February 20, 2018

ENTECH
ENGINEERING, INC.

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Classic Communities
6385 Corporate Drive, Suite 200
Colorado Springs, Colorado 80919

Attn: Benny Bustos

Re: Pavement Recommendations
Forest Lakes, Filing No. 2B - Partial
El Paso County, Colorado

Dear Mr. Bustos:

As requested, Entech Engineering, Inc. has obtained samples of the pavement subgrade soils from portions of the roadways in the Forest Lakes Filing No. 2B Subdivision. This letter presents the results of the laboratory testing and pavement recommendations for the roadway sections.

Project Description:

The roadways for this project consists of two sections; Lake Mist Drive from Channel Island Drive to the west cul-de-sac and Lakes Edge Drive approximately 100 feet to the south of Lake Mist Drive in the Forest Lakes in Filing No. 2B Subdivision in El Paso County, Colorado. Subsurface Soil Investigation and laboratory testing was performed to determine the pavement support characteristics of the soils. The Site Map and approximate locations of the test borings are presented in the Site/Test Boring Location Plan Figure 1.

Subgrade Conditions:

Two test borings were drilled along the roadways to depths of 5 feet below the existing subgrade surface. The soils consisted of silty to very silty sand fill. The Test Boring Logs are presented in Appendix A. Sieve Analysis and Atterberg Limits testing were performed on the soil samples obtained from the test borings for the purpose of classification. The percent passing the No. 200 sieve for the soils at subgrade depths ranged from approximately 25 to 48 percent. The subgrade soils classify as A-1-b and A-4 (AASHTO) for the sand soils which have very good pavement support characteristics. Based on the classification testing results, one soil type was determined. Groundwater was not encountered in any of the test borings.

Swell testing was not required on the subgrade soils based on the Plastic Index. Mitigation is not required on this site. Laboratory test results are presented in Appendix B and are summarized in Table 1.

California Bearing Ratio (CBR) testing was performed on a similar soil type from the roadways in the Filing 2B area directly adjacent to this site to determine the support characteristics of the subgrade soils for the roadway sections. The previous testing results and design could be found in the "Pavement Recommendations" report By Entech Engineering, Inc. dated March 1, 2017 Entech Job No. 170080. The results of the CBR testing can be found in the previous report and is summarized as follows:

CBR No. 1
Soil Type 1 – Silty Sand

R @ 90% = 55
R @ 95% = 75
Use R = 50 for Design

Classification Testing

Liquid Limit	21
Plasticity Index	3
Percent Passing 200	26.7
AASHTO Classification	A-2-4
Group Index	0
Unified Soils Classification	SM

Pavement Design

CBR testing from the first phase of Filing 2B, (Entech Job No. 170080, dated March 1, 2017), which is immediately adjacent to this site, was used to determine pavement sections for the roadways in this portion of the site, as the soils were similar. Pavement sections were determined utilizing El Paso County Engineering Criteria and Report Manual. The roadways classily as Local Low Volume roads which used an 18K ESAL value of 32,850 for design purposes. Alternative pavement sections were determined for full depth asphalt, asphalt supported on base course, and asphalt on cement stabilized subgrade.

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

Reliability	85%
Standard Deviation	0.44
Resilient Modulus	13,168 psi
"R" Value Subgrade	50
Serviceability Index	2.5
Hot Bituminous Pavement	0.44
Base Course	0.11
Cement Stabilized Subgrade	0.13

The pavement design calculations are presented in Appendix C. Pavement section alternatives for the roadway sections are presented as follows. Any additional grading may result in subgrade soils with different support characteristics. The following pavement sections should be re-evaluated if additional grading is performed.

Pavement Sections
Local Low Volume Streets — All Road Sections
Soil Type 1

Alternative	Asphalt	Base Course (in.)	Cement Stabilized Subgrade (in.)
1. Asphalt Over Base Course	3.0*	4.0*	
2. Full Depth Asphalt	4.0[1]*		
3. Asphalt Over Stabilized Subgrade	4.0		10.0

[1] Full depth sections are only allowed over chemically treated or suitable subgrade. Currently full depth sections are not allowed in El Paso County.
* Minimum sections required per the El Paso County Criteria.

