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Engineering Department
10/23/2019 8:58:53 AM
dsdnijkamp
EPC Planning & Community
Development Department

PAVEMENT DESIGN REPORT

VR1818

Gleneagle Subdivision Filing No. 2
Stone Eagle Place
El Paso County, Colorado

SF-18-018

PREPARED FOR:

G & S Development, Inc.
9800 Pyramid Court, Suite 340
Englewood, CO 80112

JOB NO. 172058

October 2, 2019

Respectfully Submitted,

RMG – Rocky Mountain Group

Brian Griffith, E.I.
Geotechnical Staff Engineer

Reviewed by,

RMG – Rocky Mountain Group

Geoff Webster, P.E.
Sr. Geotechnical Project Engineer

COLORADO LICENSED
GEOFF WEBSTER
10/3/19
45046
PROFESSIONAL ENGINEER

TABLE OF CONTENTS

GENERAL SITE AND PROJECT DESCRIPTION

Location

Gleneagle Subdivision filing No. 2 is located east of Struthers Road and north of Gleneagle Drive in El Paso County, Colorado. The subdivision includes one roadway, Stone Eagle Place. The location of the site is shown on the Site Vicinity Map, Figure 1.

Existing Conditions

At the time of our field investigation the proposed streets were close to grade. Sanitary sewer mains and services, and water mains had been installed. Water services were in the process of being installed. Curb and gutter had not been installed.

Project Description

This Pavement Design Report was performed to determine the subsurface conditions present along the roadway alignment and to develop recommendations for the design and construction of the proposed flexible pavements.

The proposed street included in this investigation is shown on Figure 2. Stone Eagle Place has a 50-foot right of way with two 12-foot wide paved travel lanes. The road is classified as Local Low-volume as shown on Sheet C-6 of the Gleneagle Development Plans.

FIELD INVESTIGATION AND SUBSURFACE CONDITIONS

Drilling

The subsurface conditions on the site were investigated by drilling two (2) exploratory test borings at maximum 500-foot spacing along the roadways. The approximate locations of the test borings are presented in the Test Boring Location Plan, Figure 2.

The test borings were advanced with a power-driven, continuous-flight auger drill rig to depths of about 5 to 10 feet below the existing ground surface. Samples were obtained in general accordance with ASTM D-3550 utilizing a 2½-inch OD modified California sampler. Representative bulk samples of subsurface materials were obtained from each boring at a depth of approximately 0 to 2 feet below the existing ground surface. An Explanation of Test Boring Logs is presented in Figure 3. The Test Boring Logs are presented in Figure 4.

Subsurface Materials

The subsurface materials encountered in the Test Borings consisted of well-graded silty sand. Combined bulk samples of the material classified as SW-SM according to the Unified Classification System. For pavement design purposes, a bulk sample of the silty sand classifies as A-1-b (0) in accordance with the American Association of State Highway and Transportation Officials (ASSHTO) classification system. This soil is considered "excellent" for use as subgrade material.

Groundwater

Groundwater was not encountered in the test borings at the time of drilling. Groundwater is not expected to affect the construction of the pavements. Fluctuations in groundwater and subsurface moisture conditions may occur due to variations in precipitation and other factors not readily apparent at this time. Development of the property and adjacent properties may also affect groundwater levels.

LABORATORY TESTING

Laboratory Testing

The moisture content for the recovered samples was obtained in the laboratory. Grain-size analysis and Atterberg Limits tests were performed on selected samples for purposes of classification and to develop pertinent engineering properties. Swell/consolidation tests were not performed as the soil is non-plastic and non-expansive. A Summary of Laboratory Test Results is presented in Figure 5. Soil Classification Data are presented in Figure 6.

A combined bulk sample of A-1-b (0) material was tested to determine the optimum moisture-density relationship curve in accordance with ASTM D1557 (Modified Proctor compaction test). California Bearing Ratio (CBR) tests were performed at varying densities with moisture content near optimum. At 95% of the maximum Modified Proctor density, the CBR of the bulk sample was 25. This value was used in the 1993 AASHTO Empirical Equation for Flexible Pavements to calculate the Design Structural Number, SN, for pavement on this subgrade material. Calculations and pavement recommendations for this soil are presented below. The Moisture-Density Relation Curve is presented in Figure 7. The CBR Test Results are presented in Figures 8 and 9.

The developer intends to install a composite roadway section consisting of Hot Mix Asphalt (HMA) over Aggregate Base Course (ABC). RMG performed a Mix Design for this composite section.

PAVEMENT DESIGN

The discussion presented below is based on the subsurface conditions encountered in the test borings, laboratory test results and the project characteristics previously described. If the subsurface conditions are different from those described in this report or the project characteristics change, RMG should be retained to review our recommendations and modify them, if necessary. The conclusions and recommendations presented in this report should be verified by RMG during construction.

The pavement design was performed in accordance with the El Paso County Engineering Criteria Manual, Appendix D. Pavement design parameters and design calculations are presented below utilizing the CBR value for A-1-b (0) soil. The recommended pavement section shown on Figure 2.1 is supported by the calculations below.

