results of the above services, and provides our engineering recommendations based on this data.

2.0 SCOPE OF SERVICES

AET's services were performed according to our proposal to you dated September 28, 2017. The authorized scope consists of the following:

- Two (2) standard penetration test (SPT) borings to depths of approximately 15 feet below grade within the proposed building footprint.
- Soil laboratory testing.
- Geotechnical engineering analysis based on the gained data and preparation of this report.

These services are intended for geotechnical purposes only. The scope is not intended to explore for the presence or extent of environmental contamination.

3.0 PROJECT INFORMATION

Based on the information provided, we understand the new building will have plan dimensions of approximately 12 feet x 60 feet and will be located west of the existing soccer fields on the north side of Lazelle Street. We anticipate the building will be a single story structure supported on conventional spread footings and have a concrete slab-on-grade floor system. The finished floor elevation of the new building will be approximately 2 feet above the existing ground surface.

The previously stated information represents our understanding of the proposed construction. This information is an integral part of our engineering review. It is important that you contact us if there are changes from that described so that we can evaluate whether modifications to our recommendations are appropriate.

4.0 SUBSURFACE EXPLORATION AND TESTING

4.1 Field Exploration Program

The subsurface exploration program conducted for the project consisted of two (2) SPT borings drilled at the site to depths of approximately 15 feet below grade. The borings were drilled on October 13, 2017 and were located in the field by AET personnel with assistance from City of Sturgis staff at the approximate locations shown on the Boring Location Map within Appendix A. Surface elevations at the boring locations were referenced to a temporary benchmark (TBM). The TBM used was the concrete manhole rim located on the north side of the site with an elevation of 3,359.37 feet.

The logs of the borings and details of the methods used appear in Appendix A. The logs contain information concerning soil layering, soil classification, geologic description, and moisture condition. Relative density or consistency is also noted for the natural soils, which is based on the standard penetration resistance (N-value).

4.2 Laboratory Testing

The laboratory test program included natural moisture content and sieve analysis tests. The natural moisture content test results appear in Appendix A on the individual boring logs adjacent to the samples upon which they were performed. The results of the sieve analysis are included on a separate sheet in Appendix A.

5.0 SITE CONDITIONS

5.1 Surface Observations

The site is located off the northeast corner of Blanche Street and Lazelle Street adjacent to the existing soccer fields. The area of the proposed building was covered with grass and surrounded by several trees. The site is located near commercial developments on City Park property. In general, the site is relatively flat, with less than 1 foot of elevation difference between the borings.

5.2 Subsurface Soils/Geology

In general, the site geology within the proposed building footprint consists of approximately 6-inches of sandy lean clay topsoil over sandy gravel with silt and cobbles to the final depths sampled at approximately 16 feet below grade.

5.3 Groundwater

At the time of our field work, subsurface water was measured in both borings at approximately 7.2 and 7.3 feet, respectively. The presence of subsurface water noted at the boring locations should not be taken as an accurate representation of the actual groundwater levels. A long period of time is generally required for groundwater to stabilize in the site soils present at the site; this period of time is generally not available during a typical subsurface exploration program.

6.0 RECOMMENDATIONS

6.1 Discussion

Based on the results of our field and laboratory data, it is our opinion the foundations and floor slabs of this building may be placed on reconditioned natural sandy gravel site soils.

Our recommendations in the following sections are intended to minimize, to varying degrees, swell/settlement related problems for the proposed foundations and floor slabs. Even if our recommendations are followed, we cannot guarantee that some movement will not occur. The present state of the art is such that the risk of movement cannot be accurately assessed. It depends on a number of uncontrolled variables such as climatic conditions during and after construction, long term fluctuations of the groundwater level, utility line leakage, landscaping, and other similar aspects. The risk of detrimental movement must be assumed by the project owner.

To reduce the risk of movement of the bearing strata, good drainage must be maintained during and after construction. For this reason we recommend that the excavations be left open a minimal amount of time. Also, we suggest avoiding the planting of deep rooted trees within 10 feet of the building to minimize changes in the moisture content of the subsurface soils. Additionally, the ground floor slab should be structurally independent of walls and columns and all footings should be founded below the depth of seasonal moisture change.

6.2 Site Preparation

We recommend the existing topsoil be removed from within the construction limits. The topsoil may be stockpiled on-site for later reuse in landscape areas.

Footings and floor slab excavations should continue into the sandy gravel soils to the appropriate depths. We recommend the base of the resulting excavations be observed by a geotechnical engineer to verify additional soils do not need to be excavated and that the subgrade is adequate to support the foundations and floor slabs. Any soils loosened during excavation procedures should be scarified to a minimum depth of 12-inches and recompacted to a minimum of 92% of the maximum dry density as determined by ASTM D:1557, Modified Proctor Density.

The excavated site soils are suitable for use as exterior backfill and for overlot fill. All areas to receive fill should be scarified to a depth of 8-inches, the moisture content of the scarified soils adjusted to within 3% of their optimum moisture content and recompacted to at least 92% of their maximum modified Proctor dry density. New fill can then be placed and compacted to the same moisture and compaction criteria as recommended above.

If additional fill is required, we recommend an imported granular engineered fill pre-approved by the geotechnical engineer prior to its use. The granular engineered fill should be a non-expansive material with a maximum size of 2-inches, 40% to 85% passing the #4 sieve, and no more than 15% passing the #200 sieve, with a liquid limit of less than 30. Engineered fill should be placed in 8-inch thick maximum loose lifts; the moisture content should be conditioned to within $\pm 3\%$ of optimum moisture and compacted to at least 92% of maximum modified Proctor (ASTM D 1557) dry density. For more information on site preparation see the Standard Sheets section of this report.

