



ENTECH
ENGINEERING, INC.

505 ELKTON DRIVE
COLORADO SPRINGS, CO 80907
PHONE (719) 531-5599
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July 19, 2021
Revised; July 26, 2021

Carl Turse
17572 Colonial Park Drive
Monument, CO 80132

APPROVED
Engineering Department

07/27/2021 2:30:59 PM
dsdnijkamp

EPC Planning & Community
Development Department

Re: Pavement Recommendations - Revised
Rollin Ridge, Filing 1
Cherry Crossing Drive and Bark Tree Trail
El Paso County, Colorado

Dear Mr. Turse:

As requested, Entech Engineering, Inc. obtained samples of the pavement subgrade soils from the proposed roadways at the above referenced site. Laboratory testing was performed in order to determine the pavement support characteristics of the soil. This letter presents the results of the laboratory testing and pavement recommendations for the roadways.

Project Description

The project will consist of paving of the proposed Cherry Crossing Drive and Bark Tree Trail in the Rollin Ridge, Filing 1 subdivision in El Paso County, Colorado. Subsurface Soil Investigation and laboratory testing were performed to determine the pavement support characteristics on the soils. The general layout of the site is presented in the Test Boring Location Map in Figure 1.

Subgrade Conditions

A total of four test borings were drilled along the roadways to depths of approximately 5 and 10 feet below the existing subgrade surface at the required sample frequency. At the time of our field investigation the subgrade was in good condition and adequate for vehicle traffic, including emergency vehicles.

The soils at the roadway subgrade depth consisted of silty sand (Soil Type 1) and sandy clay fill to native sandy clay (Soil Type 2). The Test Boring Logs are presented in Appendix A. Sieve Analyses and Atterberg Limit testing were performed on subgrade soil samples obtained from the test borings for the purpose of classification. The percent passing the No. 200 sieve for the Type 1 soils ranged from approximately 18 to 33 percent and 63 to 64 percent for the Type 2 soils. The Type 3 soils are beneath the subgrade influence zone.

The Type 1 soils classified as A-2-4 to A-1-b, which commonly exhibits good pavement support characteristics. The Type 2 soils classified as A-6 soils, which exhibit poor pavement support characteristics. Groundwater was not encountered in the test borings. Sulfate testing resulted in 0.00 to less than 0.01 percent soluble sulfate by weight, indicating a negligible potential for below grade concrete degradation due to sulfate attack.

Swell/Consolidation tests were not performed on the Type 1 soils due to their classification and plastic indexes. Swell tests on the Type 2 soils resulted in volume changes of 0.3 to 1.9, which are below levels in which mitigation is required. Mitigation for expansive soils is not required on this site.

PCD File No. SF-1922

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 El Paso County, Colorado

California Bearing Ratio (CBR) testing was performed on representative subgrade samples of the Type 1 and 2 materials to determine the support characteristics of the subgrade soils for the roadway sections. The results of the CBR testing, are presented in Appendix B and summarized as follows:

<u>Soil Type 1 – Silty Sand</u>	<u>Soil Type 2 – Sandy Clay</u>
<u>CBR 1</u>	<u>CBR 2</u>
R @ 95% = 45.0	R @ 95% = 7.5
R @ 90% = 30.0	R @ 90% = 1.0
Use R = 45.0 for design	Use R = 7.5 for design

<u>Classification Testing</u>		<u>Classification Testing</u>	
Liquid Limit	NV	Liquid Limit	30
Plasticity Index	NP	Plasticity Index	13
Percent Passing 200	18.5	Percent Passing 200	63.7
AASHTO Classification	A-1-b	AASHTO Classification	A-6
Group Index	0	Group Index	6
Unified Soils Classification	SM	Unified Soils Classification	CL

Pavement Design

CBR testing was used to determine pavement sections for the roadways. Pavement sections were determined utilizing El Paso County Pavement Design Criteria Manual. Cherry Crossing Drive from Hodgen Road through the intersection of Bark Tree Trail extending to a future roadway classifies as a rural minor arterial, which used an 18k ESAL value of 689,850 for design purposes. Bark Tree Trail and the cul-de-sac portion of Cherry Crossing classify as Rural Local Roads, which used an 18K ESAL value of 36,500 for design purposes. Pavement sections were determined for asphalt on cement stabilized subgrade.

Design parameters used in the pavement analysis for the roadways are as follows:

<u>Reliability</u>	
Rural Local	75%
Rural Minor Arterial	80%
<u>Δpsi</u>	
Rural Local	2.0
Rural Minor Arterial	2.5
“R” Value Subgrade (Soil Type 1)	45.0
“R” Value Subgrade (Soil Type 2)	7.5
Resilient Modulus (Soil Type 1)	11,183 psi
Resilient Modulus (Soil Type 2)	3,283 psi
Hot Bituminous Pavement	0.44
Basecourse Subgrade	0.11

The pavement design calculations are presented in Appendix C. Pavement section alternatives for the roadway sections are presented below. Any additional grading may result in subgrade

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soils with different support characteristics. The following pavement sections should be re-evaluated if additional grading is performed.

Pavement Sections
ESAL = 689,850 – Cherry Crossing Drive from Hodgen Road through the intersection with Bark Tree Trail extending to future roadway
Soil Type 2/2A

<u>Alternative</u>	<u>Asphalt (in)</u>	<u>Basecourse (in)</u>
1. Asphalt Over Basecourse	6.0	11.0

Pavement Sections
ESAL = 36,500 – Cherry Crossing Drive Cul-de-sac
Soil Type 1

<u>Alternative</u>	<u>Asphalt (in)</u>	<u>Basecourse (in)</u>
1. Asphalt Over Basecourse	3.0*	4.0

Pavement Sections
ESAL = 36,500 – Bark Tree Trail
Soil Type 2/2A

<u>Alternative</u>	<u>Asphalt (in)</u>	<u>Basecourse (in)</u>
1. Asphalt Over Basecourse	4.0	6.5

*Minimum sections required per the El Paso County Engineering Criteria Manual.

Mitigation

The El Paso County Engineering Criteria Manual requires mitigation of subgrade soils that have a swell of 2.0 percent or greater with a 200 pound per square foot surcharge. None of the swell tests exceeded the threshold. Mitigation of the subgrade soils is not required.

Roadway Construction - Asphalt on Aggregate Basecourse

Prior to placement of the asphalt, the Type 1 subgrade should be scarified, moisture conditioned, and compacted to a minimum of 95 percent of the soils maximum Modified Proctor Dry Density, ASTM D-1557 at ± 2 percent of optimum moisture content. The Type 2 soils subgrade should be scarified, moisture conditioned, and compacted to a minimum of 95% of the soils maximum Standard Proctor Dry Density, ASTM D-698 at 0 to 4 percent over optimum moisture content and properly compacted. Any loose or soft areas should be removed and replaced with suitable materials. Basecourse 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. It is noted that full-depth asphalt is currently not allowed, per El Paso County specifications

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El Paso County, Colorado

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. The pavement sections provided are based on general site soil types. If you have any questions or need additional information, please do not hesitate to contact us.

Respectfully Submitted,

ENTECH ENGINEERING, INC.



Daniel P. Stegman

JCG/bs

Encl.

Entech Job No. 211631
AAprojects/2021/211631 pr -rev2

Reviewed by:



Joseph C. Good, P.E.
President



TABLE

TABLE 1
SUMMARY OF LABORATORY TEST RESULTS

CLIENT CARL TURSE
 PROJECT ROLLIN RIDGE, FILING 1
 JOB NO. 211631

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	4	0-3			18.5	NV	NP		A-1-b		SM	SAND, SILTY
1	3	1-2			33.1	NV	NP		A-2-4		SM	SAND, SILTY
1	4	1-2			17.9	NV	NP	0.00	A-1-b		SM	SAND, SILTY
2, CBR	2	0-3	11.9	111.5	63.7	30	13		A-6	1.9	CL	CLAY, SANDY
2A	1	1-2	12.8	121.2	62.9	29	12	<0.01	A-6	0.3	CL	FILL, CLAY, SANDY
2	2	1-2	10.0	106.6	63.5	27	13		A-6	1.1	CL	CLAY, SANDY
3	3	10			11.8	NV	NP		A-1-b		SM-SW	SANDSTONE, SLIGHTLY SILTY


