Maine Department of Transportation

Highway Program

Design Guidance

Title: Structural Pavement Design	Issue Date: March 13, 2019
Discipline: Pavement Design & Quality	Revised Date: September 3, 2025
Originator: Stephen Bodge, P.E.	
Approved By: Bradford Foley, P.E.	

Background:

This guidance simplifies the methods to determine the pavement design for reconstruction projects, roadway widenings, large culvert projects, and bridge approaches, and applies to all Highway Corridor Priorities (HCP's).

Guidance:

There are two different pavement structure options in this guidance that the designer can use to determine the best and most cost-effective pavement design for their projects. These options are as follows:

- Projects with 10,000,000 ESALs or less and using subbase aggregate
- Projects with 10,000,000 ESALs or less and using base aggregate (Type A, B, and C) for the entire aggregate thickness

Traffic data impacts pavement design and local knowledge of traffic patterns and usage should be considered.

The tables below are based on the number of ESALs and the subgrade soil type. Two overall section thicknesses are used in these tables: a 24" section and a 30". Using a consistent overall section allows designers to set the pavement structure template prior to determining the final pavement design. This also allows changes to the pavement design later in the design process without having to make changes to the roadway design.

A Type C base aggregate is routinely used in Aroostook County due to the lack of subbase availability. Using a base aggregate for the entire aggregate layer will typically reduce the Hot Mix Asphalt (HMA) layer thickness. However, base aggregates are typically bid at a higher price than subbase in other areas of the State, so an estimate comparing the cost for each pavement design option is recommended before the final design is selected.

The pavement design for large culvert replacement projects takes a simpler approach to determine the HMA and subbase/base thicknesses. The following table gives two basic pavement structure options.

Pavement Design for Large Culvert Replacement Projects

ESALs	HMA (in)	Base or Subbase (in)
0 - 200,000	4	20
200,001 - 5,000,000	6	24

For large culvert replacement projects with ESALs greater than 5,000,000, the design procedure for roadways using a Type 3 subgrade soil is used to determine the HMA and aggregate thicknesses.

Pavement Design Process:

Step 1: ESAL Calculation

ESALs are calculated using the 18-kip Equivalent @ $P_{2.5}$ value located on the project traffic data sheet provided by the Traffic Analysis Section in the Bureau of Planning. ESALs should be calculated for a 20-year design life for reconstruction and large culvert projects. ESALs for roadway lane widening projects should be calculated using a 20-year design life for Priority 1 and 2 roadways, and a 20-year or 12-year design life for Priority 3 and 4 roadways.

ESALs are calculated using the following equation:

ESALs = (18-kip Equiv. P 2.5) x (12-yr or 20-yr design life) x (365 days/year)

Step 2: Determine Subgrade Soil Type

Subgrade soil type is determined from project subsurface investigations or from the Natural Resources Conservation Service (NRCS) Soil Survey information for the specific project location. The NRCS Soil Survey information is available on the NRCS Web Soil Survey website. See the attached *Using the NRCS Web Soil Survey to Determine Subgrade Soil Type* document for step-by-step how to use instructions.

Step 3: Determine HMA and Aggregate Thickness

The pavement structure design in this guidance is based on the number of ESALs and five subgrade soil types that are based on the % passing the #200 sieve. The travel lane HMA, base aggregate and subbase thicknesses can be determined using Tables 1and 2 below. These Tables are applicable for all roadway classifications and Highway Corridor Priorities (HCP's).

As per Standard Specification 203.041 - Salvage of Existing Hot Mix Asphalt Pavement, the contractor has the option to use a maximum of 3" of Recycled Asphalt Pavement (RAP) in place of the top 3" of the subbase aggregate. It can also be specified in the project plans or contract documents that the contractor shall use RAP as the top 3" of aggregate (maximum), and as the top 3” of the Type C aggregate layer. For pavement design, the RAP used for these purposes is considered to be part of the underlying aggregate or base aggregate thickness.

A: TABLE 1- Subbase Aggregate (ASCG) Option
Subbase aggregate is typically used on most MaineDOT projects and is widely available in all areas of the State except Aroostook County. Table 1 lists the HMA and subbase thicknesses for 5 types of subgrade soils.