Street Classification – Local (Low-volume)

1) Stone Eagle Place
   ESAL = 36,500 (Table D-2)
   Serviceability Index = 2.0 (Table D-1)

2) Strength coefficients (Table D-3)
   Asphalt (HMA): $a_1 = 0.44$
   Aggregate Base Course Subgrade: $a_2 = 0.11$

3) Subgrade
   M_r = CBR x 1500 = 25 x 1500 = 37,500 psi

4) Structural number (SN) = 1.0 (1993 AASHTO Empirical Equation, Appendix A)

5) Composite asphalt/base course section
   Minimum HMA thickness = D_1 = 3 inches (Table D-2)
   ABC thickness = $D_2 = \{SN – (D_1 \times a_1)\} / a_2 = \{1.0 – (3 \times 0.44)\} / 0.11 < 0$ inches

6) Minimum ABC Thickness = 4.0 inches
   Check SN = (3 x 0.44) + (4 x 0.11) = 1.76 > 1.0 (Min. SN required) => OK

Pavement Thickness

Based on the soil types and the design calculations, the recommended pavement section is presented below and on Figure 2.1.

Recommended Pavement Sections

Streets	HMA (in)	ABC (in)
Stone Eagle Place	3.0	4.0

Pavement Materials

Pavement materials should be selected, prepared, and placed in accordance with El Paso County specifications and the *Pikes Peak Region Asphalt Paving Specifications*. Tests should be performed in accordance with the applicable procedures presented in the specifications.

Soil Mitigation

The PDCM notes that mitigation measures may be required for expansive soils, shallow ground water, subgrade instability, etc. Based on the AASHTO classification of the soils in the subdivision the subgrade soils evaluated for this pavement design are non-expansive. Groundwater or wet and unstable soils were not encountered in the borings. Therefore, special mitigation measures do not appear to be necessary for subgrade preparation.

Subgrade Preparation

Subgrade for Gleneagle Subdivision Filing No. 2 shall be improved native soil. The native well-graded silty sand soil shall be moisture conditioned and compacted in accordance with the El Paso County Engineering Criteria Manual. Prior to placement of the pavement section the final subgrade shall be scarified to a depth of 12-inches, adjusted to within 2 percent of the optimum moisture content as determined by laboratory testing, and recompacted to County specifications. The subgrade shall then be proof-rolled with a heavy pneumatic tire vehicle. Areas which deform under wheel loads shall be removed and replaced with granular non-expansive soil. The final subgrade shall be compacted to a firm and unyielding condition, typically 95 percent of Modified Proctor.

Surface Drainage

Surface drainage is important for the satisfactory performance of pavement. Wetting of the subgrade soils or base course will cause a loss of strength which can result in pavement distress. Surface drainage should provide for efficient removal of storm-water runoff. Water should not pond on the pavement or at the edges of the pavement.

Subgrade Observations and Testing

The pavement thicknesses presented above assume pavement construction is completed in accordance with El Paso County specifications and the *Pikes Peak Region Asphalt Paving Specifications*. RMG should be present at the site during subgrade preparation, placement of fill, and construction of pavements to perform site observations and testing.

CLOSING

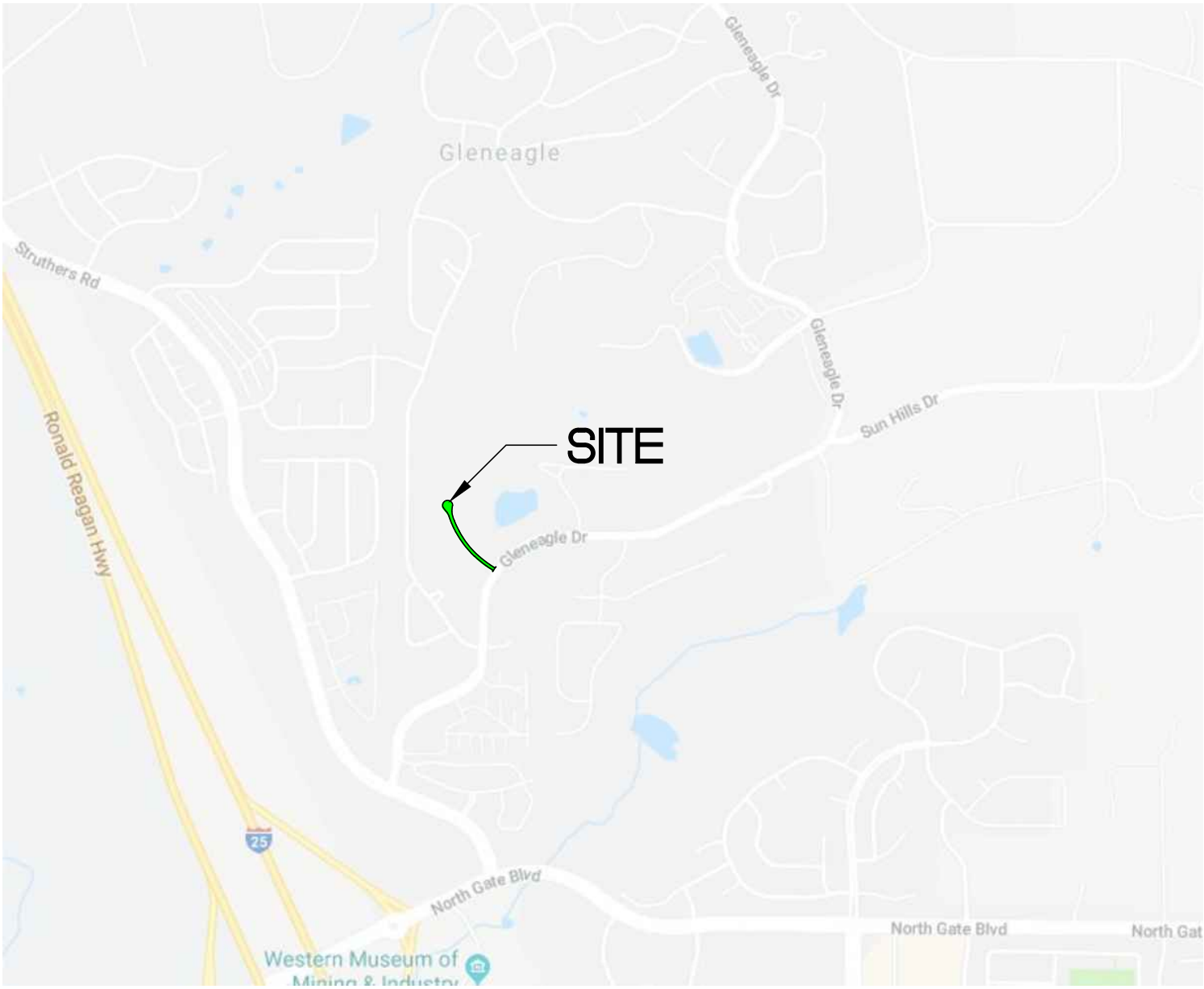
Our field exploration was conducted to provide geotechnical information for pavement thickness design. Variations in subsurface conditions not indicated by the borings may be encountered. This report has been prepared for **G & S Development, Inc.** for application as an aid in the design of the proposed development in accordance with generally accepted geotechnical engineering practices. The analyses and recommendations in this report are based in part upon data obtained from exploratory borings and test pits, site observations and the information presented in referenced reports. The nature and extent of variations may not become evident until construction. If variations then become evident, RMG should be retained to re-evaluate the recommendations of this report, if necessary.

