PARTNER

GEOTECHNICAL REPORT

Gas Station and Car Wash Property
Los Coches Road & Interstate 8
El Cajon, California 92021

September 18, 2019
Partner Project Number: 19-226305.4

Prepared for:

OnPoint Development, LLC
7514 Girard Ave
La Jolla, Califronia 92037

Engineers who understand your business

September 18, 2019

Todd Dwyer
OnPoint Development
7514 Girard Avenue
La Jolla, California 92037

Subject: Geotechnical Report
Gas Station and Car Wash Property
Los Coches Road & Interstate 8
El Cajon, California 92021
Partner Project No. 19-226305.4

Dear Todd Dwyer:

Partner Assessment Corporation (Partner) presents the following general opinion regarding the geotechnical conditions at the subject site, based on the information contained within this geotechnical report and our general experience with construction practices and geotechnical conditions on other sites. This statement does not constitute an engineering recommendation.

- *The geotechnical conditions on the site related to the planned construction are expected to be similar to more difficult in comparison with other similar sites*; given challenges associated with hilly topography, previous development and undocumented fills.* ***Additional study may be warranted depending on the final layout of retaining walls and slopes.***

The descriptions and findings of our geotechnical report are presented for your use in this electronic format, for your use as shown in the hyperlinked outline below. To return to this page after clicking a hyperlink, hold "alt" and press the "left arrow key" on your keyboard.

We appreciate the opportunity to be of service during this phase of the work.

Sincerely,

REGISTERED PROFESSIONAL ENGINEER
MATTHEW MARCUS
C-81591
CIVIL
STATE OF CALIFORNIA

Matthew Marcus, PE, PG
Technical Director – Geotechnical Engineering

Yuri Kawashima
Staff Geologist

** "similar sites" refers to sites with similar planned and current use, where we have recently performed similar work, and is a general statement not based on statistical analysis.*

1. GEOTECHNICAL EXECUTIVE SUMMARY

The executive summary is meant to consolidate information provided in more detail in the body of this report. This summary in no way replaces or overrides the detailed sections of the report.

Geologic Zones and Site Hazards:

The site is located in the City of El Cajon within the Peninsular Ranges geomorphic province of the state of California. The site appears to consist of a fill pad that may have been constructed during the development of the interchange at Los Coches Road and Interstate 8. However, the soil encountered in the borings consisted of silty sand soil that is consistent with alluvial deposits in the area. Fill depths are unknown, but may be on the order of 30 feet in some locations. The southern portion of the site is currently developed as gas station and convenience store at an elevation of roughly 700 feet above sea level. The northern portion of the site is a graded pad with an elevation of roughly 685 feet above sea level. The perimeter of the site to the north and east, slopes down to elevations of roughly 660 feet above sea level. The site may be impacted by existing buried foundations, utility lines, undocumented fills as well as other remnants of previous construction, including currently present underground storage tanks. This portion of the state is prone to ground shaking; however, the site is not mapped within a geologic hazard zone. Depending on final grades, we anticipate that some slope stability analysis may be needed prior to final design.

Excavation Conditions

We anticipate mass grading on the site as elevations varied by roughly 30 feet or more across the site. Assuming that the new buildings will be at or above frontage roadway elevations, we anticipate cuts will be 10 feet or less around the site. Based on our boring data, conventional construction equipment in good working condition should be able to perform the planned excavations. As previously mentioned, undocumented fills and remnants of previous construction may be present on the site and could cave or be difficult to remove and require additional planning and equipment. Due to underground utilities at the gas station area and possible tanks, special equipment or private locator services may be required during construction. In addition, special care should be taken to not undermine existing foundations of building.

Foundation/Slab Support

Based on the boring data, site soil will generally provide suitable bearing material for new buildings, even though it may consist of undocumented fill soil. Boring data indicated densely compacted material and the age of the fill pad is roughly 40 years or more. We anticipate that the new structures may be supported on spread foundations; however, structures to be constructed on 10 feet or more of newly placed engineered fill should be supported on structural slabs. Fill placement on slopes should follow the California Building Code guidelines for benching and keying as described in Section 5.2, and cut to grade areas should be carefully evaluated by proofrolling with repairs made as needed prior to construction of new structures.

Soil Reuse

Based on our borings site soils will generally be generally re-usable as structural fill. Existing structural materials such as concrete, asphalt, crushed aggregate, or others could potentially be re-used as site fills if processed to meet fill requirements on the site. We recommend engineered fill for the site be moisture conditioned and compacted to 95% of the Proctor determined maximum dry density, in accordance with Appendix C of this report.

Pavement Design:

Roadway Type	Subgrade Preparation	Pavement Section
Parking Area Light Duty (drives)	Proofrolled/Compacted Subgrade	3 in asphalt / 6 in aggregate base
Parking Area Heavy Duty (loading)	Proofrolled/Compacted Subgrade	6 in concrete / 4 in aggregate base

2. REPORT OVERVIEW & LIMITATIONS

2.1 Report Overview

To develop this report, Partner accessed existing information and obtained site specific data from our exploration program. Partner also used standard industry practices and our experience on previous projects to perform engineering analysis and provide recommendations for construction along with construction considerations to guide the methods of site development. The opinions on the cover letter of this report do not constitute engineering recommendations, and are only general, based on our recent anecdotal experiences and not statistical analysis. Section 1.0, Executive Geotechnical Summary, compiles data from each of the report sections, while each of sections in the report presents a detailed description of our work. The detailed descriptions in Section 5.0 and Appendix C constitute our engineering recommendations for the project, and they supersede the Executive Geotechnical Summary.

The report overview, including a description of the planned construction and a list of references, as well as an explanation of the report limitations is provided in Section 2.0. The findings of Partner's geologic review are included in Section 3.0 Geologic Conditions and Hazards. The descriptions of our methods of exploration and testing, as well as our findings are included in Section 4.0 Geotechnical Exploration and Laboratory Results. In addition, logs of our exploration excavations are included in Appendix A of the report, and laboratory testing is included in Appendix B of the report. Site Location and Site Plan maps are included as Figures in the report.

2.2 Assumed Construction

Partner's understanding of the planned construction was based on information provided by the project team. The proposed site plan is included as Figure 2 to this report. Partner's assumptions regarding the new construction are presented in the below table.

Property Data	
Property Use:	Commercial
Building footprint/height	Five Buildings ranging from 2,500 to 7,500 sf
Land Acreage (Ac):	3.27 acres
Number of Buildings:	5 with proposed canopy
Expected Cuts and Fills	15 feet or more
Type of Construction:	Assumed slab on grade with light weight frames
Foundations Type	Structural Slabs, Spread Foundations, Drilled Caisson
Anticipated Loads	2,000 psf, 25 kips
Traffic Loading	Paved parking lot, Car Wash Drives, Re-fueling areas
Site Information Sources:	8445 Los Coches Road Lakeside - Preliminary Grading Plan

2.3 References

The following references were used to generate this report:

California Dept. of Transportation, ARS Online, accessed 09/04/19

California Geological Survey, Note 36, *California Geomorphic Provinces*, 2002.

Department of Conservation California Geological Survey, *Geologic Map of El Cajon,* Tan, Williams, and Jorgensen accessed 09/04/19

Federal Emergency Management Agency, FEMA Flood Map Service Center, accessed 09/04/19

Google Earth Pro (Online), accessed 09/04/19

Historic Aerials by NETR Online, accessed 09/04/19

NGMDB, *Geologic map of El Cajon Quadrangle* – 2004, Todd, V.R., Alvarez, R.M., and Technic Graphic Systems, Inc. accessed 09/04/19

Partner Engineering and Science, Inc., Phase 1 Environmental Assessment Report, *Gas Station Property,*, El Cajon, California, 10/04/18.

Partner Engineering and Science, Inc., Phase 2 Environmental Assessment Report, *Gas Station Property,*, El Cajon, California, 10/19/18.

United States Department of Agriculture (USDA), Web Soil Survey, accessed online 09/04/19

United States Geological Survey, California Interactive Geologic Map accessed 09/04/19

United States Geological Survey, Lower 48 States 2014 Seismic Hazard Map, accessed online 09/04/19

United States Geologic Survey, Earthquake Hazards Program (Online), accessed 09/04/19

Temblor Online, 09/04/19

2.4 Limitations

The conclusions, recommendations, and opinions in this report are based upon soil samples and data obtained in widely spaced locations that were accessible at the time of exploration, and collected based on project information available at that time. Our findings are subject to field confirmation that the samples we obtained were representative of site conditions. If conditions on the site are different than what was encountered in our borings, the report recommendations should be reviewed by our office, and new recommendations should be provided based on the new information and possible additional exploration if needed. It should be noted that geotechnical subsurface evaluations are not capable of predicting all subsurface conditions, and that our evaluation was performed to industry standards at the time of the study, no other warranty or guarantee is made.

Likewise, our document review and geologic research study made a good-faith effort to review readily available documents that we could access and were aware of at the time, as listed in this letter. We are not able to guarantee that we have discovered, observed, and reviewed all relevant site documents and conditions. If new documents or studies are available following the completion of the report, the recommendations herein should be reviewed by our office, and new recommendations should be provided based on the new information and possible additional exploration if needed.

This report is intended for the use of the client in its entirety for the proposed project as described in the text. Information from this report is not to be used for other projects or for other sites. All of the report must be reviewed and applied to the project or else the report recommendations may no longer apply. If pertinent changes are made in the project plans or conditions are encountered during construction that appear to be different than indicated by this report, please contact this office for review. Significant variations may necessitate a re-evaluation of the recommendations presented in this report. The findings in this report are valid for one year from the date of the report. This report has been completed under specific Terms and Conditions relating to scope, relying parties, limitations of liability, indemnification, dispute resolution, and other factors relevant to any reliance on this report. Any parties relying on this report do so having accepted Partner's standard Terms and Conditions, a copy of which can be found at http: / www.partneresi.com/terms-and-conditions.php

If parties other than Partner are engaged to provide construction geotechnical services, they must be notified that they will be required to assume complete responsibility for the geotechnical phase of the project by concurring with the findings and recommendations in this report or providing alternate recommendations.

3. GEOLOGIC CONDITIONS & HAZARDS

This section presents the results of a geologic review performed by Partner, for the proposed new construction on site. The general location of the project is shown on Figure 1.

3.1 Site Location and Project Information

The planned construction will be situated on a developed and undeveloped parcel within a mixed residential and commercial area of El Cajon, California. The subject property is currently developed with a gas station, convenience store, and associated parking. In addition, the subject property includes a currently undeveloped parcel immediately surrounding the gas station to the North and East. The surrounding properties consist of mostly residential buildings and one commercial buildings to the West. Figure 2 presents the project site and the locations of our site exploration. Based on our review of available documents, the site has had the following previous uses:

Historical Use Information		
Period/Date	**Source**	**Description/Use**
1893-1903	Topographic Maps	Near San Diego Flume
1903-1964	Aerial Photographs, Topographic Maps	Agricultural Land
1966	Aerial Photograph	Fill Pad during Hwy Construction
1969-Present	Aerial Photographs, City Directories, Topographic Maps Agency Records, Interviews, On-Site Observations	Commercial/Gasoline Station; Automotive Repair; Retail Store

3.2 Geologic Setting

The subject property is situated within the Peninsular Ranges physiographic province of the state of California. A series of ranges is separated by northwest trending valleys, subparallel to faults branching from the San Andreas Fault. The trend of topography is similar to the Coast Ranges, but the geology is more like the Sierra Nevada, with granitic rock intruding the older metamorphic rocks. The Peninsular Ranges extend into lower California and are bound on the east by the Colorado Desert. The Los Angeles Basin and the island group (Santa Catalina, Santa Barbara, and the distinctly terraced San Clemente and San Nicolas islands), together with the surrounding continental shelf (cut by deep submarine fault troughs), are included in this province. The uppermost geologic formation underlying the soils at the subject property is Cretaceous age granodiorite and includes some Tonalite and Monzogranite.

Based on information obtained from the USDA Natural Resources Conservation Service Web Soil Survey online database, the superficial soils underneath the subject property are mapped as Vista coarse sandy loam. The Vista series consists of shallow coarse sandy loams, well drained, very low to moderately low permeable soils and residuum weathered from granodiorite and quartz-diorite parent material.

A general summary of the geologic data compiled for this project is provided in the below table.

Geologic Data		
Parameter	**Value**	**Source**
Geomorphic Zone	Peninsular Ranges	CGS
Ground Elevation	700 feet above MSL	USGS
Flood Elevation	Zone X (0.2% Flood Hazard)	FEMA
Seismic Hazard Zone	Low	USGS
Geologic Hazards	Ground shaking	CGS
Surface Cover	Disturbed Alluvium	Google Earth
Site Modifications	Fill pad with Gas Station	Google Earth
Surficial Geology	Residuum, Alluvium	USGS
Depth to Bedrock	N/A	Partner Boring
Groundwater Depth	N/A	Partner Boring
Historic Groundwater Depth	~30 and 40 feet bgs	GeoTracker

3.3 Geologic Hazards

California is tectonically active and contains numerous large, active faults. As a result, geologic hazards with the greatest potential to affect northern California include earthquakes and related hazards such as tsunamis, landslides, liquefaction, and ground shaking. According to California Department of Transportation's ARS Online Database, the three faults most relevant to the site are the Elsinore - Julian (26.2 miles from the site, MMax = 7.7), Rose Canyon- Downtown Graben (16.3 miles from the site, MMax = 6.8), and the Elsinore – Temecula (35.6 miles from the site, MMax = 7.7). The site was not mapped within a zone of seismically included hazard for liquefaction, landslide, or tsunami.