6.3 Foundation Recommendations

As indicated, all footings may be placed on the existing soils and designed for an allowable bearing capacity of 2,000 pounds per square foot (psf). We recommend all footings be placed at least 42-inches below final grades for frost protection. As constructed, the above loading should provide a theoretical safety factor of three or more with respect to a general shear or base failure of the footings. Total and differential settlement should not exceed 1 inch and 1/2-inch, respectively.

Exterior footings, interior footings in unheated portions of the building, or footings placed during freezing conditions should be placed at least four (4) feet below final grades for frost protection. Interior footings in heated areas may be placed directly below the floor slab.

6.4 Concrete Floor Slabs

Concrete slab-on-grade floors may be placed directly on the reconditioned site soils. Prior to placement of fill or structures we recommend the exposed subgrade be scarified and conditioned to within -1% to +3% of the optimum moisture content and recompacted to at least 92% of maximum modified Proctor (ASTM D 1557) dry density. We also recommend the floor slabs be constructed independent of the foundations, in the event some movement does occur.

We recommend providing a 6-inch thick continuous sand and/or gravel cushion layer directly below the garage floor slabs to prevent capillary moisture rise to the slab. This free-draining granular fill should contain less than 12% by weight passing the #200 sieve, and less than 40% passing the #40 sieve.

Refer to the “Floor Slab Moisture/Vapor Protection” document in the Standard Sheets section of this report for additional information.

6.5 Backfill Considerations

It is our opinion exterior backfill around the new concessions building, as well as all overlot fill, should be placed as follows. All recommendations are based on the Modified Proctor method (ASTM: D 1557).

1. All backfill should be free of deleterious/frozen material and have a maximum aggregate size of 2-inches.
2. All backfill should be moisture conditioned to within 3% of optimum moisture content prior to being placed.
3. All backfill should be placed in loose lift thicknesses of 8-inches or less.
4. Each lift should be compacted to at least 92% of maximum proctor density.
5. Compaction density tests should be performed on alternating lifts to ensure the minimum density is maintained.
6. Utility lines entering or exiting the structures should be leak tested prior to the placement of the slab.

7.0 CONSTRUCTION CONSIDERATIONS

7.1 Potential Difficulties

Based on the alluvial soils encountered in our borings, it is possible that large cobbles and boulders may be encountered when excavating for the foundations and floor slabs of this building. It is possible that large excavation equipment may be necessary. However, blasting of rock is not likely necessary at the site. Additional site work may be necessary if large boulders need to be removed within the building footprint. We recommend the base of the foundation and floor slab excavation be a continuous firm and unyielding surface, and no large voids be present upon removal of the possible boulders. We recommend that acceptable fill material be placed within those voids and compacted to the standards presented within this report.

Depending on the time of year in which construction takes place, soft wet subgrade soils could be encountered during the building grading operations. If encountered, additional conditioning of the soils may be required to obtain moisture contents which allow for firm and unyielding subgrade and/or compaction.

Localized areas of soft wet subgrades can be remedied with additional excavation to expose firmer soils, placement of coarse rock to provide a solid base on which to place additional fill and/or the use of geotextiles between the soft soils and the overlying fill and/or pavement sections. The appropriate means of subgrade stabilization should be evaluated by the geotechnical engineer at the time of construction.

8.2 Runoff Water in Excavation

Water can be expected to collect in the excavation bottom during times of inclement weather or snow melt. To allow observation of the excavation bottom, to reduce the potential for soil disturbance, and to facilitate filling operations, we recommend water be removed from within the excavation during construction. Based on the soils encountered, we anticipate the groundwater can be handled with conventional sump pumping.

8.3 Disturbance of Soils

The on-site soils can become disturbed under construction traffic, especially if the soils are wet. If soils become disturbed, they should be subcut to the underlying undisturbed soils. The subcut

soils can then be dried and recompact back into place, or they should be removed and replaced with drier imported fill.

8.4 Excavation Backsloping

If excavation faces are not retained, the excavations should maintain maximum allowable slopes in accordance with *OSHA Regulations (Standards 29 CFR), Part 1926, Subpart P, "Excavations"* (can be found on www.osha.gov). Even with the required OSHA sloping, water seepage or surface runoff can potentially induce sideslope erosion or running which could require slope maintenance.

8.5 Observation and Testing

The recommendations in this report are based on the subsurface conditions found at our test boring locations. Since the soil conditions can be expected to vary away from the soil boring locations, we recommend on-site observation by a geotechnical engineer/technician during construction to evaluate these potential changes. Soil density testing should also be performed on new fill placed in order to document that project specifications for compaction have been satisfied.

9.0 LIMITATIONS

Within the limitations of scope, budget, and schedule, our services have been conducted according to generally accepted geotechnical engineering practices at this time and location. Other than this, no warranty, either expressed or implied, is intended. Important information regarding risk management and proper use of this report is given in Appendix B entitled "Geotechnical Report Limitations and Guidelines for Use".

Report of Geotechnical Exploration and Review
Proposed Soccer Concessions Building, Sturgis, SD
October 31, 2017
Report No. 17-03158

AMERICAN
ENGINEERING
TESTING, INC.

STANDARD SHEETS

EXCAVATION AND REFILLING FOR STRUCTURAL SUPPORT

EXCAVATION

Excavations for structural support at soil boring locations should be taken to depths recommended in the geotechnical report. Since conditions can vary, recommended excavation depths between and beyond the boring location should be evaluated by geotechnical field personnel. If groundwater is present, the excavation should be dewatered to avoid the risk of unobservable poor soils being left in-place. Excavation base soils may become disturbed due to construction traffic, groundwater or other reasons. Such soils should be subcut to underlying undisturbed soils. Where the excavation base slopes steeper than 4:1, the excavation bottom should be benched across the slope parallel to the excavation contour.

