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

December 1, 2021

Kess Properties
4955 Austin Bluffs Parkway
Colorado Springs, Colorado 80918

Attn: Mark Phelan

Re: Pavement Recommendations
The Shire at Old Ranch
10755 Howells Road
Colorado Springs, Colorado

Dear Mr. Phelan:

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

Project Description

The project will consist of the paving, or construction of a gravel road of the parking, drive, and truck areas for the proposed commercial development. Subsurface Soil Investigation and laboratory testing were performed to determine the pavement support characteristics on the soils. The location of the proposed improvements is presented in the Vicinity Map, Figure 1. The general layout of the site is presented in the Test Boring Location Map, Figure 2.

Subgrade Conditions

A total of seven (7) test borings were drilled on this site, Test Boring Nos. 6 and 7 were placed in the parking, drive and truck areas. The test boring locations are shown in Figure No.2. The Test Boring Logs are presented in Appendix A. Representative bulk samples of the subgrade soil were obtained from Test Boring No. 6 (Soil Type 1) at the anticipated subgrade elevation. Sieve Analyses were performed on the subgrade soils for the purpose of classification. The Sieve Analyses indicated that approximately 7 to 50 percent of the soil particles passed the No. 200 sieve for the Type 1 soils at subgrade depth. The soils were non-plastic. The Type 1 soils classify as A-2-4 and A-1-b soils using the AASHTO classification. Groundwater was not encountered in the test boring. The results of laboratory testing are presented Appendix B.

The subgrade soils are anticipated to have a low expansion potential. Mitigation for expansive soils is not required on this site.

California Bearing Ratio (CBR) tests were performed on a sample of the Type 1 subgrade soils. The results of the CBR and classification testing are presented as follows and in Appendix B and on Table 1, attached. Based on the results of the classification and CBR testing, the soils on this site exhibit good pavement support characteristics.

CBR Test Results

Soil Type 1 – Very Silty Sand

R @ 90% = 17.0
R @ 95% = 73.0
Use R = 50 for Design

Classification Testing

Liquid Limit	NV
Plasticity Index	NP
Percent Passing 200	50
AASHTO Classification	A-2-4
Group Index	0
Unified Soils Classification	SM

Pavement Design

The CBR test results for the site was used to determine pavement sections for the parking, drive, and truck areas. Pavement sections were determined utilizing the El Paso County "Pavement Design Criteria Manual". An 18k ESAL value of 30,000 was used to determine the sections of the parking areas, 50,000 was used to determine pavement sections for the drive areas, and an 18k ESAL value of 90,000 was used for areas which will receive truck traffic. Pavement sections were determined for asphalt/basecourse composite sections and full depth base coarse sections.

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

Reliability	75%
Standard Deviation	0.44
Resilient Modulus	13,168 psi
Δpsi	2.0
"R" Value Subgrade	50
Hot Bituminous Pavement	0.44
Basecourse	0.12

The pavement design calculations are shown in Appendix C. Recommended pavement sections are summarized below.

Basecourse/Asphalt Pavement Sections - Soil Type 1

Parking Areas

Alternatives	Asphalt (in)	Basecourse (in)
1 – Asphalt Over Basecourse	4.0	6.0
2 – Full Depth Asphalt	5.0[1]	--

Drive Areas

Alternatives	Asphalt (in)	Basecourse (in)
1 – Asphalt Over Basecourse	4.0	6.0
2 – Full Depth Asphalt	5.0[1]	--

Truck Areas

Alternatives	Asphalt (in)	Basecourse (in)
1 – Asphalt Over Basecourse	4.0	6.0
2 – Full Depth Asphalt	5.0[1]	--

1 – Full Depth Sections are currently not allowed by El Paso County.

Basecourse (Gravel) Sections - Soil Type 1

Parking Areas

Alternatives	Basecourse (in)
1 – Basecourse	11.5

Drive Areas

Alternatives	Basecourse (in)
1 – Basecourse	12.5

Truck Areas

Alternatives	Basecourse (in)
1 – Basecourse	14.0

Since the drive, parking, and truck areas are private, thinner sections can be considered for the project. Higher maintenance costs however should be anticipated if thinner sections are used. At trash enclosures, a minimum rigid 8-inch concrete section is recommended. The thinner sections would not meet the current El Paso County Paving Specifications.

Roadway Construction

Prior to placement of the asphalt, the subgrade should be scarified, moisture-conditioned, and compacted to a minimum of 95% of the soils maximum Modified Proctor Dry Density, ASTM D-1557 within 2 percent of optimum moisture content and proof rolled after properly compacted. Any loose areas should be removed and replaced with suitable materials approved by Entech. Basecourse materials should be compacted to a minimum of 95% of its maximum Modified Proctor Dry Density, ASTM D-1557 at ± 2% of optimum moisture content. Special attention should be given to areas adjacent to manholes, inlet structures and valves.

Proctor Dry Density, ASTM D-1557 at ± 2% of optimum moisture content. Special attention should be given to areas adjacent to manholes, inlet structures and valves.

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.

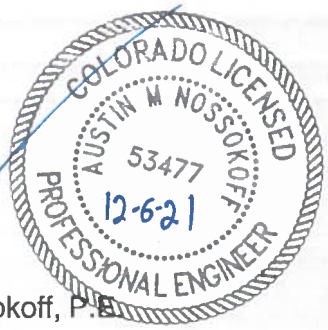
Respectfully Submitted,

ENTECH ENGINEERING, INC.

