

July 26, 2021
Revised: August 4, 2021
Revised: October 6, 2021

Glen Development
c/o Cross Company
3140 Shadybrook Lane
Colorado Springs, CO 80904



ENTECH
ENGINEERING, INC.

505 ELKTON DRIVE
COLORADO SPRINGS, CO 80907
PHONE (719) 531-5599
FAX (719) 531-5238

Approved

by Jeff Rice
El Paso County Planning and Community Development
on behalf of Elizabeth Nijkamp, Engineering Review Manager

10/07/2021 10:36:01 AM



Attn: Rudy Cross

Re: Pavement Recommendations - Revised
The Glen at Widefield, Filing No. 10
El Paso County, Colorado

Dear Mr. Cross:

As requested, Entech Engineering, Inc. has obtained samples of the subgrade soils from sections of the roadways in the Glen at Widefield Subdivision, Filing 10, in El Paso County, Colorado. Laboratory testing to determine the pavement support characteristics of the soils was performed. This letter presents the results of the laboratory testing and pavement recommendations for the roadways.

Project Description

The roadways in this project consist of a section of Pennycress Drive and Buffalo Bur Trail. The site layout and the locations of the test borings are shown on the Test Boring Location Map, Figure 1.

Subgrade Conditions

Three exploratory test borings were drilled in the roadways to depths of approximately 5 to 10 feet. The borings were spaced within the limits set forth in the El Paso County Criteria ECM Section D.2.1. The subgrade soils consisted of sandy clay fill and very clayey sand fill (Soil Type 1). The Boring Logs are presented in Appendix A.

Sieve Analyses and Atterberg Limit testing were performed on all of the subgrade soil samples obtained from the test borings for the purpose of classification. Sieve analyses indicated the percent passing the No. 200 sieve ranged from approximately 43 to 70 percent. Atterberg Limit Tests resulted in Liquid Limits ranging from 30 to 41 and Plastic Indexes of 15 to 26.

Swell/Consolidation Testing was required due to the plastic index values of the subgrade soils. Swell/Consolidation Tests performed on in-situ subgrade soil samples showed volume changes ranging from 0.9 to 8.3 percent, and testing on a remolded Type 1 soils sample, moisture-conditioned to 4 percent over optimum, showed a volume change of 1.8 percent.

Based on the results of the laboratory testing, one pavement subgrade soil type was determined. The subgrade soils classify as A-6 and A-7-6 soils using the AASHTO Classification System, which typically have poor pavement support characteristics. The laboratory testing results are presented in Appendix B and are summarized in Table 1.

Sulfate testing indicated that the clay soils exhibit negligible potential for sulfate attack.

California Bearing Ratio (CBR) testing was conducted on a representative subgrade sample for the roadways in this filing. The CBR and laboratory test results are summarized in Table 1 and included in Appendix B. The laboratory classification testing results are included in the following table.

Soil Type 1 – Very Clayey Sand Fill

R @ 90% = 6.0
R @ 95% = 10.0
Use R = 10.0 for design

Classification Testing

Liquid Limit	30
Plasticity Index	15
Percent Passing 200	42.7
AASHTO Classification	A-6
Group Index	3
Unified Soils Classification	SC
M _R	3,562 psi

Pavement Design

The CBR testing was used to determine pavement sections for this site. The pavement sections were determined utilizing the El Paso County "Pavement Design Criteria and Report" and the recommended street classifications by LSC Transportation Consultants, Inc. Buffalo Bur Trail classifies as an urban local low-volume road, which used an 18k ESAL value of 36,500 to determine the pavement sections. Pennycress Drive classifies as an urban local road, which used an 18k ESAL value of 292,000. Pavement sections for asphalt over aggregate basecourse and asphalt on cement-stabilized subgrade are provided. Design parameters used in the pavement analysis are as follows:

Serviceability Index:

Urban Local / Urban Local Low Volume	2.0
--------------------------------------	-----

Reliability:

Urban Local / Urban Local Low Volume	80%
"R" Value Subgrade	10.0
Resilient Modulus	3,562 psi

Structural Coefficients:

Hot Bituminous Pavement	0.44
Basecourse	0.11
Cement Stabilized Subgrade	0.11

Pavement calculations are attached in Appendix C. Pavement sections recommended for the site are summarized as follows:

Pavement Sections – Urban Local (low volume)

ESAL = 36,500: Buffalo Bur Trail

<u>Alternative</u>	<u>Asphalt (in)</u>	<u>Basecourse (in)</u>	<u>Cement-Stabilized Subgrade (in)</u>
1. Asphalt over Basecourse	3.5	8.5	—
2. Asphalt over Stabilized Subgrade	3.5	—	8.5

Pavement Sections – Urban Local

ESAL = 292,000: Pennycress Drive

<u>Alternative</u>	<u>Asphalt (in)</u>	<u>Basecourse (in)</u>	<u>Cement-Stabilized Subgrade (in)</u>
1. Asphalt over Basecourse	5.0	11.0	—
2. Asphalt over Stabilized Subgrade	5.0	—	11.0

Mitigation

El Paso County criteria requires mitigation of expansive soils for roadway subgrade that have a swell of 2 percent or greater with a 150 pound per square foot surcharge. One sample resulted in a volume change of 8.3 percent. A remolded swell test moisture conditioned to 4 percent over optimum, exhibited a swell of 1.8 percent. This swell level is below the threshold for mitigation. The roadway subgrade soils were initially moisture conditioned and processed during utility installation. The subgrade was conditioned and compacted to specified requirements during the utility installations. Prior to paving, the subgrade should be evaluated for proper moisture conditions. In areas that need additional moisture-conditioning, we recommend that the top 12-inches of the subgrade be scarified and moisture-conditioned to 0 to 4 percent over optimum moisture content and be recompacted. Specific areas requiring mitigation should be field determined. The subgrade soils should be observed and tested by Entech personnel prior to paving.

Roadway Construction

Prior to placement of the asphalt, the subgrade should be proofrolled and compacted to a minimum of 95 percent of its maximum Standard Proctor Dry Density, ASTM D-698 at 0 to 4 percent over optimum moisture content. Any soft areas should be removed and replaced with suitable materials. Base course materials should be compacted to a minimum of 95 percent of its maximum Modified Proctor Dry Density, ASTM D-1557 at ± 2 percent of optimum moisture content. Special attention should be given to areas adjacent to manholes, inlet structures and valves. Full-depth asphalt sections are currently not allowed by El Paso County.

Roadway Construction – Cement Stabilized Subgrade

Prior to placement of the asphalt, the subgrade may be stabilized by addition of cement to a depth of at least 8½ to 11 inches. The amount of cement applied shall be 2.0 percent (by weight) of the subgrade's maximum dry density as determined by the Modified Proctor Test (ASTM D-1557) and based on laboratory cement stabilization testing. The cement should be spread evenly on the subgrade surface and be thoroughly mixed into the subgrade over an 8½

to 11-inch depth such that a uniform blend of soil and cement is achieved. Prior to application or mixing of the cement, the upper 8½ to 11 inches of subgrade should be thoroughly moisture conditioned to the soil's optimum water content or as much as 2 percent more than the optimum water content as necessary to provide a compactable soil condition. Densification of the cement-stabilized subgrade should be completed to obtain a compaction of at least 95 percent of the subgrade maximum dry density as determined by the Modified Proctor Test (ASTM D-1557). Satisfactory compaction of the subgrade shall occur within 90 minutes from the time of mixing the cement into the subgrade.

The following conditions shall be observed as part of the subgrade stabilization:

- Type I/II cement as supplied; a local supplier shall be used. All cement used for stabilization should come from the same source. If cement sources are changed a new laboratory mix design should be completed.
- Moisture conditioning of the subgrade and/or mixing of the cement into the subgrade shall not occur when soil temperatures are below 40° F. Cement treated subgrades should be maintained at a temperature of 40° F or greater until the subgrade has been compacted as required.
- Cement placement, cement mixing and compaction of the cement treated subgrade should be observed by a Soils Engineer. The Soils Engineer should complete in situ compaction tests and construct representative compacted specimens of the treated subgrade material for subsequent laboratory quality assurance testing.

If significant grading is performed, the soils at subgrade may change. Modification to the pavement sections should be evaluated after site grading is completed.

In addition to the above guidance, the asphalt, subgrade conditions, compaction of materials and roadway construction methods shall meet the El Paso County specifications.

We trust that this has provided you with the information you required. If you have any questions or need additional information, please do not hesitate to contact us.

Respectfully Submitted,

ENTECH ENGINEERING, INC.



Daniel P. Stegman


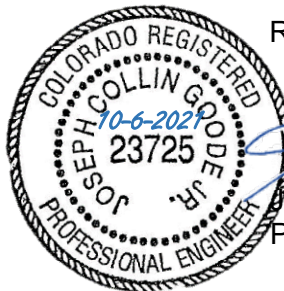
DPS/am

Encl.

