CMT ENGINEERING LABORATORIES

Geotechnical Engineering Study

Proposed Hooper Water Improvement District Water Tank

Near The Northwest Corner of 3500 W. and 5500 S.
Hooper, Utah

PREPARED FOR:

Hooper Water Improvement District
PO Box 217
Hooper, Utah 84315

PREPARED BY:

CMT Engineering Laboratories

CMT Project No. 9406

March 7, 2017

CMT ENGINEERING LABORATORIES

March 7, 2017

Hooper Water Improvement District
Attention: Mr. Scott Christiansen
PO Box 217
Hooper, Utah 84315

Subject: Geotechnical Engineering Study
Proposed Hooper Water Improvement District Water Tank
Near The Northwest Corner of 3500 West and 5500 South
Hooper, Utah
CMT Project Number 9406

Mr. Christiansen:

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 February 17, 2017, a CMT Engineering Laboratories (CMT) engineer was on-site and supervised the drilling of two borings extending to depths of approximately 31.5 and 41.5 feet below the existing ground surface. Soil samples were obtained during the field operations and subsequently transported to our laboratory for further testing.

Based on the findings of the subsurface exploration, natural soils consisted of 3.0 to 3.5 feet of clay soils overlying sand with varying silt and clay content extending to the full depth penetrated. Shallow groundwater was measured at about 3.7 feet below the existing ground surface.

For the proposed structure, conventional spread foundations may be supported directly over suitable, undisturbed natural soils or granular structural fill extending to suitable natural soils. A detailed discussion of design and construction criteria is presented in this report.

We appreciate the opportunity to work with 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.

Sincerely,
CMT Engineering Laboratories

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CMT ENGINEERING LABORATORIES

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1.0 INTRODUCTION

1.1 General

CMT Engineering Laboratories (CMT) was retained by Hooper Water Improvement District to conduct a geotechnical subsurface study for the proposed 100,000-gallon Hooper Water Improvement District water tank to be located at near the northwest corner of 3500 West and 5500 South in Hooper, Utah. (See **Figures 1** in the Appendix).

The purpose of this study was to provide an assessment of the subsurface soil conditions at the site and provide recommendations for design and construction of the proposed structure foundation. Our scope of work included supervising the drilling of two borings at the site, collecting samples of the subsurface soils from the borings, performing laboratory tests, evaluating field and laboratory test data, and preparing this report which summarizes our findings.

1.2 Objectives and Scope

The objectives and scope of our study were planned in discussions between Mr. Ryan Christensen of Gardner Engineering and Mr. Andrew Harris of CMT Engineering Laboratories (CMT).

In general, the objectives of this study were to:

1. Define and evaluate the subsurface soil and groundwater conditions across the water tank site.

2. Provide appropriate foundation and earthwork recommendations and geoseismic information to be utilized in the design and construction of the proposed water tank.

In accomplishing these objectives, our scope has included the following:

1. A field program consisting of the drilling, logging, and sampling of 2 borings.

2. A laboratory testing program.

3. An office program consisting of the correlation of available data, engineering analyses, and the preparation of this summary report.

1.3 Authorization

Authorization was provided by returning a signed copy of our Proposal dated January 10, 2017.

2.0 EXECUTIVE SUMMARY

The following is a brief summary of our findings and conclusions:

1. At the boring locations, we encountered natural surficial clay soils extending to depths of about 3.0 to 3.5 feet below the surface with major roots/topsoil within the upper 4 to 6 inches. Below the surficial clay soil, natural sand soils with varying silt/clay content was encountered to the full depths penetrated 31.5 and 41.5 feet.
2. Shallow groundwater was measured on February 22, 2017 (five days following drilling) within an installed piezometer at a depth of 3.7 feet below the ground surface at boring B-1. With shallow groundwater, some soil stabilization must be anticipated below foundations within 2 feet of groundwater.
3. The structure may be supported by conventional continuous spread and spot footings constructed on suitable undisturbed natural soils or structural fill extending to suitable natural soils.
4. CMT must verify that any disturbed, non-engineered fill, deleterious materials, or unsuitable soils have been removed below the footprint of the proposed water tank and that suitable soils have been encountered prior to placing structural site grading fills/backfills and footings.
5. Saturated sand layers were encountered within each boring that could liquefy during the design seismic event. However, calculated settlements are on the order of 1.5 inches or less and ground rupture and lateral spread are unlikely to occur.

