Architecture
Structural
Geotechnical

ROCKY MOUNTAIN GROUP
EMPLOYEE OWNED

Materials Testing
Forensic
Civil/Planning

APPROVED
Engineering Department
10/21/2020 1:44:59 PM
dsdnijkamp
EPC Planning & Community
Development Department

ADDENDUM to

PAVEMENT DESIGN REPORT

Bent Grass Residential Filing No. 2
El Paso County, Colorado

SF-19-014

PREPARED FOR:

Challenger Communities
8605 Explorer Drive, Suite 250
Colorado Springs, CO 80920

JOB NO. 173851

October 15, 2020

Respectfully Submitted,

RMG – Rocky Mountain Group

COLORADO LICENSED
GEOFF WEBSTER
10/15/20
45046
PROFESSIONAL ENGINEER

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

TABLE OF CONTENTS

GENERAL SITE AND PROJECT DESCRIPTION

Location

Bent Grass Meadows Residential Filing No. 2 is located northwest of the intersection of East Woodmen Road and Meridian Road in El Paso County, Colorado. 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 and utility mains and services had been installed. Curb and gutter had not been installed.

Project Description

This Pavement Design Report provides an Addendum to our report dated May 29, 2020, and includes portions of Berwyn Loop and Bossett Drive not included in the original report.

The proposed streets included in this Pavement Design Addendum are shown on Figure 2. Berwyn Loop and Bossett Drive are classified as Urban Local streets with 50-foot Right-of Ways and two 15-foot travel lanes.

FIELD INVESTIGATION AND SUBSURFACE CONDITIONS

Drilling

The subsurface conditions on the site were investigated by drilling three (3) exploratory test borings. 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 Figures 4 and 5.

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, well-graded silty sand according to the Unified Classification System. For pavement design, the combined bulk soil samples classified in accordance with the American Association of State Highway and Transportation Officials (ASSHTO) classification system primarily as A-1-b soil and A-2-4 soil. This soil classification is considered “excellent to good” 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 to classify the soil and to develop pertinent engineering properties. A Summary of Laboratory Test Results is presented in Figure 6. Soil Classification Data are presented in Figure 7. The soil proved to be non-plastic in laboratory testing, and therefore swell/consolidation testing was not performed.

The soils in this investigation classify the same as the soils presented in the Original Pavement Design Report. As the streets are continuations of streets for which a pavement design has already been prepared, we propose to utilize previously determined laboratory data in this report. Specifically, the moisture-density relationship and California Bearing Ratio (CBR) values are used in this pavement design. The Moisture-Density Relation Curve and CBR Test Results from the original report are presented in Appendix A for reference.

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

PAVEMENT DESIGN

The pavement design was performed using the El Paso County Engineering Criteria Manual, Appendix D. The pavement design parameters and design calculations are presented below.

Street Classification – Urban Local

1) Berwyn Loop, Bossett Drive
   ESAL = 292,000 (Table D-2)
   Serviceability Index = 2.0 (Table D-1)
   Reliability = 80% (Table D-1)

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

3) Subgrade

M_r = CBR x 1500 = 13 x 1500 = 19,500 psi

4) Structural number (SN) = 1.85 (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 x a_1)} / a_2 = {1.85 – (3 x 0.44)} / 0.11 = 4.8 inches

Use Minimum ABC = 8 inches (Table D-2)

Check SN = (3 x 0.44) + (8 x 0.11) = 2.2 > 1.85 (Min. SN required) => OK

Pavement Thickness

The recommended pavement sections are presented below and on Figure 2.1.

Recommended Pavement Section

Berwyn Loop, Bossett Drive	3" HMA	8” ABC

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 for the soils in the subdivision, the subgrade soils evaluated for this pavement design can be expected to be nonexpansive. 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

A composite section of HMA over ABC may be placed atop a 12-inch layer of prepared subgrade. Pavement areas should have topsoil, organic material, and debris removed, and be cleared and grubbed to minimum 24-inches. The upper 6 inches of exposed soil should be scarified and moisture conditioned to facilitate compaction (usually within 2 percent of the optimum moisture content) and compacted to firm and unyielding condition. Subgrade should then be brought to grade by installing clean soil in 8-inch loose lifts and compacted to 95 percent of the maximum dry density as determined by the Modified Proctor test (ASTM D-1557). The subgrade should then be proof-rolled with a heavy, pneumatic tired

vehicle, and any areas that deform under wheel loads should be removed and replaced with clean material and recompacted. Subgrade construction should continue until 12-inches of prepared subgrade has been placed.