Roadway Construction - Full Depth Asphalt and Asphalt on Aggregate Base Course Alternatives

Prior to placement of the asphalt, the subgrade should be proofrolled and compacted to a minimum of 95 percent of its maximum Modified Proctor Dry Density, ASTM D-1557 at ±2 percent of optimum moisture content. Any loose 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.

Roadway Construction — Cement Stabilized Subgrade Alternative

Prior to placement of the asphalt, the subgrade shall be stabilized by addition of cement to a depth of 10 inches. All of the residential streets will use a 4-inch asphalt layer on a 10-inch cement treated subgrade layer. The amount of cement applied shall be 2 percent (by weight) of the subgrades maximum dry density as determined by the Modified Proctor Test (ASTM D-1557) based on cement stabilization testing. The cement should be spread evenly on the subgrade surface and be thoroughly mixed into the subgrade over a 10-inch depth such that a uniform blend of soil and cement is achieved. Prior to application or mixing of the cement, the upper 10 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 1/2 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 40^0 F. Cement treated subgrades should be maintained at a temperature of 40^0 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.

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

We trust that this report contains the information you require. If you have questions or need additional information, please contact us.

Respectfully Submitted,

ENTECH ENGINEERING, INC.

Daniel P. Stegman

COLORADO LICENSED
MARK HOWARD HAUSCHILD
35140
2/21/18
PROFESSIONAL ENGINEER

Reviewed by:

Mark H. Hauschild, P.E.
Senior Engineer

DPS/rm

Entech Job No. 170080
AAprojects/2017/170080 paverec2

TABLE

TABLE 1

SUMMARY OF LABORATORY TEST RESULTS

CLIENT CLASSIC COMMUNITIES
PROJECT FOREST LAKES, F-2B
JOB NO. 170080

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	4	1-2			48.1	20	3		A-4		SM	SAND, VERY SILTY
1	5	1-2			24.7	17	2		A-1-b		SM	SAND, SILTY