Entech Job No. 211646

AAprojects/2021/211646 pr-rev2

Reviewed by:



Joseph C. Goode, Jr., P.E.
President

TABLE

TABLE 1

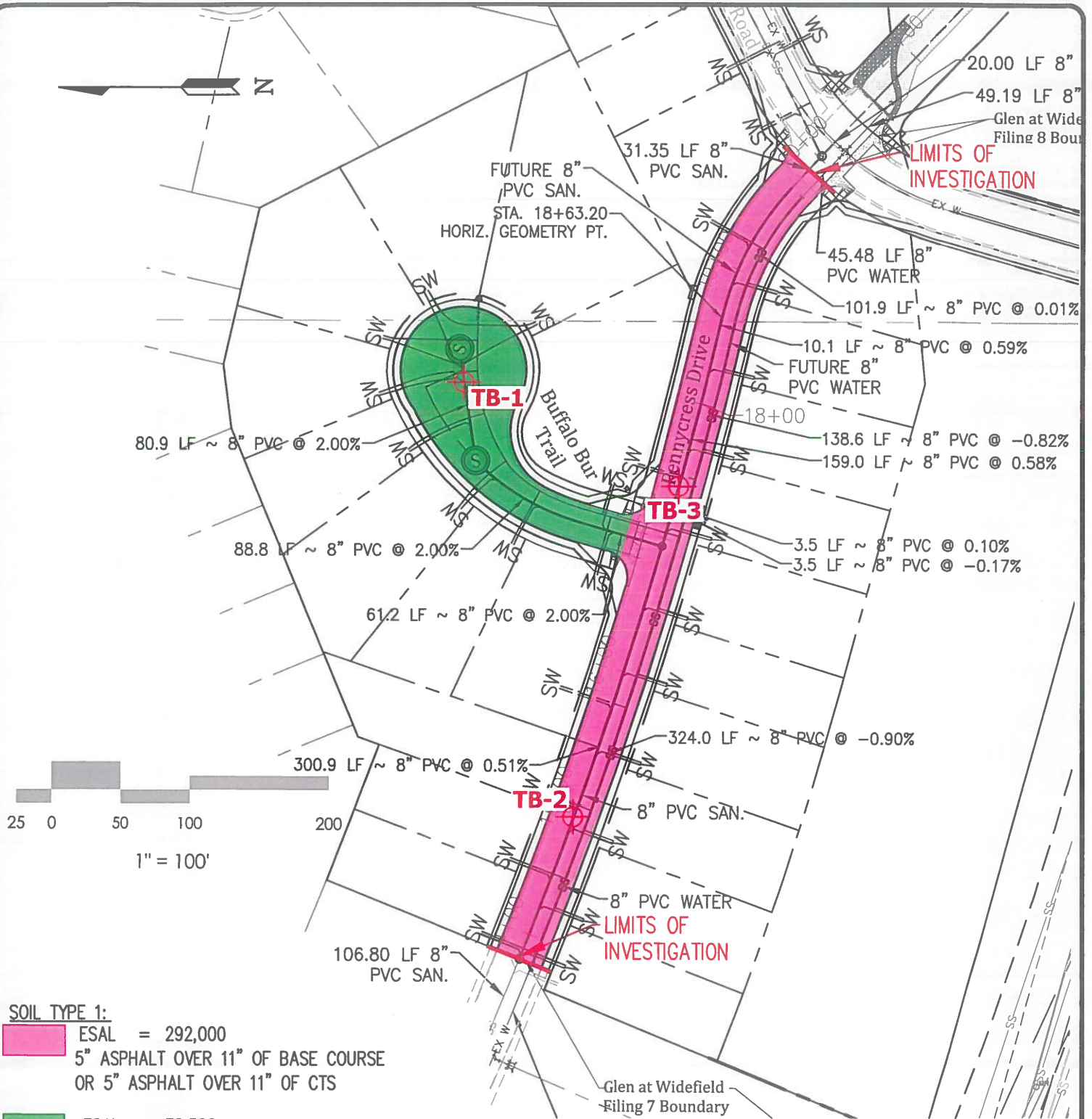
SUMMARY OF LABORATORY TEST RESULTS

CLIENT GLEN DEVELOPMENT
PROJECT GLEN AT WIDEFIELD, F-10
JOB NO. 211646

SOIL TYPE	TEST BORING NO.	DEPTH (FT)	WATER (%)	DRY DENSITY (PCF)	PASSING NO. 200 SIEVE (%)	LIQUID LIMIT (%)	PLASTIC INDEX (%)	SULFATE (WT %)	AASHTO CLASS.	SWELL/ CONSOL (%)	UNIFIED CLASSIFICATION	SOIL DESCRIPTION
1, CBR	1	0-3	15.8	109.4	42.7	30	15		A-6	0.9	SC	SAND, VERY CLAYEY
1	1	1-2	11.6	121.5	48.6	32	18		A-6	1.8	SC	SAND, VERY CLAYEY
1	2	1-2	11.8	113.3	69.9	41	26	<0.01	A-7-6	8.3	CL	CLAY, SANDY
1	2	1-2	13.9	112.4						4.2*	CL	CLAY, SANDY
1	2	1-2	16.2	112.3						1.8*	CL	CLAY, SANDY
1	3	1-2	12.3	109.5	49.1	31	17		A-6	1.6	SC	SAND, VERY CLAYEY
1	2	0-3			55.8	36	25		A-6		CL	CLAY, VERY SANDY

* - Remolded samples

FIGURE



TB- APPROXIMATE TEST BORING LOCATIONS AND NUMBERS



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TEST BORING LOCATION MAP
GLEN AT WIDEFIELD, FILING 10
EL PASO COUNTY, CO
FOR: GLEN DEVELOPMENT COMPANY

DRAWN:
JAC

DATE:
07/20/21

CHECKED:
KAH

DATE:
07/20/21

JOB NO.:
211646

FIG NO.:
1

APPENDIX A: Test Boring Logs

TEST BORING NO. 1
 DATE DRILLED 6/23/2021
 Job # 211646

TEST BORING NO. 2
 DATE DRILLED 6/23/2021
 CLIENT GLEN DEVELOPMENT
 LOCATION GLEN AT WIDEFIELD, F-10

REMARKS

DRY TO 10', 6/23/21

FILL 0-10', SAND, VERY CLAYEY,
 FINE GRAINED, GRAY BROWN,
 MEDIUM DENSE TO LOOSE,
 MOIST

GRAVELLY LENSE

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
			10	11.3	1
5			17	11.7	1
10			8	4.3	1
15					
20					

REMARKS

DRY TO 5', 6/23/21

FILL 0-5', CLAY, SANDY, GRAY,
 STIFF, MOIST

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
			15	11.1	1
5			16	9.6	1
10					
15					
20					



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TEST BORING LOG

DRAWN:

DATE

CHECKED:

DATE: 7/12/21

JOB NO:
 211646

FIG NO:
 A- 1

TEST BORING NO. 3
 DATE DRILLED 6/23/2021
 Job # 211646

TEST BORING NO.
 DATE DRILLED
 CLIENT
 LOCATION GLEN DEVELOPMENT
 GLEN AT WIDEFIELD, F-10

REMARKS

DRY TO 5', 6/23/21

FILL 0-5', SAND, VERY CLAYEY,
 FINE GRAINED, GRAY, MEDIUM
 DENSE, MOIST

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
5			20	11.6	1
5			11	10.9	1
10					
15					
20					

REMARKS

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
5					
10					
15					
20					



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TEST BORING LOG

DRAWN:

DATE:

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DATE: 7/12/21

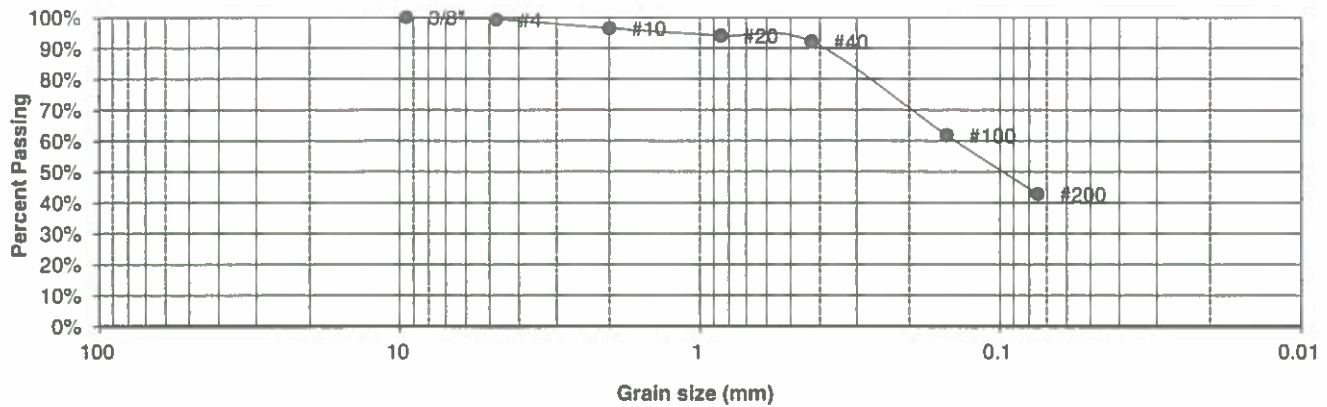
JOB NO.:
 211646

FIG NO.:
 A- 2

APPENDIX B: Laboratory Test Results

<u>UNIFIED CLASSIFICATION</u>	SC	<u>CLIENT</u>	GLEN DEVELOPMENT
<u>SOIL TYPE #</u>	1, CBR	<u>PROJECT</u>	GLEN AT WIDFIELD, F-10
<u>TEST BORING #</u>	1	<u>JOB NO.</u>	211646
<u>DEPTH (FT)</u>	0-3	<u>TEST BY</u>	BL
<u>AASHTO CLASSIFICATION</u>	A-6	<u>GROUP INDEX</u>	3

**Sieve Analysis
Grain Size Distribution**



<u>U.S. Sieve #</u>	<u>Percent Finer</u>
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	99.3%
10	96.4%
20	94.0%
40	92.1%
100	61.8%
200	42.7%

<u>Atterberg Limits</u>	
Plastic Limit	15
Liquid Limit	30
Plastic Index	15

<u>Swell</u>	
Moisture at start	
Moisture at finish	
Moisture increase	
Initial dry density (pcf)	
Swell (psf)	



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**LABORATORY TEST
RESULTS**

DRAWN:

DATE:

CHECKED:

[Signature]

DATE: 7/12/21

JOB NO:

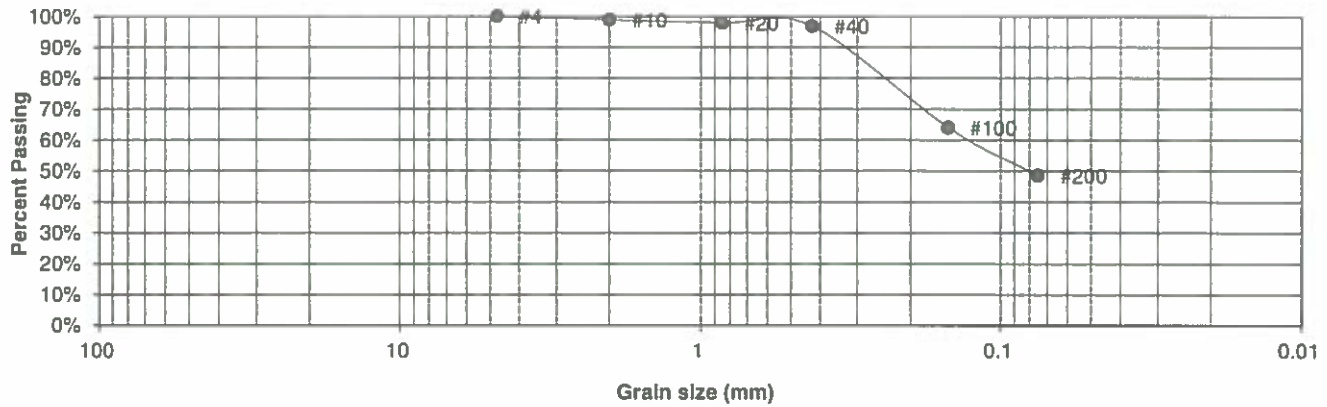
211646

FIG NO:

B-1

<u>UNIFIED CLASSIFICATION</u>	SC	<u>CLIENT</u>	GLEN DEVELOPMENT
<u>SOIL TYPE #</u>	1	<u>PROJECT</u>	GLEN AT WIDEFIELD, F-10
<u>TEST BORING #</u>	1	<u>JOB NO.</u>	211646
<u>DEPTH (FT)</u>	1-2	<u>TEST BY</u>	BL
<u>AASHTO CLASSIFICATION</u>	A-6	<u>GROUP INDEX</u>	5

**Sieve Analysis
Grain Size Distribution**



<u>U.S. Sieve #</u>	<u>Percent Finer</u>
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	
4	100.0%
10	98.8%
20	97.8%
40	96.8%
100	64.0%
200	48.6%

<u>Atterberg Limits</u>	
Plastic Limit	14
Liquid Limit	32
Plastic Index	18

<u>Swell</u>	
Moisture at start	
Moisture at finish	
Moisture increase	
Initial dry density (pcf)	
Swell (psf)	



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LABORATORY TEST RESULTS

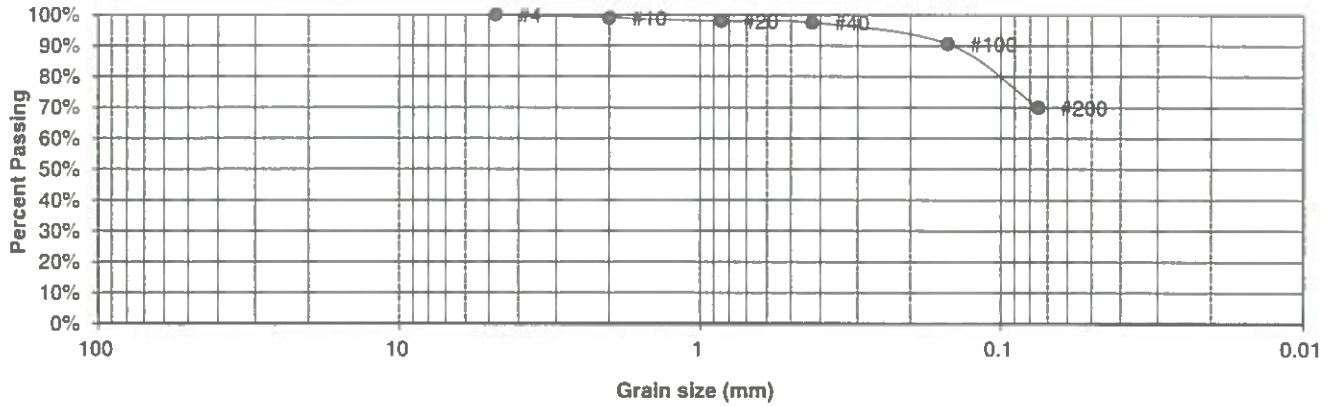
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JOB NO. 211646

FIG NO. B-2

<u>UNIFIED CLASSIFICATION</u>	CL	<u>CLIENT</u>	GLEN DEVELOPMENT
<u>SOIL TYPE #</u>	1	<u>PROJECT</u>	GLEN AT WIDFIELD, F-10
<u>TEST BORING #</u>	2	<u>JOB NO.</u>	211646
<u>DEPTH (FT)</u>	1-2	<u>TEST BY</u>	BL
<u>AASHTO CLASSIFICATION</u>	A-7-6	<u>GROUP INDEX</u>	16

**Sieve Analysis
Grain Size Distribution**



<u>U.S. Sieve #</u>	<u>Percent Finer</u>
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	
4	100.0%
10	99.0%
20	97.9%
40	97.5%
100	90.6%
200	69.9%

<u>Atterberg Limits</u>	
Plastic Limit	15
Liquid Limit	41
Plastic Index	26

<u>Swell</u>	
Moisture at start	
Moisture at finish	
Moisture increase	
Initial dry density (pcf)	
Swell (psf)	



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LABORATORY TEST RESULTS

DRAWN:

DATE:

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DATE: 7/12/14

JOB NO.:

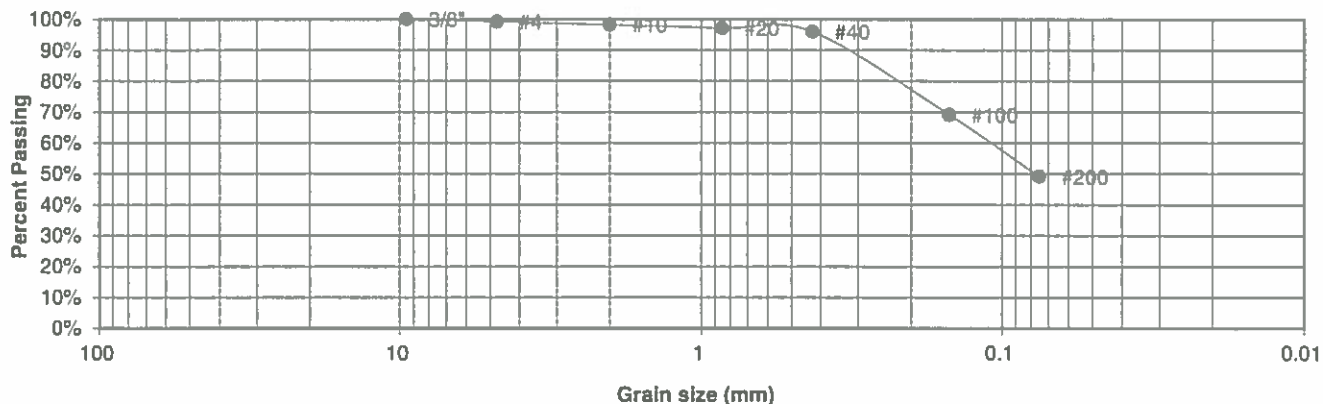
211646

FIG NO.:

6-3

<u>UNIFIED CLASSIFICATION</u>	SC	<u>CLIENT</u>	GLEN DEVELOPMENT
<u>SOIL TYPE #</u>	1	<u>PROJECT</u>	GLEN AT WIDEFIELD, F-10
<u>TEST BORING #</u>	3	<u>JOB NO.</u>	211646
<u>DEPTH (FT)</u>	1-2	<u>TEST BY</u>	BL
<u>AASHTO CLASSIFICATION</u>	A-6	<u>GROUP INDEX</u>	4

**Sieve Analysis
Grain Size Distribution**



<u>U.S. Sieve #</u>	<u>Percent Finer</u>
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	99.2%
10	98.2%
20	97.1%
40	96.0%
100	69.1%
200	49.1%

<u>Atterberg Limits</u>	
Plastic Limit	15
Liquid Limit	31
Plastic Index	17

<u>Swell</u>	
Moisture at start	
Moisture at finish	
Moisture increase	
Initial dry density (pcf)	
Swell (psf)	



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**LABORATORY TEST
RESULTS**

DRAWN:	DATE:	CHECKED: <i>h</i>	DATE: 7/12/21
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JOB NO.:

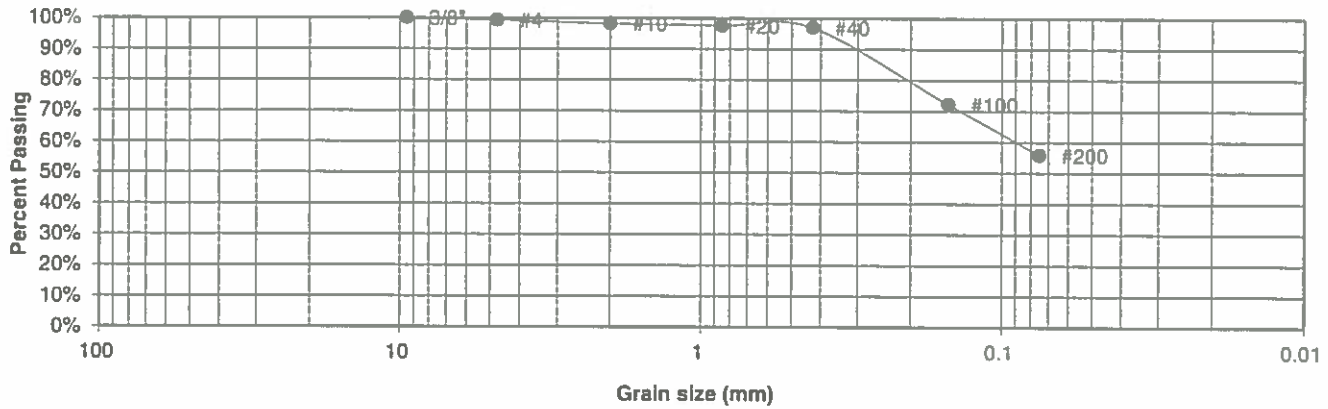
211646

FIG NO.:

B-4

<u>UNIFIED CLASSIFICATION</u>	CL	<u>CLIENT</u>	GLEN DEVELOPMENT
<u>SOIL TYPE #</u>	1	<u>PROJECT</u>	GLEN AT WIDEFIELD, F-10
<u>TEST BORING #</u>	2	<u>JOB NO.</u>	211646
<u>DEPTH (FT)</u>	0-3	<u>TEST BY</u>	BL
<u>AASHTO CLASSIFICATION</u>	A-6	<u>GROUP INDEX</u>	10

**Sieve Analysis
Grain Size Distribution**



<u>U.S. Sieve #</u>	<u>Percent Finer</u>
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	99.3%
10	98.2%
20	97.6%
40	97.0%
100	72.2%
200	55.8%

<u>Atterberg Limits</u>	
Plastic Limit	12
Liquid Limit	36
Plastic Index	25

<u>Swell</u>	
Moisture at start	
Moisture at finish	
Moisture increase	
Initial dry density (pcf)	
Swell (psf)	



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**LABORATORY TEST
RESULTS**

DRAWN:	DATE:	CHECKED:	DATE:
		<i>[Signature]</i>	7/12/21

JOB NO.:

211646

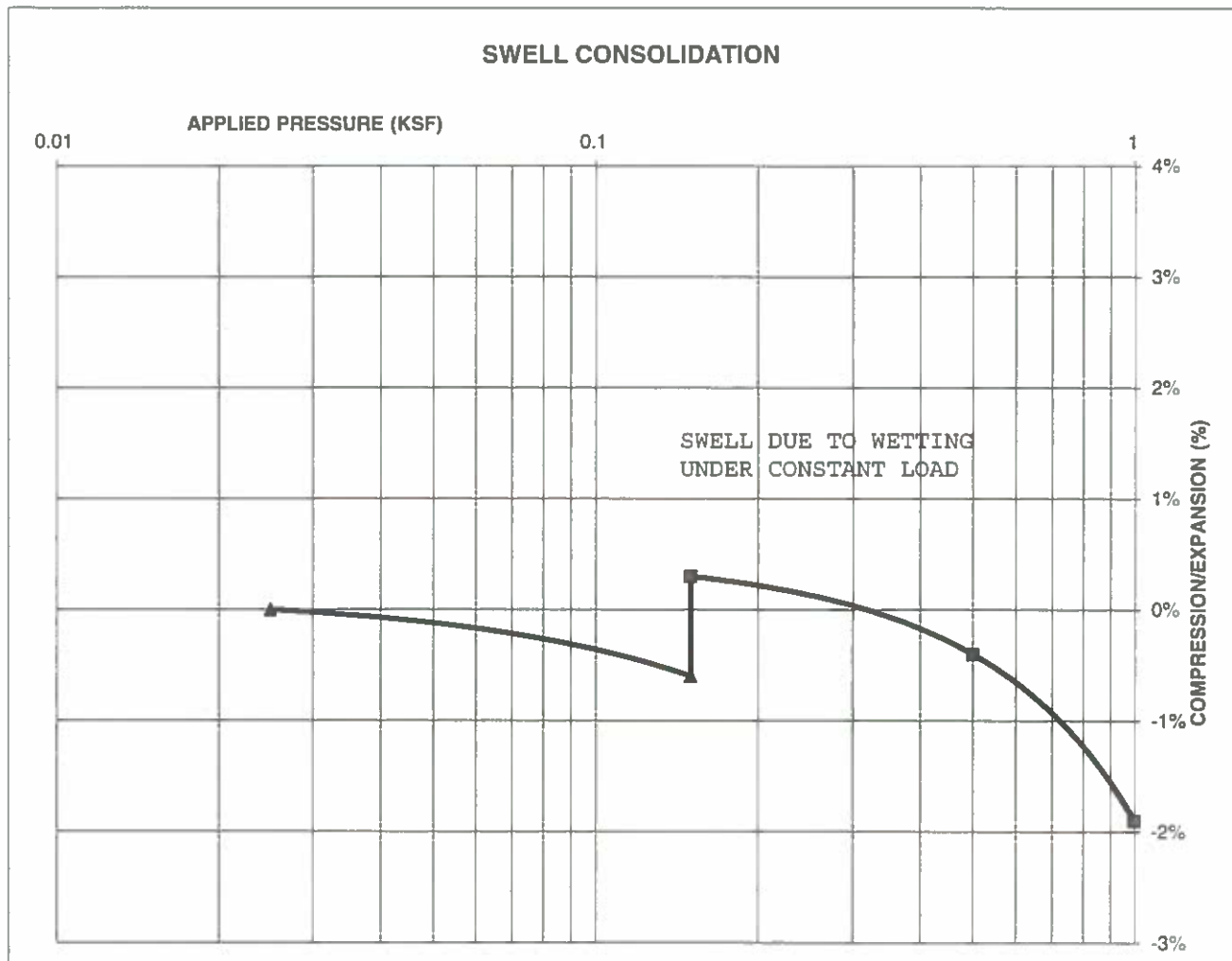
FIG NO.

B-5

CONSOLIDATION TEST RESULTS

TEST BORING #	I	DEPTH(ft)	0-3
DESCRIPTION	SC	SOIL TYPE	1, CBR
NATURAL UNIT DRY WEIGHT (PCF)			109
NATURAL MOISTURE CONTENT			15.8%
SWELL/CONSOLIDATION (%)			0.9%

JOB NO. 211646
 CLIENT GLEN DEVELOPMENT
 PROJECT GLEN AT WIDFIELD, F-10



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SWELL CONSOLIDATION TEST RESULTS

DRAWN

DATE

CHECKED

DATE

JOB NO.:

211646

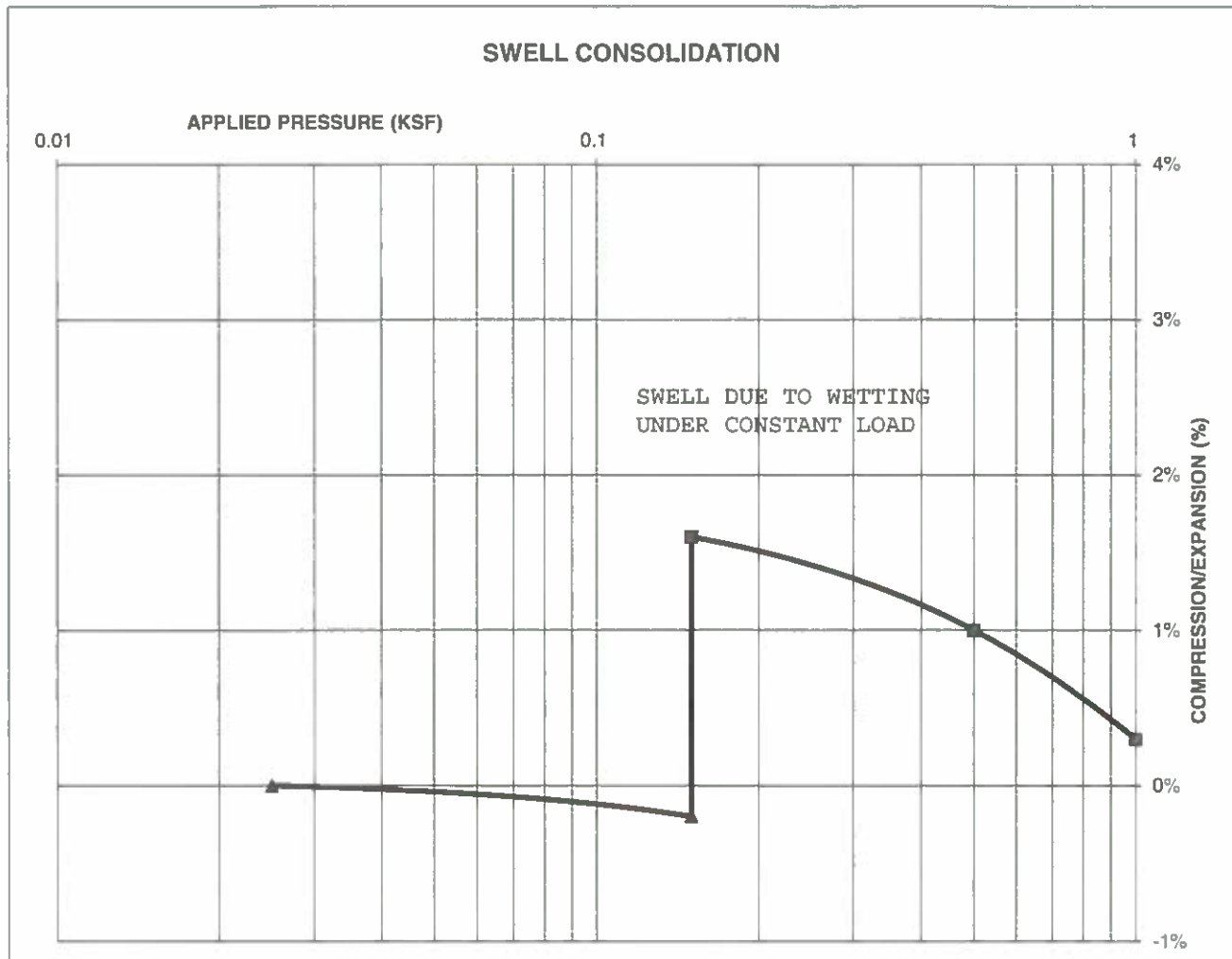
FIG NO.:

B-6

CONSOLIDATION TEST RESULTS

TEST BORING #	1	DEPTH(ft)	1-2
DESCRIPTION	SC	SOIL TYPE	1
NATURAL UNIT DRY WEIGHT (PCF)	121		
NATURAL MOISTURE CONTENT	11.6%		
SWELL/CONSOLIDATION (%)	1.8%		

JOB NO. 211646
 CLIENT GLEN DEVELOPMENT
 PROJECT GLEN AT WIDFIELD, F-10



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SWELL CONSOLIDATION TEST RESULTS

DRAWN:

DATE:

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DATE: 7/12/24

JOB NO.: 211646

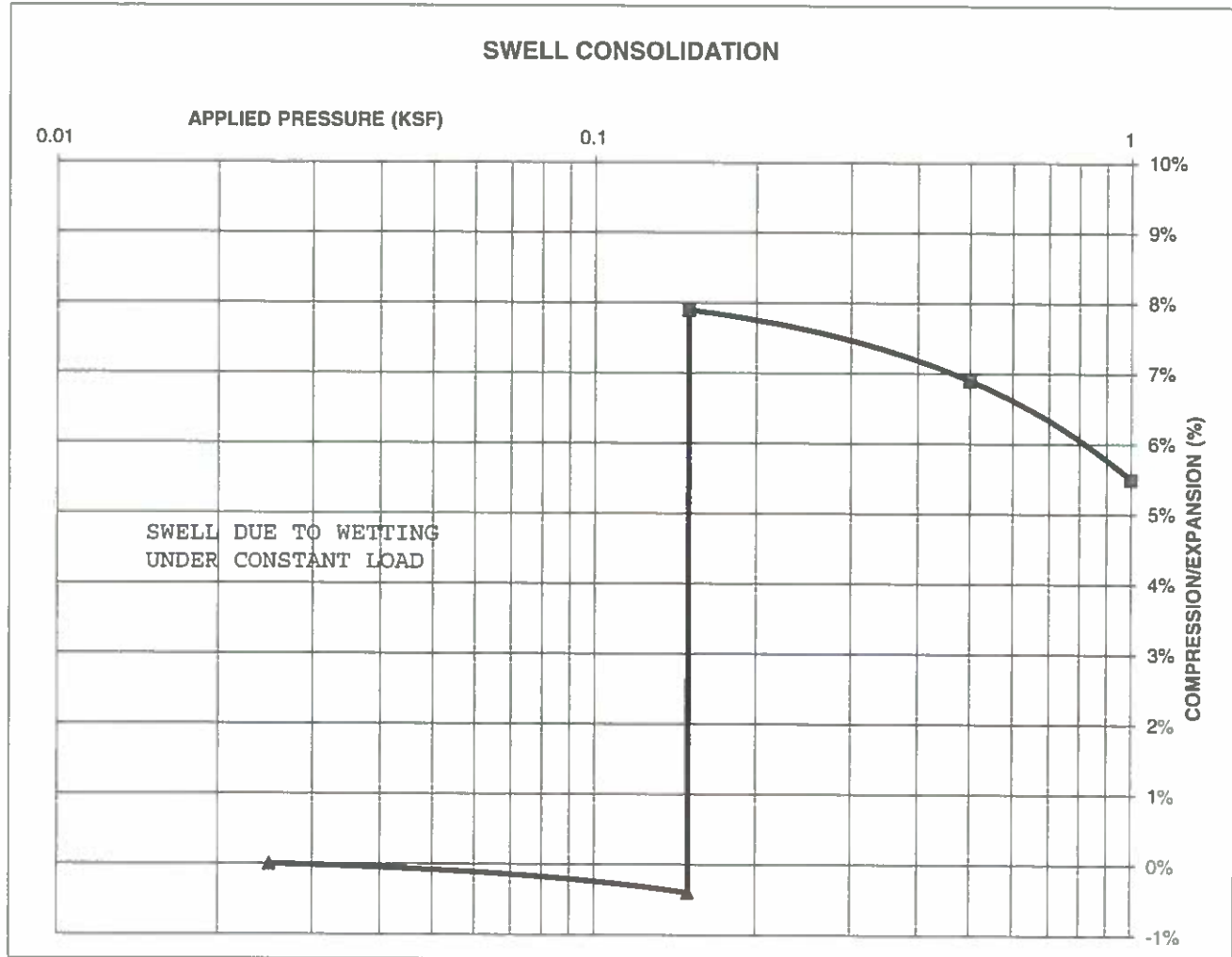
FIG NO:

57

CONSOLIDATION TEST RESULTS

TEST BORING #	2	DEPTH(ft)	1-2
DESCRIPTION	CL	SOIL TYPE	1
NATURAL UNIT DRY WEIGHT (PCF)	113		
NATURAL MOISTURE CONTENT	11.8%		
SWELL/CONSOLIDATION (%)	8.3%		

JOB NO. 211646
 CLIENT GLEN DEVELOPMENT
 PROJECT GLEN AT WIDFIELD, F-10



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 COLORADO SPRINGS, COLORADO 80907

SWELL CONSOLIDATION TEST RESULTS

DRAWN

DATE

CHECKED

DATE: 7/12/21

JOB NO.:

211646

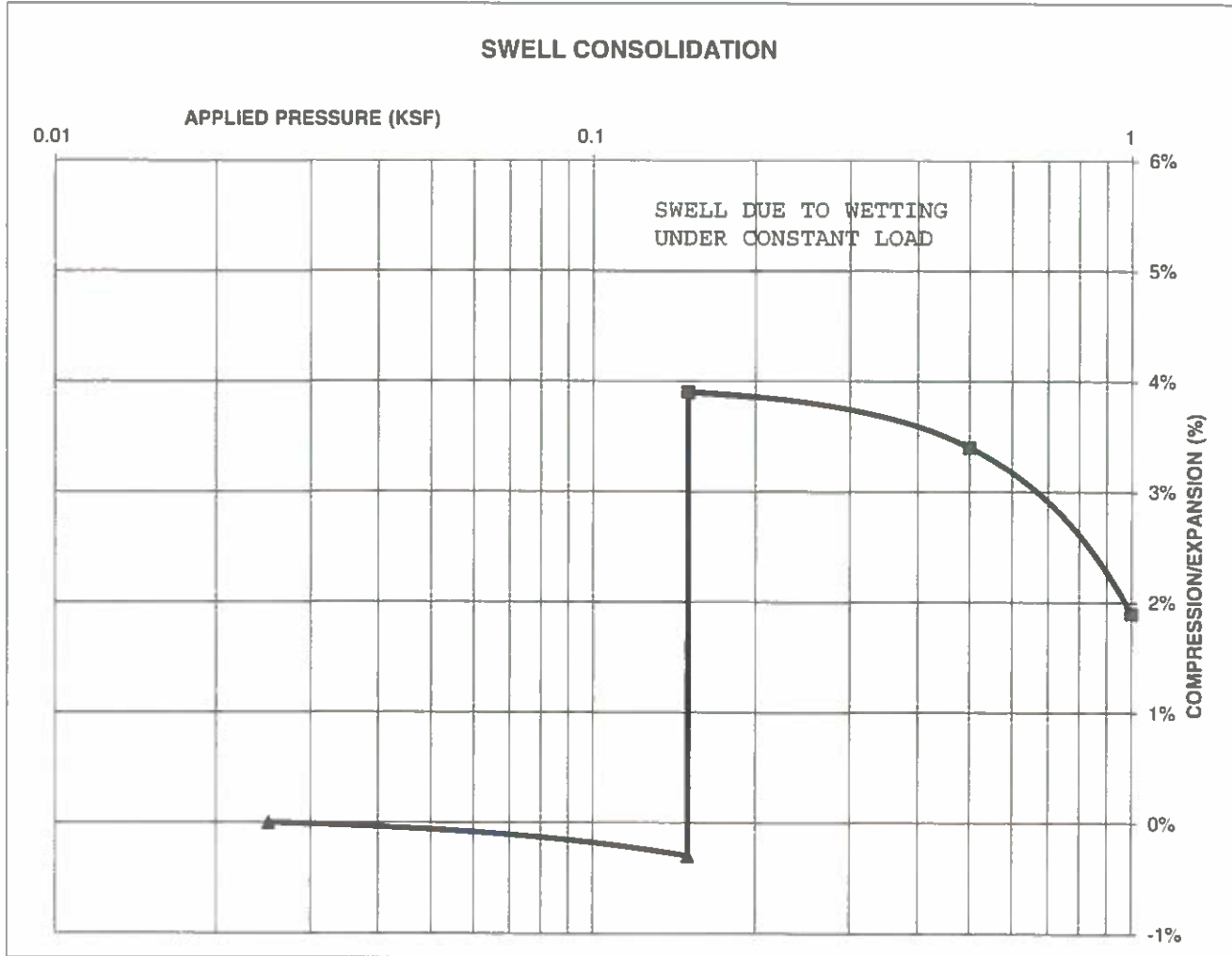
FIG NO.:

B-8

CONSOLIDATION TEST RESULTS

TEST BORING #	2	DEPTH(ft)	1-2
DESCRIPTION	CL	SOIL TYPE	1
NATURAL UNIT DRY WEIGHT (PCF)	112		
NATURAL MOISTURE CONTENT	13.9%		
SWELL/CONSOLIDATION (%)	4.2%		