Our professional services were performed using that degree of care and skill ordinarily exercised, under similar circumstances, by geotechnical engineers practicing in this or similar localities. RMG Engineers does not warrant the work of regulatory agencies or other third parties supplying information which may have been used during the preparation of this report. No warranty, express or implied is made. Any contractor reviewing this report for bidding purposes must draw his own conclusions regarding site conditions and specific construction techniques to be used on this project.

This report is for the exclusive purpose of providing geotechnical information and pavement thickness design recommendations. The scope of services for this project does not include, either specifically or by implication, environmental assessment of the site or identification of contaminated or hazardous materials or conditions. Development of recommendations for the mitigation of environmentally related conditions, including but not limited to biological or toxicological issues, are beyond the scope of this report. If the Client desires investigation into the potential for such contamination or conditions, other studies should be undertaken.

If we can be of further assistance in discussing the contents of this report or analysis of the proposed development, from a geotechnical engineering point-of-view, please feel free to contact us.

FIGURES



NOT TO SCALE

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SITE VICINITY MAP

GLENEAGLE GOLF COURSE
RESIDENTIAL INFILL DEVELOPMENT
COLORADO SPRINGS, CO
G & S DEVELOPMENT, INC.

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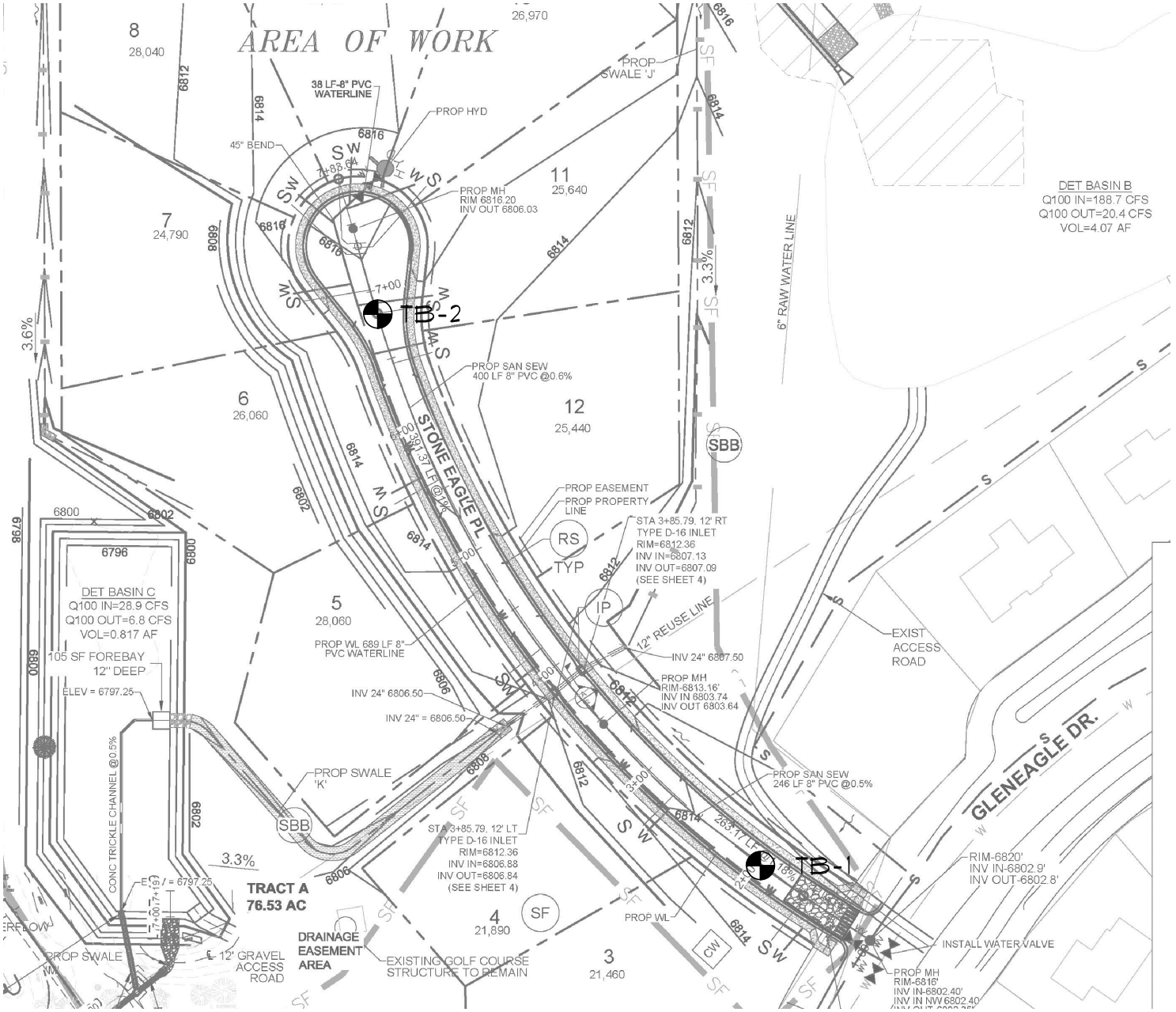
FIG No. 1

