PAVEMENT DESIGN REPORT
BASELINE ROAD – 57TH AVENUE TO 61ST AVENUE
PHOENIX, ARIZONA

Prepared for:
City of Phoenix
Street Transportation Department
200 West Washington Street, 5th Floor
Phoenix, Arizona 85003

Prepared by:
Alpha Geotechnical & Materials, Inc.
2504 W. Southern Avenue
Tempe, Arizona 85282

Job # 18-G-7856
December 7, 2018

Alpha
Geotechnical & Materials, Inc.

December 7, 2018
Alpha Project #18-G-7856

City of Phoenix
Street Transportation Department
200 West Washington Street, 5th Floor
Phoenix, Arizona 85003

Attention: Myesha Harris, CCM, CFM

Re: Pavement Design Report
Baseline Road – 57th Avenue to 61st Avenue
Phoenix, Arizona

In accordance with your request and authorization, Alpha Geotechnical & Materials, Inc. (Alpha) has performed a geotechnical subsurface exploration for the planned reconstruction of asphaltic pavement as part of the overall State Route 202 improvements along Baseline Road, between 57th Avenue and 61st Avenue in Phoenix, Arizona. The purpose of this report is to evaluate the subgrade conditions and confirm a previously designed and approved asphaltic concrete (AC) pavement section.

This report presents a project description, a discussion of roadway subgrade conditions and recommended design of flexible pavement structures.

We appreciate the opportunity to provide our services for this project. If you have questions regarding this report or if we may be of further assistance, please contact the undersigned.

Sincerely,

ALPHA GEOTECHNICAL & MATERIALS, INC.

Registered Professional Engineer (Civil) CERTIFICATE NO. 63517 GARRETT CLATANOFF DATE SIGNED 12-7-18 ARIZONA U.S.A. Expires: 3/31/2020

Garrett Clatanoff, PE
Geotechnical Engineer

Reviewed By:

Registered Professional Engineer (Civil) CERTIFICATE NO. 51569 STEPHEN V. HARGUS Date Signed 12-7-18 ARIZONA, U.S.A. Expires 12/31/2019

Stephen V. Hargus, PE
Senior Geotechnical Engineer

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1.0 INTRODUCTION

This report presents the results of the geotechnical investigation in support of the planned reconstruction of asphaltic pavement as part of the overall State Route 202 improvements along Baseline Road, between 57th Avenue and 61st Avenue in Phoenix, Arizona. The scope of services is in general accordance with our proposal 18-G-7856, dated October 17, 2018.

Evaluations of the geotechnical conditions beneath the planned roadways were performed to support the design of the planned pavement structures. This report presents a summary of the subsurface investigation, laboratory results, subgrade conditions, a review of the proposed pavement section, and recommended pavement sections for asphaltic concrete (AC) pavement construction.

2.0 PROJECT DESCRIPTION

The project is located on Baseline Road, between 57th Avenue and 61st Avenue in Phoenix, Arizona. The proposed construction will consist of the reconstruction of existing asphaltic pavement along Baseline Road as part of the overall State Route 202 improvements. Alpha completed geotechnical investigation along Baseline Road to evaluate the subgrade conditions and confirm a previously designed and approved asphaltic concrete pavement section. The pavement design was completed in general accordance with the City of Phoenix design guidelines (2009). The approved AC pavement section consists of 8 inches of AC placed directly over 12 inches of previously compacted subgrade.

3.0 INVESTIGATION

3.1 Review of Existing Documents

The following documents were provided by the City of Phoenix and were reviewed for information to assist with the pavement design:

- *Baseline Road Traffic Interchange Traffic Report* by Connect 202 Partners, November 29, 2016.

3.2 Subsurface Investigation

A subsurface investigation was conducted on November 14, 2018, by Garrett Clatanoff, PE of Alpha. Four soil brings to a depth of approximately 5 feet below existing site grades for a total drill depth of 20 feet. Two borings were completed in the existing roadway (B-1 and B-2) and

two borings were completed on the unpaved shoulder (B-3 and B-4). The site plan in **Figure 1** shows the approximate location of each boring.

A CME-75 truck-mounted drill rig utilizing an 8-inch outer-diameter hollow stem auger was used to advance the soil borings. The soils encountered at each soil boring were visually classified in general accordance with ASTM D2488 and recorded on a field log. Spoon samples from standard penetration testing (SPT) or ring samples were collected at 2.5 foot intervals. A bulk sample from the upper five feet was also collected at each boring. Samples were submitted to the laboratory for testing. After completion of the laboratory tests on the samples retrieved, the field logs were reviewed and modified, where necessary, to produce the final borings logs presented in **Appendix A**.

Arizona 811 was contacted prior to the start of drilling to locate existing utilities at the boring locations. The borings were backfilled with excavated materials and the surface of borings B-1 and B-2 were patched with cold patch.

3.3 Laboratory Testing

Selected soil samples from the borings were tested in the laboratory for classification purposes and to evaluate their engineering properties. The laboratory tests included:

- Sieve analysis and plasticity index (Atterberg limits) – Soil classification. (ASTM C117/C136) (ASTM D4318);
- Moisture-Density Relationship (Proctor) – Determination of the remolded density and moisture content for the one-dimensional swell (ASTM D698); and,
- One-Dimensional Swell – Assessment of swell potential of near-surface soils under the pavement (ASTM D4546).

A brief description of each test preformed on the soil samples and the results are presented in **Appendix B**. Laboratory test results are summarized in **Table B-1** along with individual laboratory sheets are also provided in **Appendix B**.

4.0 SITE CHARACTERIZATION

4.1 Site Conditions

Construction of an overpass is in progress along Baseline Road as part of State Route 202 improvements. Baseline Road is currently a two-lane, asphalt paved roadway. The site is immediately adjoined by agricultural land to the north and south. Residential areas, consisting of primarily single family homes, are located east and west of the site. A high school is present southeast of the site. Site topography was relatively flat.