Ground shaking should be anticipated at the project site. The seismic design parameters based on the USGS Design Maps Detailed Report for ASCE 7-10 Standard Method are presented below. State, County, City, and other jurisdictions in seismically active areas update seismic standards on a regular basis. The design team should carefully evaluate all of the building requirements for the project.

Seismic Item	Value	Seismic Item	Value
Site Classification	D	Seismic Design Category	D
Fa	1.1	Fv	1.7
Ss	0.887g	S_1	0.341
S_{MS}	1.016g	S_{M1}	0.586g
S_{DS}	0.677g	S_{D1}	0.39g
PGA Max (ASCE '10)	0.388g	67% PGA (ASCE '10)	0.260g

4. GEOTECHNICAL EXPLORATION & LABORATORY RESULTS

Our evaluation of soils on the site included field exploration and laboratory testing. The field exploration and laboratory testing programs are briefly described below. Data reports from the field exploration and laboratory testing are provided in Appendix A and Appendix B, respectively.

4.1 Soil Borings

The soil boring program was conducted on September 9, 2019. Seven (7) borings were advanced by the use of a truck-mounted drill using hollow-stem auger drilling techniques. The borings were made to depths of 15 to 20 feet in the building footprints (B1 to B7). The approximate locations of the exploratory borings are shown on Figure 2. An infiltration test was also conducted at a depth of 5 feet. Results of the test are included in Section 4.4.

Logs of subsurface conditions encountered in the borings were prepared in the field by a representative of Partner Engineering. Soil samples consisting of relatively undisturbed Standard Penetration Tests (SPT) samples were collected at approximately 2.5 and 5-foot depth intervals and were returned to the laboratory for testing. The SPTs were performed in accordance with ASTM D 1586. Typed boring logs were prepared from the field logs and are presented in Appendix A. A summary table description is provided below:

Surficial Geology		
Strata	**Depth to Bottom of Layer (bgs*)**	**Description**
Fill Material	Unknown	Silty sand
Native Stratum 1	Unknown	Silty sandy soils
Groundwater	Not encountered	In boring
Bedrock	N/A	Not observed

bgs – below ground surface

4.2 Groundwater/Soil Moisture:

Groundwater was not encountered on the site during drilling. However, groundwater levels fluctuate over time and may be different at the time of construction and during the project life.

4.3 Laboratory Evaluation

Selected samples collected during drilling activities were tested in the laboratory to assist in evaluating engineering properties of subsurface materials at the site. The results of laboratory analyses are presented in Appendix B. Site soils contained large amounts of clay.

4.4 Infiltration Test Results:

One infiltration test was performed, as shown on Figure 2. The test was performed using the borehole method per San Diego County requirements at a depth of 18.5 feet. Results indicated the site may be conducive to surficial storm water infiltration. Data is shown in Appendix B, and is summarized below:

Parameter	P1
Location	North Parking Area
Elevation of Tested Area	685 feet
Pre-soak Depth	3 feet
Test Start Depth	17 inches
Water Drop During Test	5 inches
Un-factored Percolation Rate	2.0 minutes per inch
Infiltration Rate (Porchet Method)	0.98 inches per minute
Suitability Assessment Factor	1.5
Design Factor	TBD
Reduced Infiltration Rate	**0.65 in/hr**

5. GEOTECHNICAL RECOMMENDATIONS & PARAMETERS

The following discussion of findings for the site is based on the assumed construction, geologic review, results of the field exploration, and laboratory testing programs. The recommendations of this report are contingent upon adherence to Appendix C of this report, General Geotechnical Design and Construction Considerations. For additional details on the below recommendations, please see Appendix C.

5.1 Geotechnical Recommendations

The proposed construction is generally feasible from a geotechnical perspective provided the recommendations and assumptions of this report are followed.

Geologic/General Site Considerations

- The site is located in the City of El Cajon within the Peninsular Ranges geomorphic province of the state of California. The site appears to consist of a fill pad that may have been constructed during the development of the interchange at Los Coches Road and Interstate 8. Previous grading may have also been performed for agricultural uses along the alignment of the historic San Diego Flume. However, the soil encountered in the borings consisted of silty sand soil that is consistent with alluvial deposits in the area. Fill depths are unknown but may be on the order of 30 feet in some locations.
- The southern portion of the site is currently developed as gas station and convenience store at an elevation of roughly 700 feet above sea level. The northern portion of the site is a graded pad with an elevation of roughly 685 feet above sea level. The perimeter of the site to the north and east slopes down to elevations of roughly 660 feet above sea level. The site may be impacted by existing buried foundations, utility lines, undocumented fills as well as other remnants of previous construction, including currently present underground storage tanks. This portion of the state is prone to ground shaking; however, the site is not mapped within a geologic hazard zone. Depending on final grades, we anticipate that some slope stability analysis may be needed prior to final design.
- Given the presence of the site in a seismically active area, ground shaking during earthquakes should be anticipate during the project life. State, County, City, and other jurisdictions in seismically active areas update seismic standards on a regular basis. The design team should carefully evaluate all of the building requirements for the project.

Excavation Considerations

- We anticipate mass grading on the site as elevations varied by roughly 30 feet or more across the site. Assuming that the new buildings will be at or above frontage roadway elevations, we anticipate cuts will be 10 feet or less. Based on our boring data, conventional construction equipment in good working condition should be able to perform the planned excavations. As previously mentioned, undocumented fills and remnants of previous construction may be present on the site and could cave or be difficult to remove and require additional planning and equipment. Due to underground utilities at the gas station area and possible tanks, special equipment or private locator services may be required during construction. In addition, special care should be taken to not undermine existing foundations of building.

- Groundwater was not encountered below ground surface during drilling. However, groundwater levels can fluctuate over time. Excavations should be sloped and/or shored to protect worker safety and adjacent properties, per OSHA and local guidelines and the presence of existing utilities should be thoroughly and carefully checked prior to digging. Appendix C further discusses excavation recommendations in the following sections, which can be accessed by clicking hyperlinks: Earthwork, Underground Pipeline, Excavation De-Watering..

Foundations

- Based on the boring data, site soil will generally provide suitable bearing material for new buildings, even though it may consist of undocumented fill soil. Boring data indicated densely compacted material and the age of the fill pad is roughly 40 years or more. We anticipate that the new structures may be supported on spread foundations; however, structures to be constructed on 10 feet or more of newly placed engineered fill should be supported on structural slabs. Foundations can bear on newly placed fill that is 24 inches or more in thickness below the base of foundation. In cut areas, over-excavation is recommended to provide the fill base. Fill placement on slopes should follow the California Building Code guidelines for benching and keying as described in Section 5.2, and cut to grade areas should be carefully evaluated by proofrolling with repairs made as needed prior to construction of new structures.
- Section 5.2 of this report provides a table outlining the embedment depth, bearing capacity, settlement and other parameters for foundation design and construction.

On-Grade Construction Considerations

- We anticipate that retaining walls may be needed in support of new fill across the site. As such, work could be staged so as not to result in a temporary steep cut-back condition for wall installation. We assume that the backfill material to be used for the retaining wall on the site will consist of import soil. As we do not know the source of the soil, we have provided recommended soil parameters for the design of site retaining walls in Section 5.2. Import sources should be checked to verify that the meet the design parameters. The retaining wall should be water-proofed and contain a back-drainage system with weep-holes to reduce the impact of hydro-static pressure build up behind the wall. Site grades should be designed to limit water being directed toward or over the walls.
- The wall designer should check the wall for sliding, overturning, and internal stability. Once final grading plans are approved, Partner can perform global stability for the site walls sections that are over 6 feet in height, if any. In addition, any slopes that have final grades of steeper than 2:1 horizontal to vertical should be evaluated for slope stability. Additional borings may be needed to evaluate slopes and wall foundation bearing grades, and Partner should review the civil drawings when the wall locations are determined. Construction should proceed in general accordance with Appendix C, with specific attention to Laterally Loaded Structures.

- For native slopes on the site greater than 10% in grade, benching and keying of new fills will be needed to create a roughly horizontal surface for new fill compaction. Horizontal benches should be cut wide enough for compaction equipment to operate parallel to the slope. For new fill zones where more than 5 feet of fill will support the new building or parking areas, 98% compaction is required to reduce the potential of differential settlement. It is recommended, that the fill zone start 5 feet from the edge of building or pavement, and extend at a 1:1 slope to the base of fill. In order to achieve this level of compaction, careful attention to moisture conditioning, lift thickness, and compaction equipment selection will be needed.
- In new structural areas of the site, all remnants of previous construction, vegetation and/or deleterious materials should be completely removed to exposed clean subgrade soil. In new fill, structural, and pavement areas, cleaned subgrade should be proofrolled and evaluated by the engineer with a loaded water truck (4,000 gallon) or equivalent rubber-tired equipment. In locations where proofrolling is not feasible, probing, dynamic cone penetration testing or other methods may be employed. Soft or unstable areas should be repaired per the direction of the engineer. Once approved, the subgrade soil should be scarified to a depth of 12 inches, moisture conditioned, and compacted as engineered fill. Improvements in these areas should extend laterally beyond the new structure limits 2 feet or a distance equal to or greater than the layer thickness, whichever is greater. This zone should extend vertically from the bearing grade elevation to the base of the fill. The thicknesses of the layer, settlement estimates, and modulus values are provided on the design tables in the next section.
- Based on our borings, we anticipate that some over-excavation will result from proofrolling operations. In areas where deep instability is encountered, we recommend test pits be excavated and an engineer be called to perform an evaluation of the issue and to propose a resolution. Such resolutions may include but are not limited to: the use of geotextiles, chemical treatments (soil cement, hydrated lime, etc.) thickened slabs or pavements sections, lime-treated aggregate base, or others. Pavement sections provided in Section 5.2 are based on approved, compacted in-place soils being used in the subgrade. If subgrade conditions in the upper 3 feet of pavement areas vary or are improved, the pavement sections may be modified.
- Appendix C provides additional recommendations for foundations in the following sections: Cast-in-place Concrete, Foundations, Earthwork, Paving, Subgrade Preparation which can be accessed by clicking the hyperlinks.

Soil Reuse Considerations

- Based on our borings site soils will generally be generally re-usable as structural fill. Existing structural materials such as concrete, asphalt, crushed aggregate, or others could potentially be re-used as site fills if processed to meet fill requirements on the site. We recommend engineered fill for the site be moisture conditioned and compacted to 95% of the Proctor determined maximum dry density, in accordance with Appendix C of this report.
- Appendix C provides additional recommendations for foundations in the following sections: EARTHWORK, SUBGRADE PREPARATION which can be accessed by clicking the hyperlinks.

Geotechnical Concrete and Steel Construction Considerations

- Soil/rock may be corrosive to concrete. We recommend using corrosion resistant concrete (*e.g.* Type II/V Portland Cement, a fly ash mixture of 25 percent cement replacement, and a water/cement ratio of 0.45 or less) as directed by the producer, engineer or other qualified party based on their knowledge of the materials and site conditions. Concrete exposed to freezing weather should be air-entrained. Mix designs should be well-established and reviewed by the project engineers prior to placement, to verify the design is appropriate to meet the project needs and parameters provided in this report. Quality control testing should be performed to verify appropriate mixes are used and are properly handled and placed. Please refer to Appendix C, Cast In-Place Concrete for more details.
- Soil/rock may be corrosive to un-protected metallic elements such as pipes, poles, rebar, etc. We recommend the use of coatings and/or cathodic protection for metals in contact with the ground, as directed by the product manufacturer, engineer or other qualified party based on their knowledge of the materials to be used and site soil conditions.

Site Storm Water Considerations

- Surface drainage and landscaping design should be carefully planned to protect the new structures from erosion/undermining, and to maintain the site earthwork and structure subgrades in a relatively consistent moisture condition. Water should not flow towards or pond near to new structures, and high water-demand plants should not be planned near to structures. Appendix C provides additional recommendations for foundations in the following sections: SITE GRADING AND DRAINAGE, WATER PROOFING which can be accessed by clicking the hyperlinks.
- We recommend consulting with the landscape designer and civil engineer regarding management of site storm water and irrigation water, as changes in moisture content below the site after construction will lead to soil movement and potential distress to the building.

5.2 Geotechnical Parameters

Based on the findings of our field and laboratory testing, we recommend that design and construction proceed per industry accepted practices and procedures, as described in Appendix C, General Geotechnical Design and Construction Considerations (Considerations).

Prepared Subgrade Parameters – (hyperlink to Construction Considerations)

Prepared Subgrade Parameters				
Structure	**Design Values**	**Cover Depth**	**Bearing Surface** [a]	**Static Settlement** [d]
Slab on Grade	k=150 pci [b] q_{all} = 100 psf[c] μ = 0.45	NA	Proofrolled, Approved, Compacted In-place soil	1 inch
Spread Foundations++	q_{all} = 2.0 ksf[c] μ = 0.45	18 inches	Engineered fill extending to Approved, Compacted In-place soil (24 inches minimum)	1 inch

[a] Repairs in bearing *surface areas should be structural fill per the recommendation of the* <u>*Earthwork*</u> *section of Appendix C that is moisture conditioned to within 3 percent below to optimum moisture content and compacted to 95 percent or more of the soil maximum dry density per ASTM D1557. Expansive material should not be located within the upper* 3 feet of the soil subgrade.

