GEOTECHNICAL ENGINEERING STUDY

Proposed Arena Grandstands

About 3200 North 1000 West
Tremonton, Utah
CMT PROJECT NO. 12189

FOR:
Box Elder County
1 South Main Street, Suite 34
Brigham City, Utah 84302

December 26, 2018
December 26, 2018

Mr. Codey Illum
Box Elder County
1 South Main Street, Suite 34
Brigham City, Utah 84302

Subject: Geotechnical Engineering Study
Proposed Arena Grandstands
About 3200 North 1000 West
Tremonton, Utah
CMT Project No. 12189

Mr. Illum:

Submitted herewith is the report of our geotechnical engineering study for the subject site. This report contains the results of our findings and an engineering interpretation of the results with respect to the available project characteristics. It also contains recommendations to aid in the design and construction of the earth related phases of this project.

On November 28, 2018, a CMT Engineering Laboratories (CMT) engineer was on-site and supervised the excavation of 5 test pits extending to depths of about 8.0 to 13.5 feet below the existing ground surface. Soil samples were obtained during the field operations and subsequently transported to our laboratory for further testing and observation.

Conventional spread and/or continuous footings may be utilized to support the proposed structures, provided the recommendations in this report are followed. A detailed discussion of design and construction criteria is presented in this report.

We appreciate the opportunity to work with you at this stage of the project. CMT offers a full range of Geotechnical Engineering, Geological, Material Testing, Special Inspection services, and Phase I and II Environmental Site Assessments. With 8 offices throughout Utah and Arizona, our staff is capable of efficiently serving your project needs. If we can be of further assistance or if you have any questions regarding this project, please do not hesitate to contact us at (801) 492-4132.

Sincerely,
CMT Engineering Laboratories

Reviewed by:
Bryan N. Roberts, P.E.
Senior Geotechnical Engineer

Andrew M. Harris, P.E.
Geotechnical Division Manager
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Figure 1: Site Plan

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1.0 INTRODUCTION

1.1 General

CMT Engineering Laboratories (CMT) was retained to conduct a geotechnical subsurface study for the proposed new arena grandstand structure. The area to be developed is situated on the south side of the existing arena within the Box Elder County Fairgrounds in Tremonton, Utah, as shown in the Vicinity Map below.

![Vicinity Map](image)

1.2 Objectives, Scope and Authorization

The objectives and scope of our study were planned in discussions between Mr. Codey Illum of Box Elder County, and Mr. Andrew Harris of CMT Engineering Laboratories (CMT). In general, the objectives of this study were to define and evaluate the subsurface soil and groundwater conditions at the site, and provide appropriate foundation, earthwork, pavement and seismic recommendations to be utilized in the design and construction of the proposed development.

In accomplishing these objectives, our scope of work has included performing field exploration, which consisted of the excavating/logging/sampling of 5 test pits, performing laboratory testing on representative samples, and conducting an office program, which consisted of correlating available data, performing engineering analyses, and preparing this summary report. This scope of work was authorized by returning a signed copy of our proposal dated November 26, 2018.
1.3 Description of Proposed Construction

We understand that the proposed new grandstand structure will be constructed of steel post and beam construction. A new bathroom structure and concession stand are also planned for the site and anticipated to be one level, slab-on-grade, and of masonry construction. We project that maximum loads for the structures will be on the order of 2 to 5 kips per lineal foot for continuous wall footings and up to 150 kips for column footings. Floor slab loads are anticipated to be relatively light, with an average uniform loading not exceeding 100 pounds per square foot. If the loading conditions are different than we have projected, please notify us so that any appropriate modifications to our conclusions and recommendations contained herein can be made.

Site development will require some earthwork in the form of minor cutting and filling. A site grading plan was not available at the time of this report, but we project that maximum cuts and fills may be on the order of 1 to 3 feet.

1.4 Executive Summary

Our evaluation indicates that the proposed structures may be supported upon conventional spread and continuous wall foundations established upon suitable, undisturbed, natural soils and/or upon structural fill extending to suitable natural soils. To control settlement, more heavily loaded footings must be established over some thickness of granular structural replacement fill. The most significant geotechnical aspects regarding site development include the following:

1. Existing non-engineered fills across the surface ranging from about 1 to 3 feet thick at the test pit locations. The thickness of these surficial fills must be anticipated to vary both laterally and with depth across the site. All non-engineered fill must be removed below all foundations and floor slabs.
2. Groundwater was encountered between 7.5 and 8.5 feet in each of the test pits.
3. Some demolition will likely be necessary of existing structures for new construction.

CMT must assess that topsoil, non-engineered fills, debris, disturbed or unsuitable soils have been removed and that suitable soils have been encountered prior to placing site grading fills, footings, and slabs.

In the following sections, detailed discussions pertaining to the site and subsurface descriptions, geologic/seismic setting, earthwork, foundations, lateral resistance, lateral pressure, and floor slabs, are provided.

2.0 FIELD EXPLORATION

2.1 General

In order to define and evaluate the subsurface soil and groundwater conditions at the site, 5 test pits were excavated with a backhoe at the site to depths of approximately 8.0 to 13.5 feet below the existing ground surface. Locations of the test pits are shown on Figure 1, Site Plan, included in the Appendix. The field exploration was performed under the supervision of an experienced member of our geotechnical staff.
Representative soil samples were collected by obtaining disturbed "grab" samples and cutting relatively undisturbed "block" samples from within each test pit. The samples were placed in sealed plastic bags and containers prior to transport to the laboratory.

