American Geotechnical, Inc.
GEOTECHNICAL ENGINEERING / MATERIALS TESTING & INSPECTION

September 15, 2015 F.N. 5620-01

City of Torrance
Public Works/Engineering Division
20500 Madrona Avenue
Torrance, CA 90503

Attention: Mr. John Dettle

Subject: **GEOTECHNICAL INVESTIGATION**
Sewer Improvement Project on Opal Street
Opal Street between Madrona Avenue and Maple Street
Torrance, California

Dear Mr. Dettle:

As requested, American Geotechnical performed a geotechnical investigation for the Opal Street sewer line improvement project, located in the City of Torrance, California. We performed a subsurface exploration consisting of drilling two (2), hollow stem auger borings along the proposed sewer line alignment. Both bulk and relatively-undisturbed soil samples were collected from the exploratory borings for classification and laboratory testing. Our findings, conclusions, and recommendations are provided below.

1.0 PROJECT DESCRIPTION AND SCOPE OF WORK

Based on the available site plan and project description, it is our understanding that the project consists of placement of a 15-inch diameter vitrified clay pipe sewer line along Opal Street between Madrona Avenue to the west and Maple Avenue to the east. The approximate length of the pipe line is 1,500 linear feet. Placement of the pipe will be located along the center of Opal Street. Pipe invert is approximately 13.5 to 15 feet below existing grade. A Site Location Map and an Aerial View are shown on the attached Plates 1 and 2, respectively.

Our scope of work consisted of the following:

- Project coordination and scheduling;
- Site reconnaissance for marking the proposed boring locations for Underground Service Alert;
- Obtaining the necessary permits for field investigation from the City of Torrance;
- Drilling of two (2) hollow stem auger borings, AGB-1 and AGB-2 to a maximum depth of 26 feet below street grade utilizing a truck mounted rig;
- Logging of the borings using visual and tactile methods;
- Collection of both bulk and relatively undisturbed samples from the borings;
- Laboratory testing of selected soil samples;
- Engineering analyses of the field and laboratory data; and
- Preparation of this report presenting our findings, conclusions, and recommendations for the proposed project.

2.0 FIELD INVESTIGATION

Our field investigation was performed on August 18, 2015, and consisted of the excavation of two (2), hollow stem auger borings, AGB-1 and AGB-2 along Opal Street. AGB-1 was drilled on the east portion of Opal Street in the vicinity of Maple Avenue. The west side of Opal Street near Madrona Avenue was where AGB-2 was drilled.

Both borings were drilled to a maximum depth of 26 feet below the existing street grade. Relatively undisturbed and bulk samples were collected from the borings at regular intervals and brought to the laboratory for testing. Upon the completion of drilling, each boring was backfilled with native soil and capped with asphalt cold patch. The approximate locations of the borings are shown on the Site/Boring Location Plan, Plate 3.

The existing asphalt pavement sections of the borings consist of approximately 2 to 5 inches of asphaltic concrete over 8 to 12 inches of aggregate base. The soils encountered in both borings consisted of silty sand, clayey sand, and silty clay in the upper 16 feet of the borings. At both boring locations, poorly graded sand was encountered below 16 feet. This sand layer was found to be medium

dense to very dense. Groundwater was not encountered at the time of our drilling. However, available maps indicate the historical groundwater was at approximately 10 to 20 feet below ground surface.

3.0 LABORATORY TESTING

Laboratory testing was performed on representative soil samples collected during our field exploration. Laboratory tests included in-situ moisture-density, grain-size analysis, direct shear, and soil chemical testing (pH, electrical resistivity, soluble sulfates, and soluble chlorides). A summary of the laboratory test results is presented in Appendix B.

4.0 CONCLUSIONS AND RECOMMENDATIONS

Based on our review of available information, geotechnical exploration, laboratory testing, and engineering analyses, it is our opinion that that the construction for the proposed sewer line project is feasible from geotechnical standpoint provided that the recommendations in this report are incorporated into the design and construction.