Joseph H. Robinson

Reviewed by:

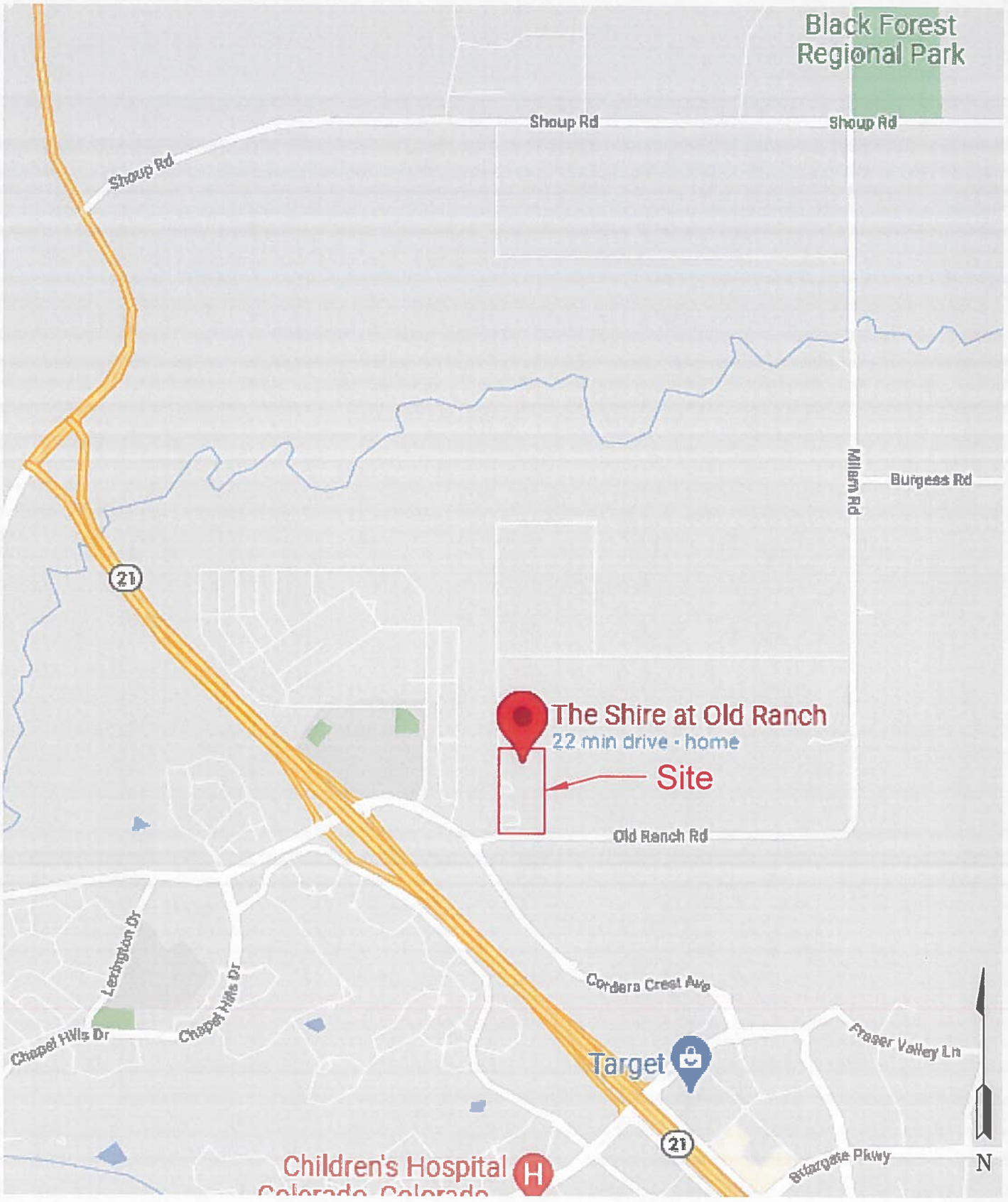
Austin M. Nossokoff, P.E.



AMN/jr

Encl.

Entech Job No. 212362
AAprojects/2021/212362 - pr



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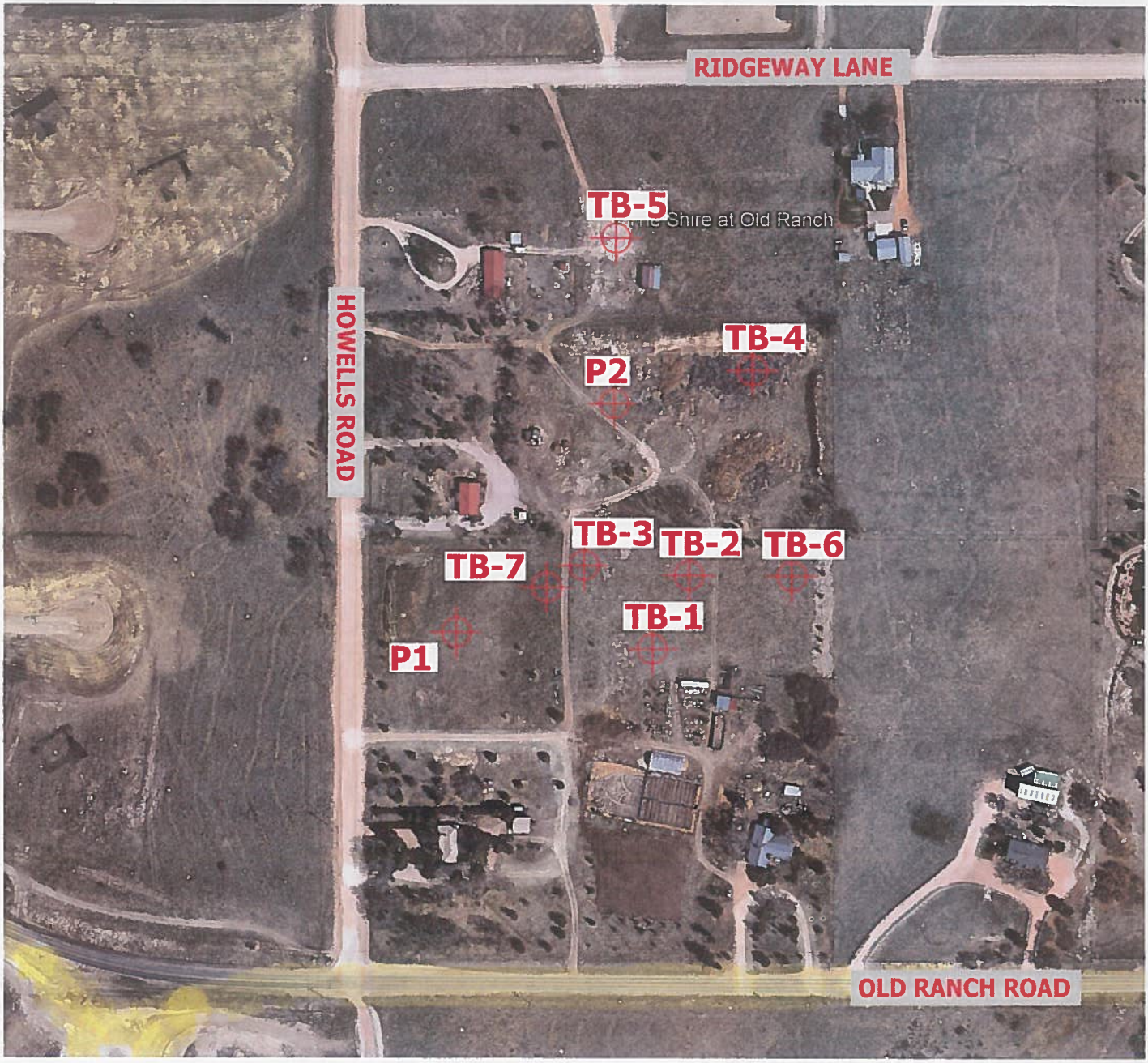
VICINITY MAP
THE SHIRE AT OLD RANCH
10755 HOWELLS RD
COLORADO SPRINGS, CO
FOR: KESS PROPERTIES