B: TABLE 2 - Base Aggregate Option (ABC – Type A, B, and C)
On high ESAL roadways, using a base aggregate will reduce the HMA layer thickness. The base aggregate thickness as shown in Table 2 is intended for the entire thickness of the aggregate layer. Subbase aggregate is often not available in Aroostook County, therefore a Type C base aggregate should be selected for projects where there is no availability of subbase. Table 2 lists the HMA and base aggregate thicknesses for 5 types of subgrade soils.

Submittals:

All pavement designs using Table 1 and 2 shall be reviewed and approved by the Pavement Design & Quality section prior to the Preliminary Design Report (PDR) stage of the project. The pavement design review shall contain all supporting documentation including the ***Pavement Design Review Form***, a project location map, traffic data sheet(s), subsurface investigation report if available, or the NRCS soil survey information used for the design. The overall pavement and HMA thicknesses may be adjusted for ease of constructability or other reasons following the review.

TABLE 1 – HMA over Aggregate Subbase

Type 1 Subgrade (0% - 14% passing #200)

ESALs	HMA (in)	Subbase (in)
0 - 900,000	4	20
900,001 - 2,000,000	4	26
2,000,001 - 4,000,000	5	25
4,000,001 - 6,500,000	6	24
6,500,001 - 10,000,000	7	23

Type 2 Subgrade (14% - 34% passing #200)

ESALs	HMA (in)	Subbase (in)
0 - 700,000	4	20
700,001 - 1,50,000	4	26
1,500,001 - 3,000,000	5	25
3,000,001 - 5,000,000	6	24
5,000,001 - 7,500,000	7	23
7,500,001 - 10,000,000	8	22

Type 3 Subgrade (34% - 55% passing #200)

ESALs	HMA (in)	Subbase (in)
0 - 600,000	4	20
600,001 - 1,250,000	4	26
1,250,001 - 2,000,000	5	25
2,000,001 - 3,500,000	6	24
3,500,001 - 6,000,000	7	23
6,000,001 - 10,000,000	8	22

Type 4 Subgrade (55% - 82% passing #200)

ESALs	HMA (in)	Subbase (in)
0 - 400,000	4	20
400,001 - 900,000	4	26
900,001 - 1,500,000	5	25
1,500,001 - 2,500,000	6	24
2,500,001 - 4,500,000	7	23
4,500,001 - 7,500,000	8	22
7,500,000 - 10,000,000	Coachpoint Recommended	

Type 5 Subgrade (82% - 100% passing #200)

ESALs	HMA (in)	Subbase (in)
0 - 300,000	4	20
300,001 - 600,000	4	26
600,001 - 1,000,000	5	25
1,000,001 - 2,000,000	6	24
2,000,001 - 3,000,000	7	23
3,000,001 - 5,500,000	8	22
5,500,000 - 10,000,000	Coachpoint Recommended	

TABLE 2 – HMA over Aggregate Base Course

Type 1 Subgrade (0% - 14% passing #200)

ESALs	HMA (in)	Base Agg (in)
0 - 2,000,000	4	20
2,000,000 - 7,000,000	4	26
7,000,000 - 10,000,000	5	25

Type 2 Subgrade (14% - 34% passing #200)

ESALs	HMA (in)	Base Agg (in)
0 - 1,500,000	4	20
1,500,001 - 5,000,000	4	26
5,000,001 - 8,000,000	5	25
8,000,001 - 10,000,000	6	24

Type 3 Subgrade (34% - 55% passing #200)

ESALs	HMA (in)	Base Agg (in)
0 - 1,000,000	4	20
1,000,001 - 4,000,000	4	26
4,000,001 -6,000,000	5	25
6,000,001 - 9,000,000	6	24
9,000,001 - 10,000,000	7	23

Type 4 Subgrade (55% - 82% passing #200)

ESALs	HMA (in)	Base Agg (in)
0 - 500,000	4	20
500,001 - 2,000,000	4	26
2,000,001 - 4,000,000	5	25
4,000,001 - 7,000,000	6	24
7,000,001 - 10,000,000	7	23

Type 5 Subgrade (82% - 100% passing #200)

ESALs	HMA (in)	Base Agg (in)
0 - 500,000	4	20
500,001 - 1,500,000	4	26
1,500,001 - 3,000,000	5	25
3,000,001 - 5,000,000	6	24
5,000,001 - 8,000,000	7	23
8,000,001 - 10,000,000	8	22

Example Designs:

A. Determine the HMA and subbase layer thicknesses for a project that has a 20-year design life, an 18-kip Equivalent $P_{2.5}$ value of 350, and has a Type 3 subgrade.