FIGURE

REVISION BY	DATE	DESCRIPTION

ENTTECH

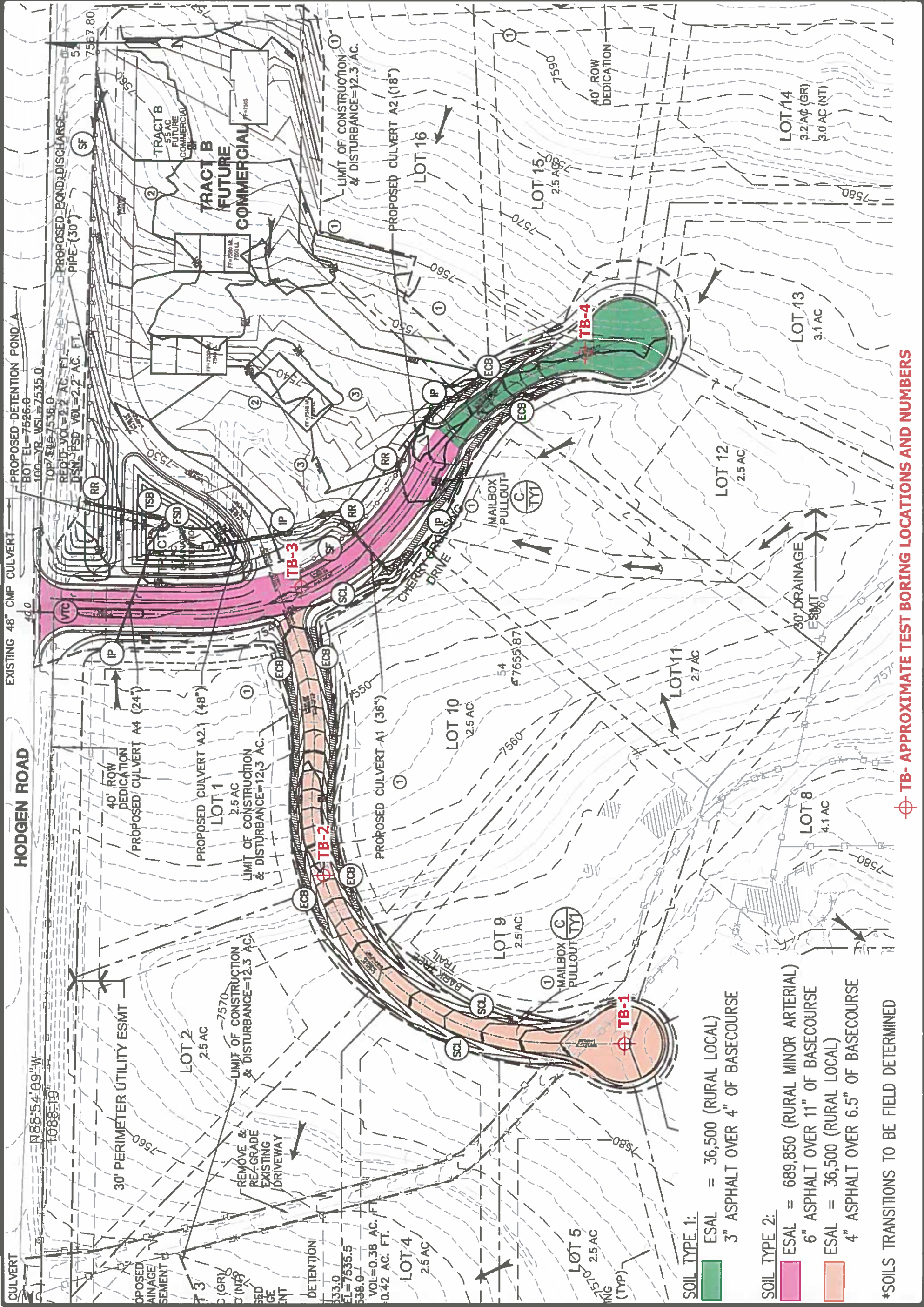
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TEST BORING LOCATION MAP
ROLLIN RIDGE, FILING 1
EL PASO COUNTY, CO
FOR: CARL TURSE

DATE	7/27/21
BY	
CHECKED BY	
DATE	
SCALE	1" = 100'
PROJECT NO.	211051
PLATE NO.	1



APPENDIX A: Test Boring Logs

TEST BORING NO. 1
 DATE DRILLED 6/18/2021
 Job # 211631

TEST BORING NO. 2
 DATE DRILLED 6/18/2021
 CLIENT CARL TURSE
 LOCATION ROLLIN RIDGE, FILING 1

REMARKS

DRY TO 5', 6/18/21
 FILL 0-2', CLAY, SANDY, BROWN,
 VERY STIFF, MOIST
 SAND, SILTY, FINE GRAINED,
 TAN, MEDIUM DENSE, MOIST

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
0-5	[Diagonal Hatching]	[Solid Black]	31	12.4	2A
5-10	[Dotted]	[Solid Black]	10	12.3	1
10-15	[Vertical Lines]	[Solid Black]			
15-20	[Vertical Lines]	[Solid Black]			

REMARKS

DRY TO 5', 6/18/21
 CLAY, SANDY, TAN, FIRM TO
 STIFF, MOIST

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
0-5	[Diagonal Hatching]	[Solid Black]	11	11.2	2
5-10	[Diagonal Hatching]	[Solid Black]	15	12.0	2
10-15	[Vertical Lines]	[Solid Black]			
15-20	[Vertical Lines]	[Solid Black]			



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TEST BORING LOG

DRAWN:

DATE:

CHECKED: *RTA*

DATE: 7/7/21

JOB NO.:
 211631

FIG NO.:
 A- 1

TEST BORING NO. 3
 DATE DRILLED 6/18/2021
 Job # 211631

TEST BORING NO. 4
 DATE DRILLED 6/18/2021
 CLIENT CARL TURSE
 LOCATION ROLLIN RIDGE, FILING 1

REMARKS

DRY TO 10', 6/18/21

FILL 0-1, CLAY, SANDY, BROWN
 SAND, SILTY, FINE GRAINED,
 TAN, MEDIUM DENSE TO DENSE,
 MOIST

SANDSTONE, SLIGHTLY SILTY,
 FINE TO COARSE GRAINED,
 TAN, VERY DENSE, MOIST

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
			29	11.6	2A
5			43	3.7	1
10			50 6"	4.3	3
15					
20					

REMARKS

DRY TO 5', 6/18/21

SAND, SILTY, FINE GRAINED,
 BROWN, MEDIUM DENSE, DRY
 TO MOIST

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
			22	2.7	1
5			26	4.5	1
10					
15					
20					



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TEST BORING LOG

DRAWN:

DATE:

CHECKED:
RPT

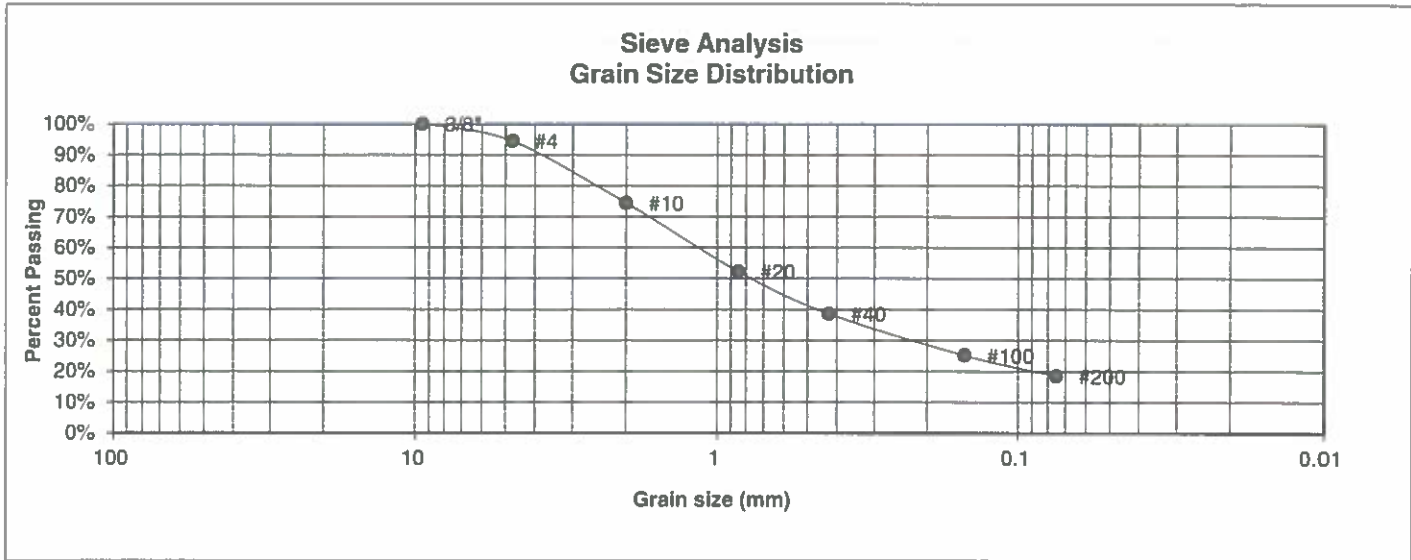
DATE:
 7/7/21

JOB NO.
 211631

FIG NO.
 A- 2

APPENDIX B: Laboratory Testing Results

UNIFIED CLASSIFICATION	SM	CLIENT	CARL TURSE
SOIL TYPE #	1, CBR	PROJECT	ROLLIN RIDGE, FILING 1
TEST BORING #	4	JOB NO.	211631
DEPTH (FT)	0-3	TEST BY	BL
AASHTO CLASSIFICATION	A-1-b	GROUP INDEX	0



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	94.5%
10	74.4%
20	52.2%
40	38.6%
100	25.2%
200	18.5%

Atterberg Limits	
Plastic Limit	NP
Liquid Limit	NV
Plastic Index	NP

Swell
 Moisture at start
 Moisture at finish
 Moisture increase
 Initial dry density (pcf)
 Swell (psf)



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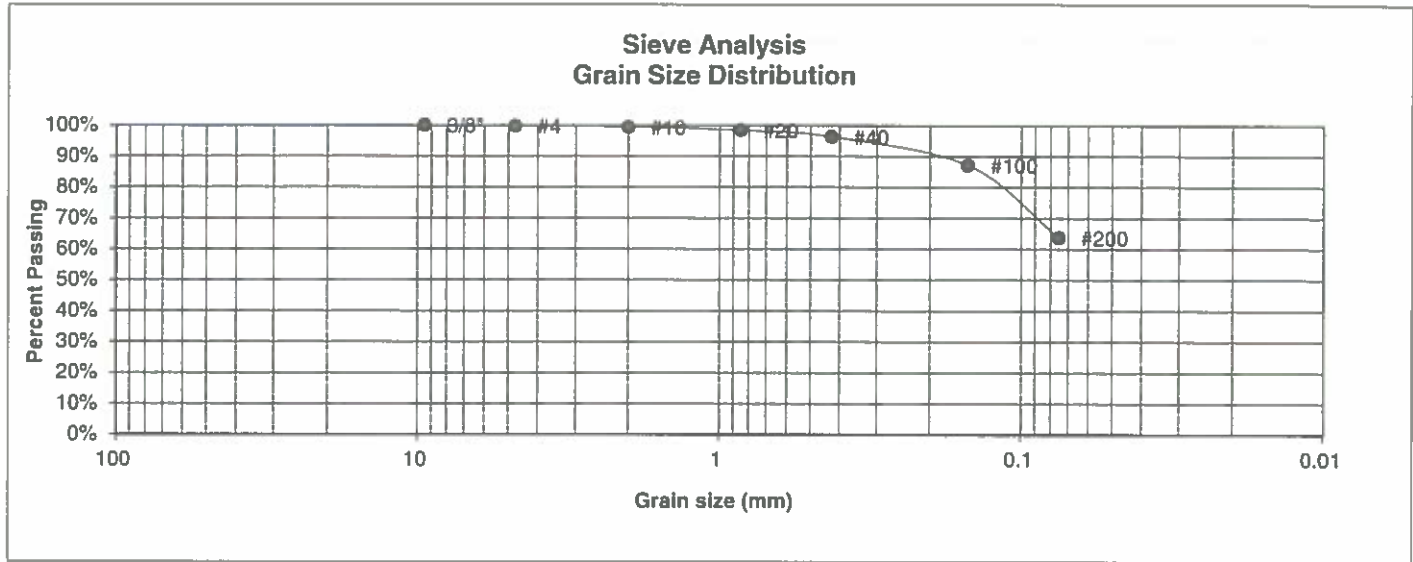
**LABORATORY TEST
RESULTS**