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 that 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 **Challenger Communities** 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

ARCHITECTS RMG ENGINEERS
ROCKY MOUNTAIN GROUP

Southern Office
Colorado Springs,CO 80918
(719) 548-0600
Central Office:
Englewood, CO 80112
(303) 688-9475
Northern Office:
Greeley / Evans, CO 80620
(970) 330-1071

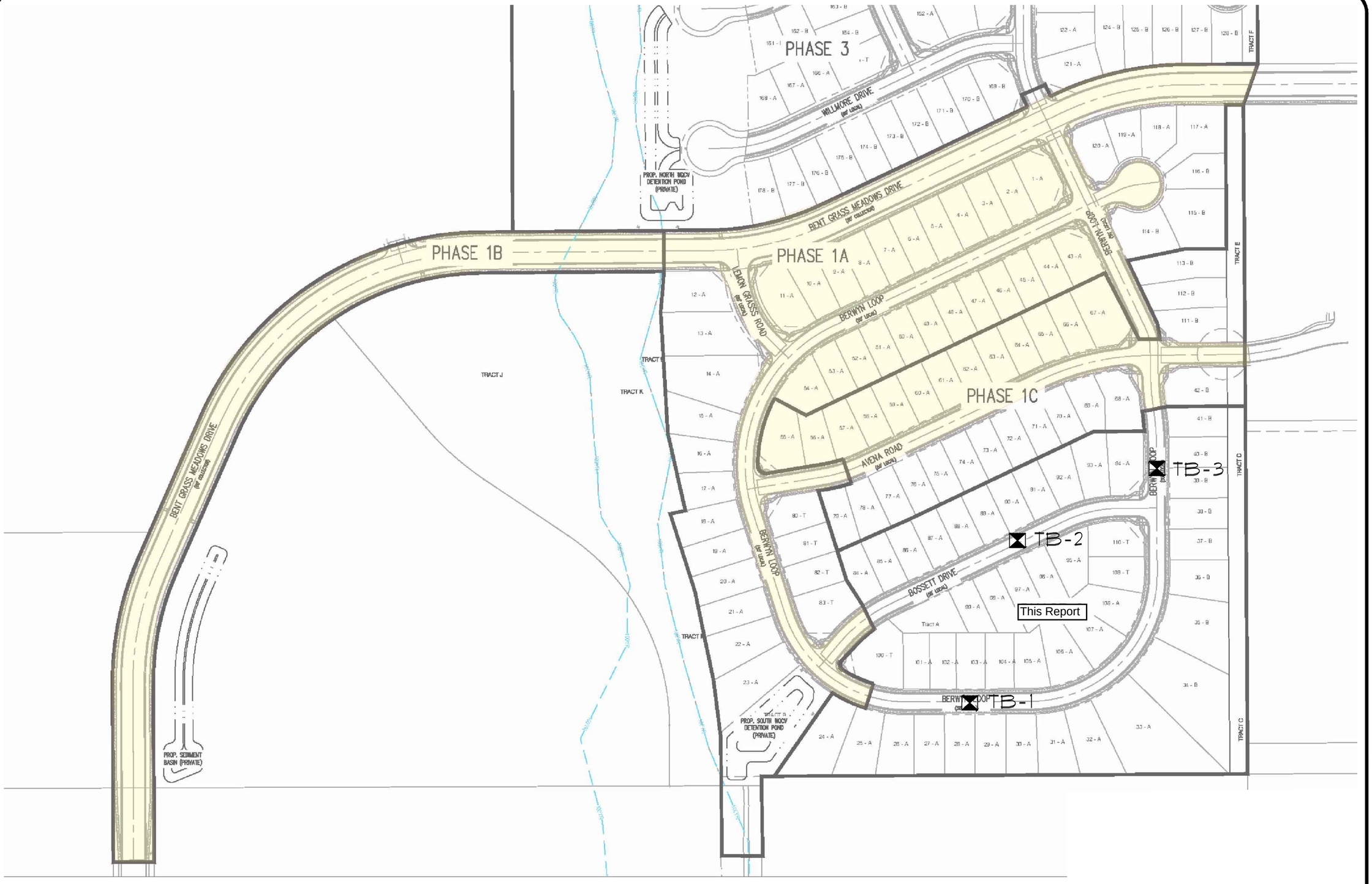
SITE VICINITY MAP

BENT GRASS RESIDENTIAL FILING NO. 2
EL PASO COUNTY, COLORADO
CHALLENGER COMMUNITIES

JOB No. 173851

FIG No. 1

DATE 10-15-2020



NOT TO SCALE

0 500'