4.2 Existing Pavement

The existing pavement thickness was measured during the subsurface investigation at borings B-3 and B-4. The following table shows the existing pavement thicknesses.

Existing Pavement Thickness

Boring	AC (inches)	Aggregate Base (inches)
B-3	6.5	8.0
B-4	7.0	9.0

4.3 Roadway Geotechnical Profile

The subsurface soils encountered during the investigation consisted primarily of sandy clays (CL) and clayey sands (SC) with occasional to trace fine grained gravel. The fines content (material passing the No. 200 sieve) of the laboratory tested soils ranged between 48 and 65 percent. The soils were typically uncemented with low to medium plasticity. SPT blow counts were typically below 20 with an isolated refusal blow count at B-1 likely because the boring was drill through existing construction access road. Bedrock and groundwater were not encountered.

4.4 Subgrade Support

This section presents the results of completed laboratory testing and recommended design, based on procedures presented in the ADOT Pavement Design Manual (ADOT 2017). The tested samples were within 5 feet or less of the proposed finished grade and are representative of the materials that will form the final roadway subgrade.

Appendix C presents the results of the four correlated R-values which were determined using Table 2-3 in the ADOT Pavement Manual (ADOT 2017). The correlated R-values ranged from 23 to 36 with a mean correlated R-value of 30 and a standard deviation of 6.21. No R-values tested as part of this report. An R-value of 25 was selected for design based on the mean and standard deviation of the correlated test results.

Using a seasonal variation factor (SVF) of 1.0 for project area and the design R-value, the subgrade resilient modulus (Mr) is 14,900 pounds per square inch (psi).

4.5 Swell Potential

Two swell tests were performed in accordance with ASTM D4546 on samples from B-1 and B-3 and the results were 0.8 and 0.7 percent swell, respectively. The samples were remolded to 95 percent of the maximum dry density and minus two percent of the optimum moisture content

determined in accordance with ASTM D698 and loaded to 144 pounds per square foot. Based on these results, there is limited potential for swell for the existing site soils.

5.0 PAVEMENT DESIGN

5.1 Traffic Design Parameters

5.1.1 Traffic Volumes

Traffic volumes for the project were determined utilizing the City of Phoenix *Traffic Volume Map* (2018). **Appendix C** presents the traffic data analysis and computed equivalent single-axle loads (ESALs) used in the pavement design for Baseline Road. A summary of the ESALs for the design years is presented in **Appendix C**.

5.1.2 Growth Rate

The Baseline Road Traffic Interchange Traffic Report (Connect 202 Partners 2016) did not provide a growth rate. Alpha estimated a constant growth rate of 2 percent for the design life of the roadway.

5.1.3 Percent Trucks

A recent traffic study performed by the City of Phoenix for this section of Baseline Road measured 5 percent trucks. This value was utilized in the design.

5.1.4 Load Equivalency Factors

A truck factor equal to 1.2, which corresponds to a heavy truck, was used in the design along with an automobile factor equal to 0.0008.

5.1.5 Directional Distribution

The traffic volumes from the City of Phoenix Traffic Volume Map (2018) showed 11,001 vehicles in the westbound direction and 10,450 vehicles in the eastbound direction equal to a split of 51 percent to 49 percent, respectively. A 51 percent direction distribution was used for the design.

5.1.6 Lane Distribution

After the State Route 202 improvements are complete, the mainline lane configuration will consist of three lanes in each direction. A lane distribution factor of 70 percent was used.

5.1.7 Design ESALs

The determination of ESALs was done using the criteria presented in the previous sections. A summary of all ESAL calculations is presented in **Appendix C**.

5.2 Pavement Design Parameters

5.2.1 Combined Standard Error and Level of Reliability

A combined standard error of 0.40 was used for “Arterials”. This value is in accordance with current City of Phoenix design guidelines.

A level of reliability of 95 percent was selected, requiring a standard normal deviate (Z_r) value of –1.645 be used for design.

5.2.2 Serviceability Index

A change in serviceability index (Δ_{psi}) of 2.5 was assigned in accordance with current City of Phoenix design guidelines.

5.2.3 Resilient Modulus

As discussed in Section 4.4 of this report, an R-value of 25 was selected for the design of all pavements. A resilient modulus of 14,900 psi was determined based on the design R-value of 25 and a seasonal variation factor of 1.0 for the project.

5.2.4 Drainage Coefficient

A drainage coefficient of 1.00 was assigned based on a seasonal variation factor of 1.0 for the project area and fair drainage conditions associated with the subgrade.

5.2.5 Structural Coefficients

A structural coefficient of 0.39 was selected for design for the asphaltic concrete.

5.3 Flexible Pavement Design

The Baseline Road structural number (SN) was calculated using a 20-year design life starting in 2019. The minimum required SN for the pavement section is 3.28 and the design SN is 3.32. The calculations to determine the structural numbers are provided in **Appendix C**.

6.0 RECOMMENDATIONS

6.1 Pavement Section

The recommended pavement section is 8.5 inches of AC placed directly over compacted subgrade. This pavement section is 1/2-inch thicker than the previously approved AC pavement section which consists of 8 inches of AC placed directly over 12 inches of compacted subgrade.

6.2 Subgrade Acceptance

As discussed in Section 4.4 of this report, an R-value of 25 was selected for the design of all pavements. A subgrade acceptance chart has been provided on **Figure 2**. Should import material be necessary, it should be verified using **Figure 2** based on fines content (material passing the No. 200 sieve) and plasticity index. In addition, the swell potential of the import material should be less that 2 percent when tested in accordance with ASTM D4546 and remolded to 95 percent of the maximum dry density and minus 2 percent of optimum moisture.

