ENTECH
ENGINEERING, INC.
505 ELKTON DRIVE
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July 2, 2020
Revised July 16, 2020

PPR199

M.A. Infrastructure
17145 Colonial Park Drive
Monument, CO 80132

Approved
By: Elizabeth Nijkamp
Date:07/24/2020
El Paso County Planning & Community Development

Attn: Matt Dunston

Re: Pavement Recommendations - Revised
Monument Academy High School
El Paso County, Colorado

Dear Mr. Dunston:

As requested, Entech Engineering, Inc. obtained samples of the pavement subgrade soils from the existing and 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 Jane Lundeen Drive, Pinehurst Circle, and a portion of Walker Road. A Subsurface Soil Investigation and laboratory testing were performed to determine the pavement support characteristics on the soils. The general location is shown on the Vicinity Map Figure 1. The general layout of the site is presented in the Test Boring Location Map in Figure 2.

Subgrade Conditions

A total of ten test borings were drilled along the roadways to depths of approximately 5 and 10 feet below the existing subgrade surface.

The soils at the roadway subgrade depth consisted of slightly silty to silty sand fill (Soil Type 1), silty to very clayey sand fill (Soil Type 2), and native slightly silty to silty sand to clayey sand (Soil Type 3). Silty to slightly silty sandstone (Soil Type 4) was encountered at depths below the subgrade influence zone. The Test Boring Logs are presented in Appendix A. Sieve Analyses and Atterberg Limit testing were performed on 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 8 to 30 percent, and 37 to 42 percent for the Type 2 soils, and 6 to 27 percent for the Type 3 soils. Two subgrade soil types were determined for pavement evaluation based on the laboratory testing (Types 1 and 2). The Type 1 subgrade soils classified as A-2-4, A-2-5, A-6-6, and A-1-b soils which exhibit good pavement support. The Type 2 subgrade soils classified as A-4 and A-6 soils, which exhibit fair to poor pavement support, using the AASHTO classification system. Due to the similarities of the Type 1 and Type 3 soils, the design for both types will be grouped together as Type 1 soils. 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 Testing was not required on the Type 1 subgrade soils based on their soil type. Swell tests on the Type 2 soils resulted in a consolidation of 0.02 and a volume change of 0.00 percent, which are below levels in which mitigation is required. Mitigation for expansive soils is not required on this site.

California Bearing Ratio (CBR) testing was performed on representative subgrade samples 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:

Soil Type 1 – Silty Sand Fill	Soil Type 2 – Very Clayey to Silty Sand Fill
CBR 1	CBR 2
R @ 90% = 71.0	R @ 90% = 22.0
R @ 95% = 74.0	R @ 95% = 35.0
Use R = 50.0 for design	Use R = 35.0 for design

Classification Testing		Classification Testing	
Liquid Limit	NV	Liquid Limit	22
Plasticity Index	NP	Plasticity Index	5
Percent Passing 200	15.8	Percent Passing 200	42.1
AASHTO Classification	A-2-4	AASHTO Classification	A-4
Group Index	0	Group Index	0
Unified Soils Classification	SM	Unified Soils Classification	SC-SM

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. Pinehurst Circle classifies as an urban residential collector, which used an 18k ESAL value of 821,000 for design purposes. Jane Lundeen Drive classifies as an urban residential collector, which used a modified ESAL value of 1,079,500 for design purposes. Walker Road classifies as a minor arterial, which used an 18k ESAL value of 1,971,000 for design purposes. Alternative pavement sections were determined for asphalt on cement stabilized subgrade.

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

Reliability	
Minor Collector	85%
Standard Deviation	0.45
Δpsi	2.5
"R" Value Subgrade (Soil Type 1: A-2-4)	50.0
"R" Value Subgrade (Soil Type 2: A-4)	35.0
Resilient Modulus (Soil Type 1: A-2-4)	13,168 psi
Resilient Modulus (Soil Type 2: A-4)	8,065 psi
Hot Bituminous Pavement	0.44
Cement Stabilized Subgrade	0.12

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

Pavement Sections
ESAL = 1,079,500– Jane Lundeen Drive
Soil Type 1

Alternative	Asphalt (in)	Cement Stabilized Subgrade (in)
1. Asphalt Over Stabilized Subgrade	4.0*	8.0*

Pavement Sections
ESAL = 821,000 –Pinehurst Circle
Soil Type 1

Alternative	Asphalt (in)	Cement Stabilized Subgrade (in)
1. Asphalt Over Stabilized Subgrade	4.0*	8.0*

Soil Type 2

Alternative	Asphalt (in)	Cement Stabilized Subgrade (in)
1. Asphalt Over Stabilized Subgrade	4.0*	10.0

Pavement Sections
ESAL = 1,971,000 – Walker Road
Soil Type 1

Alternative	Asphalt (in)	Cement Stabilized Subgrade (in)
1. Asphalt Over Stabilized Subgrade	5.0*	10.0

Soil Type 2

Alternative	Asphalt (in)	Cement Stabilized Subgrade (in)
1. Asphalt Over Stabilized Subgrade	5.0*	10.0

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

Roadway Construction – Cement Stabilized Subgrade

Prior to placement of the asphalt, the subgrade should be scarified, moisture-conditioned, compacted to a minimum of 95% of its maximum Standard Proctor Dry Density, ASTM D-698 at 0 to 3 percent over optimum moisture content and proofrolled after properly compacted. Any soft areas should be removed and replaced with suitable materials approved by Entech. Base course 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.

Due to the nature of the subgrade soils, overexcavation and cement-treatment of the subgrade to a depth of 8 to 10 inches is recommended, (See Tables above). The subgrade shall be stabilized by the addition of cement to a depth of 8 inches for the collector roads and 10 inches for the arterial roads. The amount of cement applied shall be 3.0 percent (by weight) of the subgrade's maximum dry density as determined by the Standard Proctor Test (ASTM D-698) based on laboratory cement stabilization testing. The cement should be spread evenly on the subgrade surface and be thoroughly mixed into the subgrade over the recommended 8 and 10-inch depths such that a uniform blend of soil and cement is achieved. Prior to application or mixing of the cement, the subgrade should be thoroughly moisture conditioned to the soil's optimum water content or as much as 3 to 4 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 Standard Proctor Test (ASTM D-698). 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 II cement as supplied by 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 materials, subgrade conditions, compaction of materials, testing, inspections, and roadway construction methods shall meet the El Paso County Pavement Design Criteria.

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

DPS/bs

Encl.

Entech Job No. 201127
AAprojects/2020/201127 pr-REV

Reviewed by:

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

TABLE

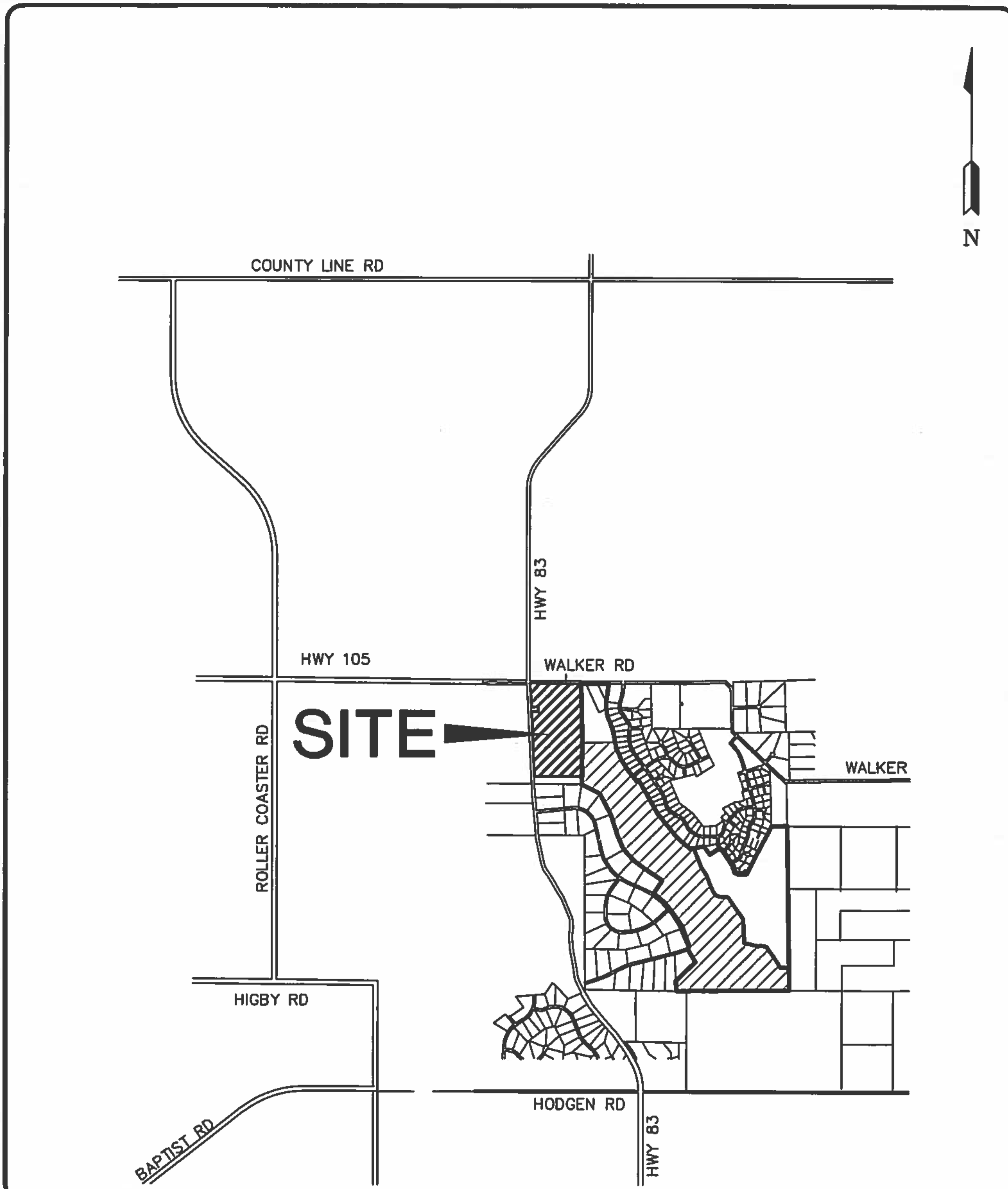
TABLE 1

SUMMARY OF LABORATORY TEST RESULTS

CLIENT MA INFRASTRUCTURE
PROJECT MONUMENT ACADEMY
JOB NO. 201127

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	2	0-3			15.8	NV	NP		A-2-4		SM	FILL, SAND, SILTY
1	2	1-2			13.9	NV	NP	<0.01	A-2-4		SM	FILL, SAND, SILTY
1	4	1-2			7.8	NV	NP		A-1-b		SM-SW	FILL, SAND, SLIGHTLY SILTY
1	5	1-2			30.0	28	10		A-2-4		SC	FILL, SAND, CLAYEY
1	6	1-2			19.3	NV	NP	0.00	A-1-b		SM	FILL, SAND, SILTY
1	9	1-2			8.3	NV	NP		A-1-b		SM-SW	FILL, SAND, SLIGHTLY SILTY
1	6	0-3			23.3						SM	FILL, SAND, SILTY
2, CBR	7	0-3			42.1	22	5		A-4		SC-SM	FILL, SAND, VERY CLAYEY, SILTY
2	1	1-2	5.0	109.8	38.5	22	5		A-4	-0.2	SC-SM	FILL, SAND, VERY CLAYEY, SILTY
2	7	1-2	7.5	110.9	37.3	31	14		A-6	0.0	SC	FILL, SAND, CLAYEY
3	3	1-2			26.5	NV	NP		A-2-4		SM	SAND, SILTY
3	2	10			16.1	NV	NP	<0.01	A-2-5		SM	SAND, SILTY
3	8	1-2			7.7	NV	NP		A-1-b		SM-SW	SAND, SLI GHTLY SILTY
3	10	10			5.9	NV	NP	0.00	A-1-b		SM-SW	SAND, SLIGHTLY SILTY
3	10	1-2			30.8	30	13	0.00	A-2-6		SC	SAND, CLAYEY
3	3	0-3			21.5						SM	SAND, SILTY
4	4	10			19.3	NV	NP	<0.01	A-2-4		SM	SANDSTONE, SILTY
4	9	5			11.6	NV	NP	<0.01	A-1-b		SM-SW	SANDSTONE, SLIGHTLY SILTY
4	8	5			15.6	NV	NP		A-1-b		SM	SANDSTONE, SILTY

FIGURES



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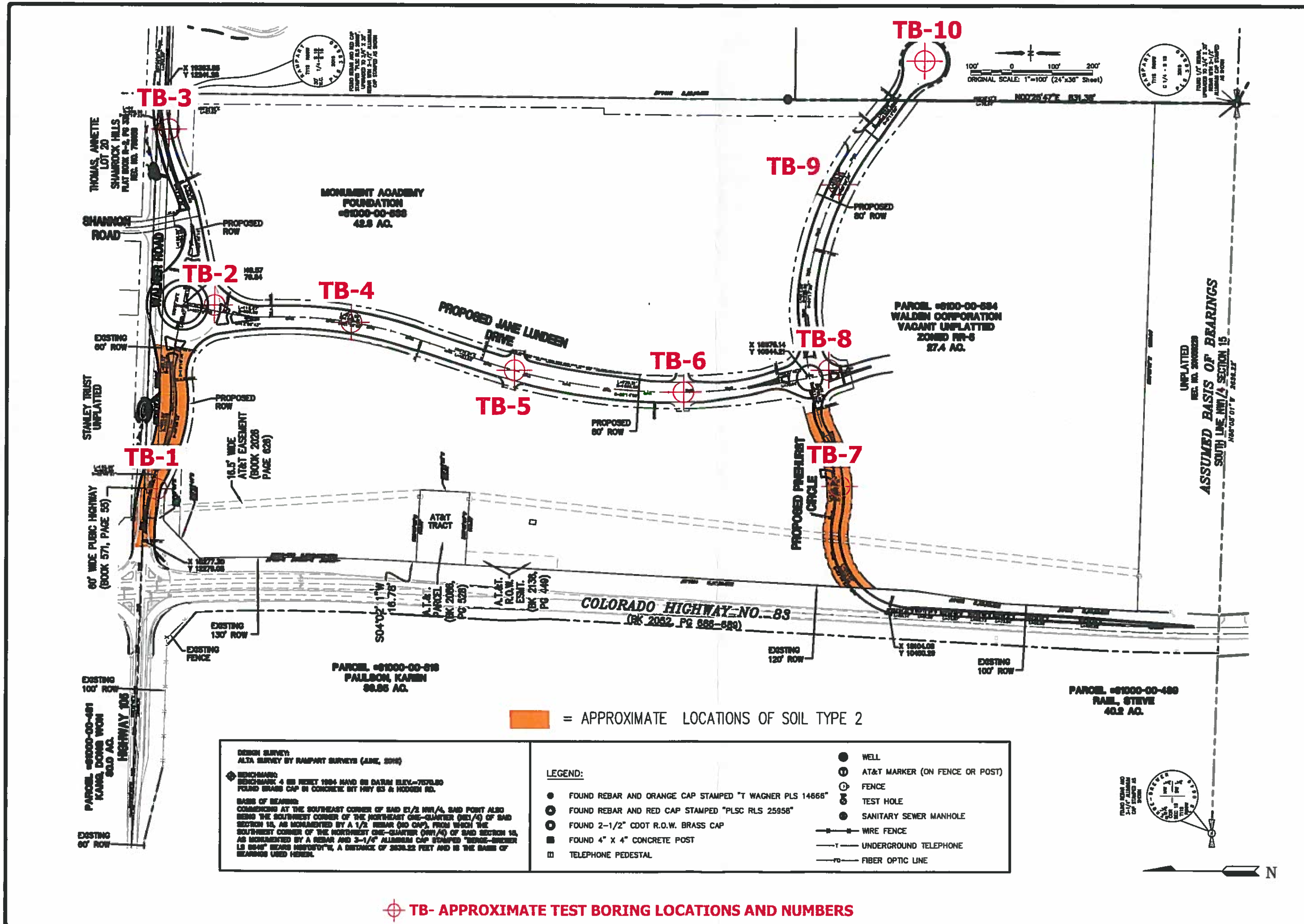
VICINITY MAP
MONUMENT ACADEMY
EL PASO COUNTY, COLORADO
For: M.A. INFRASTRUCTURE