As we understand, the work involved includes deep trench excavation in the center of Opal Street, trench shoring, trench subgrade preparation, installation of pipe bedding, installation of a sewer pipe, trench backfill and compaction, and replacement of the existing street structural section including base and asphalt. We recommend that the subsurface soil conditions discussed in this report be considered and evaluated prior to the start of this project. No particular difficulty during trenching for the sewer line is anticipated. The on-site, excavated soil is generally considered suitable to be used as backfill material. However, the native soils derived from the excavation may be wet. Drying of these soils may be necessary before utilizing as a backfill material. Recommendations for excavations and backfilling as well as other geotechnical considerations are provided below.

4.1 Design Criteria for Sewer Replacement

The new sewer pipe should be designed for an overburden pressure calculated based on 120 pounds per cubic feet of soil density. Additionally, the design should be performed by proper evaluation of all possible loads acting on the pipeline including traffic loads and other surcharge loads. It should be noted that the actual loads acting on the underground pipe depend on several factors including the type

of pipe (rigid or flexible), the depth and width of the trench, the type of backfill, and the type of bedding materials. An allowable soil bearing value of 3,000 pounds per square foot (psf) should be used in the design when the pipe is located at a minimum depth of 5 feet below the lowest adjacent grade. Additional soil parameters are given below:

* Soil density.....120 pcf
* Angle of internal friction.....32 degrees
* Coefficient of active earth pressure 0.31
* Coefficient of passive earth pressure 3.25

4.2 Temporary Excavations and Shoring

All temporary excavations and trenches should be constructed in accordance with Occupational Safety and Health Administration (OSHA) requirements. The temporary excavations should not be steeper than 1.5:1 (horizontal:vertical). However, with the limited space, this temporary sloping excavation may not be feasible at the site. If excavations with vertical walls are planned, temporary shoring should be designed and implemented at the site. The design for the temporary braced shoring should be accomplished based on the criteria presented on Plate 4. In addition to the criteria presented on this plate, surcharge loads adjacent to the shoring due to soil stockpiles, construction equipment, etc., should be applied. Even though no groundwater was encountered, depth to historical groundwater and hyrdrostatic pressures should also be considered in the shoring design. It should be noted that the shoring design parameters provided herein should be considered as guidelines.

Based on our subsurface investigation, the groundwater was not encountered during the time of drilling at the site. However, the actual conditions may vary due to seasonal fluctuations of the groundwater depth. Considerations may be given to evaluate the existing groundwater conditions at the time of construction. If groundwater is encountered in the temporary excavations, a dewatering plan should be implemented. At all times, the groundwater should be at least 2 feet below the bottom of the excavation. If braced sheet piles are used to shore the excavations, dewatering could be accomplished with sump pumps at the base of the excavations. In such cases, these sheet piles should be driven at least 5 feet below the bottom of the excavations to minimize the potential for bottom heave. The design of a proper dewatering system should be performed by an engineer experienced with the site conditions.

It should be noted that temporary lowering of the water table may produce adverse effects, such as settlement due to the change in the effective stress. These adverse effects should be considered in the overall design of the dewatering system by the dewatering contractor. A survey of existing improvements located near the pipeline alignment before and during construction should also be performed to monitor the performance of the shoring and dewatering activity.

4.3 Bedding and Backfill

It is recommended that the new sewer pipe be underlain by a minimum of 8 inches of bedding material. In addition, a minimum of 12 inches of bedding material is also recommended above the top of the pipe. The bedding material should be predominantly granular with a minimum sand equivalent of 30 or more. It is recommended that the soils engineer review the bottom of the excavations and determine the suitability of the supporting materials. The loose soil at the bottom of the excavations, if present should also be removed and replaced with bedding soil.

The soils encountered in the excavations may be used as backfill materials provided that they are free of any debris, vegetation or deleterious materials. Additionally, the fill materials should also be free of cobbles and rocks larger than 4 inches in diameter. Any wet soil from the excavations, should be dried before utilizing as backfill soil. As an alternative to on-site soil, imported, predominantly granular soil may be utilized for backfill purposes. The backfill soil should be placed within the excavation in thin layers, 8 inches or less in thickness, and be compacted to at least 90 percent to the maximum laboratory density. Aggregate base and upper 12 inches of subgrade below the pavement areas should be compacted to minimum 95 percent of their respective maximum densities. Care should be exercised to prevent damage to the pipes during the compaction effort.