6.3 Subgrade Preparation

The subgrade should be scarified, moisture conditioned and compacted to 95 percent of the maximum dry density and within a range of plus 2 percent and to minus 2 percent of the optimum moisture content as determined by ASTM D698.

7.0 CLOSURE

7.1 Limitations

Our professional services have been performed using the degree and skill ordinarily exercised, under similar circumstances, by reputable Geotechnical Engineers practicing in this or similar localities. No warranty is expressed or implied.

The recommendations contained in this report are based on our field exploration, laboratory test results, and our understanding of the proposed construction. The subsurface data used in the preparation of this report was obtained from the test borings excavated during the field subsurface exploration. It is anticipated that some variations in the soil conditions will exist on-site. The nature and extent of variations may not be evident until construction occurs. If any conditions are encountered at this site that are different from those described in this report, we should be immediately notified so that we may make any necessary revisions to the recommendations contained in this report. In addition, if the scope of the proposed construction changes from that described in this report, our firm should also be notified.

It is the Client's responsibility to see that all parties to the project including the designer, contractor, subcontractor, etc. are made aware of this report in its entirety. The use of information contained in this report for bidding purposes should be done at the contractor's option and risk.

This report is for the exclusive purpose of providing Geotechnical Engineering and/or testing information and recommendations. The scope of services for this project does not include, either specifically or by implication, any environmental assessment of the site or identification of contaminated or hazardous materials or conditions. If the owner is concerned about the potential for such contamination, other studies should be undertaken. This report has also not addressed the site geology and the possible presence of geologic hazards.

This report may be used only by the Client and only for the purposes stated, within a reasonable time from its issuance. Land use, site conditions (both on and off-site), or other factors may change over time, and additional work may be required with the passage of time. Any party, other than the Client, who wishes to use this report, should notify Alpha of such intended use. Based on the intended use of this report, Alpha may require that additional work be performed and that an updated report be issued.

7.2 Recommended Additional Services

This report is a **pavement design report** completed for **Baseline Road between 57th Avenue and 61st Avenue**.

The recommendations provided in this report are based on the assumption that an adequate program of tests and observations will be performed during the construction. These tests and observations should be performed by the Geotechnical Engineer's representative and should include, but are not necessarily be limited to the following:

- Observe and document that any existing surficial vegetation and other deleterious materials have been removed from the site as required.
- Approve any import material to document that it meets the requirements outlined in this report.
- Monitor the scarification operations of the exposed subgrade.
- Perform field density tests, as needed, to verify compaction compliance. The representative should monitor the progress of compaction and filling operations.
- Keep records of on-site activity and progress.

8.0 REFERENCES

Arizona Department of Transportation, 2017. *Pavement Design Manual*. Roadway Engineering Group, Pavement Design Section, September 29.

City of Phoenix, 2009. *Street Planning and Design Guidelines*, Maintained by: Design Section, Planning, Design, and Programming Division, Street Transportation Department, December 1.

City of Phoenix, 2018. Traffic Volume Map accessed at https://www.phoenix.gov/streets/traffic-management/traffic-volume-map in November, 2018.

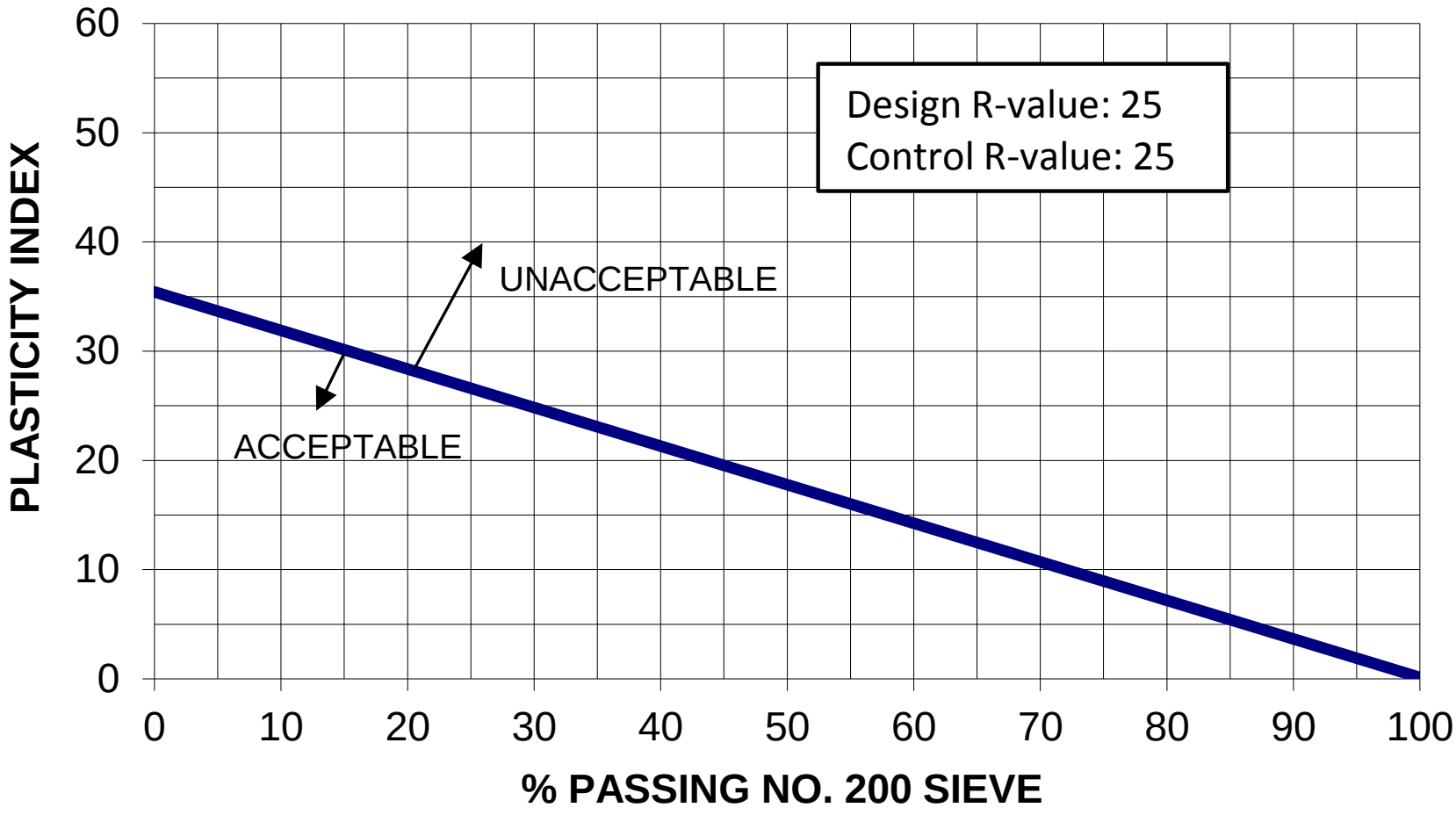
Connect 202 Partners, 2016. *Baseline Road Traffic Interchange Traffic Report-Final*, SR 202L (South Mountain Freeway), I-10 (Maricopa Freeway) - I-10 (Papago Freeway), November 29.

