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PAVEMENT DESIGN REPORT

Meridian Road Acceleration Lane
Bent Grass Meadows Drive at Meridian Road
El Paso County, Colorado

PREPARED FOR:

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

JOB NO. 173851

March 12, 2020

Respectfully Submitted,

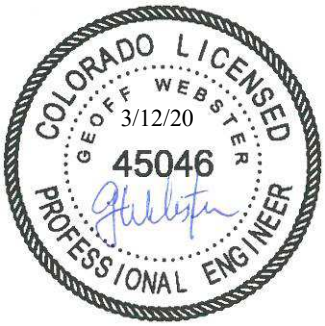
RMG – Rocky Mountain Group

Brian Griffith, E.I.
Geotechnical Staff Engineer

Reviewed by,

RMG – Rocky Mountain Group

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



CDR 19-004 **SF-_____**

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GENERAL SITE AND PROJECT DESCRIPTION

Location

The intersection of Bent Grass Meadows Drive with Meridian Road is located approximately 3,300 feet north of Woodmen 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 fully constructed roadways with asphalt surface course.

Project Description

The right hand turn lane on Bent Grass Meadows Drive is to be widened to provide access to southbound Meridian Road. An acceleration lane is to be constructed southbound along Meridian Road. This Pavement Design Report was performed to determine the subsurface conditions present along the roadway alignments and to develop recommendations for the design and construction of the proposed flexible pavements.

The proposed streets included in this investigation are shown on Figure 2. Bent Grass Meadows Drive is classified as Urban Nonresidential Collector as shown on Sheet number C1.00 of the Bent Grass Residential Filing No. 2 plans. Meridian Road is classified as a 2-lane Minor Arterial according to El Paso County documents. For this pavement design, the 2-lane Minor Arterial classification will be used for both the acceleration lane on Meridian Road, and the right-hand turn lane on Bent Grass Meadows Drive.

FIELD INVESTIGATION AND SUBSURFACE CONDITIONS

Drilling

The subsurface conditions on the site were investigated by drilling four (4) 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 a depth of 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 primarily of silty sand. Combined bulk samples of the material classified as SW-SM according to the Unified Classification System. For pavement design purposes, bulk samples of the soil classified as A-1-b and A-2-4 soils in accordance with the American Association of State Highway and Transportation Officials (ASSHTO) classification system. A-1-b and A-2-4 soils are 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. Swell/consolidation tests were not performed as the soil proved to be non-plastic. A Summary of Laboratory Test Results is presented in Figure 6. Soil Classification Data are presented in Figure 7.

California Bearing Ratio tests (CBR) were performed on combined bulk samples of soil. Combined samples classified as A-1-b soil. The soil was tested to determine the optimum moisture-density relationship in accordance with ASTM D-1557 (Modified Proctor compaction test). The maximum dry density of the soil proved to be 131-pcf at 7-percent moisture. CBR tests were performed at varying densities with moisture content near optimum. At 95% of the maximum Modified Proctor Density, 124.5 pcf, the CBR of the A-1-b soil was 34.5. The Moisture-Density Relation Curve is presented in Figure 8. CBR Test Results are presented in Figures 9 and 10.

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 soil. The recommended pavement sections shown on Figure 2.1 are supported by the calculations below.

Street Classification – 2-lane Minor Arterial

1) Meridian Road, Bent Grass Meadows Drive
   ESAL = 1,971,000 (Table D-2)
   Serviceability Index = 2.5 (Table D-1)
   Reliability = 85% (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 = 34.5 x 1500 = 51,750 psi

4) Structural number (SN) = 1.8 (1993 AASHTO Empirical Equation, Appendix A)

5) Composite asphalt/base course section
   Minimum HMA thickness = D_1 = 5 inches (Table D-2)
   ABC thickness = $D_2 = \{SN – (D_1 \times a_1)\} / a_2 = \{1.8 – (5 \times 0.44)\} / 0.11 < 0$ inches
   Use Minimum ABC Thickness = 8-inches (Table D-2)

6) Use Asphalt thickness = 5-inches and ABC thickness = 8 inches
   Check SN = (5 x 0.44) + (8 x 0.11) = 3.1 > 1.8 (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)
Meridian Road Acceleration Lane Bent Grass Meadows Parkway	5.0	8.0
Note: Match existing pavement sections if greater than values shown.		

