PURPOSE:

- Provide standard and heavy-duty pavement design for flexible (bituminous) pavement

ASSUMPTIONS:

Design Life: 20 years
Design Standards:

- 592 Daily Trips (Traffic Impact and Access Study, revised January 2022; excerpt attached)
  - 68 Trucks and 524 Cars

- Standard Duty
  - 30 Trucks (assume 5%) (with Trailer)/day (5-axle truck ESAL Factor = 2.3719)
  - 562 Passenger Cars/day (Car ESAL Factor = 0.0008)

- Heavy Duty
  - 68 Trucks (with Trailer)/day (5-axle truck ESAL Factor = 2.3719)
  - 524 Passenger Cars/day (Car ESAL Factor = 0.0008)

CBR: 10 (estimated based on a sandy subgrade; subgrade soil laboratory results attached)

Design Serviceability Loss, ΔP= 2.2 [Initial Serviceability (4.2) - Terminal Serviceability (2.0)]
Reliability = 85%

METHOD:

Design using AASHTO design standards (AASHTO Design of Pavement – 1993)

CALCULATION:

FLEXIBLE PAVEMENT:

Standard Duty

ESALs

$$ESAL = \sum_{i=1}^{n} (vehical\ load)(pavement\ life)(ESAL\ Factor)$$

$$ESAL = \left(562\ \frac{car}{day} \times 365 \frac{day}{yr} \times 20\ yr \times 0.0008\right) + \left(30\ \frac{trailers}{day} \times 365 \frac{day}{yr} \times 20\ yr \times 2.3719\right)$$

$$ESAL = 0.52\ million\ ESALs = w_{18,Standard}$$

Initial assumption of 3.0-inches of asphalt (1.5-inch wearing, 1.5-inch binder) over 12-inch base course.

Pavement Structural Numbers
From Table 75.10

Wearing Course = 0.44/in $SN_1 = 0.44 \frac{1}{in} \times 1.5\ in = 0.66$

Binder Course = 0.34/in $SN_2 = 0.34 \frac{1}{in} \times 1.5\ in = 0.51$

Base Coarse = 0.11/in $SN_3 = 0.11 \frac{1}{in} \times 12\ in = 1.32$

$$\sum SN = 2.49$$

Resilient Modulus
$M_R = 1500(CBR)$ [AASHTO Guide Eq. 1.5.1] (Equation 75.27)
$M_R = 1500(10) = 15{,}000\ psi = 15ksi$

Determined required structural number for standard duty based on Figure 75.9 AASHTO Nomograph for flexible Pavement Design (See attached)

$$SN_{REQ} = 2.35$$

$SN(2.49) > SN_{REQ}(2.35)$, therefore, initial assumption of 3.0-inches of asphalt (1.5-inch wearing, 1.5-inch binder) over 12-inch base course is sufficient.

Heavy Duty

ESALs

$$ESAL = \sum_{i=1}^{n} (vehical\ load)(pavement\ life)(ESAL\ Factor)$$

$$ESAL = \left(524\ \frac{car}{day} \times 365 \frac{day}{yr} \times 20\ yr \times 0.0008\right) + \left(68\ \frac{trailers}{day} \times 365 \frac{day}{yr} \times 20\ yr \times 2.3719\right)$$

$$ESAL = 1.18\ million\ ESALs = w_{18,Heavy}$$

Initial assumption of 4.0-inches of asphalt (1.5-inch wearing, 2.5-inch binder) over 12-inch base course.

Pavement Structural Numbers
From Table 75.10

Wearing Course = 0.44/in $SN_1 = 0.44 \frac{1}{in} \times 1.5\ in = 0.66$

Binder Course = 0.34/in $SN_2 = 0.34 \frac{1}{in} \times 2.5\ in = 0.85$

Recycled Subbase Layer = 0.11/in $SN_3 = 0.11 \frac{1}{in} \times 12\ in = 1.32$

$$\sum SN = 2.83$$

Resilient Modulus
$M_R = 1500(CBR)$ [AASHTO Guide Eq. 1.5.1] (Equation 75.27)
$M_R = 1500(10) = 15{,}000\ psi = 15ksi$

Determined required structural number for standard duty based on Figure 75.9 AASHTO Nomograph for flexible Pavement Design (See attached)

$$SN_{REQ} = 2.6$$

$SN(2.83) > SN_{REQ}(2.6)$, therefore, initial assumption of 4.0-inches of asphalt (1.5-inch wearing, 2.5-inch binder) over 12-inch base course is sufficient.

