WAPA
WISCONSIN ASPHALT PAVEMENT ASSOCIATION

TECHNICAL BULLETIN

CONTENTS

The first step in using the graphs in this document is to identify the right soil type. A graph is presented for each of the three soil types.

Pavement Structure Design

When constructing a new pavement, it's important to specify the proper pavement and base layer thickness to handle the job. The most significant design factors in new pavement construction are underlying soil type and the expected traffic. When soil type and traffic values are known, the three graphs presented in this guidance document can be used to specify pavement and base course layer thickness for standard asphalt pavements, long-life asphalt pavements and comparable concrete pavements.

Design methodology

This document is based on the American Association of State Highway and Transportation Officials' Guide for Design of Pavement Structures (**https://bookstore.transportation.org/Item_details.aspx?id=374**), created in 1972 and revised several times since then. It is also based on the Wisconsin Department of Transportation's Facilities Development Manual (**roadwaystandards.dot.wi.gov/standards/fdm/**) and its WisPave design software (**ftp://pavuser:dotpave@ftp.dot.state.wi.us/design/software/WisPave/**), both of which draw from AASHTO's methodology.

AASHTO's design procedures are based on an expected pavement life of 20 years. In developing its design formulas, AASHTO collected and analyzed data from test pavements built on different kinds of soil subgrades and subjected to varying traffic loads, and then it created the formulas based on empirical evidence of distress over time.

Subgrade soil conditions

The subgrade soil, which lies beneath the pavement layer and the crushed aggregate base course, helps bear the load of the roadway traffic. The quality of the soil, as determined by its components, determines how thick a pavement must be. For example, higher quality soils can handle more load and require thinner pavement layers.

WisDOT FDM section 14-1-1 (**roadwaystandards.dot.wi.gov/standards/fdm/14-01.pdf**) discusses how asphalt and concrete design methods use different scales for quantifying soil quality in their design calculations. Asphalt design uses **Soil Stability Value**, or **SSV**, and concrete design uses a **K value**. Comparable SSV and K values can be identified through the AASHTO soil classification designation.

The graphs in this document represent three soil types: good, moderate and poor. The components of these soil types along with their SSVs and K values are shown in Table 1.

Table 1 Pavement Design Values Based on Soil Type and Soil Components

Soil Type	Components	SSV (asphalt design)	K value (concrete design)
Good	Fine-grained materials: gravel and sand	4.8	225
Moderate	Components of good soil mixed with clay	4.2	175
Poor	Components of good or moderate soil mixed with silt	3.6	100

Traffic

Generally, the more traffic that a pavement will have to carry, the thicker the pavement will need to be. The AASHTO methodology found that light vehicles—such as cars and pickups—have little impact on pavement life. Fatigue failure is attributed to heavier trucks.

The second step in using the graphs is to calculate the expected traffic level, based on 20-year design ESALs, and locate that value along the bottom axis of the graph.

Though trucks come in many sizes with different wheel configurations and loads, the design procedure is simplified with a term called the **equivalent single axle load**, or **ESAL**, which represents the load of 18,000 pounds exerted on a single axle. Any single truck will cause more or less distress than an ESAL, but for this simplified pavement design using typical Wisconsin trucks, a useful approximation for a **design ESAL** is:

Each truck pass = 1 design ESAL

For a 20-year design, the number of expected truck passes in a day is multiplied by 365 days per year and then multiplied by 20 years. For example, if a street is expected to carry 100 truck passes per day, the approximate 20-year design ESAL value is:

100 x 365 days/year x 20 years = 730,000 design ESALs over 20 years

Note that during actual pavement design, the approximation above (one truck pass equals 1 design ESAL) is usually replaced by more rigorous analysis, which incorporates the effects of different truck types on asphalt or concrete, distribution factors and lane direction factors. WisDOT FDM section 14-1-5 (**roadwaystandards.dot.wi.gov/standards/fdm/14-01.pdf**, page 2) explains these factors in greater detail.

Pavement thickness based on soil and traffic

For a selected soil type and design ESAL value, the graphs presented in this document provide a structural number, or SN, for asphalt pavement design and a slab thickness for concrete pavement design.

For example, when building on good soil and expecting 100 design ESALs per day (or 730,000 design ESALs per 20 years), the graph specifies an SN of 3.48 for asphalt (the green curve) and a slab thickness of 7 inches for portland cement concrete (the blue curve), as shown in Figure 1.