REFERENCE

DENOTES APPROXIMATE LOCATIONS OF Test Borings

JOB No. 173851

ARCHITECTS RMG ENGINEERS

ROCKY MOUNTAIN GROUP

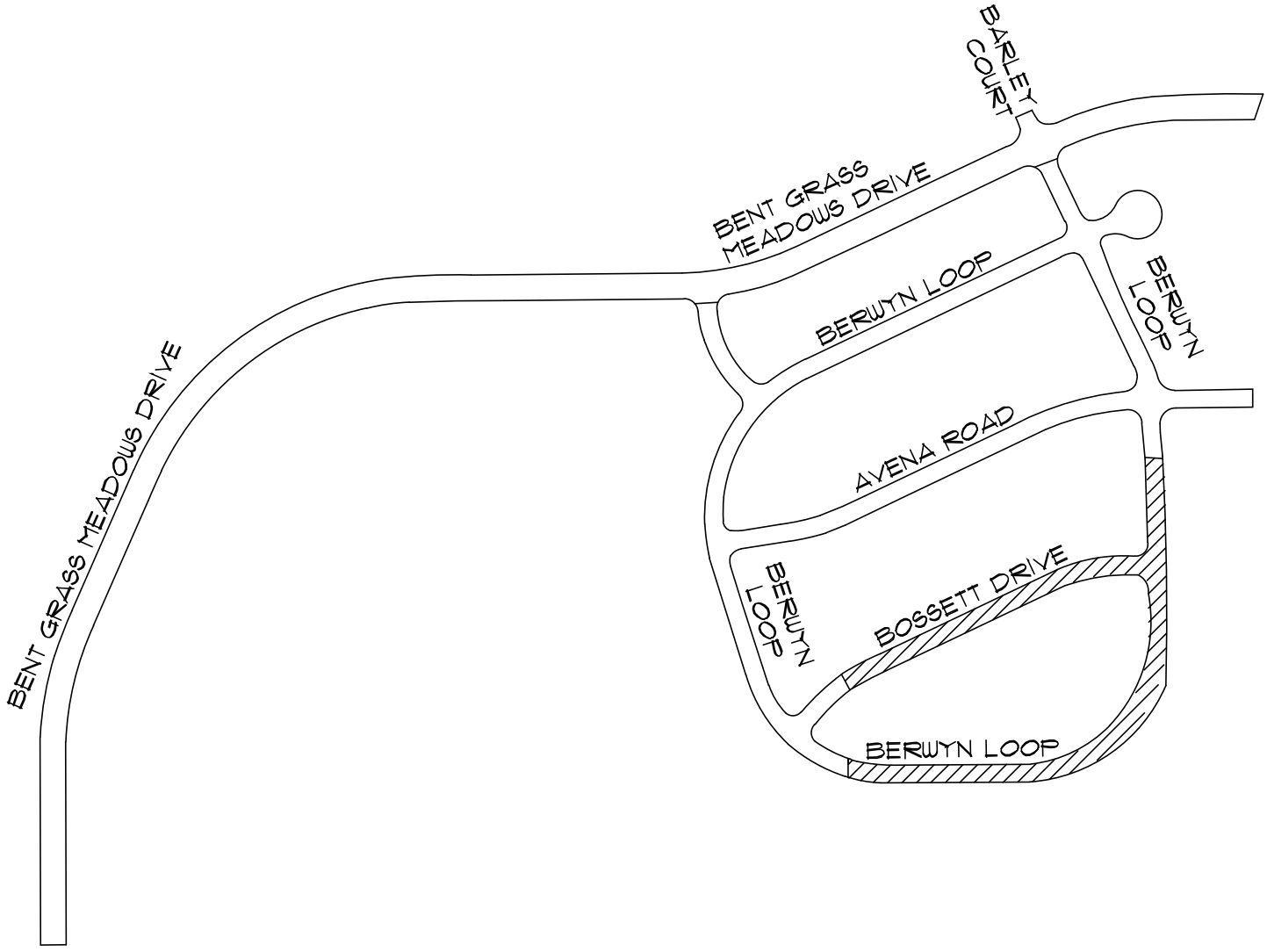
Southern Office
Colorado Springs, CO 80918
(719) 548-0600
Central Office:
Englewood, CO 80112
(303) 688-9475
Northern Office:
Greeley / Evans, CO 80620
(970) 330-1071
Woodland Park Office:
(719) 687-6077
Monument Office:
(719) 488-2145
Pueblo / Canon City:
(719) 544-7750