DRAWN:	DATE:	CHECKED:	DATE:
RPJ	07/01/20	DPS	07/01/20

JOB NO.: 201127

FIG NO.: 1



REVISION	BY

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TEST BORING LOCATION MAP
MONUMENT ACADEMY
EL PASO COUNTY, COLORADO
For: M.A. INFRASTRUCTURE

DRAWN	RPJ
CHECKED	DPS
DATE	07/01/20
SCALE	AS SHOWN
JOB NO.	201127
FIGURE NO.	2

APPENDIX A: Test Boring Logs

TEST BORING NO.	1	TEST BORING NO.	2
DATE DRILLED	6/18/2020	DATE DRILLED	6/18/2020
Job #	201127	CLIENT	MA INFRASTRUCTURE
		LOCATION	MONUMENT ACADEMY

TEST BORING NO. 1

REMARKS

DRY TO 5', 6/18/20

Depth (ft)	Description	Samples	Blows per foot	Watercontent %	Soil Type
0-5	FILL 0-5', SAND, VERY CLAYEY, VERY SILTY, FINE GRAINED, BROWN, MEDIUM DENSE TO VERY DENSE, MOIST	■	22	4.2	2
5		■	50	7.8	2
10					
15					
20					

TEST BORING NO. 2

REMARKS

DRY TO 10', 6/18//20

Depth (ft)	Description	Samples	Blows per foot	Watercontent %	Soil Type
0-5	POSS. FILL 0-5', SAND, SILTY, FINE TO COARSE GRAINED, BROWN, MEDIUM DENSE, MOIST	■	17	12.9	1
5		■	10	11.6	1
5-10	SAND, SILTY, FINE TO COARSE GRAINED, TAN, DENSE, MOIST				
10		■	34	7.7	3
15					
20					

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TEST BORING LOG

DRAWN:	DATE:	CHECKED:	DATE:
		[handwritten initials]	6/30/20

JOB NO.: 201127

FIG NO.: A-1

TEST BORING NO. 3
DATE DRILLED 6/18/2020
Job # 201127

REMARKS

DRY TO 5', 6/18/20

Description	Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
SAND, SILTY, FINE TO COARSE GRAINED, BROWN, MEDIUM DENSE, MOIST				15	7.6	3
SANDSTONE, SILTY, FINE TO COARSE GRAINED, TAN, VERY DENSE, DRY	5			50/9"	1.5	4
	10					
	15					
	20					

TEST BORING NO. 4
DATE DRILLED 6/18/2020
CLIENT MA INFRASTRUCTURE
LOCATION MONUMENT ACADEMY

REMARKS

DRY TO 10', 6/18//20

Description	Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
POSS. FILL 0-4', SAND, SLIGHTLY SILTY, FINE TO COARSE GRAINED, BROWN, MEDIUM DENSE, MOIST				23	5.5	1
SANDSTONE, SILTY, FINE TO COARSE GRAINED, TAN, VERY DENSE, MOIST	5			50/8"	6.8	4
	10			50/8"	10.9	4
	15					
	20					

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TEST BORING LOG

DRAWN:	DATE:	CHECKED:	DATE:
		h	07/30/20

JOB NO.: 201127
FIG NO.: A-2

TEST BORING NO. 5
DATE DRILLED 6/18/2020
Job # 201127

REMARKS

DRY TO 5', 6/18/20

Description	Depth (ft)	Blows per foot	Watercontent %	Soil Type
POSS. FILL 0-5', SAND, CLAYEY, FINE TO COARSE GRAINED, BROWN, MEDIUM DENSE TO DENSE, MOIST		20	9.1	1
	5	35	7.3	1

TEST BORING NO. 6
DATE DRILLED 6/18/2020
CLIENT MA INFRASTRUCTURE
LOCATION MONUMENT ACADEMY

REMARKS

DRY TO 5', 6/18/20

Description	Depth (ft)	Blows per foot	Watercontent %	Soil Type
POSS. FILL 0-4', SAND, SILTY, FINE TO COARSE GRAINED, BROWN, MEDIUM DENSE, MOIST		23	7.1	1
SAND, SILTY, FINE TO COARSE GRAINED, BROWN, DENSE, MOIST	5	39	4.5	3

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TEST BORING LOG

DRAWN:	DATE:	CHECKED:	DATE: 6/30/20

JOB NO.: 201127
FIG NO.: A-3

TEST BORING NO. 7
DATE DRILLED 6/18/2020
Job # 201127

REMARKS

DRY TO 5', 6/18/20

Description	Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
FILL 0-5', SAND, VERY CLAYEY, FINE TO COARSE GRAINED, BROWN, MEDIUM DENSE TO DENSE, MOIST				15	11.0	2
	5			48	6.4	2
	10					
	15					
	20					

TEST BORING NO. 8
DATE DRILLED 6/18/2020
CLIENT MA INFRASTRUCTURE
LOCATION MONUMENT ACADEMY

REMARKS

DRY TO 10', 6/18/20

Description	Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
SAND, SLIGHTLY SILTY, FINE TO COARSE GRAINED, TAN, DENSE, MOIST				41	4.3	3
SANDSTONE, SILTY, FINE TO COARSE GRAINED, TAN, VERY DENSE, MOIST	5			50/9"	8.0	4
	10			50/7"	6.7	4
	15					
	20					

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TEST BORING LOG

DRAWN: DATE: CHECKED: [signature] DATE: 6/30/20

JOB NO.: 201127
FIG NO.: A-4

TEST BORING NO. 9
DATE DRILLED 6/18/2020
Job # 201127

REMARKS

DRY TO 5', 6/18/20

Description	Depth (ft)	Samples	Blows per foot	Watercontent %	Soil Type
POSS. FILL 0-3', SAND, SLIGHTLY SILTY, FINE TO COARSE GRAINED, BROWN, DENSE, MOIST		■	33	5.4	1
SANDSTONE, SLIGHTLY SILTY, FINE TO COARSE GRAINED, TAN, VERY DENSE, MOIST	5	■	50/7"	4.4	4
	10				
	15				
	20				

TEST BORING NO. 10
DATE DRILLED 6/18/2020
CLIENT MA INFRASTRUCTURE
LOCATION MONUMENT ACADEMY

REMARKS

DRY TO 10', 6/18/20

Description	Depth (ft)	Samples	Blows per foot	Watercontent %	Soil Type
SAND, CLAYEY, FINE GRAINED, BROWN, MEDIUMD ENSE TO DENSE, MOIST		■	19	7.5	3
	5	■	35	6.2	3
SAND, SLIGHTLY SILTY, FINE TO COARSE GRAINED, BROWN, DENSE, MOIST	10	■	37	3.6	3
	15				
	20				

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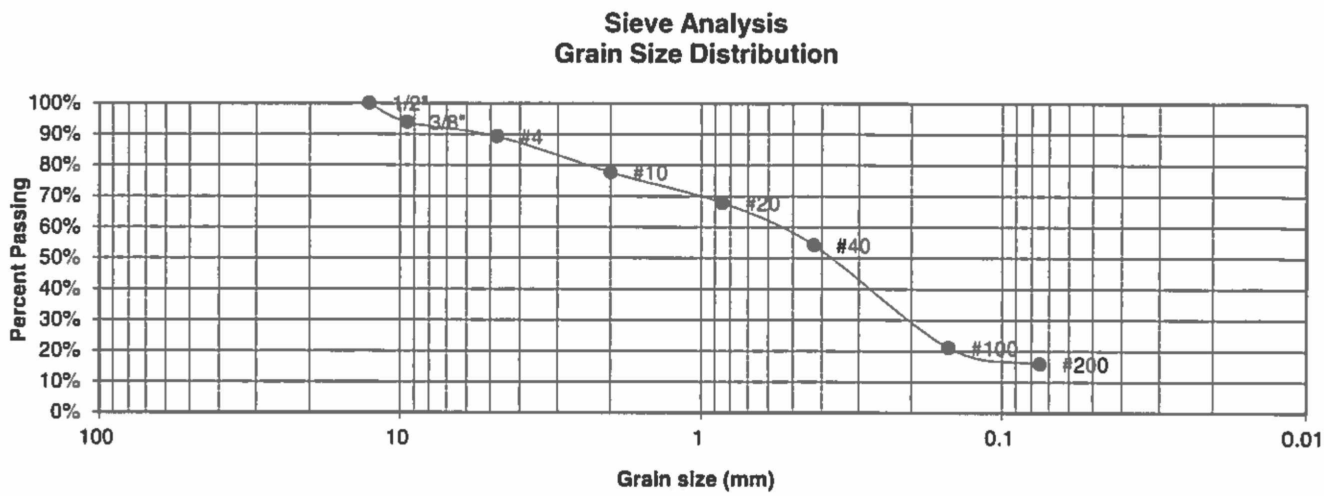
TEST BORING LOG

DRAWN: DATE: CHECKED: [signature] DATE: 6/30/20

JOB NO.: 201127
FIG NO.: A-5

APPENDIX B: Laboratory Testing Results

UNIFIED CLASSIFICATION	SM	CLIENT	MA INFRASTRUCTURE
SOIL TYPE #	1, CBR	PROJECT	MONUMENT ACADEMY
TEST BORING #	2	JOB NO.	201127
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"	93.9%
4	89.3%
10	77.7%
20	67.8%
40	54.1%
100	21.1%
200	15.8%

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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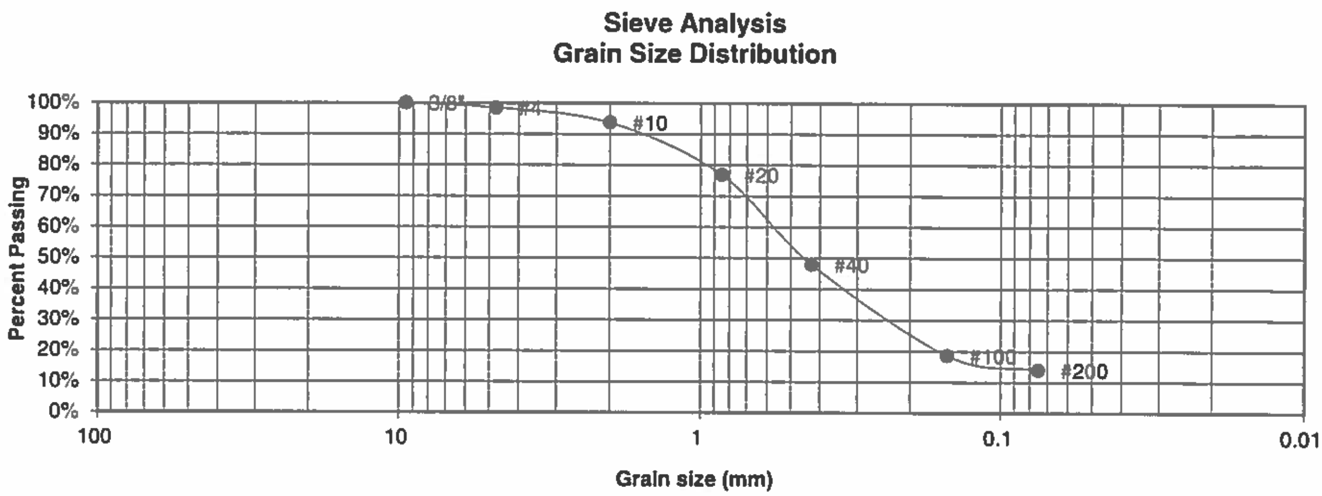
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED:	DATE:
		h	6/30/20

JOB NO.: 201127
FIG NO.: B-1

UNIFIED CLASSIFICATION	SM	CLIENT	MA INFRASTRUCTURE
SOIL TYPE #	1	PROJECT	MONUMENT ACADEMY
TEST BORING #	2	JOB NO.	201127
DEPTH (FT)	1-2	TEST BY	BL
AASHTO CLASSIFICATION	A-2-4	GROUP INDEX	0



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	98.5%
10	93.7%
20	76.9%
40	47.9%
100	18.6%
200	13.9%

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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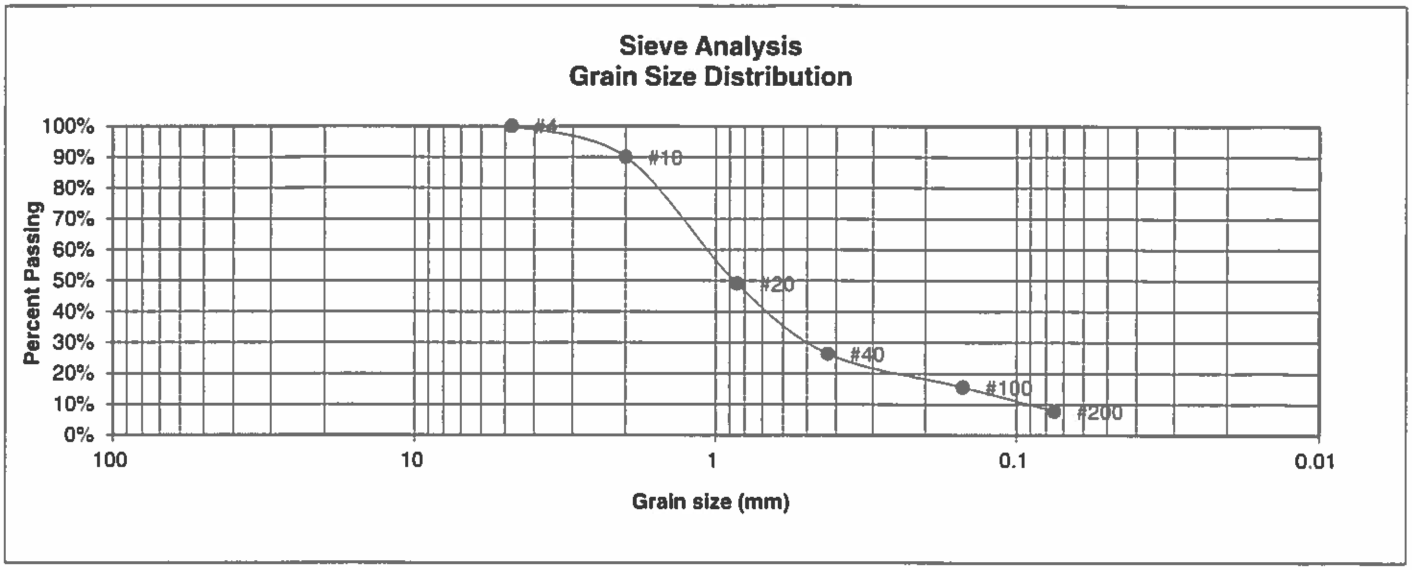
LABORATORY TEST RESULTS