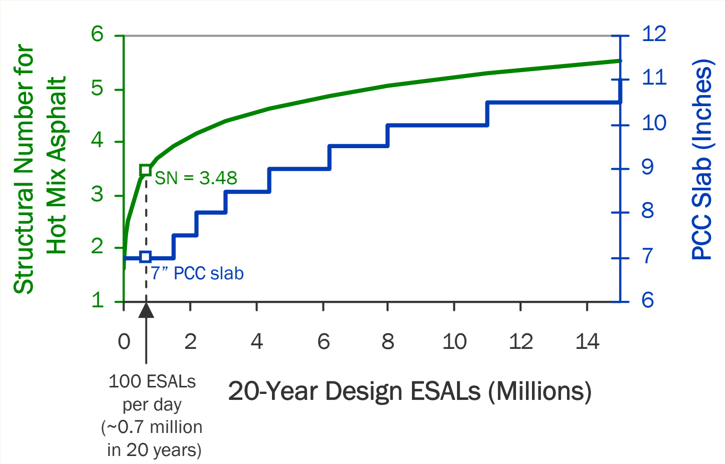

Figure 1 Example pavement design process (shown for good soil)

Asphalt

The SN curve is smooth, and it is generated based on a formula in WisDOT's FDM. The SN is a "target" number for an asphalt design. With a desired SN target known (for example, 3.48 above), it is possible to create a variety of asphalt designs according to the following formula:

> (**Asphalt thickness in inches** x 0.44) + (**Base thickness in inches** x 0.14) = **Target SN**

Asphalt layers are specified in quarter-inch increments and the base layer in half-inch increments. So, two different ways to satisfy the example SN target of 3.48 are:

> (**4.25 inches of asphalt** x 0.44) + (**12 inches of base** x 0.14) = SN of **3.55**, slightly over target

or, alternatively,

> (**6 inches of asphalt** x 0.44) + (**6 inches of base** x 0.14) = SN of **3.48**, right on target

The first of these designs has a base course about three times the size of the asphalt layer. This is considered a standard design.

The second design uses a base layer of 6 inches (considered a minimum pavement construction platform) with the asphalt layer then maximized to reach the target SN. An asphalt pavement with a maximized asphalt layer is called a **long-life**—or deep strength—design, and it has many benefits over a standard design.

The three graphs presented in this document show SN values and associated long-life pavement designs for several different ESAL levels.

For more on asphalt design and the basis of the formulas above, see WisDOT FDM section 14-10-5 (**roadwaystandards.dot.wi.gov/standards/fdm/14-10.pdf**).

Figure 2 The quality of the sub-grade soil plays an important role in determining pavement thick-ness.

Concrete

Concrete slabs are specified in half-inch increments, so the PCC curves shown in the design graphs are stepped. Using the minimum construction platform, the base course layer is always 6 inches. Because the long-life asphalt base course is also 6 inches, it is very easy to compare concrete and long-life asphalt pavement designs.

For more on concrete design, see WisDOT FDM section 14-10-10 (**roadwaystandards.dot.wi.gov/standards/fdm/14-10.pdf**, page 5).

Pavement design graphs

Figures 3, 4 and 5 provide pavement design guidance for good, moderate and poor soil subgrades, respectively. Please refer to the explanatory information in this document for instructions on how to use these graphs.

For more information about this design methodology or for assistance with designing an asphalt pavement for your specific needs, contact WAPA at 608-255-3114, **strand@wispave.org** or **www.wispave.org**.