Soil stresses under footings spread out with depth. Therefore, the excavation bottom and subsequent fill system should be laterally oversized beyond footing edges to support the footing stresses. A lateral oversize equal to the depth of fill below the footing (i.e., 1:1 oversize) is usually recommended. The lateral oversize is usually increased to 1.5:1 where compressible organic soils are exposed on the excavation sides. Variations in oversize requirements may be recommended in the geotechnical report or can be evaluated by the geotechnical field personnel.

Unless the excavation is retained, the backslopes should be maintained in accordance with OSHA Regulations (Standards-29 CFR), Part 1926, Subpart P, "Excavations" (found on www.osha.gov). Even with the required OSHA sloping, groundwater can induce sideslope raveling or running which could require that flatter slopes or other approaches be used.

FILLING

Filling should proceed only after the excavation bottom has been approved by the geotechnical engineer/technician. Approved fill material should be uniformly compacted in thin lifts to the compaction levels specified in the geotechnical report. The lift thickness should be thin enough to achieve specified compaction through the full lift thickness with the compaction equipment utilized. Typical thicknesses of 4" to 8" should be used. Fine grained soils are moisture sensitive and are often wet (water content exceeds the "optimum moisture content" defined by a Proctor test). In this case, the soils should be scarified and dried to achieve a water content suitable for compaction. This drying process can be time consuming, labor intensive, and requires favorable weather.

Filling operations for structural support should be closely monitored for fill type and compaction by a geotechnical technician. Monitoring should be on a full-time basis in cases where vertical fill placement is rapid; during freezing weather conditions; where groundwater is present; or where sensitive bottom conditions are present.

EXCAVATION/REFILLING DURING FREEZING TEMPERATURES

Soils that freeze will heave and lose density. Upon thawing, these soils will not regain their original strength and density. The extent of heave and density loss depends on the soil type and moisture condition; and is most pronounced in clays and silts. Foundations, slabs, and other improvements should be protected from frost intrusion during freezing weather. For earthwork during freezing weather, the areas to be filled should be stripped of frozen soil, snow and ice prior to new fill placement. In addition, new fill should not be allowed to freeze during or after placement. For this reason, it may be preferable to do earthwork operations in small plan areas so grade can be quickly attained instead of large areas where much frost stripping may be needed.

FREEZING WEATHER EFFECTS ON BUILDING CONSTRUCTION

GENERAL

Because water expands upon freezing and soils contain water, soils which are allowed to freeze will heave and loose density. Upon thawing, these soils will not regain their original strength and density. The extent of heave and density/strength loss depends on the soil type and moisture condition. Heave is greater in soils with higher percentages of fines (silts/clays). High silt content soils are most susceptible, due to their high capillary rise potential which can create ice lenses. Fine grained soils generally heave about 1/4" to 3/8" for each foot of frost penetration. This can translate to 1" to 2" of total frost heave. This total amount can be significantly greater if ice lensing occurs.

DESIGN CONSIDERATIONS

Frost heave may be critical in doorway areas. Stoops or sidewalks adjacent to doorways could be designed as structural slabs supported on frost footings with void spaces below. With this design, movements may then occur between the structural slab and the adjacent on-grade slabs. Non-frost susceptible granular soils (with less than 12% passing a #200 sieve) can be used below such areas. Depending on the function of surrounding areas, the granular soil layer may need a thickness transition away from the area where movement is critical. With granular soil placement over slower draining soils, subsurface drainage would be needed for the granular layer. High density extruded insulation could be used within the granular soils to reduce frost penetration, thereby reducing the granular soil thickness needed. We caution that insulation placed near the surface can increase the potential for ice glazing of the surface.

The possible effects of adfreezing should be considered if clayey or silty soils are used as backfill. Adfreezing occurs when backfill adheres to rough surfaced foundation walls and lifts the wall as it freezes and heaves. This occurrence is most common with masonry block walls, unheated or poorly heated building situations and clay backfill. The potential is also increased where backfill soils are poorly compacted and become saturated. The risk of adfreezing can be decreased by placing a low friction separating layer between the wall and backfill.

Adfreezing can occur on exterior piers (such as deck, fence or other similar pier footings), even if a smooth surface is provided. This is more likely in poor drainage situations where soils become saturated. Additional footing embedment and/or widened footings below the frost zones (which include tensile reinforcement) can be used to resist uplift forces. Specific designs would require individual analysis.

CONSTRUCTION CONSIDERATIONS

Foundations, slabs, and other improvements which may be affected by frost movements should be insulated from frost penetration during freezing weather. If filling takes place during freezing weather, all frozen soils, snow, and ice should be stripped from areas to be filled prior to new fill placement. The new fill should not be allowed to freeze during transit, placement, or compaction. This should be considered in the project scheduling, budgeting, and quantity estimating. It is usually beneficial to perform cold weather earthwork operations in small areas where grade can be attained quickly rather than working large areas where a greater amount of frost stripping may be needed. If slab subgrade areas freeze, we recommend the subgrade be thawed prior to floor slab placement. The frost action may also require reworking and recompaction of the thawed subgrade.

FLOOR SLAB MOISTURE/VAPOR PROTECTION

Floor slab design relative to moisture/vapor protection should consider the type and location of two elements, a granular layer and a vapor membrane (vapor retarder, water resistant barrier or vapor barrier). In the following sections, the pros and cons of the possible options regarding these elements will be presented, such that you and your specifier can make an engineering decision based on the benefits and costs of the choices.

