● **RED**

Geotechnical Engineering Exploration and Analysis
DRAFT

Proposed Chick-fil-A Restaurant #4003
Main & Almond FSU
202 N. Main Street
Orange, California

Prepared for:

Chick-fil-A, Inc.
Irvine, California

Prepared by:

Giles Engineering Associates, Inc.

December 14, 2016
Project No. 2G-1610007

GILES
ENGINEERING ASSOCIATES, INC.

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GEOTECHNICAL, ENVIRONMENTAL & CONSTRUCTION MATERIALS CONSULTANTS

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December 14, 2016

Chick-fil-A, Inc.
15635 Alton Parkway, Suite 350
Irvine, California 92618

Attention: Ms. Beth Witt
Development Coordinator

Subject: Geotechnical Engineering Exploration and Analysis - Draft
Proposed Chick-fil-A Restaurant #4003
Main & Almond FSU
202 N. Main Street
Orange, California
Project No. 2G-1610007

Dear Ms. Witt:

Giles Engineering Associates, Inc. (Giles) is pleased to present our *Geotechnical Engineering Exploration and Analysis* report prepared for the above-referenced project. Conclusions and recommendations developed from the exploration and analysis are discussed in the accompanying report.

We appreciate the opportunity to be of service on this project. If we may be of additional assistance, should geotechnical related problems occur or to provide construction observation and testing services, please do not hesitate to call at any time.

Respectfully submitted,

GILES ENGINEERING ASSOCIATES, INC.

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40 GILES YEARS

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GEOTECHNICAL ENGINEERING EXPLORATION AND ANALYSIS-DRAFT

CHICK-FIL-A RESTAURANT #4003
MAIN & ALMOND FSU
202 N. MAIN STREET
ORANGE, CALIFORNIA
PROJECT NO. 2G-1610007

1.0 EXECUTIVE SUMMARY OUTLINE

The executive summary is provided solely for purposes of overview. Any party who relies on this report must read the full report. The executive summary omits a number of details, any one of which could be crucial to the proper application of this report.

Subsurface Conditions

- Site Class designation D is recommended for seismic design considerations.
- Based on our review of the Geologic Map for the Orange County California prepared by California Department of Conservation, the site is mapped as being underlain by Young Alluvial Fan Deposits that typically consist of unconsolidated, loose to moderately dense sand, sandy silt and silt.
- Fill materials were encountered within test borings B-1 to B-5 to depths of about 1½ to 2 feet below existing grades. These materials were noted to be generally moist, very loose silty sand with trace to little clay.
- Native soils encountered below the fill materials and beneath the pavement within test borings B-6 to B-8 were generally damp to very moist, very loose to medium dense in relative density silty sand and clayey sand, and soft in comparative consistency sandy clay.

Site Development

- The proposed site development will include the demolition of existing building (with basement) for the construction of a new Chick-fil-A single-story building and site improvements that will include new concrete walkways, parking stalls, driveways, drive thru lane, and trash enclosure.
- New Building: Due to the presence of variable and low strength soils and the likely disturbance during demolition, we recommend that the subgrade soils within the proposed building area (non-basement area) be over-excavated and backfilled as outlined within the report text. The soils exposed at the bottom of the soil over-excavation and beneath the existing basement should be examined by the geotechnical engineer to assess the suitability of these soils for building support. If unsuitable soils are observed, over-excavation may be needed, as recommended by the geotechnical engineer. The building pad area may then be backfilled with a properly placed and compacted engineered fill.
- The existing building possesses a basement. The basement walls and floor slab should be removed. However, alternatively, the basement floor slab could be left in-place provided the slab is punctured on about 6 foot centers and the initial one foot of fill consist of a free-draining aggregate.

Building Foundation

- Shallow spread footing foundation systems or turned-down slabs may be designed for a maximum, net allowable soil pressure of 2,500 psf soil bearing pressure underlain by competent subgrade soils.
- We recommend that all strip footings be reinforced with at least 4 No. 5 bars (2 top and 2 bottom).

Building Floor Slab

- It is recommended that on grade slab be a minimum 4-inch thick slab-on-grade or turned-down slab over properly prepared subgrade.
- A minimum 10-mil vapor retarder is recommended to be directly below the floor slab or base course where required to protect moisture sensitive floor coverings.
- Minimum slab reinforcing recommended consisting of No. 3 rebars spaced at 18 inches on center, each way.

Parking Improvement

- Asphalt Pavements: 3 inches of asphaltic concrete underlain by 4 and 6 inches of base course aggregate in parking stalls and driveways, respectively.
- Portland Cement Concrete: 6 inches in thickness underlain by 4 inches of base course in high stress areas such as entrance/exit aprons, trash enclosure-loading zone, and the drive through area.

RED - This site has been given a red designation due to potential increased costs associated with the removal of the basement and placement of engineered fill.

2.0 SCOPE OF SERVICES

This report provides the results of the *Geotechnical Engineering Exploration and Analysis* that Giles Engineering Associates, Inc. (“Giles”) conducted regarding the proposed development. The *Geotechnical Engineering Exploration and Analysis* included several separate, but related, service areas referenced hereafter as the Geotechnical Subsurface Exploration Program, Geotechnical Laboratory Services, and Geotechnical Engineering Services. The scope of each service area was narrow and limited, as directed by our client and in consideration of the proposed project. The scope of each service area is briefly explained in this report.

Geotechnical-related recommendations for design and construction of the foundation and ground-bearing floor slab for the proposed building are provided in this report. Geotechnical-related recommendations are also provided for the proposed parking lot improvements. Site preparation recommendations are also given; however, those recommendations are only preliminary since the means and methods of site preparation will depend on factors that were unknown when this report was prepared. Those factors include the weather before and during construction, the water table at the time of construction, subsurface conditions that are exposed during construction, and finalized details of the proposed development.

Giles conducted a *Phase 1 Environmental Site Assessment* for the subject site. The results of that assessment were provided under separate cover.

3.0 SITES AND PROJECT DESCRIPTION

3.1 Site Description

A new Chick-fil-A restaurant with drive-thru lane is proposed at 202 N. Main Street in the city of Orange, California. The site is currently occupied by a vacant one to two story Manhattan Steak and Seafood restaurant building with basement. It is unknown if the existing basement extends beneath the entire building. The building is located in the northeast corner of the property with paved parking stalls and driveways to the west and south of the building. The site is bordered on the north by Almond Avenue, on the east by Main Street, on the south by a two story office/medical building and on the east by a single story preschool building. Access to the site is through driveways at Almond Avenue and Main Street.

Other existing site improvements include asphalt pavements, concrete curbs and gutters, concrete walkways, block walls along the southerly and westerly property lines, some planter areas that contain trees and shrubs and underground utilities. The existing site parking lot and parking areas are considered to be in fair condition.

Our review of the ALTA/ACSM survey prepared by Truxaw and Associates Inc. (Truxaw) indicated elevations within the site ranged from Elevation (EL.) 159.8 feet along the northeast corner of the site to El. 156.7 along the southwest corner of the site. Additionally, according to Truxaw site survey, the existing multi story vacant building has basement. However, whether this is a full or partial basement is not known as of the date of this report. The subject property is situated at approximately latitude 33.7859° North and longitude -117.8677° West.

3.2 Proposed Project Description

Based on our review of the Preliminary Site Plan (PSP-7) prepared by CRHO Architecture (Project Architect), the existing building (Manhattan Steak and Seafood restaurant) will be demolished to accommodate the construction of a new 4,998 square feet Chick-fil-A building. The new building will be constructed in the northeast corner of the property and within a portion of the existing building (Figure 1). Although detailed building plans are not yet ready for our review, it is our understanding that the proposed building will be a single-story wood-frame structure with no basement or underground level. We were not provided with specific loading information for this project at the time of this report; however, based on previous Chick-fil-A projects, we expect the maximum combined dead and live loads supported by the bearing walls and columns will be 2 to 3 kips per lineal foot (klf) and 40 to 50 kips, respectively. The live load supported by the floor slab is expected to be a maximum of 100 pounds per square foot (psf).

Other planned improvements include a drive-thru lane to the north, east and south of the new building, new parking stalls, menu board signs, a new trash enclosure, an outdoor patio, new concrete walkways, and new planter areas.

Preliminary project information did not indicate the planned finished floor elevation for the proposed building. However, it is anticipated that the finished floor of the new building will roughly match the existing building finished floor elevation. Based on the topographic information provided in the ALTA Survey, we estimate a finished floor elevation of about El. 159.5. Based upon the existing site elevations, site grading is anticipated to be minimal with the exception of backfilling of the existing basement.

The traffic loading on the proposed parking lot is understood to predominantly consist of automobiles with occasional heavy trucks resulting from deliveries and trash removal. The parking lot pavement sections have been designed on the basis of an assumed Traffic Index of 4.0 for the parking stall areas (light duty) and 5.0 for the drive lanes (medium duty). Pavement designs are based on a 20-year design period.

4.0 SUBSURFACE EXPLORATION

4.1 Subsurface Exploration

Our subsurface exploration consisted of the drilling of eight (8) exploratory test borings to depths of about 5 to 16½ feet below existing ground surfaces. Some of the boring locations were restricted due to the existing building. The approximate test boring locations are shown in the Test Boring Location Plan (Figure 1). The Test Boring Location Plan and Test Boring Logs (Records of Subsurface

Exploration) are enclosed in Appendix A. Field and laboratory test procedures and results are enclosed in Appendix B and C, respectively. The terms and symbols used on the Test Boring Logs are defined on the General Notes in Appendix D.

Our subsurface exploration included the collection of relatively undisturbed samples of subsurface soil materials for laboratory testing purposes. Bulk samples consisted of composite soil materials obtained at selected depth intervals from the borings. Relatively undisturbed samples were collected (per ASTM D-3550) using a 3-inch outside-diameter, modified California split-spoon soil sampler (CS) lined with 1-inch high brass rings. The sampler was driven with successive 30-inch drops of a hydraulically operated, 140-pound automatic trip hammer. Blow counts for each 6-inch driving increment were recorded on the field exploration logs. The central portions of the driven core samples were placed in sealed containers and transported to our laboratory for testing.

Where deemed appropriate, standard split-spoon tests (SS), also called Standard Penetration Test (SPT), were also performed at selected depth intervals in accordance with the American Society for Testing Materials (ASTM) Standard Procedure D 1586. This method consists of mechanically driving an unlined standard split-barrel sampler 18 inches into the soil with successive 30-inch drops of the 140-pound automatic trip hammer. Blow counts for each 6-inch driving increment were recorded on the exploration logs. The number of blows required to drive the standard split-spoon sampler for the last 12 of the 18 inches was identified as the uncorrected standard penetration resistance (N). Disturbed soil samples from the unlined standard split-spoon samplers were placed in plastic containers and transported to our laboratory for testing.

4.2 Subsurface Conditions

The subsurface conditions as subsequently described have been simplified somewhat for ease of report interpretation. A more detailed description of the subsurface conditions at the test boring locations is provided by the logs of the test borings enclosed in Appendix A of this report.

Site Geologic Setting

Based on our review of the Geologic Map for the Orange County California prepared by California Department of Conservation, the site is mapped as being underlain by Young Alluvial Fan Deposits that typically consist of unconsolidated, loose to moderately dense sand, sandy silt and silt.

Pavement

Existing pavement encountered consisted of approximately 2½ to 6 inches thick asphaltic concrete with no base noted, except at Test Boring B-5 where about 4 inches of aggregate base was encountered. Based on our visual observation, the existing pavement is in fair condition.

Soil

Fill materials were encountered within our exploratory Test Borings B-1 to B-5 to depths of about 1½ to 2 feet below existing grades. These materials were noted to be generally moist, very loose silty sand with trace to little clay. Additional fill soils may be situated adjacent to the existing basement foundation walls associated with the existing building.

Native soils encountered below the fill materials and beneath the pavement within Test Borings B-6 to B-8 were generally damp to very moist, very loose to medium dense in relative density silty sand and clayey sand, and soft in comparative consistency sandy clay.

Groundwater

Groundwater was not encountered during our subsurface investigation to the maximum depth explored (16.5 feet). Based on a review of the Seismic Hazard Zone Report for the Orange Quadrangle, the depth to historic high groundwater is reported to be greater than 40 feet below grade. However, fluctuations of the groundwater table, localized zones of perched water, and rise in soil moisture content should be anticipated during and after the rainy season. Irrigation of landscape areas on or adjacent to the site can also cause fluctuations of local or shallow perched groundwater levels.

4.3 Infiltration Testing

It is our understanding that an on-site below grade storm water infiltration system is being considered for the site. Two percolation tests (B-6 @ 5 feet and B-7 @ 6 feet) were conducted at the site (Figure 1) and involved the drilling of a test boring utilizing a hollow-stem auger drill rig with an outside diameter of approximately 8 inches. Within the drilled test hole gravel about 2 inches in thickness was placed at the bottom of the test hole, then a two-inch diameter perforated pvc pipe was installed inside the boring and pea gravel was used as filter pack around the outside diameter of the pipe. Testing involved presoaking the test holes and filling the test holes with water, and recording the drop in the water surface. The approximate locations of the percolation tests are shown on the attached Figure 1.