<u>*SOLUTION:*</u>

ESALs = (18-kip Equiv $P_{2.5}$) x (12-yr or 20-yr design life) x (365 days/year)

ESALs = (250) x (20 years) x (365 days/year) = 2,555,000

Using Table 1, the final pavement structure = 6" HMA, 24" Subbase
Using Table 2, the final pavement structure = 4" HMA, 26" Base aggregate

Note: The minimum shoulder HMA thickness is 3". However, with a 4" HMA layer, 4" of HMA will need to be placed on the shoulders for constructability reasons, therefore this should be considered when doing an estimate~

B: Determine the HMA and subbase layer thicknesses for a project that has a 12-year design life, an 18-kip Equivalent $P_{2.5}$ value of 125, and is a large culvert project.

<u>*SOLUTION:*</u>

ESALs = (18-kip Equiv $P_{2.5}$) x (12-yr or 20-yr design life) x (365 days/year)

ESALs = (125) x (12 years) x (365 days/year) = 547,500

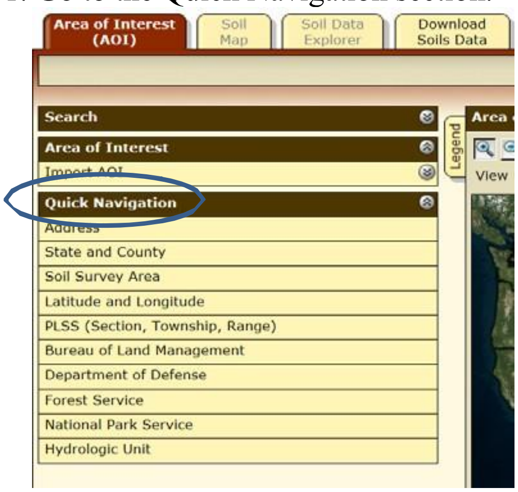
Use Type 3 subgrade soil since the new subgrade will be fill.

Using Table 1, the final pavement structure = 4" HMA, 20" subbase
Using Table 2, the final pavement structure = 4" HMA, 20" base aggregate

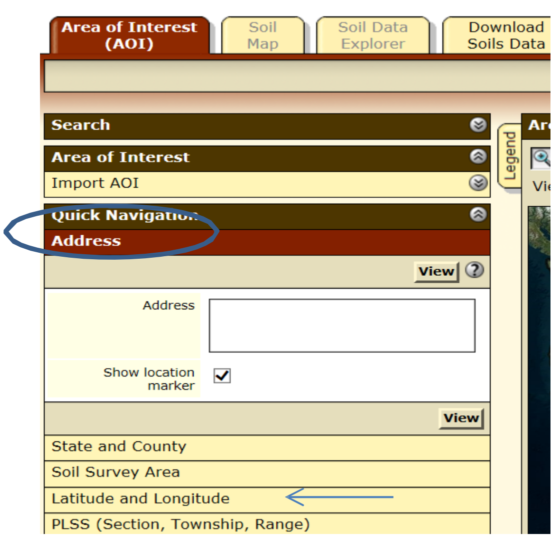
Using the NRCS Web Soil Survey to Determine Subgrade Soil Type:

Use this link: https://websoilsurvey.nrcs.usda.gov/app/. Click the green Start WS button.

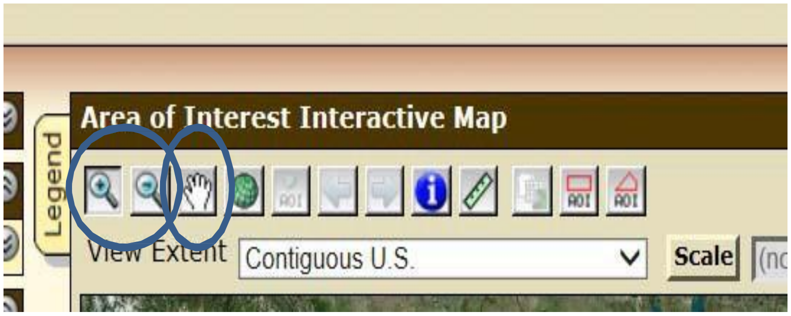
1. Go to the Quick Navigation section.