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 expected to have nil expansive potential. 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 – ABC

Pavement areas should have topsoil, organic material, and debris removed, and be cleared and grubbed to minimum 24-inches depth. 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 native 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

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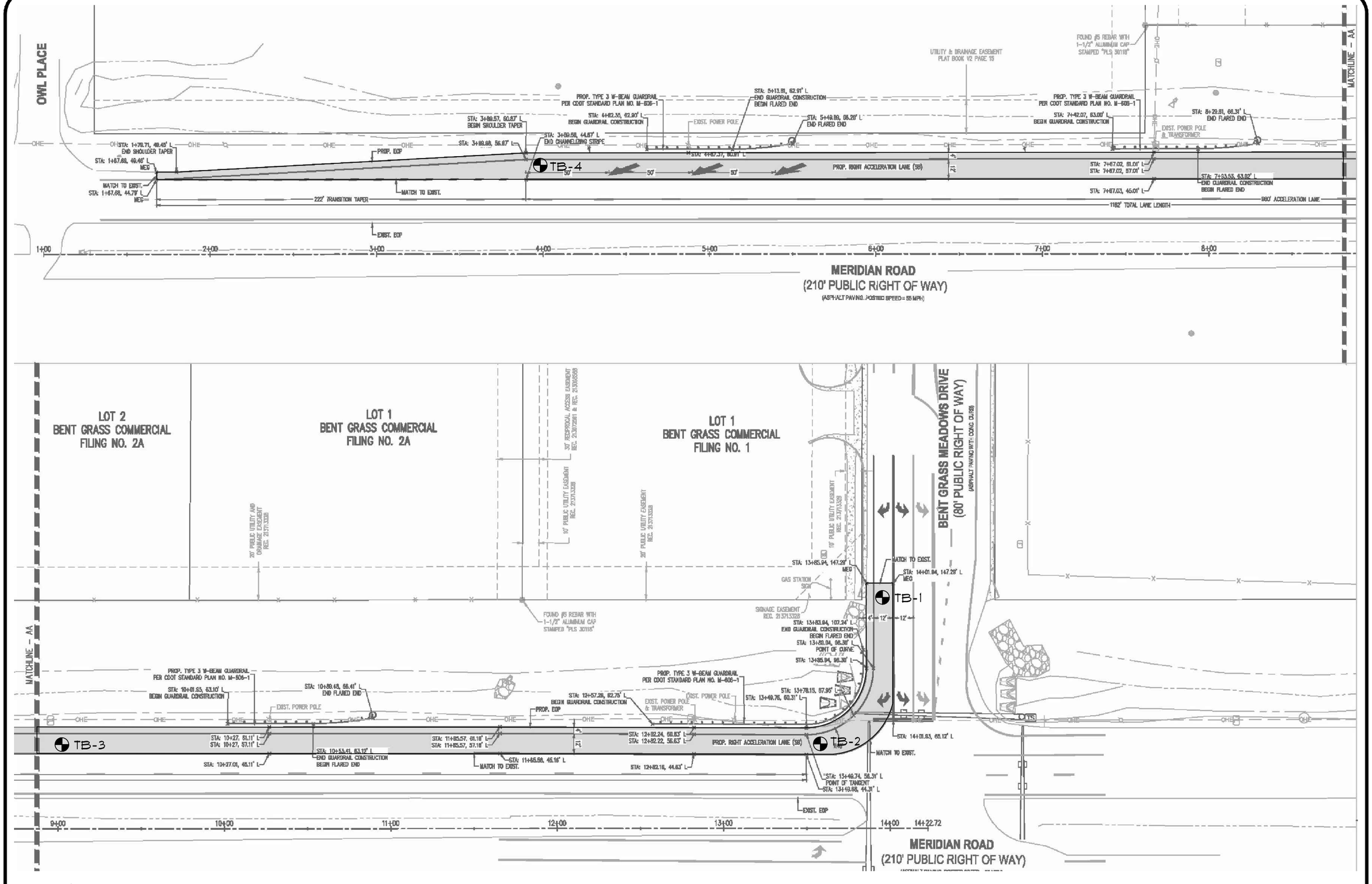
SITE VICINITY MAP