The infiltration test procedure outlined in the Orange County Technical Guidance Document (OCTGD) was used as a guide in our percolation testing. A summary of the results of the percolation tests is provided in Table 1 below.

The drop in water level over time is the pre-adjusted percolation rate at the test location. The pre-adjusted percolation rates were reduced to account for the discharge of water from both the sides and bottom of the boring. The formula below was used to calculate for the infiltration rate.

Infiltration Rate = $\Delta H\ (60r) / \Delta t\ (r + 2H_{avg})$

Where: r is the radius of the test hole (in)

ΔH is the change in height over the time interval (in)
Δt is the time interval (min)
Havg is the average head height over the time interval

Additionally, the calculated infiltration rates were also adjusted to reflect a factor safety (FS) of 2 applied to the rates obtained from the infiltration test results and are summarized below.

TABLE 1 – PERCOLATION TEST RESULTS

Test Hole	Test Depth[1] (feet)	Pre-Adjusted Percolation Rate (in/hr)	Infiltration Rate [2] (in/hr)	Soil Type
B-6	5.0±	12.24	1.00	Silty Sand
B-7	6.0±	24.48	1.12	Silty Sand

1) Depth is referenced to the existing surface grade at the test location.
2) Reflects FS of 2 per Worksheet H of OCTGD

It should be noted that the infiltration rate of the on-site soils represents a specific area and depth tested and may fluctuate throughout other areas of the site.

4.4 Photoionization Detector (PID) Screening

Soil samples taken from our subsurface exploration were screened with a Photoionization Detector (PID) to check for the possible presence of volatile vapors. Volatile vapors were detected within test borings B-1 at 3.5 feet and B-4 at 10 feet and measured about 42.1 and 18.2 ppm, respectively, with the use of a PID instrument. PID field-screening results are included on the soil boring logs and also provided to our environmental department.

5.0 LABORATORY TESTING

Several laboratory tests were performed on selected samples considered representative of those encountered in order to evaluate the engineering properties of on-site soils. The following are brief description of our laboratory test results.

In Situ Moisture and Density

Tests were performed on select samples from the test borings to determine the subsoils dry density and natural moisture contents in accordance with Test Method ASTM 2216-05. The results of these tests are included in the Test Boring Logs enclosed in Appendix A.

Sieve Analysis

Sieve Analyses including Passing No. 200 Sieve were performed on selected samples from Test Borings B-2, B-4, B-6 and B-7 to assist in soil classification. These tests were performed in accordance with Test Method ASTM D 1140-00 (Reapproved 2006) and ASTC C 1369-96. The results of the sieve analyses are graphically presented as Figure 2 and passing no. 200 sieve results are presented on Test Boring Logs, Appendix A.

Expansion

To evaluate the expansive potential of the near surface soils encountered during our subsurface exploration, a composite sample collected from Test Boring B-2 (1 to 5 feet) was subjected to Expansive Index (EI) testing in accordance with Test Method ASTM D 4829-08a. The result of our expansion index (EI) test indicates that the near surface sample has a *very low* expansion potential (EI= 0).

Consolidation Test

The consolidation characteristics of the site soils under anticipated loads were made on the basis of one-dimensional consolidation tests. These tests were performed in general accordance with Test Method ASTM D 2435-11. The test samples were inundated at 2,000 psf pressure in order to evaluate the sudden increase in moisture condition (swell or collapse potential). Results of this tests indicated that the near surface soils exhibited a low collapse potential of 0.04% and 0.63% at a loading of 2000 psf. The Consolidation test curves, Figures 3 and 4, are included in Appendix A.

.Soluble Sulfate Analysis and Soil Corrosivity

A representative sample of the near surface soils which may contact shallow buried utilities and structural concrete was performed to determine the corrosion potential for buried ferrous metal conduits and the concentrations present of water soluble sulfate which could result in chemical attack of cement. The following table presents the results of our laboratory testing.

Parameter	**B-2** **1 to 5 feet**
pH	7.88
Chloride	96 ppm
Sulfate	0.0156%
Resistivity	4,000 ohm-cm

The chloride content of the near-surface soils was determined for a selected sample in accordance with California Test Method No. 422. The results of this test indicated that tested on-site soil has a Low exposure to chloride. The results of limited in-house testing of soil pH and resistivity were determined in accordance with California test Method No. 643 and indicated that on-site soil is slightly alkaline with respect to pH.

These test results have been evaluated in accordance with criteria established by the Cast Iron Pipe Research Association, Ductile Iron Pipe Research Association, the American Concrete Institute and the National Association of Corrosion Engineers. The test results on a near surface bulk sample from the site generally indicate that tested site soils has a moderate corrosive potential when in contact with ferrous materials. Therefore, special protection for underground cast iron pipe or ductile pipe may be warranted depending on the actual materials in contact with the pipe. We recommend that a corrosion engineer review these results in order to provide specific recommendations for corrosion protection as well as appropriate recommendations for other types of buried metal structures.

Corrosivity testing also included determination of the concentrations of water-soluble sulfates present in the tested soil sample in accordance with California Test Method No. 417. Our laboratory test data indicated that near surface soils contain approximately 0.0156 percent of water soluble sulfates. Based on the 2013 California Building Code (CBC), concrete that may be exposed to sulfate containing soils shall comply with the provisions of ACI 318-05, Section 4.3. Therefore, according to Table 4.3.1 of the ACI 318-05, a low exposure to sulfate corrosivity can be expected for concrete placed in contact with the tested on-site soils. No special sulfate resistant cement is considered necessary for concrete which will be in contact with the tested on-site soils.

6.0 GEOLOGIC AND SEISMIC HAZARD

6.1 Active Fault Zones

The project site is located in the highly seismic Southern California region within the influence of several fault systems. However, the site is not mapped within the boundaries of an Earthquake Fault Zone as defined by the State of California in the Alquist-Priolo Earthquake Fault Zoning Act.

6.2 Seismic Hazard Zones

Our review of the published Seismic Hazard Evaluation Report for the Orange Quadrangle (within which the subject site is located) indicates that the subject site does not lie within a designated Liquefaction Hazard Zone. Therefore, an assessment of the potential for liquefaction is not considered necessary.

General types of ground failures that might occur as a consequence of severe ground shaking typically include landsliding, ground lurching and shallow ground rupture. The probability of occurrence of each type of ground failure depends on the severity of the earthquake, distance from faults, topography, subsoils and groundwater conditions, in addition to other factors. Based on our subsurface exploration and the seismic designation for this site, all of the above effects of seismic activity are considered unlikely at the site.

6.3 Landslide Hazards

The subject site does not lie within the designated Landslide Hazard Zone based on our review of the published Seismic Hazard Evaluation Report for the Orange Quadrangle. Since the subject site is generally level and not located near unstable slope, mitigation of landslide hazards is not necessary for the site.

7.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the results of our subsurface exploration and laboratory testing, the planned development for the subject site is considered feasible from a geotechnical point of view provided the following conclusions and recommendations are incorporated in the design and project specifications.

Conditions imposed by the proposed improvement have been evaluated on the basis of the engineering characteristics of the subsurface materials encountered during our subsurface investigation and their anticipated behavior both during and after construction. Conclusions and recommendations, along with site preparation recommendations and construction considerations are discussed in the following sections of this report.

We recommend that Giles Engineering Associates, Inc. be involved in the review of the grading and foundation plans for the site to ensure our recommendations are interpreted correctly. Based on the results of our review, modifications to our recommendations or the plans may be warranted.

7.1 Seismic Design Considerations

Faulting/Seismic Design Parameters

Research of available maps published by the California Geological Survey (CGS) indicates that the site is not located within an Alquist-Priolo Earthquake Fault Zone. The potential for fault rupture through the site is, therefore, considered to be low. The site may however be subject to strong groundshaking during seismic activity. The proposed structure should be designed in accordance with the current version of the 2013 California Building Code (CBC) and applicable local codes. Based on our subsurface exploration, a Site Class D is recommended for design.

According to the 2008 National Seismic Hazard Maps prepared by USGS, the San Joaquin Hills, Puente Hills (Coyote Hills), Elsinore:W+GI+T+J+CM, and Newport Inglewood Connected alt 2 faults are the closest known active faults and are located about 6.51, 6.67, 9.41 and 10.46 miles, respectively, from the site and with an anticipated maximum moment magnitude (Mw) of 7.10, 6.90, 7.85 and 7.50, respectively.

The proposed structure should be designed in accordance with the current version of the 2013 California Building Code (CBC) and applicable local codes. Within the International Code Council's 2012 International Building Code (IBC), the five-percent damped design spectral response accelerations at short periods, S_{DS}, and at 1-second period, S_{D1}, are used to determine the seismic design base shear. These parameters, which are a function of the site's seismicity and soil, are also used as parts of triggers for other code requirements. The following values are determined by using the USGS published U.S. Seismic Design Maps program based upon the 2013 CBC referenced ASCE 7 (with July 2013 errata).

IBC 2012/ CBC 2013, Earthquake Loads	
Site Class Definition (Table 1613.5.2)	D
Mapped Spectral Response Acceleration Parameter, S_s (Figure 1613.3.1(1) for 0.2 second)	1.488
Mapped Spectral Response Acceleration Parameter, S_1 (Figure 1613.3.1(2) for 1.0 second)	0.543
Site Coefficient, F_a (Table 1613.3.3 (1) short period)	1.000
Site Coefficient, F_v (Table 1613.3.3 (2) 1-second period)	1.500
Adjusted Maximum Considered Earthquake Spectral Response Acceleration Parameter, S_{MS} (Eq. 16-37)	1.488
Adjusted Maximum Considered Earthquake Spectral Response Acceleration Parameter, S_{M1} (Eq. 16-38)	0.814
Design Spectral Response Acceleration Parameter, S_{DS} (Eq. 16-39)	0.992
Design Spectral Response Acceleration Parameter, S_{D1} (Eq. 16-40)	0.543

7.2 Site Development Recommendations

The following recommendations for site development have been based upon the assumed floor elevation and foundation bearing grades and the conditions encountered at the test boring locations.

Site Clearing & Demolition

Clearing operations should include the demolition and removal of all existing landscape areas and structural features such as building footings and floor slab, basement walls or other below-grade construction, asphaltic concrete pavement, and concrete walkways within the area of the proposed new building and site improvements. The basement floor slab may be removed or can be left in-place provided the concrete slab is punctured at intervals of about 6 feet on center and the initial one foot of backfill consists of a free-draining aggregate. This procedure is recommended to allow drainage through the slab should it be desired to leave in-place. The basement should be backfilled with a properly placed and compacted fill as recommended in a subsequent section of this report.

If desired, basement walls may be left in-place outside of the new building location. All basement walls to be left in-place should be cut-off at least 3 feet below finished grade and any hollow CMU cores should be filled with grout. The locations of any walls to be left in-place should be evaluated to verify that the existing walls will not interfere with future utility line excavation.

All soils disturbed by the demolition and clearing operations should be removed and stockpiled for future use. All debris resulting from the demolition and clearing operations should be legally disposed off-site. Clearing operations should also include the removal of all vegetation within the area of proposed development. Trees and large shrubs to be removed should include their stumps and major roots. Existing pavement within areas of proposed development should be removed or processed to a maximum 3-inch size and stockpiled for use as compacted fill or stabilizing material for the new development. Processed asphalt may be used as fill, sub-base course material, or subgrade stabilization material beyond the building perimeter. Processed concrete or existing base may be used as fill, sub-base course material, or subgrade stabilization material both within and outside of the building perimeter. Due to the moisture sensitivity and variable support characteristics of the on-site soils, the pavement is recommended to remain in-place as long as possible to help protect the subgrade from construction traffic.

Should any unusual soil conditions or subsurface structures be encountered during clearing/demolition operations or during grading, they should be brought to the immediate attention of the project geotechnical consultant for corrective recommendations.

Existing Utilities

All existing utilities should be located. Utilities that are not reused should be capped off and removed or properly abandoned in-place in accordance with local codes and ordinances. The excavations made for removed utilities that are in the influence zone of new construction are recommended to be backfilled with structural compacted fill. Underground utilities, which are to be reused or abandoned in-place, are recommended to be evaluated by the structural engineer and utility backfill is recommended to be evaluated by the geotechnical engineer, to determine their potential effect on the new improvement. If any existing utilities are to be preserved, grading operations must be carefully performed so as not to disturb or damage the existing utility.

Building Area

Due to the presence of variable and low strength soils and the likely disturbance of the subgrade soils during demolition operations, we recommend that the subgrade beneath the proposed building area (non-basement area) be over-excavated to a depth of at least 2 feet below the bottom of proposed footings and/or slabs and at least 3 feet below existing grade, whichever is deeper. The soil exposed at the bottom of the soil over-excavation and at the bottom of the existing basement (if exposed) should then be examined by the geotechnical engineer to assess the suitability of these soils for building support. The exposed soils should then be scarified, where possible, to a depth of 12 inches, moisture conditioned and then compacted to at least 90% of the soil’s maximum dry density. The lateral extent of this recommendation should include the area at least 5 feet beyond the new building limits.

Positive drainage devices such as sloped concrete flatwork, earth swales, and sheet flow gradients in landscape, setback, and easement areas should be designed for the site. The drainage system should drain to a suitable discharge area. The purpose of this drainage system is to reduce water infiltration into the subgrade soils and to direct water away from buildings and site improvements.