DRAWN:	DATE:	CHECKED:	DATE:
JHR	12/1/21	AMN	

JOB NO.: 212362

FIG NO.: 1



TB- APPROXIMATE TEST BORING LOCATIONS AND NUMBERS

P- APPROXIMATE PERCOLATION BORING LOCATIONS AND NUMBERS

N

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TEST BORING LOCATION MAP
THE SHIRE AT OLD RANCH
10755 HOWELLS RD
COLORADO SPRINGS, CO
FOR: KESS PROPERTIES

DRAWN:	DATE:	CHECKED:	DATE:
JHR	12/1/21	AMN	

JOB NO.: 212362

FIG NO.: 2

APPENDIX A: Test Boring Logs

TEST BORING NO. 6
DATE DRILLED 10/20/2021
Job # 212362

REMARKS

DRY TO 10', 10/20/21

SAND, SLIGHTLY SILTY, FINE TO COARSE GRAINED, TAN, DENSE TO MEDIUM DENSE, DRY TO MOIST

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
			37	2.3	1
5			19	8.6	1
10			26	6.0	1
15					
20					

TEST BORING NO. 7
DATE DRILLED 10/20/2021
CLIENT KESS PROPERTIES
LOCATION THE SHIRE AT OLD RANCH

REMARKS

DRY TO 5', 10/20/21

SAND, SLIGHTLY SILTY, FINE TO COARSE GRAINED, TAN, MEDIUM DENSE TO DENSE, DRY

Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
			13	2.1	1
5			34	1.5	1
10					
15					
20					

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TEST BORING LOG

DRAWN:	DATE:	CHECKED:	DATE:
		SHR	12/6/21

JOB NO.: 212362
FIG NO.: A- 1

APPENDIX B: Laboratory Testing Results

CBR TEST LOAD DATA

JOB NO: 212362
CLIENT: KESS PROPERTIES
PROJECT: THE SHIRE AT OLD RANCH
SOIL TYPE: 1

PISTON DIAMETER (cm)	PISTON AREA (in^2)
4.958	2.993

PENETRATION DEPTH (INCHES)	*10 BLOWS* MOLD # 1 LOAD(LBS) (LBS)	STRESS (PSI)	*25 BLOWS* MOLD # 2 LOAD(LBS) (LBS)	STRESS (PSI)	*56 BLOWS* MOLD # 3 LOAD(LBS) (LBS)	STRESS (PSI)
0.000	0	0.00	0	0.00	0	0.00
0.025	242	80.87	269	89.89	307	102.59
0.050	405	135.34	485	162.07	497	166.08
0.075	545	182.12	675	225.56	706	235.92
0.100	650	217.21	1009	337.18	1248	417.04
0.125	790	263.99	1200	401.00	1508	503.92
0.150	960	320.80	1324	442.44	1965	656.64
0.175	1103	368.59	1473	492.23	2262	755.89
0.200	1278	427.07	1897	633.92	2708	904.93
0.300	1608	537.34	2567	857.81	4551	1520.80
0.400	1928	644.28	3177	1061.65	5416	1809.85
0.500	2222	742.52	3869	1292.89	6000	2005.01

FINAL MOISTURE CONTENT

	MOLD # 1	MOLD # 2	MOLD # 3
CAN #	345	342	343
WT. CAN	8.49	8.51	8.47
WT. CAN+WET	187.06	212.55	186.1
WT. CAN+DRY	168.41	191.78	170.56
WT. H20	18.65	20.77	15.54
WT. DRY SOIL	159.92	183.27	162.09
MOISTURE CONTENT	11.66%	11.33%	9.59%