GRANULAR LAYER

In American Concrete Institute (ACI) 302.1-96, a “base material” is recommended, rather than the conventional cleaner “sand cushion” material. The manual maintains that clean sand (common “cushion” sand) is difficult to compact and maintain until concrete placement is complete. ACI recommends a clean, fine graded material (with at least 10% to 30% of particles passing a #100 sieve) which is not contaminated with clay, silt or organic material. We refer you to ACI 302.1-96 for additional details regarding the requirements for the base material.

In cases where potential static water levels or significant perched water sources appear near or above the floor slab, an underfloor drainage system may be needed wherein a drain tile system is placed within a thicker clean sand or gravel layer. Such a system should be properly engineered depending on subgrade soil types and rate/head of water inflow.

VAPOR MEMBRANE

The need for a vapor membrane depends on whether the floor slab will have a vapor sensitive covering, will have vapor sensitive items stored on the slab, or if the space above the slab will be a humidity controlled area. If the project does not have this vapor sensitivity or moisture control need, placement of a vapor membrane may not be necessary. Your decision will then relate to whether to use the ACI base material or a conventional sand cushion layer. However, if any of the above sensitivity issues apply, placement of a vapor membrane is recommended. Some floor covering systems (adhesives and flooring materials) require a vapor membrane to maintain a specified maximum slab moisture content as a condition of their warranty.

VAPOR MEMBRANE/GRANULAR LAYER PLACEMENT

A number of issues should be considered when deciding whether to place the vapor membrane above or below the granular layer. The benefits of placing the slab on a granular layer, with the vapor membrane placed **below** the granular layer, include **reduction** of the following:

- Slab curling during the curing and drying process.
- Time of bleeding, which allows for quicker finishing.
- Vapor membrane puncturing.
- Surface blistering or delamination caused by an extended bleeding period.
- Cracking caused by plastic or drying shrinkage.

The benefits of placing the vapor membrane **over** the granular layer include the following:

- The moisture emission rate is achieved faster.
- Eliminates a potential water reservoir within the granular layer above the membrane.
- Provides a “slip surface”, thereby reducing slab restraint and the associated random cracking.

If a membrane is to be used in conjunction with a granular layer, the approach recommended depends on slab usage and the construction schedule. The vapor membrane should be placed above the granular layer when:

- Vapor sensitive floor covering systems are used or vapor sensitive items will be directly placed on the slab.
- The area will be humidity controlled, but the slab will be placed before the building is enclosed and sealed from rain.
- Required by a floor covering manufacturer’s system warranty.

The vapor membrane should be placed below the granular layer when:

- Used in humidity controlled areas (without vapor sensitive coverings/stored items), with the roof membrane in place, and the building enclosed to the point where precipitation will not intrude into the slab area. Consideration should be given to slight sloping of the membrane to edges where drain tile or other disposal methods can alleviate potential water sources, such as pipe or roof leaks, foundation wall damp proofing failure, fire sprinkler system activation, etc.

There may be cases where membrane placement may have a detrimental effect on the subgrade support system (e.g., expansive soils). In these cases, your decision will need to weigh the cost of subgrade options and the performance risks.

Appendix A

AET Project No. 17-03158

Geotechnical Field Exploration and Testing
 Boring Log Notes
Unified Soil Classification System
 Site Location Map
 Boring Location Map
Subsurface Boring Logs
 Sieve Analysis Results

A.1 FIELD EXPLORATION

The subsurface conditions at the site were explored by drilling and sampling standard penetration test (SPT) borings. The locations of the borings appear on Figure 1, preceding the Subsurface Boring Logs in this appendix.

A.2 SAMPLING METHODS

A.2.1 Ring-lined barrel Samples - Calibrated to N_{60} Values

Standard penetration (ring-lined barrel) samples were collected in general accordance with ASTM: D3550. The ASTM test method consists of driving a 2.5-inch O.D. thick-walled, split-barrel sampler lined with brass rings into the in-situ soil with a 140-pound hammer dropped from a height of 30 inches. The sampler is driven a total of 18 inches into the soil. After an initial set of 6 inches, the number of hammer blows to drive the sampler the final 12 inches is known as the standard penetration resistance or N-value.

A.2.2 Disturbed Samples (DS)/Spin-up Samples (SU)

Sample types described as “DS” or “SU” on the boring logs are disturbed samples, which are taken from the flights of the auger. Because the auger disturbs the samples, possible soil layering and contact depths should be considered approximate.

A.2.3 Sampling Limitations

Unless actually observed in a sample, contacts between soil layers are estimated based on the spacing of samples and the action of drilling tools. Cobbles, boulders, and other large objects generally cannot be recovered from test borings, and they may be present in the ground even if they are not noted on the boring logs.

Determining the thickness of “topsoil” layers is usually limited, due to variations in topsoil definition, sample recovery, and other factors. Visual-manual description often relies on color for determination, and transitioning changes can account for significant variation in thickness judgment. Accordingly, the topsoil thickness presented on the logs should not be the sole basis for calculating topsoil stripping depths and volumes. If more accurate information is needed relating to thickness and topsoil quality definition, alternate methods of sample retrieval and testing should be employed.

A.3 CLASSIFICATION METHODS

Soil descriptions shown on the boring logs are based on the Unified Soil Classification (USC) system. The USC system is described in ASTM: D2487 and D2488. Where laboratory classification tests (sieve analysis or Atterberg Limits) have been performed, accurate classifications per ASTM: D2487 are possible. Otherwise, soil descriptions shown on the boring logs are visual-manual judgments. Charts are attached which provide information on the USC system, the descriptive terminology, and the symbols used on the boring logs.