Figures

Baseline Road & 59th Avenue **Phoenix , Arizona**	**Figure 1 – Site Map**	**Alpha Geotechnical & Materials, Inc.**
	Boring to 5 – foot depth 2018 Google Earth	

Figure 2 - SUBGRADE ACCEPTANCE CHART

Baseline Road - 57th Avenue to 61st Avenue
Phoenix, Arizona



APPENDIX A
Field Investigation

FIELD INVESTIGATION

SOIL TEST BORINGS

The subsurface conditions at the site were explored November 14, 2018, by advancing four soil test borings using a CME-75 truck mounted drill rig. The locations of soil test borings advanced for this investigation are shown in Figure 1 of the report.

Our field engineer maintained a log of the excavations; visually classified soils encountered according to the Unified Soil Classification System (USCS) (see USCS Table) and obtained samples of the subsurface materials.

SAMPLING PROCEDURES

Bulk samples were taken from the test borings at selected intervals. Soil samples were packaged and sealed in the field to reduce moisture loss and disturbance, and returned to our laboratory for further testing. After the soil test borings were completed, they were backfilled with the excavated soils.

LIST OF ATTACHMENTS

The following exhibits are attached and complete this appendix.

Unified Soil Classification System
Logs of Soil Test Borings

UNIFIED SOIL CLASSIFICATION SYSTEM					CONSISTENCY OR RELATIVE DENSITY		
Major Divisions			Group Symbols	Typical Names	CRITERIA		
Coarse-Grained Soils (More than 50% retained on No. 200 sieve)	Gravels (50% or more of coarse fraction retained on No. 4 sieve)	Clean Gravels	GW	Well-graded gravels and gravel-sand mixtures, little or no fines	**Standard Penetration Test** Density of Granular Soils		
			GP	Poorly graded gravels and gravel-sand mixtures, little or no fines	Penetration Resistance N (blows/ft)	Relative Density	
		Gravels With Fines	GM	Silty gravels, gravel-sand-silt mixtures			
			GC	Clayey gravels, gravel-sand-clay mixtures	0-4	Very Loose	
	Sands (More than 50% of coarse fraction passes No. 4 sieve)	Clean Sands	SW	Well-graded sands and sand-gravel mixtures, little or no fines	5-10	Loose	
			SP	Poorly graded sands and sand-gravel mixtures, little or no fines	11-30	Medium	
		Sands With Fines	SM	Silty sands, sand-gravel-silt mixtures	31-50	Dense	
			SC	Clayey sands, sand-gravel-clay mixtures	>50	Very Dense	
Fine-Grained Soils (50% or more passes No. 200 sieve)	Silts and Clays (Liquid Limit 50% or less)		ML	inorganic silts, very fine sands, silty or clayey fine sands, clayey silts with slight plasticity	**Standard Penetration Test** Consistency of Cohesive Soils		
			CL	Inorganic clays of low to medium plasticity, gravelly clays, siltly clays, sandy clays lean clays	Penetration Resistance N (blows/ft)	Consistency	Unconfined Compressive Strength (Tons/ft2)
			OL	Organic silts and organic silty clays of low plasticity	0-4	Very Soft	<0.25
	Silts and Clays (Liquid Limit greater than 50%)		MH	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts	5-8	Soft	0.25-0.50
			CH	Inorganic clays of high plasticity, fat clays	9-15	Moderately Firm	0.50-1.00
			OH	Organic clays and organic silts of medium to high plasticity	16-30	Firm	1.00-2.00
Highly Organic Soils			PT	Peat, humus, and swamp soils with high organic content	31-50	Very Firm	2.00-4.00
					50+	Hard	>4.0

		3"		3/4"	#4	#10	#40	#200 U.S. Standard Sieve
Unified Soil Classification	Cobbles	Gravel			Sand			Silt or Clay
		coarse	fine		coarse	medium	fine	

MOISTURE CONDITIONS

Slightly Moist	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water; usually is below water table

MATERIAL QUANTITY

rare	<2%
occasional	<5%
trace	10%
some	20%
considerable	30%

OTHER SYMBOLS

U	Undisturbed
S	SPT Sample
A	Bulk Sample
▼	Groundwater
Qp	Pocket Penetrometer

BASIC LOG FORMAT:
Group name, Group symbol, (grain size), color, moisture, consistency or relative density. Additional comments: odor, presence of roots, mica, gypsum, coarse grained particles, ect