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

211631
FIG NO.:
B-1

UNIFIED CLASSIFICATION	CL	CLIENT	CARL TURSE
SOIL TYPE #	2, CBR	PROJECT	ROLLIN RIDGE, FILING 1
TEST BORING #	2	JOB NO.	211631
DEPTH (FT)	0-3	TEST BY	BL
AASHTO CLASSIFICATION	A-6	GROUP INDEX	6



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	99.7%
10	99.4%
20	98.4%
40	96.3%
100	87.2%
200	63.7%

Atterberg Limits	
Plastic Limit	17
Liquid Limit	30
Plastic Index	13

Swell	
Moisture at start	
Moisture at finish	
Moisture increase	
Initial dry density (pcf)	
Swell (psf)	



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LABORATORY TEST RESULTS

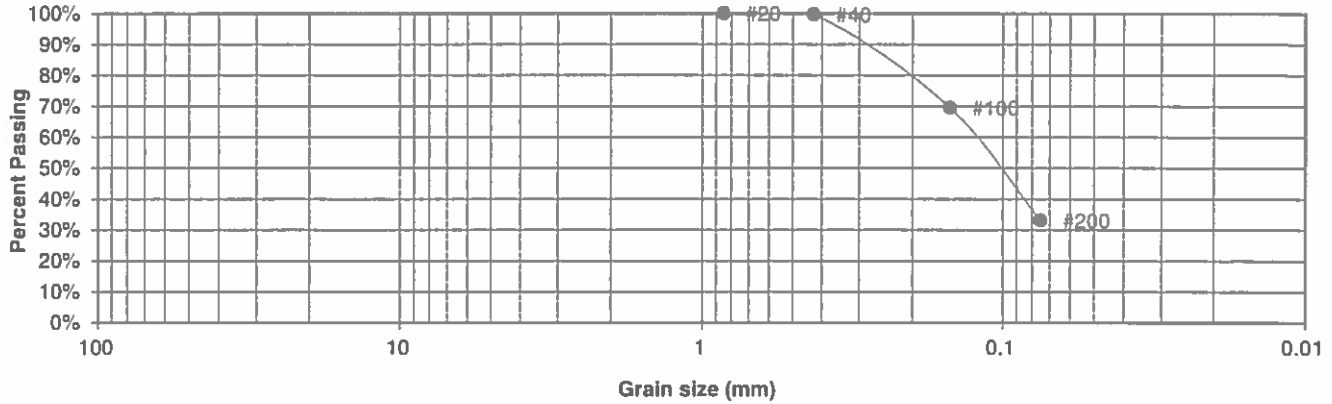
DRAWN:	DATE:	CHECKED: <i>APJ</i>	DATE: 7/7/21
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JOB NO.:
211631
FIG NO.:
B-2

UNIFIED CLASSIFICATION SM
SOIL TYPE # 1
TEST BORING # 3
DEPTH (FT) 1-2
AASHTO CLASSIFICATION A-2-4

CLIENT CARL TURSE
PROJECT ROLLIN RIDGE, FILING 1
JOB NO. 211631
TEST BY BL
GROUP INDEX 0

**Sieve Analysis
Grain Size Distribution**



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	
4	
10	
20	100.0%
40	99.7%
100	69.5%
200	33.1%

Atterberg Limits
 Plastic Limit NP
 Liquid Limit NV
 Plastic Index NP

Swell
 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>RPJ</i>	DATE: 7/7/21
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JOB NO:

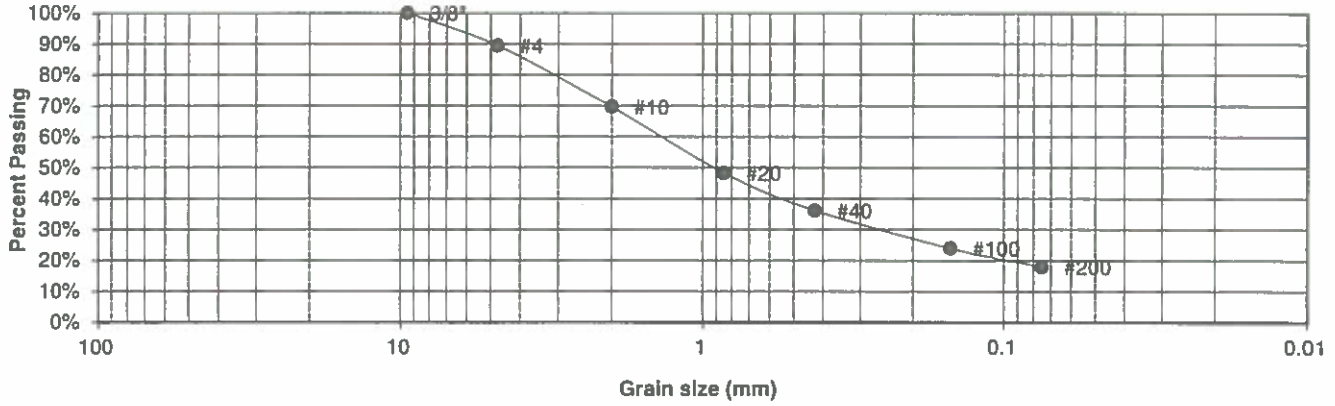
211631
FIG NO:

B-3

UNIFIED CLASSIFICATION SM
SOIL TYPE # 1
TEST BORING # 4
DEPTH (FT) 1-2
AASHTO CLASSIFICATION A-1-b

CLIENT CARL TURSE
PROJECT ROLLIN RIDGE, FILING 1
JOB NO. 211631
TEST BY BL
GROUP INDEX 0

**Sieve Analysis
Grain Size Distribution**



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	89.4%
10	69.7%
20	48.3%
40	36.1%
100	23.9%
200	17.9%

Atterberg Limits
 Plastic Limit NP
 Liquid Limit NV
 Plastic Index NP

Swell
 Moisture at start
 Moisture at finish
 Moisture increase
 Initial dry density (pcf)
 Swell (psf)



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**LABORATORY TEST
RESULTS**

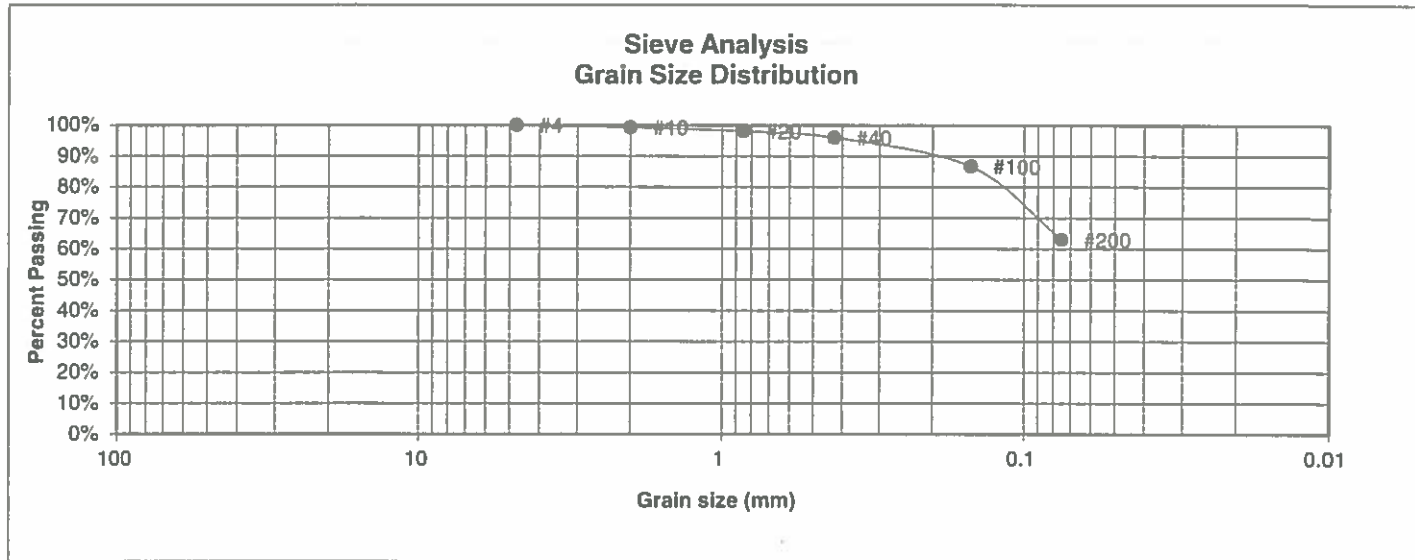
DRAWN:	DATE:	CHECKED: <i>RLA</i>	DATE: 7/7/21
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JOB NO.:

211631
FIG NO.:

B-4

<u>UNIFIED CLASSIFICATION</u>	CL	<u>CLIENT</u>	CARL TURSE
<u>SOIL TYPE #</u>	2A	<u>PROJECT</u>	ROLLIN RIDGE, FILING 1
<u>TEST BORING #</u>	1	<u>JOB NO.</u>	211631
<u>DEPTH (FT)</u>	1-2	<u>TEST BY</u>	BL
<u>AASHTO CLASSIFICATION</u>	A-6	<u>GROUP INDEX</u>	5



<u>U.S. Sieve #</u>	<u>Percent Finer</u>
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	
4	100.0%
10	99.3%
20	98.0%
40	96.0%
100	86.7%
200	62.9%

<u>Atterberg Limits</u>	
Plastic Limit	17
Liquid Limit	29
Plastic Index	12

Swell
 Moisture at start
 Moisture at finish
 Moisture increase
 Initial dry density (pcf)
 Swell (psf)