BENT GRASS RESIDENTIAL
FILING NO. 2
EL PASO COUNTY, COLORADO
CHALLENGER COMMUNITIES

ENGINEER:	GW
DRAWN BY:	BG
CHECKED BY:	GW
ISSUED:	10-15-2020
REVISION:	
	173851

TEST BORING LOCATION PLAN

SHEET No.
FIG-2



3" HMA OVER
8" ABC

NOT TO SCALE

ARCHITECTS RMG ENGINEERS
ROCKY MOUNTAIN GROUP

Southern Office
Colorado Springs,CO
80918
(719) 548-0600
Central Office:
Englewood, CO 80112
(303) 688-9475
Northern Office:
Greeley / Evans, CO 80620
(970) 330-1071

PAVEMENT DESIGN

BENT GRASS RESIDENTIAL FILING NO. 2
EL PASO COUNTY, COLORADO
CHALLENGER COMMUNITIES

JOB No. 173851

FIG No. 2.1

DATE 10-15-2020

SOILS DESCRIPTION

 CLAYEY SAND

 SANDSTONE

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 (%)

ROCKY MOUNTAIN GROUP

Architectural
Structural
Forensics

ARCHITECTS RMG ENGINEERS

Geotechnical
Materials Testing
Civil, Planning

Colorado Springs: (Corporate Office)
2910 Austin Bluffs Parkway
Colorado Spings, CO 80918
(719) 548-0600
SOUTHERN COLORADO, DENVER METRO, NORTHERN COLORADO

EXPLANATION OF TEST BORING LOGS

JOB No. 173851

FIGURE No. 3

DATE Oct/15/2020

TEST BORING: **TB-1** ELEVATION (FT): DATE DRILLED: 10/6/20 NO GROUNDWATER ON	DEPTH (FT)	SYMBOL	SAMPLES	BLOWS PER FT.	WATER CONTENT %
SAND, CLAYEY, with gravel, brown, medium dense, moist				35	9.4
				36	12.0
	5				

TEST BORING: **TB-2** ELEVATION (FT): DATE DRILLED: 10/6/20 NO GROUNDWATER ON	DEPTH (FT)	SYMBOL	SAMPLES	BLOWS PER FT.	WATER CONTENT %
SAND, CLAYEY, with gravel, light brown to brown, medium dense, moist				20	8.4
				47	8.2
	5				
SANDSTONE, SILTY, light brown, medium hard, moist				50/7"	8.7
	10				

ROCKY MOUNTAIN GROUP

Architectural
Structural
Forensics

ARCHITECTS RMG ENGINEERS

Geotechnical
Materials Testing
Civil, Planning

Colorado Springs: (Corporate Office)
2910 Austin Bluffs Parkway
Colorado Spings, CO 80918
(719) 548-0600
SOUTHERN COLORADO, DENVER METRO, NORTHERN COLORADO

TEST BORING LOG

JOB No. 173851

FIGURE No. 4

DATE Oct/15/2020

TEST BORING: **TB-3** ELEVATION (FT): DATE DRILLED: 10/6/20 NO GROUNDWATER ON	DEPTH (FT)	SYMBOL	SAMPLES	BLOWS PER FT.	WATER CONTENT %	
SAND, CLAYEY, with gravel, brown, loose to medium dense, moist				20	7.4	
				16	5.3	
	5					

ROCKY MOUNTAIN GROUP

Architectural
Structural
Forensics

ARCHITECTS RMG ENGINEERS

Geotechnical
Materials Testing
Civil, Planning

Colorado Springs: (Corporate Office)
2910 Austin Bluffs Parkway
Colorado Spings, CO 80918
(719) 548-0600
SOUTHERN COLORADO, DENVER METRO, NORTHERN COLORADO

TEST BORING LOG

JOB No. 173851

FIGURE No. 5

DATE Oct/15/2020

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
TB-1	2.0	9.4		26	13	16.0	42.7	31.9		A-2-4 (1)
TB-1	4.0	12.0								
TB-2	2.0	8.4		27	12	23.1	55.4	20.9		A-2-4 (0)
TB-2	4.0	8.2								
TB-2	9.0	8.7								
TB-3	2.0	7.4		NP	NP	18.4	57.7	13.7		A-1-b (0)
TB-3	4.0	5.3								