FIGURE

SITE/TEST BORING LOCATION PLAN
FOREST LAKES, FILING NO.2B
COLORADO SPRINGS, CO.
FOR: CLASSIC HOMES

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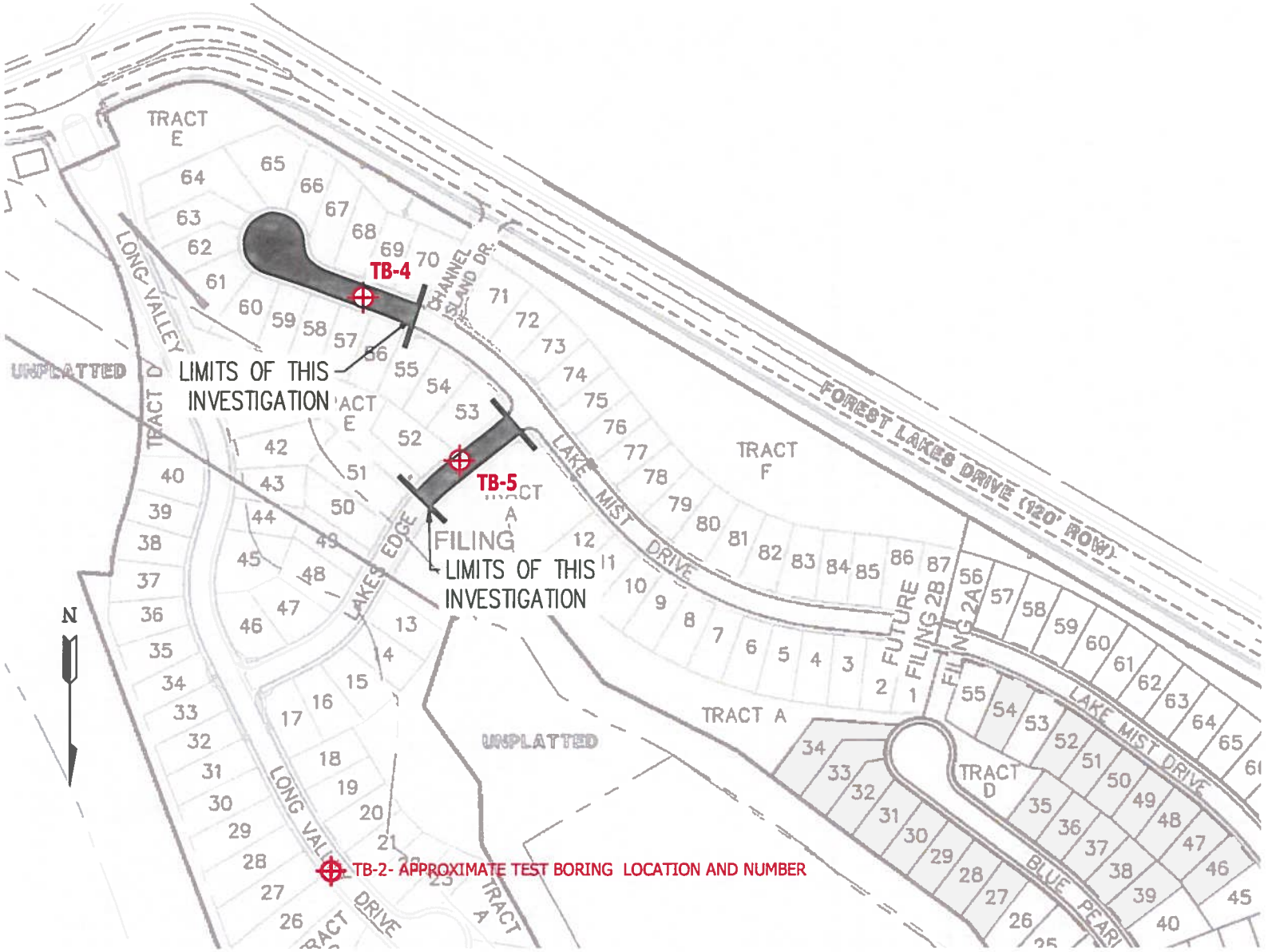

APPENDIX A: Test Boring Logs

TEST BORING NO. 4
DATE DRILLED 12/8/2017
Job # 170080

REMARKS

DRY TO 5', 12/8/17

FILL 0-5', SAND, VERY SILTY, FINE TO COARSE GRAINED, TAN, DENSE, MOIST

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
			34	9.9	1
5			40	8.2	1
10					
15					
20					

TEST BORING NO. 5
DATE DRILLED 12/8/2017
CLIENT CLASSIC COMMUNITIES
LOCATION FOREST LAKES, F-2B

REMARKS

DRY TO 5', 12/8/17

FILL 0-5', SAND, SILTY, FINE TO COARSE GRAINED, TAN, DENSE, MOIST

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
			35	5.0	1
5			31	4.0	1
10					
15					
20					