The subsurface soils encountered in the test pits were logged and described in general accordance with ASTM D-2488. Soil samples were collected as described above, and were classified in the field based upon visual and textural examination. These field classifications were supplemented by subsequent examination and testing of select samples in our laboratory. Graphical representations of the subsurface conditions encountered are presented on each individual Test Pit Log, Figures 2 through 6, included in the Appendix. A Key to Symbols defining the terms and symbols used on the logs, is provided as Figure 7 in the Appendix.

When backfilling the test pits, only minimal effort was made to compact the backfill and no compaction testing was performed. Thus, settlement of the backfill in the test pits over time should be anticipated and the backfill at this time must be considered as non-engineered fill.

3.0 LABORATORY TESTING

Selected samples of the subsurface soils were subjected to various laboratory tests to assess pertinent engineering properties, as follows:

1. Moisture Content, ASTM D-2216, Percent moisture representative of field conditions
2. Dry Density, ASTM D-2937, Dry unit weight representing field conditions
3. Atterberg Limits, ASTM D-4318, Plasticity and workability
4. Gradation Analysis, ASTM D-1140/C-117, Grain Size Analysis
5. One Dimension Consolidation, ASTM D-2435, Consolidation properties

Laboratory test results are presented on the test pit logs (Figures 2 through 6) and in the following Lab Summary table:

<table>
<thead>
<tr>
<th>Bore Hole</th>
<th>Depth (feet)</th>
<th>Soil Class</th>
<th>Sample Type</th>
<th>Moisture Content (%)</th>
<th>Dry Density (pcf)</th>
<th>Gradation</th>
<th>Atterberg Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Grav</td>
<td>Sand</td>
</tr>
<tr>
<td>TP-1</td>
<td>3</td>
<td>CL</td>
<td>Block</td>
<td>21.7</td>
<td>99</td>
<td>85.7</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>CL</td>
<td>Block</td>
<td>26.8</td>
<td>97</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TP-2</td>
<td>5</td>
<td>CL</td>
<td>Block</td>
<td>29.5</td>
<td>89</td>
<td>96.2</td>
<td>48</td>
</tr>
<tr>
<td>TP-3</td>
<td>4</td>
<td>CL</td>
<td>Block</td>
<td>26.6</td>
<td>98</td>
<td></td>
<td>42</td>
</tr>
<tr>
<td>TP-4</td>
<td>3</td>
<td>CL</td>
<td>Block</td>
<td>24.5</td>
<td>86</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>CL</td>
<td>Block</td>
<td>25.7</td>
<td>96</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TP-5</td>
<td>2.5</td>
<td>Fill/CL</td>
<td>Block</td>
<td>22.1</td>
<td>88</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1American Society for Testing and Materials
3.3 One-Dimensional Consolidation Tests

To provide data necessary for our settlement analyses, a consolidation test was performed on each of 4 representative sample of the surficial clay soils encountered across the site. Based upon data obtained from the consolidation testing, the undisturbed natural clay soils at this site are moderately over-consolidated and will exhibit moderate strength and compressibility characteristics under the planned loading. One consolidation test was completed on a near surface sample of the existing clay fill soils at about 2.5 feet below the surface in test pit TP-5 which exhibited up to 2.5 percent collapse under relatively light loading indicative of poorly consolidated soils (non-engineered fill/disturbed soils). Detailed results of the test are maintained within our files and can be transmitted to you, if so desired.

4.0 GEOLOGIC & SEISMIC CONDITIONS

4.1 Geologic Setting

The subject site is located in the east-central portion of Box Elder County in northern Utah. The site sits at an elevation of approximately 4,330 feet above sea level. The site is located in the Bear River Valley which is bound by the northern Wasatch Mountains on the east and the Point Lookout Mountains and Blue Spring Hills to the west. The Valley is a deep, sediment-filled basin that is part of the Basin and Range Physiographic Province. The valley was formed by extensional tectonic processes during the Tertiary and Quaternary geologic time periods. The Valley is located within the Intermountain Seismic Belt, a zone of ongoing tectonism and seismic activity extending from southwestern Montana to southwestern Utah. The active (evidence of movement in the last 10,000 years) Wasatch Fault Zone is part of the Intermountain Seismic Belt and extends from southeastern Idaho to central Utah along the western base of the Wasatch Mountain Range.

Much of northwestern Utah, including the valley in which the subject site is located, was also previously covered by the Pleistocene age Lake Bonneville. The Great Salt Lake, located along the western margin of the valley and beyond, is a remnant of this ancient fresh water lake. Lake Bonneville reached a high-stand elevation of between approximately 5,100 and 5,200 feet above sea level at between 18,500 and 17,400 years ago. Approximately 17,400 years ago, the lake breached its basin in southeastern Idaho and dropped relatively fast, by almost 300 feet, as water drained into the Snake River. Following this catastrophic release, the lake level continued to drop slowly over time, primarily driven by drier climatic conditions, until reaching the current level of the Great Salt Lake. Shoreline terraces formed at the high-stand elevation of the lake and several subsequent lower lake levels are visible in places on the mountain slopes surrounding the valley. Much of the sediment within the Valley was deposited as lacustrine sediments during both the transgressive (rise) and regressive (fall) phases of Lake Bonneville and in older, pre-Bonneville lakes that previously occupied the basin. Since the recession of Lake Bonneville, the Bear River has continued to deposit sediment in its flood plain throughout the valley.

Geologic mapping of the Tremonton area is poor and the only geologic map covering the location of the site is a 1:500,000 scale geologic map of the State of Utah by Hintze². The referenced map shows the general geology at the location of the site to be “alluvium and colluvium” (Map Unit Qa) dated to be Quaternary.