UNIFIED SOIL CLASSIFICATION SYSTEM

Alpha Engineering | Testing | Solutions

Alpha Project Number:	18-G-7856	**Boring No.**	B-1
Project Name:	Baseline Road- 57th Avenue to 61st Avenue	**Rig Type:**	CME-75
Project Location:	Phoenix, Arizona	**Boring Type:**	Hollow Stem Auger
Date(s) Complete:	11/14/2018	**Boring Location:**	See site plan

Depth (Feet)	Sample	Sample Type	Blow Count (6 inch Interval)			Dry Density (PCF)	Moisture (%)	Unified Soil Classification	Remarks
0									
		S		50/5"				CL	moist moderately firm to hard
		U		44	(NR)				
5		S	3	4	5				
10									
15									
20									

Field and Drilling Notes:
NR = no recovery

Visual Classification

SANDY CLAY
Trace fine grained, subangular to subrounded gravel, considerable predominantly fine-grained sand, low plasticity, brown

NOTE: Sandy silt lenes from 0 to 5 feet.

NOTE: Boring located on access road of existing construction site.

Stopped Auger at 4.5'
Sampled to 6.0'
Backfilled with drill cuttings

The stratification lines represent the approximate boundary lines between soil and rock types: In-situ, the transition may be gradual.

Sample Type Key: S = Split Spoon
A = Auger Cuttings U = Relatively Undisturbed Ring D = Disturbed Bulk

Alpha Geotechnical & Materials, Inc.
2504 West Southern Avenue
Tempe, Arizona 85282

GROUNDWATER		
DEPTH	TIME	DATE
N/A	N/A	N/A

Alpha Project Number:	18-G-7856	**Boring No.**	B-2
Project Name:	Baseline Road- 57th Avenue to 61st Avenue	**Rig Type:**	CME-75
Project Location:	Phoenix, Arizona	**Boring Type:**	Hollow Stem Auger
Date(s) Complete:	11/14/2018	**Boring Location:**	See site plan

Depth (Feet)	Sample	Sample Type	Blow Count (6 inch Interval)			Dry Density (PCF)	Moisture (%)	Unified Soil Classification	Remarks
0									
		S	7	6	6			CL	moist very soft to moderately firm
		U		8					
5		S	1	2	2				
10									Stopped Auger at 4.5' Sampled to 6.0' Backfilled with drill cuttings
15									
20									

Field and Drilling Notes:

Visual Classification

SANDY CLAY
Trace fine grained, subangular to subrounded gravel, considerable predominantly fine-grained sand, low plasticity, brown

The stratification lines represent the approximate boundary lines between soil and rock types: In-situ, the transition may be gradual.

Sample Type Key: S = Split Spoon
A = Auger Cuttings U = Relatively Undisturbed Ring D = Disturbed Bulk

Alpha Geotechnical & Materials, Inc.
2504 West Southern Avenue
Tempe, Arizona 85282

GROUNDWATER		
DEPTH	TIME	DATE
N/A	N/A	N/A

Alpha Project Number:	18-G-7856	**Boring No.**	B-3
Project Name:	Baseline Road- 57th Avenue to 61st Avenue	**Rig Type:**	CME-75
Project Location:	Phoenix, Arizona	**Boring Type:**	Hollow Stem Auger
Date(s) Complete:	11/14/2018	**Boring Location:**	See site plan

Depth (Feet)	Sample	Sample Type	Blow Count (6 inch Interval)	Dry Density (PCF)	Moisture (%)	Unified Soil Classification	Remarks	Field and Drilling Notes:
0								**Visual Classification**
								6.5" AC on 8" ABC
						CL		**SANDY CLAY**
		S	5 9 11					Occasioninal fine grained, subangular to subrounded gravel, considerable predominantly fine-grained sand, low to medium plasticity, blackish brown
							moist	**NOTE:** Color change at 4.5 feet to reddish brown
5		S	2 4 6				moderately firm to firm	
								Stopped Auger at 4.5'
								Sampled to 6.0'
								Backfilled with drill cuttings
								Cold patch surface
10								
15								
20								

The stratification lines represent the approximate boundary lines between soil and rock types: In-situ, the transition may be gradual.

Sample Type Key: S = Split Spoon
A = Auger Cuttings U = Relatively Undisturbed Ring D = Disturbed Bulk

Alpha Geotechnical & Materials, Inc.
2504 West Southern Avenue
Tempe, Arizona 85282

GROUNDWATER

DEPTH	TIME	DATE
N/A	N/A	N/A

Alpha Project Number:	18-G-7856	**Boring No.**	B-4
Project Name:	Baseline Road- 57th Avenue to 61st Avenue	**Rig Type:**	CME-75
Project Location:	Phoenix, Arizona	**Boring Type:**	Hollow Stem Auger
Date(s) Complete:	11/14/2018	**Boring Location:**	See site plan

Depth (Feet)	Sample	Sample Type	Blow Count (6 inch Interval)			Dry Density (PCF)	Moisture (%)	Unified Soil Classification	Remarks	Field and Drilling Notes: / Visual Classification
0										**Visual Classification**
										7" AC on 9" ABC
		U		18				**ML**		**SANDY SILT** Occasioninal fine grained, subangular to subrounded gravel, considerable predominantly fine-grained sand, low plasticity, brown
									moist	
									moderately firm	
5										
		S	1	4	5					
										Stopped Auger at 4.5' Sampled to 6.0' Backfilled with drill cuttings Cold patch surface
10										
15										
20										

The stratification lines represent the approximate boundary lines between soil and rock types: In-situ, the transition may be gradual.

Sample Type Key: S = Split Spoon
A = Auger Cuttings U = Relatively Undisturbed Ring D = Disturbed Bulk

Alpha Geotechnical & Materials, Inc.
2504 West Southern Avenue
Tempe, Arizona 85282

GROUNDWATER		
DEPTH	TIME	DATE
N/A	N/A	N/A

APPENDIX B
Laboratory Test Results

APPENDIX B
LABORATORY TESTING

LABORATORY TESTS

Laboratory tests were performed on selected samples to aid in soil classification and to evaluate physical properties of the soils, which may affect the Geotechnical aspects of project design and construction. A description of the laboratory testing program is presented below.