3.0 DESCRIPTION OF PROPOSED CONSTRUCTION

We understand that a 50-foot diameter, 100,000-gallon water tank on the order of 8 feet tall is planned for this site. The tank will likely be constructed above grade and of reinforced concrete. Projected xaximum continuous wall and column loads are anticipated to be 1 kips per lineal foot and 60 kips, respectively.

Site development will require a moderate amount of earthwork in the form of site grading. We estimate in general that maximum cuts and fills to achieve design grades will be on the order of 2 feet. Larger cuts and fills may be required in isolated areas.

4.0 FIELD EXPLORATION AND SITE CONDITIONS

4.1 Field Exploration

The subsurface soil conditions were explored by drilling two borings within the proposed footprint of the water tank at the approximate locations shown on **Figure 2** in the Appendix. The borings extended to depths of approximately 31.5 and 41.5 feet below the existing ground surface. During the course of the drilling operations, a continuous log of the subsurface conditions encountered was maintained. Relatively undisturbed samples of the subsurface soils were obtained during drilling by hydraulically pushing a 3-inch diameter (Shelby) tube into the undisturbed soils below the drill augers. Disturbed samples were collected utilizing a standard split spoon sampler. The split spoon sampler was driven 18 inches into the soils below the drill augers using a 140-pound hammer free-falling a distance of 30 inches. The number of hammer blows needed for each 6-inch interval was recorded. The sum of the hammer blows for the final 12 inches of penetration is known as a standard penetration test and this 'blow count' was recorded on the boring logs. The blow count provides a reasonable approximation of the relative density of granular soils, but only a limited indication of the relative consistency of fine grained soils because the consistency of these soils is significantly influenced by the moisture content.

The collected samples were logged and described in general accordance with ASTM 2488, packaged, and transported to our laboratory. The soils were classified in the field based upon visual and textural examination. These classifications have been supplemented by subsequent inspection and testing in our laboratory. The subsurface conditions encountered in the field exploration are discussed below in Section 4.3 Subsurface Soil and Groundwater. Boring logs, including a description of the soil strata encountered, is presented on **Figures 3A and 3B, Bore Hole Log** in the Appendix. Sampling information and other pertinent data and observations are also included on the logs. In addition, a Key to Symbols defining the terms and symbols used on the logs is provided as **Figure 4** in the Appendix.

4.2 General Geology

The subject site is located in the south-central portion of Weber County in north-central Utah. The site sits at an elevation of approximately 4,304 feet above sea level. The site is located in a valley bound by the Wasatch Mountains on the east and Antelope Island (Great Salt Lake) and the Promontory Mountains 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 approximately 5,092 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.

The geology of the USGS Roy, Utah 7.5 Minute Quadrangle, that includes the location of the subject site, has been mapped by Sack[1]. The surficial geology at the location of the subject site and adjacent properties is mapped as "Undifferentiated lacustrine and alluvial deposits" (Map Unit Qla) dated to be Holocene to upper Pleistocene. No fill has been mapped at the location of the site on the geologic map. Unit Qla is described in the referenced mapping as "Fluvially reworked lake sediments and intermingled lake and alluvial fan deposits. Sandy fines through gravelly sand deposited from about 12.6 ka to the present. Thickness generally less than 10 feet (3 m)."

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.

4.2 Site Surface Conditions

The location of the proposed water tank is within an open agricultural field directly northeast of an existing well houses structure. The site relatively flat and surrounded by residential homes to the south and west and similar vacant property to the north and east. (see **Figure 1** in the appendix for more detail).