ROCKY MOUNTAIN GROUP

Architectural
Structural
Forensics

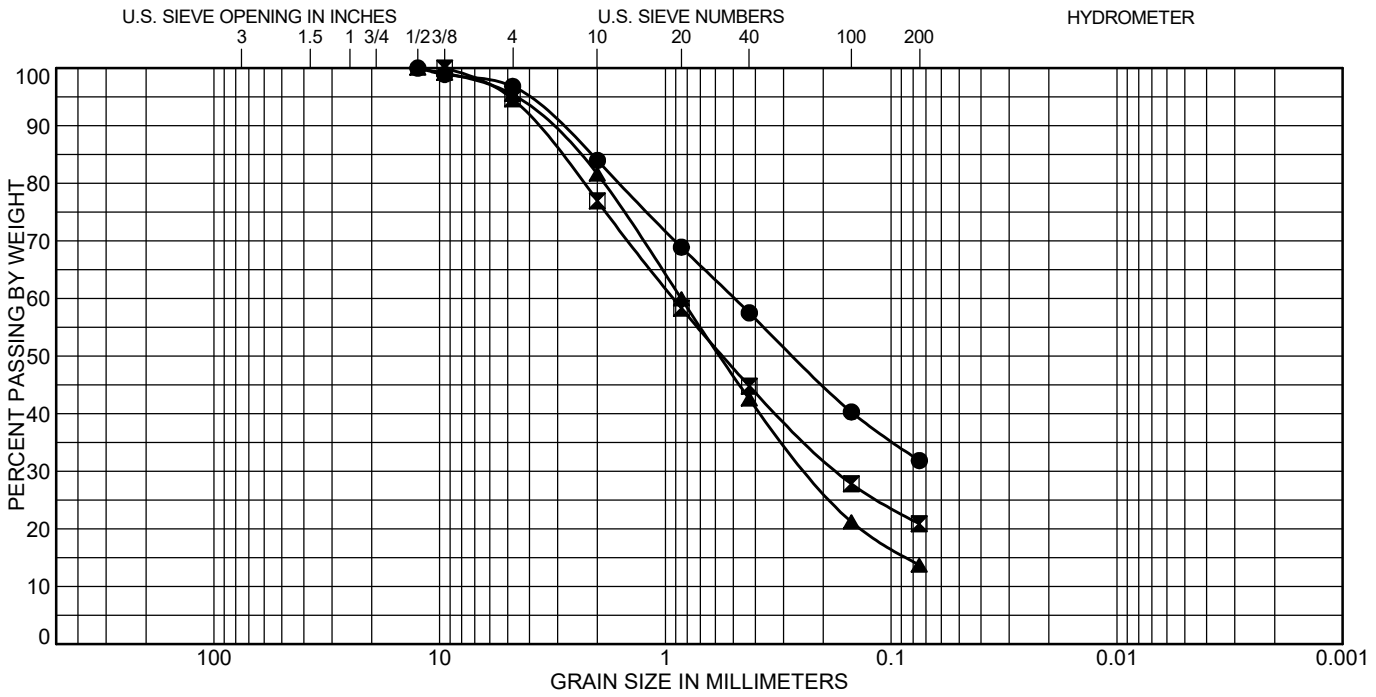
ARCHITECTS RMG ENGINEERS

Geotechnical
Materials Testing
Civil, Planning

Colorado Springs: (Corporate Office)
2910 Austin Bluffs Parkway
Colorado Spings, CO 80918
(719) 548-0600
SOUTHERN COLORADO, DENVER METRO, NORTHERN COLORADO

SUMMARY OF LABORATORY TEST RESULTS

JOB No. 173851
FIGURE No. 6
PAGE 1 OF 1
DATE Oct/15/2020



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Test Boring		Depth (ft)	Classification	LL	PL	PI	Cc	Cu
●	**TB-1**	**2.0**	**A-2-4 (1)**	**26**	**13**	**13**		
⧓	**TB-2**	**2.0**	**A-2-4 (0)**	**27**	**15**	**12**		
▲	**TB-3**	**2.0**	**A-1-b (0)**	**NP**	**NP**	**NP**		

Test Boring		Depth (ft)	%Gravel	%Sand	%Silt	%Clay
●	**TB-1**	**2.0**	**3.2**	**65.0**	**31.9**	
⧓	**TB-2**	**2.0**	**5.4**	**73.8**	**20.9**	
▲	**TB-3**	**2.0**	**4.6**	**81.7**	**13.7**	

ROCKY MOUNTAIN GROUP

Architectural
Structural
Forensics

ARCHITECTS RMG ENGINEERS

Geotechnical
Materials Testing
Civil, Planning

Colorado Springs: (Corporate Office)
2910 Austin Bluffs Parkway
Colorado Spings, CO 80918
(719) 548-0600
SOUTHERN COLORADO, DENVER METRO, NORTHERN COLORADO