Proofroll and Compact

After site clearing and lowering of site grades where necessary, the subgrades within the proposed pavement areas should be proofrolled in the presence of the geotechnical engineer with appropriate rubber-tire mounted heavy construction equipment or a loaded truck to detect very loose/soft yielding soil which should be removed to a stable subgrade. Following proofrolling and completion of any necessary over-excavation, the subgrade should be scarified to a minimum depth of 12 inches, moisture conditioned and recompacted to at least 90 percent of the Modified Proctor (ASTM D1557-00) maximum density. The upper 1 foot of the pavement subgrade should have minimum in-place density of at least 95% of the maximum dry density. Low areas and excavations may then be backfilled in lifts with suitable very low expansive (EI less than 21) structural compacted fill. The selection, placement and compaction of structural fill should be performed in accordance with the project specifications.

The Guide Specifications included in Appendix D (Modified Proctor) of this report are recommended to be used, at a minimum, as an aid in developing the project specifications. The floor slab subgrade may need to be recompacted prior to slab construction due to weather and equipment traffic effects on the previously compacted soils.

Reuse of On-site Soil

On-site material may be reused as structural compacted fill within the proposed building and pavement improvement area provided they are moisture conditioned and compacted as recommended, and do not contain oversized materials, significant quantities of organic matter, or other deleterious materials. Care should be used in controlling the moisture content of the soils to achieve proper compaction for pavement support. All subgrade soil compaction as well as the selection, placement and compaction of new fill soils should be performed in accordance with the project specifications under engineering controlled conditions.

Import Structural Fill

Any soil imported to the site (if required) for use as structural fill should consist of very low expansive soils (EI less than 21). Material designated for import should be submitted to the project geotechnical engineer no less than three working days prior to placement for evaluation.

In addition to expansion criteria, soils imported to the site should exhibit adequate shear strength characteristics for the recommended allowable soil bearing pressure; soluble sulfate content and corrosivity; and pavement support characteristics.

Subgrade Protection

The near surface soils that are expected to comprise the subgrade are sensitive to water. Unstable soil conditions will develop if these soils are exposed to moisture increases or are disturbed (rutted) by construction traffic. The site should be graded to prevent water from ponding within construction areas and/or flowing into excavations. Accumulated water must be removed immediately along with any unstable soil. Foundation concrete should be placed and excavations backfilled as soon as possible to protect the bearing grade. The degree of subgrade instability and associated remedial construction is dependent, in part, upon precautions taken by the contractor to protect the subgrade during site development.

Silt fences or other appropriate erosion control devices should be installed in accordance with local, state and federal requirements at the perimeter of the development areas to control sediment from erosion. Since silt fences or other erosion control measures are temporary structures, careful and continuous monitoring and periodic maintenance to remove accumulated soil and/or replacement should be anticipated.

Fill Placement

Material for engineered fill should be moisture conditioned and compacted in accordance with the specifications, be free of organic material, debris, and other deleterious substances, and should not contain fragments greater than 3 inches in maximum dimension. On-site excavated soils that meet these requirements may be used to backfill the excavated pavement areas.

All fill should be placed in 8-inch-thick maximum loose lifts, moisture conditioned and then compacted in accordance with recommendation herein and with the enclosed “Guide Structural Fill Specifications”. A representative of the geotechnical engineer should be present on-site during grading operations to verify proper placement and compaction of all fill, as well as to verify compliance with the other geotechnical recommendations presented herein.

7.3 Construction Considerations

Construction Dewatering

Groundwater was not encountered during our subsurface investigation. Therefore, groundwater is not expected to impact shallow excavations for footings and utilities. However, the site may be susceptible to shallow perched water conditions. In the event that shallow perched water is encountered, filter sump pumps placed within pits in the bottoms of excavations are expected to be the most feasible method of construction dewatering.

Soil Excavation

Some localized slope stability problems may be encountered in steep, unbraced excavations considering the granular nature of the subsoils. All excavations must be performed in accordance with CAL-OSHA requirements, which is the responsibility of the contractor. Shallow excavations may be adequately sloped for bank stability while deeper excavations or excavations where adequate back sloping cannot be performed may require some form of external support such as shoring or bracing.

7.4 Foundation Recommendations

Vertical Load Capacity

Upon completion of the building pad preparation, the proposed structure may be supported by a shallow foundation system underlain by newly placed engineered fill. The foundation system may consist of either independently constructed spread footings or monolithically constructed foundation and floor slab thereby using a turned-down slab construction technique. Foundations may be designed for a maximum, net, allowable soil-bearing pressure of 2,500 pounds per square foot (psf). Minimum foundation widths for walls and columns should be 16 and 24 inches, respectively, regardless of the calculated soil bearing pressure. The recommended allowable soil bearing pressure may be increased by one-third for short term wind and/or seismic loads.

Reinforcing

The recommended minimum quantity of longitudinal reinforcing for geotechnical considerations within continuous strip footing is four No. 5 bars (2 top and 2 bottom) continuous through column pads within the strip footings. The recommended quantity of longitudinal reinforcing pertains to a minimum 12-inch thick and a maximum 24-inch wide footing pad; additional reinforcing may be necessary if a thinner or wider footing pad is used to develop equivalent rigidity. Conventional reinforcing is considered suitable in isolated column pad footings. The final design of the foundations as well as determination of the actual quantity of steel reinforcing and the footing dimensions should be performed by the project structural engineer.

Lateral Load Resistance

Lateral load resistance will be developed by a combination of friction acting at the base of foundations and slabs and the passive earth pressure developed by footings below grade. Passive pressure and friction may be used in combination, without reduction, in determining the total resistance to lateral loads. A one-third increase in the passive pressure value may be used for short duration wind or seismic loads.

A coefficient of friction of 0.35 may be used with dead load forces for footings placed on newly placed compacted fill soil. An allowable passive earth pressure of 250 psf per foot of footing depth (pcf) below the lowest adjacent grade may be used for the sides of footings placed against newly placed structural fill. The maximum recommended allowable passive pressure is 1,500 psf.

Bearing Material Criteria

Soil suitable to serve as the foundation bearing grade should exhibit at least a loose relative density (average N value of at least 8) for non-cohesive soils for the recommended 2,500 psf allowable soil bearing pressure. For design and construction estimating purposes, suitable bearing soils are expected to be encountered at nominal foundation depths following the recommended site preparation activities. However, field testing by the Geotechnical Engineer within the foundation bearing soils is recommended to document that the foundation support soils possess the minimum strength parameters noted above. If unsuitable bearing soils are encountered, they should be recompacted in-place, if feasible, or excavated to a suitable bearing soil subgrade and to a lateral extent as defined by Item No. 3 of the enclosed Guide Specifications, with the excavation backfilled with structural compacted fill to develop a uniform bearing grade. As an alternate, a lean concrete slurry (minimum 28-day compressive strength of 500 psi) could be used as backfill and would limit the lateral over-excavation as needed with a soil backfill. If the lean concrete slurry option is used, it should extend at least 3 inches beyond to footing element. The effectiveness of the lean concrete option may also be limited due to anticipated caving within the granular soils.

Foundation Embedment

The California Building Code (CBC) requires a minimum 12-inch foundation embedment depth. However, it is recommended that exterior foundations extend at least 18 inches below the adjacent exterior grade for bearing capacity and to provide greater protection of the moisture sensitive bearing soils. Interior footings may be supported at nominal depth below the floor. All footings must be protected against weather and water damage during and after construction, and must be supported within suitable bearing materials.

Estimated Foundation Settlement

Post-construction total and differential static movement (settlement) of a shallow foundation system designed and constructed in accordance with the recommendations provided in this report are estimated to be less than ¾ and ½ inch, respectively, for static conditions. The estimated differential movement is anticipated to result in an angular distortion of about 0.002 inches per inch on the basis of a minimum clear span of 20 feet. The maximum estimated total and differential movement is considered within tolerable limits for the proposed structure provided it is considered in the structural design.

7.5 Floor Slab Recommendations

Subgrade

The floor slab subgrade should be prepared in accordance with the appropriate recommendations presented in the Site Development Recommendations section of this report. Foundation, utility trenches and other below-slab excavations should be backfilled with structural compacted fill in accordance with the project specifications.

Design

The floor of the proposed building may be designed and constructed as a conventional slab-on-grade supported on a properly prepared subgrade. If desired, the floor slab may be poured monolithically with perimeter foundations where the foundations consist of thickened sections thereby using a turned-down slab construction technique. The minimum slab reinforcing for geotechnical considerations is recommended to consist of No. 3 rebars at 18 inches on center, each way. Based on the recommended reinforcing and the assumed live loading, the slab is recommended to be a minimum of 4 inches in thickness. A qualified structural engineer should perform the actual design of the slab to ensure proper thickness and reinforcing.

A minimum 10-mil synthetic sheet should be placed below the floor slab to serve as a vapor retarder where required to protect moisture sensitive floor coverings (i.e. tile, or carpet, etc.). The sheets of the vapor retarder material should be evaluated for holes and/or punctures prior to placement and the edges overlapped and taped. If materials underlying the synthetic sheet contain sharp, angular particles, a layer of coarse sand (Sand Equivalent>30) approximately 2 inches thick or a geotextile should be provided to protect it from puncture. An additional 2-inch thick layer of coarse sand may be needed between the slab and the vapor retarder to promote proper curing. Proper curing techniques are recommended to reduce the potential for shrinkage cracking and slab curling.

Estimated Movements

Post-construction total and differential movements of the floor slab designed and constructed in accordance with the recommendations provided in this report are estimated to be less than ½ and ⅓ inch, respectively. Movements on the order of those estimated for foundations should be expected when the foundation and floor slab are structurally connected or constructed monolithically. The estimated differential movement is anticipated to occur across the short dimension of the structure. The maximum total and differential movement is considered within tolerable limits for the proposed structure, provided that the structural design adequately considers this distortion.

7.6 New Pavement

The following recommendations for the new pavement are intended for vehicular traffic associated with the restaurant development within the subject property.

New Pavement Subgrades

Following completion of the recommended subgrade preparation procedures, the subgrade in areas of new pavement construction are expected to consist of existing soil that exhibit a very low expansion potential. The anticipated subgrade soils are classified as a fairs subgrade material with estimated R-value of 40 to 50 when properly prepared based on the Unified Soil Classification System designation of SM. An R-value of 40 has been assumed in the preparation of the pavement design. It should however, be recognized that the City of Orange may require a specific R-value test to verify the use of the following design. It is recommended that this testing, if required, be conducted following completion of rough grading in the proposed pavement areas so that the R-value test results are indicative of the actual pavement subgrade soils. Alternatively, a minimum code pavement section may be required if a specific R-value test is not performed. To use this R-value, all fill added to the pavement subgrade must have pavement support characteristics at least equivalent to the existing soils, and must be placed and compacted in accordance with the project specifications.

Asphalt Pavements

The following table presents recommended thicknesses for a new flexible pavement structure consisting of asphaltic concrete over a granular base, along with the appropriate CALTRANS specifications for proper materials and placement procedures. An alternate pavement section has been provided for use in parking stall areas due to the anticipated lower traffic intensity in these areas. However, care must be used so that truck traffic is excluded from areas where the thinner pavement section is used, since premature pavement distress may occur. In the event that heavy vehicle traffic cannot be excluded from the specific areas, the pavement section recommended for drive lanes should be used throughout the parking lot.

ASPHALT PAVEMENTS

Materials	**Thickness (inches)**		**CALTRANS Specifications**
	Parking Stalls (TI=4.0)	**Drive Lanes (TI=5.0)**	
Asphaltic Concrete Surface Course (b)	1	1	Section 39, (a)
Asphaltic Concrete Binder Course (b)	2	2	Section 39, (a)
Crushed Aggregate Base Course	4	6	Section 26, Class 2 (R-value at least 78)

NOTES:
(a) Compaction to density between 95 and 100 percent of the 50-Blow Marshall Density
(b) The surface and binder course may be combined as a single layer placed in one lift if similar materials are utilized.

Pavement recommendations are based upon CALTRANS design parameters for a twenty-year design period and assume proper drainage and construction monitoring. It is, therefore, recommended that the geotechnical engineer monitors and tests subgrade preparation, and that the subgrade be evaluated immediately before pavement construction.

Portland Concrete Pavements

Portland Cement Concrete pavements are recommended in areas where traffic is concentrated such as the entrance/exit aprons as well as areas subjected to heavy loads such as the trash enclosure loading zone. The preparation of the subgrade soils within concrete pavement areas should be performed as previously described in this report. Portland Cement Concrete pavements in high stress areas are recommended to be at least 6 inches thick containing No. 3 bars at 18-inch on-center both ways placed at mid-height. The pavement should be constructed in accordance with Section 40 of the CALTRANS Standard Specifications. A minimum 4-inch thick layer of base course (CALTRANS Class 2) is recommended below the concrete pavement. This base course should be compacted to at least 95% of the material's maximum dry density.