[1]Sack, D., 2005, Geologic Map of the Roy 7.5' Quadrangle, Weber and Davis Counties, Utah; Utah Geological Survey Miscellaneous Publication, Map MP-05-03, Scale 1:24,000.

4.3 Subsurface Soil And Groundwater

The subsurface soil conditions encountered within each boring was similar and consisted of silty clay from the surface extending to depths of about 3.0 to 3.5 feet at the surface underlain by sand with varying silt/clay content extending to the full depths penetrated, 31.5 to 41.5 feet. The upper 3 to 6 inches of soil at the surface contained major roots/topsoil.

The natural clay soils were generally soft to medium stiff, moist grading saturated, brown in color, and will exhibit moderate strength and compressibility characteristics under the anticipated static loading.

The natural sand soils encountered were generally medium dense, saturated, brown to reddish brown in color, and will exhibit moderately high strength and low compressibility characteristics under the anticipated static loading.

For a more detailed description of the subsurface soil conditions, please refer to Figures 3A and 3B, Bore Hole Log. The lines designating the interface between soil types on the bore hole logs generally represent approximate boundaries. In-situ, the transition between soil types may be gradual.

4.4 Groundwater

Groundwater was encountered at the time of drilling at about 4 feet below the surface. Static groundwater was measured within the piezometer installed within boring B-1 on February 22, 2017 (five days following drilling) at a depth of 3.7 feet below the ground surface.

4.5 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 beyond the exploratory locations. Seasonal fluctuations in ground water conditions may also occur.

4.6 Seismic Setting

4.6.1 General

Utah municipalities have adopted the International Building Code (IBC) 2015. The IBC 2015 code 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).

4.6.2 Faulting

Based upon our review of available literature, no active faults are known to pass through the site. The nearest mapped active fault trace is the Weber section of the Wasatch Fault located about 6.75 mile to the east.

4.6.3 Soil Class

For dynamic structural analysis, the Site Class D – Stiff Soil Profile as defined in Chapter 20 of ASCE 7 (per Section 1613.3.2, Site Class Definitions, of IBC 2015) can be utilized based on subsurface soil conditions encountered within the depths penetrated.

4.6.4 Ground Motions

The 2008 USGS mapping provides values of short and long period accelerations for the Site Class B boundary for 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 and short and long period accelerations for the MCE event and incorporates the appropriate soil amplification factor for a Site Class D soil profile. Based on the site latitude and longitude (41.16476 degrees north and -112.06642 degrees west, respectively), the values for this site are tabulated below.

Spectral Acceleration Value, T	Site Class B Boundary [mapped values] (% g)	Site Coefficient	Site Class D [adjusted for site class effects] (% g)	Design Values (% g)
Peak Ground Acceleration	48.2	F_a = 1.018	49.0	32.7
0.2 Seconds (Short Period Acceleration)	S_S = 120.4	F_a = 1.018	S_{MS} = 122.6	S_{DS} = 81.7
1.0 Second (Long Period Acceleration)	S_1 = 40.1	F_v = 1.599	S_{M1} = 64.1	S_{D1} = 42.7

4.6.5 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 Weber County as having "High" liquefaction potential. Liquefaction is defined as the condition when saturated, loose, granular soils lose their 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.

Calculations were performed using the procedures described in the 2008 Soil Liquefaction During Earthquakes Monograph by Idriss and Boulanger[2] and the 2014 Soil Liquefaction During Earthquakes Monograph by Idriss and Boulanger Boulanger[3]. Our calculations indicate that loose, saturated sand soils encountered between about 18.0 and 23.0 feet at boring B-1, a thin layer between about 5 and 7 feet and a layer between about 23.0 and 27.0 feet at boring B-2 could liquefy curing the design seismic event. Calculated settlement associated with the liquefiable zone encountered at boring B-1 was on the order of about 1.5 inches. The combined calculated settlement associated with the liquefiable zones encountered at boring B-2 was on the order of about 1.45 inches. The magnitude of settlement should be tolerable to design for life safety. Additionally, lateral spread and ground rupture are unlikely to occur.