Visual-manual judgment of the AASHTO Soil Group is also noted as a part of the soil description. A chart presenting details of the AASHTO Soil Classification System is also attached.

The boring logs include descriptions of apparent geology. The geologic depositional origin of each soil layer is interpreted primarily by observation of the soil samples, which can be limited. Observations of the surrounding topography, vegetation, and development can sometimes aid this judgment.

A.4 WATER LEVEL MEASUREMENTS

The ground water level measurements are shown at the bottom of the boring logs. The following information appears under “Water Level Measurements” on the logs:

- ◆ Date and Time of measurement
- ◆ Sampled Depth: lowest depth of soil sampling at the time of measurement
- ◆ Casing Depth: depth to bottom of casing or hollow-stem auger at time of measurement
- ◆ Cave-in Depth: depth at which measuring tape stops in the borehole
- ◆ Water Level: depth in the borehole where free water is encountered
- ◆ Drilling Fluid Level: same as Water Level, except that the liquid in the borehole is drilling fluid

The true location of the water table at the boring locations may be different than the water levels measured in the boreholes. This is possible because there are several factors that can affect the water level measurements in the borehole. Some of these factors include: permeability of each soil layer in profile, presence of perched water, amount of time between water level readings, presence of drilling fluid, weather conditions, and use of borehole casing.

A.5 LABORATORY TEST METHODS

A.5.1 Water Content Tests

Conducted per AET Procedure 01-LAB-010, which is performed in general accordance with ASTM: D2216 and AASHTO: T265.

A.5.2 Atterberg Limits Tests

Conducted per AET Procedure 01-LAB-030, which is performed in general accordance with ASTM: D4318 and AASHTO: T89, T90.

A.6 TEST STANDARD LIMITATIONS

Field and laboratory testing is done in general conformance with the described procedures. Compliance with any other standards referenced within the specified standard is neither inferred nor implied.

A.7 SAMPLE STORAGE

Unless notified to do otherwise, we routinely retain representative samples of the soils recovered from the borings for a period of 30 days.

BORING LOG NOTES

DRILLING AND SAMPLING SYMBOLS

Symbol	Definition
AR:	Sample of material obtained from cuttings blown out the top of the borehole during air rotary procedure.
B, H, N:	Size of flush-joint casing
CAS:	Pipe casing, number indicates nominal diameter in inches
COT:	Clean-out tube
DC:	Drive casing; number indicates diameter in inches
DM:	Drilling mud or bentonite slurry
DR:	Driller (initials)
DS:	Disturbed sample from auger flights
DP:	Direct push drilling; a 2.125 inch OD outer casing with an inner 1½ inch ID plastic tube is driven continuously into the ground.
FA:	Flight auger; number indicates outside diameter in inches
HA:	Hand auger; number indicates outside diameter
HSA:	Hollow stem auger; number indicates inside diameter in inches
LG:	Field logger (initials)
MC:	Column used to describe moisture condition of samples and for the ground water level symbols
N (BPF):	Standard penetration resistance (N-value) in blows per foot (see notes)
NQ:	NQ wireline core barrel
PQ:	PQ wireline core barrel
RDA:	Rotary drilling with compressed air and roller or drag bit.
RDF:	Rotary drilling with drilling fluid and roller or drag bit
REC:	In split-spoon (see notes), direct push and thin-walled tube sampling, the recovered length (in inches) of sample. In rock coring, the length of core recovered (expressed as percent of the total core run). Zero indicates no sample recovered.
SS:	Standard split-spoon sampler (steel; 1.5" is inside diameter; 2" outside diameter); unless indicated otherwise
SU	Spin-up sample from hollow stem auger
TW:	Thin-walled tube; number indicates inside diameter in inches
WASH:	Sample of material obtained by screening returning rotary drilling fluid or by which has collected inside the borehole after "falling" through drilling fluid
WH:	Sampler advanced by static weight of drill rod and hammer
WR:	Sampler advanced by static weight of drill rod
94mm:	94 millimeter wireline core barrel
▼:	Water level directly measured in boring
▽:	Estimated water level based solely on sample appearance

TEST SYMBOLS

Symbol	Definition
CONS:	One-dimensional consolidation test
DEN:	Dry density, pcf
DST:	Direct shear test
E:	Pressuremeter Modulus, tsf
HYD:	Hydrometer analysis
LL:	Liquid Limit, %
LP:	Pressuremeter Limit Pressure, tsf
OC:	Organic Content, %
PERM:	Coefficient of permeability (K) test; F - Field; L - Laboratory
PL:	Plastic Limit, %
q _p :	Pocket Penetrometer strength, tsf (<u>approximate</u>)
q _c :	Static cone bearing pressure, tsf
q _u :	Unconfined compressive strength, psf
R:	Electrical Resistivity, ohm-cms
RQD:	Rock Quality Designation of Rock Core, in percent (aggregate length of core pieces 4" or more in length as a percent of total core run)
SA:	Sieve analysis
TRX:	Triaxial compression test
VSR:	Vane shear strength, remolded (field), psf
VSU:	Vane shear strength, undisturbed (field), psf
WC:	Water content, as percent of dry weight
%-200:	Percent of material finer than #200 sieve

STANDARD PENETRATION TEST NOTES

(Calibrated Hammer Weight)

The standard penetration test consists of driving a split-spoon sampler with a drop hammer (calibrated weight varies to provide N₆₀ values) and counting the number of blows applied in each of three 6" increments of penetration. If the sampler is driven less than 18" (usually in highly resistant material), permitted in ASTM: D1586, the blows for each complete 6" increment and for each partial increment is on the boring log. For partial increments, the number of blows is shown to the nearest 0.1' below the slash.