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No active surface fault traces are shown on the referenced geologic map crossing or projecting toward the subject site. No landslide deposits or features, including lateral spread deposits, are mapped on or adjacent to the site. The site is not located within a known or mapped potential debris flow, stream flooding, or rock fall hazard area. Refer to the Geologic Map, shown below.

**GEOLOGIC MAP**

### 4.2 Faulting

No surface fault traces are shown on the referenced geologic map crossing or projecting toward the subject site. The nearest mapped active fault trace is the Collinston Segment of the Wasatch fault located about 6 miles east of the site.
The Wasatch Fault is considered a “normal” fault because movement along the fault is typically vertical. The east side of the fault, or the mountain block, typically moves upward relative to the valley block on the west side of the fault. The fault generally dips to the west below the valleys. In an earthquake, the point where the fault initially ruptures is called the ‘focus” and generally occurs about 10 miles below the surface. The point on the surface directly above the focus, the epicenter, typically out in the valley, is usually where the strongest ground shaking occurs. The Wasatch Fault is one of the longest and most active normal faults in the world.

4.3 Seismicity

4.3.1 Site Class

Utah has adopted the International Building Code (IBC) 2015. IBC 2015 determines the seismic hazard for a site based upon 2008 mapping of bedrock accelerations prepared by the United States Geologic Survey (USGS) and the soil site class. The USGS values are presented on maps incorporated into the IBC code and are also available based on latitude and longitude coordinates (grid points). For site class definitions, IBC 2015 (Section 1613.3.2) refers to Chapter 20, Site Classification Procedure for Seismic Design, of ASCE\(^3\). Given the subsurface soils at the site, including our projection of soils within the upper 100 feet of the soil profile, it is our opinion the site best fits Site Class D – Stiff Soil Profile, which we recommend for seismic structural design.

4.3.2 Ground Motions

The 2008 USGS mapping utilized by the IBC provides values of peak ground, short period and long period accelerations for the Site Class B boundary and the Maximum Considered Earthquake (MCE). This Site Class B boundary represents average bedrock values for the Western United States and must be corrected for local soil conditions. The following table summarizes the peak ground, short period and long period accelerations for the MCE event, and incorporates the appropriate soil correction factor for a Site Class D soil profile at site grid coordinates of 41.712744 degrees north latitude and 112.1827 degrees west longitude:

<table>
<thead>
<tr>
<th>SPECTRAL ACCELERATION VALUE, T</th>
<th>SITE CLASS B BOUNDARY [Mapped Values] (g)</th>
<th>SITE COEFFICIENT</th>
<th>SITE CLASS D [Adjusted for Site Class Effects] (g)</th>
<th>DESIGN VALUES (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Ground Acceleration</td>
<td>0.356</td>
<td>(F_a = 1.144)</td>
<td>0.408</td>
<td>0.272</td>
</tr>
<tr>
<td>Short Period Acceleration (0.2 Seconds)</td>
<td>(S_s = 0.891)</td>
<td>(F_a = 1.144)</td>
<td>(S_{MS} = 1.019)</td>
<td>(S_{DS} = 0.679)</td>
</tr>
<tr>
<td>Short Period Acceleration (1.0 Second)</td>
<td>(S_1 = 0.284)</td>
<td>(F_v = 1.832)</td>
<td>(S_{M1} = 0.520)</td>
<td>(S_{D1} = 0.347)</td>
</tr>
</tbody>
</table>

4.3.3 Liquefaction

The site is located in an area that has been identified by the Utah Earthquake Preparedness Information Center Utah Division of Comprehensive Emergency Management for Box Elder County as having “Moderate to High” liquefaction potential. Liquefaction is defined as the condition when saturated, loose, granular soils lose their

\(^3\) American Society of Civil Engineers
support capabilities because of excessive pore water pressure which develops during a seismic event. Clayey soils, even if saturated, generally will not liquefy during a major seismic event.

A liquefaction study was not completed as part of this study and would require drilling with Standard Penetration Test sampling (SPT) to a minimum depth of 30 feet below the ground surface and/or Cone Penetrometer Testing (CPT) in order to evaluate the saturated sand soils. However, based on the cohesive clay soils encountered the potential for liquefaction to occur within the depths penetrated is low.

4.4 Other Geologic Hazards

No landslide deposits or features, including lateral spread deposits, are mapped on or adjacent to the site. The site is not located within a currently known or mapped potential debris flow, stream flooding, or rock fall hazard area.

5.0 SITE CONDITIONS

5.1 Surface Conditions

The site is located at the existing Box Elder County fairgrounds. At present there are some bleachers and a small single-story structure located in the area for the planned grandstand. The site surface if relatively flat and blanketed with fill/disturbed soils. An aerial view of the site along with the test pit locations may be seen on the attached Figure 1 in the appendix.

5.2 Subsurface Soils

The subsurface soil encountered at the test pit locations were quite similar. The upper about 1 to 3 feet consisted of fill soils considered to be non-engineered. Below the non-engineered fill, natural soils were encountered which consisted of brown silty clay with some fine sand and occasional fine sand layers extending to the full depths penetrated, about 8.0 to 13.5 feet. The natural clay soils were visibly medium stiff to stiff, moist to wet, moderately over-consolidated and will exhibit moderate strength and compressibility characteristics under the planned loading.

For a more descriptive interpretation of subsurface conditions, please refer to the test pit logs, Figures 2 through 6, which graphically represent the subsurface conditions encountered. The lines designating the interface between soil types on the logs generally represent approximate boundaries - in situ, the transition between soil types may be gradual.

5.3 Groundwater

Groundwater was encountered in the test pits at depths of about 7.5 to 8.5 feet below existing grade at the time of our field exploration.
Groundwater levels can fluctuate as much as 1.5 to 2 feet seasonally. Numerous other factors such as heavy precipitation, local irrigation, and other unforeseen factors, may also influence ground water elevations at the site. The detailed evaluation of these and other factors, which may be responsible for ground water fluctuations, is beyond the scope of this study.