5.0 LABORATORY TESTING

5.1 Laboratory Examination

In order to provide data necessary for our engineering analyses, a laboratory testing program was completed. The program included partial gradation and consolidation tests. The following paragraphs describe the tests and summarize the test data.

5.2 Gradation Tests

To aid in classifying the granular soils, partial gradation tests were performed. Results of the tests are tabulated on the following page:

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2 Idriss, I. M., and Boulanger, R. W. (2008), Soil liquefaction during earthquakes: Monograph MNO-12, Earthquake Engineering Research Institute, Oakland, CA, 261 pp.

3 Boulanger, R. W. and Idriss, I. M. (2014), "CPT and SPT Based Liquefaction Triggering Procedures." Report No. UCD/CGM-14/01, Center for Geotechnical Modeling, Department of Civil and Environmental Engineering, University of California, Davis, CA, 134 p.

Boring No.	Depth (feet)	Percent Passing No. 200 Sieve	Moisture Content Percent	Soil Classification
B-1	7.5	46.3	25.6	SC-SM
B-1	15.0	20.3	22.5	SM
B-1	20.0	21.4	25.6	SM
B-1	30.0	27.0	22.0	SM
B-2	7.5	32.6	26.5	SM
B-2	10.0	23.3	22.3	SM
B-2	15.0	11.5	23.0	SP-SM
B-2	25.0	11.4	21.7	SP-SM
B-2	30.0	19.9	18.9	SM

6.0 SITE PREPARATION AND GRADING

6.1 Site Preparation

Site preparation shall consist of the removal of all surface vegetation, debris and any deleterious materials, from beneath an area extending out at least 3 feet from the perimeter of the proposed tank structure.

To provide a uniform bearing surface for the water tank floor CMT recommends excavating and replacing a minimum of 18 inches of subgrade with compacted granular structural fill. Subsequent to stripping and prior to the placement of structural fill, the floor slab, foundations, and exterior flatwork, the exposed subgrade must be proof rolled by passing moderate-weight rubber tire-mounted construction equipment over the surface at least twice. Where groundwater is within 2 feet of the working surface, proofrolling is not recommended.

If excessively soft or otherwise unsuitable soils are encountered beneath the tank floor and 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.

Static groundwater was measured at depths of 3.7 feet below the surface at boring B-1. The shallow groundwater encountered at the site will likely affect the installation of associated utilities and therefore may require dewatering. To reduce the potential for hydrostatic pressure below the tank floor slab it is recommended that the floor slabs be maintained a minimum 2.0 feet above measured groundwater.

Due to the easily disturbed nature of the native clays, stabilization may be required prior to placement of footings, structural site grading fill and the tank floor slab. If installed below the floor slab, stabilizing fill may be incorporated into the minimum 18 inches of structural replacement fill recommended below the slab. Stabilization recommendations are provided in sections 6.3 and 6.5 below.

We recommend that a representative of CMT must verify that suitable natural soils have been encountered prior to placing site grading fills, footings, and slabs.

6.2 Temporary Excavations

The upper 3 to 3.5 feet of soil encountered was predominately clay soil. Below this surficial clay soil, sand (cohesionless) soil was encountered.

Temporary excavations up to 4 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:1.0V).

Temporary construction excavations in granular (cohesionless) soils above the water table, not exceeding 4 feet, should be no steeper than three-quarter horizontal to one vertical (0.75H:1V). Groundwater was encountered at a depth of about 3.7 feet below the existing ground surface. Excavations encountering saturated cohesionless soils will be very difficult and will require very flat sideslopes and/or shoring, bracing and dewatering.

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 Structural 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 as replacement fill below the tank floor slab and possibly footings. All structural fill must be free of sod, rubbish, topsoil, frozen soil, and other deleterious materials.

Import structural fill below foundations and the floor slab shall consist of a well graded sand and gravel mixture with less than 30 percent retained on the 0.75-inch sieve and less than 15 percent passing the No. 200 Sieve (clays and silts).