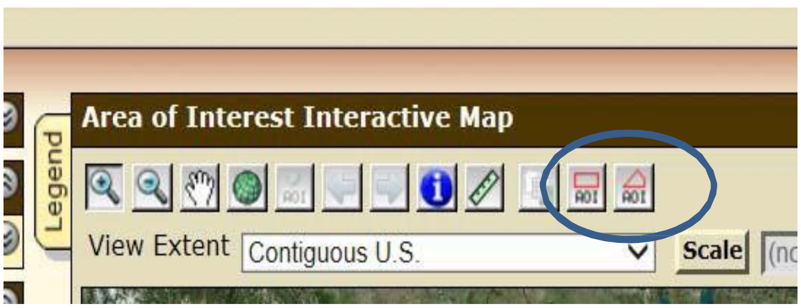
2. Select Address and enter Route, Town, State. Latitude and longitude coordinates may also be used. Click the View button.



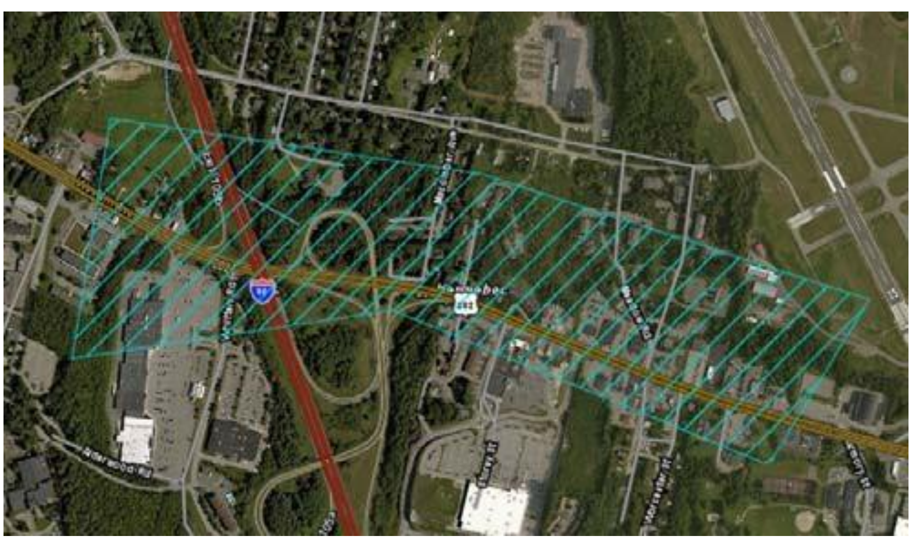
3. Use the Hand Tool to navigate to project location. Use the magnifying tool to pinpoint the exact project limits.



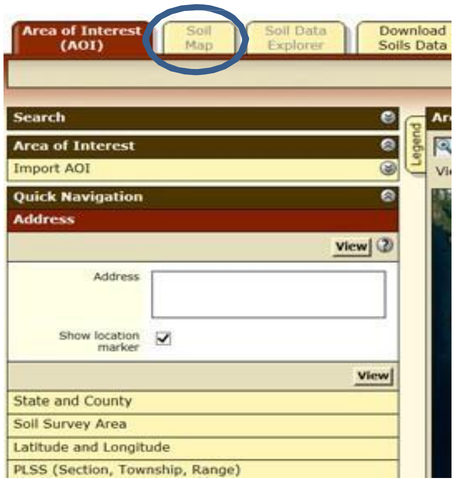
4. Select the Area of Interest Button located just above the map. The choice of area to be drawn is a rectangle or irregular shape. The irregular shape button works the best for roadway projects.