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**LABORATORY TEST
RESULTS**

<u>DRAWN:</u>	<u>DATE:</u>	<u>CHECKED:</u> <i>RPJ</i>	<u>DATE:</u> 7/7/21
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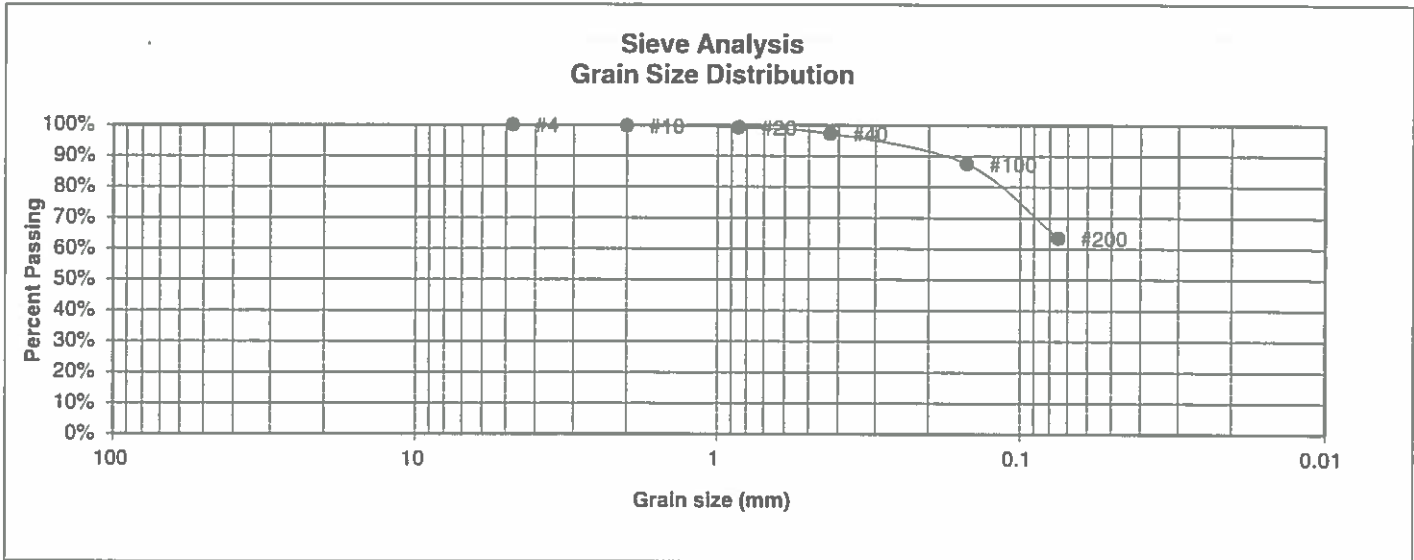
JOB NO:

211631
FIG NO:

B-5

UNIFIED CLASSIFICATION CL
SOIL TYPE # 2
TEST BORING # 2
DEPTH (FT) 1-2
AASHTO CLASSIFICATION A-6

CLIENT CARL TURSE
PROJECT ROLLIN RIDGE, FILING 1
JOB NO. 211631
TEST BY BL
GROUP INDEX 5



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	
4	100.0%
10	99.7%
20	99.2%
40	97.2%
100	87.5%
200	63.5%

Atterberg Limits
 Plastic Limit 14
 Liquid Limit 27
 Plastic Index 13

Swell
 Moisture at start
 Moisture at finish
 Moisture increase
 Initial dry density (pcf)
 Swell (psf)



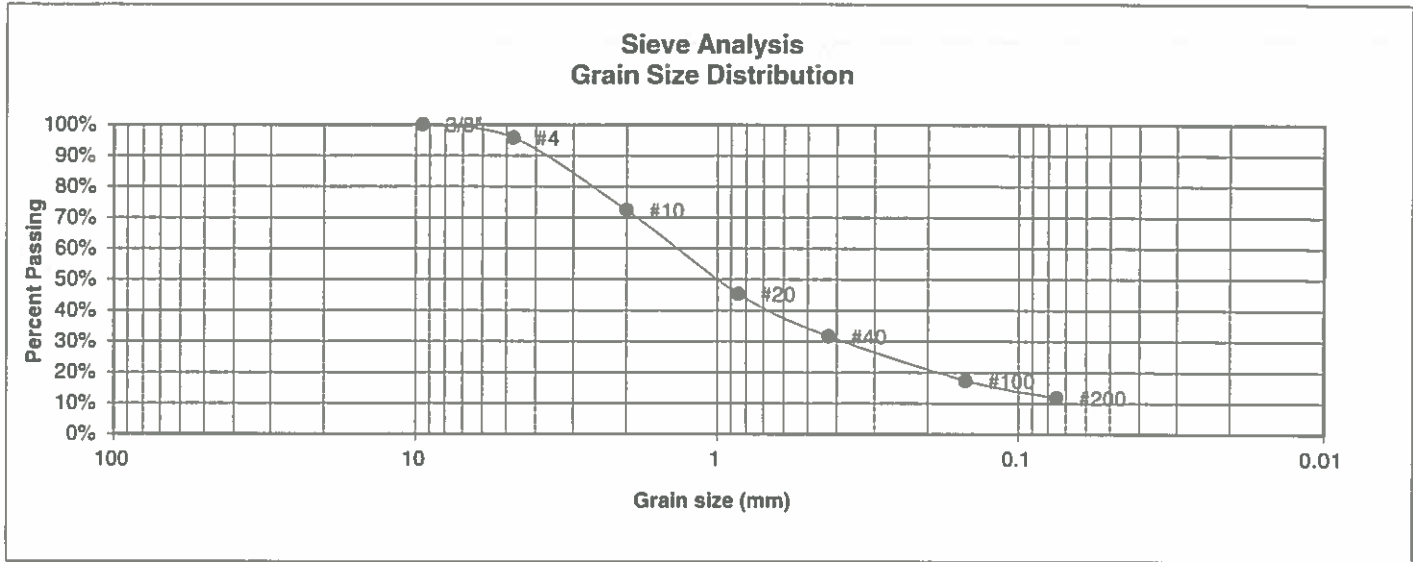
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LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED: <i>RLJ</i>	DATE: 7/7/21
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JOB NO.:
 211631
 FIG NO.:
 B-6

UNIFIED CLASSIFICATION	SM-SW	CLIENT	CARL TURSE
SOIL TYPE #	3	PROJECT	ROLLIN RIDGE, FILING 1
TEST BORING #	3	JOB NO.	211631
DEPTH (FT)	10	TEST BY	BL
AASHTO CLASSIFICATION	A-1-b	GROUP INDEX	0



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	95.8%
10	72.4%
20	45.4%
40	31.6%
100	17.3%
200	11.8%

Atterberg Limits	
Plastic Limit	NP
Liquid Limit	NV
Plastic Index	NP

Swell	
Moisture at start	
Moisture at finish	
Moisture increase	
Initial dry density (pcf)	
Swell (psf)	



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**LABORATORY TEST
RESULTS**

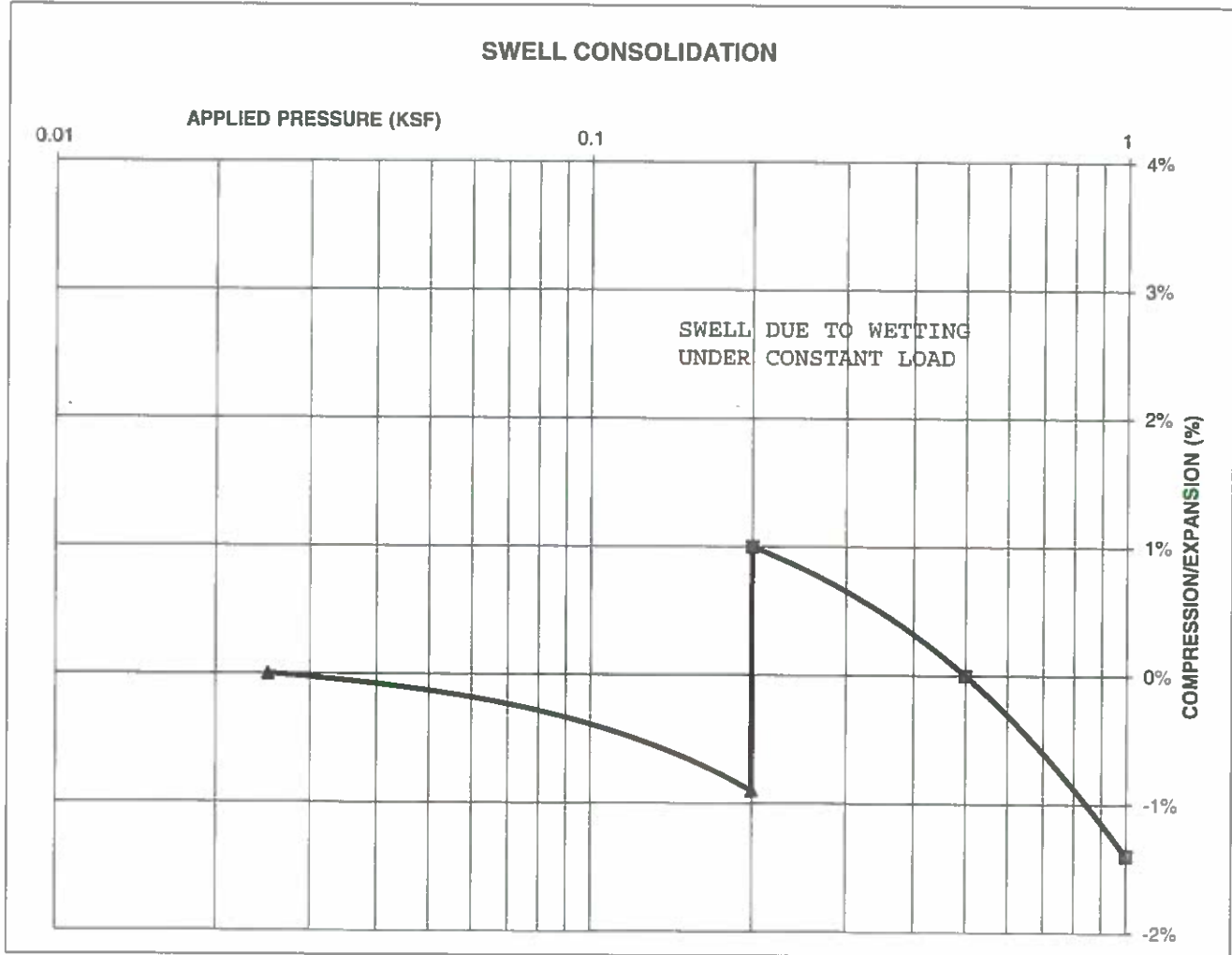
DRAWN:	DATE:	CHECKED: <i>RPJ</i>	DATE: <i>7/7/21</i>
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JOB NO.:
211631
FIG NO.:
B-7