To stabilize soft subgrade conditions (if encountered) or where structural fill is required to be placed closer than 1.0 foot above the water table at the time of construction, a mixture of coarse angular gravels and cobbles and/or 1.5- to 2.0-inch gravel (stabilizing fill) should be utilized. It may also help to utilize a stabilization fabric, such as Mirafi 600X or equivalent, placed on the native ground if 1.5- to 2.0-inch gravel is used as stabilizing fill.

Non-structural site grading fill is defined as all fill material not designated as structural fill and may consist of any cohesive or granular soils not containing excessive amounts of degradable material.

6.4 Utility Trenches

All utility trench backfill material below structurally loaded facilities (flatwork, floor slabs, roads, etc.) shall be placed at the same density requirements established for structural fill. If the surface of the backfill becomes disturbed during the course of construction, the backfill shall be proofrolled and/or properly compacted prior to the construction of any exterior flatwork over a backfilled trench. Proofrolling shall be performed by passing moderately loaded rubber tire-mounted construction equipment uniformly over the surface at least twice. If excessively loose or soft areas are encountered during proofrolling, they shall be removed to a maximum depth of 2 feet below design finish grade and replaced with structural fill.

6.5 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 as determined by the ASTM[4] D-1557(AASHTO[5] T-180) compaction criteria in accordance with the table below:

Location	Total Fill Thickness (feet)	Minimum Percentage of Maximum Dry Density
Beneath an area extending at least 3 feet beyond the perimeter of the structure	0 to 8	95
Site grading fills outside area defined above	0 to 5	90
Site grading fills outside area defined above	5 to 8	95
Utility trenches within structural areas	--	96

4 American Society for Testing and Materials
5 American Association of State Highway and Transportation Officials

Structural fills greater than 8 feet thick are not anticipated at the site. We recommend for best compaction results that the moisture content for structural fill/backfill be within 2 percent of optimum.

Subsequent to stripping and prior to the placement of structural site grading fill, the subgrade shall be prepared as discussed in Section 6.1, Site Preparation, of this report. In confined areas, subgrade preparation should consist of the removal of all loose or disturbed soils.

The natural fine grained 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 Mirafi 600X or equivalent, over soft subgrade may also be advantageous.

Non-structural fill may be placed in lifts not exceeding 12 inches in loose thickness and compacted by passing construction, spreading, or hauling equipment over the surface at least twice.

Field density tests should be performed on each lift as necessary to verify that compaction is being achieved.

7.0 LATERAL EARTH PRESSURES

The structure will be constructed near or at 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.

Uniform Lateral Pressures			
Wall Height (Feet)	**Active Pressure Case (psf)**	**Moderately Yielding Case (psf)**	**At Rest/Non-Yielding Case (psf)**
4	26	54	82

The given values for design are based on granular soils in place behind walls.

8.0 FOUNDATION RECOMMENDATIONS

The following recommendations have been developed on the basis of the previously described project characteristics, the subsurface conditions observed in the field, the laboratory test data, as well as common engineering practice.

8.1 Foundation Recommendations

The results of our analyses indicate that the proposed structure may be supported upon conventional spread and/or continuous wall foundations established upon suitable natural soils or granular structural fill extending to suitable natural soils. For design, with respect to the proposed construction and anticipated loading given in Section 3.0, Proposed Construction, the following parameters are recommended:

Minimum Recommended Depth of Embedment for Frost Protection - 30 inches

Minimum Recommended Depth of Embedment for Non-frost Conditions - 15 inches

Recommended Minimum Width for Continuous Wall Footings - 18 inches

Minimum Recommended Width for Isolated Spread Footings - 24 inches

Recommended Net Bearing Pressure for Real Load Conditions on Suitable Natural Soil - 2,000 pounds per square foot

Recommended Net Bearing Pressure for Real

Load Conditions with Footings Supported Over 18 Inches of Granular Structural Fill Over Suitable Natural Soil - 2,500 pounds per square foot

Bearing Pressure Increase for Seismic Loading - 30 percent

The term “net bearing pressure” refers to the pressure imposed by the portion of the structure located above lowest adjacent final grade. Therefore, the weight of the footing and backfill to lowest adjacent final grade need not be considered. Real loads are defined as the total of all dead plus frequently applied live loads. Total load includes all dead and live loads, including seismic and wind.