DATE 10-2-2019



0 500'

REFERENCE

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DENOTES APPROXIMATE LOCATION OF TEST BORINGS

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TEST BORING LOCATION PLAN

GLENEAGLE GOLF COURSE
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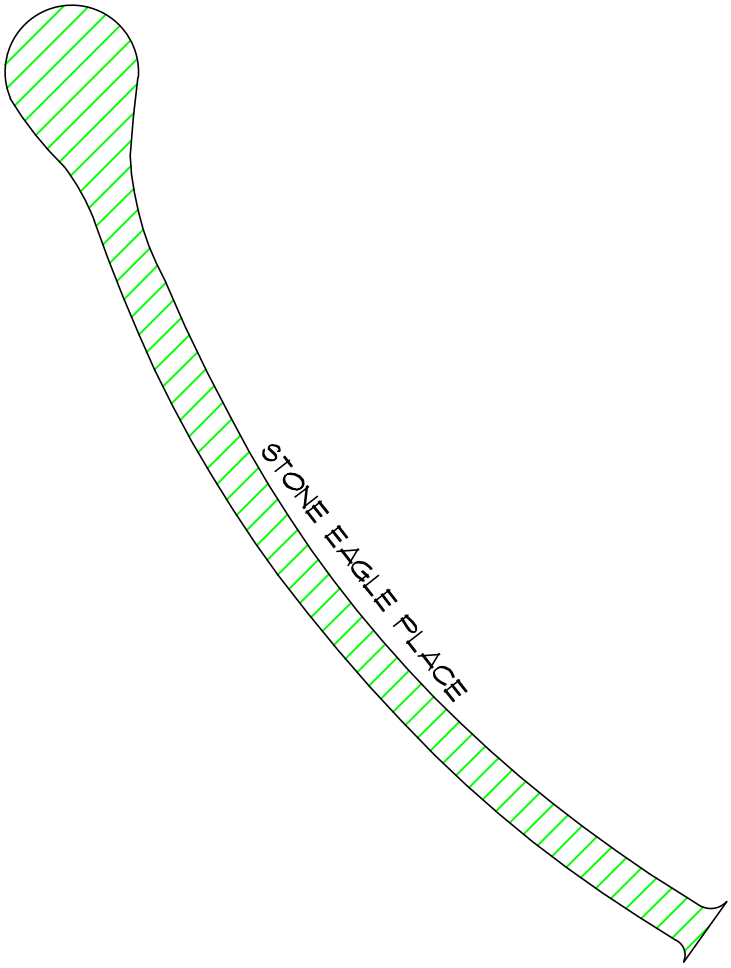
FIG No. 2

DATE 10-2-2019



3" HMA OVER
4" ABC

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PAVEMENT DESIGN

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FIG No. 2.1

DATE 10-2-2019

SOILS DESCRIPTION


FILL: SAND, SILTY TO CLAYEY


SILTY SAND

UNLESS NOTED OTHERWISE, ALL LABORATORY
TESTS PRESENTED HEREIN WERE PERFORMED BY:
RMG - ROCKY MOUNTAIN GROUP
2910 AUSTIN BLUFFS PARKWAY
COLORADO SPRINGS, COLORADO

SYMBOLS AND NOTES


XX — STANDARD PENETRATION TEST - MADE BY DRIVING A SPLIT-BARREL SAMPLER INTO THE SOIL BY DROPPING A 140 LB. HAMMER 30", IN GENERAL ACCORDANCE WITH ASTM D-1586. NUMBER INDICATES NUMBER OF HAMMER BLOWS PER FOOT (UNLESS OTHERWISE INDICATED).