DRAWN: DATE: CHECKED: h DATE: 6/30/20

JOB NO.: 201127
FIG NO.: B-2

UNIFIED CLASSIFICATION	SM-SW	CLIENT	MA INFRASTRUCTURE
SOIL TYPE #	1	PROJECT	MONUMENT ACADEMY
TEST BORING #	4	JOB NO.	201127
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"	
4	100.0%
10	90.0%
20	49.1%
40	26.4%
100	15.6%
200	7.8%

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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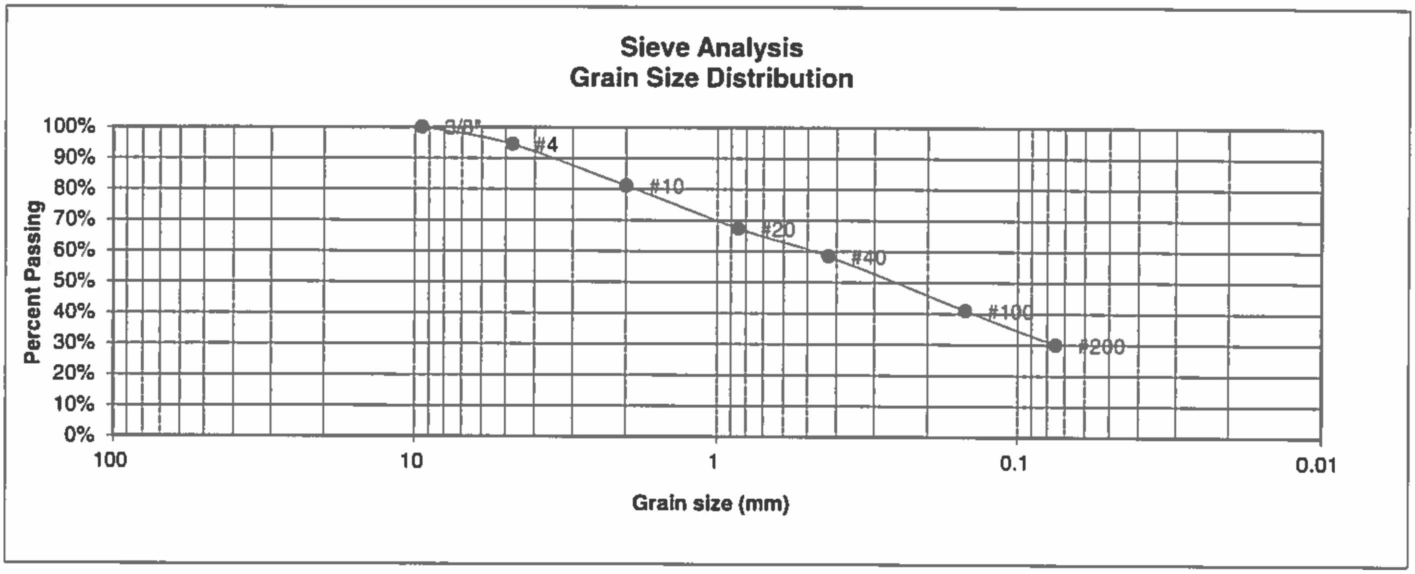
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED: LL	DATE: 6/30/20

JOB NO.: 201127

FIG NO.: B-3

UNIFIED CLASSIFICATION	SC	CLIENT	MA INFRASTRUCTURE
SOIL TYPE #	1	PROJECT	MONUMENT ACADEMY
TEST BORING #	5	JOB NO.	201127
DEPTH (FT)	1-2	TEST BY	BL
AASHTO CLASSIFICATION	A-2-4	GROUP INDEX	0



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	94.5%
10	81.1%
20	67.4%
40	58.5%
100	41.0%
200	30.0%

Atterberg Limits

Plastic Limit	18
Liquid Limit	28
Plastic Index	10

Swell

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

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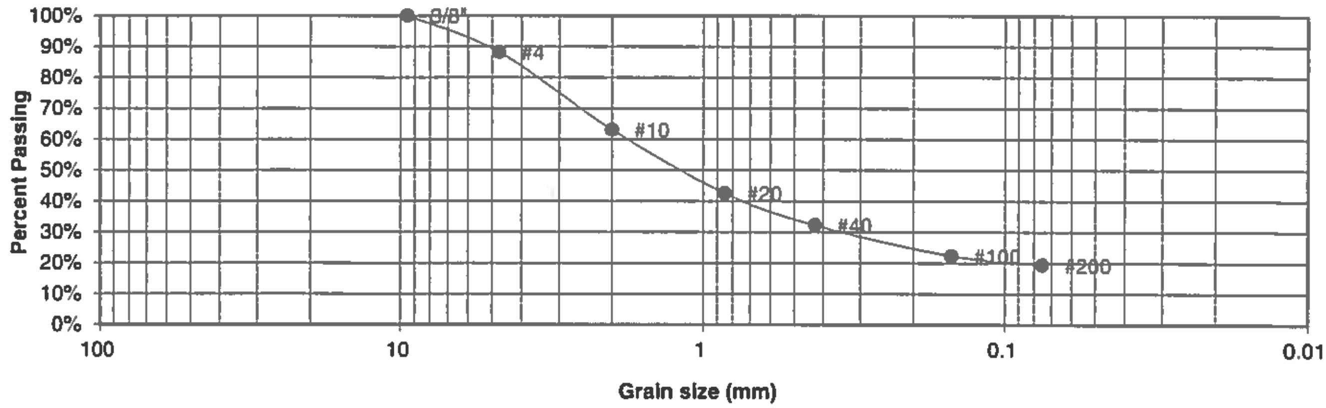
LABORATORY TEST RESULTS

DRAWN: | DATE: | CHECKED: LL | DATE: 6/30/20

JOB NO.: 201127
FIG NO.: B-4

UNIFIED CLASSIFICATION	SM	CLIENT	MA INFRASTRUCTURE
SOIL TYPE #	1	PROJECT	MONUMENT ACADEMY
TEST BORING #	6	JOB NO.	201127
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	88.2%
10	63.1%
20	42.5%
40	32.2%
100	22.3%
200	19.3%

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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505 ELKTON DRIVE
COLORADO SPRINGS, COLORADO 80907

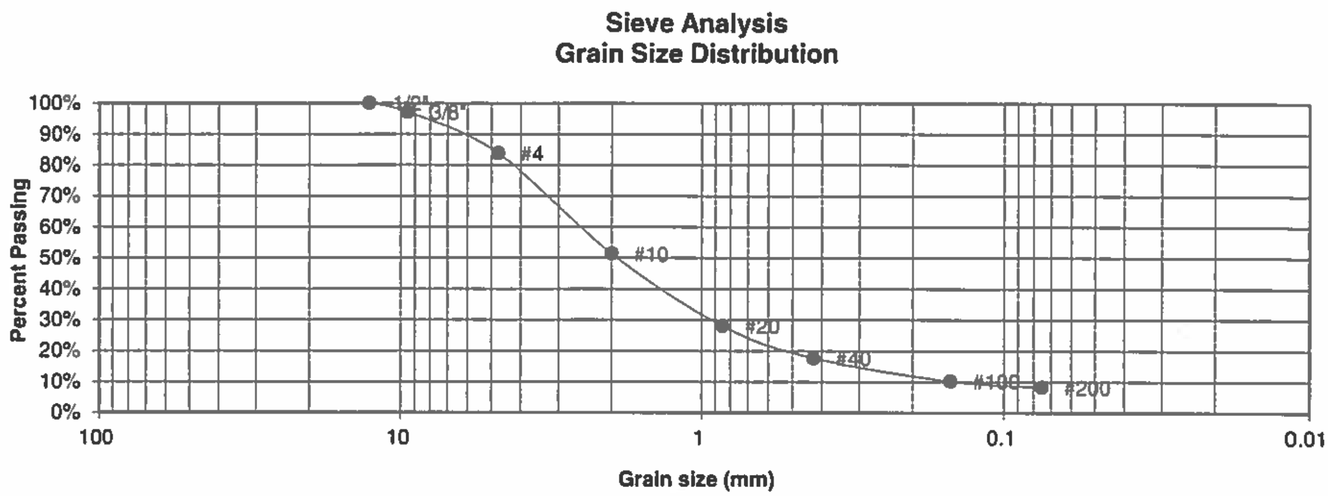
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED:	DATE:
		h	6/30/20

JOB NO.: 201127

FIG NO.: B-5

UNIFIED CLASSIFICATION	SM-SW	CLIENT	MA INFRASTRUCTURE
SOIL TYPE #	1	PROJECT	MONUMENT ACADEMY
TEST BORING #	9	JOB NO.	201127
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"	97.1%
4	83.9%
10	51.3%
20	28.1%
40	17.6%
100	10.2%
200	8.3%

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)

ENTECH ENGINEERING, INC.
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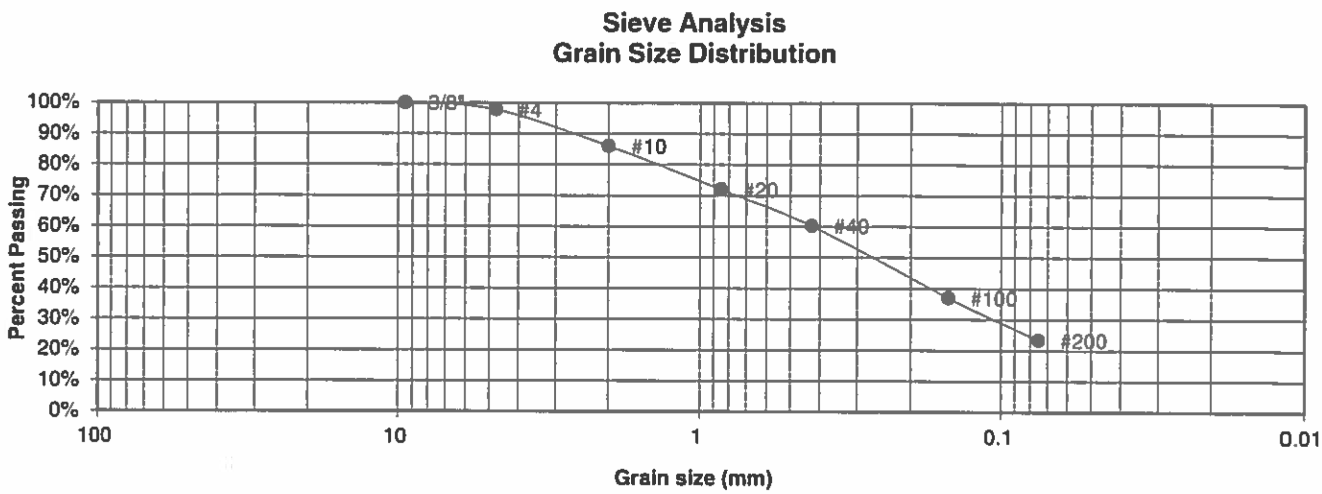
LABORATORY TEST RESULTS

DRAWN: | DATE: | CHECKED: lr | DATE: 6/30/20

JOB NO.: 201127
FIG NO.: B-6

UNIFIED CLASSIFICATION	SM	CLIENT	MA INFRASTRUCTURE
SOIL TYPE #	1	PROJECT	MONUMENT ACADEMY
TEST BORING #	6	JOB NO.	201127
DEPTH (FT)	0-3	TEST BY	BL
AASHTO CLASSIFICATION		GROUP INDEX	#VALUE!



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	97.7%
10	86.0%
20	72.0%
40	60.3%
100	37.0%
200	23.3%

Atterberg Limits
Plastic Limit
Liquid Limit
Plastic Index

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

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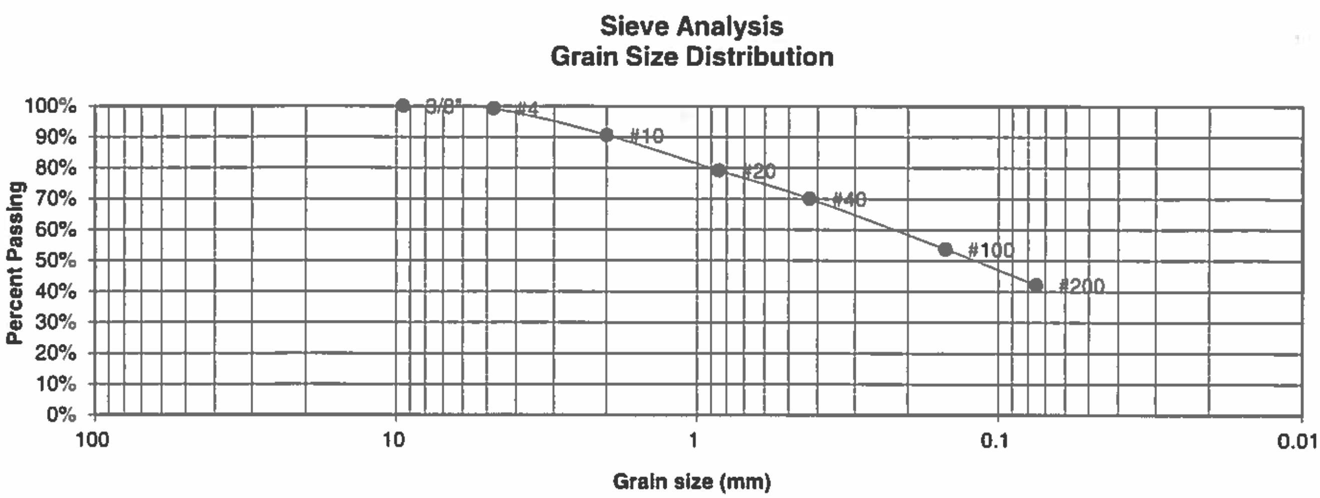
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED:	DATE:
		LL	4/30/20