SOIL CLASSIFICATION DATA

JOB No. 173851

FIGURE No. 7

DATE Oct/15/2020

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}): 292000

2. Reliability

Reliability Level in percent (R): 80

Combined Standard Error (S_0): 0.44

3. Serviceability

Initial Serviceability Index (p_i): 4.2

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	19500	N/A

OUTPUT

1. Calculation Parameters

Standard Normal Deviate (z_R): -0.841

ΔPSI: 2.2

Design Structural Number (SN): 1.845

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

Surface: 4.5

Total SN based on layer depths: 1.98

See Solution Details

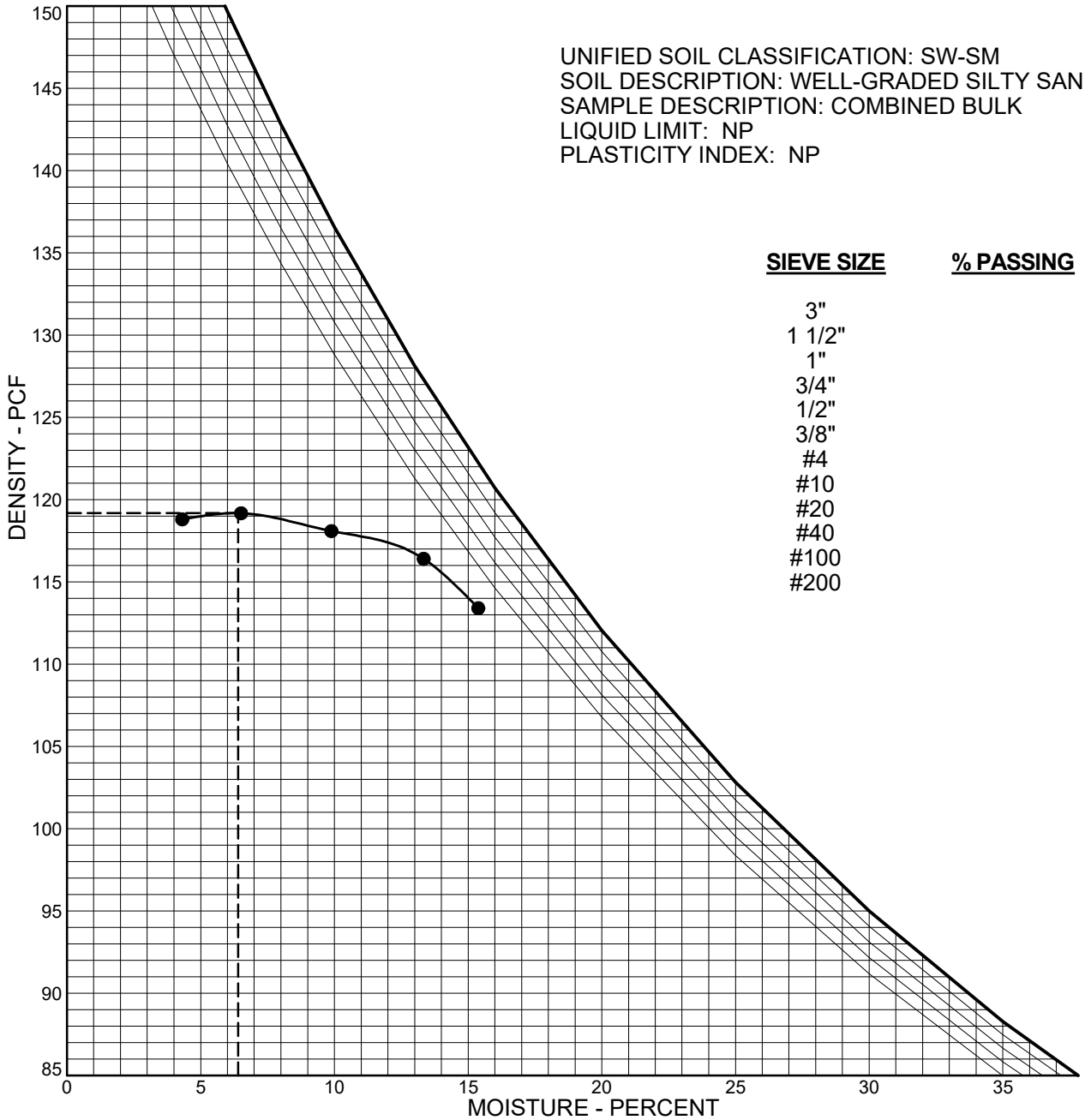
Comments

Urban Local Roadway SN

Calculate

CLIENT: Challenger Communities **SAMPLE NUMBER:** A-1-b PROCTOR

PROJECT: **Bent Grass Filing No. 2 - Pavement Design, El Paso County, Colorado**



UNIFIED SOIL CLASSIFICATION: SW-SM
SOIL DESCRIPTION: WELL-GRADED SILTY SAND
SAMPLE DESCRIPTION: COMBINED BULK
LIQUID LIMIT: NP
PLASTICITY INDEX: NP

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

DESIGNATION **ASTM D-1557A**
MAX. DRY DENSITY **119.2 pcf**
OPTIMUM MOISTURE **6.4 %**
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
Gs = 2.75
Gs = 2.80