4.4 Concrete

Laboratory testing indicated that the site soil has low levels of sulfates, and as such, no special sulfate resistant concrete mix design is required. However, we recommend that low-permeable concrete be utilized for the project considering site environment. For this purpose, the water to cement ratio in the concrete should be limited to 0.5. Use of utilize Type V cement is also preferred.

4.5 Corrosion

In addition to sulfate tests, Chloride, pH and resistivity tests on site soil were performed. Results of these tests are presented in Appendix B. Test results indicate relatively low corrosion potential for buried metals. However, appropriate design considerations should be made for the risk of damage from corrosion.

4.6 Pavement Replacement

Proposed construction will require removal of the existing pavement along the sewer line alignment. However, it is our understanding that the disturbed asphalt pavement will be replaced to the existing conditions. Therefore, no new pavement design recommendations are provided herein. As recommended before, the aggregate base and upper 12 inches of subgrade should be compacted to 95 percent of their respective maximum density. The asphalt concrete should also be compacted to a minimum 95 percent its maximum density.

5.0 PLAN REVIEW AND CONSTRUCTION OBSERVATION

When the detailed construction plans, including temporary shoring and dewatering plans are developed, they should be reviewed by the geotechnical engineer. During the actual construction, it is recommended that the geotechnical engineer review and verify site geotechnical conditions and determine the conformance with the intentions of the recommendations for construction. It should be noted that prior to placing the new pipe, the subgrade soil should be reviewed and approved by the geotechnical engineer.

6.0 REMARKS

Only a portion of subgrade conditions have been reviewed and evaluated. Conclusions, recommendations, and other information contained in this report are based upon the assumptions that subsurface conditions do not vary appreciably between and adjacent to observation points. Although no significant variation is anticipated, it must be recognized that variations can occur.

This report has been prepared for the sole use and benefit of our client. The intent of the report is to advise our client on geotechnical matters involving the proposed sewer line rehabilitation. It should be understood that the geotechnical consulting provided and the contents of this report are not perfect. Any errors or omissions noted by any party reviewing this report, and/or any other geotechnical aspect of the project, should be reported to this office to directly receive the advice. Subsequent use of this report can only be authorized by the client. Any transferring of information or other directed use by the client should be considered "advice by the client."

Geotechnical engineering is characterized by uncertainty. Geotechnical engineering is often described as an inexact science or art. Conclusions and recommendations presented herein are partly based upon the evaluations of technical information gathered, partly on experience, and partly on professional judgment. The conclusions and recommendations presented should be considered "advice." Other consultants could arrive at different conclusions and recommendations. Typically, "minimum" recommendations have been presented. Although some risk will always remain, lower risk of future problems would usually result if more restrictive criteria were adopted. Final decisions on matters presented are the responsibility of the client and/or the governing agencies. No warranties in any respect are made as to the performance of the project.

We appreciate the opportunity to be of service. Should you have any questions or if we can be of further service, please do not hesitate to contact our office.

Respectfully submitted,

AMERICAN GEOTECHNICAL, INC.

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Enclosures: Appendix A – Boring Logs
Appendix B – Laboratory Results

Distribution: Addressee (Regular Mail and Email: jdettle@torranceca.gov)

Wpdata/LA/5620-01.M Principe.Sept 15 2015.GeoInvestigation

Opal Street Sewer Improvement

Site Location Map

PLATE 1

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Opal Street Sewer Improvement

Aerial View

PLATE 2

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Opal Street Sewer Improvement