JOB NO.: 201127
FIG NO.: B-7

UNIFIED CLASSIFICATION	SC-SM	CLIENT	MA INFRASTRUCTURE
SOIL TYPE #	2, CBR	PROJECT	MONUMENT ACADEMY
TEST BORING #	7	JOB NO.	201127
DEPTH (FT)	0-3	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	99.2%
10	90.6%
20	79.2%
40	70.0%
100	53.8%
200	42.1%

Atterberg Limits	
Plastic Limit	17
Liquid Limit	22
Plastic Index	5

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

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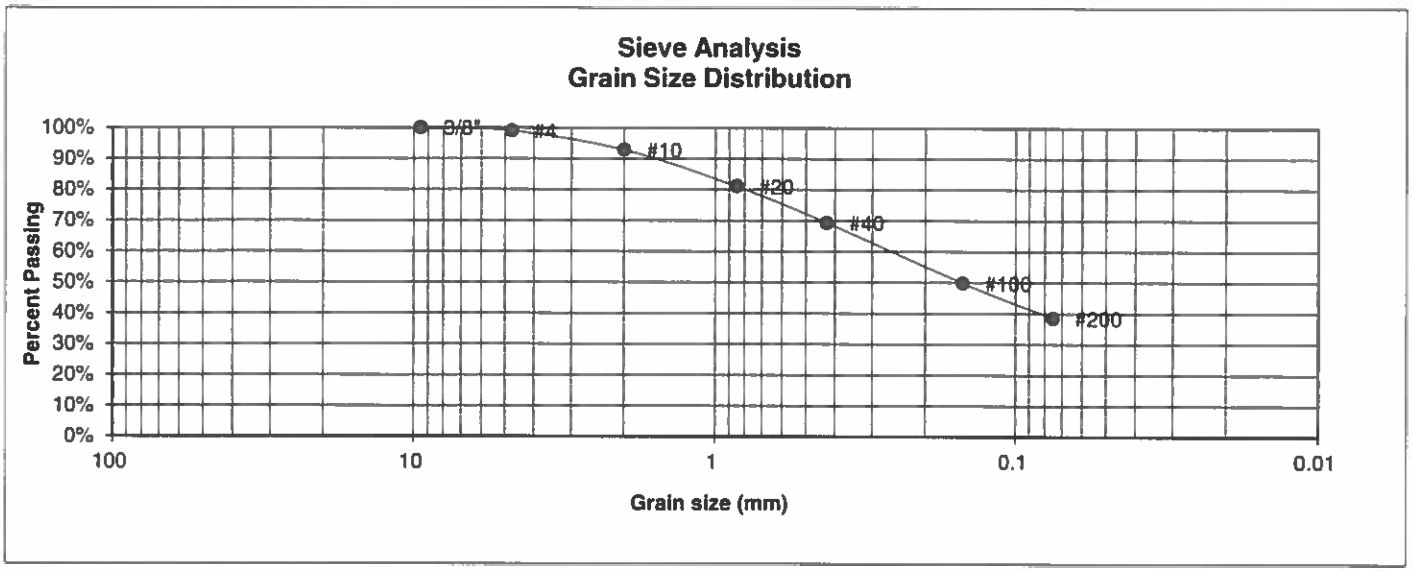
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED:	DATE:
		LI	6/30/20

JOB NO.: 201127
FIG NO.: B-8

UNIFIED CLASSIFICATION	SC-SM	CLIENT	MA INFRASTRUCTURE
SOIL TYPE #	2	PROJECT	MONUMENT ACADEMY
TEST BORING #	1	JOB NO.	201127
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	99.0%
10	92.9%
20	81.1%
40	69.3%
100	49.8%
200	38.5%

Atterberg Limits	
Plastic Limit	18
Liquid Limit	22
Plastic Index	5

Swell

Moisture at start

Moisture at finish

Moisture increase

Initial dry density (pcf)

Swell (psf)

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505 ELKTON DRIVE
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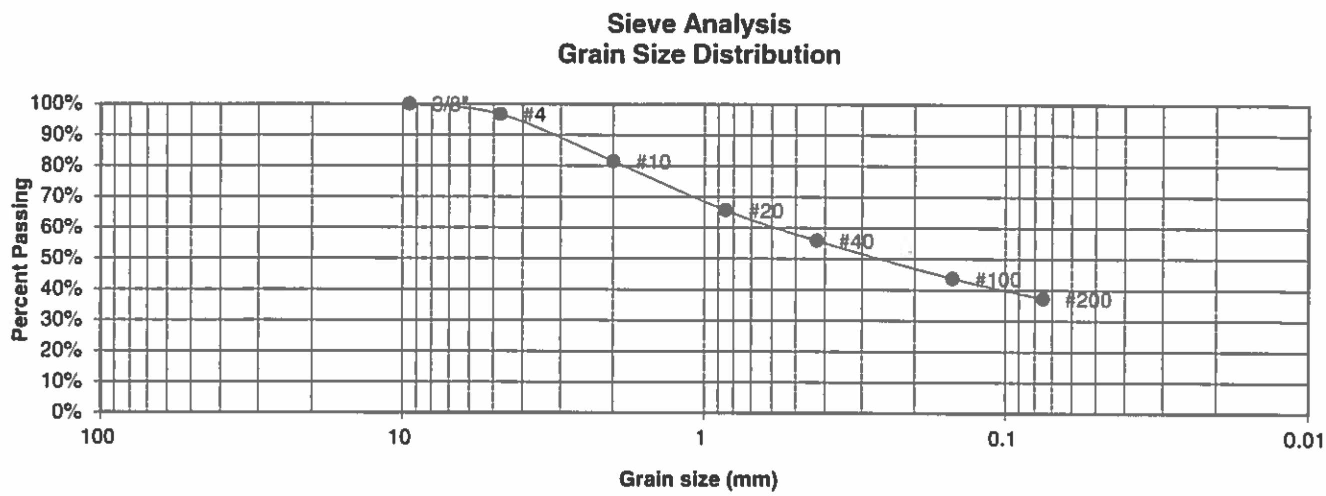
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED: h	DATE: 6/30/20

JOB NO.: 201127

FIG NO.: B-9

UNIFIED CLASSIFICATION	SC	CLIENT	MA INFRASTRUCTURE
SOIL TYPE #	2	PROJECT	MONUMENT ACADEMY
TEST BORING #	7	JOB NO.	201127
DEPTH (FT)	1-2	TEST BY	BL
AASHTO CLASSIFICATION	A-6	GROUP INDEX	1



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	96.7%
10	81.5%
20	65.6%
40	55.9%
100	43.7%
200	37.3%

Atterberg Limits

Plastic Limit	17
Liquid Limit	31
Plastic Index	14

Swell

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

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505 ELKTON DRIVE
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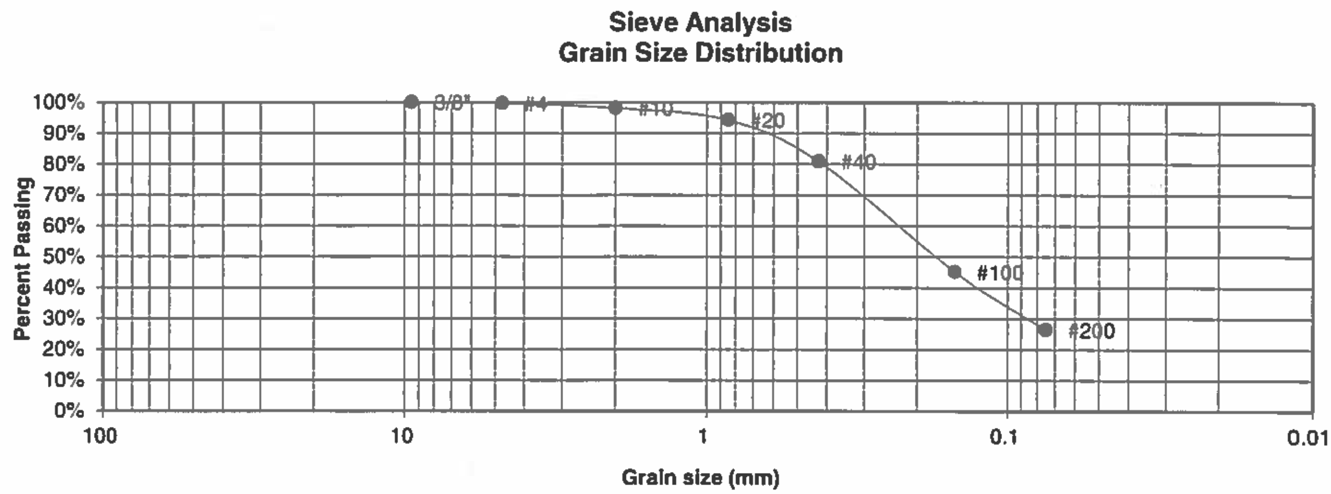
LABORATORY TEST RESULTS

DRAWN: DATE: CHECKED: [signature] DATE: 6/30/20

JOB NO.: 201127
FIG NO.: B-10

UNIFIED CLASSIFICATION	SM	CLIENT	MA INFRASTRUCTURE
SOIL TYPE #	3	PROJECT	MONUMENT ACADEMY
TEST BORING #	3	JOB NO.	201127
DEPTH (FT)	1-2	TEST BY	BL
AASHTO CLASSIFICATION	A-2-4	GROUP INDEX	0



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	99.7%
10	98.1%
20	94.3%
40	80.9%
100	45.2%
200	26.5%

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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505 ELKTON DRIVE
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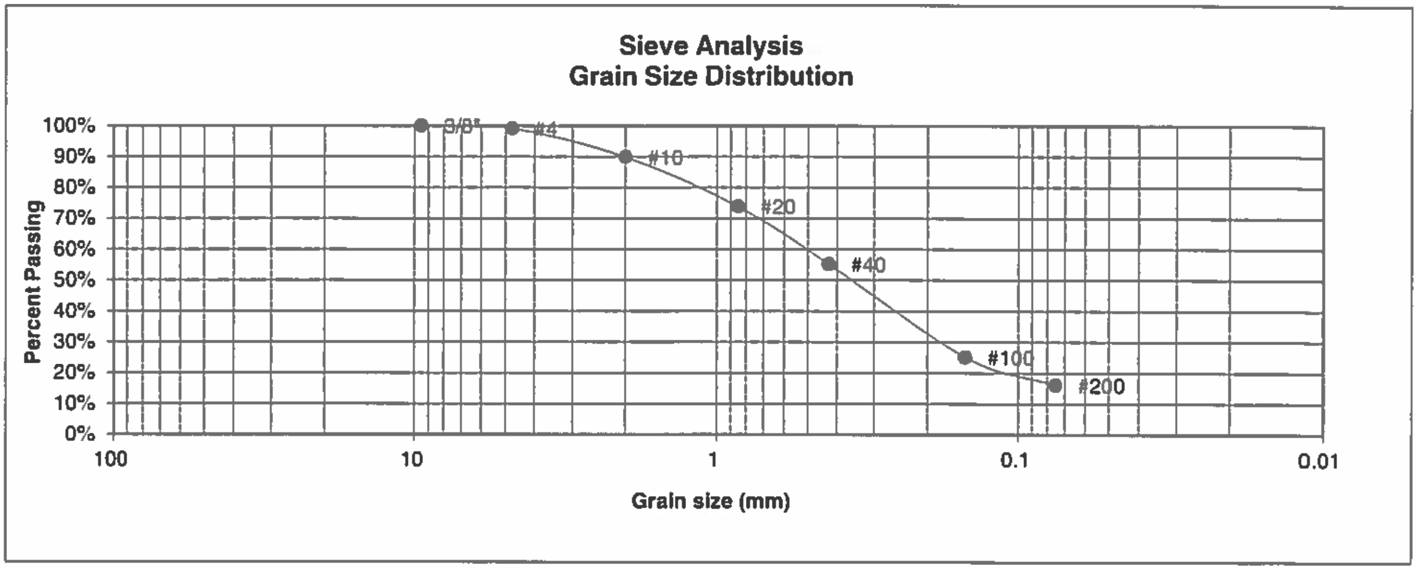
LABORATORY TEST RESULTS

DRAWN: | DATE: | CHECKED: LL | DATE: 6/30/20

JOB NO.: 201127

FIG NO.: B-11

UNIFIED CLASSIFICATION	SM	CLIENT	MA INFRASTRUCTURE
SOIL TYPE #	3	PROJECT	MONUMENT ACADEMY
TEST BORING #	2	JOB NO.	201127
DEPTH (FT)	10	TEST BY	BL
AASHTO CLASSIFICATION	A-2-5	GROUP INDEX	0



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	99.1%
10	89.9%
20	73.8%
40	55.2%
100	25.1%
200	16.1%

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)

ENTECH ENGINEERING, INC.

505 ELKTON DRIVE
COLORADO SPRINGS, COLORADO 80907

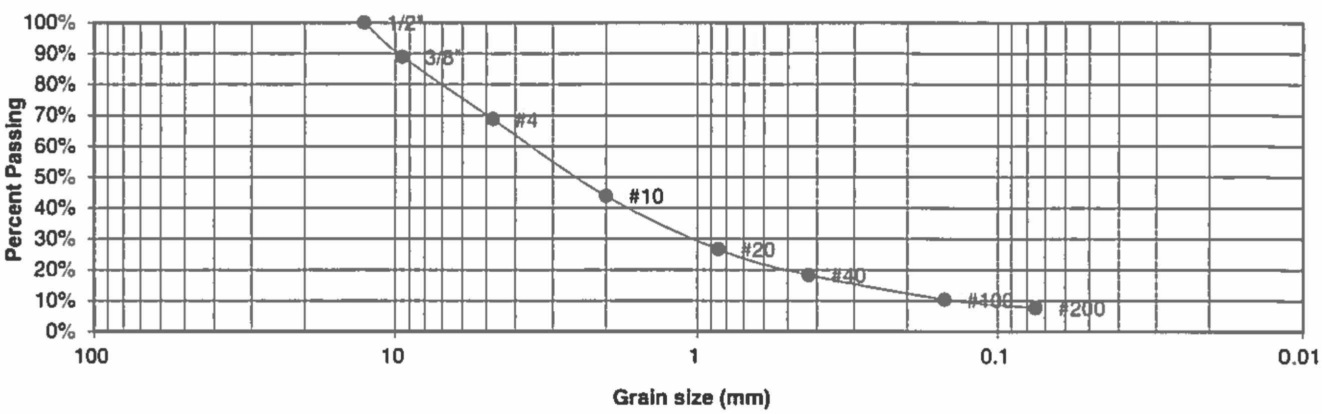
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED:	DATE:
		h	6/30/20

JOB NO.: 201127

FIG NO.: B-12

UNIFIED CLASSIFICATION	SM-SW	CLIENT	MA INFRASTRUCTURE
SOIL TYPE #	3	PROJECT	MONUMENT ACADEMY
TEST BORING #	8	JOB NO.	201127
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"	88.9%
4	68.7%
10	43.8%
20	26.6%
40	18.3%
100	10.4%
200	7.7%