RESULTS:

	Flexible
Standard Duty	3.0-inches Asphalt
	12-inches Base Course
Heavy Duty	4.0-inches Asphalt
	12-inches Base Course

REFERENCES:

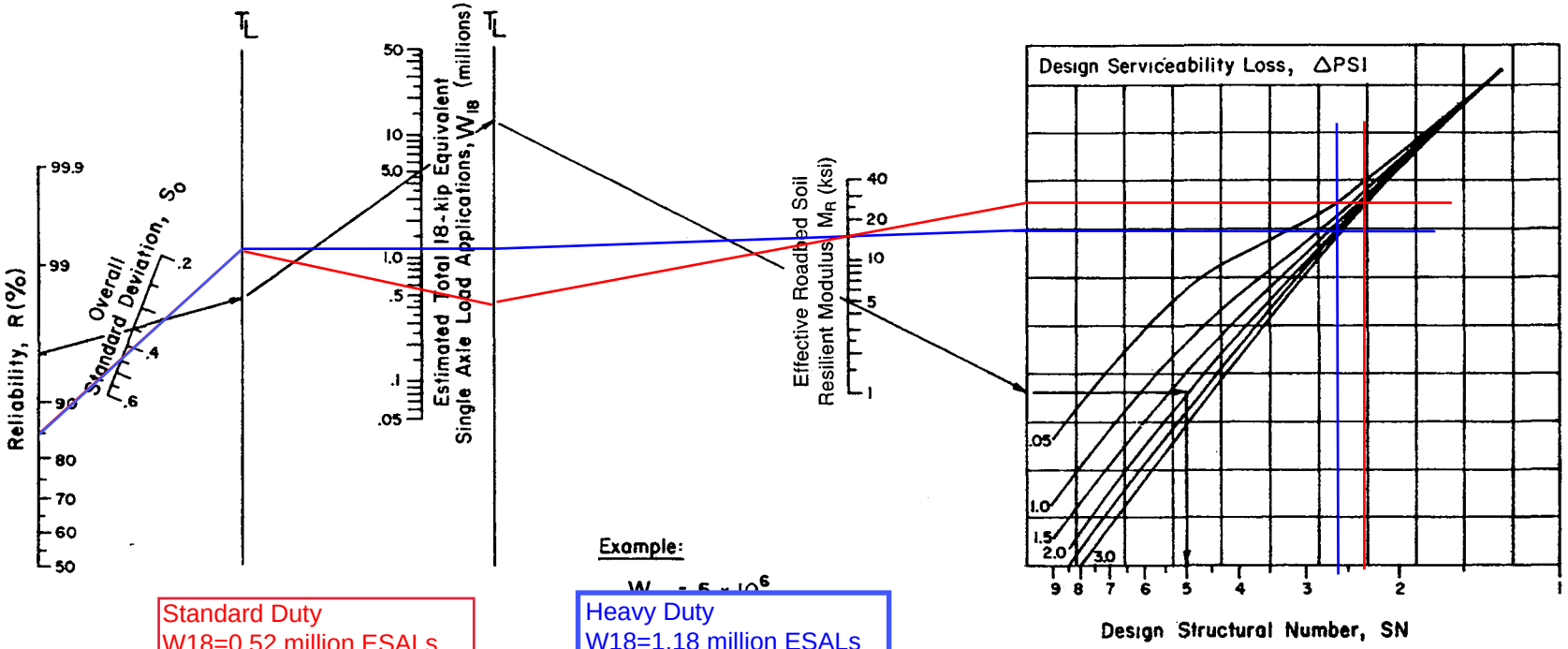
AASHTO (1993) AASHTO Guide for Design of Pavement Structures, American Association of State Highway and Transportation Officials, Washington, D.C.