Site/Boring Location Map

Legend

AGB-2 — Approximate Boring Location

PLATE 3

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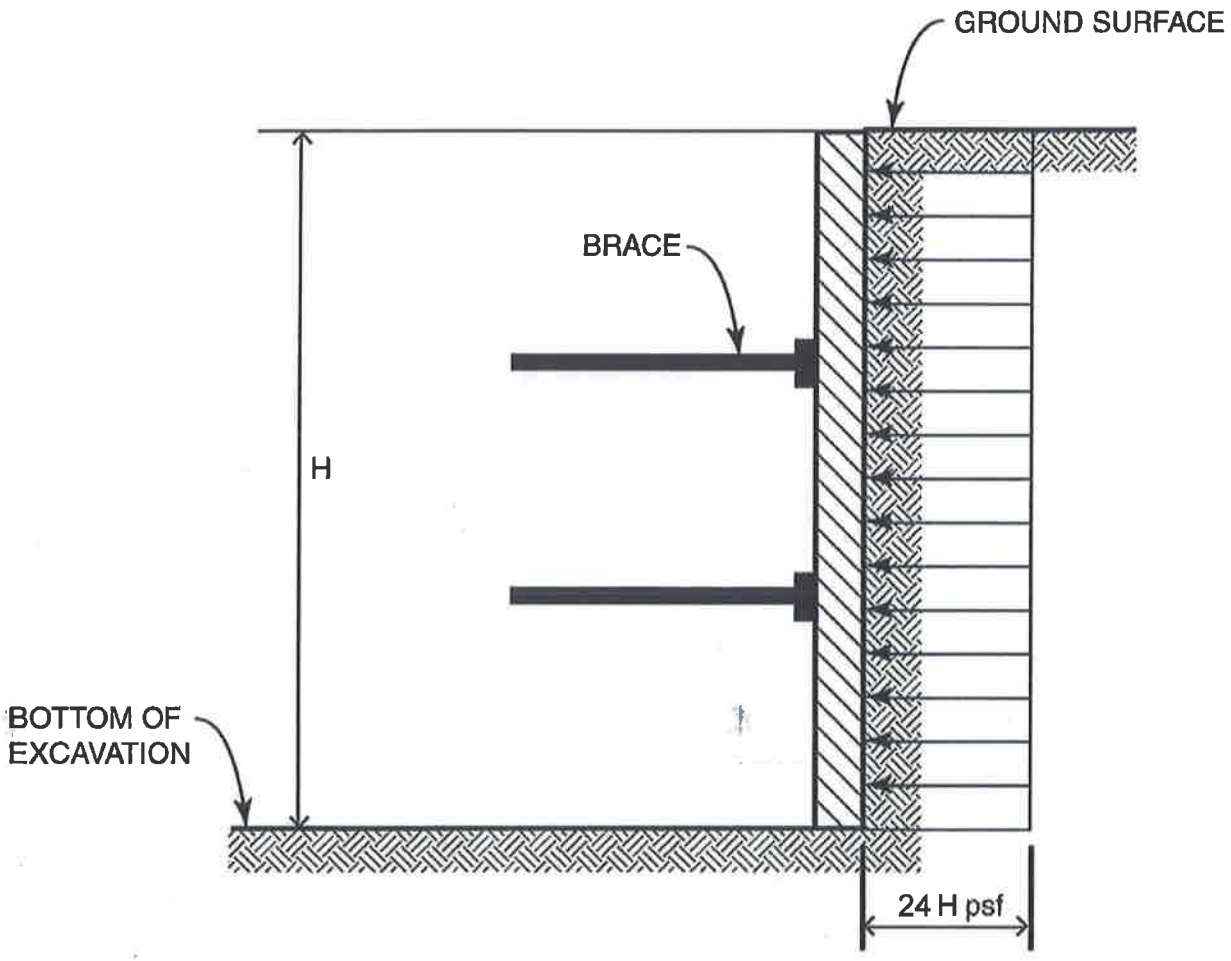

H = HEIGHT OF EXCAVATION IN FEET

BRACED SHORING

NOTE:
SURCHARGE FROM VEHICLES, AND STOCKPILE OF MATERIALS, ETC ARE NOT INCLUDED.