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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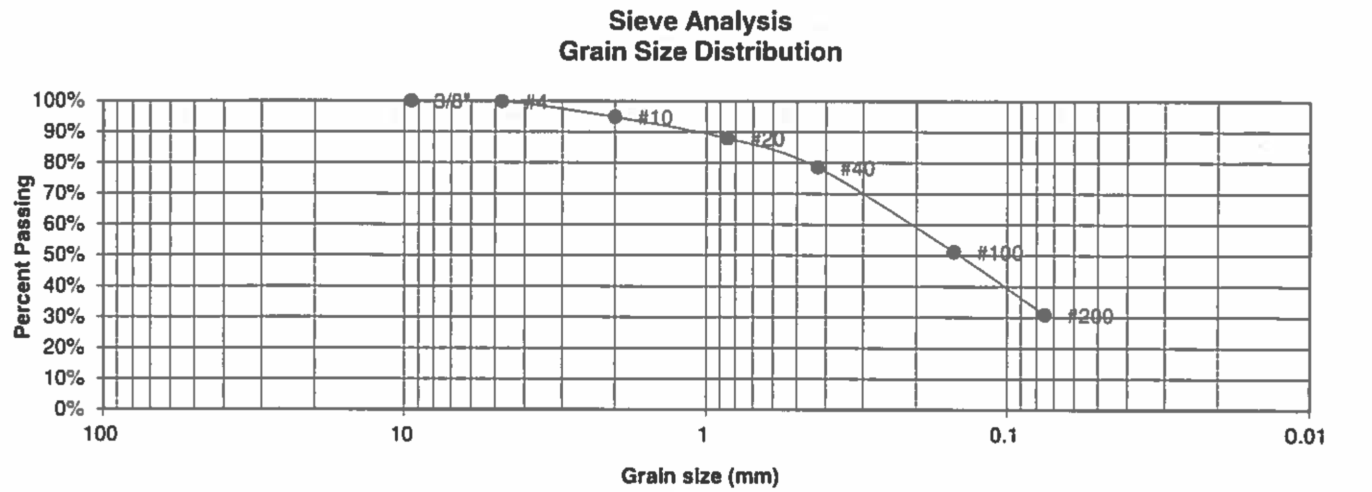
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED: [signature]	DATE: 6/30/20

JOB NO.: 201127

FIG NO.: B-13

UNIFIED CLASSIFICATION	SC	CLIENT	MA INFRASTRUCTURE
SOIL TYPE #	3	PROJECT	MONUMENT ACADEMY
TEST BORING #	10	JOB NO.	201127
DEPTH (FT)	1-2	TEST BY	BL
AASHTO CLASSIFICATION	A-2-6	GROUP INDEX	0



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	99.8%
10	94.8%
20	87.9%
40	78.5%
100	51.1%
200	30.8%

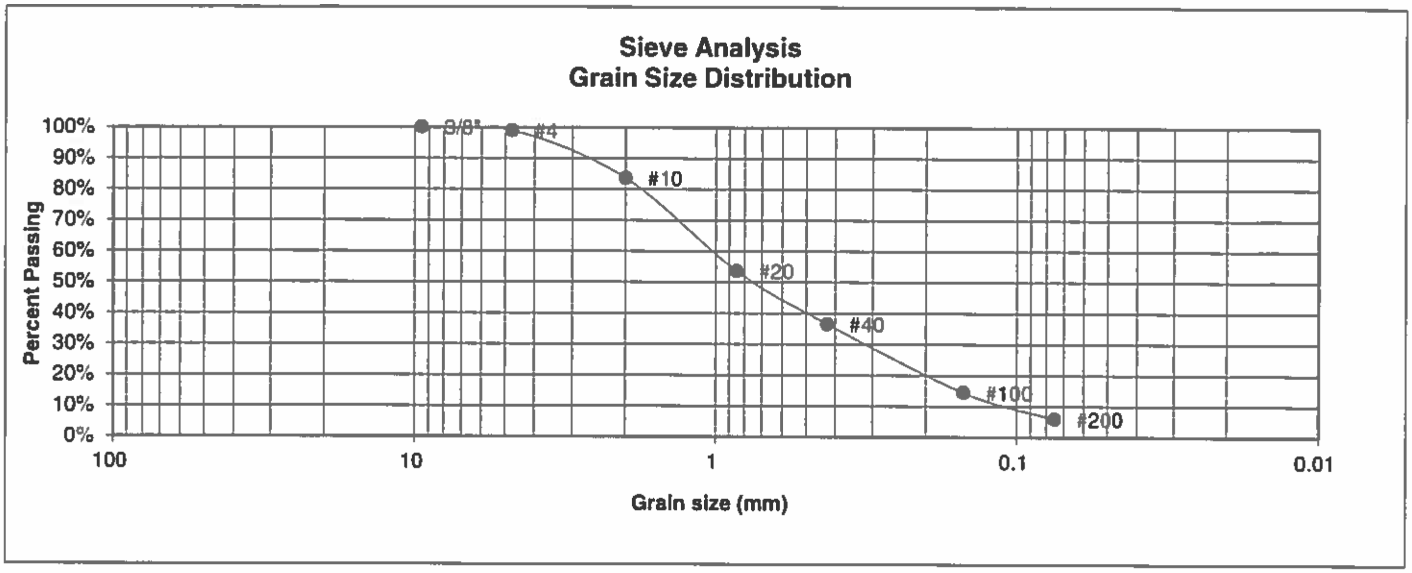
Atterberg Limits

Plastic Limit	18
Liquid Limit	30
Plastic Index	13

Swell

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

UNIFIED CLASSIFICATION	SM-SW	CLIENT	MA INFRASTRUCTURE
SOIL TYPE #	3	PROJECT	MONUMENT ACADEMY
TEST BORING #	10	JOB NO.	201127
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	99.0%
10	83.7%
20	53.6%
40	36.5%
100	14.5%
200	5.9%

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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505 ELKTON DRIVE
COLORADO SPRINGS, COLORADO 80907

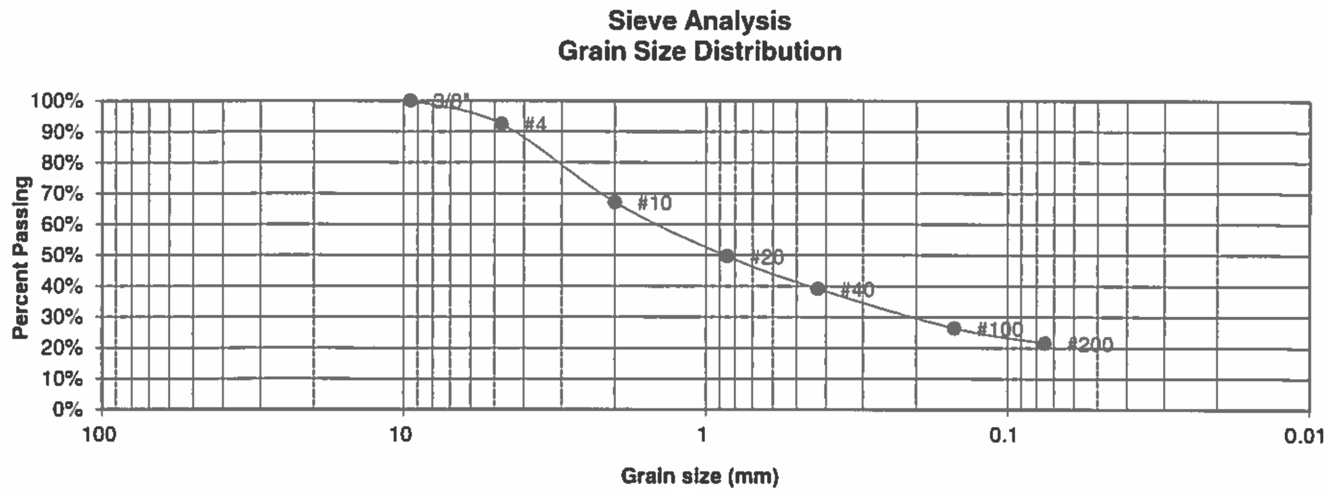
LABORATORY TEST RESULTS

DRAWN: | DATE: | CHECKED: lr | DATE: 6/30/20

JOB NO.: 201127

FIG NO.: B-15

UNIFIED CLASSIFICATION	SM	CLIENT	MA INFRASTRUCTURE
SOIL TYPE #	3	PROJECT	MONUMENT ACADEMY
TEST BORING #	3	JOB NO.	201127
DEPTH (FT)	0-3	TEST BY	BL
AASHTO CLASSIFICATION		GROUP INDEX	

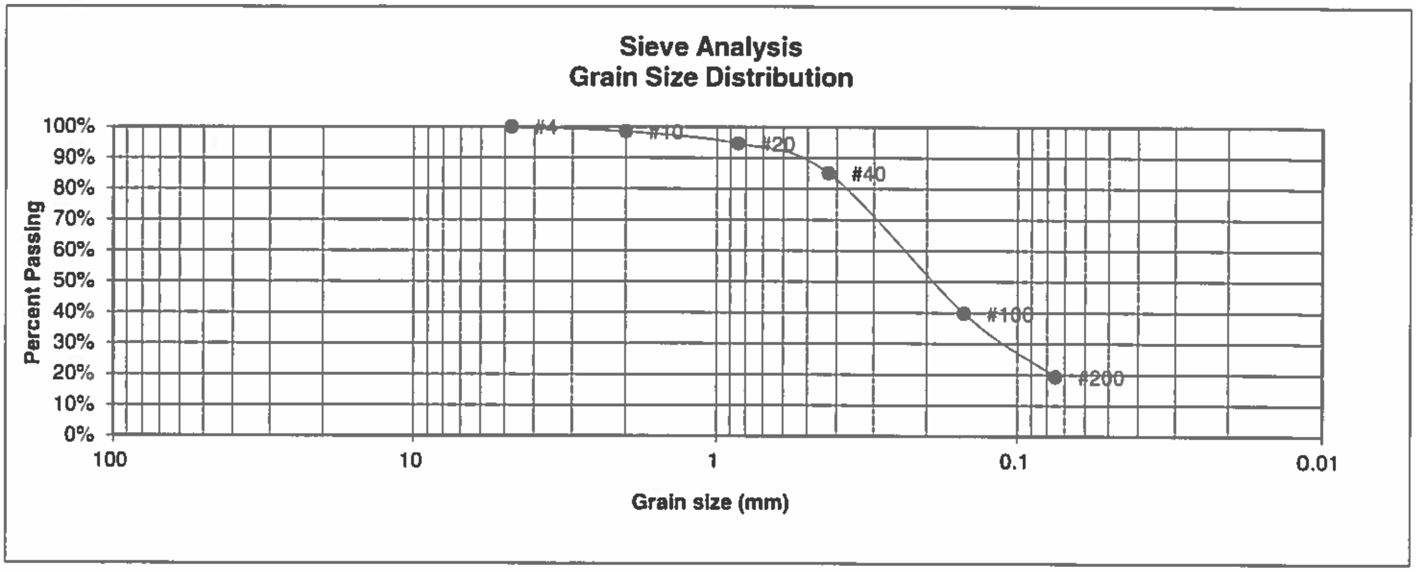


U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	92.5%
10	67.1%
20	49.6%
40	39.1%
100	26.4%
200	21.5%

Atterberg
Limits
Plastic Limit
Liquid Limit
Plastic Index

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

UNIFIED CLASSIFICATION	SM	CLIENT	MA INFRASTRUCTURE
SOIL TYPE #	4	PROJECT	MONUMENT ACADEMY
TEST BORING #	4	JOB NO.	201127
DEPTH (FT)	10	TEST BY	BL
AASHTO CLASSIFICATION	A-2-4	GROUP INDEX	0



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	
4	100.0%
10	98.5%
20	94.6%
40	85.1%
100	39.7%
200	19.3%

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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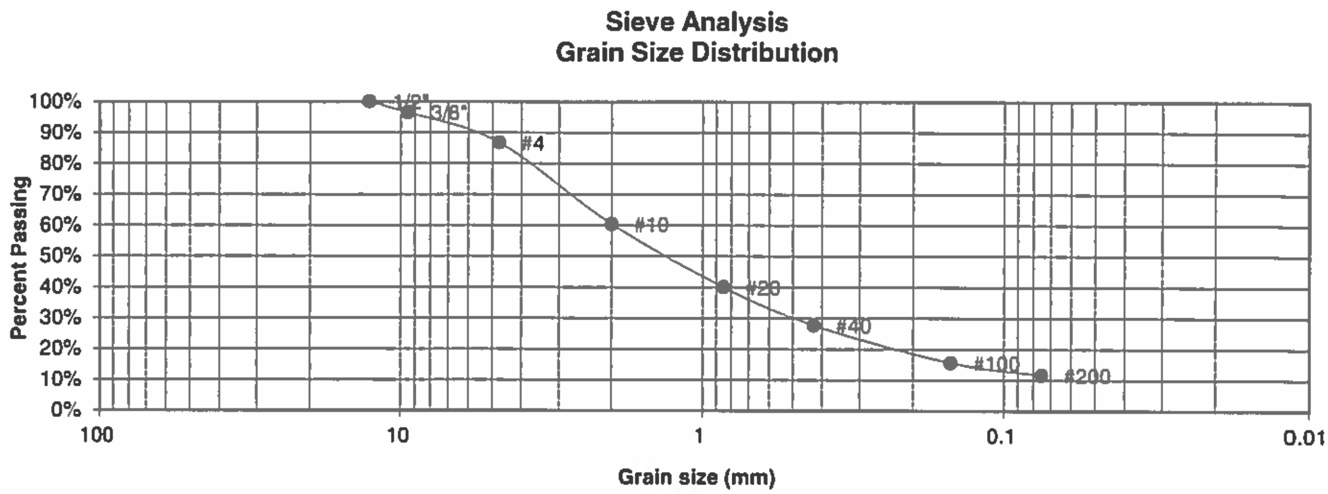
COLORADO SPRINGS, COLORADO 80907

LABORATORY TEST RESULTS

DRAWN: DATE: CHECKED: G DATE: 6/30/20

JOB NO.: 201127
FIG NO.: B-17

UNIFIED CLASSIFICATION	SM-SW	CLIENT	MA INFRASTRUCTURE
SOIL TYPE #	4	PROJECT	MONUMENT ACADEMY
TEST BORING #	9	JOB NO.	201127
DEPTH (FT)	5	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"	96.5%
4	86.7%
10	60.4%
20	40.0%
40	27.7%
100	15.5%
200	11.6%