Traffic Impact and Access Study, 16 Bulge Road Proposed Development, Devens, Massachusetts, prepared by Vanasse Hangen Brustlin, Inc., dated April 2021 – revised January 2022

AASHTO Nomograph for Flexible Pavement Design
Project: Devens
Project #: 4864.00
Performed by: J. McCarthy Date: 2/18/2022
Checked by: L. Norton Date: 2/18/2022

NOMOGRAPH SOLVES:

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



Standard Duty
W18=0.52 million ESALs
R=85%
S0=0.45
Mr= 15 ksi
Delta PSI=2.2
SN=2.35

Heavy Duty
W18=1.18 million ESALs
R=85%
S0=0.45
Mr= 15 ksi
Delta PSI=2.2
SN=2.6

Figure 3.1. Design Chart for Flexible Pavements Based on Using Mean Values for Each Input

TRAFFIC IMPACT AND ACCESS STUDY

16 Bulge Road Proposed Development

Devens, Massachusetts

PREPARED FOR

Scannell Properties
8801 River Crossing Road
Suite 300
Indianapolis, IN 46240

PREPARED BY

101 Walnut Street
PO Box 9151
Watertown, MA 02471
617.924.1770

April 2021 – revised January 2022

Trip Generation

The rate at which any development generates traffic is dependent upon a number of factors such as size, location and concentration of surrounding developments. As previously stated, the proposed development consists of a 150,843 square foot manufacturing building. The number of vehicle-trips to be generated by the proposed Project was estimated based on trip generation rates published by the Institute of Transportation Engineers (ITE)[5]. ITE land use code 140 (manufacturing) was determined to be the most appropriate land use code for this development.

Table 3 summarizes the projected trip generation associated with the proposed Project based on the standardized ITE rates. The trip generation worksheet is included in the Appendix to this report.

Table 3 Trip Generation Summary

Time Period	Movement	Site-Generated Vehicle Trips [a]
Weekday Daily [b]	Enter	296
	Exit	296
	Total	592
Weekday Morning Peak Period [c]	Enter	72
	Exit	22
	Total	94
Weekday Evening Peak Period [c]	Enter	31
	Exit	70
	Total	101

a Based on ITE land use code 140 (manufacturing) for 150,843 sf
b vehicles per day
c vehicles per hour

As shown in Table 3, the Project is expected to generate approximately 592 new vehicle trips (296 entering/296 exiting) on a typical weekday, with 94 new vehicle trips (72 entering/22 exiting) during the weekday morning peak hour and 101 new vehicle trips (31 entering/70 exiting) during the weekday evening peak hour.