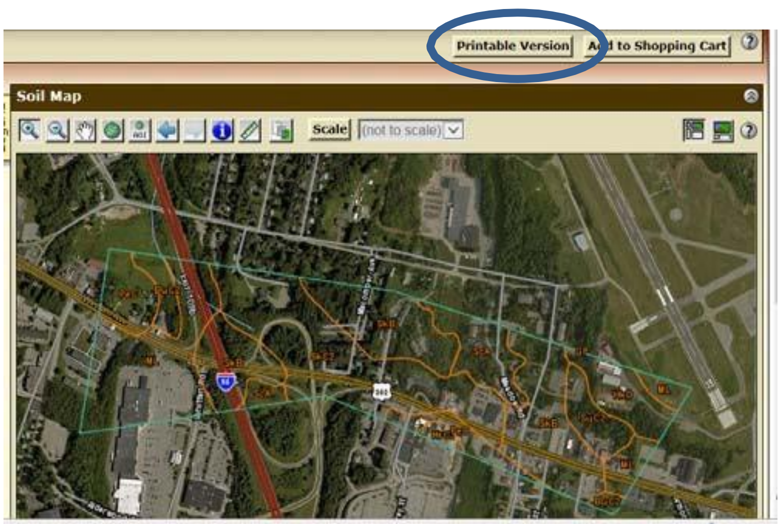
5. Draw the project limits and double click to close the polygon and create the Area of Interest. The square will automatically close. A hatched area will appear when created.



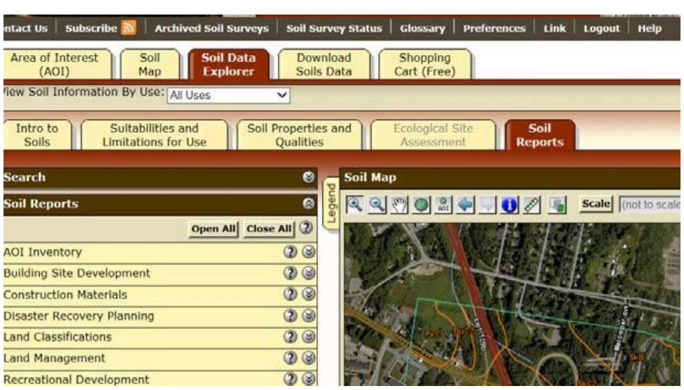
6. Click the Soil Map tab located at top of screen. The soil map will be created.



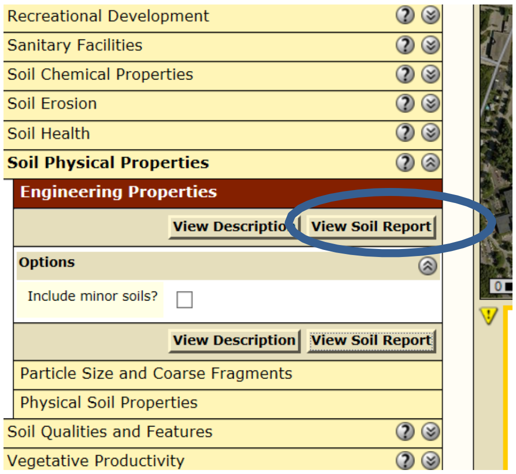
7. Click the Printable Version button and then View. A PDF of the Soil map is created. Save the map and then close the PDF.



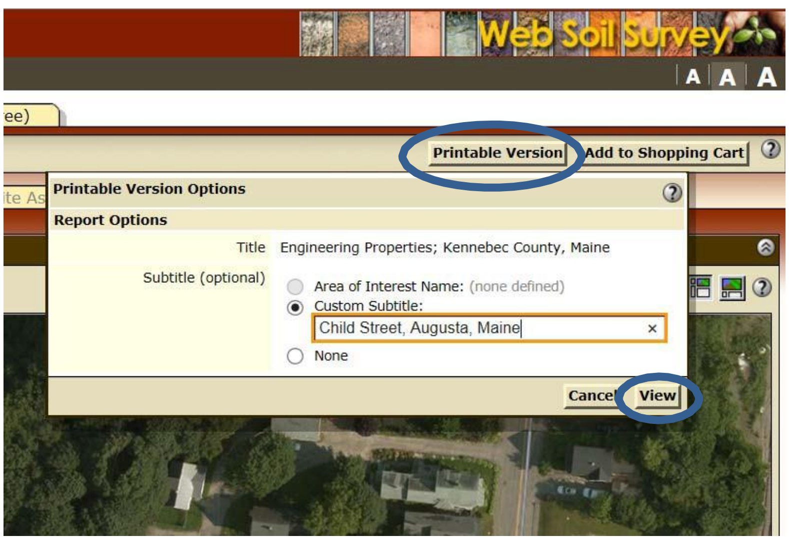
8. Select the Soils Data Explorer tab, and then the Soil Reports tab.