[b] *Subgrade modulus value "k", assuming the grade slab is supported by aggregate layer roughly equal to slab thickness (minimum 4 inches), as required for capillary break*

[c] *Can be increased by 1/3 for temporary loading such as seismic and wind, allowable parameters, estimated FS of 2.5*

[d] Differential settlement is expected to be half to ¾ of total settlement

Paving Structural Sections – (hyperlink to Construction Considerations)

For heavy traffic areas, such as the gas station fueling areas and locations where tankers will access the tanks, we recommend concrete pavements be used. This would also apply to the drive through lanes associated with the car wash, dumpster areas, etc. Asphalt pavements can be used in the parking lot areas. We recommend a 3-inch minimum asphalt surface section for drive lanes and primary parking field locations to account for damage caused by engine drippings, heat, etc. Remote parking field sections can be reduced to the preference of the owner. We recommend the below pavement sections.

Pavement Sections		
Roadway Type	**Subgrade Preparation [a]**	**Pavement Section [b]**
Parking Area Light Duty (drives)	Proofrolled/Compacted Subgrade	3 in asphalt / 6 in aggregate base
Loading Areas	Proofrolled/Compacted Subgrade	4 in asphalt / 6 in aggregate base
Gas Station Parking Area (Light)	Proofrolled/Compacted Subgrade	6 in concrete / 4 in aggregate base
Heavy Duty Concrete (loading)	Proofrolled/Compacted Subgrade	8 in concrete / 4 in aggregate base

[a] *Repairs in proofrolled areas should be structural fill per the recommendation of the* <u>*APPCEarthwork*</u> *(hyperlink to Construction Considerations) that is moisture conditioned to within 3 percent above to optimum moisture content and compacted to 95 percent or more of the soil maximum dry density per ASTM D1557.*

[b] *1 inch of pavement may be reduced if 6-in of* <u>*lime or cement-treated*</u> *soil is used with a 500 psi 28-day compressive strength. Soils with Plasticity Index of 10 or more are generally candidates for lime treatment, other soils are candidates for cement treatment, if any.*

Laterally Loaded Structures Parameters– (hyperlink to Construction Considerations)

Lateral Earth Pressures [b*]				
Soil Type	**Coefficient of Friction (μ)**	**Static Fluid Pressure (pcf)**	**Active Fluid Pressure (pcf)**	**Passive Fluid Pressure (pcf)**
In-place Sandy Soil (Foundation Level	0.45	55	35	400
Import Sandy Soil, PI<15	0.35	55	35	300

[a] *Assumed GW table below level of new construction. For underground structures where water is only on one side, the hydrostatic pressure of 62.4 psf should be added*

[b] *These loads should be modified by surcharge loads as shown in the below equations*

**Values provided in this table are UNFACTORED. The wall designer should select appropriate safety factors for their design*

Traffic Surcharge Loading Equation

Table 1*

Equivalent Height of Soil for Vehicular Loading on Retaining Wall and Shoring Parallel to Traffic

Excavation/Wall Height (ft)	Distance from the edge of excavation (ft)	
	0.0 ft	1.0 ft or further
5.0	5.0	2.0
10.0	3.5	2.0
≥20.0	2.0	2.0

* From Table 3.11.6.4-2 of the AASHTO document referenced above.

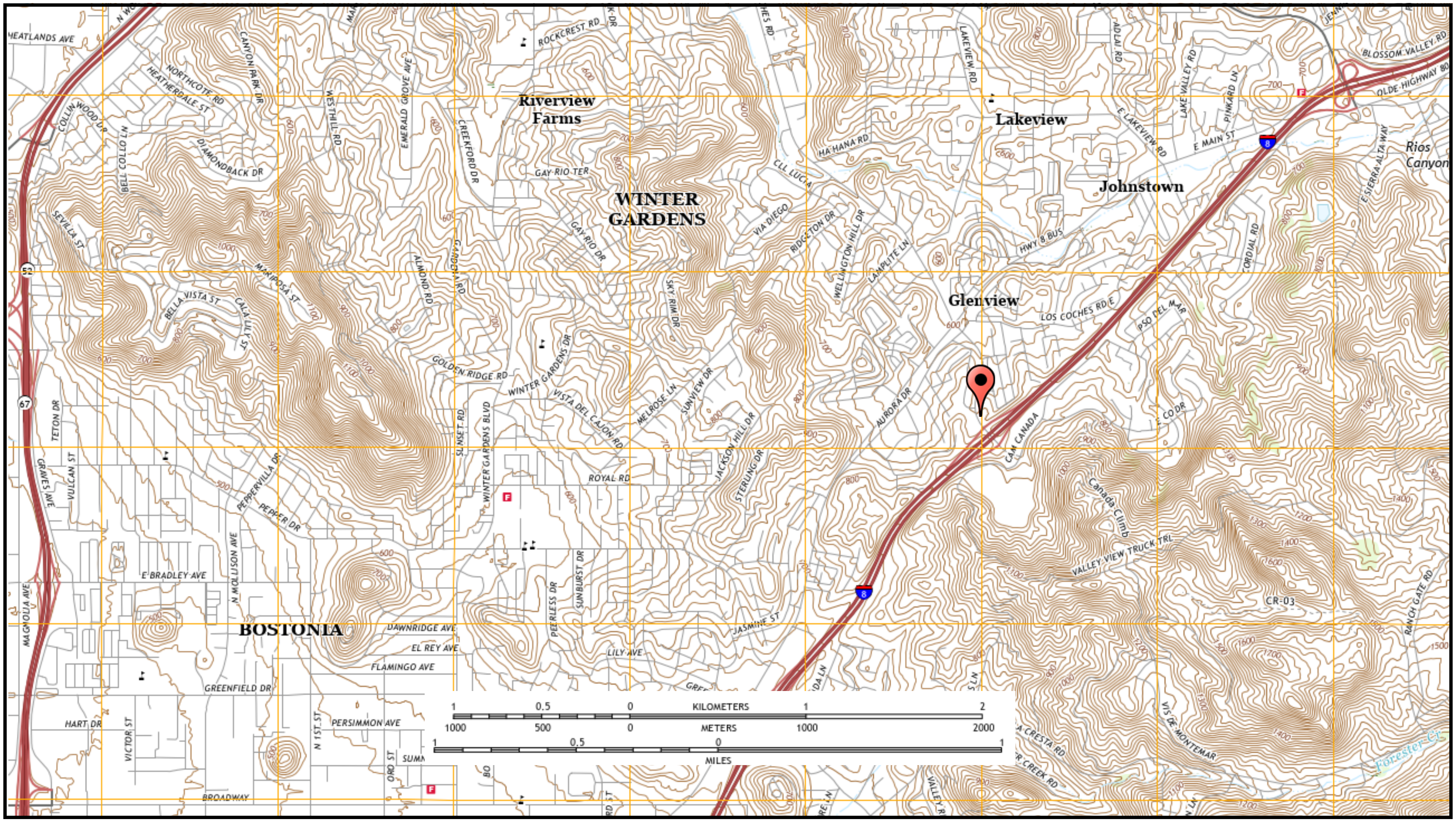
$$q = k \times \gamma_s \times H_{eq}$$

Where:
- q = lateral surcharge pressure (psf) in rectangular distribution
- k = active or at-rest earth pressure coefficient from Soils Report
- γ_s = total unit weight of soil (pcf)
- H_{eq} = equivalent height of soil from "Table 1" above

FIGURES

- Site Location Map
- Site Exploration Map
- Geologic Map

PARTNER



Source: USGS Topographic 7.5 El Cajon Quadrangle Map 2018.

N

Key:

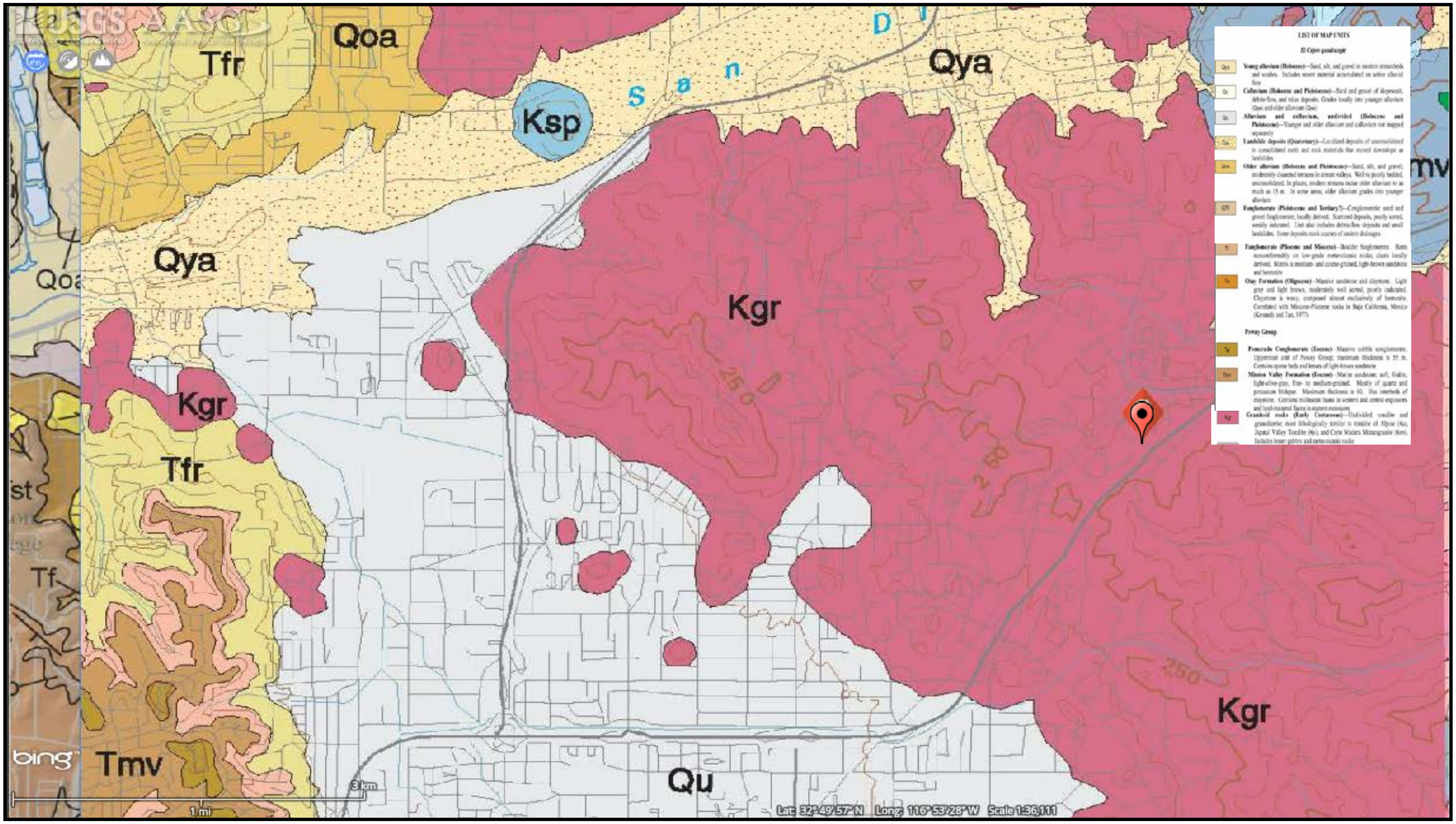
Approximate Site Location

Source: Google Earth, 2018, Gas Station and Car Wash Development Boring Map, 2019

Key:

Approximate Boring Location

Approximate Percolation Test Location



Source: Geologic Map of the El Cajon 30' x 60' quadrangle, Southern California - 2004, Todd, V.R., Alvarez, R.M., and Techni Graphic Systems, Inc, 1: 100,000

N

Key:

Approximate Site Location

APPENDIX A

Boring Logs

PARTNER

BORING LOG KEY - EXPLANATION OF TERMS

SURFACE COVER: General discription with thickness to the inch, ex. Topsoil, Concrete, Asphalt, etc,

FILL: General description with thickness to the 0.5 feet. Ex. Roots, Debris, Processed Materials (Pea Gravel, etc.)