WET DENSITY (PCF)	130.2	134.0	138.7
DRY DENSITY (PCF)	120.2	123.7	128.1

BEARING RATIO	21.72	33.72	41.70

90% OF DRY DENSITY	116.0
95% OF DRY DENSITY	122.3

BEARING RATIO AT 90% OF MAX	7.23	~ R VALUE	17
BEARING RATIO AT 95% OF MAX	28.67	~ R VALUE	73

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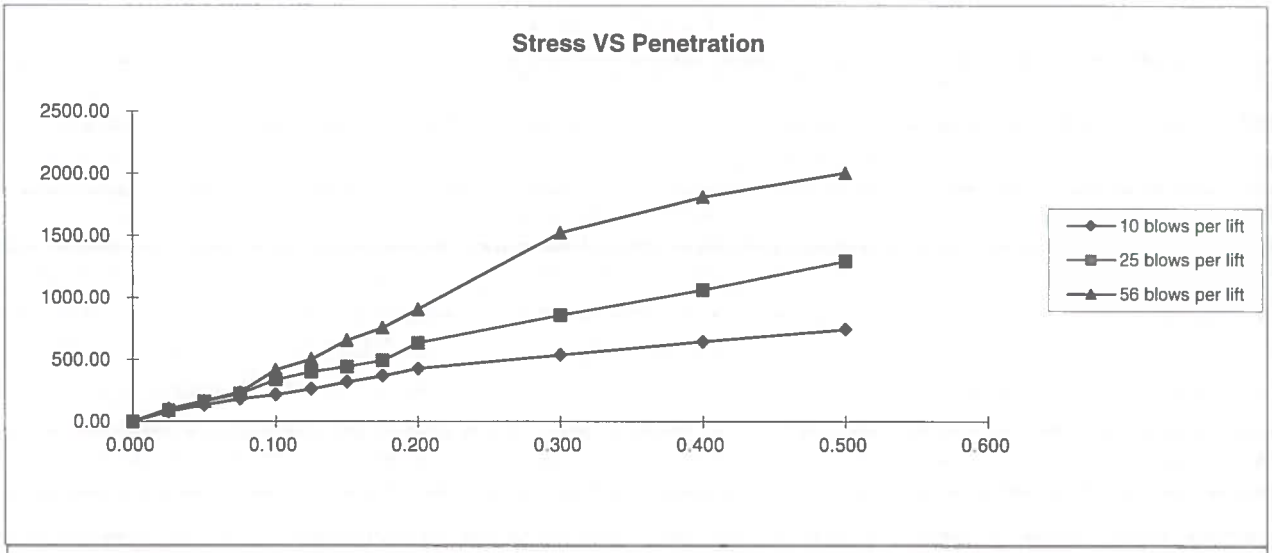
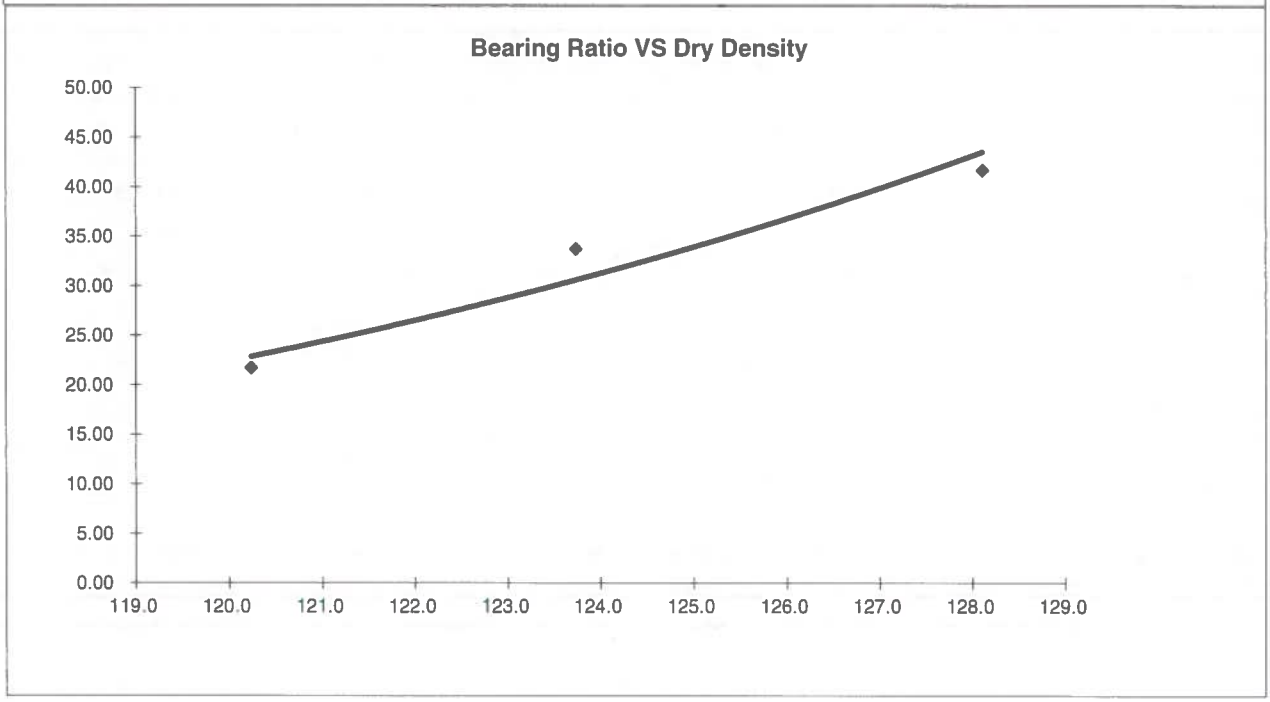
CBR TEST DATA

DRAWN:	DATE:	CHECKED:	DATE:

JOB NO.: 212362
FIG NO.: B - 1





BEARING RATIO AT 90% OF MAX	7.23	~ R VALUE	17.00
BEARING RATIO AT 95% OF MAX	28.67	~ R VALUE	73.00

JOB NO: 212362
SOIL TYPE: 1

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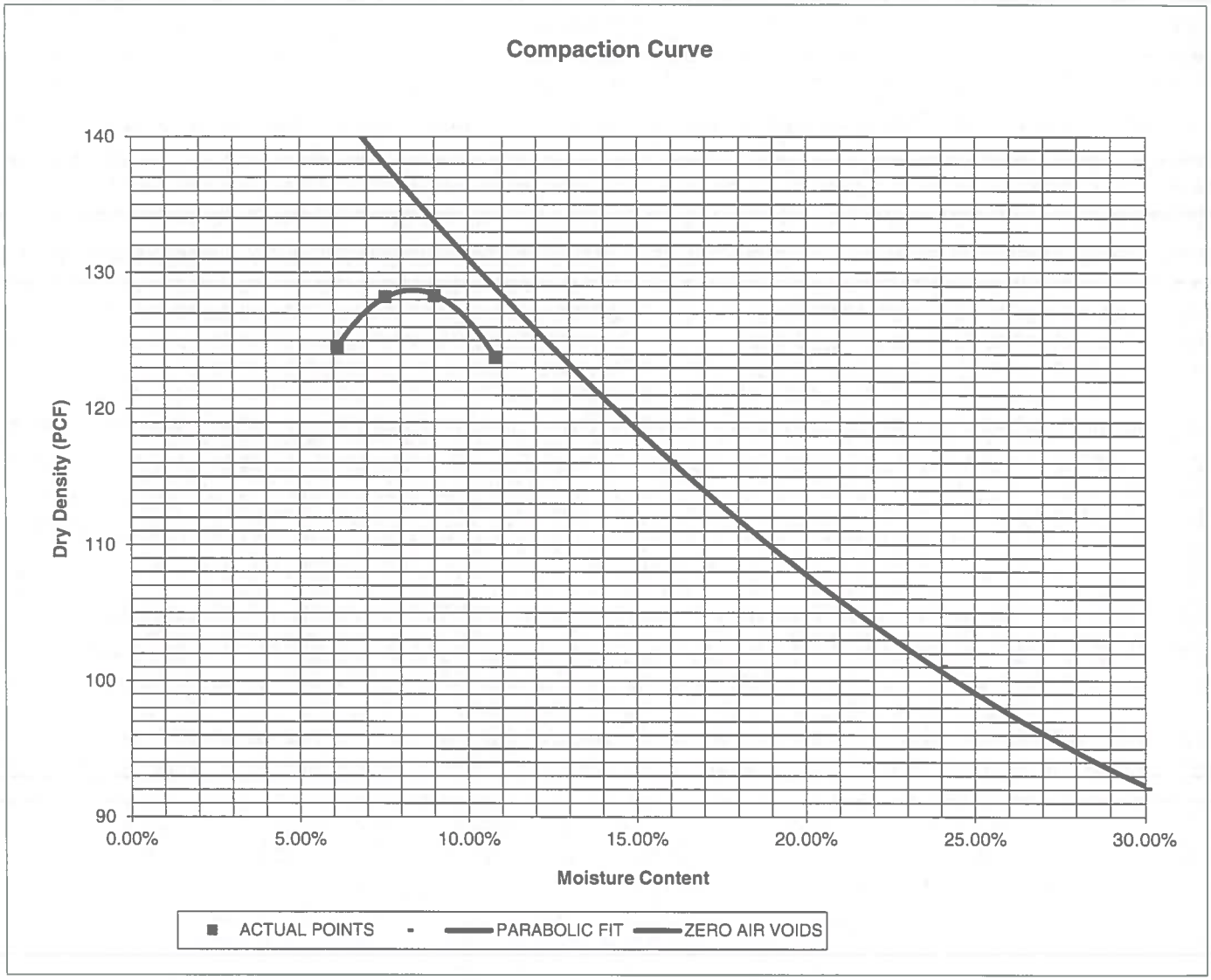
CALIFORNIA BEARING RATIO

DRAWN:	DATE:	CHECKED:	DATE:

JOB NO.: 212362
FIG NO.: B-2

PROJECT	THE SHIRE AT OLD RANCH	CLIENT	KESS PROPERTIES
SAMPLE LOCATION	TB-6 @ 0-3'	JOB NO.	212362
SOIL DESCRIPTION	SAND, VERY SILTY, BROWN	DATE	10/28/21

IDENTIFICATION	SM	COMPACTION TEST #	1
TEST DESIGNATION / METHOD	ASTM D-1557-A	TEST BY	BC
MAXIMUM DRY DENSITY (PCF)	128.9	OPTIMUM MOISTURE	8.3%