RIGHT-TURN AND ACCELERATION LANE
BENT GRASS MEADOWS DRIVE AND
MERIDIAN ROAD
EL PASO COUNTY, COLORADO
CHALLENGER COMMUNITIES

JOB No. 173851

FIG No. 1

DATE 3-12-2020



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0 — 500'

DENOTES APPROXIMATE LOCATION OF TEST BORINGS

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Monument Office:
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Pueblo / Canon City:
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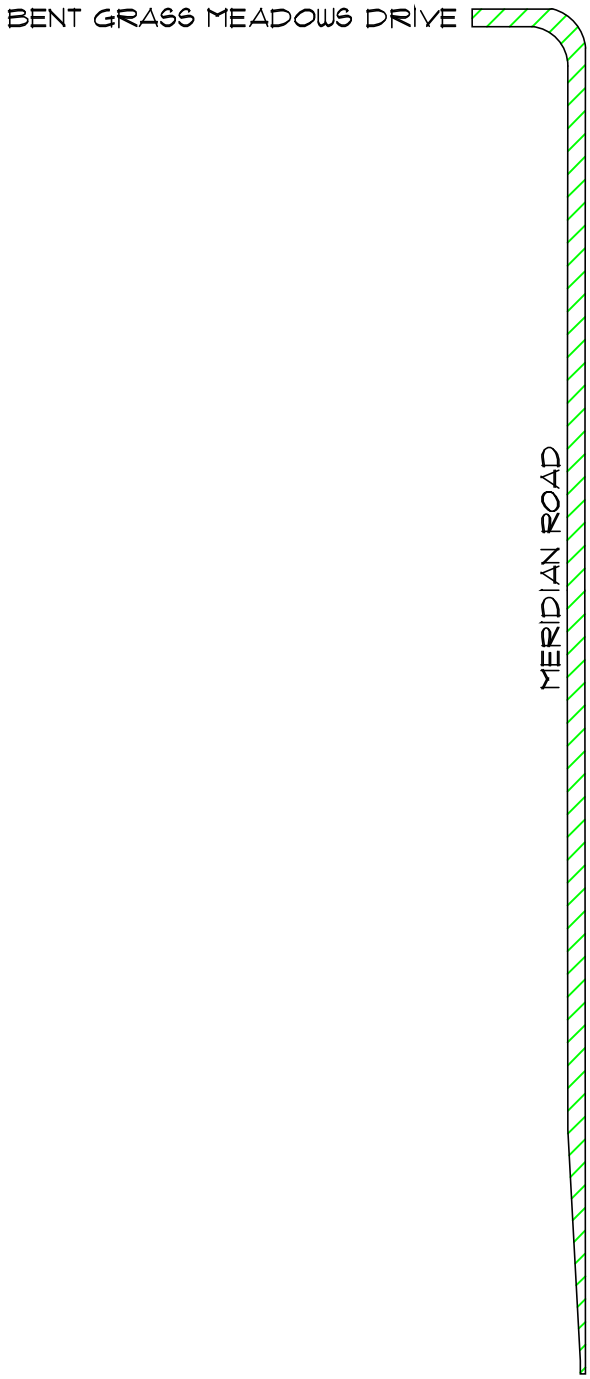
RIGHT-TURN AND ACCELERATION LANE
BENT GRASS MEADOWS DRIVE AND MERIDIAN ROAD
EL PASO COUNTY, COLORADO
CHALLENGER COMMUNITIES

ENGINEER:	TM
DRAWN BY:	BG
CHECKED BY:	TM
ISSUED:	3-12-2020

TEST BORING LOCATION PLAN

SHEET No.
FIG-2



5" HMA OVER
8" ABC

MATCH EXISTING PAVEMENT SECTIONS ON BOTH ROADWAYS IF GREATER THAN THE VALUES SHOWN

NOT TO SCALE

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PAVEMENT DESIGN

RIGHT-TURN AND ACCELERATION LANE
BENT GRASS MEADOWS DRIVE AND
MERIDIAN ROAD
EL PASO COUNTY, COLORADO
CHALLENGER COMMUNITIES