The maximum joint spacing within all of the Portland Cement Concrete pavements is recommended to be 15 feet to control shrinkage cracking. Load transfer reinforcing is recommended at construction joints perpendicular to traffic flow if construction joints are not properly keyed. In this event, ¾-inch diameter smooth dowel bars, 18 inches in length placed at 12 inches on-center are recommended where joints are perpendicular to the anticipated traffic flow. Expansion joints are recommended only where the pavement abuts fixed objects such as light standard foundations. Tie bars are recommended at the first joint within the perimeter of the concrete pavement area. Tie bars are recommended to be No. 4 bars at 42-inch on-center spacings and at least 48 inches in length.

General Considerations

Pavement recommendations assume proper drainage and construction monitoring and are based on traffic loads as indicated previously. Pavement designs are based on either PCA or CALTRANS design parameters for twenty (20) year design period. However, these designs are also based on a routine pavement maintenance program and significant asphalt concrete pavement rehabilitation after about 8 to 10 years, in order to obtain a reasonable pavement service life.

7.7 Recommended Construction Materials Testing Services

The report was prepared assuming that Giles will perform Construction Materials Testing (CMT) services during construction of the proposed development. In general, CMT services are recommended (and expected) to at least include observation and testing of foundation and pavement support soil and other construction materials. It might be necessary for Giles to provide supplemental geotechnical recommendations based on the results of CMT services and specific details of the project not known at this time.

7.8 Basis of Report

This report is based on Giles' proposal, which is dated October 18, 2016 and is referenced by Giles' proposal number 2GEP-1610016. The actual services for the project varied somewhat from those described in the proposal because of the conditions that were encountered while performing the services and in consideration of the proposed project.

This report is strictly based on the project description given earlier in this report. Giles must be notified if any parts of the project description or our assumptions are not accurate so that this report can be amended, if needed. This report is based on the assumption that the facility will be designed and constructed according to the codes that govern construction at the site.

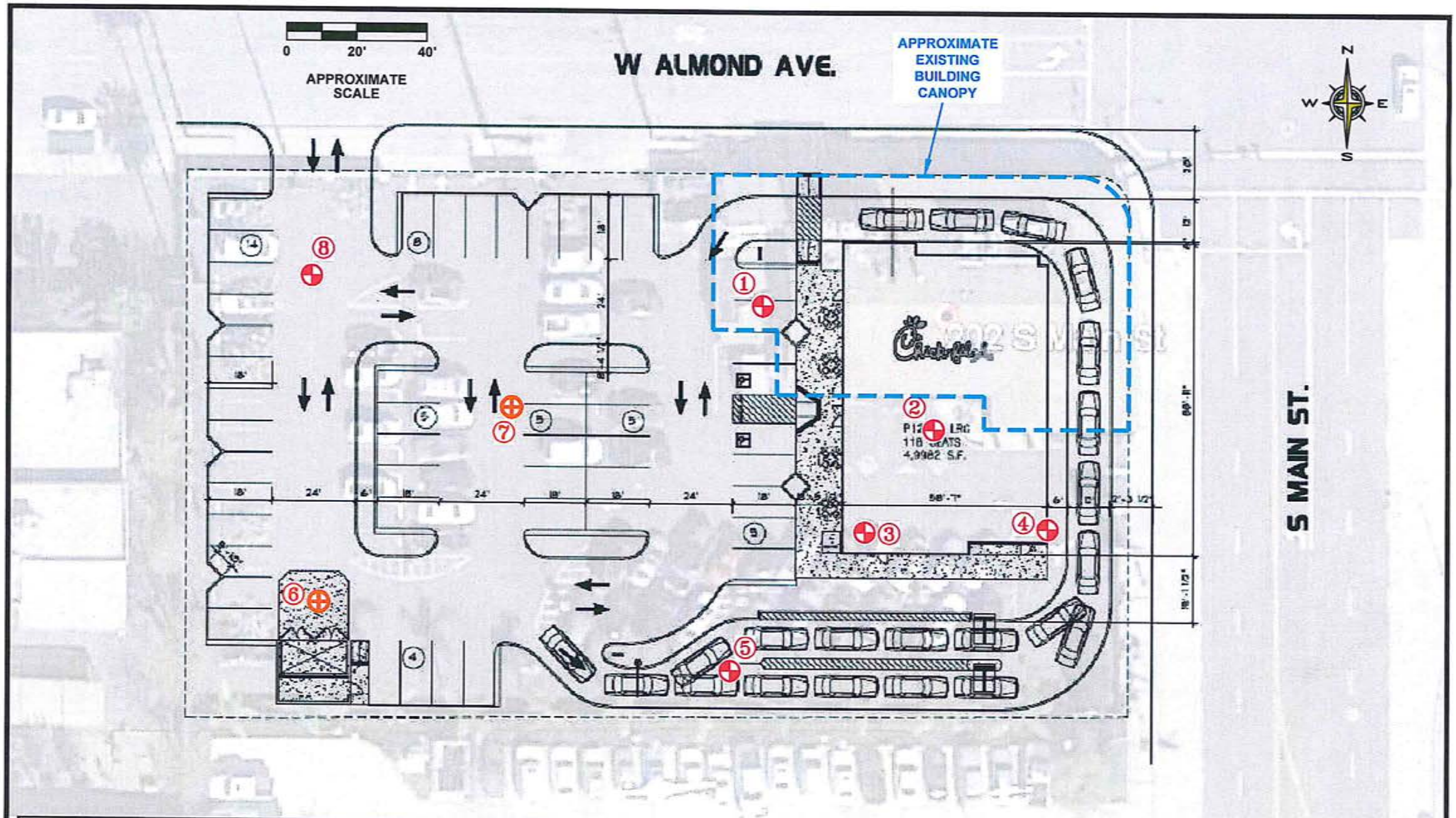
The conclusions and recommendations in this report are based on estimated subsurface conditions as shown on the *Records of Subsurface Exploration*. Giles must be notified if the subsurface conditions that are encountered during construction of the proposed development differ from those shown on the *Records of Subsurface Exploration* because this report will likely need to be revised. General comments and limitations of this report are given in the appendix.

APPENDIX A

FIGURES AND TEST BORING LOGS

The Test Boring Location Plan contained herein was prepared based upon information supplied by *Giles'* client, or others, along with *Giles'* field measurements and observations. The diagram is presented for conceptual purposes only and is intended to assist the reader in report interpretation.

The Test Boring Logs and related information enclosed herein depict the subsurface (soil and water) conditions encountered at the specific boring locations on the date that the exploration was performed. Subsurface conditions may differ between boring locations and within areas of the site that were not explored with test borings. The subsurface conditions may also change at the boring locations over the passage of time.



GILES **E**NGINEERING **A**SSOCIATES, INC.
1965 N. MAIN STREET
ORANGE, CA 92865 (714)279-0817

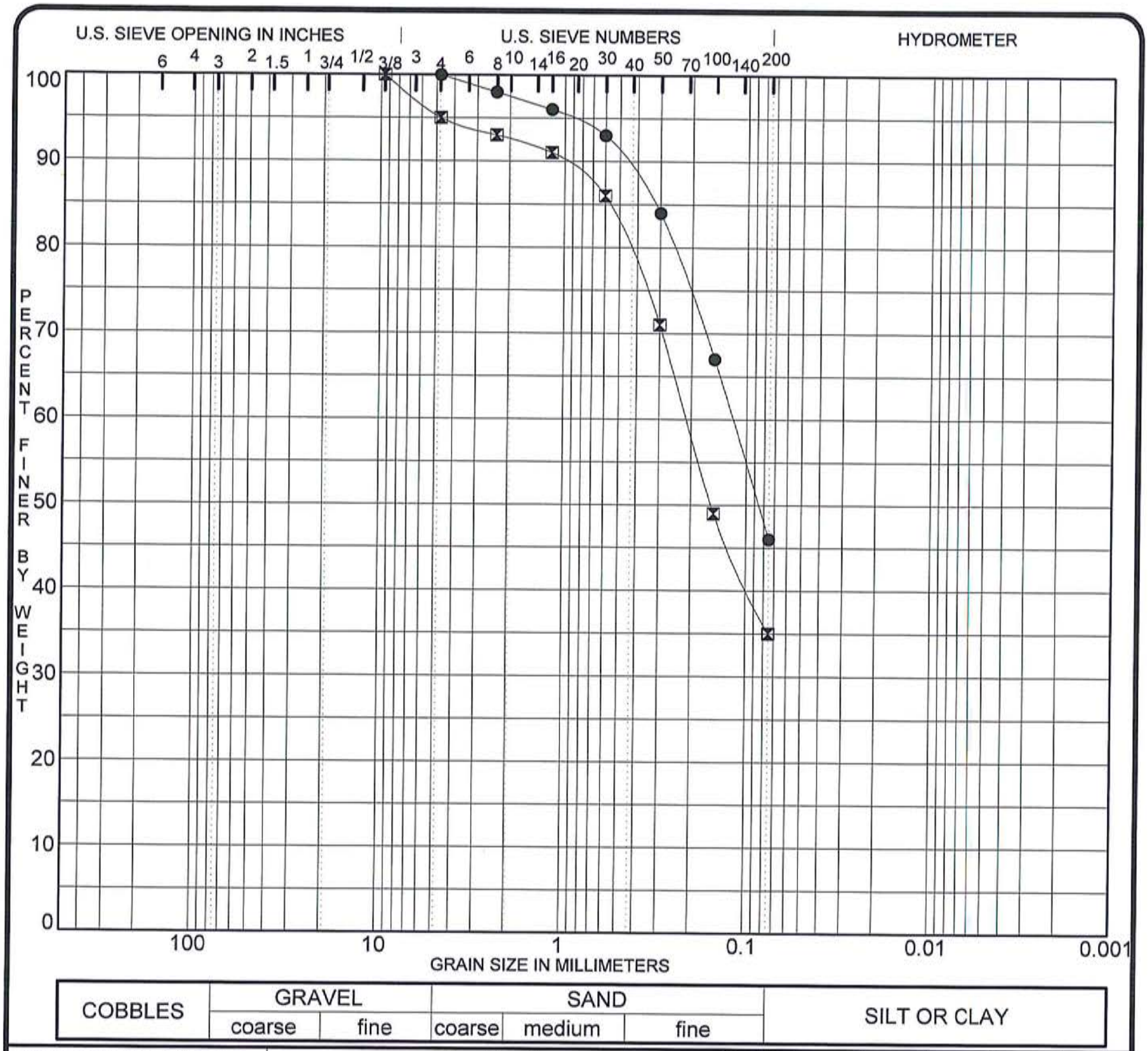
FIGURE 1
TEST BORING LOCATION PLAN
PROPOSED CHICK-FIL-A RESTAURANT NO. 04003
MAIN & ALMOND FSU
202 SOUTH MAIN STREET
ORANGE, CALIFORNIA

DESIGNED	DRAWN	SCALE	DATE	REVISED
ELG	JSZ	approx. 1"=40'	12-08-16	--
PROJECT NO.: 2G-1610007			CAD No. 2g1610007-blp	

LEGEND:

①	GEOTECHNICAL TEST BORING
⑥	GEOTECHNICAL TEST BORING / PERCOLATION TEST BORING

NOTES:
1.) TEST BORING LOCATIONS ARE APPROXIMATE.
2.) BASE MAP DEVELOPED FROM THE "PRELIMINARY SITE PLAN" (SHEET PSP-7), REV. 8-29-16, PREPARED BY C-R-H-O.



Specimen Identification			Classification	MC%	LL	PL	PI	Cc	Cu
●	B-6	3.5	Silty Sand						
☒	B-7	3.5	Sity Sand with little Gravel						

Specimen Identification			D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	B-6	3.5	4.75	0.12			0.0	54.0	46.0	
☒	B-7	3.5	9.50	0.21			5.0	60.0	35.0	