NATIVE GEOLOGIC MATERIAL: Deposit type, 1.Color, 2.moisture, 3.density, 4.SOIL TYPE, other notes - Thickness to 0.5 feet

1. Color - Generalized

Light Brown (usually indicates dry soil, rock, caliche)
Brown (usually indicates moist soil)
Dark Brown (moist to wet soil, organics, clays)
Reddish (or other bright colors) Brown (moist, indicates some soil development/or residual soil)
Greyish Brown (Marine, sub groundwater - not the same as light brown above)
Mottled (brown and gray, indicates groundwater fluctuations)

2. Moisture

dry - only use for wind-blown silts in the desert
damp - soil with little moisture content
moist - near optimum, has some cohesion and stickyness
wet - beyond the plastic limit for clayey soils, and feels wet to the touch for non clays
saturated - Soil below the groundwater table, sampler is wet on outside

3. Density (based on blow counts or hand evaluation)

SPT	Ring	Granular	Cohesive		
0-5	0-7	very loose	very soft	Unsuitable	Thumb penetrates through
5-10	7-14	loose	soft	<1,500psf	Thumb penetrates part way
10-20	14-28	medium dense	firm	<3,000psf	Thumb dents only
20-75	28-100	dense	stiff	>3,000psf	Thumbnail dents
75+	100+	very dense	hard	Hard Dig	Thumbnail does not dent

4. Classification

Determine percent Gravel (bigger than 3/8")
Determine percent fines (silt and clay feel soft, with no grit)
Determine percent sand (between silt and clay, feels gritty)
Determine if clayey (make soil moist, if it easily roll into a snake it is clayey)

Sands and gravels (more gravel starts with G, more sand starts with S)

GP	SP	Mostly sand and gravel, with less than 5 % fines	sandy GRAVEL	SAND
GP-GM	SP-SM	Mostly sand and gravel 7-12% fines, non-clayey	sandy GRAVEL with silt	SAND with Silt
GP-GC	SP-SC	Mostly sand and gravel 7-12% fines, clayey	sandy GRAVEL with clay	SAND with clay
GC	SC	Mostly sand and gravel >12% fines clayey	clayey GRAVEL	clayey SAND
GM	SM	Mostly sand and gravel >12% fines non-clayey	silty GRAVEL	silty SAND

Cohesive Soil (generaly forms long chunks (more than 2 inches) in sampler

ML	Soft, non clayey	SILT with sand
MH	Very rare, holds a lot of water, and is pliable with very low strength	high plasticity SILT
CL	If sandy can be hard when dry, will be stiff/plastic when wet	CLAY with sand/silt
CH	Hard and resiliant when dry, very strong/sticky when wet (may have sand in it)	FAT CLAY

H = Liquid limit over 50%, L - LL under 50%
C = Clay
M = Silt

Samplers

S = Standard split spoon (SPT)
R = Modified ring
Bulk = Excavation spoils
ST = Shelby tube
C = Rock core

Boring Number:	B1	Boring Log Page 1 of 1	
Location:	Center of proposed canopy	Date Started:	9/9/2019
Site Address:	8445 Los Coches Road El Cajon, California 92021	Date Completed:	9/9/2019
		Depth to Groundwater:	N/A
Project Number:	19-226305.4	Field Technician:	Y. Kawashima
Drill Rig Type:	CME 75	**Partner Engineering and Science**	
Sampling Equipment:	SPT and Rings	**11839 Sorrento Valley Road, Suite 906**	
Borehole Diameter:	8"	**San Diego, CA 92121**	

Depth	Sample	N-Value	USCS	Description
0				**SURFACE COVER**: Asphalt (6")
1				
2	R	85 / 10"	SM	**FILL**: Brown, damp, very dense, silty SAND
3				
4				
5	S	19	SM	**NATIVE**: Brown, damp, medium dense, silty SAND
6				
7	S	28		Dense
8				
9				
10	S	27		
11				
12				
13				
14				
15	S	20		
16				
17				
18				
19	S	32		Grey
20				Boring terminated at 20'
21				Backfilled with drill cuttings upon completion, patched with asphalt
22				Groundwater not encountered
23				
24				
25				
26				
27				
28				
29				

Boring Number:	B2	Boring Log Page 1 of 1	
Location:	Center of Proposed USTs	Date Started:	9/9/2019
Site Address:	8445 Los Coches Road	Date Completed:	9/9/2019
	El Cajon, California 92021	Depth to Groundwater:	N/A
Project Number:	19-226305.4	Field Technician:	Y. Kawashima
Drill Rig Type:	CME 75	**Partner Engineering and Science**	
Sampling Equipment:	SPT and Rings	**11839 Sorrento Valley Road, Suite 906**	
Borehole Diameter:	8"	**San Diego, CA 92121**	

Depth	Sample	N-Value	USCS	Description
0				**SURFACE COVER**: None/ shrubs
1				
2	S	25	SM	**NATIVE:** Brown, damp, dense, silty SAND with gravel (Moisture Content: 4.9%, Fines:
3				16%, LL: 28)
4				
5	R	27		(Dry density: 124.7 pcf, Moisture Content: 6.2%)
6				
7	S	33		
8				
9				
10	S	18		Medium dense, with some clay
11				
12				
13				
14				
15	S	24	SC	Brown, damp, dense, clayey SAND
16				
17				
18				
19	S	24	SM	Brown, damp, dense, silty SAND with gravel
20				Boring terminated at 20'
21				Backfilled with drill cuttings upon completion
22				Groundwater not encountered
23				
24				
25				
26				
27				
28				
29				

Boring Number:	B3	Boring Log Page 1 of 1	
Location:	NE corner of Proposed Restaurant in NW corner	Date Started:	9/9/2019
Site Address:	8445 Los Coches Road	Date Completed:	9/9/2019
	El Cajon, California 92021	Depth to Groundwater:	N/A
Project Number:	19-226305.4	Field Technician:	Y. Kawashima
Drill Rig Type:	CME 75	**Partner Engineering and Science**	
Sampling Equipment:	SPT and Rings	**11839 Sorrento Valley Road, Suite 906**	
Borehole Diameter:	8"	**San Diego, CA 92121**	

Depth	Sample	N-Value	USCS	Description
0				**SURFACE COVER**: None/shrubs
1				
2	S	29	SM	**NATIVE:** Brown, damp, dense, silty SAND with some gravel
3				
4				
5	R	38		(Dry density: 122.0 pcf, Moisture Content: 6.1%)
6				
7	S	36		
8				
9				
10	S	40		
11				
12				
13				
14				
15	S	28		Brown to dark gray, silty SAND with silt pockets
16				Boring terminated at 16.5'
17				Backfilled with drill cuttings upon completion
18				Groundwater not encountered
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				

Boring Number:	B4	Boring Log Page 1 of 1	
Location:	SW corner of Proposed Restuarnt along W boundary	Date Started:	9/9/2019
Site Address:	8445 Los Coches Road El Cajon, California 92021	Date Completed:	9/9/2019
		Depth to Groundwater:	N/A
Project Number:	19-226305.4	Field Technician:	Y. Kawashima
Drill Rig Type:	CME 75	**Partner Engineering and Science**	
Sampling Equipment:	SPT and Rings	**11839 Sorrento Valley Road, Suite 906**	
Borehole Diameter:	8"	**San Diego, CA 92121**	

Depth	Sample	N-Value	USCS	Description
0				**SURFACE COVER**: None
1				
2	R	62	SM	**NATIVE:** Brown, damp, dense, silty SAND with gravel
3				
4				
5	S	28		
6				
7	S	25		
8				
9				
10	S	25		
11				
12				
13				
14				
15	S	23		With little clay
16				Boring terminated at 16.5'
17				Backfilled with drill cuttings upon completion
18				Groundwater not encountered
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				

Boring Number:	B5	Boring Log Page 1 of 1	
Location:	SW corner of Proposed Retail	Date Started:	9/9/2019
Site Address:	8445 Los Coches Road	Date Completed:	9/9/2019
	El Cajon, California 92021	Depth to Groundwater:	N/A
Project Number:	19-226305.4	Field Technician:	Y. Kawashima
Drill Rig Type:	CME 75	**Partner Engineering and Science**	
Sampling Equipment:	SPT and Rings	**11839 Sorrento Valley Road, Suite 906**	
Borehole Diameter:	8"	**San Diego, CA 92121**	

Depth	Sample	N-Value	USCS	Description
0				**SURFACE COVER**: Aspahlt (6") / Base (6")
1				
2	S	21	SM	**FILL:** Brown, damp, dense, silty SAND (Moisture Content: 6.2%)
3				
4				
5	R	31	SM	**NATIVE:** Brown, damp, dense, silty SAND
6				
7	S	22		
8				
9				
10	S	21		
11				
12				
13				
14				
15	S	21		
16				Boring terminated at 16.5'
17				Backfilled with drill cuttings upon completion,patched with asphalt
18				Groundwater not encountered
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				

Boring Number:	B6	Boring Log Page 1 of 1	
Location:	SW corner of Proposed Oil building	Date Started:	9/9/2019
Site Address:	8445 Los Coches Road	Date Completed:	9/9/2019
	El Cajon, California 92021	Depth to Groundwater:	N/A
Project Number:	19-226305.4	Field Technician:	Y. Kawashima
Drill Rig Type:	CME 75	**Partner Engineering and Science**	
Sampling Equipment:	SPT and Rings	**11839 Sorrento Valley Road, Suite 906**	
Borehole Diameter:	8"	**San Diego, CA 92121**	

Depth	Sample	N-Value	USCS	Description
0				**SURFACE COVER**: None/ shrubs
1				
2	R	45	SM	**NATIVE:** Brown, damp, dense, silty SAND with gravel
3				
4				
5	S	26		
6				
7	S	27		Brown with some orange oxidation
8				
9				
10	S	34		
11				
12				
13				
14				
15	S	23		
16				Boring terminated at 16.5'
17				Backfilled with drill cuttings upon completion
18				Groundwater not encountered
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				

Boring Number:	B7	Boring Log Page 1 of 1	
Location:	NE corner of Proposed Retail	Date Started:	9/9/2019
Site Address:	8445 Los Coches Road	Date Completed:	9/9/2019
	El Cajon, California 92021	Depth to Groundwater:	N/A
Project Number:	19-226305.4	Field Technician:	Y. Kawashima
Drill Rig Type:	CME 75	**Partner Engineering and Science**	
Sampling Equipment:	SPT and Rings	**11839 Sorrento Valley Road, Suite 906**	
Borehole Diameter:	8"	**San Diego, CA 92121**	

Depth	Sample	N-Value	USCS	Description
0				**SURFACE COVER**: asphalt (6")/base (6")
1				
2	R	34	SM	**FILL:** Brown, damp, dense, silty SAND with gravel (Dry density: 122.6 pcf, Moisture
3				Content: 6.1%)
4				
5	S	22		with small plastic pieces
6				
7	S	22	SM	**NATIVE:** Brown, damp, dense, silty SAND
8				
9				
10	S	20		Brown to dark grey, damp, very dense, silty SAND with gravel
11				
12				
13				
14				
15	S	24		
16				Boring terminated at 16.5'
17				Backfilled with drill cuttings upon completion
18				Groundwater not encountered
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				

APPENDIX B

Lab and Infiltration Data

LABORATORY TEST DATA

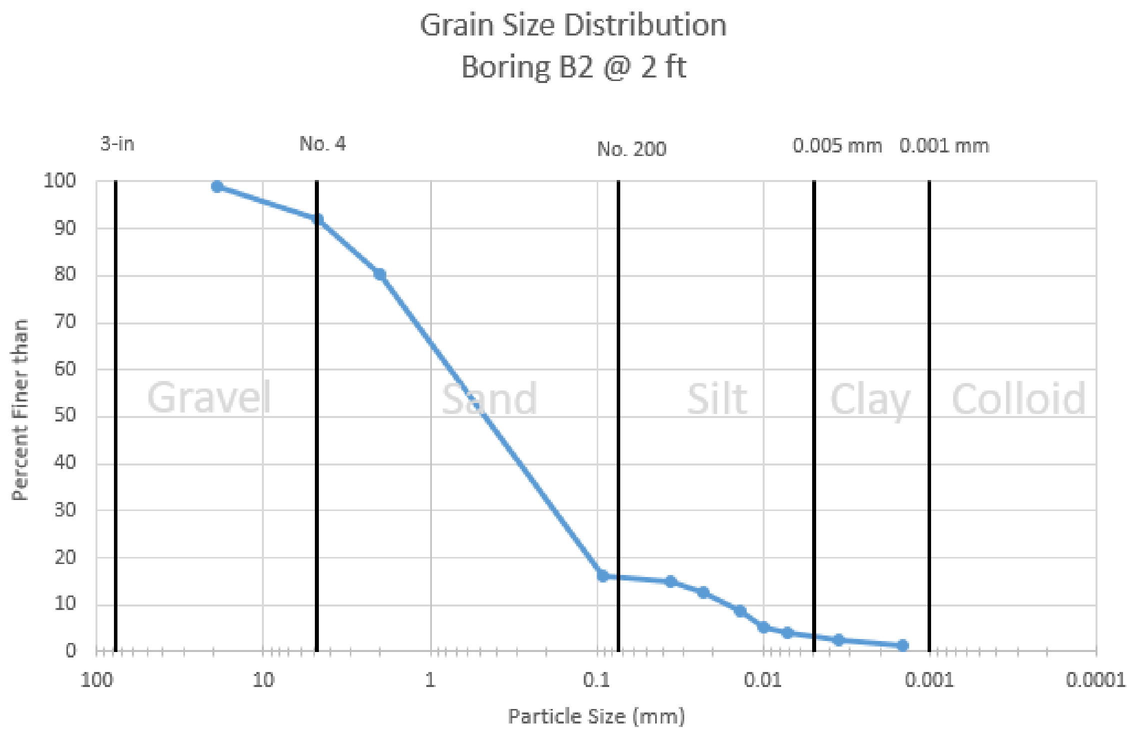
Index Test Results

Soil Sample	Plasticity Index	Liquid Limit	Fines Content (%)	Minus No. 10 Sieve Content (%)
B2 @ 2 feet	NP	28	16	80.2

In-Place Moisture and Density

Soil Sample	Dry Density (pcf)	Wet Density (pcf)	Moisture Content (%)
B2 @ 2 feet	-	-	4.9
B2 @ 5 feet	124.7	132.3	6.2
B3 @ 5 feet	122.0	129.5	6.1
B5 @ 2 feet	-	-	9.6
B7 @ 2 feet	122.6	130.0	6.1

HYDROMETER TEST DATA



Pecolation Test Data Sheet	
Project:	El Cajon Gas Station
Project No.:	19-226305.4
Date:	9/9/2019
Test Hole:	P1
Tested by:	Y. Kawashima
Depth of Hole, ft, D:	18.5
Boring Radius, in:	8
UCSD:	SM

$$I_t = \frac{\Delta H(60r)}{\Delta t(r + 2H_{avg})}$$

Pre-Soak Procedure (See notes)						Calculations	
Reading #	Start Time	Stop Time	Δ t Time Interval	Do Initial Depth to Water Level	Df Final Depth to Water Level	Δ D Change in Water Level	Greater than 6"
	hr:mm	hr:mm	min	in	in	in	(y/n)
1	8:45	9:15	30	24	30	6.0	Y
2	9:15	9:45	30	30	53	23.0	Y

IN RIVERSIDE, 2Y=SAND: 10 min intervals for 1 hour. **IF NOT SAND:** 12 intervals at 30 min each, refilling each time

IN SAN DIEGO, Presoak for at least 2 hours if sandy soils. Rates of fall are measured for six hours, refilling each half hour (or 10 minutes for sand). Tests are generally repeated until consistent results are obtained.