Atterberg Limits

Plastic Limit	NP
Liquid Limit	NV
Plastic Index	NP

Swell

Moisture at start

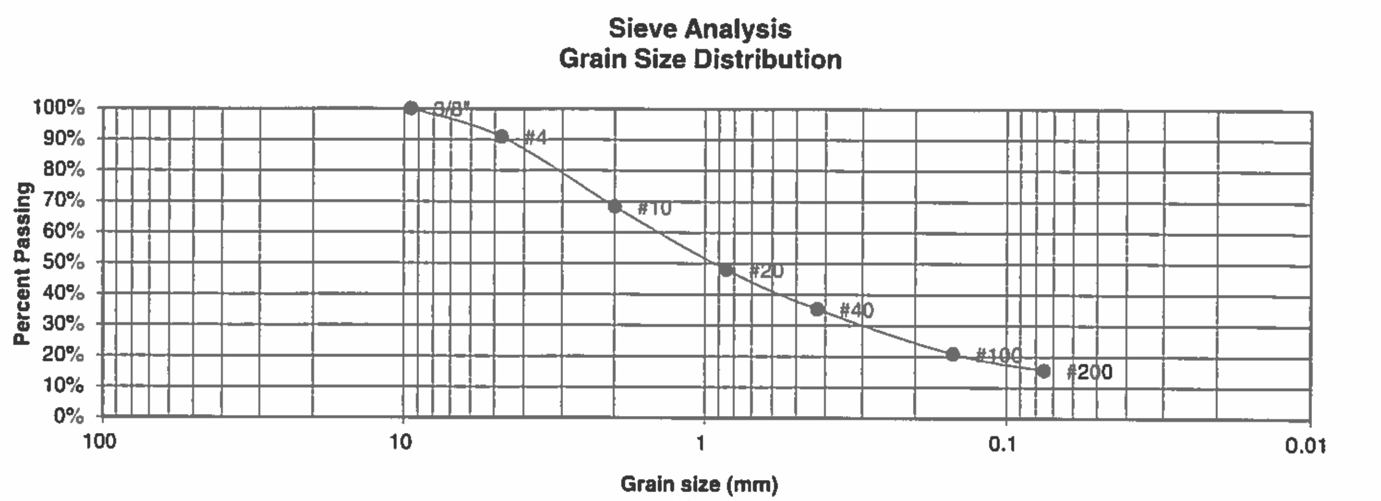
Moisture at finish

Moisture increase

Initial dry density (pcf)

Swell (psf)

UNIFIED CLASSIFICATION	SM	CLIENT	MA INFRASTRUCTURE
SOIL TYPE #	4	PROJECT	MONUMENT ACADEMY
TEST BORING #	8	JOB NO.	201127
DEPTH (FT)	5	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	90.9%
10	68.3%
20	48.0%
40	35.3%
100	20.9%
200	15.6%

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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505 ELKTON DRIVE
COLORADO SPRINGS, COLORADO 80907

LABORATORY TEST RESULTS

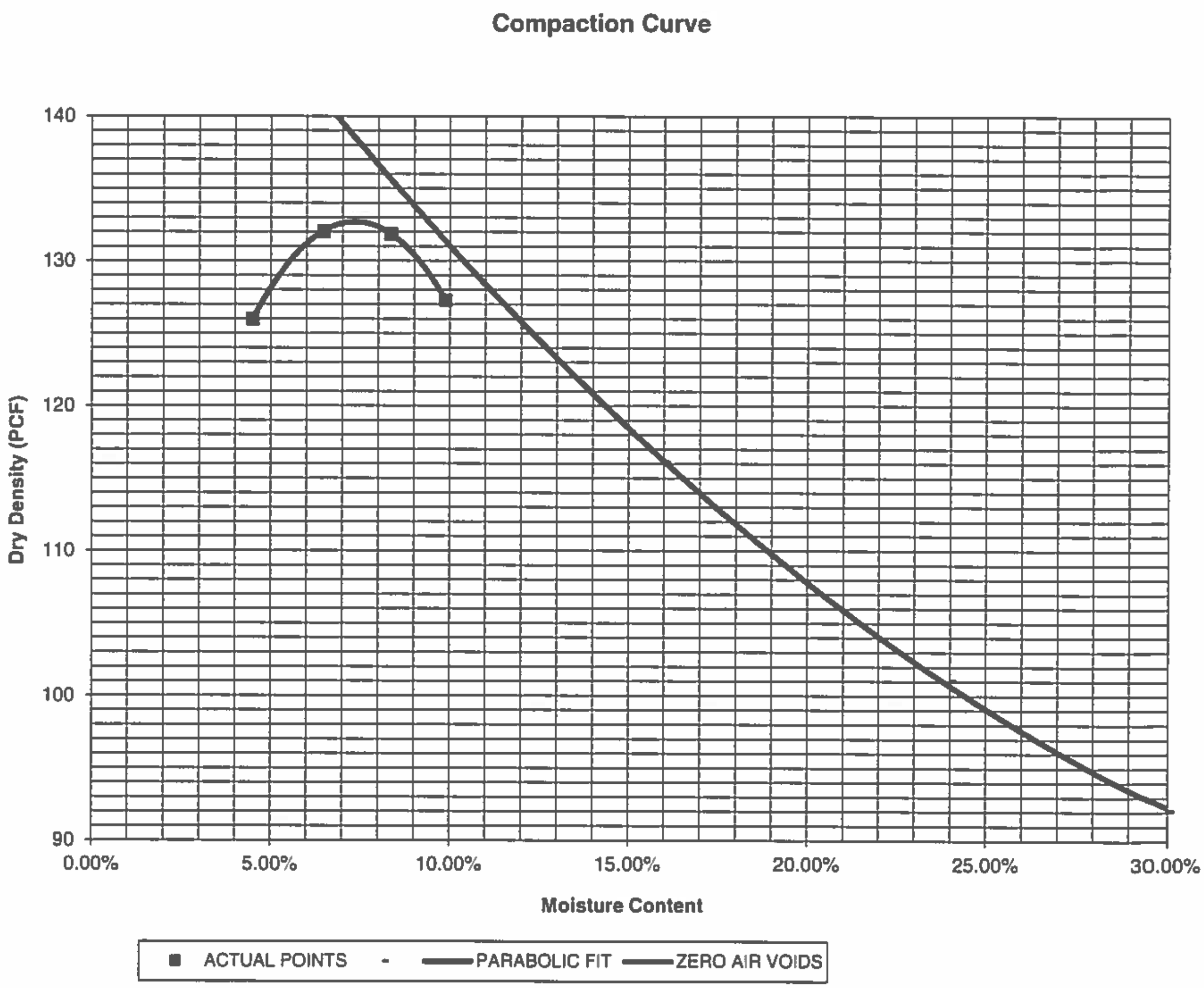
DRAWN: DATE: CHECKED: [signature] DATE: 6/30/20

JOB NO.: 201127

FIG NO.: B-19

PROJECT	MONUMENT ACADEMY	CLIENT	MA INFRASTRUCTURE
SAMPLE LOCATION	TB-2 @ 0-3'	JOB NO.	201127
SOIL DESCRIPTION	FILL, SAND, SILTY, BROWN	DATE	06/04/20

IDENTIFICATION	SM	COMPACTION TEST #	I
TEST DESIGNATION / METHOD	ASTM D-1557-A	TEST BY	KW
MAXIMUM DRY DENSITY (PCF)	132.9	OPTIMUM MOISTURE	7.3%



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505 ELKTON DRIVE
COLORADO SPRINGS, COLORADO 80907

MOISTURE DENSITY RELATION

DRAWN:	DATE:	CHECKED:	DATE:
		[signature]	6/30/20

JOB NO.: 201127

FIG NO.: B-20

CBR TEST LOAD DATA

JOB NO: 201127
CLIENT: MA INFRASTRUCTURE
PROJECT: MONUMENT ACADEMY
SOIL TYPE: 1

PISTON DIAMETER (cm)	PISTON AREA (in²)
4.958	2.99250919

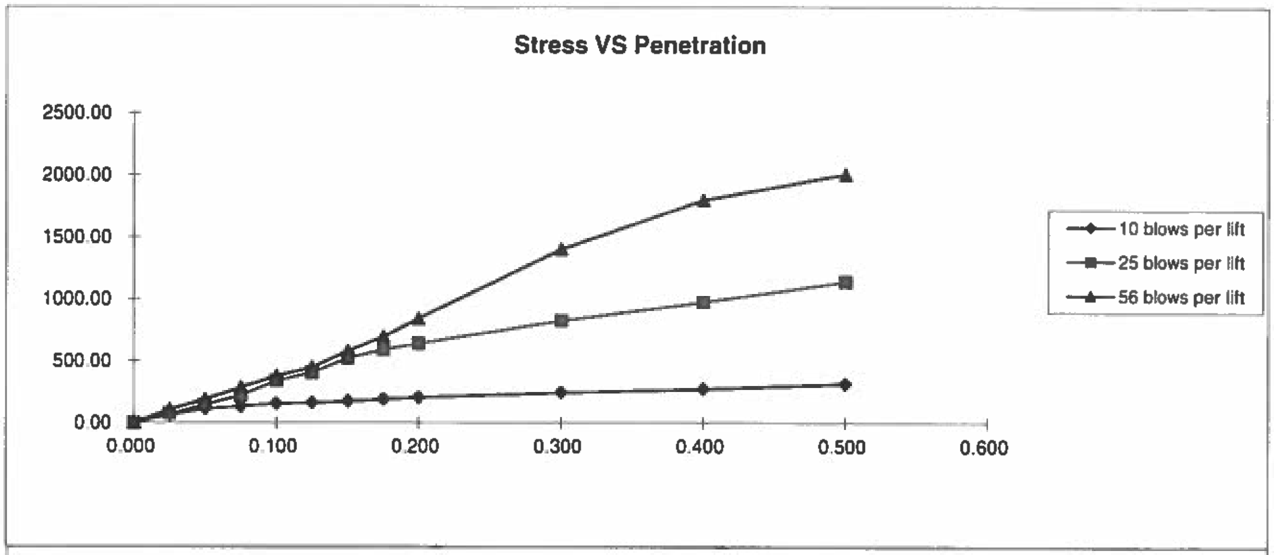
	10 BLOWS		25 BLOWS		56 BLOWS	
PENETRATION DEPTH (INCHES)	MOLD # 1 LOAD(LBS) (LBS)	STRESS (PSI)	MOLD # 2 LOAD(LBS) (LBS)	STRESS (PSI)	MOLD # 3 LOAD(LBS) (LBS)	STRESS (PSI)
0.000	0	0.00	0	0.00	0	0.00
0.025	194	64.83	224	74.85	324	108.27
0.050	341	113.95	444	148.37	568	189.81
0.075	396	132.33	660	220.55	858	286.72
0.100	460	153.72	1021	341.19	1135	379.28
0.125	479	160.07	1211	404.68	1338	447.12
0.150	519	173.43	1563	522.30	1733	579.11
0.175	562	187.80	1759	587.80	2078	694.40
0.200	607	202.84	1915	639.93	2515	840.43
0.300	725	242.27	2467	824.39	4191	1400.50
0.400	821	274.35	2915	974.10	5375	1796.15
0.500	941	314.45	3408	1138.84	6000	2005.01

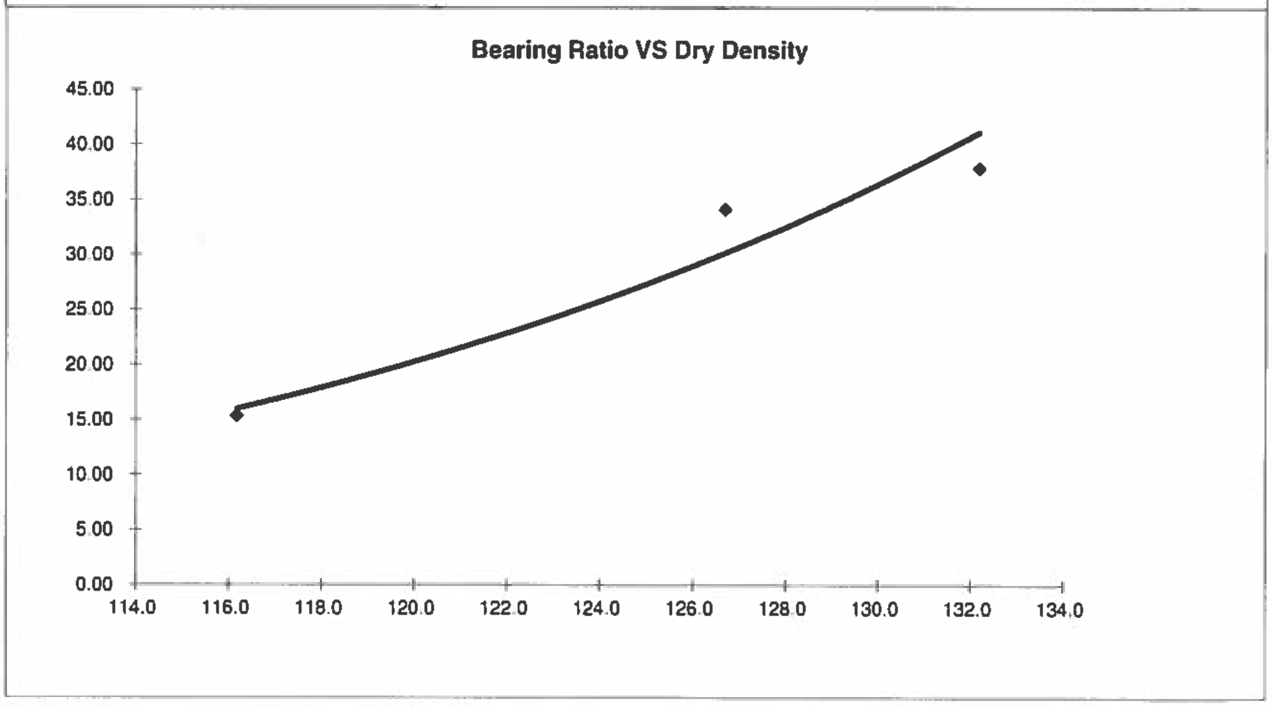
FINAL MOISTURE CONTENT

	MOLD # 1	MOLD # 2	MOLD # 3
CAN #	349	343	342
WT. CAN	8.43	8.49	8.49
WT. CAN+WET	280.95	287.65	359.15
WT. CAN+DRY	251.63	262.98	331.5
WT. H20	29.32	24.67	27.65
WT. DRY SOIL	243.2	254.49	323.01
MOISTURE CONTENT	12.06%	9.69%	8.56%
WET DENSITY (PCF)	124.7	135.9	141.8
DRY DENSITY (PCF)	116.2	126.7	132.2
BEARING RATIO	15.37	34.12	37.93