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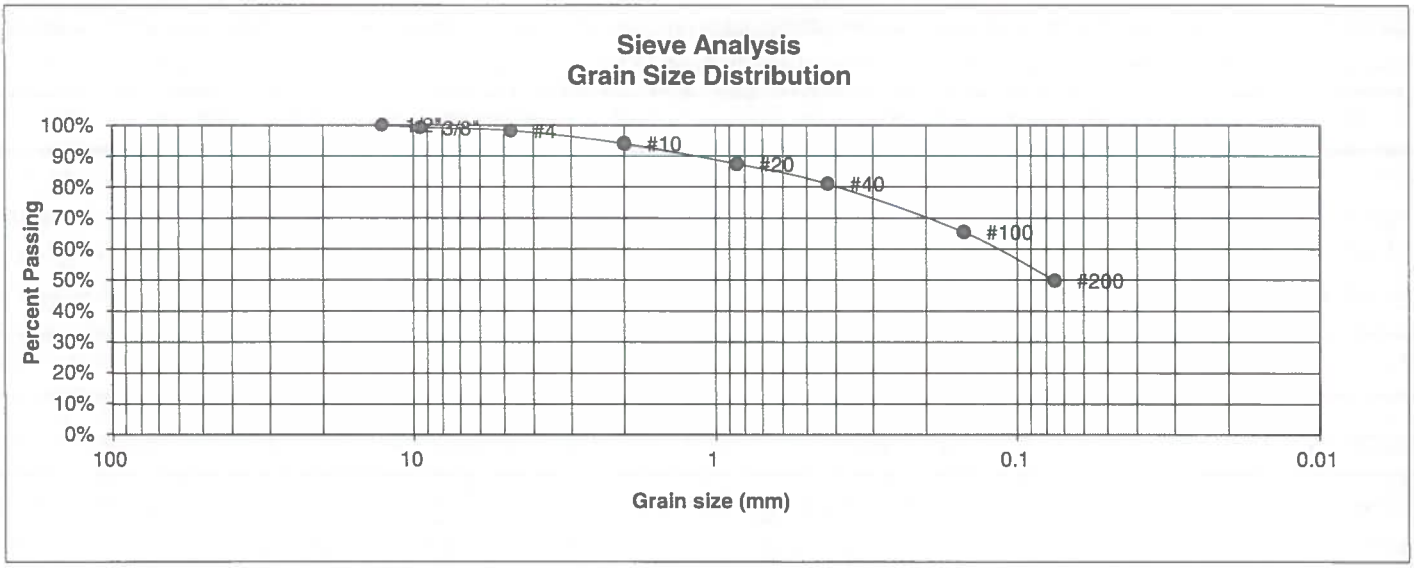
MOISTURE DENSITY RELATION

DRAWN:	DATE:	CHECKED:	DATE:

JOB NO.: 212362

FIG NO.: B-3

UNIFIED CLASSIFICATION	SM	CLIENT	KESS PROPERTIES
SOIL TYPE #	1, CBR	PROJECT	THE SHIRE AT OLD RANCH
TEST BORING #	6	JOB NO.	212362
DEPTH (FT)	0-3	TEST BY	BL
AASHTO CLASSIFICATION	A-2-4	GROUP INDEX	0



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	100.0%
3/8"	99.1%
4	98.1%
10	94.0%
20	87.4%
40	81.0%
100	65.4%
200	49.8%

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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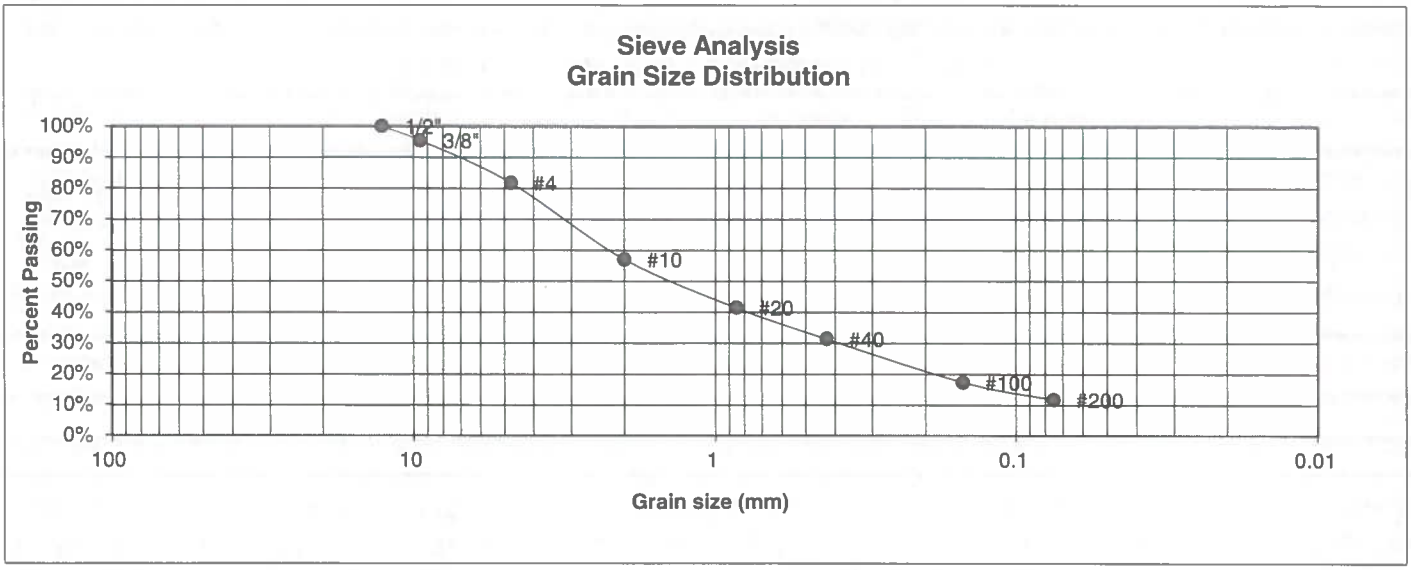
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED:	DATE:

JOB NO.: 212362
FIG NO.: B-4

UNIFIED CLASSIFICATION	SM-SW	CLIENT	KESS PROPERTIES
SOIL TYPE #	1	PROJECT	THE SHIRE AT OLD RANCH
TEST BORING #	6	JOB NO.	212362
DEPTH (FT)	1-2	TEST BY	BL
AASHTO CLASSIFICATION	A-1-b	GROUP INDEX	0



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	100.0%
3/8"	95.5%
4	81.8%
10	57.1%
20	41.5%
40	31.4%
100	17.3%
200	11.7%