Raw Data						Calculations		
Reading #	Start Time	Stop Time	Δ t Time Interval (10 or 30)	Do Initial Depth to Water Level	Df Final Depth to Water Level	Δ D Change in Water Level	Percolation Rate	Corrected Infiltration Rate
	hr:mm	hr:mm	min	inches (0.25" precision)			min/ in	in/hr
1	9:45	10:15	30	53.0	72.0	19.0	1.6	0.93
2	10:30	10:40	10	72.0	80.0	8.0	1.3	1.28
3	10:40	10:50	10	80.0	85.0	5.0	2.0	0.84
4	10:50	11:00	10	85.0	88.0	3.0	3.3	0.52
5	11:03	11:13	10	88.0	91.0	3.0	3.3	0.53
6	11:13	11:23	10	91.0	96.0	5.0	2.0	0.91
7	11:27	11:37	10	96.0	101.0	5.0	2.0	0.94
8	11:37	11:47	10	101	106	5.0	2.0	0.98
9								
10								
11								
12								

Sources:

Appendix D, Approved Infiltration Rate Assessment Methods for Selection of Storm Water BMPs (San Diego)

Appendix A, Infiltration Testing (Riverside County)

Appendix D, Infiltration Rate Protocol, 2011 (Orange County)

APPENDIX C

General Geotechnical Design and Construction Considerations

PARTNER

SUBGRADE PREPARATION

1. In general, construction should proceed per the project specifications and contract documents, as well as governing jurisdictional guidelines for the project site, including but not limited to the applicable State Department of Transportation, City and/or County, Army Corps of Engineers, Federal Aviation, Occupational Safety and Health Administration (OSHA), and any other governing standard details and specifications. In areas where multiple standards are applicable the more stringent should be considered. Work should be performed by qualified, licensed contractors with experience in the specific type of work in the area of the site.
2. Subgrade preparation in this section is considered to apply to the initial modifications to existing site conditions to prepare for new planned construction.
3. Prior to the start of subgrade preparation, a detailed conflict study including as-builts, utility locating, and potholing should be conducted. Existing features that are to be demolished should also be identified and the geotechnical study should be referenced to determine the need for subgrade preparation, such as over-excavation, scarification and compaction, moisture conditioning, and/or other activities below planned new structural fills, slabs on grade, pavements, foundations, and other structures.
4. The site conflicts, planned demolitions, and subgrade preparation requirements should be discussed in a pre-construction meeting with the pertinent parties, including the geotechnical engineer, inspector, contractors, testing laboratory, surveyor, and others.
5. In the event of preparations that will require work near to existing structures to remain in-place, protection of the existing structures should be considered. This also includes a geotechnical review of excavations near to existing structures and utilities and other concerns discussed in General Geotechnical Design and Construction Considerations, EARTHWORK and UNDERGROUND PIPELINE INSTALLATION.
6. Features to be demolished should be completely removed and disposed of per jurisdictional requirements and/or other conditions set forth as a part of the project. Resulting excavations or voids should be backfilled per the recommendations in the General Geotechnical Design and Construction Considerations, EARTHWORK section.
7. Vegetation, roots, soils containing organic materials, debris and/or other deleterious materials on the site should be removed from structural areas and should be disposed of as above. Replacement of such materials should be in accordance with the recommendations in the General Geotechnical Design and Construction Considerations, EARTHWORK section
8. Subgrade preparation required by the geotechnical report may also call for as over-excavation, scarification and compaction, moisture conditioning, and/or other activities below planned structural fills, slabs on grade, pavements, foundations, and other structures. These requirements should be provided within the geotechnical report. The execution of this work should be observed by the geotechnical engineering representative or inspector for the site. Testing of the subgrade preparation should be performed per the recommendations in the General Geotechnical Design and Construction Considerations, EARTHWORK section.

9. Subgrade Preparation cannot be completed on frozen ground or on ground that is not at a proper moisture condition. Wet subgrades may be dried under favorable weather if they are disked and/or actively worked during hot, dry, weather, when exposed to wind and sunlight. Frozen ground or wet material can be removed and replaced with suitable material. Dry material can be pre-soaked, or can have water added and worked in with appropriate equipment. The soil conditions should be monitored by the geotechnical engineer prior to compaction. Following this type of work, approved subgrades should be protected by direction of surface water, covering, or other methods, otherwise, re-work may be needed.

EARTHWORK – STRUCTURAL FILL

1. In general, construction should proceed per the governing jurisdictional guidelines for the project site, including but not limited to the applicable State Department of Transportation, City and/or County, Army Corps of Engineers, Federal Aviation, Occupational Safety and Health Administration (OSHA), and any other governing standard details and specifications. In areas where multiple standards are applicable the more stringent should be considered. Work should be performed by qualified, licensed contractors with experience in the specific type of work in the area of the site.
2. Earthwork in this section is considered to apply to the re-shaping and grading of soil, rock, and aggregate materials for the purpose of supporting man-made structures. Where earthwork is needed to raise the elevation of the site for the purpose of supporting structures or forming slopes, this is referred to as the placement of structural fill. Where lowering of site elevations is needed prior to the installation of new structures, this is referred to as earthwork excavations.
3. Prior to the start of earthwork operations, the geotechnical study should be referenced to determine the need for subgrade preparation, such as over-excavation or scarification and compaction of unsuitable soils below planned structural fills, slabs on grade, pavements, foundations, and other structures. These required preparations should be discussed in a pre-construction meeting with the pertinent parties, including the geotechnical engineer, inspector, contractors, testing laboratory, surveyor, and others. The preparations should be observed by the inspector or geotechnical engineer representative, and following such subgrade preparation, the geotechnical engineer should observe the prepared subgrade to approve it for the placement of earthwork fills or new structures.
4. Structural fill materials should be relatively free of organic materials, man-made debris, environmentally hazardous materials, and brittle, non-durable aggregate, frozen soil, soil clods or rocks and/or any other materials that can break down and degrade over time.
5. In deeper structural fill zones, expansive soils (greater than 1.5 percent swell at 100 pounds per square foot surcharge) and rock fills (fills containing particles larger than 4 inches and/or containing more than 35 percent gravel larger than ¾-inch diameter or more than 50 percent gravel) may be used with the approval and guidance of the geotechnical report or geotechnical engineer. This may require the placement of geotextiles or other added costs and/or conditions. These conditions may also apply to corrosive soils (less than 2,000 ohm-cm resistivity, more than 50 ppm chloride content, more than 0.1 percent sulfates)
6. For structural fill zones that are closer in depth below planed structures, low expansive materials, and materials with smaller particle size are generally recommended, as directed by the geotechnical report (see criteria above in 5). This may also apply to corrosive soils.
7. For structural fill materials, in general the compaction equipment should be appropriate for the thickness of the loose lift being placed, and the thickness of the loose lift being placed should be at least two times the maximum particle size incorporated in the fill.
8. Fill lift thickness (including bedding) should generally be proportioned to achieve 95 percent or more of a standard proctor (ASTM D689) maximum dry density (MDD) or 90 percent or more of a modified proctor (ASTM D1557) MDD, depending on the state practices. For subgrades below

roadways, the general requirement for soil compaction is usually increased to 100 percent or more of the standard proctor MDD and 95 percent or more of the modified proctor MDD.

9. Soil compaction should be performed at a moisture content generally near optimum moisture content determined by either standard or modified proctor, and ideally within 3 percent below to 1 percent over the optimum for a standard proctor, and from 2 percent below to 2 percent above optimum for a modified proctor.
10. In some instances fill areas are difficult to access. In such cases a low-strength soil-cement slurry can be used in the place of compacted fill soil. In general such fills should be rated to have a 28-day strength of 75 to 125 psi, which in some areas is referred to as a "1-sack" slurry. It should be noted that these materials are wet during placement, and require a period of 2 days (24 hours) to cure before additional fill can be placed above them. Testing of this material can be done using concrete cylinder compression strength testing equipment, but care is needed in removing the test specimens from the molds. Field testing using the ball method, and spread or flow testing is also acceptable.
11. For fills to be placed on slopes, benching of fill lifts is recommended, which may require cutting into existing slopes to create a bench perpendicular to the slope where soil can be placed in a relatively horizontal orientation. For the construction of slopes, the slopes should be over-built and cut back to grade, as the material in the outer portion of the slope may not be well compacted.
12. For subgrade below roadways, runways, railways or other areas to receive dynamic loading, a proofroll of the finished, compacted subgrade should be performed by the geotechnical engineer or inspector prior to the placement of structural aggregate, asphalt or concrete. Proofrolling consists of observing the performance of the subgrade under heavy-loaded equipment, such as full, 4,000 Gallon water truck, loaded tandem-axel dump truck or similar. Areas that exhibit instability during proofroll should be marked for additional work prior to approval of the subgrade for the next stage of construction.
13. Quality control testing should be provided on earthwork. Proctor testing should be performed on each soil type, and one-point field proctors should be used to verify the soil types during compaction testing. If compaction testing is performed with a nuclear density gauge, it should be periodically correlated with a sand cone test for each soil type. Density testing should be performed per project specifications and or jurisdictional requirements, but not less than once per 12 inches elevation of any fill area, with additional tests per 12-inch fill area for each additional 7,500 square-foot section or portion thereof.
14. For earthwork excavations, OSHA guidelines should be referenced for sloping and shoring. Excavations over a depth of 20 feet require a shoring design. In the event excavations are planned near to existing structures, the geotechnical engineer should be consulted to evaluate whether such excavation will call for shoring or underpinning the adjacent structure. Pre-construction and post-construction condition surveys and vibration monitoring might also be helpful to evaluate any potential damage to surrounding structures.
15. Excavations into rock, partially weathered rock, cemented soils, boulders and cobbles, and other hard soil or "hard-pan" materials, may result in slower excavation rates, larger equipment with

specialized digging tools, and even blasting. It is also not unusual in these situations for screening and or crushing of rock to be called for. Blasting, hard excavating, and material processing equipment have special safety concerns and are more costly than the use of soil excavation equipment. Additionally, this type of excavation, especially blasting, is known to cause vibrations that should be monitored at nearby structures. As above, a pre-blast and post-blast conditions assessment might also be warranted.

UNDERGROUND PIPELINE – STRUCTURAL BACKFILL

1. In general, construction should proceed per the governing jurisdictional guidelines for the project site, including but not limited to the applicable State Department of Transportation, the State Department of Environmental Quality, the US Environmental Protection Agency, City and/or County Public Works, Occupational Safety and Health Administration (OSHA), Private Utility Companies, and any other governing standard details and specifications. In areas where multiple standards are applicable the more stringent should be considered, and in some cases work may take place to multiple different standards. Work should be performed by qualified, licensed contractors with experience in the specific type of work in the area of the site.
2. Underground pipeline in this section is considered to apply to the installation of underground conduits for water, storm water, irrigation water, sewage, electricity, telecommunications, gas, etc. Structural backfill refers to the activity of restoring the grade or establishing a new grade in the area where excavations were needed for the underground pipeline installation.
3. Prior to the start of underground pipeline installation, a detailed conflict study including as-builts, utility locating, and potholing should be conducted. The geotechnical study should be referenced to determine subsurface conditions such as caving soils, unsuitable soils, shallow groundwater, shallow rock and others. In addition, the utility company responsible for the line also will have requirements for pipe bedding and support as well as other special requirements. Also, if the underground pipeline traverses other properties, rights-of-way, and/or easements etc. (for roads, waterways, dams, railways, other utility corridors, etc.) those owners may have additional requirements for construction.
4. The required preparations above should be discussed in a pre-construction meeting with the pertinent parties, including the geotechnical engineer, inspector, contractors, testing laboratory, surveyor, and other stake holders.
5. For pipeline excavations, OSHA guidelines should be referenced for sloping and shoring. Excavations over a depth of 20 feet require a shoring design. In the event excavations are planned near to existing structures or pipelines, the geotechnical engineer should be consulted to evaluate whether such excavation will call for shoring or supporting the adjacent structure or pipeline. A pre-construction and post-construction condition survey and vibration monitoring might also be helpful to evaluate any potential damage to surrounding structures.
6. Excavations into rock, partially weathered rock, cemented soils, boulders and cobbles, and other hard soil or "hard-pan" materials, may result in slower excavation rates, larger equipment with specialized digging tools, and even blasting. It is also not unusual in these situations for screening and or crushing of rock to be called for. Blasting, hard excavating and material processing equipment have special safety concerns and are more costly than the use soil excavation equipment. Additionally, this type of excavation, especially blasting, is known to cause vibrations that should be monitored at nearby structures. As above, a pre-blast and post-blast conditions assessment might also be warranted.
7. Bedding material requirements vary between utility companies and might depend of the type of pipe material and availability of different types of aggregates in different locations. In general,

bedding refers to the material that supports the bottom of the pipe, and extends to 1 foot above the top of the pipe. In general the use of aggregate base for larger diameter pipes (6-inch diameter or more) is recommended lacking a jurisdictionally specified bedding material. Gas lines and smaller diameter lines are often backfilled with fine aggregate meeting the ASTM requirements for concrete sand. In all cases bedding with less than 2,000 ohm-cm resistivity, more than 50 ppm chloride content or more than 0.1 percent sulfates should not be used.