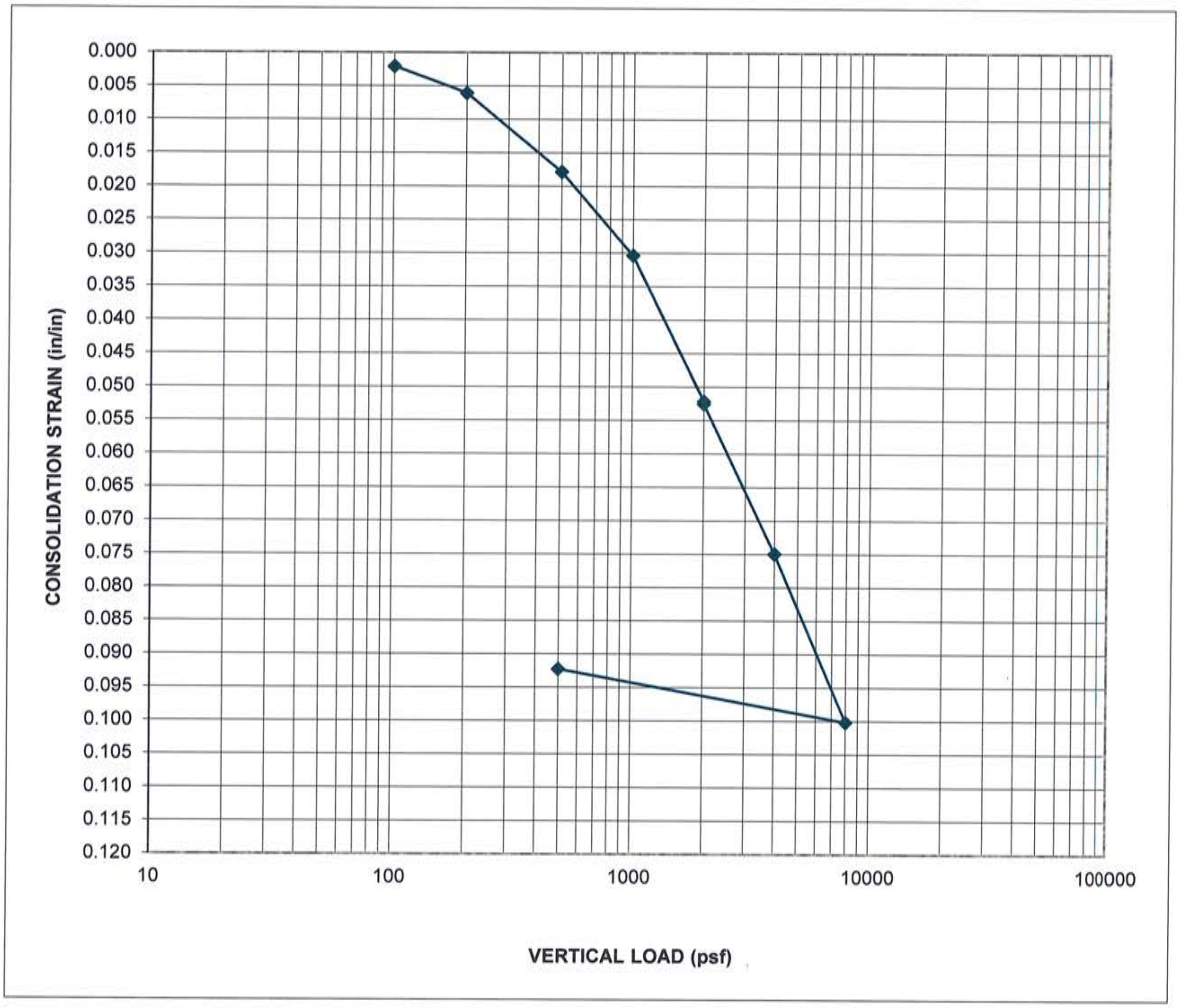
PROJECT **Proposed CFA #4003 - Orange, CA**
FIGURE 2

JOB NO. **2G-1610007**
DATE **12/12/16**

GRADATION CURVES

Giles Engineering Associates, Inc

CONSOLIDATION / COLLAPSE TEST ASTM D2435/ASTM D5333



Classification	Silty Sand
Boring No.	B-1
Sample No.	2-CS
Depth (ft.)	3.5 - 5.0
Elevation	
Liquid Limit	NP
Plastic Limit	NP
Specimen Diameter (in.)	2.42
Initial Specimen Thickness (in.)	1.00

Initial Moisture Content (%)	11.4
Final Moisture Content (%)	14.5
Natural Density (pcf)	119.9
Initial Dry Density (pcf)	107.6
Final Dry Density (pcf)	118.6
Collapse at 2000 psf	0.04%

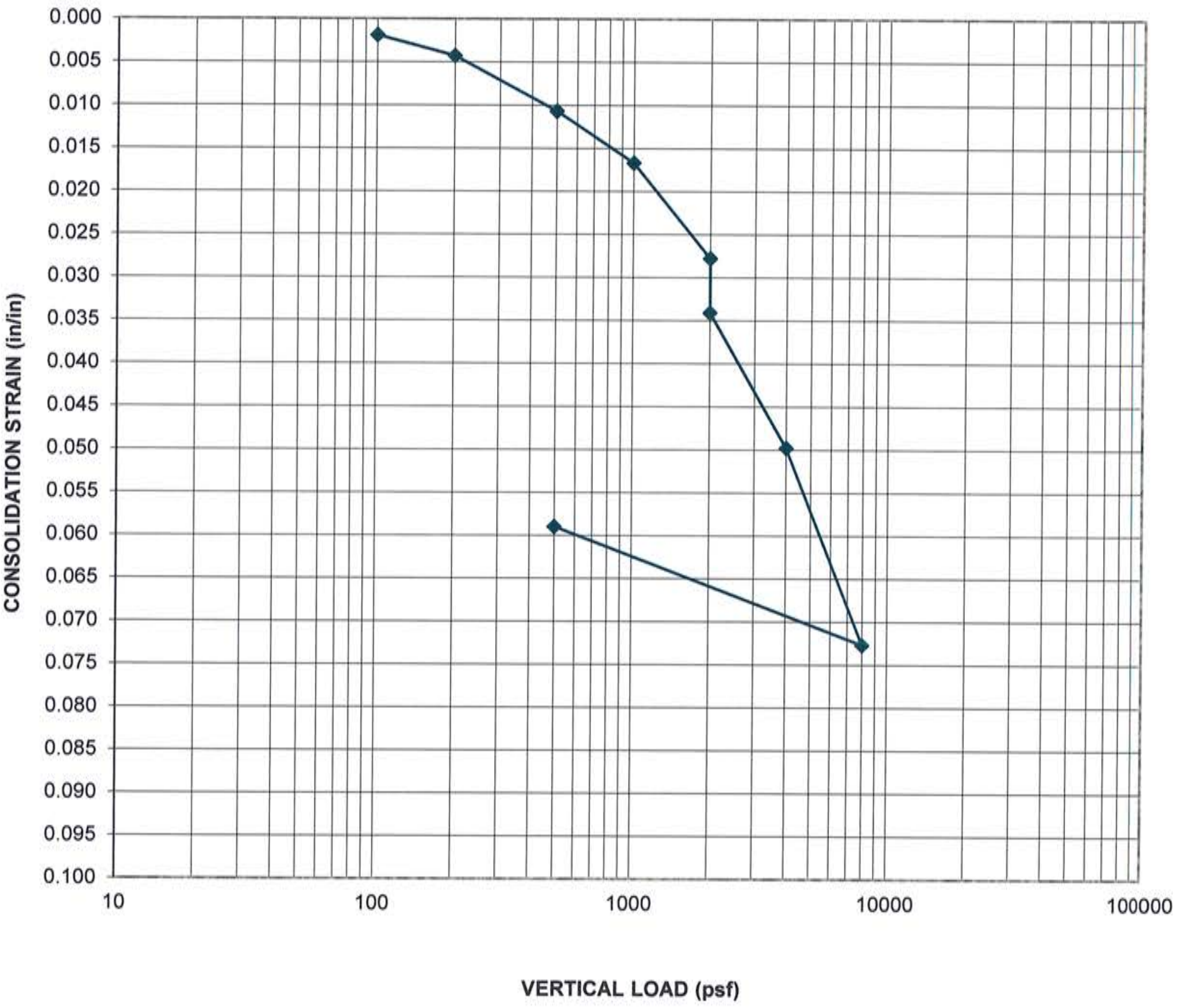
Sample inundated at 2000 psf pressure

Project:	CFA#4003 Orange, CA
Client:	Chick-fil-A Inc.
Project No.:	2G-1610007
Figure No.:	3

GILES ENGINEERING ASSOCIATES, INC.

-GEOTECHNICAL, ENVIRONMENTAL, AND CONSTRUCTION MATERIALS-
1965 NORTH MAIN STREET, ORANGE, CALIFORNIA
OFFICE: 714-279-0817 FAX : 714-279-9687

CONSOLIDATION / COLLAPSE TEST ASTM D2435/ASTM D5333



Classification	Silty Sand
Boring No.	B-1
Sample No.	4CS
Depth (ft.)	10.0 - 11.5
Elevation	
Liquid Limit	NP
Plastic Limit	NP
Specimen Diameter (in.)	2.42
Initial Specimen Thickness (in.)	1.00

Initial Moisture Content (%)	18.2
Final Moisture Content (%)	20.1
Natural Density (pcf)	119.7
Initial Dry Density (pcf)	101.3
Final Dry Density (pcf)	107.6
Collapse at 2000 psf	0.63%

Sample inundated at 2000 psf pressure

Project: CFA#4003
Orange, CA
Client: Chick-fil-A Inc.

Project No.: 2G-1610007

Figure No.: 4

GILES ENGINEERING ASSOCIATES, INC.

-GEOTECHNICAL, ENVIRONMENTAL, AND CONSTRUCTION MATERIALS-
1965 NORTH MAIN STREET, ORANGE, CALIFORNIA
OFFICE: 714-279-0817 FAX : 714-279-9687

BORING NO. & LOCATION: B-1

SURFACE ELEVATION: 158.5 feet

COMPLETION DATE: 11/19/16

FIELD REP: LARRY BALLARD

TEST BORING LOG

PROPOSED CHICK-FIL-A RESTAURANT #4003

202 SOUTH MAIN STREET
ORANGE, CA

PROJECT NO: 2G-1610007

GILES ENGINEERING ASSOCIATES, INC.

MATERIAL DESCRIPTION	Depth (ft)	Elevation	Sample No. & Type	N	Q_u (tsf)	Q_p (tsf)	Q_s (tsf)	W (%)	PID	NOTES
Approximately 4.5 inches of asphaltic concrete										
Brown Silty fine Sand - Moist (Fill)			1-SS	4				9	BDL	
Light Brown Silty fine Sand, trace of Clay - Moist (Native)			2-CS	6				11	42.1	Dd=107.5 pcf
Brown to Light Brown fine to coarse Sand, trace to little Silt, some Gravel - Damp to Moist			3-CS	9				5	BDL	Dd=110.2 pcf
Olive Brown Silty fine to coarse Sand, some Clay, trace to little Gravel, some thin layers of Sandy Clay - Moist to Very Moist			4-CS	6				18	BDL	Dd=101.3 pcf
			5-SS	2				21	BDL	

No groundwater encountered
Boring Terminated at about 16.5 feet (EL. 142')

	Water Observation Data
∇	Water Encountered During Drilling: None
▼	Water Level At End of Drilling:
░	Cave Depth At End of Drilling:
▼	Water Level After Drilling:
▒	Cave Depth After Drilling:

Remarks:

CS = California Split Spoon

SS = Standard Penetration Test

BDL - Below Detection Level

Changes in strata indicated by the lines are approximate boundary between soil types. The actual transition may be gradual and may vary considerably between test borings. Location of test boring is shown on the Boring Location Plan.

BORING NO. & LOCATION:
B-2

SURFACE ELEVATION:
158.9 feet

COMPLETION DATE:
11/19/16

FIELD REP:
LARRY BALLARD

TEST BORING LOG

PROPOSED CHICK-FIL-A RESTAURANT #4003

202 SOUTH MAIN STREET
ORANGE, CA

PROJECT NO: 2G-1610007

GILES ENGINEERING ASSOCIATES, INC.

MATERIAL DESCRIPTION	Depth (ft)	Elevation	Sample No. & Type	N	Q_u (tsf)	Q_p (tsf)	Q_s (tsf)	W (%)	PID	NOTES
Approximately 4.5 inches of asphaltic concrete										
Brown Silty fine Sand, trace of Clay - Moist (Fill)			1-SS	4				11	BDL	P_{200}=28%
Brown to Light Brown Silty fine Sand, trace to little Clay, little Gravel - Damp to Moist (Native)		155	2-SS	2				12	BDL	P_{200}=35%
	5		3-SS	14				5	BDL	P_{200}=16%
		150								
Brown fine Sand, trace to little Silt, little Gravel - Damp	10		4-SS	11				3	BDL	P_{200}=9%
		145								
Olive Brown Sandy Clay, little Silt, trace of Gravel - Very Moist	15		5-SS	3				22	BDL	

No groundwater encountered
Boring Terminated at about 16.5 feet (EL. 142.4')

	Water Observation Data
▽	Water Encountered During Drilling: None
▽	Water Level At End of Drilling:
▨	Cave Depth At End of Drilling:
▼	Water Level After Drilling:
▭	Cave Depth After Drilling:

Remarks:

SS = Standard Penetration Test

BDL - Below Detection Level

Changes in strata indicated by the lines are approximate boundary between soil types. The actual transition may be gradual and may vary considerably between test borings. Location of test boring is shown on the Boring Location Plan.

BORING NO. & LOCATION: B-3	# TEST BORING LOG	GILES ENGINEERING ASSOCIATES, INC.
SURFACE ELEVATION: 158.4 feet	PROPOSED CHICK-FIL-A RESTAURANT #4003	
COMPLETION DATE: 11/19/16	202 SOUTH MAIN STREET ORANGE, CA	
FIELD REP: LARRY BALLARD	PROJECT NO: 2G-1610007	

MATERIAL DESCRIPTION	Depth (ft)	Elevation	Sample No. & Type	N	Q_u (tsf)	Q_p (tsf)	Q_s (tsf)	W (%)	PID	NOTES
Approximately 6 inches of asphaltic concrete										
Brown Silty fine Sand - Moist (Fill)										
Light Brown to Brown Silty fine Sand, little Clay - Moist (Native)			1-SS	2				9	BDL	
		155								
			2-CS	6				11	BDL	Dd=104.4 pcf
	5									
Light Brown fine to coarse Sand, trace to little Silt, some Gravel - Damp			3-CS	17				3	BDL	Dd=103.4 pcf
		150								
	10									
			4-CS	22				3	18.2	Dd=110.1 pcf
		145								
	15									
Olive Brown Clayey fine Sand - Moist			5-CS	6				11	BDL	

No groundwater encountered
Boring Terminated at about 16.5 feet (EL. 141.9')

	Water Observation Data	Remarks:
▽	Water Encountered During Drilling: None	CS = California Split Spoon
▼	Water Level At End of Drilling:	SS = Standard Penetration Test
▨	Cave Depth At End of Drilling:	BDL - Below Detection Level
▼	Water Level After Drilling:	
▨	Cave Depth After Drilling:	

Changes in strata indicated by the lines are approximate boundary between soil types. The actual transition may be gradual and may vary considerably between test borings. Location of test boring is shown on the Boring Location Plan.