ROCKY MOUNTAIN GROUP
Architectural Structural Forensics
ARCHITECTS RMG ENGINEERS
Geotechnical Materials Testing Civil, Planning
Colorado Springs: (Corporate Office)
2910 Austin Bluffs Parkway
Colorado Spings, CO 80918
(719) 548-0600
SOUTHERN COLORADO, DENVER METRO, NORTHERN COLORADO

MOISTURE-DENSITY RELATION CURVE

JOB No. 173851

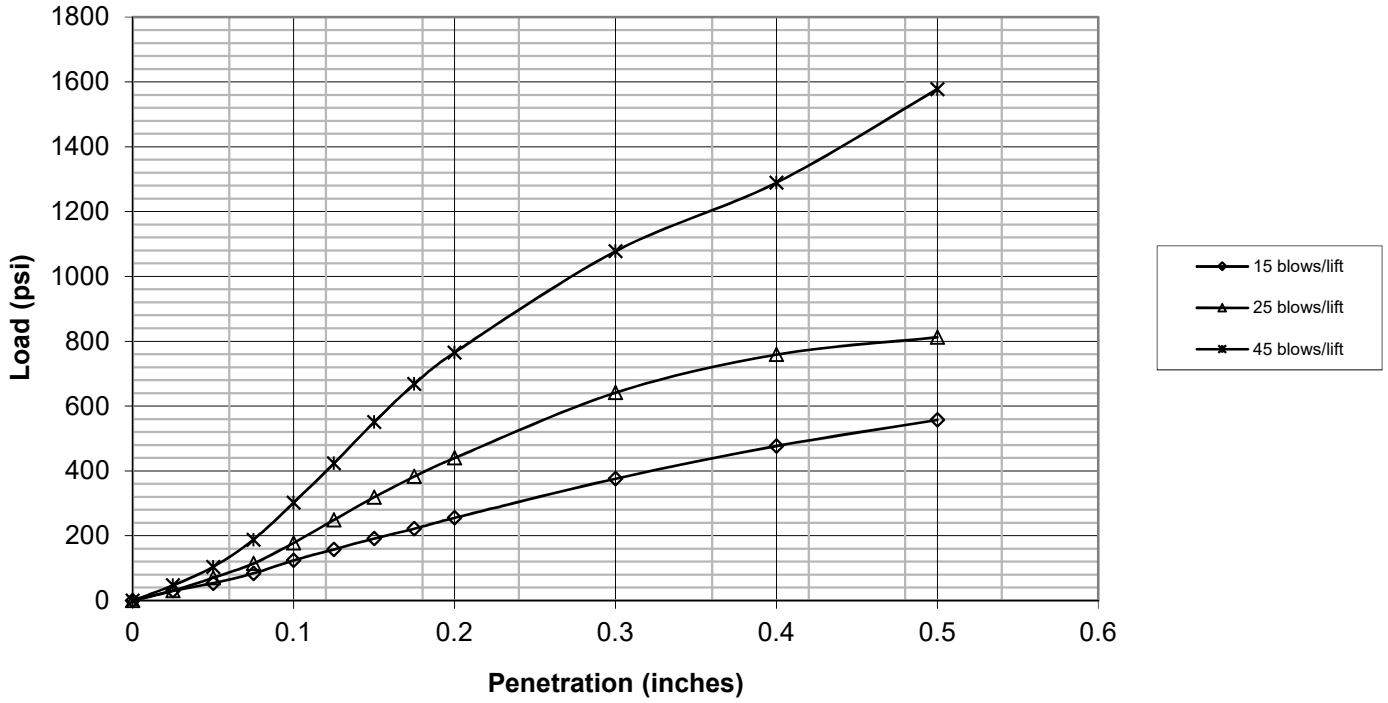
FIGURE No. 18

DATE May/29/2020

CALIFORNIA BEARING RATIO TEST RESULTS

PROJECT: Bent Grass Filing No. 2
JOB NUMBER: 173851 TEST DATE: 5/22/2020
AASHTO A-1
SAMPLE NUMBER: CBR
SAMPLE LOCATION: Combination bulk sample from A-1 Test Borings
SOIL DESCRIPTION: Sand, Silty (SM)

	15 blows/lift	25 blows/lift	45 blows/lift
Penetration (in)	Load (psi)	Load (psi)	Load (psi)
0.000	0.0	0.0	0.0
0.025	30.2	30.2	47.0
0.050	53.7	70.5	104.1
0.075	83.9	114.1	188.0
0.100	124.2	177.9	302.1
0.125	157.8	248.4	423.0
0.150	191.3	318.9	550.5
0.175	221.6	382.7	668.0
0.200	255.1	439.8	765.4
0.300	376.0	641.2	1077.6
0.400	476.7	758.7	1289.1
0.500	557.3	812.4	1577.8