8. Structural backfill materials above the bedding should be relatively free of organic materials, man-made debris, environmentally hazardous materials, frozen material, and brittle, non-durable aggregate, soil clods or rocks and/or any other materials that can break down and degrade over time.
9. In general the backfill soil requirements will depend on the future use of the land above the buried line, but in most cases, excessive settlement of the pipe trench is not considered advisable or acceptable. As such, the structural backfill compaction equipment should be appropriate for the thickness of the loose lift being placed. The thickness of the loose lift being placed should be at least two times the maximum particle size incorporated in the fill. Care should be taken not to damage the pipe during compaction or compaction testing.
10. Fill lift thickness (including bedding) should generally be proportioned to achieve 95 percent or more of a standard proctor (ASTM D689) maximum dry density (MDD) or 90 percent or more of a modified proctor (ASTM D1557) MDD, depending on the state practices (in general the modified proctor is required in California and for projects in the jurisdiction of the Army Corps of Engineers). For backfills within the upper poritons of roadway subgrades, the general requirement for soil compaction is usually increased to 100 percent or more of the standard proctor MDD and 95 percent or more of the modified proctor MDD.
11. Soil compaction should be performed at a moisture content generally near optimum moisture content determined by either standard or modified proctor, and ideally within 3 percent below to 1 percent over the optimum for a standard proctor, and from 2 percent below to 2 percent above optimum for a modified proctor.
12. In some instances fill areas are difficult to access. In such cases a low-strength soil-cement slurry can be used in the place of compacted fill soil. In general such fills should be rated to have a 28-day strength of 75 to 125 psi, which in some areas is referred to as a "1-sack" slurry. It should be noted that these materials are wet, and require a period of 2 days (24 hours) to cure before additional fill can be placed above it. Testing of this material can be done using concrete cylinder compression strength testing equipment, but care is needed in removing the test specimens from the molds. Field testing using the ball method, and spread or flow testing is also acceptable.
13. Quality control testing should be provided on structural backfill to assist the contractor in meeting project specifications. Proctor testing should be performed on each soil type, and one-point field proctors should be used to verify the soil types during compaction testing. If compaction testing is performed with a nuclear density gauge, it should be periodically correlated with a sand cone test for each soil type.

14. Density testing should be performed on structural backfill per project specifications and or jurisdictional requirements, but not less than once per 12 inches elevation in each area, and additional tests for each additional 500 linear-foot section or portion thereof.

CAST-IN-PLACE CONCRETE

SLABS-ON-GRADE/STRUCTURES/PAVEMENTS

1. In general, construction should proceed per the governing jurisdictional guidelines for the project site, including but not limited to the applicable American Concrete Institute (ACI), International Code Council (ICC), State Department of Transportation, City and/or County, Army Corps of Engineers, Federal Aviation, Occupational Safety and Health Administration (OSHA), and any other governing standard details and specifications. In areas where multiple standards are applicable the more stringent should be considered. Work should be performed by qualified, licensed contractors with experience in the specific type of work in the area of the site.
2. Cast-in-place concrete (concrete) in this section is considered to apply to the installation of cast-in-place concrete slabs on grade, including reinforced and non-reinforced slabs, structures, and pavements.
3. In areas where concrete is bearing on prepared subgrade or structural fill soils, testing and approval of this work should be completed prior to the beginning of concrete construction.
4. In locations where a concrete is approved to bear on in-place (native) soil or in locations where approved documented fills have been exposed to weather conditions after approval, a concrete subgrade evaluation should be performed prior to the placement of reinforcing steel and or concrete. This can consist of probing with a "t"-handled rod, borings, penetrometer testing, dynamic cone penetration testing and/or other methods requested by the geotechnical engineer and/or inspector. Where unsuitable, wet, or frozen bearing material is encountered, the geotechnical engineer should be consulted for additional recommendations.
5. Slabs on grade should be placed on a 4-inch thick or more capillary barrier consisting of non-corrosive (more than 2,000 ohm-cm resistivity, less than 50 ppm chloride content and less than 0.1 percent sulfates) aggregate base or open-graded aggregate material. This material should be compacted or consolidated per the recommendations of the structural engineer or otherwise would be covered by the General Considerations for EARTHWORK.
6. Depending on the site conditions and climate, vapor barriers may be required below in-door grade-slabs to receive flooring. This reduces the opportunity for moisture vapor to accumulate in the slab, which could degrade flooring adhesive and result in mold or other problems. Vapor barriers should be specified by the structural engineer and/or architect. The installation of the barrier should be inspected to evaluate the correct product and thickness is used, and that it has not been damaged or degraded.
7. At times when rainfall is predicted during construction, a mud-mat or a thin concrete layer can be placed on prepared and approved subgrades prior to the placement of reinforcing steel or tendons. This serves the purpose of protecting the subgrades from damage once the reinforcement placement has begun.
8. Prior to the placement of concrete, exposed subgrade or base material and forms should be wetted, and form release compounds should be applied. Reinforcement support stands or ties should be

checked. Concrete bases or subgrades should not be so wet that they are softened or have standing water.

9. For a cast-in-place concrete, the form dimensions, reinforcement placement and cover, concrete mix design, and other code requirements should be carefully checked by an inspector before and during placement. The reinforcement should be specified by the structural engineering drawings and calculations.
10. For post-tension concrete, an additional check of the tendons is needed, and a tensioning inspection form should be prepared prior to placement of concrete.
11. For Portland cement pavements, forms an additional check of reinforcing dowels should performed per the design drawings.
12. During placement, concrete should be tested, and should meet the ACI and jurisdictional requirements and mix design targets for slump, air entrainment, unit weight, compressive strength, flexural strength (pavements), and any other specified properties. In general concrete should be placed within 90 minutes of batching at a temperature of less than 90 degrees Fahrenheit. Adding of water to the truck on the jobsite is generally not encouraged.
13. Concrete mix designs should be created by the accredited and jurisdictionally approved supplier to meet the requirements of the structural engineer. In general a water/cement ratio of 0.45 or less is advisable, and aggregates, cement, flyash, and other constituents should be tested to meet ASTM C-33 standards, including Alkali Silica Reaction (ASR). To further mitigate the possibility of concrete degradation from corrosion and ASR, Type II or V Portland Cement should be used, and fly ash replacement of 25 percent is also recommended. Air entrained concrete should be used in areas where concrete will be exposed to frozen ground or ambient temperatures below freezing.
14. Control joints are recommended to improve the aesthetics of the finished concrete by allowing for cracking within partially cut or grooved joints. The control joints are generally made to depths of about 1/4 of the slab thickness and are generally completed within the first day of construction. The spacing should be laid out by the structural engineer, and is often in a square pattern. Joint spacing is generally 5 to 15 feet on-center but this can vary and should be decided by the structural engineer. For pavements, construction joints are generally considered to function as control joints. Post-tensioned slabs generally do not have control joints.
15. Some slabs are expected to meet flatness and levelness requirements. In those cases, testing for flatness and levelness should be completed as soon as possible, usually the same day as concrete placement, and before cutting of control joints if possible. Roadway smoothness can also be measured, and is usually specified by the jurisdictional owner if is required.
16. Prior to tensioning of post-tension structures, placement of soil backfills or continuation of building on newly-placed concrete, a strength requirement is generally required, which should be specified by the structural engineer. The strength progress can be evaluated by the use of concrete compressive strength cylinders or maturity monitoring in some jurisdictions. Advancing with backfill, additional concrete work or post-tensioning without reaching strength benchmarks could result in damage and failure of the concrete, which could result in danger and harm to nearby people and property.

17. In general, concrete should not be exposed to freezing temperatures in the first 7 days after placement, which may require insulation or heating. Additionally, in hot or dry, windy weather, misting, covering with wet burlap or the use of curing compounds may be called for to reduce shrinkage cracking and curling during the first 7 days.

FOUNDATIONS

1. In general, construction should proceed per the governing jurisdictional guidelines for the project site, including but not limited to the applicable American Concrete Institute (ACI), International Code Council (ICC), State Department of Transportation, City and/or County, Army Corps of Engineers, Federal Aviation, Occupational Safety and Health Administration (OSHA), and any other governing standard details and specifications. In areas where multiple standards are applicable the more stringent should be considered. Work should be performed by qualified, licensed contractors with experience in the specific type of work in the area of the site.
2. Foundations in this section are considered to apply to the construction of structural supports which directly transfer loads from man-made structures into the earth. In general, these include shallow foundations and deep foundations. Shallow foundations are generally constructed for the purpose of distributing the structural loads horizontally over a larger area of earth. Some types of shallow foundations (or footings) are spread footings, continuous footings, mat foundations, and reinforced slabs-on-grade. Deep foundations are generally designed for the purpose of distributing the structural loads vertically deeper into the soil by the use of end bearing and side friction. Some types of deep foundations are driven piles, auger-cast piles, drilled shafts, caissons, helical piers, and micro-piles.
3. For shallow foundations, the minimum bearing depth considered should be greater than the maximum design frost depth for the location of construction. This can be found on frost depth maps (ICC), but the standard of practice in the city and/or county should also be consulted. In general the bearing depth should never be less than 18 inches below planned finished grades.
4. Shallow continuous foundations should be sized with a minimum width of 18 inches and isolated spread footings should be a minimum of 24 inches in each direction. Foundation sizing, spacing, and reinforcing steel design should be performed by a qualified structural engineer.
5. The geotechnical engineer will provide an estimated bearing capacity and settlement values for the project based on soil conditions and estimated loads provided by the structural engineer. It is assumed that appropriate safety factors will be applied by the structural engineer.
6. In areas where shallow foundations are bearing on prepared subgrade or structural fill soils, testing and approval of this work should be completed prior to the beginning of foundation construction.
7. In locations where the shallow foundations are approved to bear on in-place (native) soil or in locations where approved documented fills have been exposed to weather conditions after approval, a foundation subgrade evaluation should be performed prior to the placement of reinforcing steel. This can consist of probing with a “t”-handled rod, borings, penetrometer testing, dynamic cone penetration testing and/or other methods requested by the geotechnical engineer and/or inspector. Where unsuitable foundation bearing material is encountered, the geotechnical engineer should be consulted for additional recommendations.
8. For shallow foundations to bear on rock, partially weathered rock, hard cemented soils, and/or boulders, the entire foundation system should bear directly on such material. In this case, the rock surface should be prepared so that it is clean, competent, and formed into a roughly horizontal, stepped base. If that is not possible, then the entire structure should be underlain by a zone of

structural fill. This may require the over-excavation in areas of rock removal and/or hard dig. In general this zone can vary in thickness but it should be a minimum of 1 foot thick. The geotechnical engineer should be consulted in this instance.

9. At times when rainfall is predicted during construction, a mud-mat or a thin concrete layer can be placed on prepared and approved subgrades prior to the placement of reinforcing steel. This serves the purpose of protecting the subgrades from damage once the reinforcing steel placement has begun.
10. For cast-in-place concrete foundations, the excavations dimensions, reinforcing steel placement and cover, structural fill compaction, concrete mix design, and other code requirements should be carefully checked by an inspector before and during placement.

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11. For deep foundations, the geotechnical engineer will generally provide design charts that provide foundations axial capacity and uplift resistance at various depths given certain-sized foundations. These charts may be based on blow count data from drilling and or laboratory testing. In general safety factors are included in these design charts by the geotechnical engineer.
12. In addition, the geotechnical engineer may provide other soil parameters for use in the lateral resistance analysis. These parameters are usually raw data, and safety factors should be provided by the shaft designer. Sometimes, direct shear and or tri-axial testing is performed for this analysis.
13. In general the spacing of deep foundations is expected to be 6 shaft diameters or more. If that spacing is reduced, a group reduction factor should be applied by the structural engineer to the foundation capacities per FHWA guidelines. The spacing should not be less than 2.5 shaft diameters.
14. For deep foundations, a representative of the geotechnical engineer should be on-site to observe the excavations (if any) to evaluate that the soil conditions are consistent with the findings of the geotechnical report. Soil/rock stratigraphy will vary at times, and this may result in a change in the planned construction. This may require the use of fall protection equipment to perform observations close to an open excavation.
15. For driven foundations, a representative of the geotechnical engineer should be on-site to observe the driving process and to evaluate that the resistance of driving is consistent with the design assumptions. Soil/rock stratigraphy will vary at times and may this may result in a change in the planned construction.
16. For deep foundations, the size, depth, and ground conditions should be verified during construction by the geotechnical engineer and/or inspector responsible. Open excavations should be clean, with any areas of caving and groundwater seepage noted. In areas below the groundwater table, or areas where slurry is used to keep the trench open, non-destructive testing techniques should be used as outlined below.
17. Steel members including structural steel piles, reinforcing steel, bolts, threaded steel rods, etc. should be evaluated for design and code compliance prior to pick-up and placement in the foundation. This includes verification of size, weight, layout, cleanliness, lap-splices, etc. In addition, if non-destructive testing such as crosshole sonic logging or gamma-gamma logging is required, access tubes should be attached to the steel reinforcement prior to placement, and should be

relatively straight, capped at the bottom, and generally kept in-round. These tubes must be filled with water prior to the placement of concrete.