XX — UNDISTURBED CALIFORNIA SAMPLE - MADE BY DRIVING A RING-LINED SAMPLER INTO THE SOIL BY DROPPING A 140 LB. HAMMER 30", IN GENERAL ACCORDANCE WITH ASTM D-3550. NUMBER INDICATES NUMBER OF HAMMER BLOWS PER FOOT (UNLESS OTHERWISE INDICATED).


FREE WATER TABLE


DEPTH AT WHICH BORING CAVED


BULK — DISTURBED BULK SAMPLE


AUG — AUGER "CUTTINGS"

4.5 — WATER CONTENT (%)

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EXPLANATION OF TEST BORING LOGS

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FIGURE No. 3

DATE 10/1/19

TEST BORING: **1** DATE DRILLED: 9/19/19 NO GROUNDWATER ON 9/19/19	DEPTH (IN)	SYMBOL	SAMPLES	BLOWS PER FT.	WATER CONTENT %
SAND, SILTY, light brown, medium dense, moist				24	3.5
				21	4.5
	5				

TEST BORING: **2** DATE DRILLED: 9/19/19 NO GROUNDWATER ON 9/19/19	DEPTH (IN)	SYMBOL	SAMPLES	BLOWS PER FT.	WATER CONTENT %
FILL: SAND, SILTY, light brown, medium dense, moist				28	5.0
SAND, SILTY, dark brown, medium dense, moist				22	6.0
	5				
				30	13.0
	10				

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TEST BORING LOG

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FIGURE No. 4

DATE 10/1/19

Test Boring No.	Depth	Water Content (%)	Dry Density (pcf)	Liquid Limit	Plasticity Index	% Retained No.10 Sieve	% Retained No.40 Sieve	% Passing No. 200 Sieve	% Swell @ 100 psf	AASHTO Classification
1	1.0	5.4		NP	NP	25.4	60.4	12.9		A-1-b (0)
1	2.0	3.5								
1	4.0	4.5								
2	1.0	5.5		NP	NP	22.4	54.9	19.5		A-1-b (0)
2	2.0	5.0								
2	4.0	6.0								
2	9.0	13.0								

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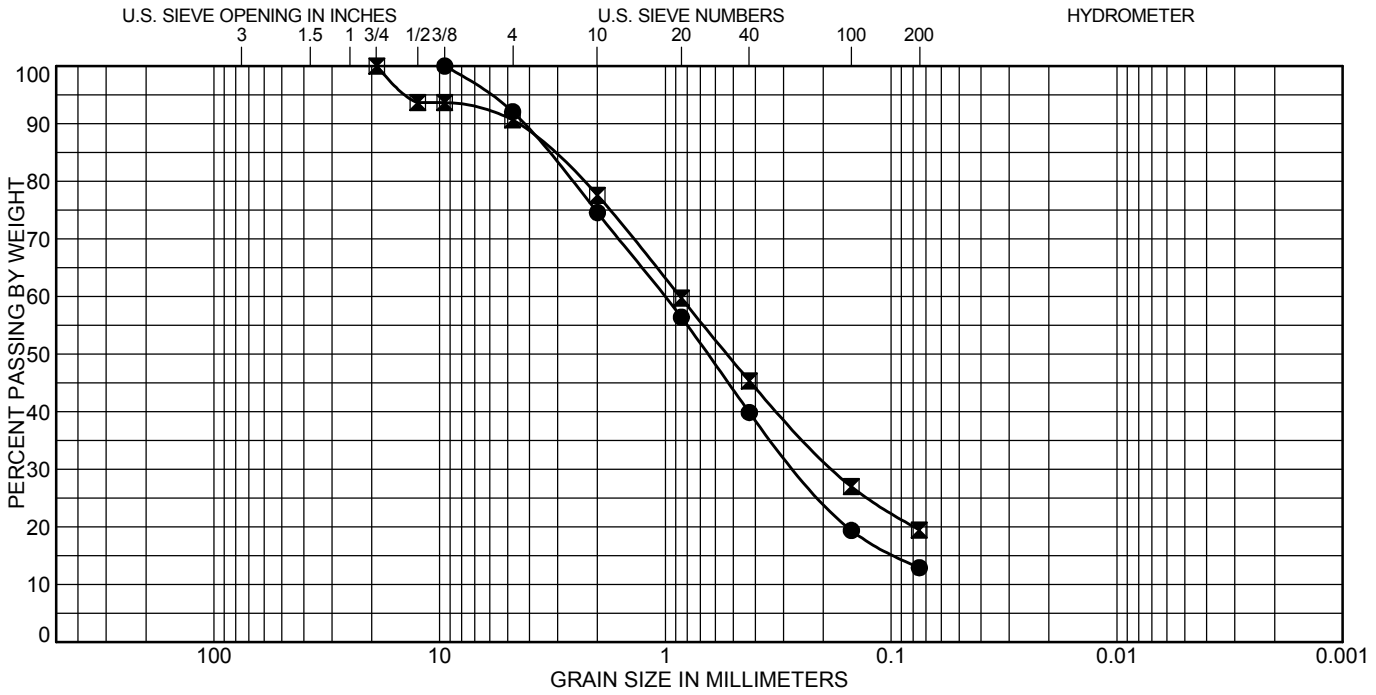
SUMMARY OF LABORATORY TEST RESULTS