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TITLE: TEMPORARY BRACED SHORING DESIGN CRITERIA		
SCALE: N.T.S	DATE: Sept. 2015	FILE NO.: 05620-01

PLATE 4

File No. 5620-01
September 15, 2015

APPENDIX A

Boring Logs

FIELD BORING LOG

Boring Log No: AGB-1 **FN:** 05620-01

Project Name: Opal Street Sewer Improvement Project Sheet: 1 of 2

Location: Opal Street Start: 8/18/2015

Estimated Surface Elev. 84 +/- feet End: 8/18/2015

Total Depth (ft.) 26 +/- feet Initials: MP

Drill Rig Type: (hammer, drop, etc.) CME 75, 8" Diameter, 140lb Hammer, HSA

Completion, Groundwater, etc. No GW

Depth (feet)	Sample Type: INTACT	Sample Type: BULK	Blow Counts	Dry Unit Wt (PCF)	Moisture Content (%)	Laboatory Tests	USCS Symbol	Graphic Log	Field Description
									Surface Condition: Asphalt Concrete
									Subsurface Conditions: FORMATION; Color, Classification, Moisture content, density/stiffness, etc.
0									Asphalt Concrete (2")
									Base (8" - 12") (silty/clayey Sand trace gravel)
							SM		Silty Sand trace clay (SM/SC), reddish brown, moist, sand is fine to medium grained
5			88/11"	108.1	17.3		SM		@ 5.0' becomes very dense
10			95/10"	107.0	13.5		SM		Silty Sand (SM), reddish brown, moist, very dense, sand is fine to medium grained
			80/8"				SM		
15			88/10"	96.1	5.6		SP		Poorly Graded Sand (SP), light brown, moist, very dense, sand is medium grained
			76/6"				SP		
			81/8"	102.0	4.0		SP		
20									

Notes: Sampler: California Modified

Plate A1

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FIELD BORING LOG

Boring Log No: AGB-1 **FN:** 05620-01

Project Name: Opal Street Sewer Improvement Project Sheet: 2 of 2

Location: Opal Street Start: 8/18/2015

Estimated Surface Elev. 84 +/- feet End: 8/18/2015

Total Depth (ft.) 26 +/- feet Initials: MP

Drill Rig Type: (hammer, drop, etc.) CME 75, 8" Diameter, 140lb Hammer, HSA

Completion, Groundwater, etc. No GW

Depth (feet)	Sample Type: INTACT	Sample Type: BULK	Blow Counts	Dry Unit Wt (PCF)	Moisture Content (%)	Laboatory Tests	USCS Symbol	Graphic Log	Field Description
									Surface Condition:
									Subsurface Conditions: FORMATION; Color, Classification, Moisture content, density/stiffness, etc.
20									
							SP		
25			69/6"	88.9	5.9				
									End of boring at 26.0'. No GW
30									
35									
40									

Notes:

Plate A1

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FIELD BORING LOG

Boring Log No: AGB-2 **FN:** 05620-01

Project Name: Opal Street Sewer Improvement Project Sheet: 1 of 2

Location: Opal Street Start: 8/18/2015

Estimated Surface Elev. 92 +/- feet End: 8/18/2015

Total Depth (ft.) 26 +/- feet Initials: MP

Drill Rig Type: (hammer, drop, etc.) CME 75, 8" Diameter, 140lb Hammer, HAS

Completion, Groundwater, etc. No GW

Depth (feet)	Sample Type: INTACT	Sample Type: BULK	Blow Counts	Dry Unit Wt (PCF)	Moisture Content (%)	Laboatory Tests	USCS Symbol	Graphic Log	Field Description
									Surface Condition: Asphalt Concrete
									Subsurface Conditions: FORMATION; Color, Classification, Moisture content, density/stiffness, etc.
0							SM		Aspalt Concrete (4" - 5")
									Base (8" - 12") (Silty Sand trace gravel)
									Silty Sand (SM), reddish brown, moist, trace clay, sand is fine to medium grained
5			24	92.7	12.1		SM		@ 5.0' becomes medium dense
			49				SC		Clayey Sand (SC), reddish brown with mottled light gray, moist, dense, minor silt, sand is fine to medium grained
10			81/8"	106.6	20.9		CL		Silty Clay (CL), gray with mottled reddish brown, moist, hard, trace sand, sand is fine to medium grained
			53	100.7	21.7		CL		
15			95/9"				SM		Silty Sand (SM), light brown, moist, very dense, sand is fine to medium grained
			83/8"	100.4	17.4		SM		@ 15.0' 1/2" clay lens present
			78/8"				SP		Poorly Graded Sand (SP), light brown, moist, very dense, sand is medium grained
20									