18. In cases where steel welding is required, this should be observed by a certified welding inspector.
19. In many cases, a crane will be used to lower steel members into the deep foundations. Crane picks should be carefully planned, including the ground conditions at placement of outriggers, wind conditions, and other factors. These are not generally provided in the geotechnical report, but can usually be provided upon request.
20. Cast-in-place concrete, grout or other cementations materials should be pumped or distributed to the bottom of the excavation using a tremmie pipe or hollow stem auger pipe. Depending on the construction type, different mix slumps will be used. This should be carefully checked in the field during placement, and consolidation of the material should be considered. Use of a vibrator may be called for.
21. For work in a wet excavation (slurry), the concrete placed at the bottom of the excavation will displace the slurry as it comes up. The upper layer of concrete that has interacted with the slurry should be removed and not be a part of the final product.
22. Bolts or other connections to be set in the top after the placement is complete should be done immediately after final concrete placement, and prior to the on-set of curing.
23. For shafts requiring crosshole sonic logging or gamma-gamma testing, this should be performed within the first week after placement, but not before a 2 day curing period. The testing company and equipment manufacturer should provide more details on the requirements of the testing.
24. Load testing of deep foundations is recommended, and it is often a project requirement. In some cases, if test piles are constructed and tested, it can result in a significant reduction of the amount of needed foundations. The load testing frame and equipment should be sized appropriately for the test to be performed, and should be observed by the geotechnical engineer or inspector as it is performed. The results are provided to the structural engineer for approval.

LATERALLY LOADED STRUCTURES - RETAINING WALLS/SLOPES/DEEP FOUNDATIONS/MISCELLANEOUS

1. In general, construction should proceed per the governing jurisdictional guidelines for the project site, including but not limited to the applicable American Concrete Institute (ACI), International Code Council (ICC), State Department of Transportation, City and/or County, Army Corps of Engineers, Federal Aviation, Occupational Safety and Health Administration (OSHA), and any other governing standard details and specifications. In areas where multiple standards are applicable the more stringent should be considered. Work should be performed by qualified, licensed contractors with experience in the specific type of work in the area of the site.
2. Laterally loaded structures for this section are generally meant to describe structures that are subjected to loading roughly horizontal to the ground surface. Such structures include retaining walls, slopes, deep foundations, tall buildings, box culverts, and other buried or partially buried structures.
3. The recommendations put forth in General Geotechnical Design and Construction Considerations for FOUNDATIONS, CAST-IN-PLACE CONCRETE, EARTHWORK, and SUBGRADE PREPARATION should be reviewed, as they are not all repeated in this section, but many of them will apply to the work. Those recommendations are incorporated by reference herein.
4. Laterally loaded structures are generally affected by overburden pressure, water pressure, surcharges, and other static loads, as well as traffic, seismic, wind, and other dynamic loads. The structural engineer must account for these loads. In addition, eccentric loading of the foundation should be evaluated and accounted for by the structural engineer. The structural engineer is also responsible for applying the appropriate factors of safety to the raw data provided by the geotechnical engineer.
5. The geotechnical report should provide data regarding soil lateral earth pressures, seismic design parameters, and groundwater levels. In the report the pressures are usually reported as raw data in the form of equivalent fluid pressures for three cases. 1. Static is for soil pressure against a structure that is fixed at top and bottom, like a basement wall or box culvert. 2. Active is for soil pressure against a wall that is free to move at the top, like a retaining wall. 3. Passive is for soil that is resisting the movement of the structure, usually at the toe of the wall where the foundation and embedded section are located. The structural engineer is responsible for deciding on safety factors for design parameters and groundwater elevations based on the raw data in the geotechnical report.
6. Generally speaking, direct shear or tri-axial shear testing should be performed for this evaluation in cases of soil slopes or unrestrained soil retaining walls over 6 feet in height or in lower walls in some cases based on the engineer’s judgment. For deep foundations and completely buried structures, this testing will be required per the discretion of the structural engineer.
7. For non-confined retaining walls (walls that are not attached at the top) and slopes, a geotechnical engineer should perform overall stability analysis for sliding, overturning, and global stability. For walls that are structurally restrained at the top, the geotechnical engineer does not generally perform this analysis. Internal wall stability should be designed by the structural engineer.

8. Cut slopes into rock should be evaluated by an engineering geologist, and rock coring to identify the orientation of fracture plans, faults, bedding planes, and other features should be performed. An analysis of this data will be provided by the engineering geologist to identify modes of failure including sliding, wedge, and overturning, and to provide design and construction recommendations.
9. For laterally loaded deep foundations that support towers, bridges or other structures with high lateral loads, geotechnical reports generally provide parameters for design analysis which is performed by the structural engineer. The structural engineer is responsible for applying appropriate safety factors to the raw data from the geotechnical engineer.
10. Construction recommendations for deep foundations can be found in the General Geotechnical Design and Construction Considerations-FOUNDATIONS section.
11. Construction of retaining walls often requires temporary slope excavations and shoring, including soil nails, soldier piles and lagging or laid-back slopes. This should be done per OSHA requirements and may require specialty design and contracting.
12. In general, surface water should not be directed over a slope or retaining wall, but should be captured in a drainage feature trending parallel to the slope, with an erosion protected outlet to the base of the wall or slope.
13. Waterproofing for retaining walls is generally required on the backfilled side, and they should be backfilled with an 18-inch zone of open graded aggregate wrapped in filter fabric or a synthetic draining product, which outlets to weep holes or a drain at the base of the wall. The purpose of this zone, which is immediately behind the wall is to relieve water pressures from building behind the wall.
14. Backfill compaction around retaining walls and slopes requires special care. Lighter equipment should be considered, and consideration to curing of cementitious materials used during construction will be called for. Additionally, if mechanically stabilized earth walls are being constructed, or if tie-backs are being utilized, additional care will be necessary to avoid damaging or displacing the materials. Use of heavy or large equipment, and/or beginning of backfill prior to concrete strength verification can create dangers to construction and human safety. Please refer to the General Geotechnical Design and Construction Considerations-CAST-IN-PLACE CONCRETE section. These concerns will also apply to the curing of cell grouting within reinforced masonry walls.
15. Usually safety features such as handrails are designed to be installed at the top of retaining walls and slopes. Prior to their installation, workers in those areas will need to be equipped with appropriate fall protection equipment.

EXCAVATION AND DEWATERING

1. In general, construction should proceed per the governing jurisdictional guidelines for the project site, including but not limited to the applicable American Concrete Institute (ACI), International Code Council (ICC), State Department of Transportation, City and/or County, Army Corps of Engineers, Federal Aviation, Occupational Safety and Health Administration (OSHA), and any other governing standard details and specifications. In areas where multiple standards are applicable the more stringent should be considered. Work should be performed by qualified, licensed contractors with experience in the specific type of work in the area of the site.
2. Excavation and Dewatering for this section are generally meant to describe structures that are intended to create stable, excavations for the construction of infrastructure near to existing development and below the groundwater table.
3. The recommendations put forth in General Geotechnical Design and Construction Considerations for LATERALLY LOADED STRUCTURES, FOUNDATIONS, CAST-IN-PLACE CONCRETE, EARTHWORK, and SUBGRADE PREPARATION should be reviewed, as they are not all repeated in this section, but many of them will apply to the work. Those recommendations are incorporated by reference herein.
4. The site excavations will generally be affected by overburden pressure, water pressure, surcharges, and other static loads, as well as traffic, seismic, wind, and other dynamic loads. The structural engineer must account for these loads as described in Section 5.2 of this report. In addition, eccentric loading of the foundation should be evaluated and accounted for by the structural engineer. The structural engineer is also responsible for applying the appropriate factors of safety to the raw data provided by the geotechnical engineer.
5. The geotechnical report should provide data regarding soil lateral earth pressures, seismic design parameters, and groundwater levels. In the report the pressures are usually reported as raw data in the form of equivalent fluid pressures for three cases. 1. Static is for soil pressure against a structure that is fixed at top and bottom, like a basement wall or box culvert. 2. Active is for soil pressure against a wall that is free to move at the top, like a retaining wall. 3. Passive is for soil that is resisting the movement of the structure, usually at the toe of the wall where the foundation and embedded section are located. The structural engineer is responsible for deciding on safety factors for design parameters and groundwater elevations based on the raw data in the geotechnical report.
6. The parameters provided above are based on laboratory testing and engineering judgement. Since numerous soil layers with different properties will be encountered in a large excavation, assumptions and judgement are used to generate the equivalent fluid pressures to be used in design. Factors of safety are not included in those numbers and should be evaluated prior to design.
7. Groundwater, if encountered will dramatically change the stability of the excavation. In addition, pumping of groundwater from the bottom of the excavation can be difficult and costly, and it can result in potential damage to nearby structures if groundwater drawdown occurs. As such, we recommend that groundwater monitoring be performed across the site during design and prior to construction to assist in the excavation design and planning.
8. Groundwater pumping tests should be performed if groundwater pumping will be needed during construction. The pumping tests can be used to estimate drawdown at nearby properties, and also

will be needed to determine the hydraulic conductivity of the soil for the design of the dewatering system.

9. For excavation stabilization in granular and dense soil, the use of soldier piles and lagging is recommended. The soldier pile spacing and size should be determined by the structural engineer based on the lateral loads provided in the report. In general, the spacing should be more than two pile diameters, and less than 8 feet. Soldier piles should be advanced 5 feet or more below the base of the excavation. Passive pressures from Section 5.2 can be used in the design of soldier piles for the portions of the piles below the excavation.
10. If the piles are drilled, they should be grouted in-place. If below the groundwater table, the grouting should be accomplished by tremmie pipe, and the concrete should be a mix intended for placement below the groundwater table. For work in a wet excavation, the concrete placed at the bottom of the excavation will displace the water as it comes up. The upper layer of concrete that has interacted with the water should be removed and not be a part of the final product. Lagging should be specially designed timber or other lagging. The temporary excavation will need to account for seepage pressures at the toe of the wall as well as hydrostatic forces behind the wall.
11. Depending on the loading, tie back anchors and/or soil nails may be needed. These should be installed beyond the failure envelope of the wall. This would be a plane that is rotated upward 55 degrees from horizontal. The strength of the anchors behind this plane should be considered, and bond strength inside the plane should be ignored. If friction anchors are used, they should extend 10 feet or more beyond the failure envelope. Evaluation of the anchor length and encroachment onto other properties, and possible conflicts with underground utilities should be carefully considered. Anchors are typically installed 25 to 40 degrees below horizontal. The capacity of the anchors should be checked on 10% of locations by loading to 200% of the design strength. All should be loaded to 120% of design strength, and should be locked off at 80%
12. The shoring and tie backs should be designed to allow less than ½ inch of deflection at the top of the excavation wall, where the wall is within an imaginary 1:1 line extending downward from the base of surrounding structures. This can be expanded to 1 inch of deflection if there is no nearby structure inside that plane. An analysis of nearby structures to locate their depth and horizontal position should be conducted prior to shored excavation design.
13. Assuming that the excavations will encroach below the groundwater table, allowances for drainage behind and through the lagging should be made. The drainage can be accomplished by using an open-graded gravel material that is wrapped in geotextile fabric. The lagging should allow for the collected water to pass through the wall at select locations into drainage trenches below the excavation base. These trenches should be considered as sump areas where groundwater can be pumped out of the excavation.
14. The pumped groundwater needs to be handled properly per jurisdictional guidelines.
15. In general, surface water should not be directed over a slope or retaining wall, but should be captured in a drainage feature trending parallel to the slope, with an erosion protected outlet to the base of the wall or slope.

16. Safety features such as handrails or barriers are to be designed to be installed at the top of retaining walls and slopes. Prior to their installation, workers in those areas will need to be equipped with appropriate fall protection equipment.

Waterproofing and Back Drainage

1. In general, construction should proceed per the governing jurisdictional guidelines for the project site, including but not limited to the applicable American Concrete Institute (ACI), International Code Council (ICC), State Department of Transportation, City and/or County, Army Corps of Engineers, Federal Aviation, Occupational Safety and Health Administration (OSHA), and any other governing standard details and specifications. In areas where multiple standards are applicable the more stringent should be considered. Work should be performed by qualified, licensed contractors with experience in the specific type of work in the area of the site.
2. Waterproofing and Back drainage structures for this section are generally meant to describe permanent subgrade structures that are planned to be below the historic high groundwater elevation of 20 feet below existing grades.
3. The recommendations put forth in General Geotechnical Design and Construction Considerations for FOUNDATIONS, CAST-IN-PLACE CONCRETE, EARTHWORK, and SUBGRADE PREPARATION should be reviewed, as they are not all repeated in this section, but many of them will apply to the work. Those recommendations are incorporated by reference herein.
4. In general, surface water should not be directed over a slope or retaining wall, but should be captured in a drainage feature trending parallel to the slope, with an erosion protected outlet to the base of the wall or slope.
5. Waterproofing for retaining walls is generally required on the backfilled side, and they should be backfilled with an 18-inch zone of open graded aggregate wrapped in filter fabric or a synthetic draining product, which outlets to weep holes or a drain at the base of the wall. The purpose of this zone, which is immediately behind the wall is to relieve water pressures from building behind the wall.
6. For the basement walls on this site, sump pumps will be needed to reduce the build-up of water in the basement. The design should be for a historic high groundwater level of 20 feet bgs. The pumping system should be designed to keep the slab and walls relatively dry so that mold, efflorescence, and other detrimental effects to the concrete structure will not result.
7. Backfill compaction around retaining walls and slopes requires special care. Lighter equipment should be considered, and consideration to curing of cementitious materials used during construction will be called for. Additionally, if mechanically stabilized earth walls are being constructed, or if tie-backs are being utilized, additional care will be necessary to avoid damaging or displacing the materials. Use of heavy or large equipment, and/or beginning of backfill prior to concrete strength verification can create dangers to construction and human safety. Please refer to the General Geotechnical Design and Construction Considerations-CAST-IN-PLACE CONCRETE section. These concerns will also apply to the curing of cell grouting within reinforced masonry walls.