The length of sample recovered, as shown on the "REC" column, may be greater than the distance indicated in the N column. The disparity is because the N-value is recorded below the initial 6" set (unless partial penetration defined in ASTM: D1586 is encountered) whereas the length of sample recovered is for the entire sampler drive (which may even extend more than 18").

UNIFIED SOIL CLASSIFICATION SYSTEM

ASTM Designations: D 2487, D2488

**AMERICAN
ENGINEERING
TESTING, INC.**



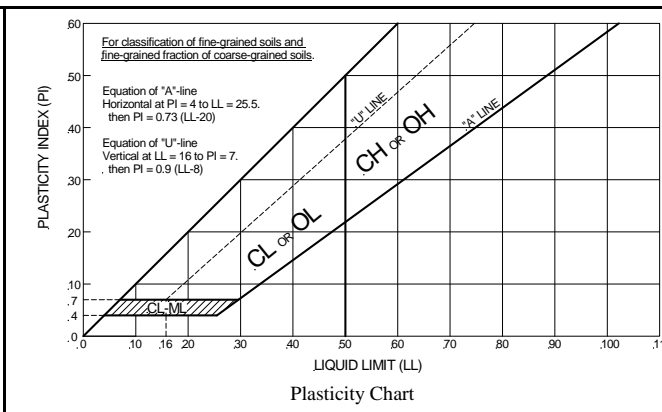
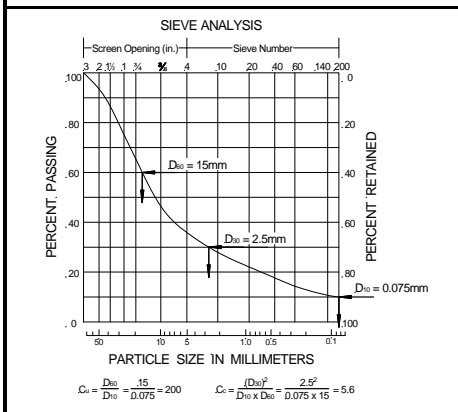
Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests ^A			Soil Classification		
			Group Symbol	Group Name ^B	
Coarse-Grained Soils More than 50% retained on No. 200 sieve	Gravels More than 50% coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines ^C	$Cu \geq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

Notes

- ^ABased on the material passing the 3-in (75-mm) sieve.
^BIf field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.
^CGravels 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
^DSands 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

$$^E C_u = D_{60} / D_{10}, \quad C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$$

- ^FIf soil contains $\geq 15\%$ sand, add "with sand" to group name.
^GIf fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.
^HIf fines are organic, add "with organic fines" to group name.
^IIf soil contains $\geq 15\%$ gravel, add "with gravel" to group name.
^JIf Atterberg limits plot is hatched area, soils is a CL-ML silty clay.
^KIf soil contains 15 to 29% plus No. 200 add "with sand" or "with gravel", whichever is predominant.
^LIf soil contains $\geq 30\%$ plus No. 200, predominantly sand, add "sandy" to group name.
^MIf soil contains $\geq 30\%$ plus No. 200, predominantly gravel, add "gravelly" to group name.
^N $PI \geq 4$ and plots on or above "A" line.
^O $PI < 4$ or plots below "A" line.
^PPI plots on or above "A" line.
^QPI plots below "A" line.
^RFiber Content description shown below.

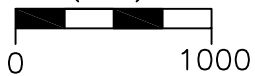


ADDITIONAL TERMINOLOGY NOTES USED BY AET FOR SOIL IDENTIFICATION AND DESCRIPTION

Grain Size	Gravel Percentages	Consistency of Plastic Soils	Relative Density of Non-Plastic Soils
Term Boulders Cobbles Gravel Sand Fines (silt & clay)	Term A Little Gravel With Gravel Gravelly	Term Very Soft Soft Firm Stiff Very Stiff Hard	Term Very Loose Loose Medium Dense Dense Very Dense
Particle Size Over 12" 3" to 12" #4 sieve to 3" #200 to #4 sieve Pass #200 sieve	Percent 3% - 14% 15% - 29% 30% - 50%	N-Value, BPF less than 2 2 - 4 5 - 8 9 - 15 16 - 30 Greater than 30	N-Value, BPF 0 - 4 5 - 10 11 - 30 31 - 50 Greater than 50
Moisture/Frost Condition D (Dry): M (Moist): W (Wet/ Waterbearing): F (Frozen):	Layering Notes Laminations: Lenses:	Fiber Content of Peat Term Fibric Peat: Hemic Peat: Sapric Peat:	Organic/Roots Description (if no lab tests) Soils are described as <i>organic</i> , if soil is not peat and is judged to have sufficient organic fines content to influence the soil properties. <i>Slightly organic</i> used for borderline cases. With roots: Trace roots:



SCALE
(FEET)



PROJECT: SOCCER FIELD CONCESSIONS BUILDING
STURGIS, SOUTH DAKOTA

SUBJECT: SITE LOCATION MAP

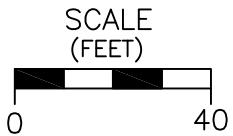
SCALE: 1 INCH = 1000 FEET

PROJECT NO. 17-03158

DATE: OCTOBER 19, 2017

DRAWN BY: JR

REVIEWED BY: WF



PROJECT: SOCCER FIELD CONCESSIONS BUILDING STURGIS, SOUTH DAKOTA	PROJECT NO.	17-03158
	SUBJECT:	DATE: OCTOBER 19, 2017
	SCALE: 1 INCH = 40 FEET	DRAWN BY: JR