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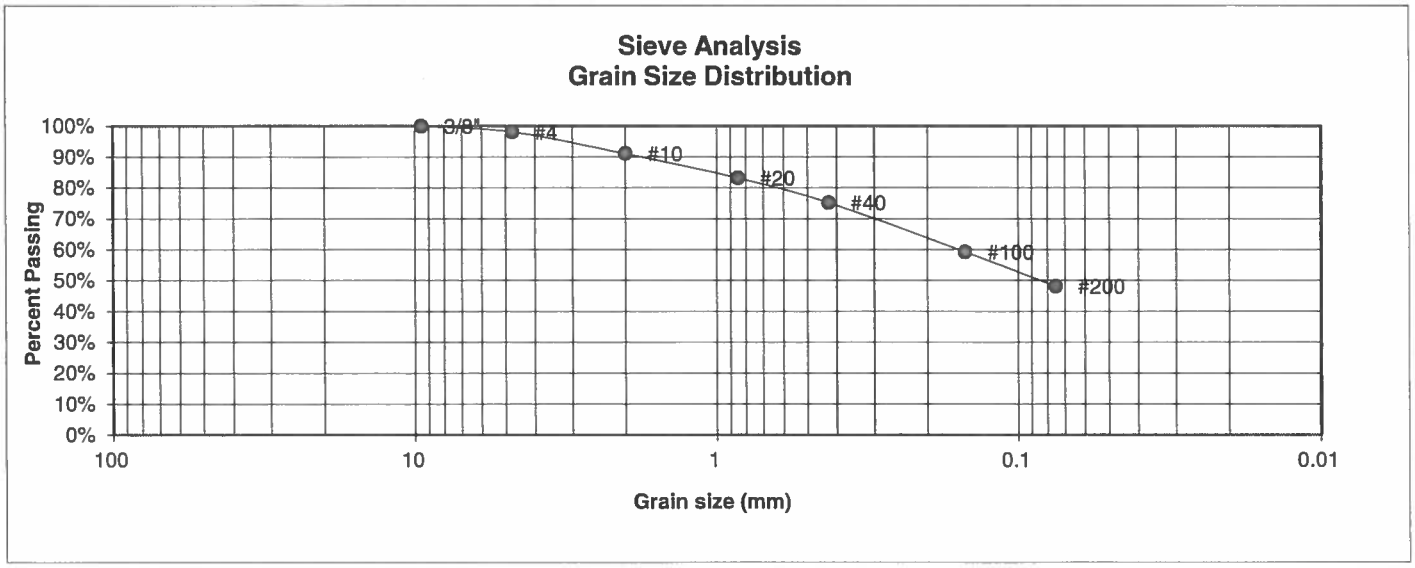
TEST BORING LOG

DRAWN:	DATE:	CHECKED:	DATE:
		DS	2/12/18

JOB NO.: 170080
FIG NO.: A-1

APPENDIX B: Laboratory Test Results

UNIFIED CLASSIFICATION	SM	CLIENT	CLASSIC COMMUNITIES
SOIL TYPE #	1	PROJECT	FOREST LAKES, F-2B
TEST BORING #	4	JOB NO.	170080
DEPTH (FT)	1-2	TEST BY	BL
AASHTO CLASSIFICATION	A-4	GROUP INDEX	0



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	98.1%
10	91.1%
20	83.2%
40	75.2%
100	59.2%
200	48.1%

Atterberg Limits	
Plastic Limit	17
Liquid Limit	20
Plastic Index	3

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

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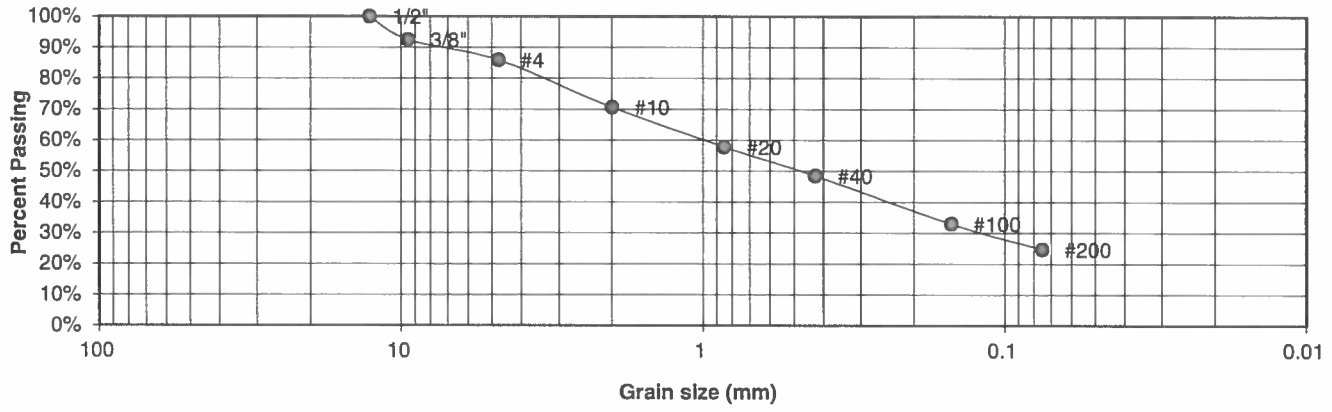
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED:	DATE:
		DS	2/5/18