BORING NO. & LOCATION:
B-4

SURFACE ELEVATION:
159.3 feet

COMPLETION DATE:
11/19/16

FIELD REP:
LARRY BALLARD

TEST BORING LOG

PROPOSED CHICK-FIL-A RESTAURANT #4003

202 SOUTH MAIN STREET
ORANGE, CA

PROJECT NO: 2G-1610007

GILES ENGINEERING ASSOCIATES, INC.

MATERIAL DESCRIPTION	Depth (ft)	Elevation	Sample No. & Type	N	Q_u (tsf)	Q_p (tsf)	Q_s (tsf)	W (%)	PID	NOTES
Approximately 4 inches of asphaltic concrete										
Brown Silty fine Sand, trace of Gravel - Moist (Fill)			1-SS	3				12	BDL	P_{200}=37%
Light Brown to Brown fine to coarse Sand, trace to little Silt, little Gravel - Damp (Native)		155	2-SS	11				3	BDL	P_{200}=6%
	5									
			3-SS	15				3	BDL	P_{200}=5%
		150								
	10		4-SS	10				6	BDL	
Olive Brown to Brown Silty fine Sand, some Clay, some layers of Sandy Clay - Very Moist		145								
	15		5-SS	3				19	BDL	

No groundwater encountered
Boring Terminated at about 16.5 feet (EL. 142.8')

Water Observation Data

▽ Water Encountered During Drilling: None
▽ Water Level At End of Drilling:
▨ Cave Depth At End of Drilling:
▼ Water Level After Drilling:
▨ Cave Depth After Drilling:

Remarks:

SS = Standard Penetration Test

BDL - Below Detection Level

Changes in strata indicated by the lines are approximate boundary between soil types. The actual transition may be gradual and may vary considerably between test borings. Location of test boring is shown on the Boring Location Plan.

BORING NO. & LOCATION: B-5

SURFACE ELEVATION: 158 feet

COMPLETION DATE: 11/19/16

FIELD REP: LARRY BALLARD

TEST BORING LOG

PROPOSED CHICK-FIL-A RESTAURANT #4003

202 SOUTH MAIN STREET
ORANGE, CA

PROJECT NO: 2G-1610007

GILES ENGINEERING ASSOCIATES, INC.

MATERIAL DESCRIPTION	Depth (ft)	Elevation	Sample No. & Type	N	Q_u (tsf)	Q_p (tsf)	Q_s (tsf)	W (%)	PID	NOTES
Approximately 4 inches of asphaltic concrete over 4 inches of aggregate base										
Brown Silty fine Sand, trace to little Clay - Moist (Fill)		157.5								
Brown to Light Brown Silty fine Sand to Clayey fine Sand, some pockets of Sand - Damp to Moist (Native)			1-SS	5				7	BDL	
	2.5	155.0								
			2-SS	7				5	BDL	
	5.0									

No groundwater encountered
Boring Terminated at about 5 feet (EL. 153')

	Water Observation Data
▽	Water Encountered During Drilling: None
▼	Water Level At End of Drilling:
▨	Cave Depth At End of Drilling:
▼	Water Level After Drilling:
▭	Cave Depth After Drilling:

Remarks:

SS = Standard Penetration Test

BDL - Below Detection Level

Changes in strata indicated by the lines are approximate boundary between soil types. The actual transition may be gradual and may vary considerably between test borings. Location of test boring is shown on the Boring Location Plan.

BORING NO. & LOCATION:
B-6

SURFACE ELEVATION:
157 feet

COMPLETION DATE:
11/19/16

FIELD REP:
LARRY BALLARD

TEST BORING LOG

PROPOSED CHICK-FIL-A RESTAURANT #4003

202 SOUTH MAIN STREET
ORANGE, CA

PROJECT NO: 2G-1610007

GILES ENGINEERING ASSOCIATES, INC.

MATERIAL DESCRIPTION	Depth (ft)	Elevation	Sample No. & Type	N	Q_u (tsf)	Q_p (tsf)	Q_s (tsf)	W (%)	PID	NOTES
Approximately 5 inches of asphaltic concrete										
Brown Silty fine Sand, little Clay - Damp (Native)										
		155.0	1-SS	7				5	BDL	
	2.5									
		152.5	2-SS	17				5	BDL	
	5.0									
Boring Terminated at about 5 feet (EL. 152')										

	Water Observation Data
▽	Water Encountered During Drilling: None
▼	Water Level At End of Drilling:
▨	Cave Depth At End of Drilling:
▼	Water Level After Drilling:
▨	Cave Depth After Drilling:

Remarks:

SS = Standard Penetration Test

BDL - Below Detection Level

Changes in strata indicated by the lines are approximate boundary between soil types. The actual transition may be gradual and may vary considerably between test borings. Location of test boring is shown on the Boring Location Plan.

BORING NO. & LOCATION:
B-7

SURFACE ELEVATION:
157.6 feet

COMPLETION DATE:
11/19/16

FIELD REP:
LARRY BALLARD

TEST BORING LOG

PROPOSED CHICK-FIL-A RESTAURANT #4003

202 SOUTH MAIN STREET
ORANGE, CA

PROJECT NO: 2G-1610007

GILES ENGINEERING ASSOCIATES, INC.

MATERIAL DESCRIPTION	Depth (ft)	Elevation	Sample No. & Type	N	Q_u (tsf)	Q_p (tsf)	Q_s (tsf)	W (%)	PID	NOTES
Approximately 5.5 inches of asphaltic concrete		157.5								
Brown Silty fine Sand, trace to little Clay - Moist (Native)			1-SS	4				8	BDL	
	2.5	155.0								
			2-SS	2				9	BDL	
	5.0	152.5								

No groundwater encountered
Boring Terminated at about 6 feet (EL. 151.6')

	Water Observation Data
▽	Water Encountered During Drilling: None
▽	Water Level At End of Drilling:
▨	Cave Depth At End of Drilling:
▼	Water Level After Drilling:
▨	Cave Depth After Drilling:

Remarks:

SS = Standard Penetration Test

BDL - Below Detection Level

Changes in strata indicated by the lines are approximate boundary between soil types. The actual transition may be gradual and may vary considerably between test borings. Location of test boring is shown on the Boring Location Plan.

BORING NO. & LOCATION:
B-8

SURFACE ELEVATION:
157.5 feet

COMPLETION DATE:
11/19/16

FIELD REP:
LARRY BALLARD

TEST BORING LOG

PROPOSED CHICK-FIL-A RESTAURANT #4003

202 SOUTH MAIN STREET
ORANGE, CA

PROJECT NO: 2G-1610007

GILES ENGINEERING ASSOCIATES, INC.

MATERIAL DESCRIPTION	Depth (ft)	Elevation	Sample No. & Type	N	Q_u (tsf)	Q_p (tsf)	Q_s (tsf)	W (%)	PID	NOTES
Approximately 2.5 inches of asphaltic concrete										
Brown Silty fine Sand, trace to little Clay, some pockets of fine Sand - Moist (Native)			1-SS	3				9	BDL	
	2.5	155.0								
			2-SS	7				7	BDL	
	5.0	152.5								

No groundwater encountered
Boring Terminated at about 5 feet (EL. 152.5')

Water Observation Data

∇ Water Encountered During Drilling: None
∇ Water Level At End of Drilling:
Cave Depth At End of Drilling:
▼ Water Level After Drilling:
Cave Depth After Drilling:

Remarks:

SS = Standard Penetration Test

BDL - Below Detection Level

Changes in strata indicated by the lines are approximate boundary between soil types. The actual transition may be gradual and may vary considerably between test borings. Location of test boring is shown on the Boring Location Plan.

APPENDIX B

FIELD PROCEDURES

The field operations were conducted in general accordance with the procedures recommended by the American Society for Testing and Materials (ASTM) designation D 420 entitled “Standard Guide for Sampling Rock and Rock” and/or other relevant specifications. Soil samples were preserved and transported to *Giles’* laboratory in general accordance with the procedures recommended by ASTM designation D 4220 entitled “Standard Practice for Preserving and Transporting Soil Samples.” Brief descriptions of the sampling, testing and field procedures commonly performed by *Giles* are provided herein.

GENERAL FIELD PROCEDURES

Test Boring Elevations

The ground surface elevations reported on the Test Boring Logs are referenced to the assumed benchmark shown on the Boring Location Plan (Figure 1). Unless otherwise noted, the elevations were determined with a conventional hand-level and are accurate to within about 1 foot.

Test Boring Locations

The test borings were located on-site based on the existing site features and/or apparent property lines. Dimensions illustrating the approximate boring locations are reported on the Boring Location Plan (Figure 1).

Water Level Measurement

The water levels reported on the Test Boring Logs represent the depth of “free” water encountered during drilling and/or after the drilling tools were removed from the borehole. Water levels measured within a granular (sand and gravel) soil profile are typically indicative of the water table elevation. It is usually not possible to accurately identify the water table elevation with cohesive (clayey) soils, since the rate of seepage is slow. The water table elevation within cohesive soils must therefore be determined over a period of time with groundwater observation wells.

It must be recognized that the water table may fluctuate seasonally and during periods of heavy precipitation. Depending on the subsurface conditions, water may also become perched above the water table, especially during wet periods.

Borehole Backfilling Procedures

Each borehole was backfilled upon completion of the field operations. If potential contamination was encountered, and/or if required by state or local regulations, boreholes were backfilled with an “impervious” material (such as bentonite slurry). Borings that penetrated pavements, sidewalks, etc. were “capped” with Portland Cement concrete, asphaltic concrete, or a similar surface material. It must, however, be recognized that the backfill material may settle, and the surface cap may subside, over a period of time. Further backfilling and/or re-surfacing by *Giles’* client or the property owner may be required.

FIELD SAMPLING AND TESTING PROCEDURES

Auger Sampling (AU)

Soil samples are removed from the auger flights as an auger is withdrawn above the ground surface. Such samples are used to determine general soil types and identify approximate soil stratifications. Auger samples are highly disturbed and are therefore not typically used for geotechnical strength testing.

Split-Barrel Sampling (SS) – (ASTM D-1586)

A split-barrel sampler with a 2-inch outside diameter is driven into the subsoil with a 140-pound hammer free-falling a vertical distance of 30 inches. The summation of hammer-blows required to drive the sampler the final 12-inches of an 18-inch sample interval is defined as the “Standard Penetration Resistance” or N-value is an index of the relative density of granular soils and the comparative consistency of cohesive soils. A soil sample is collected from each SPT interval.

Shelby Tube Sampling (ST) – (ASTM D-1587)

A relatively undisturbed soil sample is collected by hydraulically advancing a thin-walled Shelby Tube sampler into a soil mass. Shelby Tubes have a sharp cutting edge and are commonly 2 to 5 inches in diameter.

Bulk Sample (BS)

A relatively large volume of soils is collected with a shovel or other manually-operated tool. The sample is typically transported to *Giles’* materials laboratory in a sealed bag or bucket.

Dynamic Cone Penetration Test (DC) – (ASTM STP 399)

This test is conducted by driving a 1.5-inch-diameter cone into the subsoil using a 15-pound steel ring (hammer), free-falling a vertical distance of 20 inches. The number of hammer-blows required to drive the cone 1¾ inches is an indication of the soil strength and density, and is defined as “N”. The Dynamic Cone Penetration test is commonly conducted in hand auger borings, test pits and within excavated trenches.

- Continued -

Ring-Lined Barrel Sampling – (ASTM D 3550)

In this procedure, a ring-lined barrel sampler is used to collect soil samples for classification and laboratory testing. This method provides samples that fit directly into laboratory test instruments without additional handling/disturbance.

Sampling and Testing Procedures

The field testing and sampling operations were conducted in general accordance with the procedures recommended by the American Society for Testing and Materials (ASTM) and/or other relevant specifications. Results of the field testing (i.e. N-values) are reported on the Test Boring Logs. Explanations of the terms and symbols shown on the logs are provided on the appendix enclosure entitled “General Notes”.

APPENDIX C

LABORATORY TESTING AND CLASSIFICATION

The laboratory testing was conducted under the supervision of a geotechnical engineer in accordance with the procedures recommended by the American Society for Testing and Materials (ASTM) and/or other relevant specifications. Brief descriptions of laboratory tests commonly performed by *Giles* are provided herein.

LABORATORY TESTING AND CLASSIFICATION

Photoionization Detector (PID)

In this procedure, soil samples are "scanned" in *Giles'* analytical laboratory using a Photoionization Detector (PID). The instrument is equipped with an 11.7 eV lamp calibrated to a Benzene Standard and is capable of detecting a minute concentration of **certain** Volatile Organic Compound (VOC) vapors, such as those commonly associated with petroleum products and some solvents. Results of the PID analysis are expressed in HNu (manufacturer's) units rather than actual concentration.