8.2 Installation

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

The width of structural replacement fill below footings should be equal to the width of the footing plus one 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.

8.3 Estimated Settlement

Foundations designed and constructed in accordance with our recommendations could experience some settlement, but we anticipate that settlement of footings founded as recommended above will be 1 inch or less. We expect approximately 40 percent of initial settlement to take place during construction.

8.4 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 should be utilized for natural soils and 0.40 for granular structural fills. Passive resistance provided by properly placed and compacted granular structural fill above the water table may be considered equivalent to a fluid with a density of 300 pounds per cubic foot.

A combination of passive earth resistance and friction may be utilized provided that the friction component of the total is divided by 1.5.

9.0 FLOOR SLAB

To provide a uniform bearing surface for the water tank floor, CMT recommends excavating and replacing a minimum of 18 inches of subgrade with compacted granular structural fill. The structural fill may be established upon suitable natural soils prepared as discussed in Section 6.1, Site Preparation, of this report. Under no circumstances shall floor slabs be established directly over unprepared non-engineered fills, loose or disturbed soils, sod, rubbish, construction debris, other deleterious materials, frozen soils, or within ponded water.

10.0 DRAINAGE RECOMMENDATIONS

It is important to the long term performance of foundations 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. 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.

3. Other precautions may become evident during construction.

11.0 QUALITY CONTROL

Our recommendations in this report are based on the assumption that adequate quality control testing and observations will be conducted by CMT during construction to verify compliance. This 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

We recommend compaction testing by CMT is required for all structural supporting fill materials. Maximum Dry Density (Proctor-ASTM 1557) tests should be requested by the contractor prior to fill placement. 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 Quality Control

All excavation procedures and processes should be observed by a geotechnical engineer from CMT. 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 borings and site exploration. The boring data reflects the subsurface conditions only at the specific locations at the particular time designated on the bore hole 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.

Appendix

Hooper Water Tank

NW Corner of 3500 West and 5500 South

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Vicinity Map

Date: 7-Mar-17
Job # 9406

Figure: 1

Hooper Water Tank

NW Corner of 3500 West and 5500 South

CMT ENGINEERING LABORATORIES

Site Map

Date: 7-Mar-17

Job # 9406

Figure: 2

Hooper Water

Northwest Corner of 3500 West and 5500 South

Bore Hole Log

B-1

Boring Type: HSA	Total Depth: 41.5 Feet	Date: 2-22-17	
Surface Elev. (approx):	Water Level: 3.7'	Job #: 9406	

Depth (ft.)	Soil Description	Sample Type	Sample #	Blows (N)	Total	Moisture (%)	Gravel %	Sand %	Fines %	LL	PL	PI	Dry Density
0	Brown silty CLAY with some fine sand (CL) Major roots/topsoil upper 4 to 6 inches. Moist, Soft to Medium Stiff												
			1	0, 3, 2	5								
3	Reddish brown silty/clayey fine SAND (SC- SM) Very moist, Loose												
	No recovery with shelby tube. Pushed SPT. Saturated		2										
	Medium Dense		3	7, 9, 10	19	25.6			46.3				
			4	3, 11, 5	16								
	Grades interbedded clay and silty sand (CL/SM)												
			5			29.8							92
	Brown, silty SAND with occasional clay layers up to 1/4-inches (SM) Saturated, Medium dense												
			6	4, 8, 7	15	22.5			20.3				
	Grades with occasional to some clay lenses. Very Loose		7	3, 0, 1	1	25.6			21.4				

Remarks: Piezometer installed in boring.