	15 blows/lift	25 blows/lift	45 blows/lift
Corrected Penetration (in)	Corrected Load (psi)	Corrected Load (psi)	Corrected Load (psi)
0.1	12.4	17.8	30.2
0.2	17.0	29.3	51.0

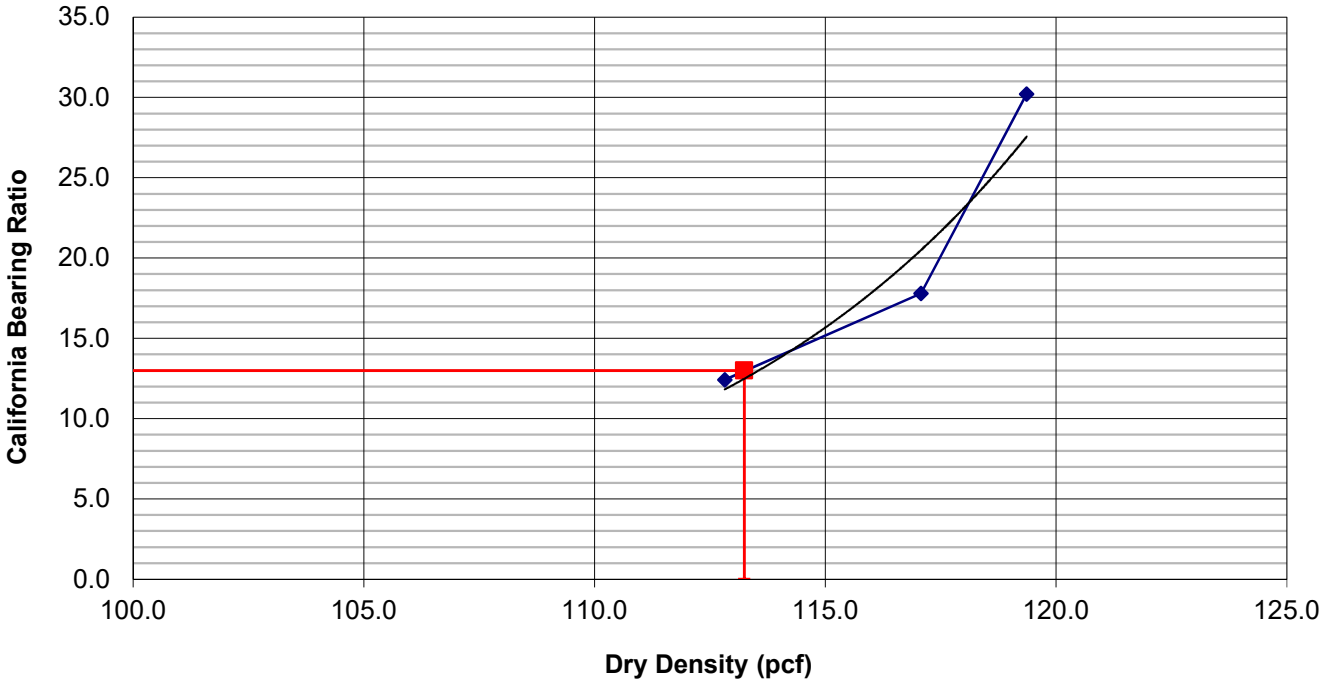
Structural • Geotechnical RMG ENGINEERS

Figure No. 19

CALIFORNIA BEARING RATIO TEST RESULTS

PROJECT:	Bent Grass Filing No. 2
JOB NUMBER:	173851
TEST DATE:	5/22/2020
AASHTO CLASSIFICATION:	A-1
SAMPLE NUMBER:	CBR
SAMPLE LOCATION:	Combination bulk sample from A-1 Test Borings
SOIL DESCRIPTION:	Sand, Silty (SM)

	15 blows/lift	25 blows/lift	45 blows/lift
Corrected California Bearing Ratio	12.4	17.8	30.2
Dry Density (pcf)	112.8	117.1	119.4
Percent Compaction	95	98	100
Percent Moisture After Soaking	10.4	10.0	9.3
Percent Expansion/Compression	0.0	0.0	0.0
Surcharge Weight (lbs)	12.62	12.61	12.61



California Bearing Ratio	**13.0**
Dry Density (pcf)	119.2
Percent Compaction	95.00%
Target Dry Density	113.2
Compaction Test Method	ASTM D-1557
Condition of sample	Soaked

Structural • Geotechnical
RMG ENGINEERS

Figure No. 20