JOB No. 172058
FIGURE No. 5
PAGE 1 OF 1
DATE 10/1/19



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Test Boring		Depth (ft)	Classification	LL	PL	PI	Cc	Cu
●	1	1.0	**A-1-b (0)**	**NP**	**NP**	**NP**		
⊠	2	1.0	**A-1-b (0)**	**NP**	**NP**	**NP**		

Test Boring		Depth (ft)	%Gravel	%Sand	%Silt	%Clay
●	1	1.0	**7.9**	**79.2**	**12.9**	
⊠	2	1.0	**9.3**	**71.2**	**19.5**	

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SOIL CLASSIFICATION DATA

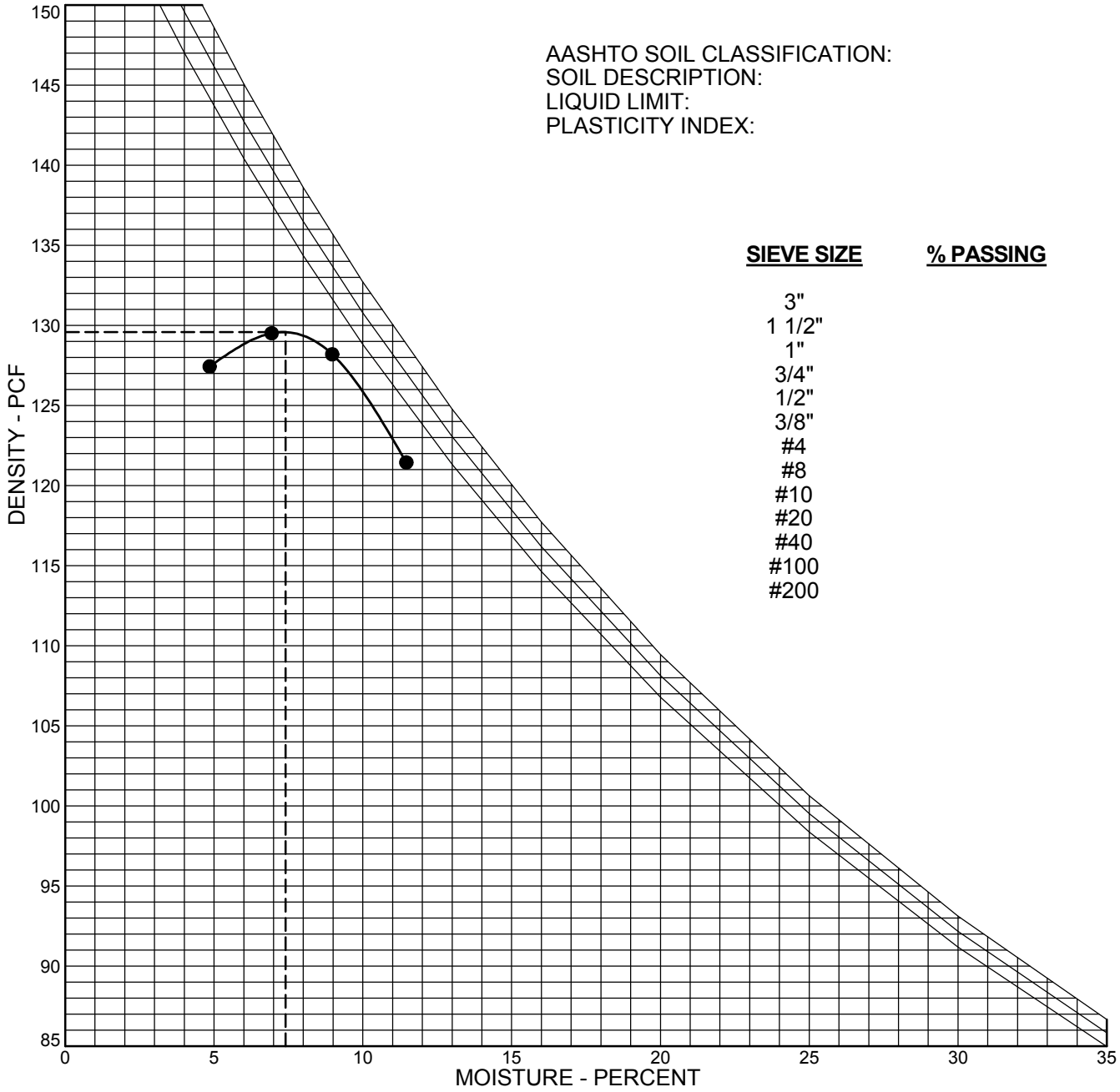
JOB No. 172058

FIGURE No. 6

DATE 10/1/19

CLIENT: **G & S Development, Inc.** SAMPLE NUMBER: **A-1-b**

PROJECT: Gleneagle Golf Course Residential Infill, Filing No. 2, Colorado Springs, Colorado



AASHTO SOIL CLASSIFICATION:
SOIL DESCRIPTION:
LIQUID LIMIT:
PLASTICITY INDEX:

SIEVE SIZE	% PASSING
3"	
1 1/2"	
1"	
3/4"	
1/2"	
3/8"	
#4	
#8	
#10	
#20	
#40	
#100	
#200	

DESIGNATION **AASHTO 1557A**
MAX. DRY DENSITY **129.7 pcf**
OPTIMUM MOISTURE **7.4 %**
FRACTION USED **#4**
MOLD VOLUME **0.0332 cu.ft.**

NOTE:
ZERO AIR VOIDS CURVES PLOTTED FOR:
Gs = 2.60
Gs = 2.65
Gs = 2.70

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MOISTURE-DENSITY RELATION CURVE

JOB No. 172058

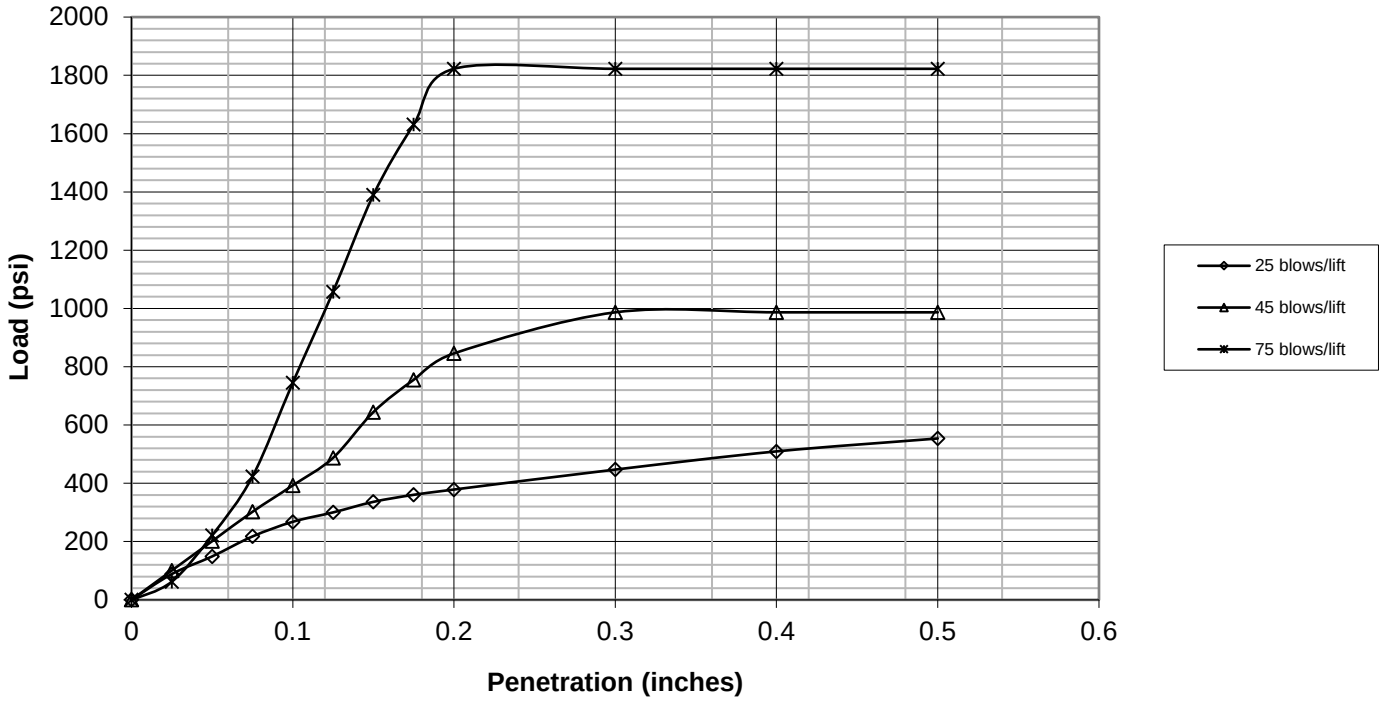
FIGURE No. 7

DATE 10/1/19

CALIFORNIA BEARING RATIO TEST RESULTS

PROJECT: Glen Eagle Filing 2 - Stone Eagle Place
JOB NUMBER: 172058 TEST DATE: 9/27/2019
AASHTO A-1-b
SAMPLE NUMBER: CBR
SAMPLE LOCATION: Combination bulk sample from Test Borings
SOIL DESCRIPTION: Well-graded silty sand

	25 blows/lift	45 blows/lift	75 blows/lift
Penetration (in)	Load (psi)	Load (psi)	Load (psi)
0.000	0.0	0.0	0.0
0.025	88.6	100.7	62.4
0.050	149.0	201.4	221.5
0.075	217.5	302.1	422.9
0.100	267.8	392.7	745.1
0.125	300.1	487.3	1057.2
0.150	336.3	644.4	1389.5
0.175	360.5	755.2	1631.2
0.200	378.6	845.8	1822.5
0.300	447.1	986.7	1822.5
0.400	509.5	986.7	1822.5
0.500	553.8	986.7	1822.5



	25 blows/lift	45 blows/lift	75 blows/lift
Corrected Penetration (in)	Corrected Load (psi)	Corrected Load (psi)	Corrected Load (psi)
0.1	26.8	39.3	74.5
0.2	25.2	56.4	121.5