Notes: Sampler: California Modified

Plate A2

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FIELD BORING LOG

Boring Log No: AGB-2 **FN:** 05620-01

Project Name: Opal Street Sewer Improvement Project Sheet: 2 of 2

Location: Opal Street Start: 8/18/2015

Estimated Surface Elev. 92 +/- feet End: 8/18/2015

Total Depth (ft.) 26 +/- feet Initials: MP

Drill Rig Type: (hammer, drop, etc.) CME 75, 8" Diameter, 140lb Hammer, HAS

Completion, Groundwater, etc. No GW

Depth (feet)	Sample Type: INTACT	Sample Type: BULK	Blow Counts	Dry Unit Wt (PCF)	Moisture Content (%)	Laboratory Tests	USCS Symbol	Graphic Log	Field Description
									Surface Condition:
									Subsurface Conditions: FORMATION; Color, Classification, Moisture content, density/stiffness, etc.
20									
25	/	50	79/8"	91.9	15.0		SP		
30									End of boring at 26.0'. No GW
35									
40									

Notes:

Plate A2

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File No. 5620-01
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APPENDIX B

Summary of Laboratory Data

Laboratory Testing Summary

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Project: Opal Street
Location: Opal Street, Torrence, CA
File No.: 05620-01
Date: 9/11/15

EXCAVATION ID	SAMPLE DEPTH (inch/feet)	SAMPLE TYPE *	VISUAL DESCRIPTION	Moisture Content (%)	Dry Density (pcf)	Saturation (%) S.G.=2.7	GRAIN SIZE	CHEMICAL ANALYSIS			
							Percent Passing #200	Resistivity (Ohm-cm)	Chloride (mg/Kg)	Sulfate (mg/Kg)	pH
AG-B1	0' - 5'	LB	Reddish Brown Silty Sand with traces of Clay	-	-	-	26	2,220	21.2	155	6.94
AG-B1	5' - 6'	R	Reddish Yellow Brown Silty Sand with traces of Clay	17.3	108.1	84.0	-	-	-	-	-
AG-B1	10'- 11'	R	Reddish Yellow Silty Sand	13.5	107.0	64.0	-	-	-	-	-
AG-B1	14' - 15'	R	Light Yellowish Brown Fine Sand	5.6	96.1	20.0	-	-	-	-	-
AG-B1	18' - 19'	R	Light Yellowish Brown Fine Sand	4.0	102.0	17.0	-	-	-	-	-
AG-B1	25' - 26'	R	Light Yellowish Brown Fine Sand	5.9	88.9	18.0	-	-	-	-	-
AG-B2	0' - 5'	LB	Reddish Brown Silty Sand with traces of Clay	-	-	-	26	12,000	3.44	9.72	7.85
AG-B2	5' - 6'	R	Reddish Brown Silty Sand with traces of Clay	12.1	92.7	40.0	-	-	-	-	-
AG-B2	10' - 11'	R	Reddish Olive Brown Silty Sand with traces of Sand	20.9	106.6	97.0	-	-	-	-	-
AG-B2	12' - 13'	R	Yellowish Grayish Brown Silty Sand with traces of Caly	21.7	100.7	87.0	-	-	-	-	-
AG-B2	16' - 17'	R	Reddish Brown Silty Sand with traces of Clay	17.4	100.4	69.0	-	-	-	-	-
AG-B2	25' - 26'	R	Yellowish Brown Fine Sand	4.6	91.9	15.0	-	-	-	-	-

Notes:

Sulfates (%) (multiply by 10,000 to get mg/kg)		Chlorides (%) (multiply by 10,000 to get mg/kg)		Resistivity (ohm-cm)	
0.00 - 0.10	Negligible	0.001 - 0.0025	Slightly Corrosive	Under 500	Very Corrosive
0.10 - 0.20	Moderate	0.0025 - 0.01	Moderately Corrosive	500 - 1000	Corrosive
0.20 - 2.00	Severe	0.01 - 0.05	Very Corrosive	1000 - 2000	Moderately Corrosive
Over 2.00	Very Severe	Over 0.05	Extremely Corrosive	2000 - 10,000	Mildly Corrosive
Sulfate directly affect concrete by chemical reactions.		Chlorides affect metal reinforcements, piping, and other metal components by corrosion.		Over 10,000	Negligible
				Resistivity indicates how	
pH is a measure of how acidic/basic water is. The range goes from 0 - 14, with 7 being neutral (e.g. pure water). pHs of less than 7 indicate acidity, whereas a pH of greater than 7 indicates a base. pH is really a					

* Percent by weight of dry soil.

Sulfate chart from Uniform Building Code, 1997 Edition, International Conference of Building Officials as well as IBC

Chloride & Resistivity Chart from Department of Navy Design Manual, Civil Engineering, NAVFAC, DM-5

* Sample Types:
R = Ring Sample
T = Shelby Tube Sample
D = Drive Tube Sample
MB = Medium Bag
LB = Large Bag

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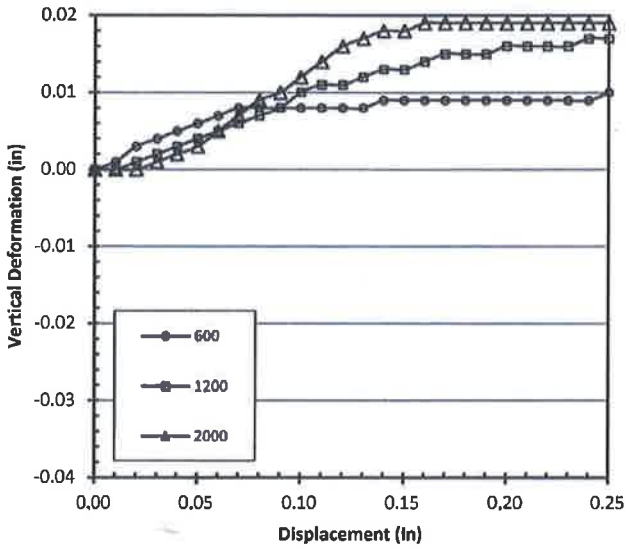
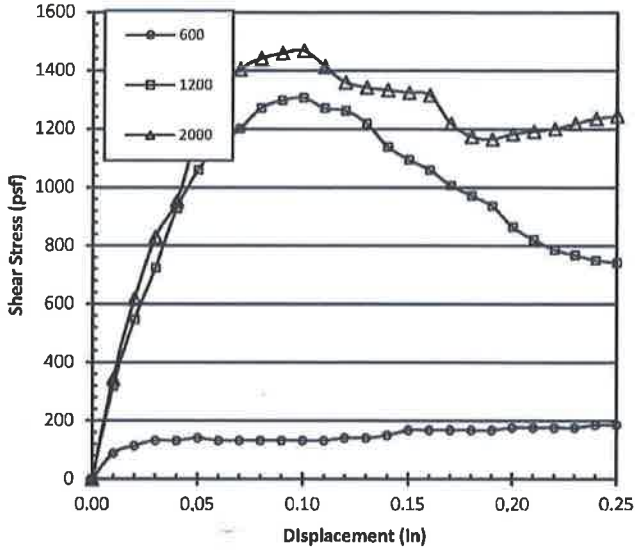
5600 Sorino Mountain Road, Suite 201, Las Vegas, NV 89146 - (702) 562-5046 - FAX (702) 562-2457