Moisture Content (w) (ASTM D 2216)

Moisture content is defined as the ratio of the weight of water contained within a soil sample to the weight of the dry solids within the sample. Moisture content is expressed as a percentage.

Unconfined Compressive Strength (qu) (ASTM D 2166)

An axial load is applied at a uniform rate to a cylindrical soil sample. The unconfined compressive strength is the maximum stress obtained or the stress when 15% axial strain is reached, whichever occurs first.

Calibrated Penetrometer Resistance (qp)

The small, cylindrical tip of a hand-held penetrometer is pressed into a soil sample to a prescribed depth to measure the soils capacity to resist penetration. This test is used to evaluate unconfined compressive strength.

Vane-Shear Strength (qs)

The blades of a vane are inserted into the flat surface of a soil sample and the vane is rotated until failure occurs. The maximum shear resistance measured immediately prior to failure is taken as the vane-shear strength.

Loss-on-Ignition (ASTM D 2974; Method C)

The Loss-on-Ignition (L.O.I.) test is used to determine the organic content of a soil sample. The procedure is conducted by heating a dry soil sample to 440°C in order to burn-off or "ash" organic matter present within the sample. The L.O.I. value is the ratio of the weight loss due to ignition compared to the initial weight of the dry sample. L.O.I. is expressed as a percentage.

Particle Size Distribution (ASTB D 421, D 422, and D 1140)

This test is performed to determine the distribution of specific particle sizes (diameters) within a soil sample. The distribution of coarse-grained soil particles (sand and gravel) is determined from a "sieve analysis," which is conducted by passing the sample through a series of nested sieves. The distribution of fine-grained soil particles (silt and clay) is determined from a "hydrometer analysis" which is based on the sedimentation of particles suspended in water.

Consolidation Test (ASTM D 2435)

In this procedure, a series of cumulative vertical loads are applied to a small, laterally confined soil sample. During each load increment, vertical compression (consolidation) of the sample is measured over a period of time. Results of this test are used to estimate settlement and time rate of settlement.

Classification of Samples

Each soil sample was visually-manually classified, based on texture and plasticity, in general accordance with the Unified Soil Classification System (ASTM D-2488-75). The classifications are reported on the Test Boring Logs.

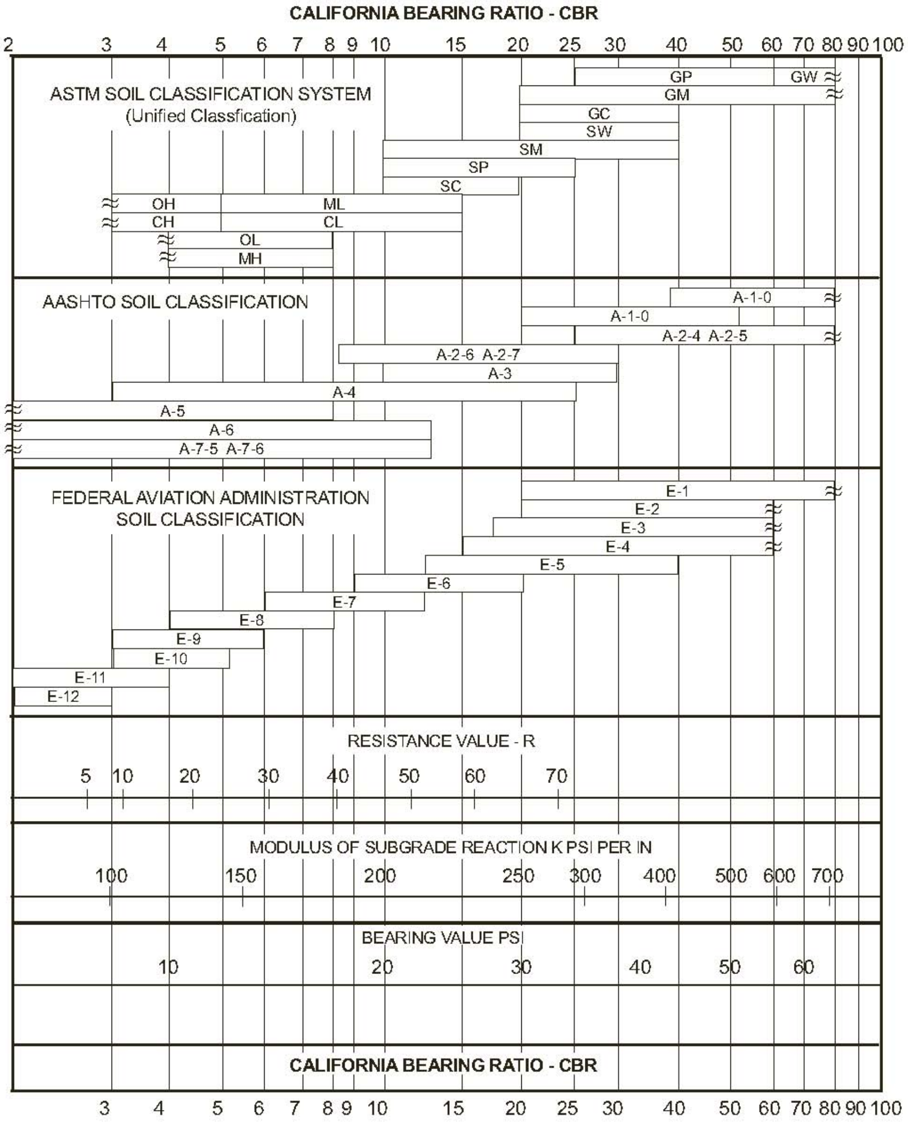
Laboratory Testing

The laboratory testing operations were conducted in general accordance with the procedures recommended by the American Society for Testing and Materials (ASTM) and/or other relevant specifications. Results of the laboratory tests are provided on the Test Boring Logs or other appendix enclosures. Explanation of the terms and symbols used on the logs is provided on the appendix enclosure entitled "General Notes."

California Bearing Ratio (CBR) Test ASTM D-1833

The CBR test is used for evaluation of a soil subgrade for pavement design. The test consists of measuring the force required for a 3-square-inch cylindrical piston to penetrate 0.1 or 0.2 inch into a compacted soil sample. The result is expressed as a percent of force required to penetrate a standard compacted crushed stone.

Unless a CBR test has been specifically requested by the client, the CBR is estimated from published charts, based on soil classification and strength characteristics. A typical correlation chart is below.



APPENDIX D

GENERAL INFORMATION

GUIDE SPECIFICATIONS FOR SUBGRADE AND PREPARATION FOR FILL, FOUNDATION, FLOOR SLAB AND PAVEMENT SUPPORT; AND SELECTION, PLACEMENT AND COMPACTION OF FILL SOILS USING MODIFIED PROCTOR PROCEDURES

1. Construction monitoring and testing of subgrades and grades for fill, foundation, floor slab and pavement; and fill selection, placement and compaction shall be performed by an experienced soils engineer and/or his representatives.

2. All compacted fill, subgrades, and grades shall be (a) underlain by suitable bearing material, (b) free of all organic frozen, or other deleterious material, and (c) observed, tested and approved by qualified engineering personnel representing an experienced soils engineer. Preparation of subgrades after stripping vegetation, organic or other unsuitable materials shall consist of (a) proofrolling to detect soft, wet, yielding soils or other unstable materials that must be undercut, (b) scarifying top 6 to 8 inches, (c) moisture conditioning the soils as required, and (d) recompaction to same minimum in-situ density required for similar material indicated under Item 5. Note: Compaction requirements for pavement subgrade are higher than other areas. Weather and construction equipment may damage compacted fill surface and reworking and retesting may be necessary for proper performance.

3. In overexcavation and fill areas, the compacted fill must extend (a) a minimum 1 foot lateral distance beyond the exterior edge of the foundation at bearing grade or pavement at subgrade and down to compacted fill subgrade on a maximum 0.5(H):1(v) slope, (b) 1 foot above footing grade outside the building, and (c) to floor subgrade inside the building. Fill shall be placed and compacted on a 5(H):1(V) slope or must be stepped or benched as required to flatten if not specifically approved by qualified personnel under the direction of an experienced soils engineer.

4. The compacted fill materials shall be free of deleterious, organic, or frozen matter, shall contain no chemicals that may result in the material being classified as "contaminated", and shall be low-expansive with a maximum Liquid Limit (ASTM D-423) and Plasticity Index (ASTM D-424) of 30 and 15, respectively, unless specifically tested and found to have low expansive properties and approved by an experienced soils engineer. The top 12 inches of compacted fill should have a maximum 3 inch particle diameter and all underlying compacted fill a maximum 6 inch diameter unless specifically approved by an experienced soils engineer. All fill material must be tested and approved under the direction of an experienced soils engineer prior to placement. If the fill is to provide non-frost susceptible characteristics, it must be classified as a clean GW, GP, SW or SP per Unified Soils Classification System (ASTM D-2487).

5. For structural fill depths less than 20 feet, the density of the structural compacted fill and scarified subgrade and grades shall not be less than 90 percent of the maximum dry density as determined by Modified Proctor (ASTM D-1557) with the exception of the top 12 inches of pavement subgrade which shall have a minimum in-situ density of 95 percent of maximum dry density, or 5 percent higher than underlying structural fill materials. Where the structural fill depth is greater than 20 feet, the portion below 20 feet should have a minimum in-place density of 95 percent of its maximum dry density or 5 percent higher than the top 20 feet. Cohesive soils shall not vary by more than -1 to +3 percent moisture content and granular soil ±3 percent from the optimum when placed and compacted or recompacted, unless specifically recommended/approved by the soils engineer observing the placement and compaction. Cohesive soils with moderate to high expansion potentials (PI>15) should, however, be placed, compacted and maintained prior to construction at a 3±1 percent moisture content above optimum moisture content to limit future heave. Fill shall be placed in layers with a maximum loose thickness of 8 inches for foundations and 10 inches for floor slabs and pavements, unless specifically approved by the soils engineer taking into consideration the type of materials and compaction equipment being used. The compaction equipment should consist of suitable mechanical equipment specifically designed for soil compaction. Bulldozers or similar tracked vehicles are typically not suitable for compaction.

6. Excavation, filing, subgrade grade preparation shall be performed in a manner and sequence that will provide drainage at all times and proper control of erosion. Precipitation, springs, and seepage water encountered shall be pumped or drained to provide a suitable working platform. Springs or water seepage encountered during grade/foundation construction must be called to the soils engineer's attention immediately for possible construction procedure revision or inclusion of an underdrain system.

7. Non-structural fill adjacent to structural fill should typically be placed in unison to provide lateral support. Backfill along walls must be placed and compacted with care to ensure excessive unbalanced lateral pressures do not develop. The type of fill material placed adjacent to below grade walls (i.e. basement walls and retaining walls) must be properly tested and approved by an experienced soils engineer with consideration for the lateral pressure used in the wall design.

8. Wherever, in the opinion of the soils engineer or the Owner's Representatives, an unstable condition is being created either by cutting or filling, the work should not proceed into that area until an appropriate geotechnical exploration and analysis has been performed and the grading plan revised, if found necessary.

GENERAL COMMENTS

The soil samples obtained during the subsurface exploration will be retained for a period of thirty days. If no instructions are received, they will be disposed of at that time.

This report has been prepared exclusively for the client in order to aid in the evaluation of this property and to assist the architects and engineers in the design and preparation of the project plans and specifications. Copies of this report may be provided to contractor(s), with contract documents, to disclose information relative to this project. The report, however, has not been prepared to serve as the plans and specifications for actual construction without the appropriate interpretation by the project architect, structural engineer, and/or civil engineer. Reproduction and distribution of this report must be authorized by the client and *Giles*.

This report has been based on assumed conditions/characteristics of the proposed development where specific information was not available. It is recommended that the architect, civil engineer and structural engineer along with any other design professionals involved in this project carefully review these assumptions to ensure they are consistent with the actual planned development. When discrepancies exist, they should be brought to our attention to ensure they do not affect the conclusions and recommendations provided herein. The project plans and specifications may also be submitted to *Giles* for review to ensure that the geotechnical related conclusions and recommendations provided herein have been correctly interpreted.

The analysis of this site was based on a subsoil profile interpolated from a limited subsurface exploration. If the actual conditions encountered during construction vary from those indicated by the borings, *Giles* must be contacted immediately to determine if the conditions alter the recommendations contained herein.

The conclusions and recommendations presented in this report have been promulgated in accordance with generally accepted professional engineering practices in the field of geotechnical engineering. No other warranty is either expressed or implied.