Sieve Analysis

Sieve analyses were performed to evaluate the gradation characteristics of the material and to aid in soil classification. Tests were performed in general accordance with ASTM Test Method C136 and D 2487.

Atterberg Limits

Atterberg Limits tests were performed to aid in soil classification and to evaluate the plasticity characteristics of the material. Additionally, test results were correlated to published data to evaluate the shrink/swell potential of near-surface site soils. Tests were performed in general accordance with ASTM Test Method D 4318.

Moisture-Density Relationship (Proctor)

Proctors were performed to determine the maximum dry density and the optimum moisture content of the material. The test results were used to determine the remolded density and moisture content of the swell tests. Tests were performed in general accordance with ASTM Test Method D 698A.

Swell

Swell tests were performed on remolded bulk soil samples to evaluate the swell potential of the subgrade soils. Test procedures were in general accordance with ASTM Test Method D4546.

Table B-1 - Summary of Laboratory Test Results

Boring Number	Depth (ft[1])		USCS/Group Symbol[2] (ASTM D2487)	Percent Fines (minus No. 200) (ASTMD422)	Percent Sand (Retained Between the No. 4 and No. 200 Sieves)	Percent Gravel (Retained Above No. 4 Sieve)	Liquid Limit (ASTM D4318)	Plasticity Index (ASTM D4318)	Remolded Swell (%[3]) (ASTM D4546)	Optimum Moisture Content (%) (ASTM D698A)	Maximum Dry Density (pcf[4]) (ASTM D698A)
	Begin	End									
B-1	0.0	4.5	CL	51	39	10	26	8	0.8	12.9	117.0
B-2	0.0	4.5	SC	48	43	9	26	11			
B-3	0.0	4.5	CL	65	28	7	33	15	0.7	16.8	109.6
B-4	0.0	4.5	CL	62	32	6	27	12			
		Average		**57**	**36**	**8**	**---**	**---**	**---**	**14.9**	**113.3**
		Standard Deviation		**8**	**7**	**2**	**---**	**---**	**---**	**2.8**	**5.2**
		Minimum		**48**	**28**	**6**	**26**	**8**	**0.7**	**12.9**	**109.6**
		Maximum		**65**	**43**	**10**	**33**	**15**	**0.8**	**16.8**	**117.0**
		Count		**4**	**4**	**4**	**4**	**4**	**2**	**2**	**2**

Notes:

[1] ft = feet

[2] USCS group symbol as determined by laboratory testing (ASTM D2487).

[3] % = percent

[4] pcf = pounds per cubic foot

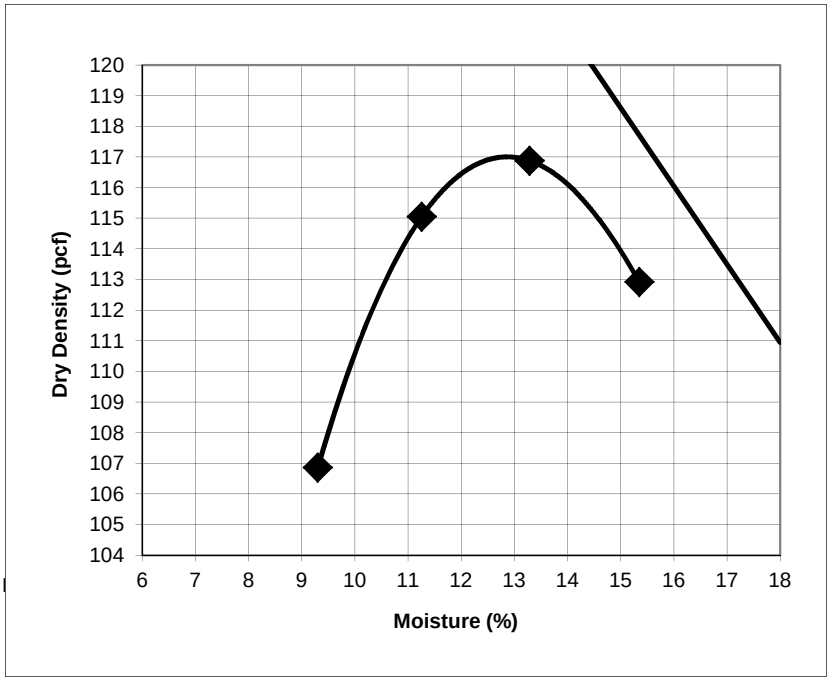
Alpha Geotechnical & Materials, Inc.

Project:	Baseline 57th Avenue to 61st Avenue	**Project Number:**	18-G-7856
Location:	61st Avenue and Baseline Road	**Sample Number:**	37040
Material:	Native Soil	**Sample Date:**	11/14/18
Sample Source:	B-1 @ 0 - 4.5'	**Sampled by:**	RL
Proposed Use:	Pads		

Laboratory Compaction Characteristics of Soils Using
Standard Efforts (12,400ft-lb-ft/cu.ft) (ASTMD698A)
Sieve Analysis of Fine and Coarse Aggregates (AASHTO T27/T11)
Liquid Limit, Plastic Limit, and Plasticity Index of Soils (ASTM D4318) (Dry Prep)

ONE DIMENSIONAL SWELL OR SETTLEMENT POTENTIAL OF COHESIVE SOILS (ASTM D-4546)

	English (pcf)	Metric (kg/cu.m)
Maximum Dry Density:	117.0	1874
Optimum Moisture (%):	12.9	12.9