CMT ENGINEERING LABORATORIES

Excavated By: GBD

Logged By: BNR

Figure: 3A

Hooper Water

Northwest Corner of 3500 West and 5500 South

Bore Hole Log

B-1

Boring Type: HSA
Surface Elev. (approx):
Total Depth: 41.5 Feet
Water Level: 3.7'
Date: 2-22-17
Job #: 9406

Depth (ft.)	Soil Description	Sample #	Blows (N)	Total:	Moisture (%)	Gravel %	Sand %	Fines %	LL	PL	PI	Dry Density
24												
	Grades no clay lenses		3									
	Medium Dense	8	12									
			11	23								
27												
30	Grades gray in color		5									
	Medium Dense to Dense		11		22			27				
			17	28								
33												
	Grade with occasional clay layers up to 4 inches thick.		5									
		9	12									
36			12	24								
39												
	Gray silty CLAY (CL)		1									
	Saturated, Very Soft	10	1									
			1	2								
42	End at 41.5 Feet'											

Remarks: Piezometer installed in boring.

CMT ENGINEERING LABORATORIES

Excavated By: GBD
Logged By: BNR

Figure: 3A

Hooper Water

Northwest Corner of 3500 West and 5500 South

Bore Hole Log

B-2

Boring Type: HSA
Surface Elev. (approx):
Total Depth: 31.5 Feet
Water Level:
Date:
Job #: 9406

Depth (ft.)	Soil Description	Sample #	Blows (N)	Total	Moisture (%)	Gravel %	Sand %	Fines %	LL	PL	PI	Dry Density
0	Brown, silty CLAY with some fine sand (CL) Major roots/ toposoil upper 4 to 6 inches. Very Moist, Soft to Med. Stiff											
3		1			24.4							99
	Brown, silty SAND with occasional silty clay layers up to 4 inches thick (SM). Saturated, Loose											
6	Saturated Loose	2	1, 2, 2	4								
	Grades reddish brown with occasional fine sandy silt layers up to 4 inches thick. Saturated, Medium Dense	3	3, 9, 7	16	32.6			26.5				
9												
		4	3, 8, 12	20	23.3			22.3				
12												
15	Brown SAND with some silt (SP-SM). Saturated, Medium Dense	5	5, 7, 11	18	11.5			23				
18												
21		6	2, 7, 10	17								

Remarks: Groundwater at about 4 feet at time of drilling.

CMT ENGINEERING LABORATORIES

Excavated By: GBD
Logged By: BNR

Figure: 3B

Hooper Water

Northwest Corner of 3500 West and 5500 South

Bore Hole Log

B-2

Boring Type: HSA
Surface Elev. (approx):
Total Depth: 31.5 Feet
Water Level:
Date:
Job #: 9406

Depth (ft.)	Soil Description	Sample Type	Sample #	Blows (N)	Total	Moisture (%)	Gravel %	Sand %	Fines %	LL	PL	PI	Dry Density
25-26.5			7	3, 5, 7	12	21.7			11.4				
30	Gray silty SAND (SM)		8	3, 7, 9	16	18.9			19.9				

End at 31.5 Feet'

Remarks: Groundwater at about 4 feet at time of drilling.

CMT ENGINEERING LABORATORIES

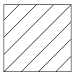
Excavated By: GBD
Logged By: BNR

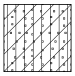
Figure: 3B

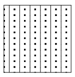
KEY TO SYMBOLS

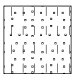
Symbol Description

Strata symbols

 **Low plasticity clay**

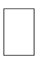
 **Poorly graded clayey silty sand**

 **Silty sand**

 **Poorly graded sand with silt**

Soil Samplers

 **Standard penetration test**

 **Undisturbed thin wall Shelby tube**

Notes:

1. Exploratory Borings were Hollow Stem Augured

2. These Logs are subjec to the limitations, conclusions, and recommendations in this report.

3. Results of tests conducted on samples recovered are reported on the logs.