5.4 Site Subsurface Variations

Based on the results of the subsurface explorations and our experience, variations in the continuity and nature of subsurface conditions should be anticipated. Due to the heterogeneous characteristics of natural soils, care should be taken in interpolating or extrapolating subsurface conditions between or beyond the exploratory locations.

Also, when logging and sampling of the test pits was completed, the test pits were backfilled with the excavated soils but minimal to no effort was made to compact these soils. Therefore, the backfill must be considered as non-engineered fill and settlement of the backfill in the test pits over time should be anticipated. Caution must be exercised when constructing over these locations.

6.0 SITE PREPARATION AND GRADING

6.1 General

Initial site preparation shall consist of the demolition of existing structures and the removal of all associated debris, and non-engineered fill, any deleterious materials, or disturbed soils from beneath all foundations and from an area extending out a minimum 3 feet from the perimeter of proposed buildings. Variation in the depth and lateral extent of disturbed soils and non-engineered fill material must be anticipated.

The existing surface fill soils generally consist of clayey gravel and gravel-clay mixtures. If free of debris these soils may be re-utilized as structural site grading fill if the appropriate compaction is achieved. Please note, however, that the fine-grained clayey soils are inherently difficult to adequately moisture prepare and re-compact and as such may become near impossible to re-compact during cold and wet periods of the year. Further, in their present state the onsite soils are likely above optimum moisture content for compacting and therefore would require some drying prior to recompacting. As an alternative, the fills/disturbed soil may be removed and replaced with imported granular structural fill over unfrozen, proof-rolled subgrade. Any loose fill piles, if present, must be completely removed.

Subsequent to stripping and prior to the placement of floor slabs, foundations, structural site grading fills, exterior flatwork, and pavements, the exposed subgrade must be proof rolled by passing moderate-weight rubber tire-mounted construction equipment over the surface at least twice. If excessively soft or otherwise unsuitable soils are encountered beneath footings, they must be completely removed. If removal depth required is greater than 2 feet below footings, CMT must be notified to provide further recommendations. In pavement, floor slab, and outside flatwork areas, unsuitable natural soils should be removed to a maximum depth of 2 feet and replaced with compacted granular structural fill.
The potential need for stabilizing the native clay subgrade, especially near groundwater or following precipitation events, prior to the placement of utilities, structural fills, or structural elements must be anticipated.

A representative of CMT must verify that suitable natural soils and proper preparation of existing soils have been encountered/met prior to placing site grading fills, footings, slabs, and pavements.

### 6.2 Temporary Excavations

The subsurface soils encountered within the test pits consisted primarily of fine grained, cohesive clay soils.

Temporary construction excavations in cohesive soil, not exceeding 4 feet in depth and above or below the groundwater table, may be constructed with near-vertical sideslopes. Temporary excavations up to 8 feet deep in fine-grained cohesive soils, above or below the water table, may be constructed with sideslopes no steeper than one-half horizontal to one vertical (0.5H:1V). Excavations deeper than 8 feet are not anticipated at the site.

For granular (cohesionless) soils, construction excavations above the water table, not exceeding 4 feet, should be no steeper than one-half horizontal to one vertical (0.5H:1V). For excavations up to 8 feet, in granular soils and above the water table, the slopes should be no steeper than one horizontal to one vertical (1H:1V). Excavations encountering saturated cohesionless soils will be very difficult and will require very flat sideslopes and/or shoring, bracing and dewatering as these soils will tend to flow into the excavation.

To reduce disturbance of the natural soils during excavation, it is recommended that smooth edge buckets/blades be utilized.

All excavations must be inspected periodically by qualified personnel. If any signs of instability or excessive sloughing are noted, immediate remedial action must be initiated. All excavations should be made following OSHA safety guidelines.

### 6.3 Fill Material

Structural fill is defined as all fill which will ultimately be subjected to structural loadings, such as imposed by footings, floor slabs, pavements, etc. Structural fill will be required as backfill over foundations and utilities, as site grading fill, and possibly as replacement fill below footings. All structural fill must be free of sod, rubbish, topsoil, frozen soil, and other deleterious materials.

Following are our recommendations for the various fill types we anticipate will be used at this site:
<table>
<thead>
<tr>
<th>Fill Material Type</th>
<th>Description/Recommended Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural Fill/replacement fill</td>
<td>Placed below structures, flatwork and pavement. Imported structural fill shall consist of Well-graded sand/gravel mixture, with maximum particle size of 4 inches, a minimum 70% passing 3/4-inch sieve, a maximum 20% passing the No. 200 sieve, and a maximum Plasticity Index of 10.</td>
</tr>
<tr>
<td>Imported General Site Grading Fill</td>
<td>Placed over larger areas to raise the site grade. Sandy to gravelly soil, with a maximum particle size of 6 inches, a minimum 70% passing 3/4-inch sieve, and a maximum 40% passing No. 200 sieve.</td>
</tr>
<tr>
<td>Non-Structural Fill</td>
<td>Placed below non-structural areas, such as landscaping. On-site soils or imported soils, with a maximum particle size of 8 inches, including silt/clay soils not containing excessive amounts of degradable/organic material (see discussion below).</td>
</tr>
<tr>
<td>Stabilization Fill</td>
<td>Placed to stabilize soft areas prior to placing structural fill and/or site grading fill. Coarse angular gravels and cobbles 1 inch to 8 inches in size. May also use 1.5- to 2.0-inch gravel placed on stabilization fabric, such as Mirafi RS280i or equivalent (see Section 6.6).</td>
</tr>
</tbody>
</table>

On-site clayey gravel fill soils at the surface may be used as site grading fill and non-structural fill. However, please note that where these soils contain a significant amount of fines, (clay and silt) they may be considered to be moisture-sensitive. Note that such moisture-sensitive soils are inherently more difficult to work with in proper moisture conditioning (they are very sensitive to changes in moisture content), requiring very close moisture control during placement and compaction. This will be very difficult, if not impossible, during wet and cold periods of the year.