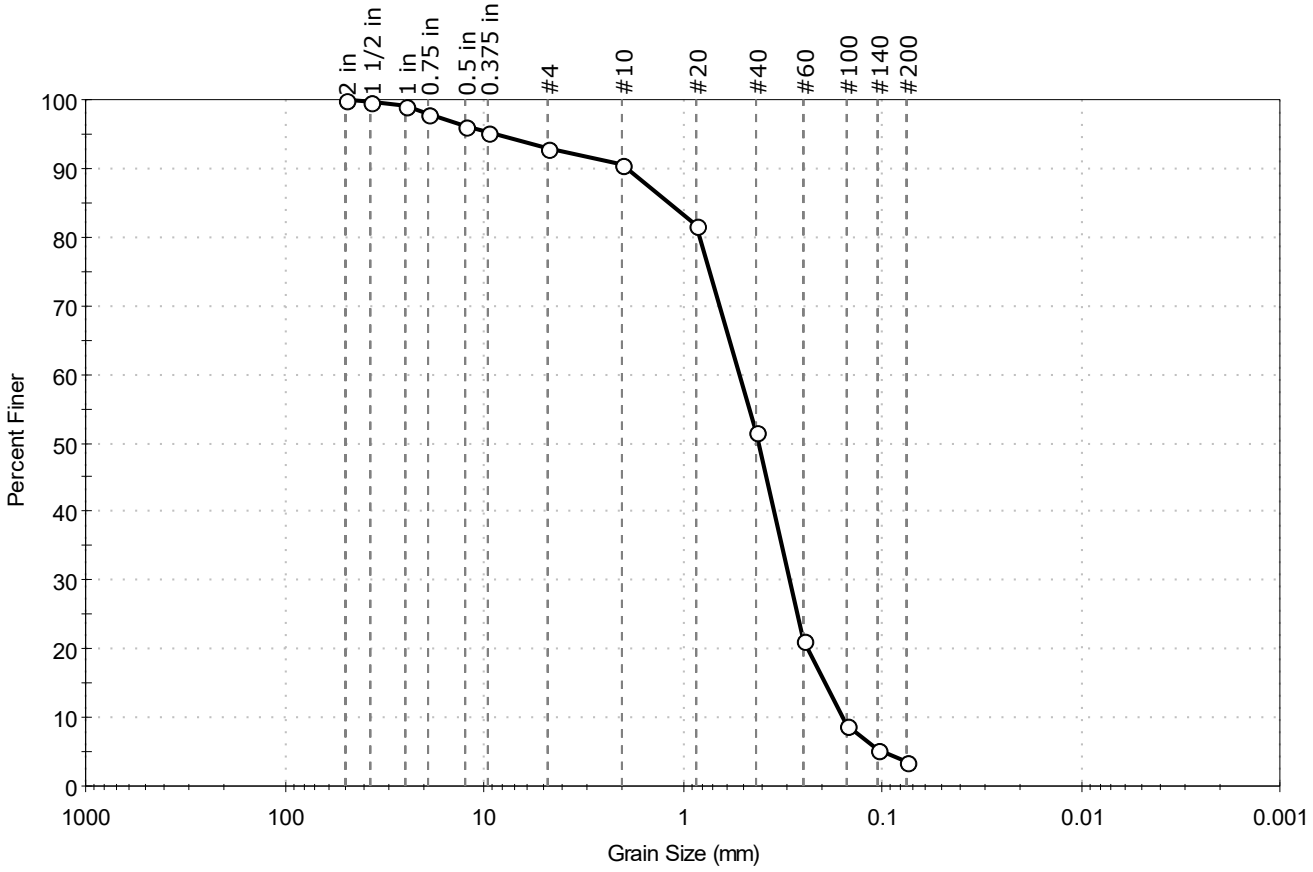
Mode Share

A transportation survey was completed by Devens residents and business employees as part of the 2015 Devens Traffic Monitoring Report. As summarized in the survey, nearly all Devens commuters travel to and from work via private vehicle, with approximately 98 percent commuting by vehicle (either by driving alone or in a carpool). Of the remaining two

5 Trip Generation Manual, 10th Edition; Institute of Transportation Engineers (ITE); Washington, D.C.; 2017.

Client:	Sanborn, Head & Associates, Inc.				
Project:	Scannell Devens				
Location:	Devens, MA			Project No:	GTX-313208
Boring ID:	---	Sample Type:	bag	Tested By:	ckg
Sample ID:	Layer C1 Composite	Test Date:	02/23/21	Checked By:	emm
Depth :	---	Test Id:	610735		
Test Comment:	---				
Visual Description:	Moist, lght yellowish brown sand				
Sample Comment:	---				

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	7.2	89.2	3.6

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
2 in	50.00	100		
1 1/2 in	37.50	100		
1 in	25.00	99		
0.75 in	19.00	98		
0.5 in	12.50	96		
0.375 in	9.50	95		
#4	4.75	93		
#10	2.00	91		
#20	0.85	82		
#40	0.42	52		
#60	0.25	21		
#100	0.15	9		
#140	0.11	5		
#200	0.075	3.6		

Coefficients

D_{85} = 1.1697 mm	D_{30} = 0.2916 mm
D_{60} = 0.5168 mm	D_{15} = 0.1936 mm
D_{50} = 0.4140 mm	D_{10} = 0.1577 mm
C_u = 3.277	C_c = 1.043

Classification

ASTM Poorly graded SAND (SP)

AASHTO Fine Sand (A-3 (1))