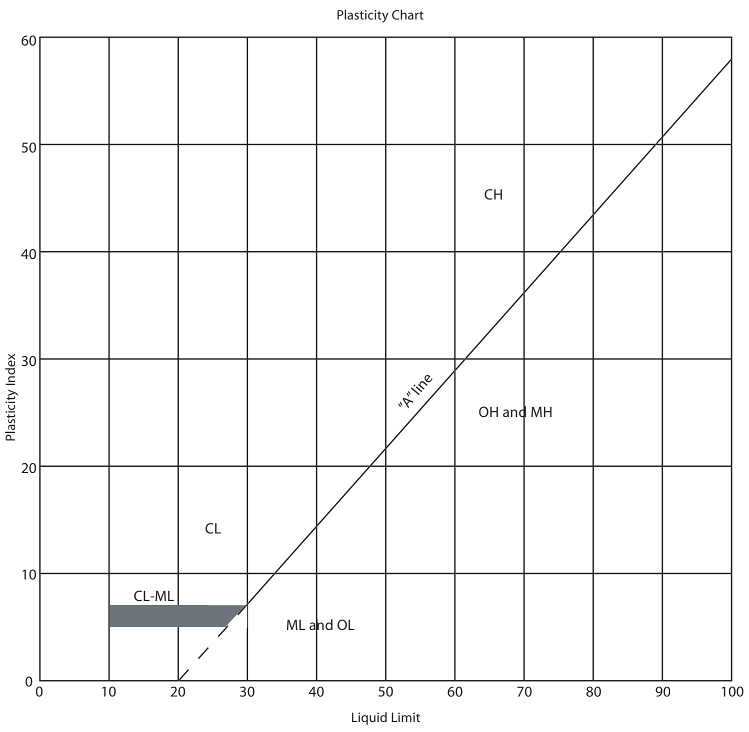
CHARACTERISTICS AND RATINGS OF UNIFIED SOIL SYSTEM CLASSES FOR SOIL CONSTRUCTION *

Class	Compaction Characteristics	Max. Dry Density Standard Proctor (pcf)	Compressibility and Expansion	Drainage and Permeability	Value as an Embankment Material	Value as Subgrade When Not Subject to Frost	Value as Base Course	Value as Temporary Pavement	
								With Dust Palliative	With Bituminous Treatment
GW	Good: tractor, rubber-tired, steel wheel or vibratory roller	125-135	Almost none	Good drainage, pervious	Very stable	Excellent	Good	Fair to poor	Excellent
GP	Good: tractor, rubber-tired, steel wheel or vibratory roller	115-125	Almost none	Good drainage, pervious	Reasonably stable	Excellent to good	Poor to fair	Poor	
GM	Good: rubber-tired or light sheepsfoot roller	120-135	Slight	Poor drainage, semipervious	Reasonably stable	Excellent to good	Fair to poor	Poor	Poor to fair
GC	Good to fair: rubber-tired or sheepsfoot roller	115-130	Slight	Poor drainage, impervious	Reasonably stable	Good	Good to fair **	Excellent	Excellent
SW	Good: tractor, rubber-tired or vibratory roller	110-130	Almost none	Good drainage, pervious	Very stable	Good	Fair to poor	Fair to poor	Good
SP	Good: tractor, rubber-tired or vibratory roller	100-120	Almost none	Good drainage, pervious	Reasonably stable when dense	Good to fair	Poor	Poor	Poor to fair
SM	Good: rubber-tired or sheepsfoot roller	110-125	Slight	Poor drainage, impervious	Reasonably stable when dense	Good to fair	Poor	Poor	Poor to fair
SC	Good to fair: rubber-tired or sheepsfoot roller	105-125	Slight to medium	Poor drainage, impervious	Reasonably stable	Good to fair	Fair to poor	Excellent	Excellent
ML	Good to poor: rubber-tired or sheepsfoot roller	95-120	Slight to medium	Poor drainage, impervious	Poor stability, high density required	Fair to poor	Not suitable	Poor	Poor
CL	Good to fair: sheepsfoot or rubber-tired roller	95-120	Medium	No drainage, impervious	Good stability	Fair to poor	Not suitable	Poor	Poor
OL	Fair to poor: sheepsfoot or rubber-tired roller	80-100	Medium to high	Poor drainage, impervious	Unstable, should not be used	Poor	Not suitable	Not suitable	Not suitable
MH	Fair to poor: sheepsfoot or rubber-tired roller	70-95	High	Poor drainage, impervious	Poor stability, should not be used	Poor	Not suitable	Very poor	Not suitable
CH	Fair to poor: sheepsfoot roller	80-105	Very high	No drainage, impervious	Fair stability, may soften on expansion	Poor to very poor	Not suitable	Very poor	Not suitable
OH	Fair to poor: sheepsfoot roller	65-100	High	No drainage, impervious	Unstable, should not be used	Very poor	Not suitable	Not suitable	Not suitable
Pt	Not suitable		Very high	Fair to poor drainage	Should not be used	Not suitable	Not suitable	Not suitable	Not suitable

* "The Unified Classification: Appendix A - Characteristics of Soil, Groups Pertaining to Roads and Airfields, and Appendix B - Characteristics of Soil Groups Pertaining to Embankments and Foundations," Technical Memorandum 357, U.S. Waterways Ixperiment Station, Vicksburg, 1953.

** Not suitable if subject to frost.

UNIFIED SOIL CLASSIFICATION SYSTEM (ASTM D-2487)

Major Divisions			*Group Symbols*		*Typical Names*	*Laboratory Classification Criteria*		
Coarse-grained soils (more than half of material is larger than No. 200 sieve size)	Gravels (More than half of coarse fraction is larger than No. 4 sieve size)	Clean gravels (little or no fines)	GW		Well-graded gravels, gravel-sand mixtures, little or no fines	Determine percentages of sand and gravel from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows: Less than 5 percent: GW, GP, SW, SP More than 12 percent: GM, GC, SM, SC 5 to 12 percent: *Borderline* cases requiring dual symbols[b]	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			GP		Poorly graded gravels, gravel-sand mixtrues, little or no fines		Not meeting all gradation requirements for GW	
		Gravels with fines (appreciable amount of fines)	GM[a]	d	Silty gravels, gravel-sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4	Limits plotting within shaded area, above "A" line with P.I. between 4 and 7 are *borderline* cases requiring use of dual symbols
				u				
			GC		Clayey gravels, gravel-sand-clay mixtures		Atterberg limits above "A" line or P.I. greater than 7	
	Sands (More than half of coarse fraction is smaller than No. 4 sieve size)	Clean sands (Little or no fines)	SW		Well-graded sands, gravelly sands, little or no fines		$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			SP		Poorly graded sands, gravelly sands, little or no fines		Not meeting all gradation requirements for SW	
		Sands with fines (Appreciable amount of fines)	SM[a]	d	Silty sands, sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4	Limits plotting within shaded area, above "A" line with P.I. between 4 and 7 are *borderline* cases requiring use of dual symbols
				u				
			SC		Clayey sands, sand-clay mixtures		Atterberg limits above "A" line or P.I. greater than 7	
Fine-grained soils (More than half material is smaller than No. 200 sieve size)	Silts and clays (Liquid limit less than 50)		ML		Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, or clayey silts with slight plasticity			
			CL		Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays			
			OL		Organic silts and organic silty clays of low plasticity			
	Silts and clays (Liquid limit greater than 50)		MH		Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts			
			CH		Inorganic clays of high plasticity, fat clays			
			OH		Organic clays of medium to high plasticity, organic silts			
	Highly organic soils		Pt		Peat and other highly organic soils			

[a] Division of GM and SM groups into subdivisions of d and u are for roads and airfields only. Subdivision is based on Atterberg limits, suffix d used when L.L. is 28 or less and the P.I. is 6 or less; the suffix u is used when L.L. is greater than 28.

[b] Borderline classifications, used for soils possessing characteristics of two groups, are designated by combinations of group sympols. For example GW-GC, well-graded gravel-sand mixture with clay binder.

GENERAL NOTES

SAMPLE IDENTIFICATION

All samples are visually classified in general accordance with the Unified Soil Classification System (ASTM D-2487-75 or D-2488-75)

DESCRIPTIVE TERM (% BY DRY WEIGHT)

Trace:	1-10%
Little:	11-20%
Some:	21-35%
And/Adjective	36-50%

PARTICLE SIZE (DIAMETER)

Boulders:	8 inch and larger
Cobbles:	3 inch to 8 inch
Gravel:	coarse - ¾ to 3 inch fine – No. 4 (4.76 mm) to ¾ inch
Sand:	coarse – No. 4 (4.76 mm) to No. 10 (2.0 mm) medium – No. 10 (2.0 mm) to No. 40 (0.42 mm) fine – No. 40 (0.42 mm) to No. 200 (0.074 mm)
Silt:	No. 200 (0.074 mm) and smaller (non-plastic)
Clay:	No 200 (0.074 mm) and smaller (plastic)

SOIL PROPERTY SYMBOLS

Dd:	Dry Density (pcf)
LL:	Liquid Limit, percent
PL:	Plastic Limit, percent
PI:	Plasticity Index (LL-PL)
LOI:	Loss on Ignition, percent
Gs:	Specific Gravity
K:	Coefficient of Permeability
w:	Moisture content, percent
qp:	Calibrated Penetrometer Resistance, tsf
qs:	Vane-Shear Strength, tsf
qu:	Unconfined Compressive Strength, tsf
qc:	Static Cone Penetrometer Resistance (correlated to Unconfined Compressive Strength, tsf)
PID:	Results of vapor analysis conducted on representative samples utilizing a Photoionization Detector calibrated to a benzene standard. Results expressed in HNU-Units. (BDL=Below Detection Limit)
N:	Penetration Resistance per 12 inch interval, or fraction thereof, for a standard 2 inch O.D. (1⅜ inch I.D.) split spoon sampler driven with a 140 pound weight free-falling 30 inches. Performed in general accordance with Standard Penetration Test Specifications (ASTM D-1586). N in blows per foot equals sum of N-Values where plus sign (+) is shown.
Nc:	Penetration Resistance per 1¾ inches of Dynamic Cone Penetrometer. Approximately equivalent to Standard Penetration Test N-Value in blows per foot.
Nr:	Penetration Resistance per 12 inch interval, or fraction thereof, for California Ring Sampler driven with a 140 pound weight free-falling 30 inches per ASTM D-3550. Not equivalent to Standard Penetration Test N-Value.

DRILLING AND SAMPLING SYMBOLS

SS:	Split-Spoon
ST:	Shelby Tube – 3 inch O.D. (except where noted)
CS:	3 inch O.D. California Ring Sampler
DC:	Dynamic Cone Penetrometer per ASTM Special Technical Publication No. 399
AU:	Auger Sample
DB:	Diamond Bit
CB:	Carbide Bit
WS:	Wash Sample
RB:	Rock-Roller Bit
BS:	Bulk Sample
Note:	Depth intervals for sampling shown on Record of Subsurface Exploration are not indicative of sample recovery, but position where sampling initiated

SOIL STRENGTH CHARACTERISTICS

COHESIVE (CLAYEY) SOILS

COMPARATIVE CONSISTENCY	**BLOWS PER FOOT (N)**	**UNCONFINED COMPRESSIVE STRENGTH (TSF)**
Very Soft	0 - 2	0 - 0.25
Soft	3 - 4	0.25 - 0.50
Medium Stiff	5 – 8	0.50 - 1.00
Stiff	9 – 15	1.00 - 2.00
Very Stiff	16 – 30	2.00 - 4.00
Hard	31+	4.00+

NON-COHESIVE (GRANULAR) SOILS

RELATIVE DENSITY	**BLOWS PER FOOT (N)**
Very Loose	0 - 4
Loose	5 - 10
Firm	11 - 30
Dense	31 - 50
Very Dense	51+

DEGREE OF PLASTICITY	**PI**
None to Slight	0 - 4
Slight	5 - 10
Medium	11 - 30
High to Very High	31+

DEGREE OF EXPANSIVE POTENTIAL	**PI**
Low	0 - 15
Medium	15 - 25
High	25+

Important Information About Your
Geotechnical Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

The following information is provided to help you manage your risks.

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

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

Read the Full Report

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

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

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

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

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

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

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

Subsurface Conditions Can Change

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

Most Geotechnical Findings Are Professional Opinions

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

A Report's Recommendations Are *Not* Final

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

A Geotechnical Engineering Report Is Subject to Misinterpretation

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

Do Not Redraw the Engineer's Logs

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

Give Contractors a Complete Report and Guidance

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

Read Responsibility Provisions Closely

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

Geoenvironmental Concerns Are Not Covered

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

Obtain Professional Assistance To Deal with Mold

Diverse strategies can be applied during building design, construction, operation, and maintenance to prevent significant amounts of mold from growing on indoor surfaces. To be effective, all such strategies should be devised for the *express purpose* of mold prevention, integrated into a comprehensive plan, and executed with diligent oversight by a professional mold prevention consultant. Because just a small amount of water or moisture can lead to the development of severe mold infestations, a number of mold prevention strategies focus on keeping building surfaces dry. While groundwater, water infiltration, and similar issues may have been addressed as part of the geotechnical engineering study whose findings are conveyed in this report, the geotechnical engineer in charge of this project is not a mold prevention consultant; ***none of the services performed in connection with the geotechnical engineer's study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not of itself be sufficient to prevent mold from growing in or on the structure involved.***

Rely, on Your ASFE-Member Geotechncial Engineer for Additional Assistance

Membership in ASFE/The Best People on Earth exposes geotechnical engineers to a wide array of risk management techniques that can be of genuine benefit for everyone involved with a construction project. Confer with you ASFE-member geotechnical engineer for more information.

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