The natural clay soils are not recommended as structural fill but may be re-utilized in non-structural areas. All fill material should be approved by a CMT geotechnical engineer prior to placement.

### 6.4 Fill Placement and Compaction

The various types of compaction equipment available have their limitations as to the maximum lift thickness that can be compacted. For example, hand operated equipment is limited to lifts of about 4 inches and most “trench compactors” have a maximum, consistent compaction depth of about 6 inches. Large rollers, depending on soil and moisture conditions, can achieve compaction at 8 to 12 inches. The full thickness of each lift should be compacted to at least the following percentages of the maximum dry density as determined by ASTM D-1557 (or AASHTO\(^4\) T-180) in accordance with the following recommendations:

\(^4\) American Association of State Highway and Transportation Officials
<table>
<thead>
<tr>
<th>LOCATION</th>
<th>TOTAL FILL THICKNESS (FEET)</th>
<th>MINIMUM PERCENTAGE OF MAXIMUM DRY DENSITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beneath an area extending at least 3 feet beyond the perimeter of</td>
<td>0 to 5</td>
<td>95</td>
</tr>
<tr>
<td>structures, and 2 feet beyond the perimeter of flatwork and pavement</td>
<td>5 to 8</td>
<td>98</td>
</tr>
<tr>
<td>(applies to structural fill and site grading fill)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Site grading fill outside area defined above</td>
<td>0 to 5</td>
<td>92</td>
</tr>
<tr>
<td></td>
<td>5 to 8</td>
<td>95</td>
</tr>
<tr>
<td>Utility trenches within structural areas</td>
<td>--</td>
<td>96</td>
</tr>
<tr>
<td>Roadbase and subbase</td>
<td>-</td>
<td>96</td>
</tr>
<tr>
<td>Non-structural fill</td>
<td>0 to 5</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td>5 to 8</td>
<td>92</td>
</tr>
</tbody>
</table>

Structural fills greater than 8 feet thick are not anticipated at the site. For best compaction results, we recommend that the moisture content for structural fill/backfill be within 2% of optimum. Field density tests should be performed on each lift as necessary to verify that proper compaction is being achieved.

### 6.5 Utility Trenches

For the bedding zone around the utility, we recommend utilizing sand bedding fill material that meets current APWA\(^5\) requirements.

All utility trench backfill material below structurally loaded facilities (foundations, floor slabs, flatwork, parking lots/drive areas, etc.) should be placed at the same density requirements established for structural fill in the previous section.

Most utility companies and local governments are requiring Type A-1a or A-1b (AASHTO Designation) soils (sand/gravel soils with limited fines) be used as backfill over utilities within public rights of way, and the backfill be compacted over the full depth above the bedding zone to at least 96% of the maximum dry density as determined by AASHTO T-180 (ASTM D-1557).

### 6.6 Stabilization

The onsite surface clay soils could be susceptible to rutting and pumping particularly during wet periods of the year. To stabilize soft soil conditions, coarse angular gravel and cobble mixtures (stabilizing fill) may be utilize and shall be end-dumped, spread to a maximum loose lift thickness of 15 inches, and compacted by dropping a backhoe bucket onto the surface continuously at least twice. As an alternative, the stabilizing fill may be compacted by passing moderately heavy construction equipment or large self-propelled compaction equipment at least twice. Subsequent fill material placed over the coarse gravels and cobbles shall be adequately compacted so that the “fines” are “worked into” the voids in the underlying coarser gravels and cobbles. Utilization of a filter fabric, such as RS280i or equivalent, over soft subgrade may also be advantageous.

---

\(^5\) American Public Works Association
7.0 FOUNDATION RECOMMENDATIONS

The following recommendations have been developed on the basis of the previously described project characteristics, including the maximum loads discussed in Section 1.3, the subsurface conditions observed in the field and the laboratory test data, and standard geotechnical engineering practice.

7.1 Foundation Recommendations

Based on our geotechnical engineering analyses, the proposed structures may be supported upon conventional spread and/or continuous wall foundations placed on suitable, undisturbed natural soils and/or on structural fill extending to suitable natural soils. Footings may be designed using a net bearing pressure of 2,000 psf if placed on suitable, undisturbed, natural soils or structural fill extending to suitable natural soils.

In order to control total and differential settlements, more heavily loaded footings must be underlain by some thickness of structural fill, as outlined below in Section 7.3 Estimated Settlement.

The term “net bearing pressure” refers to the pressure imposed by the portion of the structure located above lowest adjacent final grade, thus the weight of the footing and backfill to lowest adjacent final grade need not be considered. The allowable bearing pressure may be increased by 1/3 for temporary loads such as wind and seismic forces.

We also recommend the following:

1. Exterior footings subject to frost should be placed at least 30 inches below final grade.
2. Interior footings not subject to frost should be placed at least 16 inches below grade.
3. Continuous footing widths should be maintained at a minimum of 18 inches.
4. Spot footings should be a minimum of 24 inches wide.

7.2 Installation

Under no circumstances shall the footings be established upon non-engineered fills, loose or disturbed soils, topsoil, sod, rubbish, construction debris, other deleterious materials, frozen soils, or within ponded water. If unsuitable soils are encountered, they must be completely removed and replaced with compacted structural fill.