Sample/Test Description

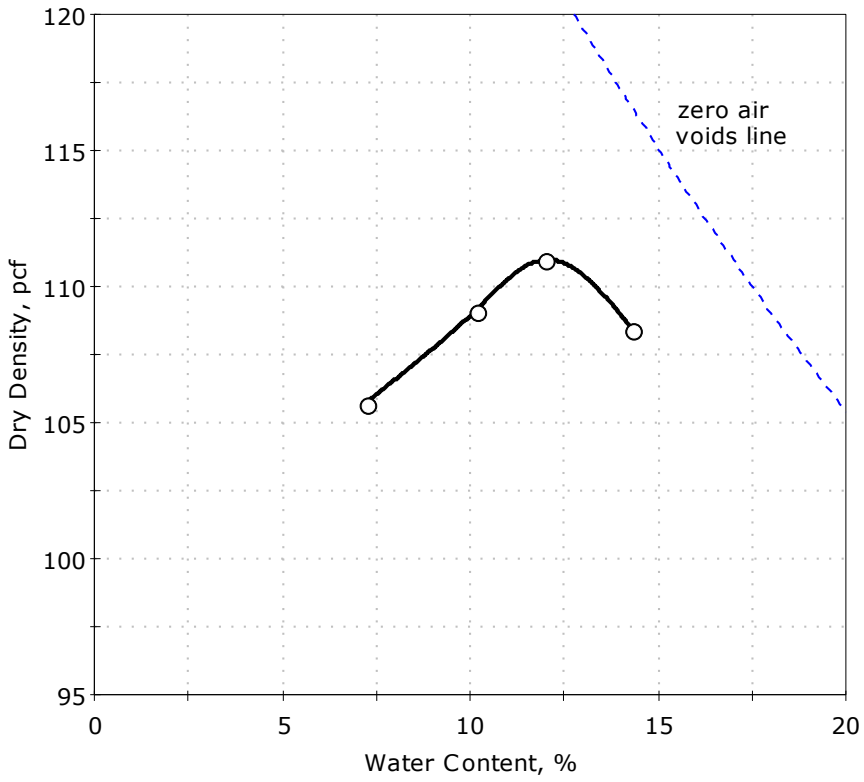
Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

GeoTesting EXPRESS

Client:	Sanborn, Head & Associates, Inc.				
Project:	Scannell Devens				
Location:	Devens, MA			Project No:	GTX-313208
Boring ID:	---	Sample Type:	bag	Tested By:	cwd
Sample ID:	Layer C1 Composite	Test Date:	02/26/21	Checked By:	emm
Depth :	---	Test Id:	610736		
Test Comment:	---				
Visual Description:	Moist, lght yellowish brown sand				
Sample Comment:	---				

Compaction Report - ASTM D1557



Data Points	Point 1	Point 2	Point 3	Point 4
Dry density, pcf	105.7	109.1	111.0	108.4
Moisture Content, %	7.2	10.2	12.0	14.3