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FIG No. 2.1

DATE 3-12-2020

SOILS DESCRIPTION

ASPHALT

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 Mar/12/2020

TEST BORING: **1** ELEVATION (FT): 0 DATE DRILLED: 2/24/20 NO GROUNDWATER ON 2/24/20	DEPTH (FT)	SYMBOL	SAMPLES	BLOWS PER FT.	WATER CONTENT %
12 INCHES ASPHALT					
SAND, SILTY, light brown, medium dense, moist				24	4.5
	5			27	6.7
	10			25	9.9

TEST BORING: **2** ELEVATION (FT): 0 DATE DRILLED: 2/24/20 NO GROUNDWATER ON 2/24/20	DEPTH (FT)	SYMBOL	SAMPLES	BLOWS PER FT.	WATER CONTENT %
12 INCHES ASPHALT					
SAND, SILTY, light brown, medium dense, moist				22	5.9
	5			21	6.6
	10			21	10.3

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TEST BORING LOG

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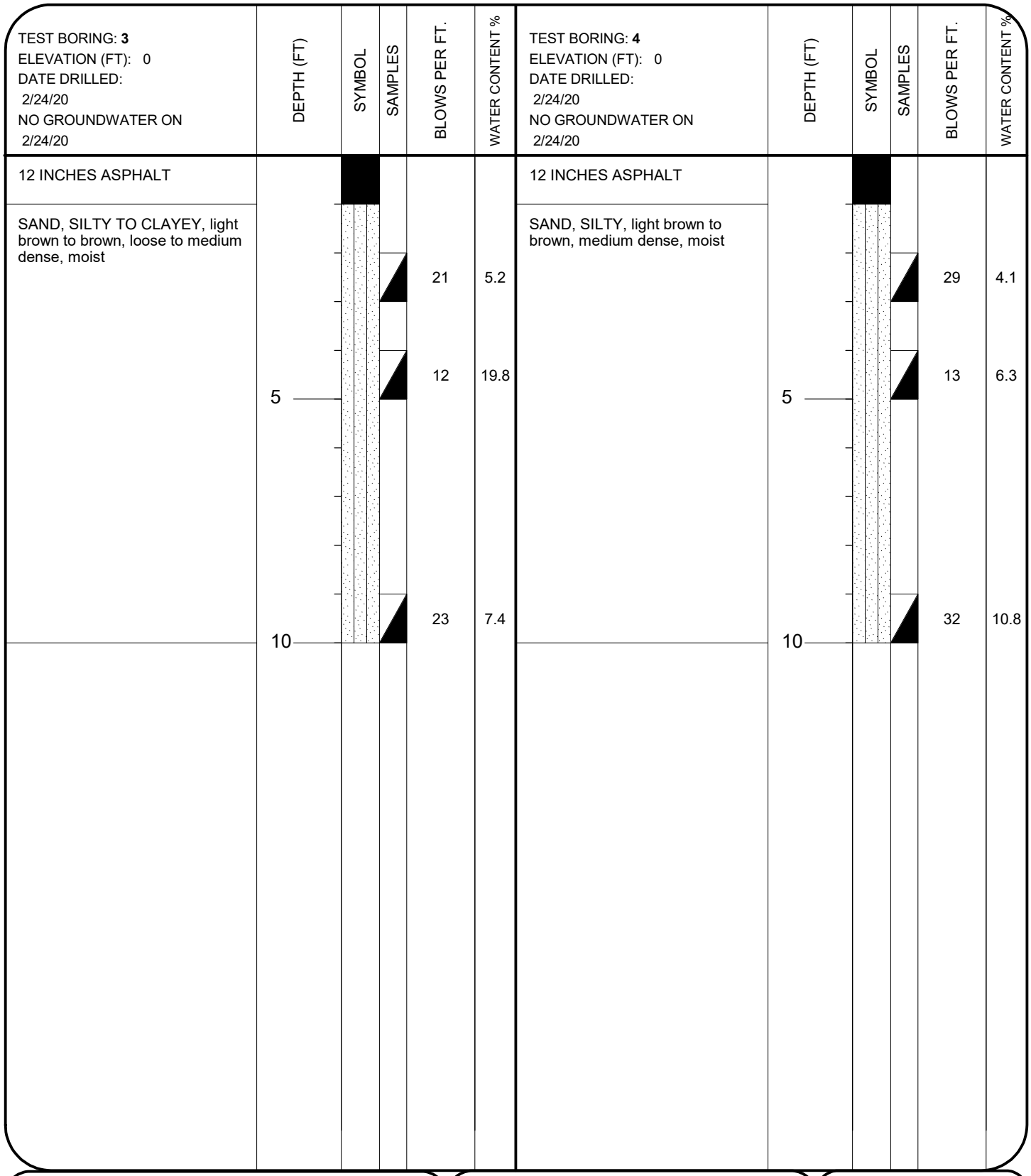
FIGURE No. 4