Excavations should be examined by a qualified geotechnical engineer to confirm that suitable bearing materials soils have been exposed.

All structural fill should meet the requirements for such, and should be placed and compacted in accordance with Section 6 above. The width of structural replacement fill below footings should be equal to the width of the footing plus 1 foot for each foot of fill thickness. For instance, if the footing width is 2 feet and the structural fill depth beneath the footing is 2 feet, the fill replacement width should be 4 feet, centered beneath the footing.
### 7.3 Estimated Settlement

Foundations designed and constructed in accordance with our recommendations could experience some settlement, but we anticipate that total settlements of footings founded as recommended above will not exceed 1 inch, provided more heavily loaded footings are placed on the minimum granular structural replacement fill thicknesses recommended below. We project that approximately 50% of the total settlement will initially take place during construction.

<table>
<thead>
<tr>
<th>Foundations</th>
<th>Bearing Pressure</th>
<th>Loading</th>
<th>Minimum Thickness of Replacement Granular Structural Fill (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spread</td>
<td>2,000</td>
<td>Up to 90 kips</td>
<td>0.0</td>
</tr>
<tr>
<td>Spread</td>
<td>2,000</td>
<td>90+ to 150 kips</td>
<td>1.0</td>
</tr>
<tr>
<td>Wall</td>
<td>2,000</td>
<td>Up to 5 kips per lineal foot</td>
<td>0.0</td>
</tr>
</tbody>
</table>

### 7.4 Lateral Resistance

Lateral loads imposed upon foundations due to wind or seismic forces may be resisted by the development of passive earth pressures and friction between the base of the footings and the supporting soils. In determining frictional resistance, a coefficient of 0.30 for natural clay soils or 0.40 for granular structural fill, may be utilized for design. Passive resistance provided by properly placed and compacted structural fill above the water table may be considered equivalent to a fluid with a density of 250 pcf. A combination of passive earth resistance and friction may be utilized if the friction component of the total is divided by 1.5.

### 8.0 LATERAL EARTH PRESSURES

The structures are anticipated to be constructed slab on grade. However, for shallow retaining walls or utility boxes up to 4 feet tall the following lateral pressure discussion is provided. Parameters, as presented within this section, are for backfills which will consist of drained granular soil placed and compacted in accordance with the recommendations presented herein.

The lateral pressures imposed upon subgrade facilities will, therefore, be basically dependent upon the relative rigidity and movement of the backfilled structure. For active walls, such as retaining walls which can move outward (away from the backfill), backfill may be considered equivalent to a fluid with a density of 40 pounds per cubic foot in computing lateral pressures. For more rigid walls (moderately yielding), backfill may be considered equivalent to a fluid with a density of 50 pounds per cubic foot. For very rigid non-yielding walls, granular backfill should be considered equivalent to a fluid with a density of at least 60 pounds per cubic foot. The above values assume that the surface of the soils slope behind the wall is horizontal and that the fill within 3 feet of the wall will be compacted with hand-operated compacting equipment.

For seismic loading of retaining/below-grade walls, the following uniform lateral pressures, in pounds per square foot (psf), should be added based on wall depth and wall case.
<table>
<thead>
<tr>
<th>Uniform Lateral Pressures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall Height (Feet)</td>
</tr>
<tr>
<td>-------------</td>
</tr>
<tr>
<td>4</td>
</tr>
</tbody>
</table>

9.0 FLOOR SLABS

Floor slabs may be established upon suitable, undisturbed, natural soils and/or on structural fill extending to suitable natural soils (same as for foundations). Under no circumstances shall floor slabs be established directly on any topsoil, non-engineered fills, loose or disturbed soils, sod, rubbish, construction debris, other deleterious materials, frozen soils, or within ponded water.

In order to facilitate curing of the concrete and provide a capillary break, we recommend that floor slabs be directly underlain by at least 4 inches of “free-draining” fill, such as “pea” gravel or 3/4-inch quarters to 1-inch minus, clean, gap-graded gravel. To help control normal shrinkage and stress cracking, the floor slabs may include the following features:

1. Adequate reinforcement for the anticipated floor loads with the reinforcement continuous through interior floor joints;
2. Frequent crack control joints; and
3. Non-rigid attachment of the slabs to foundation walls and bearing slabs.

10.0 DRAINAGE RECOMMENDATIONS

It is important to the long-term performance of foundations and floor slabs that water not be allowed to collect near the foundation walls and infiltrate into the underlying soils. We recommend the following:

1. All areas around structures should be sloped to provide drainage away from the foundations. Where possible we recommend a minimum slope of 6 inches in the first 10 feet away from the structure.
2. All roof drainage should be collected in rain gutters with downspouts designed to discharge at least 10 feet from the foundation walls or well beyond the backfill limits, whichever is greater.
3. Adequate compaction of the foundation backfill should be provided. We suggest a minimum of 90% of the maximum laboratory density as determined by ASTM D-1557. Water consolidation methods should not be used under any circumstances.
4. Sprinklers should be aimed away and kept at least 4 feet from the foundation walls. The sprinkling systems should be designed with proper drainage and be well-maintained. Over watering should be avoided.
5. Other precautions may become evident during construction.
11.0 QUALITY CONTROL

We recommend that CMT be retained as part of a comprehensive quality control testing and observation program. With CMT on-site we can help facilitate implementation of our recommendations and address, in a timely manner, any subsurface conditions encountered which vary from those described in this report. Without such a program CMT cannot be responsible for application of our recommendations to subsurface conditions which may vary from those described herein. This program may include, but not necessarily be limited to, the following:

11.1 Field Observations

Observations should be completed during all phases of construction such as site preparation, foundation excavation, structural fill placement and concrete placement.