JOB NO. 211646
 CLIENT GLEN DEVELOPMENT
 PROJECT GLEN AT WIDFIELD, F-10



REMOLDED AT +2% MOISTURE



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 COLORADO SPRINGS, COLORADO 80907

SWELL CONSOLIDATION TEST RESULTS

DRAWN:

DATE:

CHECKED:

DATE:

TS

7/26/21

JOB NO.:

211646

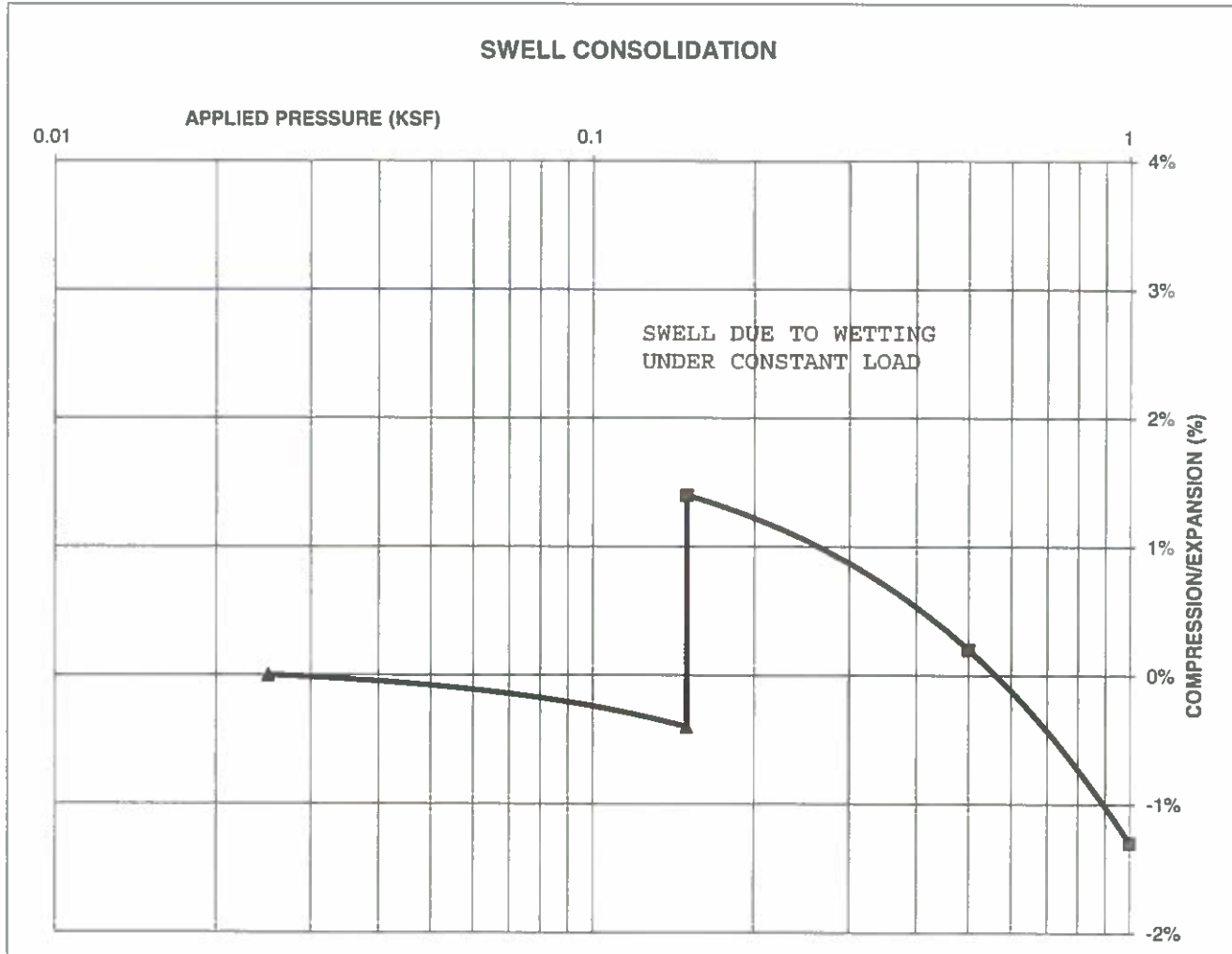
FIG NO.:

B-9

CONSOLIDATION TEST RESULTS

TEST BORING #	2	DEPTH(ft)	1-2
DESCRIPTION	CL	SOIL TYPE	1
NATURAL UNIT DRY WEIGHT (PCF)	112		
NATURAL MOISTURE CONTENT	16.2%		
SWELL/CONSOLIDATION (%)	1.8%		

JOB NO. 211646
CLIENT GLEN DEVELOPMENT
PROJECT GLEN AT WIDFIELD, F-10



REMOLED AT +4% MOISTURE



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SWELL CONSOLIDATION TEST RESULTS

DRAWN:

DATE:

CHECKED:

DATE: 7/26/21

JOB NO.:

211646

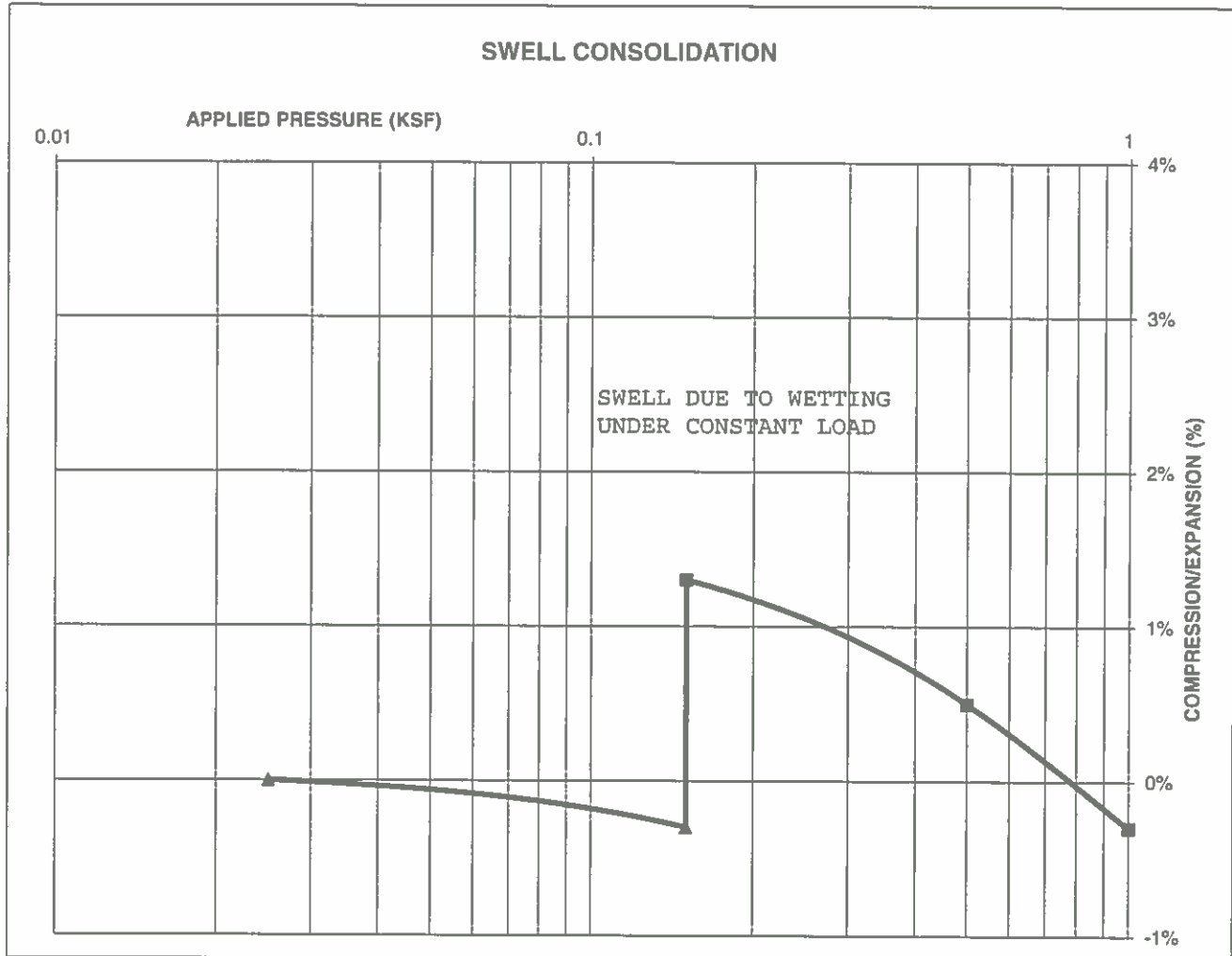
FIG NO.:

B6

CONSOLIDATION TEST RESULTS

TEST BORING #	3	DEPTH(ft)	1-2
DESCRIPTION	SC	SOIL TYPE	1
NATURAL UNIT DRY WEIGHT (PCF)	109		
NATURAL MOISTURE CONTENT	12.3%		
SWELL/CONSOLIDATION (%)	1.6%		

JOB NO. 211646
CLIENT GLEN DEVELOPMENT
PROJECT GLEN AT WIDFIELD, F-10



ENTECH
ENGINEERING, INC.