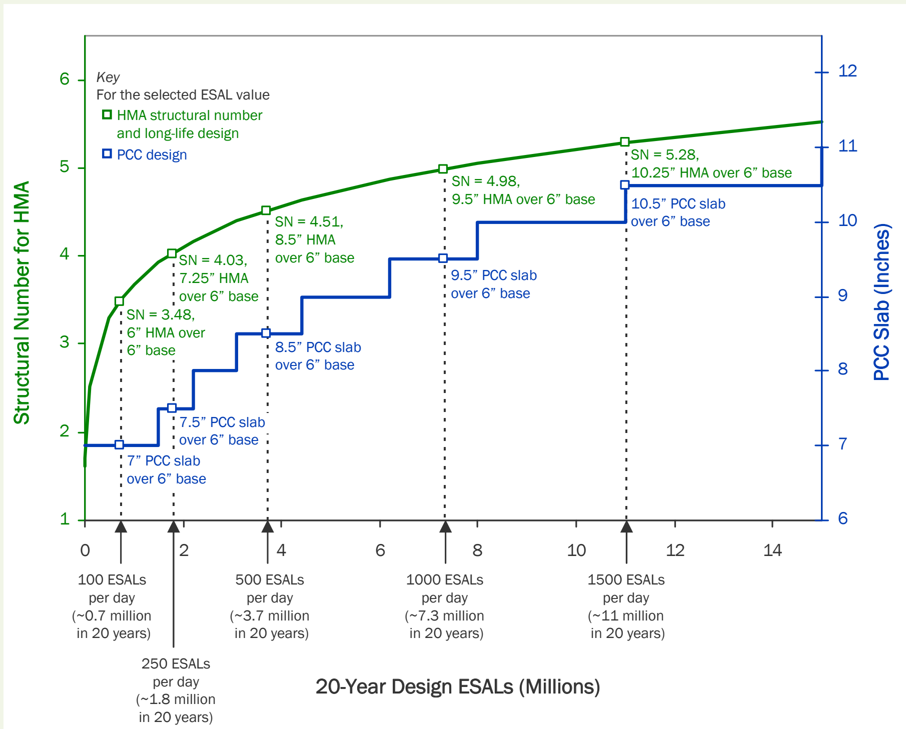

Figure 3 Pavement designs for good soil

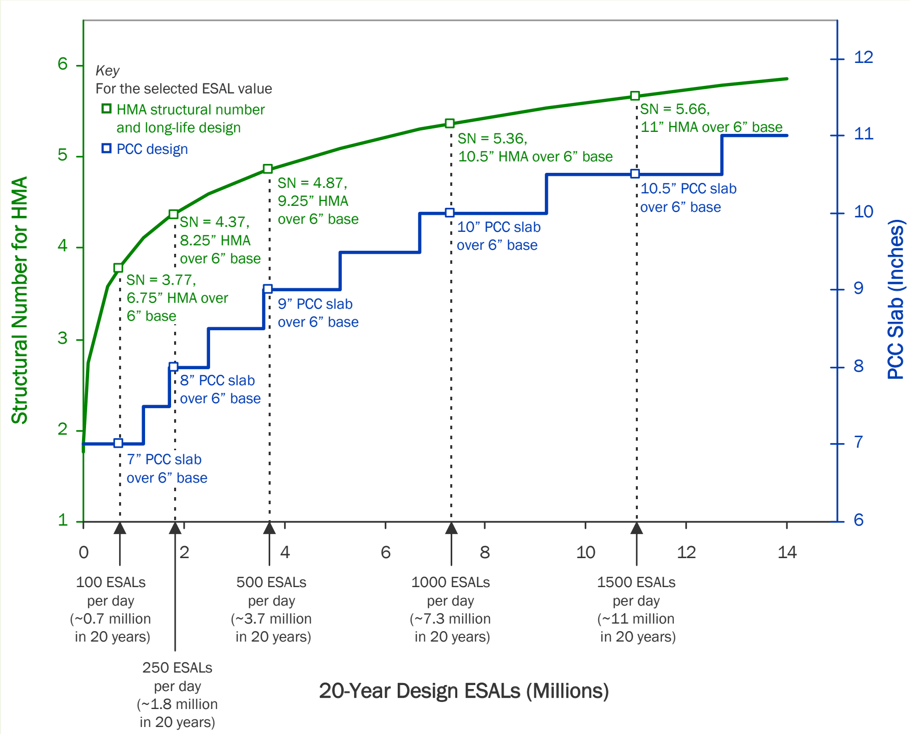

Figure 4 Pavement designs for moderate soil

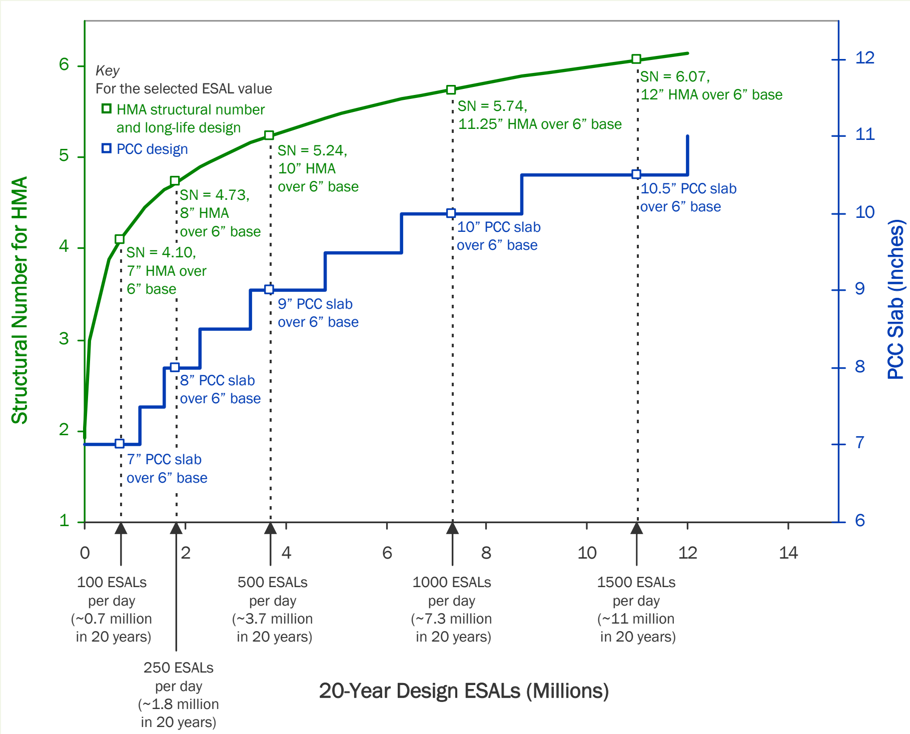

Figure 5 Pavement designs for poor soil