11.2 Fill Compaction

Compaction testing by CMT is required for all structural supporting fill materials. Maximum Dry Density (Modified Proctor, ASTM D-1557) tests should be requested by the contractor immediately after delivery of any fill materials. The maximum density information should then be used for field density tests on each lift as necessary to ensure that the required compaction is being achieved.

11.3 Excavations

All excavation procedures and processes should be observed by a geotechnical engineer from CMT or their representative. In addition, for the recommendations in this report to be valid, all backfill and structural fill placed in trenches and all pavements should be density tested by CMT. We recommend that freshly mixed concrete be tested by CMT in accordance with ASTM designations.

12.0 LIMITATIONS

The recommendations provided herein were developed by evaluating the information obtained from the subsurface explorations and soils encountered therein. The exploration logs reflect the subsurface conditions only at the specific location at the particular time designated on the logs. Soil and ground water conditions may differ from conditions encountered at the actual exploration locations. The nature and extent of any variation in the explorations may not become evident until during the course of construction. If variations do appear, it may become necessary to re-evaluate the recommendations of this report after we have observed the variation.

Our professional services have been performed, our findings obtained, and our recommendations prepared in accordance with generally accepted geotechnical engineering principles and practices. This warranty is in lieu of all other warranties, either expressed or implied.

We appreciate the opportunity to be of service to you on this project. If we can be of further assistance or if you have any questions regarding this project, please do not hesitate to contact us at (801) 870-6730. To schedule materials testing, please call (801) 381-5141.
Proposed Arena Grandstands
About 3200 North 1000 West, Tremonton, Utah

Fill Depth (feet)

Date: 5-Dec-18
Job #: 12189

Main Street
# Test Pit Log

**Box Elder Fairgrounds**

About 3200 North 1000 West, Tremonton, Utah

<table>
<thead>
<tr>
<th>Equipment: Rubber Tire Backhoe</th>
<th>Total Depth: 13.5'</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface Elev. (approx):</td>
<td>Water Depth: 7.5'</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**TP-1**

### Test Pit Log

**Total Depth:** 13.5'  
**Water Depth:** 7.5'  
**Date:** 11/28/18  
**Job #:** 12189

---

## Soil Description

### Depth (ft)  | Sample Type  | Sample #  | Moisture (%) | Dry Densitypcf | Gradation | Atterberg |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>FILL, Dark Brown Clayey GRAVEL (GC)</td>
<td></td>
<td>moist, medium dense (estimated)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Brown Silty CLAY (CL), with some fine sand</td>
<td></td>
<td>moist, medium stiff (estimated)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>very moist grades with occasional sand layers up to 1&quot; thick</td>
<td></td>
<td>wet</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>grades gray</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>END AT 13.5'</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Remarks:

Groundwater encountered during excavation at depth of 7.5 feet.

---

**Figure:** 2

---

**Excavated By:** Olivia Roberts  
**Logged By:** Olivia Roberts  
**Owner Provided:** CMT Engineering Laboratories  
**Page:** 1 of 1
Soil Description

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Sample Type</th>
<th>Sample #</th>
<th>Moisture (%)</th>
<th>Gradation</th>
<th>Atterberg</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>FILL, Dark Brown Clayey GRAVEL (GC)</td>
<td>moist, medium dense (estimated)</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Brown Silty CLAY (CL)</td>
<td>moist, medium stiff (estimated)</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>grades with some fine sand layers</td>
<td>very moist</td>
<td>7</td>
<td>29.5</td>
<td>89</td>
</tr>
<tr>
<td>8</td>
<td>END AT 9'</td>
<td>wet</td>
<td>8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Remarks: Groundwater encountered during excavation at depth of 8.5 feet.
Box Elder Fairgrounds
About 3200 North 1000 West, Tremonton, Utah

Test Pit Log
TP-3

Equipment: Rubber Tire Backhoe
Surface Elev. (approx):

Total Depth: 8'
Water Depth: 7.5'
Job #: 12189
Date: 11/28/18

Soil Description

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Sample Type</th>
<th>Moisture (%)</th>
<th>Dry Densitypcf</th>
<th>Gradation</th>
<th>Atterberg</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>FILL, Dark Brown Clayey GRAVEL (GC)</td>
<td>moist, medium dense (estimated)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Brown Silty CLAY (CL)</td>
<td>moist, medium stiff (estimated)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>very moist</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>grades with fine sand layers</td>
<td>wet</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>END AT 8'</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Remarks: Groundwater encountered during excavation at depth of 7.5 feet.
Soil Description

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Sample Type</th>
<th>Sample #</th>
<th>Moisture (%)</th>
<th>Dry Density (pcf)</th>
<th>Gradation</th>
<th>Atterberg</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>FILL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Brown Silty CLAY (CL)</td>
<td></td>
<td>moist, medium stiff (estimated)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Remarks: Groundwater encountered during excavation at depth of 8 feet.

Excavated By: Owner Provided
Logged By: Olivia Roberts
Page: 1 of 1

Figure: 5
Soil Description

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Sample Type</th>
<th>Sample #</th>
<th>Moisture (%)</th>
<th>Dry Density (pcf)</th>
<th>Gravels</th>
<th>Sands</th>
<th>Fines</th>
<th>LL</th>
<th>Pl</th>
<th>PI</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>FILL, Dark Brown Clayey GRAVEL (GC)</td>
<td>moist, medium dense (estimated)</td>
<td>14</td>
<td>22.1</td>
<td>88</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Brown Silty CLAY (CL)</td>
<td>moist, medium stiff (estimated)</td>
<td>15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>grades with occasional fine sand layers</td>
<td>16</td>
<td>23.6</td>
<td>101</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

END AT 10.5’

Remarks: Groundwater encountered during excavation at depth of 7.5 feet.