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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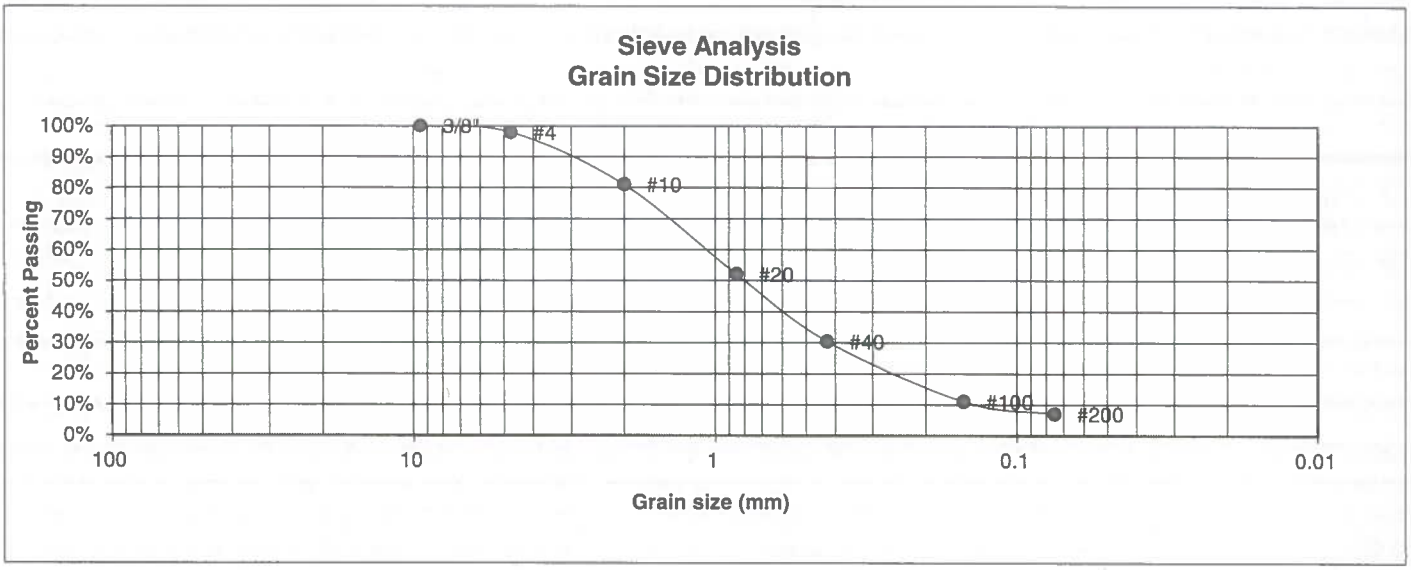
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED:	DATE:

JOB NO.: 212362
FIG NO.: B-5

UNIFIED CLASSIFICATION	SM-SW	CLIENT	KESS PROPERTIES
SOIL TYPE #	1	PROJECT	THE SHIRE AT OLD RANCH
TEST BORING #	7	JOB NO.	212362
DEPTH (FT)	1-2	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	97.9%
10	81.0%
20	52.1%
40	30.4%
100	11.0%
200	7.1%

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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COLORADO SPRINGS, COLORADO 80907

LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED:	DATE:

JOB NO.: 212362
FIG NO.: B-6

APPENDIX C: Pavement Design Calculations

FLEXIBLE PAVEMENT DESIGN

DESIGN DATA — KESS PROPERTIES - PARKING AREAS
THE SHIRE at OLD RANCH ROAD

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL (W_{18}) =	30,000
Hveem Stabilometer (R Value) Results:	R =	50
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 =	13168

Weighted Structural Number (WSN): → WSN = 1.36

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
4.48	4.48	0.0

Job No. 212362
Fig. No. C-1

DESIGN CALCULATIONS

DESIGN DATA — KESS PROPERTIES - PARKING AREAS
THE SHIRE at OLD RANCH ROAD

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL =	30,000
Hveem Stabilometer (R Value) Results:	R =	50
Weighted Structural Number (WSN):	WSN =	1.36

DESIGN EQUATION

$$WSN = C_1D_1 + C_2D_2$$

C_1 = 0.44 Strength Coefficient - Hot Bituminous Asphalt
C_2 = 0.12 Strength Coefficient - Base Course

D_1 = Depth of Asphalt (inches)
D_2 = Depth of Base Course (inches)

FOR FULL DEPTH ASPHALT SECTION

$D_1 = (WSN)/C_1$ = 3.1 inches of Full Depth Asphalt
Use 5.0 inches Full Depth

FOR ASPHALT + AGGREGATE BASE COURSE SECTION

Asphalt Thickness (t) = 4 inches
$D_2 = ((WSN) - (t)(C_1))/C_2$ = -3.3 inches of Aggregate
Base Course, use 6.0 inches

RECOMMENDED ALTERNATIVES

1. 4.0 inches of Asphalt + 6.0 inches of Aggregate Base Course, or
2. 5.0 inches of Asphalt

Job No. 212362
Fig. No. C-2

FLEXIBLE PAVEMENT DESIGN

DESIGN DATA — KESS PROPERTIES - DRIVE AREAS
THE SHIRE at OLD RANCH

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL (W_{18}) =	50,000
Hveem Stabilometer (R Value) Results:	R =	50
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 =	13168

Weighted Structural Number (WSN): → WSN = 1.50

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
4.70	4.70	0.0

Job No. 212362
Fig. No. C-3

DESIGN CALCULATIONS

DESIGN DATA — KESS PROPERTIES - DRIVE AREAS
THE SHIRE at OLD RANCH

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL =	50,000
Hveem Stabilometer (R Value) Results:	R =	50
Weighted Structural Number (WSN):	WSN =	1.50

DESIGN EQUATION

$$WSN = C_1D_1 + C_2D_2$$

C_1 = 0.44 Strength Coefficient - Hot Bituminous Asphalt
C_2 = 0.12 Strength Coefficient - 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 5.0 inches Full Depth