CONSOLIDATION TEST RESULTS

TEST BORING #	2	DEPTH(ft)	0-3
DESCRIPTION	CL	SOIL TYPE	2, CBR
NATURAL UNIT DRY WEIGHT (PCF)			111
NATURAL MOISTURE CONTENT			11.9%
SWELL/CONSOLIDATION (%)			1.9%

JOB NO. 211631
 CLIENT CARL TURSE
 PROJECT ROLLIN RIDGE, FILING 1



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**SWELL CONSOLIDATION
 TEST RESULTS**

DRAWN:

DATE:

CHECKED:

DATE: 7/7/21

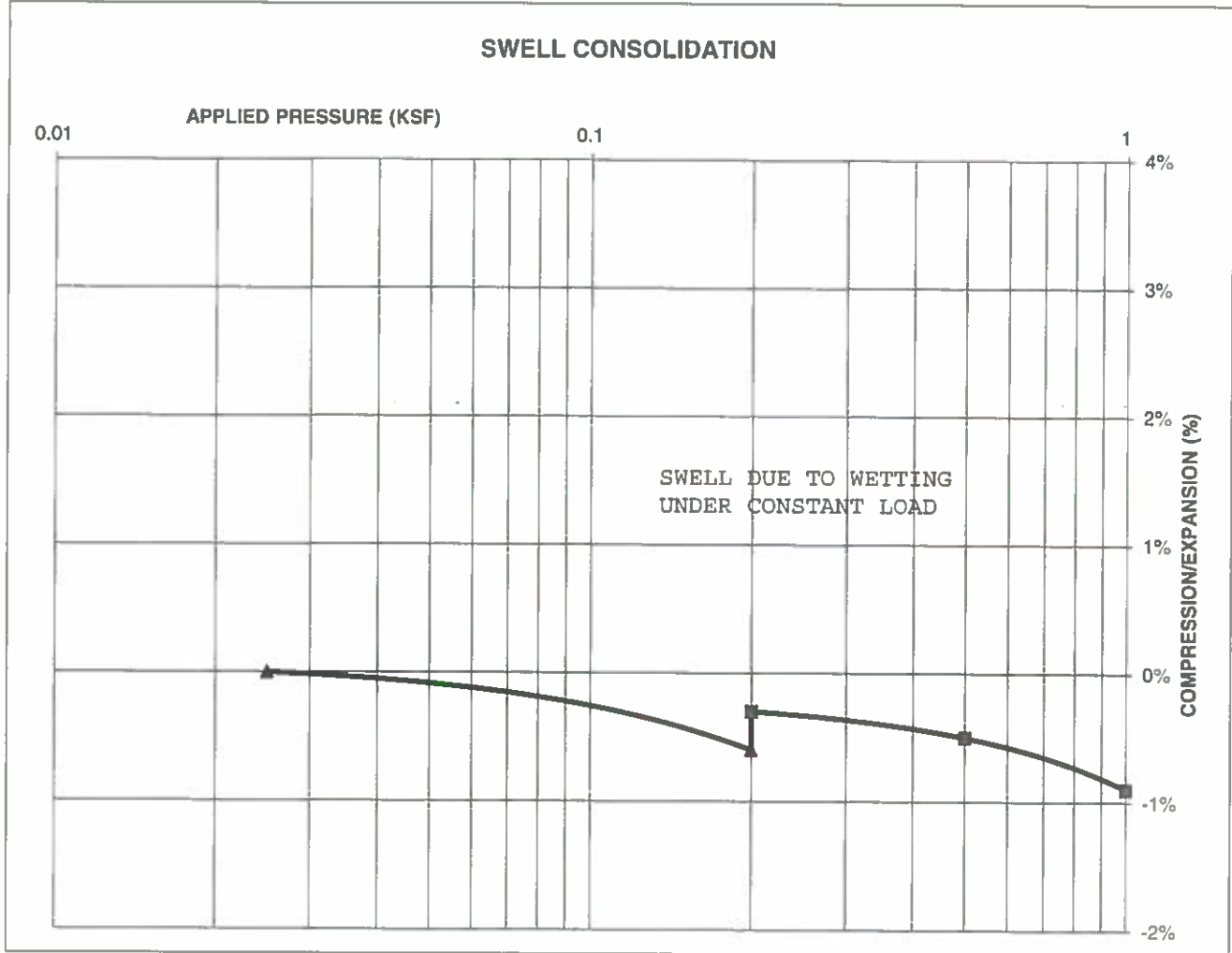
JOB NO.:
 211631

FIG NO.:
 B-8

CONSOLIDATION TEST RESULTS

TEST BORING #	1	DEPTH(ft)	1-2
DESCRIPTION	CL	SOIL TYPE	2
NATURAL UNIT DRY WEIGHT (PCF)			121
NATURAL MOISTURE CONTENT			12.8%
SWELL/CONSOLIDATION (%)			0.3%

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**SWELL CONSOLIDATION
 TEST RESULTS**

DRAWN:

DATE:

CHECKED:

DATE:

[Signature] 7/7/21

JOB NO.:

211631

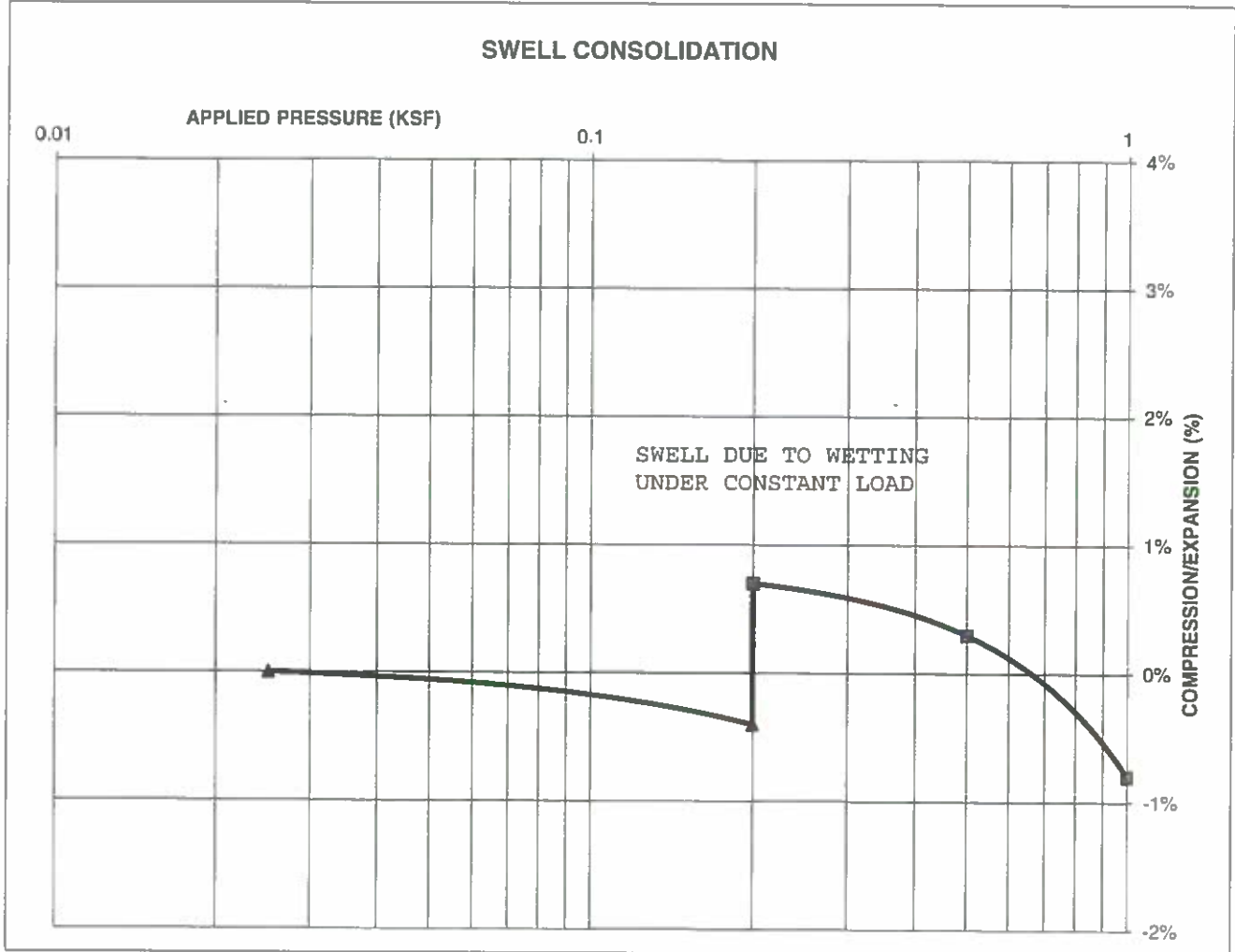
FIG NO.:

B-9

CONSOLIDATION TEST RESULTS

TEST BORING #	2	DEPTH(ft)	1-2
DESCRIPTION	CL	SOIL TYPE	2
NATURAL UNIT DRY WEIGHT (PCF)			107
NATURAL MOISTURE CONTENT			10.0%
SWELL/CONSOLIDATION (%)			1.1%

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**SWELL CONSOLIDATION
 TEST RESULTS**

DRAWN:

DATE:

CHECKED:

DATE:

RPJ

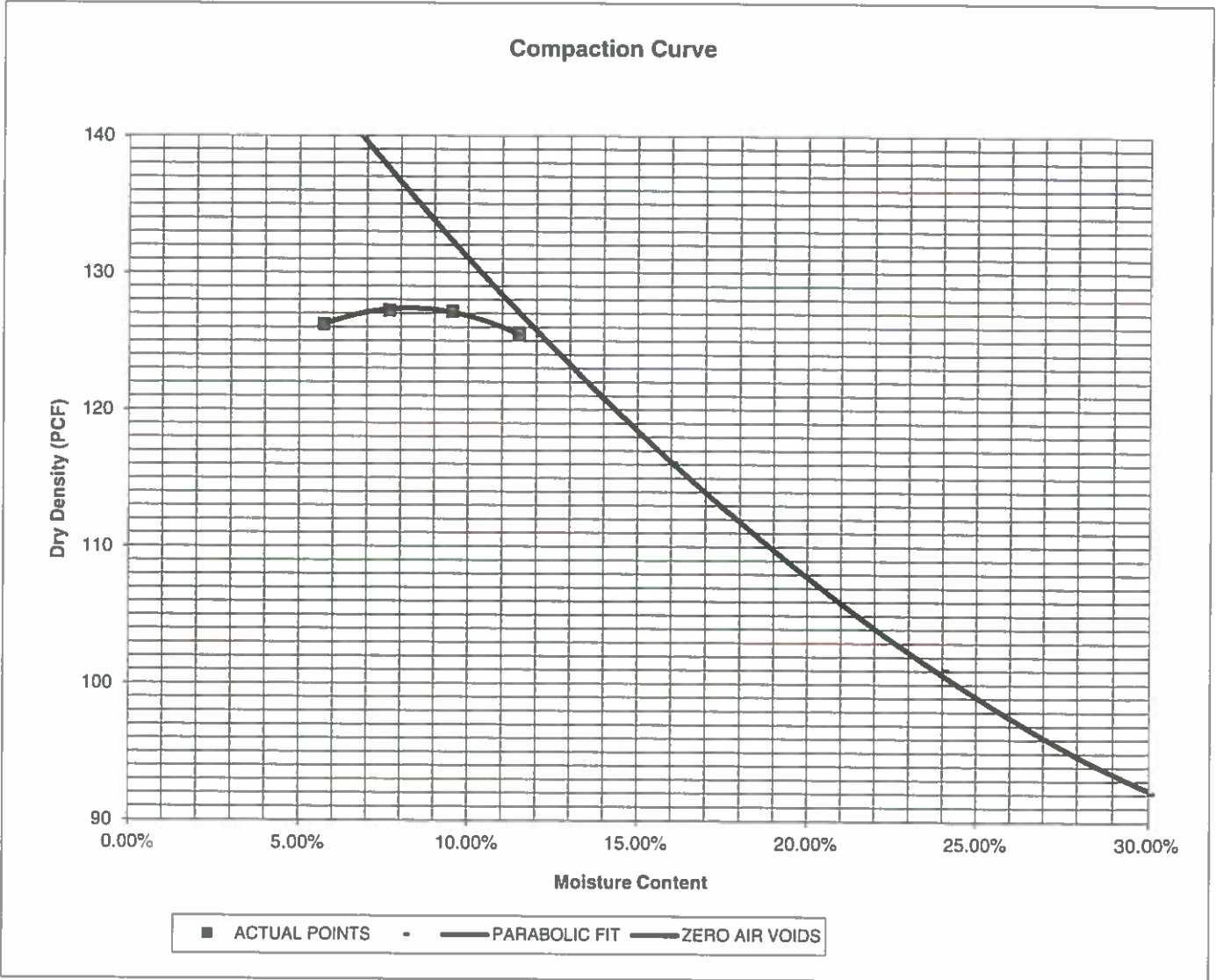
7/7/21

JOB NO.:
 211631

FIG NO.:
 B-10

PROJECT	ROLLIN RIDGE, FILING 1	CLIENT	CARL TURSE
SAMPLE LOCATION	TB-4 @ 0-3'	JOB NO.	211631
SOIL DESCRIPTION	SAND, SILTY, TAN	DATE	06/29/21

IDENTIFICATION	SM	COMPACTION TEST #	1
TEST DESIGNATION / METHOD	ASTM D-1557-A	TEST BY	AL
MAXIMUM DRY DENSITY (PCF)	127.4	OPTIMUM MOISTURE	8.1%



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505 ELKTON DRIVE
COLORADO SPRINGS, COLORADO 80907

MOISTURE DENSITY RELATION

DRAWN:

DATE:

CHECKED:

DATE:

RPJ

7/7/21

JOB NO.:

211631

FIG NO.:

B-11

CBR TEST LOAD DATA

JOB NO: 211631
 CLIENT: CARL TURSE
 PROJECT: ROLLIN RIDGE, FILING 1
 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 # 1	MOLD # 2	MOLD # 1	MOLD # 2
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		89	29.74	184	61.49	278	92.90
0.050		153	51.13	299	99.92	659	220.22
0.075		224	74.85	341	113.95	756	252.63
0.100		309	103.26	467	156.06	977	326.48
0.125		482	161.07	733	244.94	1343	448.79
0.150		550	183.79	1062	354.89	1567	523.64
0.175		583	194.82	1274	425.73	1710	571.43
0.200		620	207.18	1411	471.51	1927	643.94
0.300		791	264.33	1943	649.29	2593	866.50
0.400		929	310.44	2563	856.47	3387	1131.83
0.500		1082	361.57	2986	997.82	3874	1294.57

FINAL MOISTURE CONTENT

	MOLD # 1	MOLD # 2	MOLD # 3
CAN #	345	341	349
WT. CAN	6.86	6.89	6.84
WT. CAN+WET	118.42	120.37	133.67
WT. CAN+DRY	103.39	107.52	119.92
WT. H2O	15.03	12.85	13.75
WT. DRY SOIL	96.53	100.63	113.08
MOISTURE CONTENT	15.57%	12.77%	12.16%

WET DENSITY (PCF)	123.5	133.2	138.0
DRY DENSITY (PCF)	114.3	123.3	127.7

BEARING RATIO 10.33 15.61 32.65

90% OF DRY DENSITY 114.7

95% OF DRY DENSITY 121.0

<u>BEARING RATIO AT 90% OF MAX</u>	10.56 ~ R VALUE	30
<u>BEARING RATIO AT 95% OF MAX</u>	14.30 ~ R VALUE	45



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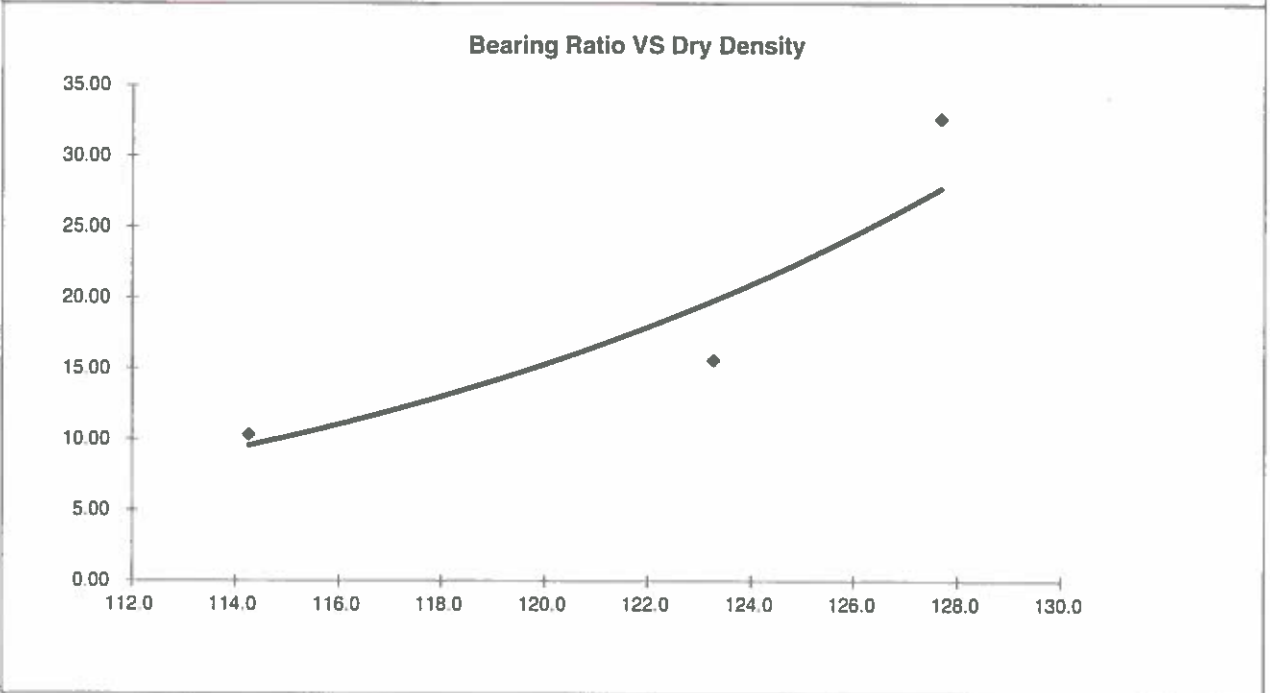
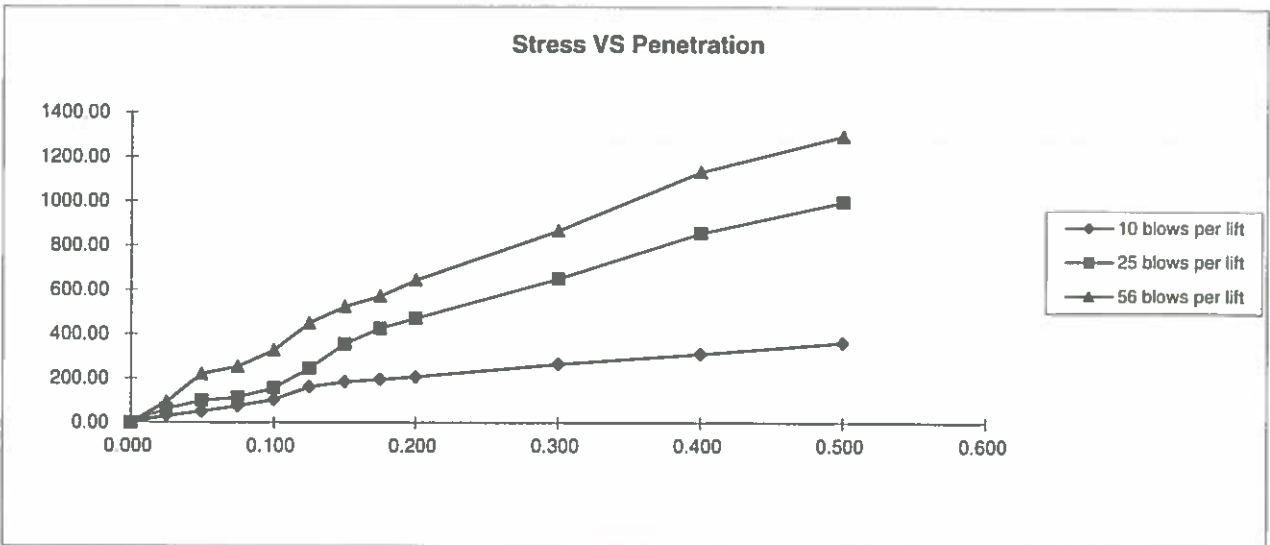
505 ELKTON DRIVE
 COLORADO SPRINGS, COLORADO 80907