Excavated By: Owner Provided
Logged By: Olivia Roberts
Page: 1 of 1
**Box Elder Fairgrounds**  
About 3200 North 1000 West, Tremonton, Utah

### Soil Description

<table>
<thead>
<tr>
<th>COLUMN DESCRIPTIONS</th>
<th>USCS SYMBOLS</th>
<th>TYPICAL DESCRIPTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth (ft): Depth (feet) below the ground surface (including groundwater depth - see water symbol below).</td>
<td>GW</td>
<td>Well-Graded Gravels, Gravel-Sand Mixtures, Little or No Fines</td>
</tr>
<tr>
<td>Graphic Log: Graphic depicting type of soil encountered (see ② below).</td>
<td>GP</td>
<td>Poorly-Graded Gravels, Gravel-Sand Mixtures, Little or No Fines</td>
</tr>
<tr>
<td>Soil Description: Description of soils encountered, including Unified Soil Classification Symbol (see below).</td>
<td>GM</td>
<td>Silty Gravels, Gravel-Sand-Silt Mixtures</td>
</tr>
<tr>
<td>Sample Type: Type of soil sample collected at depth interval shown; sampler symbols are explained below-right.</td>
<td>GC</td>
<td>Clayey Gravels, Gravel-Sand-Clay Mixtures</td>
</tr>
<tr>
<td>Sample #: Consecutive numbering of soil samples collected during field exploration.</td>
<td>SW</td>
<td>Well-Graded Sands, Gravelly Sands, Little or No Fines</td>
</tr>
<tr>
<td>Moisture (%): Water content of soil sample measured in laboratory (percentage of dry weight of sample).</td>
<td>SP</td>
<td>Poorly-Graded Sands, Gravelly Sands, Little or No Fines</td>
</tr>
<tr>
<td>Dry Density (pcf): The dry density of a soil measured in laboratory (pounds per cubic foot).</td>
<td>SM</td>
<td>Silty Sands, Sand-Silt Mixtures</td>
</tr>
<tr>
<td>Gradation: Percentages of Gravel, Sand and Fines</td>
<td>SC</td>
<td>Clayey Sands, Sand-Clay Mixtures</td>
</tr>
</tbody>
</table>

**Key to Symbols**

- **Gravel [-]**: More than 50% of material is larger than No. 200 sieve size.
- **Sand [-]**: The coarse fraction passing through No. 4 sieve.
- **Silt [-]**: The coarse fraction retained on No. 4 sieve.
- **Clay [-]**: Liquid Limit less than 50%
- **Silt [-]**: Liquid Limit greater than 50%
- **Organic [-]**: More than 50% of material is smaller than No. 200 sieve size.

**Unified Soil Classification System (USCS)**

- **Coarse-Grained Soils**: Clean Gravels, Gravel, Sand, Gravelly Sands, Gravel-Sand Mixtures.
- **Fine-Grained Soils**: Clean Sands, Sandy Sands, Sandy Clays, Silty Clays, Lean Clays.
- **Organic Soils**: Inorganic Silts, Sand, Organic Silts with No Plasticity or Organic Silts with Slight Plasticity.
- **Highly Organic Soils**: Organic Silts and Organic Silts with Low Plasticity.

**Gradation and Atterberg**

<table>
<thead>
<tr>
<th>Gradation</th>
<th>Atterberg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture (%):</td>
<td>Individual descriptions of Atterberg Tests are as follows:</td>
</tr>
<tr>
<td>Dry Density (pcf):</td>
<td>LL = Liquid Limit (%): Water content at which a soil changes from plastic to liquid behavior.</td>
</tr>
<tr>
<td>Gravel %:</td>
<td>PL = Plastic Limit (%): Water content at which a soil changes from liquid to plastic behavior.</td>
</tr>
<tr>
<td>Sand %:</td>
<td>Pt = Plasticity Index (%): Range of water content at which a soil exhibits plastic properties (= Liquid Limit - Plastic Limit).</td>
</tr>
<tr>
<td>Fines %:</td>
<td>PI = Plasticity Index (%): Water content at which a soil exhibits plastic to liquid behavior.</td>
</tr>
</tbody>
</table>

**Moisture Content**

<table>
<thead>
<tr>
<th>% Water Content</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to ½ inch</td>
<td>Trace</td>
</tr>
<tr>
<td>Up to 12 inches</td>
<td>&lt;5%</td>
</tr>
<tr>
<td>Greater than 12 in.</td>
<td>Some</td>
</tr>
<tr>
<td>1 or less per foot</td>
<td>5-12%</td>
</tr>
<tr>
<td>More than 1 per foot</td>
<td>With</td>
</tr>
<tr>
<td>&gt; 12%</td>
<td>Saturated</td>
</tr>
</tbody>
</table>

**Sample Symbols**

- **Block Sample**
- **Bulk/Bag Sample**
- **Modified California Sampler**
- **3.5° OD, 2.42” ID D&M Sampler**
- **Rock Core**
- **Standard Penetration Split Spoon Sampler**
- **Thin Wall (Shelby Tube)**

**Water Symbol**

- **Encountered Water**
- **Level**
- **Measured Water Level**

---

1. The results of laboratory tests on the samples collected are shown on the logs at the respective sample depths.
2. The subsurface conditions represented on the logs are for the locations specified. Caution should be exercised if interpolating between or extrapolating beyond the exploration locations.
3. The information presented on each log is subject to the limitations, conclusions, and recommendations presented in this report.