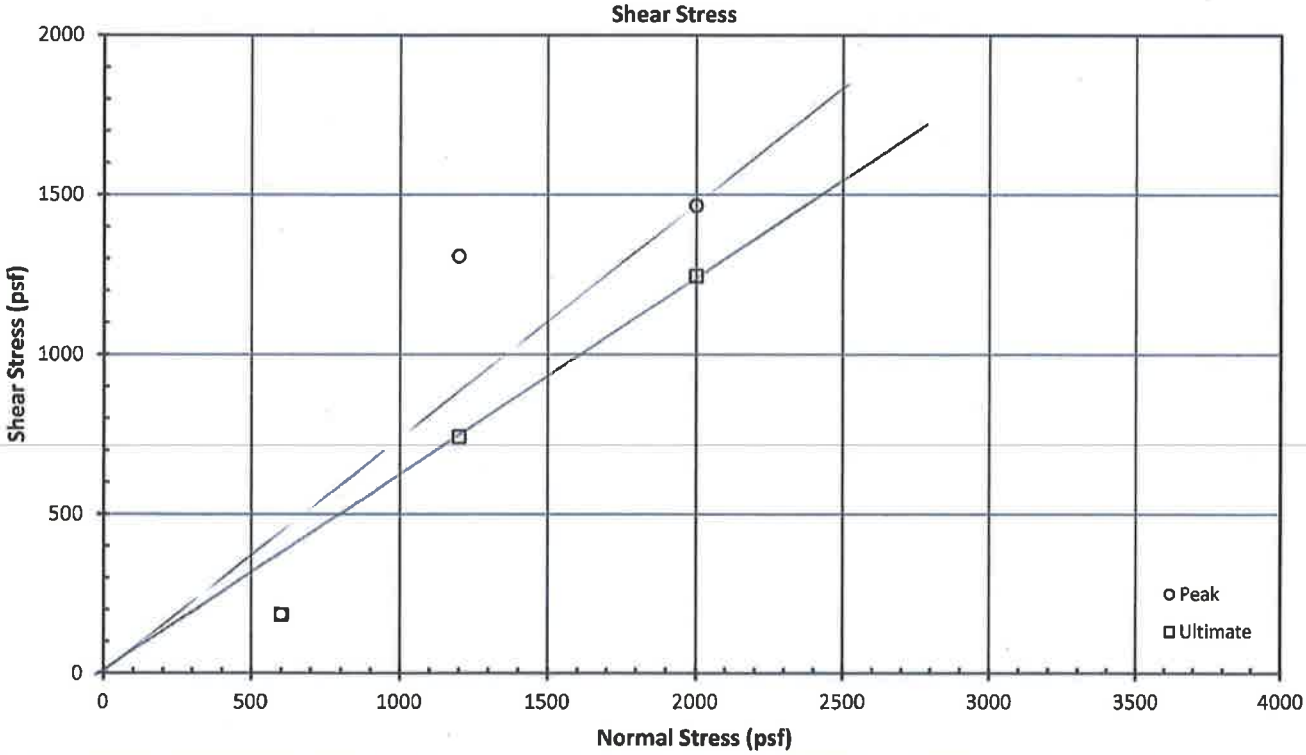
Samples Tested	1	2	3	4
Boring ID	AG-B2	AG-B2	AG-B2	0
Depth (in/ft.)	5'	10'	14'	0
Initial Dry Density (pcf)	92.69	106.57	100.37	0
Initial Moisture Content (%)	12.07	20.92	17.41	0
Normal Stress (psf)	600	1200	2000	0
Maximum Shear Stress (psf)	186	1308	1467	0
Ultimate Shear Stress (psf)	186	742	1246	0
ASTM D3080 Soil Type	Silty Sand	Silty Sand	Silty Sand	0

	Peak	Ultim.
Friction, phi (Deg)	36	32
Cohesion (psf)	0	0

Sample Type:	Intact
Method:	Drained
Consolidation:	Yes
Saturation:	Yes
Strain Rate (in/min):	0.01







American Geotechnical, Inc.	**DIRECT SHEAR TEST RESULTS** Opal Street Opal Street, Torrance, CA	F.N.: 05620-01 Date: Aug 2015	**Figure B1**