90% OF DRY DENSITY 119.6
95% OF DRY DENSITY 126.3

BEARING RATIO AT 90% OF MAX	21.48	- R VALUE	71
BEARING RATIO AT 95% OF MAX	33.33	- R VALUE	74





BEARING RATIO AT 90% OF MAX	21.48	~ R VALUE	71.00
BEARING RATIO AT 95% OF MAX	33.33	~ R VALUE	74.00

JOB NO: 201127
SOIL TYPE: 1

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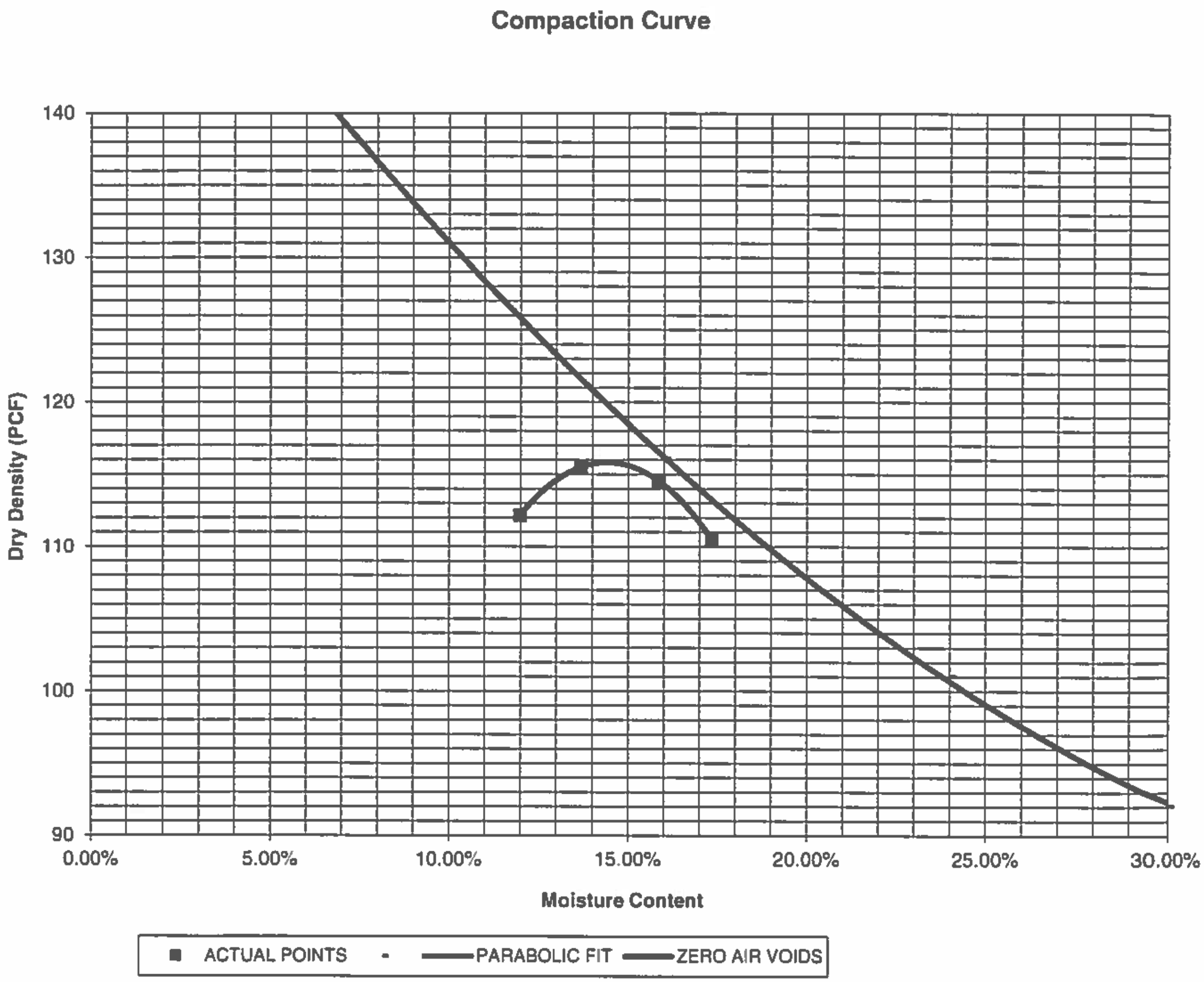
CALIFORNIA BEARING RATIO

DRAWN: | DATE: | CHECKED: h | DATE: 6/30/20

JOB NO.: 201127
FIG NO.: B-22

PROJECT	MONUMENT ACADEMY	CLIENT	MA INFRASTRUCTURE
SAMPLE LOCATION	TB-7 @ 0-3'	JOB NO.	201127
SOIL DESCRIPTION	FILL, SAND, V. CLAYEY, SILTY	DATE	06/19/20

IDENTIFICATION	SC-SM	COMPACTION TEST #	1
TEST DESIGNATION / METHOD	ASTM D-698-A	TEST BY	BL
MAXIMUM DRY DENSITY (PCF)	115.9	OPTIMUM MOISTURE	14.5%



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505 ELKTON DRIVE
COLORADO SPRINGS, COLORADO 80907

MOISTURE DENSITY RELATION

DRAWN:	DATE:	CHECKED:	DATE:
		h	6/30/20

JOB NO.: 201127

FIG NO.: B-23

CBR TEST LOAD DATA

JOB NO: 201127
CLIENT: MA INFRASTRUCTURE
PROJECT: MONUMENT ACADEMY
SOIL TYPE: 1

PISTON DIAMETER (cm)	PISTON AREA (in²)
4.958	2.99250919

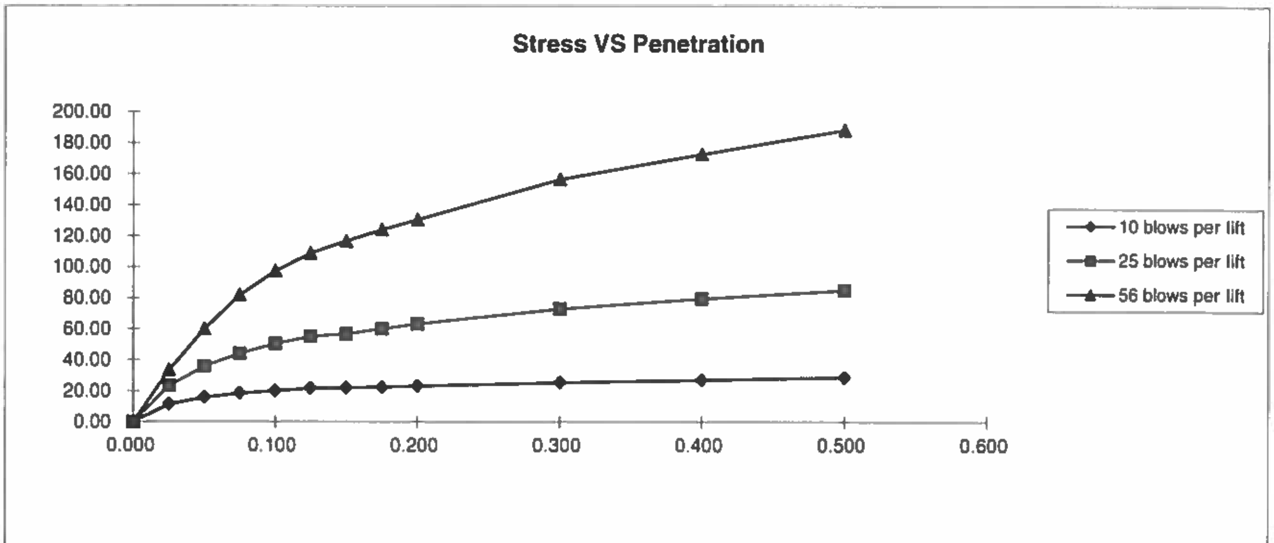
PENETRATION DEPTH (INCHES)	10 BLOWS MOLD # 1 LOAD(LBS) (LBS)	STRESS (PSI)	25 BLOWS MOLD # 2 LOAD(LBS) (LBS)	STRESS (PSI)	56 BLOWS MOLD # 3 LOAD(LBS) (LBS)	STRESS (PSI)
0.000	0	0.00	0	0.00	0	0.00
0.025	34	11.36	70	23.39	100	33.42
0.050	47	15.71	107	35.76	179	59.82
0.075	55	18.38	132	44.11	245	81.87
0.100	60	20.05	151	50.46	291	97.24
0.125	65	21.72	165	55.14	326	108.94
0.150	66	22.06	170	56.81	349	116.62
0.175	67	22.39	180	60.15	371	123.98
0.200	69	23.06	189	63.16	390	130.33
0.300	76	25.40	218	72.85	468	156.39
0.400	81	27.07	238	79.53	517	172.76
0.500	86	28.74	254	84.88	563	188.14

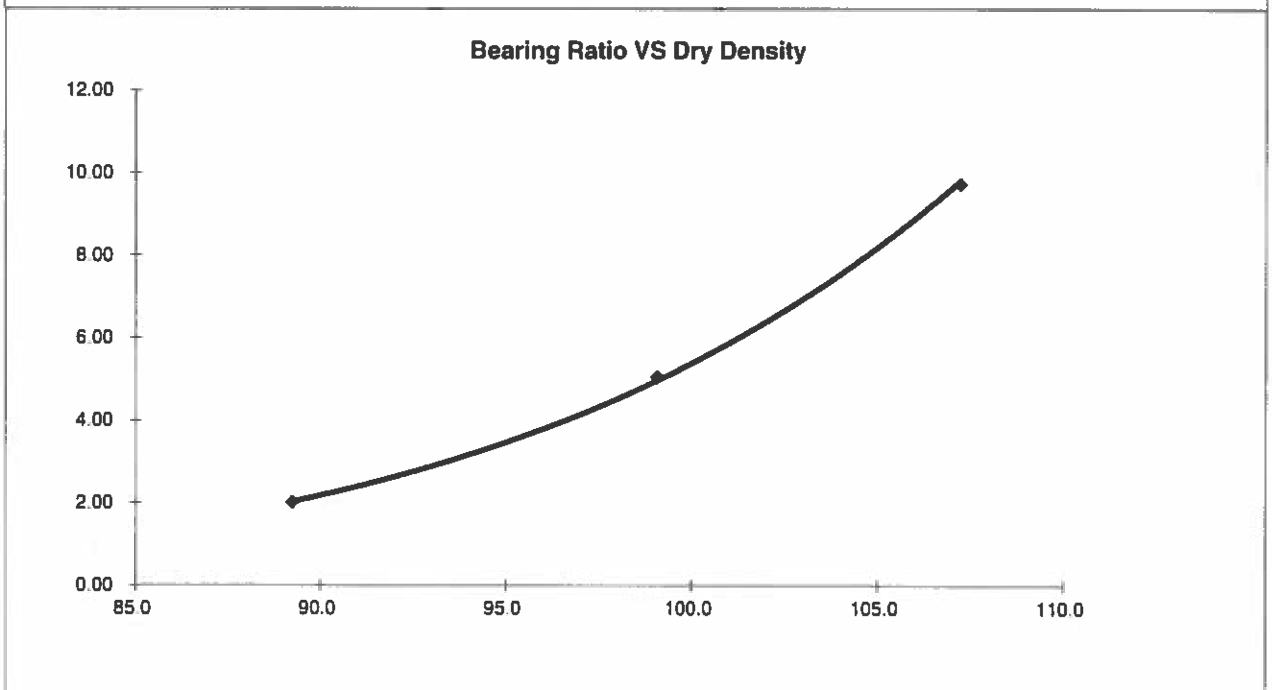
FINAL MOISTURE CONTENT

	MOLD # 1	MOLD # 2	MOLD # 3
CAN #	102	119	109
WT. CAN	9.32	9.11	9.21
WT. CAN+WET	290.23	290.77	247.92
WT. CAN+DRY	231.23	238.34	207.74
WT. H20	59	52.43	40.18
WT. DRY SOIL	221.91	229.23	198.53
MOISTURE CONTENT	26.59%	22.87%	20.24%
WET DENSITY (PCF)	102.2	113.4	122.8
DRY DENSITY (PCF)	89.2	99.1	107.2
BEARING RATIO	2.01	5.05	9.72

90% OF DRY DENSITY 104.3
95% OF DRY DENSITY 110.1

BEARING RATIO AT 90% OF MAX	8.05	~ R VALUE	22
BEARING RATIO AT 95% OF MAX	11.37	~ R VALUE	35





BEARING RATIO AT 90% OF MAX	8.05	~ R VALUE	22.00
BEARING RATIO AT 95% OF MAX	11.37	~ R VALUE	35.00

JOB NO: 201127
SOIL TYPE: 1

ENTECH ENGINEERING, INC.
505 ELKTON DRIVE
COLORADO SPRINGS, COLORADO 80907

CALIFORNIA BEARING RATIO

DRAWN: DATE: CHECKED: h DATE: 6/30/20

JOB NO.: 201127
FIG NO.: B-25

CLIENT	MA INFRASTRUCTURE	JOB NO.	201127
PROJECT	MONUMENT ACADEMY	DATE	6/10/2020
LOCATION	MONUMENT ACADEMY	TEST BY	BL

BORING NUMBER	DEPTH, (ft)	SOIL TYPE NUMBER	UNIFIED CLASSIFICATION	WATER SOLUBLE SULFATE, (wt%)
TB-2	1-2	1	SM	<0.01
TB-2	10	3	SM	<0.01
TB-4	10	4	SM-SW	<0.01
TB-6	1-2	1	SM	0.00
TB-9	5	4	SM-SW	<0.01
TB-10	1-2	3	SC	0.00
TB-10	10	3	SM-SW	0.00