9. Select Soil Physical Properties from the Soils Report list. Select Engineering Properties and then View Soil Report.



10. Select Printable Version and then View. A PDF of the Engineering Properties is created. Save the PDF.



Determine the Subgrade Soil Types

1. To determine the subgrade soils type on your project, find all the soils under the roadway along the project using the Soil Map PDF.

2. The Soil Map PDF includes a chart that shows the percentage of soils in the area of interest. If you used the irregular shape area of interest, select the soils with the highest Percent of AOI on the roadway as representative.

EXAMPLE:

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
BuC2	Buxton silt loam, 8 to 15 percent slopes	4.2	3.0%
GP	Gravel pits	0.0	0.0%
HkD	Hinckley gravelly sandy loam, 15 to 30 percent slopes	7.7	5.5%
HrC	Hollis fine sandy loam, 8 to 15 percent slopes	1.2	0.9%
ML	Made land	28.3	20.2%
PeC	Paxton-Charlton very stony fine sandy loams, 8 to 15 percent slopes	10.5	7.5%
ScA	Scantic silt loam, 0 to 3 percent slopes	9.9	7.1%
SkB	Scio very fine sandy loam, 3 to 8 percent slopes	40.0	28.6%
SkC2	Scio very fine sandy loam, 8 to 15 percent slopes, eroded	32.8	23.4%
SuC2	Suffield silt loam, 8 to 15 percent slopes, eroded	5.4	3.9%
Totals for Area of Interest		**140.1**	**100.0%**

3. Go to the Engineering Properties pdf and the Percent Passing Sieve Number columns, and then the 200 column.

4. Select the middle value (R value) for the % passing the #200 as determined above for the layers 18" to 36" below the surface.

EXAMPLE:

content=17757.wba). Three values are provided to identify the expected Low (L), Representative Value (R), and High (H).

Engineering Properties–Kennebec County, Maine														
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification		Pct Fragments		Percentage passing sieve number—				Liq lim
					Unified	AASHTO	>10 inches	3-10 inches	4	10	40	200	
			In				L-R-H	L-R-H	L-R-H	L-R-H	L-R-H	L-R-H	L-R
BuC2—Buxton silt loam, 8 to 15 percent slopes													
Buxton	85	C/D	0-7	Silt loam	ML, MH	A-7-5, A-6, A-7	0- 0- 0	0- 0- 0	96-100-100	91-100-100	85-98-100	77-90-94	35-4 -5
			7-18	Silt loam, silty clay loam	CL	A-6	0- 0- 0	0- 0- 0	96-100-100	91-100-100	85-98-100	78-90-100	30-3 -5
			18-23	Silty clay loam, silt loam, silty clay	CL	A-7-6	0- 0- 0	0- 0- 0	96-100-100	92-100-100	84-98-100	78-91-100	4-4 -5
			23-35	Silty clay loam, silty clay	CL	A-7-6	0- 0- 0	0- 0- 0	96-100-100	93-100-100	85-100-100	79-93-100	9-4 -6
			35-65	Silty cl[illegible] clay	[illegible]	[illegible]	[illegible]	[illegible]	97-100-100	93-100-100	85-100-100	[illegible]00	3-5 -6
GP—Gravel pits													

<u>Selecting Subgrade Type from NRCS Information</u>

MaineDOT Subgrade soil types are:
Type 1 Subgrade - 0% - 14% passing #200
Type 2 Subgrade - 14% - 34% passing #200
Type 3 Subgrade - 34% - 55% passing #200
Type 4 Subgrade - 55% - 82% passing #200
Type 5 Subgrade - 82% - 100% passing #200

From the above Engineering Properties example, the #200 values are 91 and 93, therefore the subgrade is a Type 5 Subgrade.