FOR ASPHALT + AGGREGATE BASE COURSE SECTION

Asphalt Thickness (t) = 4 inches
$D_2 = ((WSN) - (t)(C_1))/C_2$ = -2.2 inches of Aggregate
Base Course, use 6.0 inches

RECOMMENDED ALTERNATIVES

1. 4.0 inches of Asphalt + 6.0 inches of Aggregate Base Course, or
2. 5.0 inches of Asphalt

Job No. 212362
Fig. No. C-4

FLEXIBLE PAVEMENT DESIGN

DESIGN DATA — KESS PROPERTIES - TRUCK AREAS
THE SHIRE at OLD RANCH

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL (W_{18}) =	90,000
Hveem Stabilometer (R Value) Results:	R =	50
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 =	13168

Weighted Structural Number (WSN): → WSN = 1.66

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
4.95	4.95	0.0

Job No. 212362
Fig. No. C-5

DESIGN CALCULATIONS

DESIGN DATA — KESS PROPERTIES - TRUCK AREAS
THE SHIRE at OLD RANCH

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL =	90,000
Hveem Stabilometer (R Value) Results:	R =	50
Weighted Structural Number (WSN):	WSN =	1.66

DESIGN EQUATION

$$WSN = C_1D_1 + C_2D_2$$

C_1 = 0.44 Strength Coefficient - Hot Bituminous Asphalt
C_2 = 0.12 Strength Coefficient - Base Course

D_1 = Depth of Asphalt (inches)
D_2 = Depth of Base Course (inches)

FOR FULL DEPTH ASPHALT SECTION

$D_1 = (WSN)/C_1$ = 3.8 inches of Full Depth Asphalt
Use 5.0 inches Full Depth

FOR ASPHALT + AGGREGATE BASE COURSE SECTION

Asphalt Thickness (t) = 4 inches
$D_2 = ((WSN) - (t)(C_1))/C_2$ = -0.8 inches of Aggregate
Base Course, use 6.0 inches

RECOMMENDED ALTERNATIVES

1. 4.0 inches of Asphalt + 6.0 inches of Aggregate Base Course, or
2. 5.0 inches of Asphalt

Job No. 212362
Fig. No. C-6

FLEXIBLE PAVEMENT DESIGN

DESIGN DATA — KESS PROPERTIES - PARKING AREAS
THE SHIRE at OLD RANCH ROAD

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL (W_{18}) =	30,000
Hveem Stabilometer (R Value) Results:	R =	50
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 =	13168

Weighted Structural Number (WSN): → WSN = 1.36

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
4.48	4.48	0.0

Job No. 212362
Fig. No. C-7

DESIGN CALCULATIONS

DESIGN DATA — KESS PROPERTIES - PARKING AREAS
THE SHIRE at OLD RANCH ROAD

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL =	30,000
Hveem Stabilometer (R Value) Results:	R =	50
Weighted Structural Number (WSN):	WSN =	1.36

DESIGN EQUATION

$$WSN = C_1D_1 + C_2D_2$$

C_1 = 0.12 Strength Coefficient - Base Course

D = Depth of Base Course (inches)

FOR AGGREGATE BASE COURSE SECTION

$D_2 = ((WSN)/C_1$ = 11.4 inches of Aggregate
Base Course, use 11.5 inches

RECOMMENDED ALTERNATIVES

1. 11.5 inches of Aggregate Base Course

Job No. 212362
Fig. No. C-8

FLEXIBLE PAVEMENT DESIGN

DESIGN DATA — KESS PROPERTIES - DRIVING AREAS
THE SHIRE at OLD RANCH ROAD

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL (W_{18}) =	50,000
Hveem Stabilometer (R Value) Results:	R =	50
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 =	13168

Weighted Structural Number (WSN): → WSN = 1.50

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
4.70	4.70	0.0

Job No. 212362
Fig. No. C-9

DESIGN CALCULATIONS

DESIGN DATA — KESS PROPERTIES - DRIVING AREAS
THE SHIRE at OLD RANCH ROAD

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL =	50,000
Hveem Stabilometer (R Value) Results:	R =	50
Weighted Structural Number (WSN):	WSN =	1.50

DESIGN EQUATION

$$WSN = C_1D_1 + C_2D_2$$

C_1 = 0.12 Strength Coefficient - Base Course

D = Depth of Base Course (inches)

FOR AGGREGATE BASE COURSE SECTION

$D_2 = ((WSN)/C_1$ = 12.5 inches of Aggregate
Base Course, use 12.5 inches

RECOMMENDED ALTERNATIVES

1. 12.5 inches of Aggregate Base Course

Job No. 212362
Fig. No. C-10

FLEXIBLE PAVEMENT DESIGN

DESIGN DATA — KESS PROPERTIES - TRUCK AREAS
THE SHIRE at OLD RANCH ROAD

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL (W_{18}) =	90,000
Hveem Stabilometer (R Value) Results:	R =	50
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 =	13168

Weighted Structural Number (WSN): → WSN = 1.66

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
4.95	4.95	0.0

Job No. 212362
Fig. No. C-11

DESIGN CALCULATIONS

DESIGN DATA KESS PROPERTIES - TRUCK AREAS
THE SHIRE at OLD RANCH ROAD

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL =	90,000
Hveem Stabilometer (R Value) Results:	R =	50
Weighted Structural Number (WSN):	WSN =	1.66

DESIGN EQUATION

$$WSN = C_1D_1 + C_2D_2$$

C_1 = 0.12 Strength Coefficient - Base Course

D = Depth of Base Course (inches)

FOR AGGREGATE BASE COURSE SECTION

$D_2 = ((WSN)/C_1$ = 13.9 inches of Aggregate
Base Course, use 14.0 inches

RECOMMENDED ALTERNATIVES

1. 14.0 inches of Aggregate Base Course

Job No. 212362
Fig. No. C-12