Sieve Size	Percent Passing
6 in / 152mm	100
4 in / 100mm	100
3 in / 75mm	100
2 in / 50mm	100
1 1/2 in / 37.5mm	100
1 1/4 in / 32 mm	100
1 in / 25 mm	99
3/4 in / 19 mm	98
1/2 in / 12.5 mm	96
3/8 in / 9.5 mm	94
1/4 in / 6.4 mm	92
#4, 4.75mm	90
#8, 2.36mm	89
#10, 2.00mm	87
#16, 1.18mm	85
#30, 0.60mm	82
#40, .425mm	82
#50, .300mm	76
#100, .150mm	66
#200, .075mm	51

LL:	26
PI:	8
% Swell:	0.8
USCS:	CL

Notes:

- The Zero Air Void Curve Represents a Specific Gravity of 2.65 assumed for the -#4 Material.
- This is a Summarized Report of the Referenced Procedures and Does Not Include All Reporting Requirements. Additional Data Can be Provided at Clients Request.

Reviewed by: JV

Alpha Geotechnical and Materials, Inc.
2504 West Southern Avenue
Tempe, Arizona 85282

Alpha Geotechnical & Materials, Inc.

Project:	Baseline 57th Avenue to 61st Avenue	**Project Number:**	18-G-7856
Location:	61st Avenue and Baseline Road	**Sample Number:**	37041
Material:	Native Soil	**Sample Date:**	11/14/18
Sample Source:	B-2 @ 0 - 4.5'	**Sampled by:**	RL
Proposed Use:	Pads		

Sieve Analysis of Fine and Coarse Aggregates (AASHTO T27/T11)
Liquid Limit, Plastic Limit, and Plasticity Index of Soils (ASTM D4318) (Dry Prep)

Mechanical Analysis

Sieve Size	% Passing
6 in / 152mm	100
4 in / 100mm	100
3 in / 75mm	100
2 in / 50mm	100
1 1/2 in / 37.5mm	100
1 1/4 in / 32 mm	100
1 in / 25 mm	100
3/4 in / 19 mm	100
1/2 in / 12.5 mm	99
3/8 in / 9.5 mm	97
1/4 in / 6.4 mm	93
#4, 4.75mm	91
#8, 2.36mm	86
#10, 2.00mm	85
#16, 1.18mm	81
#30, 0.60mm	77
#40, .425mm	75
#50, .300mm	72
#100, .150mm	61
#200, .075mm	48

Atterberg Limits

LL:	26
PL:	15
PI:	11
USCS:	SC

Reviewed by: JV

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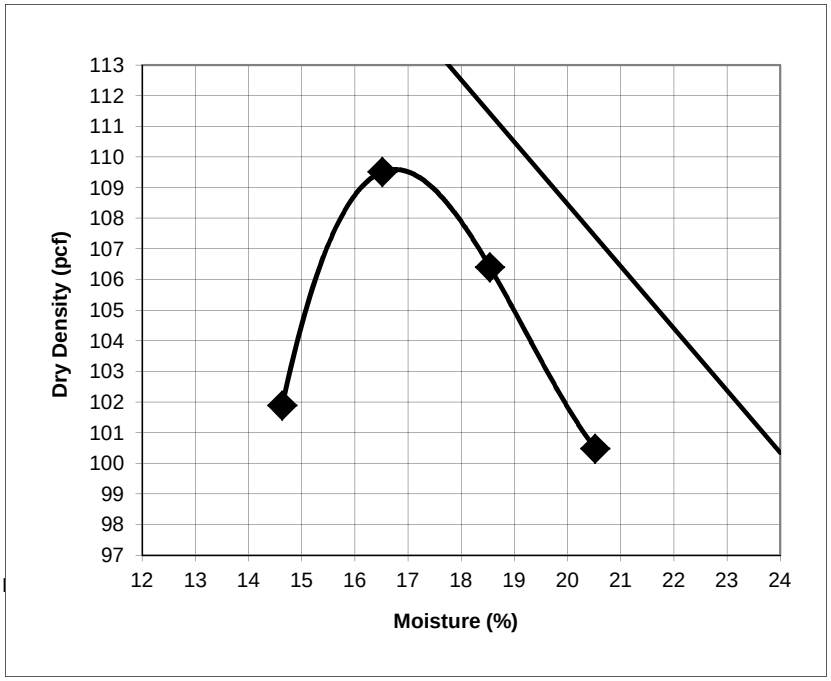
Alpha Geotechnical & Materials, Inc.

Project:	Baseline 57th Avenue to 61st Avenue	**Project Number:**	18-G-7856
Location:	61st Avenue and Baseline Road	**Sample Number:**	37042
Material:	Native Soil	**Sample Date:**	11/14/18
Sample Source:	B-3 @ 0 - 4.5'	**Sampled by:**	RL
Proposed Use:	Pads		

Laboratory Compaction Characteristics of Soils Using
Standard Efforts (12,400ft-lb-ft/cu.ft) (ASTMD698A)
Sieve Analysis of Fine and Coarse Aggregates (AASHTO T27/T11)
Liquid Limit, Plastic Limit, and Plasticity Index of Soils (ASTM D4318) (Dry Prep)

ONE DIMENSIONAL SWELL OR SETTLEMENT POTENTIAL OF COHESIVE SOILS (ASTM D-4546)

	English (pcf)	Metric (kg/cu.m)
Maximum Dry Density:	109.6	1755
Optimum Moisture (%):	16.8	16.8



Sieve Size	Percent Passing
6 in / 152mm	100
4 in / 100mm	100
3 in / 75mm	100
2 in / 50mm	100
1 1/2 in / 37.5mm	100
1 1/4 in / 32 mm	100
1 in / 25 mm	100
3/4 in / 19 mm	100
1/2 in / 12.5 mm	98
3/8 in / 9.5 mm	97
1/4 in / 6.4 mm	95
#4, 4.75mm	93
#8, 2.36mm	88
#10, 2.00mm	87
#16, 1.18mm	84
#30, 0.60mm	82
#40, .425mm	81
#50, .300mm	80
#100, .150mm	75
#200, .075mm	65

LL:	33
PI:	15
% Swell:	0.7
USCS:	CL

Notes:

- The Zero Air Void Curve Represents a Specific Gravity of 2.65 assumed for the -#4 Material.
- This is a Summarized Report of the Referenced Procedures and Does Not Include All Reporting Requirements. Additional Data Can be Provided at Clients Request.