Method : C

Preparation : DRY

As received Moisture :5 %

Rammer : Mechanical

Zero voids line based on assumed specific gravity of 2.55

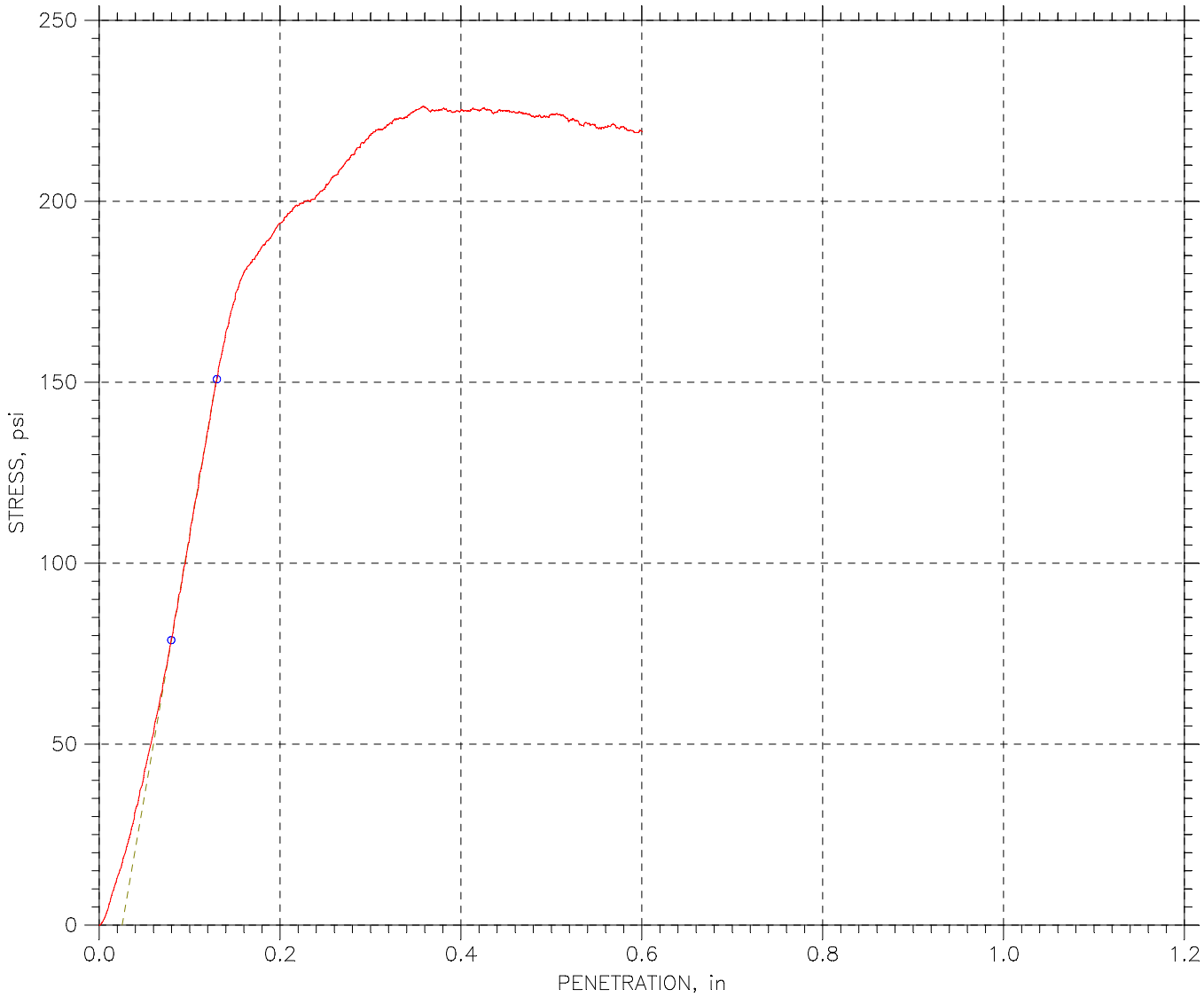
Maximum Dry Density= 111.0 pcf

Optimum Moisture= 12.1 %

GeoTesting EXPRESS

CALIFORNIA BEARING RATIO TEST REPORT

by ASTM D1883.



Sample Height: 4.58 in	California Bearing Ratio				
Sample Area: 28.274 in^2	at 0.1 in: 14	at 0.3 in: 12	at 0.5 in: 9		
Sample Volume: 0.07494 ft^3	at 0.2 in: 13	at 0.4 in: 10			
Sample Mass: 4014.8 gm					
Sample Condition: Soaked	Water Content		Before	Top	Average
Swell: 0.00 %	Tare ID		D-294	E2761	E2816
Surcharge: 4540 gm	Tare Mass, gm		8.6	8.2	8.21
Void Ratio: 0.57	Mass Tare + Wet Soil, gm		374.28	238.43	325.2
Wet Unit Weight: 118.11 pcf	Mass Tare + Dry Soil, gm		335.52	208.77	282.42
Dry Unit Weight: 105.59 pcf	Water Content, %		11.86	14.79	15.60

Project: Scannell Devens	Location: Devens Ma	Project No.: GTX-313208
Boring No.:	Tested By: md	Checked By: emm
Sample No.: Layer CL Co	Test Date: 03/02/21	Depth: +/- 1-5 ft
Test No.: CBR-1	Sample Type: remolded	Elevation: ---
Description: Moist dark yellowish brown sand		
Remarks: Target compaction: 95% of the max dry density (111.0) at the optimum moisture content (12.1%).		

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