SUBSURFACE BORING LOG

AET JOB NO: **17-03158**

LOG OF BORING NO. **B-1 (p. 1 of 1)**

PROJECT: **Soccer Field Concessions Building; Sturgis, South Dakota**

DEPTH IN FEET	SURFACE ELEVATION: 3358.8 MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	FIELD & LABORATORY TESTS							
							WC	DEN	LL	PL	%-#200			
1	TOPSOIL , Sandy Lean Clay with organics, dark brown SANDY GRAVEL with silt and cobbles, light brown, very dense (GP)	TOPSOIL ALLUVIUM												
2														
3			55	M	MC	18	6							
4														
5														
6			30	M	MC	18								
7														
8	with boulders		55	M	MC	18	9							8
9														
10														
11			71	M	MC	18								
12														
13			50/4	M	MC	11	8							
14														
15			50/4	M	MC	5								
Bottom of Boring														

AET_CORP 17-03158.GPJ AET+CPT+WELL.GDT 10/19/17

DEPTH:	DRILLING METHOD	WATER LEVEL MEASUREMENTS							NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG
		DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL	
15.0	3.25" HSA	10/13/17	9:10	15.4	15.0	NA	NA	7.2	
BORING COMPLETED: 10/13/17									
DR: BT LG: ES Rig: RC-1									



SUBSURFACE BORING LOG

AET JOB NO: **17-03158**

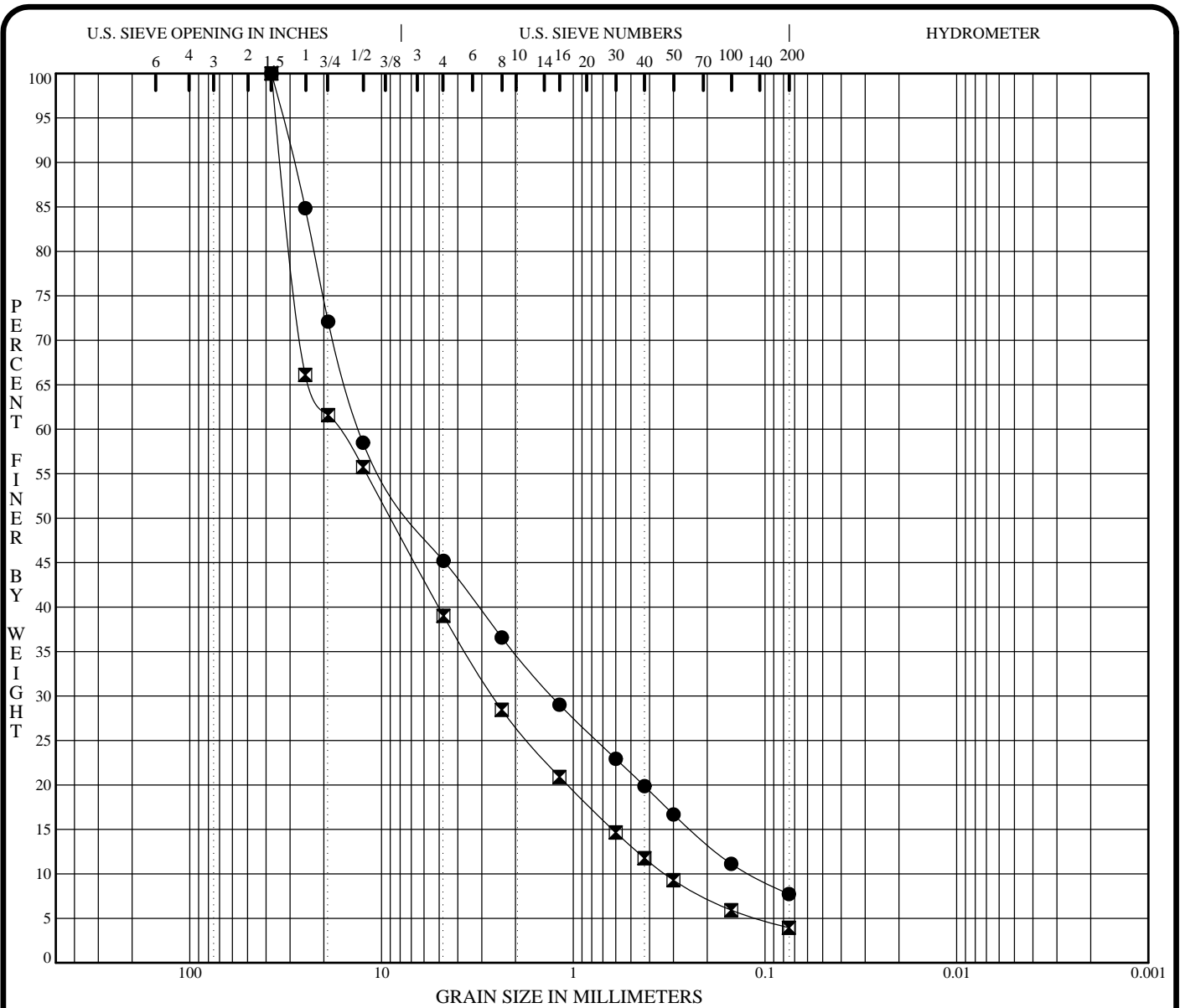
LOG OF BORING NO. **B-2 (p. 1 of 1)**

PROJECT: **Soccer Field Concessions Building; Sturgis, South Dakota**

DEPTH IN FEET	SURFACE ELEVATION: <u>3358.4</u> MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	FIELD & LABORATORY TESTS						
							WC	DEN	LL	PL	%-#200		
1	TOPSOIL , Sandy Lean Clay with organics, dark brown SANDY GRAVEL with silt and cobbles, light brown, very dense (GP)	TOPSOIL ALLUVIUM											
2													
3			75/9	M	MC	17							
4													
5													
6			45	M	MC	18	6						
7													
8			29	M	MC	18							
9													
10	with boulders												
11			50/5	M	MC	12	6					4	
12													
13			85	M	MC	18							
14													
15													
16	Bottom of Boring												