505 ELKTON DRIVE
COLORADO SPRINGS, COLORADO 80907

SWELL CONSOLIDATION TEST RESULTS

DRAWN:

DATE:

CHECKED: *h*

DATE: 7/12/21

JOB NO.:

211646

FIG NO.:

B-11

CLIENT	<u>GLEN DEVELOPMENT</u>	JOB NO.	<u>211646</u>
PROJECT	<u>GLEN AT WIDFIELD, F-10</u>	DATE	<u>7/6/2021</u>
LOCATION	<u>GLEN AT WIDFIELD, F-10</u>	TEST BY	<u>BL</u>

[illegible]

QC BLANK PASS



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505 ELKTON DRIVE
COLORADO SPRINGS, COLORADO 80907

LABORATORY TEST SULFATE RESULTS

DRAWN:

DATE: _____

CHECKED:

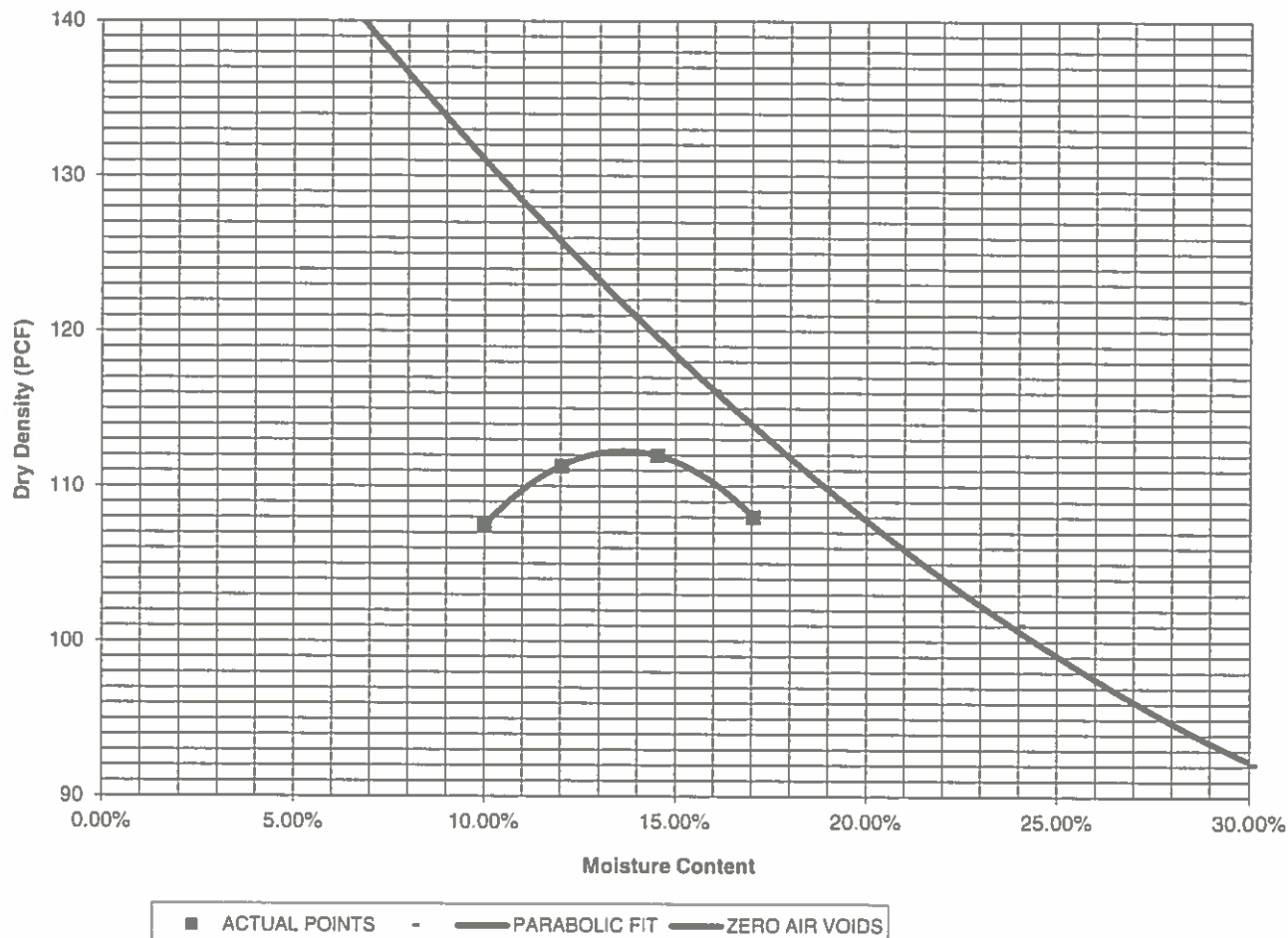
DATE: 7/12/21

JOB NO. 211646
FIG NO. B-112

PROJECT	GLEN AT WIDEFIELD, F-10	CLIENT	GLEN DEVELOPMENT
SAMPLE LOCATION	TB-1 @ 0-3'	JOB NO.	211646
SOIL DESCRIPTION	SAND, VERY CLAYEY, GRAY	DATE	06/14/21

IDENTIFICATION	SC	COMPACTION TEST #	I
TEST DESIGNATION / METHOD	ASTM D-698-A	TEST BY	BL
MAXIMUM DRY DENSITY (PCF)	112.2	OPTIMUM MOISTURE	13.6%

Compaction Curve



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505 ELKTON DRIVE
COLORADO SPRINGS, COLORADO 80907

MOISTURE DENSITY RELATION

DRAWN:

DATE:

CHECKED:

DATE:

7/12/21

JOB NO.:

211646

FIG NO.:

B-13

CBR TEST LOAD DATA

JOB NO: 211646
 CLIENT: GLEN DEVELOPMENT
 PROJECT: GLEN AT WIDEFIELD, F-10
 SOIL TYPE: 1

PISTON DIAMETER (cm) 4.958	PISTON AREA (in ²) 2.993						
		10 BLOWS		25 BLOWS		56 BLOWS	
		MOLD # 1		MOLD # 2		MOLD # 3	
PENETRATION DEPTH (INCHES)		LOAD(LBS) (LBS)	STRESS (PSI)	LOAD(LBS) (LBS)	STRESS (PSI)	LOAD(LBS) (LBS)	STRESS (PSI)
0.000		0	0.00	0	0.00	0	0.00
0.025		23	7.69	40	13.37	94	31.41
0.050		26	8.69	54	18.05	146	48.79
0.075		28	9.36	62	20.72	189	63.16
0.100		31	10.36	76	25.40	216	72.18
0.125		35	11.70	84	28.07	231	77.19
0.150		36	12.03	89	29.74	244	81.54
0.175		38	12.70	96	32.08	254	84.88
0.200		41	13.70	101	33.75	271	90.56
0.300		41	13.70	101	33.75	330	110.28
0.400		40	13.37	113	37.76	367	122.64
0.500		43	14.37	123	41.10	409	136.67

FINAL MOISTURE CONTENT

	MOLD # 1	MOLD # 2	MOLD # 3
CAN #	342	343	358
WT. CAN	6.87	6.95	6.73
WT. CAN+WET	144.96	119.44	185.78
WT. CAN+DRY	113.21	96.99	155.97
WT. H2O	31.75	22.45	29.81
WT. DRY SOIL	106.34	90.04	149.24
MOISTURE CONTENT	29.86%	24.93%	19.97%

WET DENSITY (PCF)	105.3	117.5	127.0
DRY DENSITY (PCF)	92.7	103.5	111.8

BEARING RATIO	1.04	2.54	7.22
---------------	------	------	------

90% OF DRY DENSITY	101.0
95% OF DRY DENSITY	106.6

BEARING RATIO AT 90% OF MAX	2.20 ~ R VALUE	6
BEARING RATIO AT 95% OF MAX	4.30 ~ R VALUE	10



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CBR TEST DATA

DRAWN:

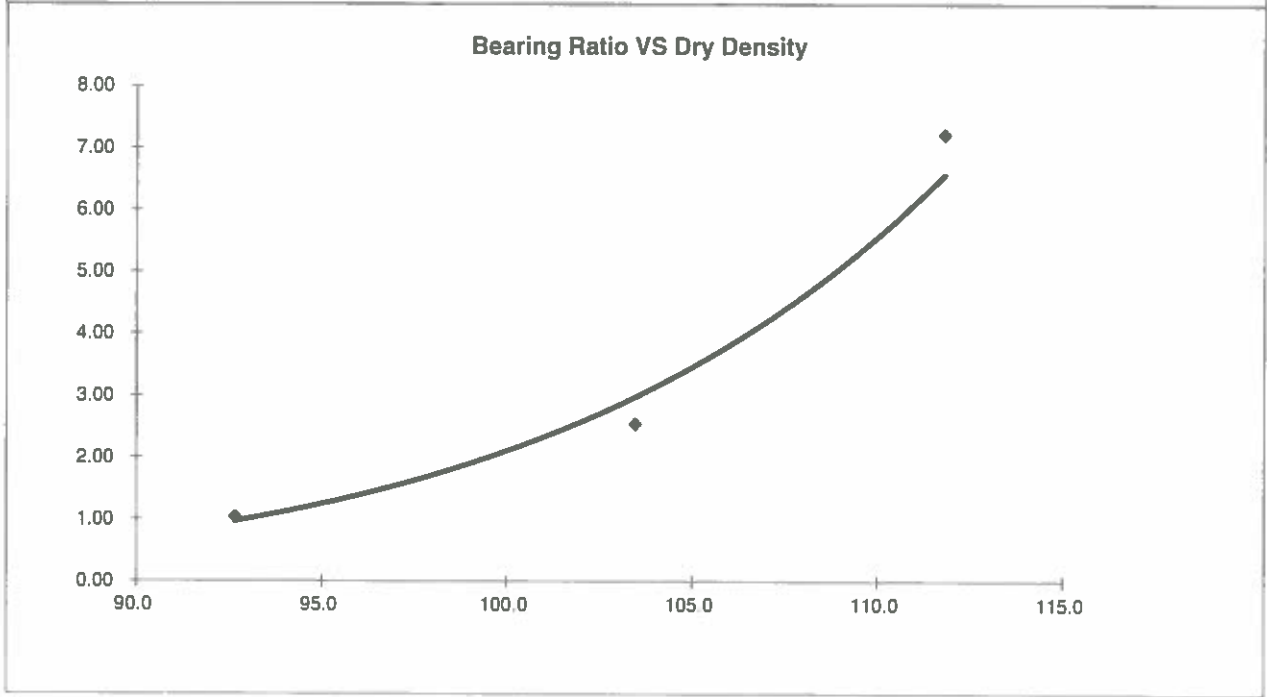
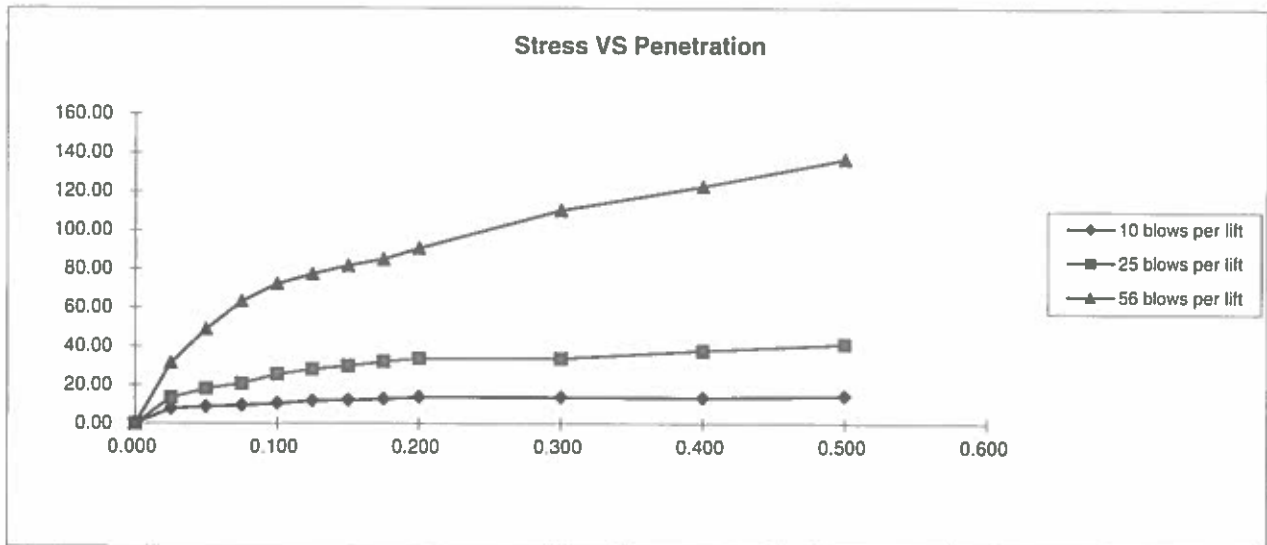
DATE:

CHECKED: *[Signature]*

DATE: 7/12/21

JOB NO:
 211646

FIG NO:
14



BEARING RATIO AT 90% OF MAX	2.20 ~ R VALUE	6.00
BEARING RATIO AT 95% OF MAX	4.30 ~ R VALUE	10.00

JOB NO: 211646
 SOIL TYPE: 1



**ENTECH
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 505 ELKTON DRIVE
 COLORADO SPRINGS, COLORADO 80907

CALIFORNIA BEARING RATIO

DRAWN:	DATE:	CHECKED:	DATE:
		<i>[Signature]</i>	7/12/21

JOB NO: 211646
 FIG NO: *B-5*

APPENDIX C: Pavement Design Calculations

FLEXIBLE PAVEMENT DESIGN

DESIGN DATA

GLEN DEVELOPMENT

THE GLEN AT WIDEFIELD # 10 - URBAN LOCAL(LOW-VOLUME)

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL (W_{18}) =	36,500
Hveem Stabilometer (R Value) Results:	R =	10
Standard Deviation	S_o =	0.44
Loss in Serviceability	Δpsi =	2.0
Reliability	Reliability =	80
Reliability (z-statistic)	Z_R =	-0.841
Soil Resilient Modulus	M_R =	3562

Weighted Structural Number (WSN): ➔ WSN = 2.44

DESIGN TABLES AND EQUATIONS

$$S_1 = [(R - 5) / 11.29] + 3$$

$$M_R = 10^{[(S_1 + 18.72) / 6.24]}$$

$$k = M_R / 19.4$$

Where:

M_R = resilient modulus (psi)

S_1 = the soil support value

R = R-value obtained from the Hveem stabilometer

CBR = California Bearing Ratio

Reliability (%) Z_R (z-statistic)

50	0
60	-0.253
70	-0.524
75	-0.674
80	-0.841
90	-1.282
95	-1.65
97	-1.88
98	-2.05
99	-2.33
99.9	-3.09
99.99	-3.75

$$\log_{10} W_{18} = Z_R * S_o + 9.36 * \log_{10} (SN+1) - 0.20 + \frac{\log_{10} \left[\frac{\Delta PSI}{4.2 - 1.5} \right]}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32 * \log_{10} M_R - 8.07$$

Left	Right	Difference
4.56	4.56	0.0

Job No. 211646

Fig. No. C-1

DESIGN CALCULATIONS

CEMENT TREATED SECTIONS

DESIGN DATA

GLEN DEVELOPMENT

THE GLEN AT WIDFIELD # 10 - URBAN LOCAL(LOW-VOLUME)

Equivalent (18 kip) Single Axle Load Applications (ESAL):

ESAL = 36,500

Hveem Stabilometer (R Value) Results:

R = 10

Weighted Structural Number (WSN):

WSN = 2.44

DESIGN EQUATION

$$WSN = C_1 D_1 + C_2 D_2$$

$C_1 = 0.44$ Strength Coefficient - Hot Bituminous Asphalt

$C_2 = 0.11$ Strength Coefficient - Cement Stabilized Subgrade

D_1 = Depth of Asphalt (inches)

D_2 = Depth of Cement Stabilized Subgrade(inches)

FOR FULL DEPTH ASPHALT SECTION(CURRENTLY NOT ALLOWED)

$D_1 = (WSN)/C_1 = 5.5$ inches of Full Depth Asphalt

Use 6.0 inches Full Depth

FOR ASPHALT + CEMENT STABILIZED SUBGRADE SECTION

Asphalt Thickness (t) = 3.5 inches

$D_2 = ((WSN) - (t)(C_1))/C_2 = 8.2$ inches of Cement Stabilized Subgrade,

use 8.5 inches

RECOMMENDED ALTERNATIVES

1. 3.5 inches of Asphalt + 8.5 inches of Cement Stabilized Subgrade, or
2. 6.0 inches of Full-Depth Asphalt

Job No. 211646

Fig. No. C-2

FLEXIBLE PAVEMENT DESIGN

DESIGN DATA

GLEN DEVELOPMENT

THE GLEN AT WIDFIELD # 10 - URBAN LOCAL

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL (W_{18}) =	292,000
Hveem Stabilometer (R Value) Results:	R =	10
Standard Deviation	S_o =	0.44
Loss in Serviceability	Δpsi =	2.0
Reliability	Reliability =	80
Reliability (z-statistic)	Z_R =	-0.841
Soil Resilient Modulus	M_R =	3562

Weighted Structural Number (WSN): ➔ WSN = 3.38

DESIGN TABLES AND EQUATIONS

$$S_1 = [(R - 5) / 11.29] + 3$$

$$M_R = 10^{[(S_1 + 18.72) / 6.24]}$$

$$k = M_R / 19.4$$

Where:

M_R = resilient modulus (psi)

S_1 = the soil support value

R = R-value obtained from the Hveem stabilometer

CBR = California Bearing Ratio

Reliability (%)	Z_R (z-statistic)
50	0
60	-0.253
70	-0.524
75	-0.674
80	-0.841
90	-1.282
95	-1.65
97	-1.88
98	-2.05
99	-2.33
99.9	-3.09
99.99	-3.75

$$\log_{10} W_{18} = Z_R * S_o + 9.36 * \log_{10} (SN+1) - 0.20 + \frac{\log_{10} \left[\frac{\Delta \text{PSI}}{4.2 - 1.5} \right]}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32 * \log_{10} M_R - 8.07$$

Left	Right	Difference
5.47	5.47	0.0

Job No. 211646

Fig. No. C-3

DESIGN CALCULATIONS

CEMENT TREATED SECTIONS

DESIGN DATA

GLEN DEVELOPMENT

THE GLEN AT WIDFIELD # 10 - URBAN LOCAL

Equivalent (18 kip) Single Axle Load Applications (ESAL):

ESAL = 292,000

Hveem Stabilometer (R Value) Results:

R = 10

Weighted Structural Number (WSN):

WSN = 3.38

DESIGN EQUATION

$$WSN = C_1 D_1 + C_2 D_2$$

$C_1 = 0.44$ Strength Coefficient - Hot Bituminous Asphalt

$C_2 = 0.11$ Strength Coefficient - Cement Stabilized Subgrade

D_1 = Depth of Asphalt (inches)

D_2 = Depth of Cement Stabilized Subgrade(inches)

FOR FULL DEPTH ASPHALT SECTION(CURRENTLY NOT ALLOWED)

$D_1 = (WSN)/C_1 = 7.7$ inches of Full Depth Asphalt

Use 8.0 inches Full Depth

FOR ASPHALT + CEMENT STABILIZED SUBGRADE SECTION

Asphalt Thickness (t) = 5 inches

$D_2 = ((WSN) - (t)(C_1))/C_2 = 10.7$ inches of Cement Stabilized Subgrade,
use 11.0 inches

RECOMMENDED ALTERNATIVES

1. 5.0 inches of Asphalt + 11.0 inches of Cement Stabilized Subgrade, or
2. 8.0 inches of Full-Depth Asphalt

Job No. 211646

Fig. No. C-4