JOB NO.: 170080
FIG NO.: B-1

UNIFIED CLASSIFICATION	SM	CLIENT	CLASSIC COMMUNITIES
SOIL TYPE #	1	PROJECT	FOREST LAKES, F-2B
TEST BORING #	5	JOB NO.	170080
DEPTH (FT)	1-2	TEST BY	BL
AASHTO CLASSIFICATION	A-1-b	GROUP INDEX	0

Sieve Analysis
Grain Size Distribution



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	100.0%
3/8"	92.5%
4	85.9%
10	70.6%
20	57.8%
40	48.5%
100	32.9%
200	24.7%

Atterberg Limits

Plastic Limit	15
Liquid Limit	17
Plastic Index	2

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:	DATE:
		DS	2/5/18

JOB NO.: 170080
FIG NO.: B-2

APPENDIX C: Pavement Design Calculations

FLEXIBLE PAVEMENT DESIGN

DESIGN DATA

FOREST LAKES - FILING 2B - PARTIAL

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL (W_{18}) =	32,850
Hveem Stabilometer (R Value) Results:	R =	50
Standard Deviation	S_o =	0.44
Loss in Serviceability	Δpsi =	2.5
Reliability	Reliability =	85
Reliability (z-statistic)	Z_R =	-1.04
Soil Resilient Modulus	M_R =	13168

Weighted Structural Number (WSN): → WSN = 1.48

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)
80	-0.84
85	-1.04
90	-1.28
93	-1.48
94	-1.56
95	-1.65
96	-1.75
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
4.52	4.52	0.0

Job No. 171635
Fig. No. C-1

DESIGN CALCULATIONS

DESIGN DATA

FOREST LAKES - FILING 2B - PARTIAL

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL =	32,850
Hveem Stabilometer (R Value) Results:	R =	50
Weighted Structural Number (WSN):	WSN =	1.48

DESIGN EQUATION

$$WSN = C_1D_1 + C_2D_2$$

C_1 = 0.44 Strength Coefficient - Hot Bituminous Asphalt
C_2 = 0.12 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 inches of Full Depth Asphalt
Use 4.0 inches Full Depth

FOR ASPHALT + AGGREGATE BASE COURSE SECTION

Asphalt Thickness (t) = [3] inches
$D_2 = ((WSN) - (t)(C_1))/C_2$ = 1.3 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. 4.0 inches of Asphalt

Job No. 171635
Fig. No. C-2

DESIGN CALCULATIONS

CEMENT TREATED SECTIONS

DESIGN DATA: FOREST LAKES NO. 2B - PARTIAL
LOCAL LOW VOLUME

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL =	32,850
Hveem Stabilometer (R Value) Results:	R =	50
Weighted Structural Number (WSN):	WSN =	1.48

DESIGN EQUATION

$$WSN = C_1D_1 + C_2D_2$$

C_1 = 0.44 Strength Coefficient - Hot Bituminous Asphalt
C_2 = 0.13 Strength Coefficient - Cement Treated Subgrade.

D_1 = Depth of Asphalt (inches)
D_2 = Depth of Cement Treated Subgrade (inches)

FOR FULL DEPTH ASPHALT SECTION - (CURRENTLY NOT ALLOWED)

$D_1 = (WSN)/C_1$ = 3.4 inches of Full Depth Asphalt
Use 4.0 inches Full Depth

FOR ASPHALT + CEMENT TREATED SUBGRADE SECTION

Asphalt Thickness (t) = 4 inches
$D_2 = ((WSN) - (t)(C_1))/C_2$ = -2.2 inches
Use 10.0 inches of Cement Treated Subgrade.

RECOMMENDED ALTERNATIVES

1. 4.0 inches of Asphalt + 10 inches of Cement Treated Subgrade.
2. 4.0 inches of Full Depth Asphalt

Job No. 170080
Fig. No. C-3