CHEMICAL TREATMENT OF SOIL

1. In general, construction should proceed per the governing jurisdictional guidelines for the project site, including but not limited to the applicable American Concrete Institute (ACI), International Code Council (ICC), State Department of Transportation, State Department of Environmental Quality, the US Environmental Protection Agency, City and/or County, Army Corps of Engineers, Federal Aviation, Occupational Safety and Health Administration (OSHA), and any other governing standard details and specifications. In areas where multiple standards are applicable the more stringent should be considered. Work should be performed by qualified, licensed contractors with experience in the specific type of work in the area of the site.
2. Chemical treatment of soil for this section is generally meant to describe the process of improving soil properties for a specific purpose, using cement or chemical lime.
3. A mix design should be performed by the geotechnical engineer to help it meet the specific strength, plasticity index, durability, and/or other desired properties. The mix design should be performed using the proposed chemical lime or cement proposed for use by the contractor, along with samples of the site soil that are taken from the material to be used in the process.
4. For the mix design the geotechnical engineer should perform proctor testing to determine optimum moisture content of the soil, and then mix samples of the soil at 3 percent above optimum moisture content with varying concentrations of lime or cement. The samples will be prepared and cured per ASTM standards, and then after 7-days for curing, they will be tested for compression strength. Durability testing goes on for 28 days.
5. Following this testing, the geotechnical engineer will provide a recommended mix ratio of cement or chemical lime in the geotechnical report for use by the contractor. The geotechnical engineer will generally specify a design ratio of 2 percent more than the minimum to account for some error during construction.
6. Prior to treatment, the in-place soil moisture should be measured so that the correct amount of water can be used during construction. Work should not be performed on frozen ground.
7. During construction, special considerations for construction of treated soils should be followed. The application process should be conducted to prevent the loss of the treatment material to wind which might transport the materials off site, and workers should be provided with personal protective equipment for dust generated in the process.
8. The treatment should be applied evenly over the surface, and this can be monitored by use of a pan placed on the subgrade. This can also be tested by preparing test specimens from the in-place mixture for laboratory testing.
9. Often, after or during the chemical application, additional water may be needed to activate the chemical reaction. In general, it should be maintained at about 3 percent or more above optimum moisture. Following this, mixing of the applied material is generally performed using specialized equipment.
10. The total amount of chemical provided can be verified by collecting batch tickets from the delivery trucks, and the depth of the treatment can be verified by digging of test pits, and the use of reagents that react with lime and or cement.

11. For the use of lime treatment, compaction should be performed after a specified amount of time has passed following mixing and re-grading. For concrete, compaction should be performed immediately after mixing and re-grading. In both cases, some swelling of the surface should be expected. Final grading should be performed the following day of the initial work for lime treatment, and within 2 to 4 hours for soil cement.
12. Quality control testing of compacted treated subgrades should be performed per the recommendations of the geotechnical report, and generally in accordance with General Geotechnical Design and Construction Considerations - EARTHWORK

PAVING

1. In general, construction should proceed per the governing jurisdictional guidelines for the project site, including but not limited to the applicable American Concrete Institute (ACI), International Code Council (ICC), State Department of Transportation, City and/or County, Army Corps of Engineers, Federal Aviation, Occupational Safety and Health Administration (OSHA), and any other governing standard details and specifications. In areas where multiple standards are applicable the more stringent should be considered. Work should be performed by qualified, licensed contractors with experience in the specific type of work in the area of the site.
2. Paving for this section is generally meant to describe the placement of surface treatments on travel-ways to be used by rubber-tired vehicles, such as roadways, runways, parking lots, etc.
3. The geotechnical engineer is generally responsible for providing structural analysis to recommend the thickness of pavement sections, which can include asphalt, concrete pavements, aggregate base, cement or lime treated aggregate base, and cement or lime treated subgrades.
4. The civil engineer is generally responsible for determining which surface finishes and mixes are appropriate, and often the owner, general contractor and/or other party will decide on lift thickness, the use of tack coats and surface treatments, etc.
5. The geotechnical engineer will generally be provided with the planned traffic loading, as well as reliability, design life, and serviceability factors by the jurisdiction, traffic engineer, designer, and/or owner. The geotechnical study will provide data regarding soil resiliency and strength. A pavement modeling software is generally used to perform the analysis for design, however, jurisdictional minimum sections also must be considered, as well as construction considerations and other factors.
6. The geotechnical report report will generally provide pavement section thicknesses if requested.
7. For construction of overlays, where new pavement is being placed on old pavement, an evaluation of the existing pavement is needed, which should include coring the pavement, evaluation of the overall condition and thickness of the pavement, and evaluation of the pavement base and subgrade materials.
8. In general, the existing pavement is milled and treated with a tack coat prior to the placement of new pavement for the purpose of creating a stronger bond between the old and new material. This is also a way of removing aged asphalt and helping to maintain finished grades closer to existing conditions grading and drainage considerations.
9. If milling is performed, a minimum of 2 inches of existing asphalt should be left in-place to reduce the likelihood of equipment breaking through the asphalt layer and destroying its integrity. After milling and before the placement of tack coat, the surface should be evaluated for cracking or degradation. Cracked or degraded asphalt should be removed, spanned with geosynthetic reinforcement, or be otherwise repaired per the direction of the civil and or geotechnical engineer prior to continuing construction. Proofrolling may be requested.
10. For pavements to be placed on subgrade or base materials, the subgrade and base materials should be prepared per the General Geotechnical Design and Construction Considerations – EARTHWORK section.

11. Following the proofrolling as described in the General Geotechnical Design and Construction Considerations – EARTHWORK section, the application of subgrade treatment, base material, and paving materials can proceed per the recommendations in the geotechnical report and/or project plans. The placement of pavement materials or structural fills cannot take place on frozen ground.
12. The placement of aggregate base material should conform to the jurisdictional guidelines. In general the materials should be provided by an accredited supplier, and the material should meet the standards of ASTM C-33. Material that has been stockpiled and exposed to weather including wind and rain should be retested for compliance since fines could be lost. Frozen material cannot be used.
13. The placement of asphalt material should conform to the jurisdictional guidelines. In general the materials should be provided by an accredited supplier, and the material should meet the standards of ASTM C-33. The material can be placed in a screed by end-dumping, or it can be placed directly on the paving surface. The temperature of the mix at placement should generally be on the order of 300 degrees Fahrenheit at time of placement and screeding.
14. Compaction of the screeded asphalt should begin as soon as practical after placement, and initial rolling should be performed before the asphalt has cooled significantly. Compaction equipment should have vibratory capabilities, and should be of appropriate size and weight given the thickness of the lift being placed and the sloping of the ground surface.
15. In cold and/or windy weather, the cooling of the screeded asphalt is a quality issue, so preparations should be made to perform screeding immediately after placement, and compaction immediately after screeding.
16. Quality control testing of the asphalt should be performed during placement to verify compaction and mix design properties are being met and that delivery temperatures are correct. Results of testing data from asphalt laboratory testing should be provided within 24 hours of the paving.

SITE GRADING AND DRAINAGE

1. In general, construction should proceed per the governing jurisdictional guidelines for the project site, including but not limited to the applicable American Concrete Institute (ACI), International Code Council (ICC), State Department of Transportation, State Department of Environmental Quality, the US Environmental Protection Agency, City and/or County, Army Corps of Engineers, Federal Aviation, Occupational Safety and Health Administration (OSHA), and any other governing standard details and specifications. In areas where multiple standards are applicable the more stringent should be considered. Work should be performed by qualified, licensed contractors with experience in the specific type of work in the area of the site.
2. Site grading and drainage for this section is generally meant to describe the effect of new construction on surface hydrology, which impacts the flow of rainfall or other water running across, onto or off-of, a newly constructed or modified development.
3. This section does not apply to the construction of site grading and drainage features. Recommendations for the construction of such features are covered in General Geotechnical Design and Construction Considerations for Earthwork – Structural Fills section and Underground Pipeline Installation – Backfill section.
4. In general, surface water flows should be directed towards storm drains, natural channels, retention or detention basins, swales, and/or other features specifically designed to capture, store, and or transmit them to specific off-site outfalls.
5. The surface water flow design is generally performed by a site civil engineer, and it can be impacted by hydrology, roof lines, and other site structures that do not allow for water to infiltrate into the soil, and that modify the topography of the site.
6. Soil permeability, density, and strength properties are relevant to the design of storm drain systems, including dry wells, retention basins, swales, and others. These properties are usually only provided in a geotechnical report if specifically requested, and recommendations will be provided in the geotechnical report in those cases.
7. Structures or site features that are not a part of the surface water drainage system should not be exposed to surface water flows, standing water or water infiltration. In general, roof drains and scuppers, exterior slabs, pavements, landscaping, etc. should be constructed to drain water away from structures and foundations. The purpose of this is to reduce the opportunity for water damage, erosion, and/or altering of structural soil properties by wetting. In general, a 5 percent or more slope away from foundations, structural fills, slopes, structures, etc. should be maintained.
8. Special considerations should be used for slopes and retaining walls, as described in the General Geotechnical Design and Construction Considerations - LATERALLY LOADED STRUCTURES section.
9. Additionally, landscaping features including irrigation emitters and plants that require large amounts of water should not be placed near to new structures, as they have the potential to alter soil moisture states. Changing of the moisture state of soil that provides structural support can lead to damage to the supported structures.

APPENDIX D

Infiltration Data and Worksheets

Table D.2-3: Determination of Safety Factor

Consideration		Assigned Weight (w)	Factor Value (v)	Product (p) p = w x v
Suitability Assessment (A)	Infiltration Testing Method	0.25	3	0.75
	Soil Texture Class	0.25	1	0.25
	Soil Variability	0.25	1	0.25
	Depth to Groundwater/Obstruction	0.25	1	0.25
	Suitability Assessment Safety Factor, $S_A = \Sigma p$			1.50
Design (B)	Pretreatment	0.50	Refer to Table D.2-4	
	Resiliency	0.25		
	Compaction	0.25		
	Design Safety Factor, $S_B = \Sigma p$			
Safety Factor, $S = S_A \times S_B$ (Must be always greater than or equal to 2)				

*Indicates field to be completed by civil engineer

Table D.2-4: Guidance for Determining Individual Factor Values

Consideration	High Concern (3 points)	Medium Concern (2 points)	Low Concern (1 point)
Infiltration Testing Method	Any	At least 2 tests of any kind within 50' of BMP.	At least 4 tests within BMP footprint, OR Large/Small Scale Pilot Infiltration Testing over at least 5% of BMP footprint.
Soil Texture Class	Unknown, Silty, or Clayey	Loamy	Granular/Slightly Loamy
Soil Variability	Unknown or High	Moderately Homogeneous	Significantly Homogeneous
Depth to Groundwater/ Obstruction	<5' below BMP	5-15' below BMP	>15' below BMP
Pretreatment	None/Minimal	Provides good pretreatment OR does not receive significant runoff from unpaved areas	Provides excellent pretreatment OR only receives runoff from rooftops and road surfaces.
Resiliency	None/Minimal	Includes underdrain/backup drainage that ensures ponding draws down in <96 hours	Includes underdrain/backup drainage AND supports easy restoration of impacted infiltration rates.
Compaction	Moderate Likelihood	Low Likelihood	Very Low Likelihood

Pecolation Test Data Sheet

Project:	El Cajon Gas Station
Project No.:	19-226305.4
Date:	9/9/2019
Test Hole:	P1
Tested by:	Y. Kawashima
Depth of Hole, ft, D:	18.5
Boring Radius, in:	8
UCSD:	SM

$$I_t = \frac{\Delta H(60r)}{\Delta t(r + 2H_{avg})}$$

Pre-Soak Procedure (See notes)						Calculations	
Reading #	Start Time	Stop Time	Δ t Time Interval	Do Initial Depth to Water Level	Df Final Depth to Water Level	Δ D Change in Water Level	Greater than 6"
	hr:mm	hr:mm	min	in	in	in	(y/n)
1	8:45	9:15	30	24	30	6.0	Y
2	9:15	9:45	30	30	53	23.0	Y

IN RIVERSIDE, 2Y=SAND: 10 min intervals for 1 hour. **IF NOT SAND:** 12 intervals at 30 min each, refilling each time

IN SAN DIEGO, Presoak for at least 2 hours if sandy soils. Rates of fall are measured for six hours, refilling each half hour (or 10 minutes for sand). Tests are generally repeated until consistent results are obtained.

Raw Data						Calculations		
Reading #	Start Time	Stop Time	Δ t Time Interval (10 or 30)	Do Initial Depth to Water Level	Df Final Depth to Water Level	Δ D Change in Water Level	Percolation Rate	Corrected Infiltration Rate
	hr:mm	hr:mm	min	inches (0.25" precision)			min/ in	in/hr
1	9:45	10:15	30	53.0	72.0	19.0	1.6	0.93
2	10:30	10:40	10	72.0	80.0	8.0	1.3	1.28
3	10:40	10:50	10	80.0	85.0	5.0	2.0	0.84
4	10:50	11:00	10	85.0	88.0	3.0	3.3	0.52
5	11:03	11:13	10	88.0	91.0	3.0	3.3	0.53
6	11:13	11:23	10	91.0	96.0	5.0	2.0	0.91
7	11:27	11:37	10	96.0	101.0	5.0	2.0	0.94
8	11:37	11:47	10	101	106	5.0	2.0	0.98
9								
10								
11								
12								

Sources:

Appendix D, Approved Infiltration Rate Assessment Methods for Selection of Storm Water BMPs (San Diego)

Appendix A, Infiltration Testing (Riverside County)

Appendix D, Infiltration Rate Protocol, 2011 (Orange County)