DATE Mar/12/2020



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TEST BORING LOG

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FIGURE No. 5

DATE Mar/12/2020

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
1	2.0	4.5		NP	NP	26.7	53.3	25.4		A-1-b (0)
1	4.0	6.7								
1	9.0	9.9								
2	2.0	5.9		NP	NP	28.6	64.5	11.6		A-1-b (0)
2	4.0	6.6								
2	9.0	10.3								
3	2.0	5.2		NP	NP	21.8	73.1	5.7		A-1-b (0)
3	4.0	19.8								
3	9.0	7.4								
4	2.0	4.1		27	9	20.3	53.0	17.4		A-2-4 (0)
4	4.0	6.3								
4	9.0	10.8								

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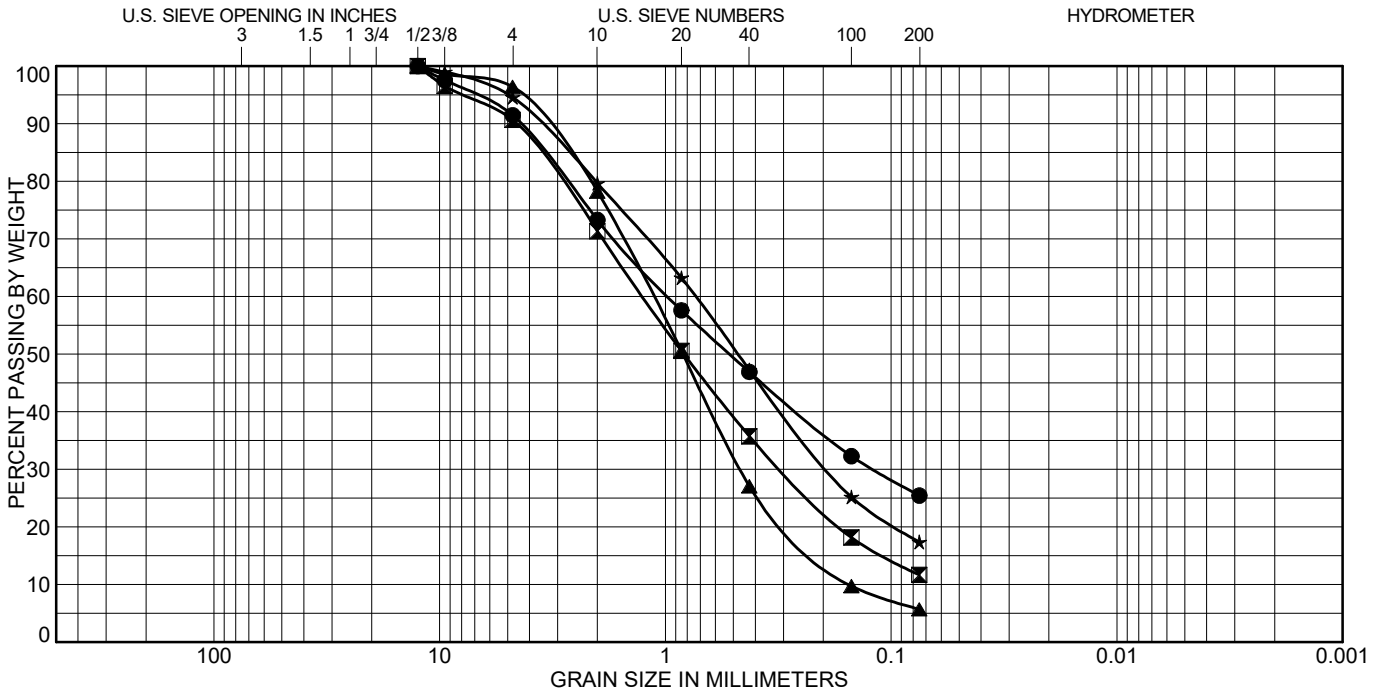
SUMMARY OF LABORATORY TEST RESULTS