QC BLANK PASS

ENTECH ENGINEERING, INC.
505 ELKTON DRIVE
COLORADO SPRINGS, COLORADO 80907

LABORATORY TEST SULFATE RESULTS

DRAWN: DATE: CHECKED: *LL* DATE: *6/30/20*

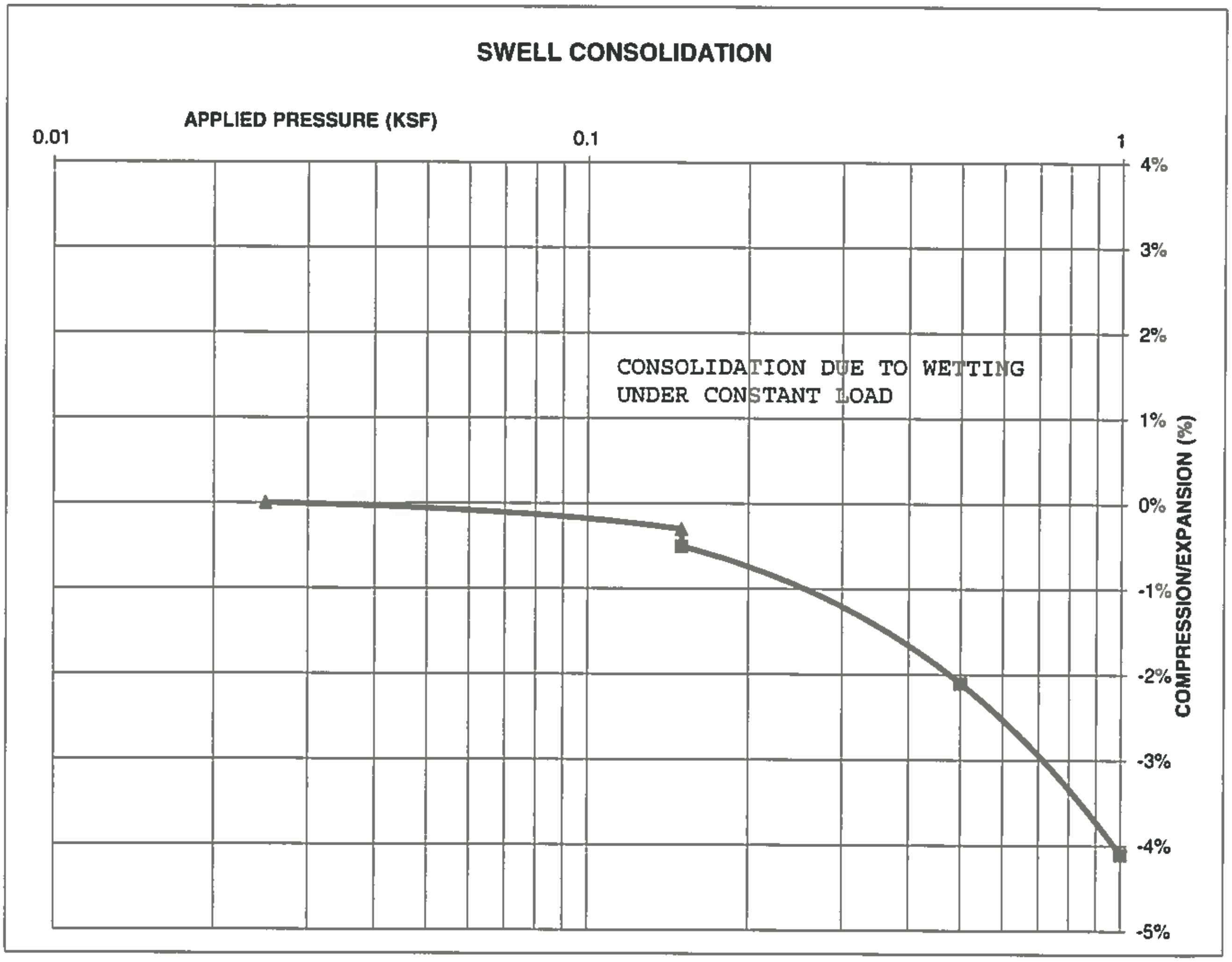
JOB NO.: 201127

FIG NO.: *B-26*

CONSOLIDATION TEST RESULTS

TEST BORING #	1	DEPTH(ft)	1-2
DESCRIPTION	SC-SM	SOIL TYPE	2
NATURAL UNIT DRY WEIGHT (PCF)			110
NATURAL MOISTURE CONTENT			5.0%
SWELL/CONSOLIDATION (%)			-0.2%

JOB NO. 201127
CLIENT MA INFRASTRUCTURE
PROJECT MONUMENT ACADEMY



ENTECH
ENGINEERING, INC.
505 ELKTON DRIVE
COLORADO SPRINGS, COLORADO 80907

SWELL CONSOLIDATION
TEST RESULTS

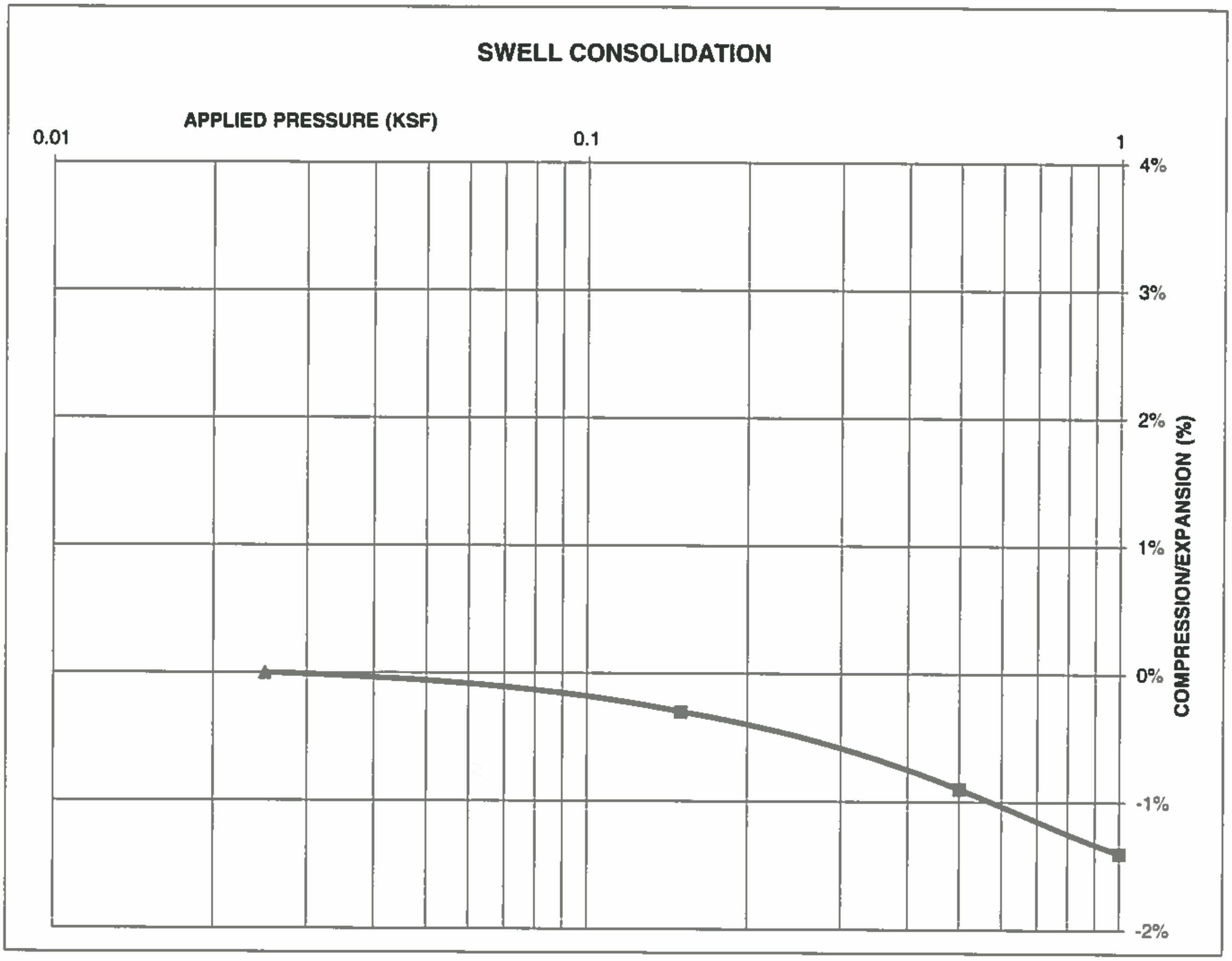
DRAWN:	DATE:	CHECKED:	DATE:
		DS	7/6/20

JOB NO.: 201127
FIG NO.: B-27

CONSOLIDATION TEST RESULTS

TEST BORING #	7	DEPTH(ft)	1-2
DESCRIPTION	SC	SOIL TYPE	2
NATURAL UNIT DRY WEIGHT (PCF)			111
NATURAL MOISTURE CONTENT			7.5%
SWELL/CONSOLIDATION (%)			0.0%

JOB NO. 201127
CLIENT MA INFRASTRUCTURE
PROJECT MONUMENT ACADEMY



ENTECH ENGINEERING, INC.
505 ELKTON DRIVE
COLORADO SPRINGS, COLORADO 80907

SWELL CONSOLIDATION
TEST RESULTS

DRAWN:	DATE:	CHECKED:	DATE:
		JB	7/6/2

JOB NO.: 201127
FIG NO.: B-28

APPENDIX C: Pavement Design Calculations

DESIGN CALCULATIONS

DESIGN DATA

MA Infastructure - Monument Academy
Jane Lundeen Drive - Urban Residential Collector
Soil Type 1

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL = 1,079,500
Hveem Stabilometer (R Value) Results:	R = 50
Weighted Structural Number (WSN):	WSN = 2.62

DESIGN EQUATION

$WSN = C_1D_1 + C_2D_2$

$C_1 =$ 0.44 Strength Coefficient - Hot Bituminous Asphalt
$C_2 =$ 0.12 Strength Coefficient - Cement Stabilized Subgrade

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

FOR ASPHALT + CEMENT STABILIZED BASE COURSE SECTION

Asphalt Thickness (t) = 4 inches
$D_2 = ((WSN) - (t)(C_1))/C_2 =$ 7.2 inches of Cement Stabilized Subgrade
CSS, use 8.0 inches

RECOMMENDED ALTERNATIVE

1. 4.0 inches of Asphalt + 8.0 inches of Cement Stabilized Subgrade

5

Job No. 201127
Fig. No. C-1

FLEXIBLE PAVEMENT DESIGN

DESIGN DATA

MA Infastructure - Monument Academy
Jane Lundeen Drive - Urban Residential Collector
Soil Type 1

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL (W_{18}) =	1,079,500
Hveem Stabilometer (R Value) Results:	R =	50
Standard Deviation	S_o =	0.45
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 = 2.62

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
6.03	6.03	0.0

Job No. 201127
Fig. No. C-2

DESIGN CALCULATIONS

DESIGN DATA

MA Infastructure - Monument Academy
Pinehurst Circle - Urban Residential Collector
Soil Type 1

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL =	821,000
Hveem Stabilometer (R Value) Results:	R =	50
Weighted Structural Number (WSN):	WSN =	2.52

DESIGN EQUATION

$$WSN = C_1D_1 + C_2D_2$$

C_1 = 0.44 Strength Coefficient - Hot Bituminous Asphalt
C_2 = 0.12 Strength Coefficient - Cement Stabilized Subgrade

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

FOR ASPHALT + CEMENT STABILIZED BASE COURSE SECTION

Asphalt Thickness (t) = 4 inches
$D_2 = ((WSN) - (t)(C_1))/C_2 =$ 6.3 inches of Cement Stabilized Subgrade
CSS, use 8.0 inches

RECOMMENDED ALTERNATIVE

1. 4.0 inches of Asphalt + 8.0 inches of Cement Stabilized Subgrade

Job No. 201127
Fig. No. C-3

FLEXIBLE PAVEMENT DESIGN

DESIGN DATA MA Infastructure - Monument Academy
Pinehurst Circle - Urban Residential Collector
Soil Type 1

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL (W_{18}) =	821,000
Hveem Stabilometer (R Value) Results:	R =	50
Standard Deviation	S_o =	0.45
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 = 2.52

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)
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
5.91	5.91	0.0

Job No. 201127
Fig. No. C-4

DESIGN CALCULATIONS

DESIGN DATA MA Infastructure - Monument Academy
Pinehurst Circle - Urban - Residential Collector
Soil Type 2

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL = 821,000
Hveem Stabilometer (R Value) Results:	R = 35
Weighted Structural Number (WSN):	WSN = 2.98

DESIGN EQUATION

$$WSN = C_1D_1 + C_2D_2$$

C_1 = 0.44 Strength Coefficient - Hot Bituminous Asphalt
C_2 = 0.12 Strength Coefficient - Cement Stabilized Subgrade

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

FOR ASPHALT + CEMENT STABILIZED BASE COURSE SECTION

Asphalt Thickness (t) = 4 inches
$D_2 = ((WSN) - (t)(C_1))/C_2 =$ 10.2 inches of Cement Stabilized Subgrade
CSS, use 10.0 inches

RECOMMENDED ALTERNATIVE

1. 4.0 inches of Asphalt + 10.0 inches of Cement Stabilized Subgrade

Job No. 201127
Fig. No. C-5

FLEXIBLE PAVEMENT DESIGN

DESIGN DATA

MA Infastructure - Monument Academy
Pinehurst Circle - Urban - Residential Collector
Soil Type 2

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL (W_{18}) =	821,000
Hveem Stabilometer (R Value) Results:	R =	35
Standard Deviation	S_o =	0.45
Loss in Serviceability	Δpsi =	2.5
Reliability	Reliability =	85
Reliability (z-statistic)	Z_R =	-1.04
Soil Resilient Modulus	M_R =	8065

Weighted Structural Number (WSN): → WSN = 2.98

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
5.91	5.91	0.0

Job No. 201127
Fig. No. C- 6

DESIGN CALCULATIONS

DESIGN DATA

MA Infastructure - Monument Academy
Walker Road - Minor Arterial
Soil Type 1

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL = 1,971,000
Hveem Stabilometer (R Value) Results:	R = 50
Weighted Structural Number (WSN):	WSN = 2.87

DESIGN EQUATION

$WSN = C_1D_1 + C_2D_2$

$C_1 =$ 0.44 Strength Coefficient - Hot Bituminous Asphalt
$C_2 =$ 0.12 Strength Coefficient - Cement Stabilized Subgrade

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

FOR ASPHALT + CEMENT STABILIZED BASE COURSE SECTION

Asphalt Thickness (t) = 5 inches
$D_2 = ((WSN) - (t)(C_1))/C_2 =$ 5.6 inches of Cement Stabilized Subgrade
CSS, use 10.0 inches

RECOMMENDED ALTERNATIVE

1. 5.0 inches of Asphalt + 10.0 inches of Cement Stabilized Subgrade

Job No. 201127
Fig. No. C-7

FLEXIBLE PAVEMENT DESIGN

DESIGN DATA — MA Infastructure - Monument Academy
Walker Road - Minor Arterial
Soil Type 1

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL (W_{18}) =	1,971,000
Hveem Stabilometer (R Value) Results:	R =	50
Standard Deviation	S_o =	0.45
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 = 2.87

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
6.29	6.29	0.0

Job No. 201127
Fig. No. C-8

DESIGN CALCULATIONS

DESIGN DATA MA Infastructure - Monument Academy
Walker Road - Minor Arterial
Soil Type 2

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL = 1,971,000
Hveem Stabilometer (R Value) Results:	R = 35
Weighted Structural Number (WSN):	WSN = 3.38

DESIGN EQUATION

$$WSN = C_1D_1 + C_2D_2$$

C_1 = 0.44 Strength Coefficient - Hot Bituminous Asphalt
C_2 = 0.12 Strength Coefficient - Cement Stabilized Subgrade

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

FOR ASPHALT + CEMENT STABILIZED BASE COURSE SECTION

Asphalt Thickness (t) = 5 inches
$D_2 = ((WSN) - (t)(C_1))/C_2 =$ 9.9 inches of Cement Stabilized Subgrade
CSS, use 10.0 inches

RECOMMENDED ALTERNATIVE

1. 5.0 inches of Asphalt + 10.0 inches of Cement Stabilized Subgrade

Job No. 201127
Fig. No. C-9

FLEXIBLE PAVEMENT DESIGN

DESIGN DATA

MA Infastructure - Monument Academy
Walker Road - Minor Arterial
Soil Type 2

Equivalent (18 kip) Single Axle Load Applications (ESAL):	ESAL (W_{18}) =	1,971,000
Hveem Stabilometer (R Value) Results:	R =	35
Standard Deviation	S_o =	0.45
Loss in Serviceability	Δpsi =	2.5
Reliability	Reliability =	85
Reliability (z-statistic)	Z_R =	-1.04
Soil Resilient Modulus	M_R =	8065

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)
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
6.29	6.29	0.0

Job No. 201127
Fig. No. C-10