Reviewed by: JV

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Alpha Geotechnical & Materials, Inc.

Project:	Baseline 57th Avenue to 61st Avenue	**Project Number:**	18-G-7856
Location:	61st Avenue and Baseline Road	**Sample Number:**	37043
Material:	Native Soil	**Sample Date:**	11/14/18
Sample Source:	B-4 @ 0 - 4.5'	**Sampled by:**	RL
Proposed Use:	Pads		

Sieve Analysis of Fine and Coarse Aggregates (AASHTO T27/T11)
Liquid Limit, Plastic Limit, and Plasticity Index of Soils (ASTM D4318) (Dry Prep)

Mechanical Analysis

Sieve Size	% Passing
6 in / 152mm	100
4 in / 100mm	100
3 in / 75mm	100
2 in / 50mm	100
1 1/2 in / 37.5mm	100
1 1/4 in / 32 mm	100
1 in / 25 mm	100
3/4 in / 19 mm	100
1/2 in / 12.5 mm	99
3/8 in / 9.5 mm	98
1/4 in / 6.4 mm	96
#4, 4.75mm	94
#8, 2.36mm	92
#10, 2.00mm	90
#16, 1.18mm	88
#30, 0.60mm	84
#40, .425mm	84
#50, .300mm	78
#100, .150mm	72
#200, .075mm	62

Atterberg Limits

LL:	27
PL:	15
PI:	12
USCS:	CL

Reviewed by: JV

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Tempe, Arizona 85282

APPENDIX C
Pavement Design

Calculate Equivalent Single Axle Loads (ESALs)

Average Daily Traffic based on traffic counts	ADT =	21,451
Traffic Count Year	Year =	2017
First Design Year	Year =	2019
Estimated Average Daily Traffic in first design year (two-way)	ADT =	22,318
All trucks ≥ Class 4	% Heavy Trucks =	5%
1-(% Heavy Trucks)	% Cars =	95%
Initial two-way daily 18-kip ESALs	$W_{0(2\text{-}18)}$ =	1,356

Annual growth rate as a percent	g =	2%
Number of years in analysis period	n =	20
Overall Growth Factor	OGF =	24.30
Two way 18-kip ESALs for the analysis period	$W_{2\text{-}18}$ =	12,025,905

Number of Lanes	# =	3
Directional distribution factor	D_D =	0.51
Lane distribution factor	D_L =	0.70
Cumulative 18-kip ESALs for design lane	**W_{18} =**	**4,293,248**

Design Year	Start Year	End Year	Annual ESALs	Cumulative ESALs
1	2019	2020	494,947	494,947
2	2020	2021	504,846	999,793
3	2021	2022	514,943	1,514,735
4	2022	2023	525,241	2,039,977
5	2023	2024	535,746	2,575,723
6	2024	2025	546,461	3,122,184
7	2025	2026	557,390	3,679,575
8	2026	2027	568,538	4,248,113
9	2027	2028	579,909	4,828,022
10	2028	2029	591,507	5,419,529
11	2029	2030	603,337	6,022,867
12	2030	2031	615,404	6,638,271
13	2031	2032	627,712	7,265,983
14	2032	2033	640,266	7,906,249
15	2033	2034	653,072	8,559,321
16	2034	2035	666,133	9,225,454
17	2035	2036	679,456	9,904,910
18	2036	2037	693,045	10,597,955
19	2037	2038	706,906	11,304,861
20	2038	2039	721,044	12,025,905

Pavement Design (City of Phoenix Planning and Design Guidelines)

Roadway Functional Classification Arterials

Effective Roadbed Soil Resilient Modulus (Subgrade Support)

R-Test Values

Correlated R-Values

Plasticity Index	% Passing No. 200	Correlated R-Value	Plasticity Index	% Passing No. 200	Correlated R-Value
8	51	36			
11	48	33			
15	65	23			
12	62	27			

Total R-Value Tests	0	Total Correlated R- Value Tests	4	Mean R-Value	30
Mean of R-value tests		Mean of Correlated R-Value tests	30	Design R-Value	25
Std. Dev of R Value Tests		Std. Dev of correlated R-Value Tests	6.21	Seasonal Variation Factor	1.00

Calculated Resilient Modulus (M_R) 14,900 pounds per square inch (psi)

Design Resilient Modulus 14,900 psi **[Maximum M_R 26,000 psi]**

Reliability

Level of Reliability	95%
Standard Normal Random Variable (Z_R)	-1.645
Overall Standard Deviation (S_0)	0.40

Performance Criteria (Serviceability)

Initial Serviceability (P_0)	5
Terminal Serviceabilty (P_t)	2.5
Change in Serviceability (ΔPSI)	2.5

Traffic Loading

Equivalent Single Axle Loads 4,293,248

Performance Criteria (Serviceability)

Strucutral Number (SN) **3.28**

Roadway Section

	Coefficients			
Material Type	**Material**	**Drainage**	**Thickness**	**Structural Number**
Asphalt Concrete	0.39	1.00	8.5	3.32
Aggregate Base	0.12	1.00		
Select Material	0.11	1.00		
Cement treated base	0.27	1.00		
Bituminous Treated Base	0.31	1.00		
			Design Structural Number	**3.32**
			Required Structural Number	**3.28**