JOB No. 173851
FIGURE No. 6
PAGE 1 OF 1
DATE Mar/12/2020



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Test Boring		Depth (ft)	Classification	LL	PL	PI	Cc	Cu
●	1	2.0	A-1-b (0)	NP	NP	NP		
⧓	2	2.0	A-1-b (0)	NP	NP	NP	1.2	19.9
▲	3	2.0	A-1-b (0)	NP	NP	NP	1.2	7.5
★	4	2.0	A-2-4 (0)	27	18	9		

Test Boring		Depth (ft)	%Gravel	%Sand	%Silt	%Clay
●	1	2.0	8.5	66.0	25.4	
⧓	2	2.0	9.3	79.0	11.6	
▲	3	2.0	3.6	90.7	5.7	
★	4	2.0	5.4	77.2	17.4	

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SOIL CLASSIFICATION DATA

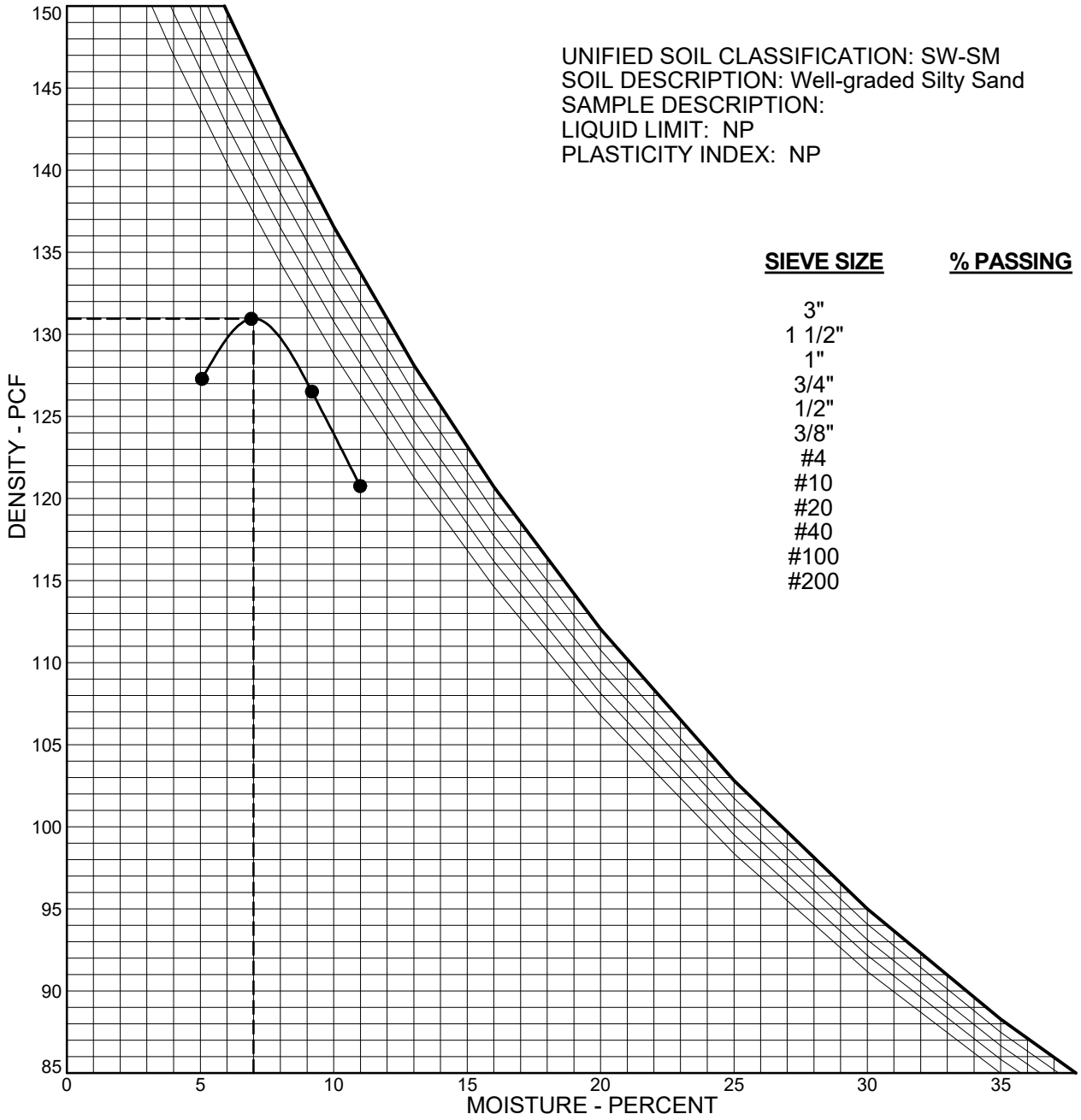
JOB No. 173851

FIGURE No. 7

DATE Mar/12/2020

CLIENT: Challenger Communities **SAMPLE NUMBER:** Combined Sample: A-1-b Soil

PROJECT: **Bent Grass Meadows Signal, El Paso County, Colorado**



UNIFIED SOIL CLASSIFICATION: SW-SM
SOIL DESCRIPTION: Well-graded Silty Sand
SAMPLE DESCRIPTION:
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 **131.0 pcf**
OPTIMUM MOISTURE **7.0 %**
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

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MOISTURE-DENSITY RELATION CURVE