CBR TEST DATA

DRAWN:	DATE:	CHECKED:	DATE:
		<i>RPT</i>	7/7/21

JOB NO:
 211631

FIG NO:
 B-12



BEARING RATIO AT 90% OF MAX	10.56 - R VALUE	30.00
BEARING RATIO AT 95% OF MAX	14.30 - R VALUE	45.00

JOB NO: 211631
SOIL TYPE: 1



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CALIFORNIA BEARING RATIO

DRAWN:

DATE:

CHECKED:

DATE:

RP

7/7/21

JOB NO.:

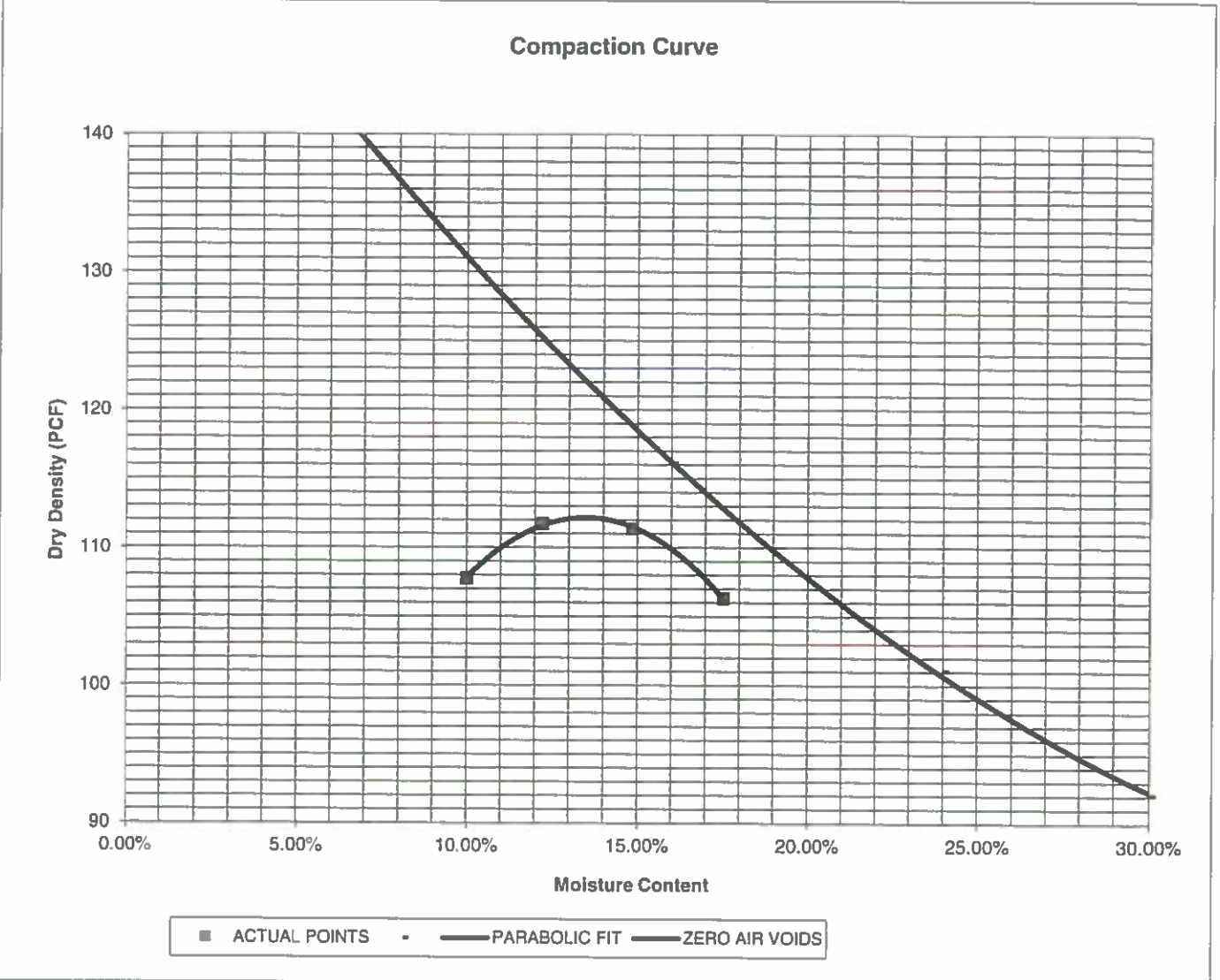
211631

FIG NO.:

B-13

PROJECT	ROLLIN RIDGE, FILING 1	CLIENT	CARL TURSE
SAMPLE LOCATION	TB-2 @ 0-3'	JOB NO.	211631
SOIL DESCRIPTION	CLAY, SANDY, BROWN	DATE	06/29/21

IDENTIFICATION	CL	COMPACTION TEST #	2
TEST DESIGNATION / METHOD	ASTM D-698-A	TEST BY	BL
MAXIMUM DRY DENSITY (PCF)	112.1	OPTIMUM MOISTURE	13.5%




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COLORADO SPRINGS, COLORADO 80907

MOISTURE DENSITY RELATION

DRAWN:	DATE	CHECKED: <i>RLA</i>	DATE: 7/7/21
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JOB NO:
211631
FIG NO:
B-14

CBR TEST LOAD DATA

JOB NO: 211631
 CLIENT: CARL TURSE
 PROJECT: ROLLIN RIDGE, FILING 1
 SOIL TYPE: 2

PISTON DIAMETER (cm) 4.958	PISTON AREA (in ²) 2.993	10 BLOWS		25 BLOWS		56 BLOWS	
		MOLD # 1	MOLD # 2	MOLD # 1	MOLD # 2	MOLD # 3	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		14	4.68	37	12.36	90	30.08
0.050		18	6.02	43	14.37	121	40.43
0.075		21	7.02	52	17.38	143	47.79
0.100		27	9.02	58	19.38	155	51.80
0.125		33	11.03	63	21.05	163	54.47
0.150		34	11.36	68	22.72	168	56.14
0.175		35	11.70	71	23.73	173	57.81
0.200		36	12.03	76	25.40	178	59.48
0.300		34	11.36	81	27.07	193	64.49
0.400		37	12.36	81	27.07	208	69.51
0.500		41	13.70	86	28.74	229	76.52

FINAL MOISTURE CONTENT

	MOLD # 1	MOLD # 2	MOLD # 3
CAN #	G-17	G-14	G-17
WT. CAN	261.64	261.71	261.64
WT. CAN+WET	334.15	477.84	443.74
WT. CAN+DRY	321.01	443.19	416.77
WT. H2O	13.14	34.65	26.97
WT. DRY SOIL	59.37	181.48	155.13
MOISTURE CONTENT	22.13%	19.09%	17.39%

WET DENSITY (PCF)	113.1	117.7	125.4
DRY DENSITY (PCF)	99.6	103.7	110.5

BEARING RATIO	0.90	1.94	5.18
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90% OF DRY DENSITY 100.9

95% OF DRY DENSITY 106.5

BEARING RATIO AT 90% OF MAX	1.23 ~ R VALUE	1
BEARING RATIO AT 95% OF MAX	3.27 ~ R VALUE	7.5



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CBR TEST DATA

DRAWN:

DATE:

CHECKED:

DATE:

RTJ

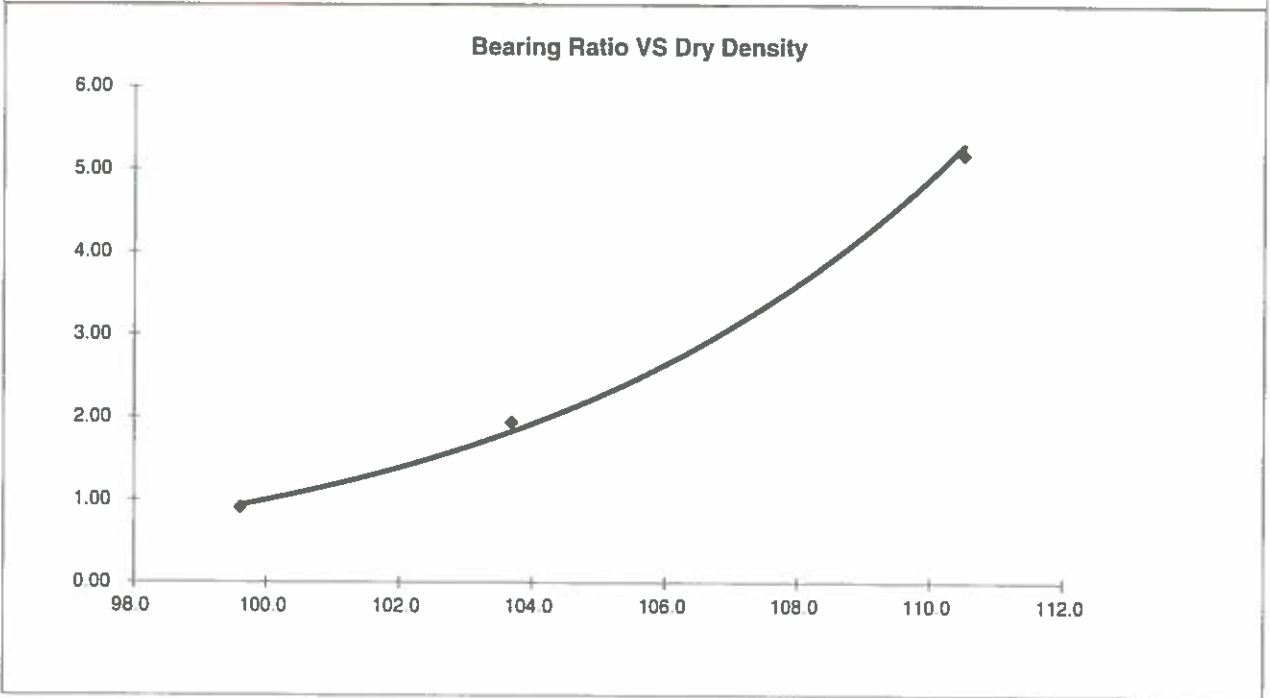
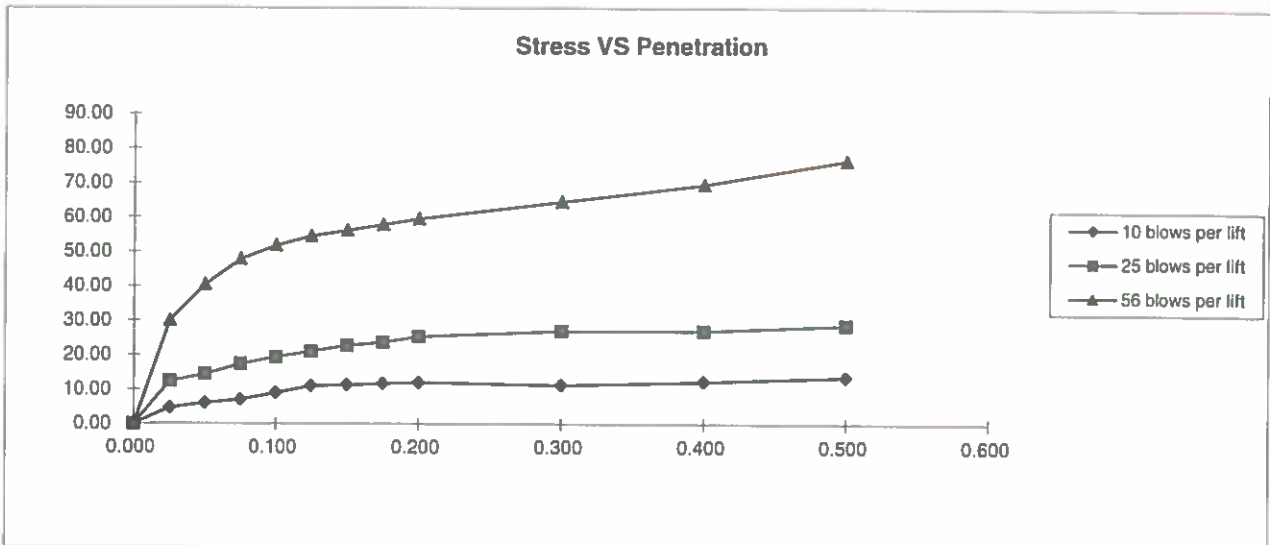
7/7/21

JOB NO.:

211631

FIG NO.:

B-15



BEARING RATIO AT 90% OF MAX	1.23 ~ R VALUE	1.00
BEARING RATIO AT 95% OF MAX	3.27 ~ R VALUE	7.50

JOB NO: 211631
SOIL TYPE: 2



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CALIFORNIA BEARING RATIO

DRAWN:	DATE:	CHECKED: <i>RPA</i>	DATE: 7/7/21
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JOB NO: 211631
FIG NO: B-16

APPENDIX C: Pavement Design Calculations

FLEXIBLE PAVEMENT DESIGN

DESIGN DATA

CARL TURSE
ROLLIN RIDGE - SOIL TYPE 1 - LOCAL

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL (W_{18}) =	36,500
Hveem Stabilometer (R Value) Results:	R =	45
Standard Deviation	S_o =	0.44
Loss in Serviceability	Δpsi =	2.0
Reliability	Reliability =	75
Reliability (z-statistic)	Z_R =	-0.674
Soil Resilient Modulus	M_R =	11183

Weighted Structural Number (WSN): ➔ WSN = 1.52

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

$$\log_{10} W_{18} = Z_R \cdot S_o + 9.36 \cdot \log_{10} (SN+1) - 0.20 + \frac{\log_{10} \left[\frac{\Delta PSI}{4.2 - 1.5} \right]}{0.40 + \frac{1094}{(SN+1)^{5.18}}} + 2.32 \cdot \log_{10} M_R - 8.07$$

Left	Right	Difference
4.56	4.56	0.0

Job No. 211631
Fig. No. C-1

DESIGN CALCULATIONS

DESIGN DATA CARL TURSE
 ROLLIN RIDGE - SOIL TYPE 1 - LOCAL

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL =	36,500
Hveem Stabilometer (R Value) Results:	R =	45
Weighted Structural Number (WSN):	WSN =	1.52

DESIGN EQUATION

$$WSN = C_1D_1 + C_2D_2$$

$C_1 = 0.44$ Strength Coefficient - Hot Bituminous Asphalt

$C_2 = 0.11$ Strength Coefficient - Aggregate Base Course

$D_1 =$ Depth of Asphalt (inches)

$D_2 =$ Depth of Base Course (inches)

FOR FULL DEPTH ASPHALT SECTION

$$D_1 = (WSN)/C_1 = 3.4 \text{ inches of Full Depth Asphalt}$$

Use 5.0 inches Full Depth

FOR ASPHALT + AGGREGATE BASE COURSE SECTION

$$\text{Asphalt Thickness (t)} = \boxed{3} \text{ inches}$$

$$D_2 = ((WSN) - (t)(C_1))/C_2 = 1.8 \text{ inches of Aggregate}$$

Base Course, use 4.0 inches

RECOMMENDED ALTERNATIVES

1. 3.0 inches of Asphalt + 4.0 inches of Aggregate Base Course, or
2. 5.0 inches of Full-Depth Asphalt

Job No. 211631
Fig. No. C-2

FLEXIBLE PAVEMENT DESIGN

DESIGN DATA

CARL TURSE
ROLLIN RIDGE - SOIL TYPE 2 - LOCAL

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL (W_{18}) =	36,500
Hveem Stabilometer (R Value) Results:	R =	7.5
Standard Deviation	S_o =	0.44
Loss in Serviceability	$\Delta\psi$ =	2.0
Reliability	Reliability =	75
Reliability (z-statistic)	Z_R =	-0.674
Soil Resilient Modulus	M_R =	3283

Weighted Structural Number (WSN): ➔ WSN = 2.46

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

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

Left	Right	Difference
4.56	4.58	0.0

Job No. 211631

Fig. No. C-3

DESIGN CALCULATIONS

DESIGN DATA CARL TURSE
 ROLLIN RIDGE - SOIL TYPE 2 - LOCAL

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL =	36,500
Hveem Stabilometer (R Value) Results:	R =	7.5
Weighted Structural Number (WSN):	WSN =	2.46

DESIGN EQUATION

$$WSN = C_1D_1 + C_2D_2$$

$C_1 = 0.44$ Strength Coefficient - Hot Bituminous Asphalt

$C_2 = 0.11$ Strength Coefficient - Aggregate Base Course

$D_1 =$ Depth of Asphalt (inches)

$D_2 =$ Depth of Base Course (inches)

FOR FULL DEPTH ASPHALT SECTION

$$D_1 = (WSN)/C_1 = 5.6 \text{ inches of Full Depth Asphalt}$$

Use 6.0 inches Full Depth

FOR ASPHALT + AGGREGATE BASE COURSE SECTION

$$\text{Asphalt Thickness (t) = } \boxed{4} \text{ inches}$$

$$D_2 = ((WSN) - (t)(C_1))/C_2 = 6.4 \text{ inches of Aggregate}$$

Base Course, use 6.5 inches

RECOMMENDED ALTERNATIVES

1. 4.0 inches of Asphalt + 6.5 inches of Aggregate Base Course, or
2. 6.0 inches of Full-Depth Asphalt

Job No. 211631

Fig. No. C-4

FLEXIBLE PAVEMENT DESIGN

DESIGN DATA

CARL TURSE
ROLLIN RIDGE - SOIL TYPE 2 - MINOR ARTERIAL

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL (W_{18}) =	689,850
Hveem Stabilometer (R Value) Results:	R =	7.5
Standard Deviation	S_o =	0.44
Loss in Serviceability	Δpsi =	2.5
Reliability	Reliability =	80
Reliability (z-statistic)	Z_R =	-0.841
Soil Resilient Modulus	M_R =	3283

Weighted Structural Number (WSN): ➔ WSN = 3.79

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

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

Left	Right	Difference
5.84	5.84	0.0

Job No. 211631

Fig. No. C-5

DESIGN CALCULATIONS

DESIGN DATA CARL TURSE
ROLLIN RIDGE - SOIL TYPE 2 - MINOR ARTERIAL

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL = 689,850
Hveem Stabilometer (R Value) Results:	R = 7.5
Weighted Structural Number (WSN):	WSN = 3.79

DESIGN EQUATION

$$WSN = C_1D_1 + C_2D_2$$

$C_1 = 0.44$ Strength Coefficient - Hot Bituminous Asphalt

$C_2 = 0.11$ Strength Coefficient - Aggregate Base Course

$D_1 =$ Depth of Asphalt (inches)

$D_2 =$ Depth of Base Course (inches)

FOR FULL DEPTH ASPHALT SECTION

$$D_1 = (WSN)/C_1 = 8.6 \text{ inches of Full Depth Asphalt}$$

Use 9.0 inches Full Depth

FOR ASPHALT + AGGREGATE BASE COURSE SECTION

$$\text{Asphalt Thickness (t)} = \boxed{6} \text{ inches}$$

$$D_2 = ((WSN) - (t)(C_1))/C_2 = 10.4 \text{ inches of Aggregate}$$

Base Course, use 11.0 inches

RECOMMENDED ALTERNATIVES

1. 6.0 inches of Asphalt + 11.0 inches of Aggregate Base Course, or
2. 9.0 inches of Full-Depth Asphalt

Job No. 211631
Fig. No. C-6