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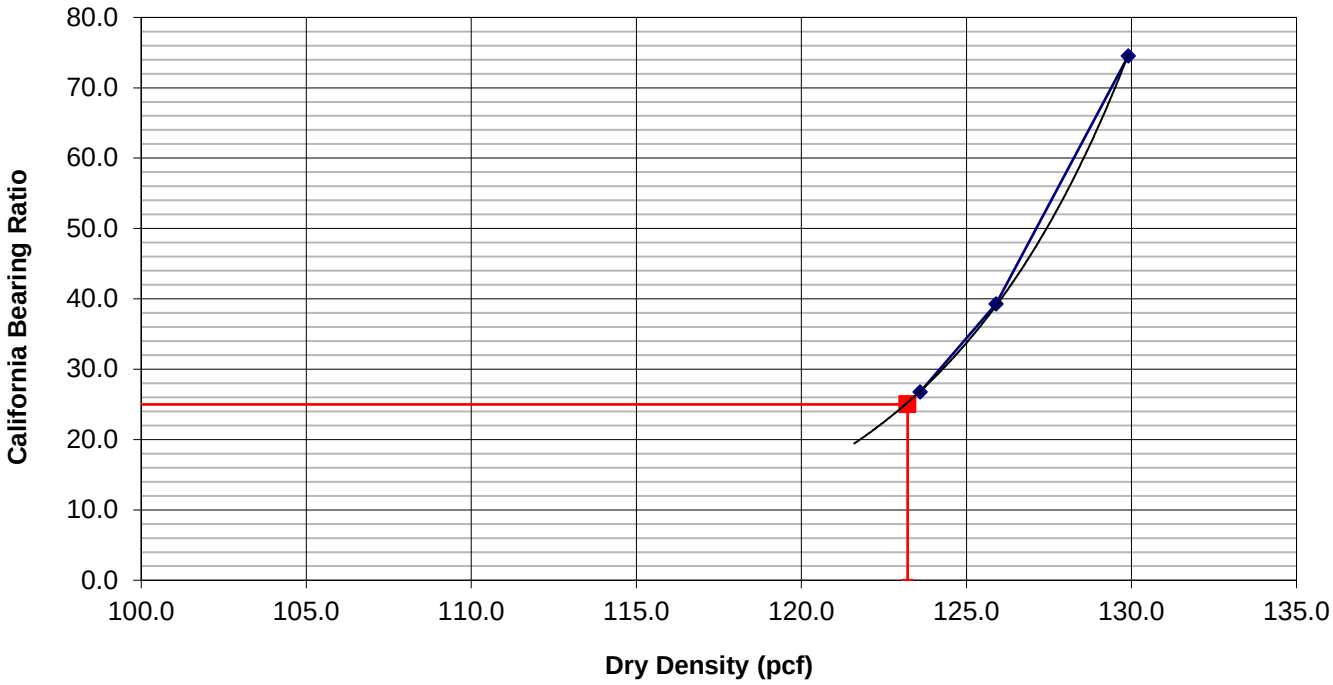
Figure No. 8

CALIFORNIA BEARING RATIO TEST RESULTS

PROJECT:	Glen Eagle Filing 2 - Stone Eagle Place
JOB NUMBER:	172058 TEST DATE: 9/27/2019
AASHTO CLASSIFICATION:	A-1-b
SAMPLE NUMBER:	CBR
SAMPLE LOCATION:	Combination bulk sample from Test Borings
SOIL DESCRIPTION:	Well-graded silty sand

	25 blows/lift	45 blows/lift	75 blows/lift
Corrected California Bearing Ratio	26.8	39.3	74.5
Dry Density (pcf)	123.6	125.9	129.9
Percent Compaction	95	97	100
Percent Moisture After Soaking	10.0	10.2	9.3
Percent Expansion/Compression	0.4	0.3	0.0
Surcharge Weight (lbs)	12.60	12.60	12.60



California Bearing Ratio	**25.0**
Dry Density (pcf)	129.7
Percent Compaction	95.00%
Target Dry Density	123.2
Compaction Test Method	ASTM D-1557
Condition of sample	Soaked

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Figure No. 9

APPENDIX A

1993 AASHTO Empirical Equation for Flexible Pavements

Equation Solver | Variable Descriptions and Typical Values | Precautions

Type in data in the grey boxes and click the calculate button to see the output. To make additional calculations, change the desired input data and click the calculate button again. Click on the text descriptions of the input or output variables for more information.

INPUT

1. Loading

Total Design ESALs (W_{18}): 36500

2. Reliability

Reliability Level in percent (R): 80

Combined Standard Error (S_0): 0.44

3. Serviceability

Initial Serviceability Index (p_i): 4.5

Terminal Serviceability Index (p_t): 2

4. Layer Parameters

Number of Base Layers: 0

	a	m	M_R	Min. Depth
Surface	0.44	1.0	N/A	0
Subgrade	N/A	N/A	37500	N/A

OUTPUT

1. Calculation Parameters

Standard Normal Deviate (z_R): -0.841

ΔPSI: 2.5

Design Structural Number (SN): 0.895

2. Layer Depths (to the nearest 1/2 inch)

Surface: 2.5

Total SN based on layer depths: 1.1

See Solution Details

Comments

Calculate