JOB No. 173851

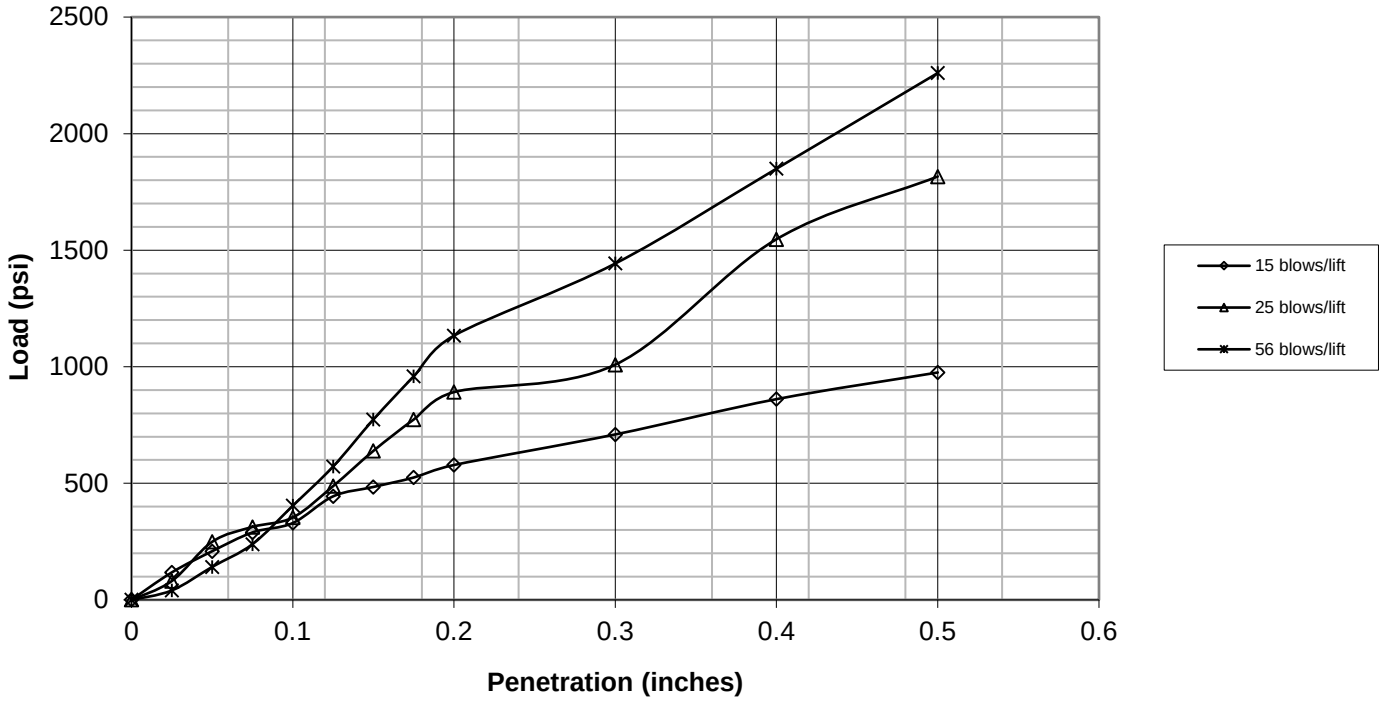
FIGURE No. 8

DATE 3/6/20

CALIFORNIA BEARING RATIO TEST RESULTS

PROJECT: Meridian Road Acceleration Lane
JOB NUMBER: 173851 TEST DATE: 3/12/2020
AASHTO A-1-b
SAMPLE NUMBER: CBR
SAMPLE LOCATION: Combination bulk sample
SOIL DESCRIPTION: Well-graded Silty Sand

	15 blows/lift	25 blows/lift	56 blows/lift
Penetration (in)	Load (psi)	Load (psi)	Load (psi)
0.000	0.0	0.0	0.0
0.025	117.7	80.7	40.4
0.050	208.5	248.9	141.2
0.075	289.2	312.8	238.8
0.100	329.6	353.1	403.6
0.125	443.9	487.6	571.7
0.150	484.3	639.0	773.5
0.175	524.6	773.5	958.5
0.200	578.4	891.2	1133.3
0.300	709.6	1008.9	1442.7
0.400	860.9	1547.0	1849.7
0.500	975.3	1816.0	2259.9



	15 blows/lift	25 blows/lift	56 blows/lift
Corrected Penetration (in)	Corrected Load (psi)	Corrected Load (psi)	Corrected Load (psi)
0.1	33.0	35.3	40.4
0.2	38.6	59.4	75.6

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Figure No. 9

CALIFORNIA BEARING RATIO TEST RESULTS

PROJECT:	Meridian Road Acceleration Lane
JOB NUMBER:	173851
TEST DATE:	3/12/2020
AASHTO CLASSIFICATION:	A-1-b
SAMPLE NUMBER:	CBR
SAMPLE LOCATION:	Combination bulk sample
SOIL DESCRIPTION:	Well-graded Silty Sand

	15 blows/lift	25 blows/lift	56 blows/lift
Corrected California Bearing Ratio	33.0	35.3	40.4
Dry Density (pcf)	122.4	125.9	130.5
Percent Compaction	93	96	100
Percent Moisture After Soaking	7.1	7.0	7.0
Percent Expansion/Compression	0.0	0.0	0.0
Surcharge Weight (lbs)	12.60	12.62	12.60

California Bearing Ratio	**34.5**
Dry Density (pcf)	131.0
Percent Compaction	95.00%
Target Dry Density	124.5
Compaction Test Method	ASTM D-1557
Condition of sample	Soaked

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Figure No. 10

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}): 1971000

2. Reliability

Reliability Level in percent (R): 85

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	51750	N/A

OUTPUT

1. Calculation Parameters

Standard Normal Deviate (z_R): -1.037

ΔPSI: 2.5

Design Structural Number (SN): 1.795

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

Surface: 4.5

Total SN based on layer depths: 1.98

See Solution Details

Comments

Calculate