AET_CORP 17-03158.GPJ AET+CPT+WELL.GDT 10/19/17

DEPTH:	DRILLING METHOD	WATER LEVEL MEASUREMENTS							NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG
		DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL	
15.0	3.25" HSA	10/13/17	10:05	16.0	15.0	NA	NA	7.3	
BORING COMPLETED: 10/13/17									
DR: BT LG: ES Rig: RC-1									



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification	Classification	MC%	LL	PL	PI	Cc	Cu
● B-1 7.5'	Sandy Gravel with silt, light brown (GP)	9				1.07	110.0
☒ B-2 10.0'	Sandy Gravel with silt, light brown (GP)	6				1.22	51.2

Specimen Identification	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
● B-1 7.5'	37.50	13.10	1.291	0.1191	54.8	37.5	7.7	
☒ B-2 10.0'	37.50	16.96	2.616	0.3314	61.0	35.1	3.9	

PROJECT **Soccer Field Concessions Building; Sturgis, South Dakota** AET JOB NO. **17-03158**
DATE **10/13/17**



**GRADATION CURVES
ASTM D422**

Appendix B

Geotechnical Report Limitations and Guidelines for Use

Geotechnical Report Limitations and Guidelines for Use

AET Project No. 17-03158

REFERENCE

This appendix provides information to help you manage your risks relating to subsurface problems which are caused by construction delays, cost overruns, claims, and disputes. This information was developed and provided by ASFE¹, of which, we are a member firm.

RISK MANAGEMENT INFORMATION

Geotechnical Services are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical engineering study conducted for a civil engineer may not fulfill the needs of a construction contractor or even another civil engineer. Because each geotechnical engineering study is unique, each geotechnical engineering report is unique, prepared solely for the client. No one except you should rely on your geotechnical engineering report without first conferring with the geotechnical engineer who prepared it. No one, not even you, should apply the report for any purpose or project except the one originally contemplated.

Read the Full Report

Serious problems have occurred because those relying on a geotechnical engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

A Geotechnical Engineering Report is Based on A Unique Set of Project-Specific Factors

Geotechnical engineers consider a number of unique, project-specific factors when establishing the scope of a study. Typically factors include: the client's goals, objectives, and risk management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, do not rely on a geotechnical engineering report that was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical engineering report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light industrial plant to a refrigerated warehouse,
- elevation, configuration, location, orientation, or weight of the proposed structure,
- composition of the design team, or
- project ownership.

As a general rule, always inform your geotechnical engineer of project changes, even minor ones, and request an assessment of their impact. Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.

Subsurface Conditions Can Change

A geotechnical engineering report is based on conditions that existed at the time the study was performed. Do not rely on a geotechnical engineering report whose adequacy may have been affected by: the passage of time; by man-made events, such as construction on or adjacent to the site; or by natural events, such as floods, earthquakes, or groundwater fluctuations. Always contact the geotechnical engineer before applying the report to determine if it is still reliable. A minor amount of additional testing or analysis could prevent major problems.

¹ ASFE, 8811 Colesville Road/Suite G106, Silver Spring, MD 20910
Telephone: 301/565-2733 : www.asfe.org

Geotechnical Report Limitations and Guidelines for Use

AET Project No. 17-03158

Most Geotechnical Findings Are Professional Opinions

Site exploration identified subsurface conditions only at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ, sometimes significantly, from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide construction observation is the most effective method of managing the risks associated with unanticipated conditions.

A Report's Recommendations Are Not Final

Do not over rely on the construction recommendations included in your report. Those recommendations are not final, because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations only by observing actual subsurface conditions revealed during construction. The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's recommendations if that engineer does not perform construction observation.

A Geotechnical Engineering Report Is Subject to Misinterpretation

Other design team members' misinterpretation of geotechnical engineering reports has resulted in costly problems. Lower that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Contractors can also misinterpret a geotechnical engineering report. Reduce that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing construction observation.

Do Not Redraw the Engineer's Logs

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical engineering report should never be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, but recognize that separating logs from the report can elevate risk.

Give Contractors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make contractors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give contractors the complete geotechnical engineering report, but preface it with a clearly written letter of transmittal. In the letter, advise contractors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need to prefer. A prebid conference can also be valuable. Be sure contractors have sufficient time to perform additional study. Only then might you be in a position to give contractors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

Read Responsibility Provisions Closely

Some clients, design professionals, and contractors do not recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce the risk of such outcomes, geotechnical engineers commonly include a variety of explanatory provisions in their report. Sometimes labeled "limitations" many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. Read these provisions closely. Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The equipment, techniques, and personnel used to perform a geoenvironmental study differ significantly from those used to perform a geotechnical study. For that reason, a geotechnical engineering report does not usually relate any geoenvironmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. Unanticipated environmental problems have led to numerous project failures. If you have not yet obtained your own geoenvironmental information, ask your geotechnical consultant for risk management guidance. Do not rely on an environmental report prepared for someone else.