Mechanistic-Empirical Design

Asphalt Institute Method
Mechanistic-Empirical Methodology

- Material Properties
- Climate Model
- Climate Information
- Structural Model
- Pavement Response
- Failure Criteria
- Trial Layer Thicknesses
- Traffic Information
- Final Layer Thicknesses

Satisfactory

Unsatisfactory
Asphalt Institute Methodology

- Freezing/Thawing Asphalt Temp
  - MAAT (°F)
- DAMA (LEA)
  - Max asphalt $\varepsilon_t$
  - Max subgrade $\varepsilon_c$
- Nf (fatigue)
  - Nd (rutting)
- Final Layer Thicknesses

- Eac, Ebs, Esg
  - $\nu_{ac}, \nu_{bs}, \nu_{sg}$
- hac, hbs

Satisfactory or Unsatisfactory
Pavement Response

(a) Full-Depth asphalt concrete and emulsified asphalt base pavements

(b) Pavements with granular base
Pavement Response

FULL-DEPTH ASPHALT PAVEMENT

DEEP-STRENGTH ASPHALT PAVEMENT

(a) Full-Depth asphalt concrete and emulsified asphalt base pavements

(b) Pavements with granular base
Pavement Response

FULL-DEPTH ASPHALT PAVEMENT

DEEP-STRENGTH ASPHALT PAVEMENT

(a) Full-Depth asphalt concrete and emulsified asphalt base pavements

(b) Pavements with granular base
Fatigue Failure Criterion

\[ N_f = 0.0796 (\varepsilon_t)^{-3.291} \quad E^* \quad -0.854 \]

- Asphalt Fatigue Life
- Asphalt Tensile Strain
- Asphalt Resilient Modulus
Rutting Failure Criterion

\[ N_d = 1.365 \times 10^{-9} (\varepsilon_c)^{-4.477} \]
Traffic

$$ESAL = (ADT)(T)(T_f)(D)(L)(G)365$$
# Climatic Regions

<table>
<thead>
<tr>
<th>MAAT (°F)</th>
<th>Asphalt Grades</th>
<th>Viscosity, $\lambda$ (at 70°F)</th>
<th>Frost Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>45</td>
<td>AC-5, AC-10</td>
<td>600,000</td>
<td>Yes</td>
</tr>
<tr>
<td>60</td>
<td>AC-10, AC-20</td>
<td>1,600,000</td>
<td>Possible</td>
</tr>
<tr>
<td>75</td>
<td>AC-40</td>
<td>5,000,000</td>
<td>No</td>
</tr>
</tbody>
</table>
Mean Monthly Air Temperatures

South Carolina (MAAT = 60°F)

<table>
<thead>
<tr>
<th>Month</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>45°F</td>
</tr>
<tr>
<td>Feb</td>
<td>38°F</td>
</tr>
<tr>
<td>Mar</td>
<td>43°F</td>
</tr>
<tr>
<td>Apr</td>
<td>45°F</td>
</tr>
<tr>
<td>May</td>
<td>56°F</td>
</tr>
<tr>
<td>Jun</td>
<td>70°F</td>
</tr>
<tr>
<td>Jul</td>
<td>78°F</td>
</tr>
<tr>
<td>Aug</td>
<td>81°F</td>
</tr>
<tr>
<td>Sept</td>
<td>78°F</td>
</tr>
<tr>
<td>Oct</td>
<td>73°F</td>
</tr>
<tr>
<td>Nov</td>
<td>58°F</td>
</tr>
<tr>
<td>Dec</td>
<td>54°F</td>
</tr>
</tbody>
</table>
Pavement Temperatures

Asphalt
Air
Pavement Temperature

\[ M_p = M_a \left( 1 + \frac{1}{z + 4} \right) - \frac{34}{z + 4} + 6 \]

- Mean monthly air temperature (°F)
- Mean monthly asphalt temp. (°F)
- Depth (in)
Asphalt Modulus

\[
\log|E^*| = c_1 + c_2 \left( P_{200} f^{-c_3} \right) - c_4 V_a + c_5 \lambda + c_6 f^{-c_7} + c_8 V_b^{0.5} T^{(c_9 + c_{10} \log f)} \left( c_{11} - c_{12} f^{-c_{13}} \right)
\]

- % passing #200 sieve
- Vol. air content %
- Asphalt viscosity
- Vol. binder content (%)
- Asphalt temp.
- Loading freq.
Unbound Base Modulus

\[ M_R = K_1 \theta^{K_2} \]

Source: WSDOT Pavement Guide Interactive CD-ROM
Unbound Base Modulus

\[ E_2 = 10.447 h_1^{-0.471} h_2^{-0.041} E_1^{-0.139} E_3^{0.287} K_1^{0.868} \]

- **Effective Modulus**
- **Asphalt Thickness**
- **Base Thickness**
- **Asphalt Modulus**
- **Subgrade Modulus**
Unbound Base Modulus

\[ \sqrt[3]{E_1} = \frac{h_s \sqrt[3]{E_s} + h_b \sqrt[3]{E_b}}{h_s + h_b} \]

\( s = \text{surface course} \)
\( b = \text{binder course} \)
Subgrade Modulus
Subgrade Modulus

South Carolina
(60°F MAAT)

Frozen Subgrade Modulus
50,000 psi

Normal Subgrade Modulus
4,000 psi
12,000 psi
22,500 psi

Thaw (Reduced) Subgrade Modulus
1,350 psi
7,200 psi
18,000 psi

Month Freeze Started
January

2 Months 1 4 Months 5 Months

Time

Month Freeze Started
January

12 Months
Asphalt Institute Method

FULL-DEPTH ASPHALT PAVEMENT

Asphalt Concrete Surface

Asphalt Concrete or Emulsified Asphalt Base

Subgrade

Not to Scale

(a) Full-Depth asphalt concrete and emulsified asphalt base pavements
Asphalt Institute Method

(b) Pavements with granular base
# Asphalt Institute Method

## TABLE VI-3 MINIMUM THICKNESS OF ASPHALT CONCRETE OVER UNTREATED AGGREGATE BASE

<table>
<thead>
<tr>
<th>Traffic EAL</th>
<th>Traffic Condition</th>
<th>Minimum Thickness of Asphalt Concrete</th>
</tr>
</thead>
<tbody>
<tr>
<td>$10^4$ or less</td>
<td>Light traffic parking lots, driveways and light rural roads</td>
<td>75mm (3.0 in.)*</td>
</tr>
<tr>
<td>Between $10^4$ &amp; $10^6$</td>
<td>Medium truck traffic</td>
<td>100mm (4.0 in.)</td>
</tr>
<tr>
<td>$10^6$ or more</td>
<td>Heavy truck traffic</td>
<td>125mm (5.0 in.) or greater</td>
</tr>
</tbody>
</table>

*For Full-Depth asphalt concrete or emulsified asphalt pavements a minimum thickness of 100mm (4 in.) applies in this traffic region, as shown on the design charts.*
Stage 1

Untreated Aggregate Base 12.0 In. Thickness

MAAT 60°F

Design Chart A-30
Stage 2

Untreated Aggregate Base 12.0 In. Thickness

MAAT 60°F

Subgrade Resilient Modulus, M*, psi

Equivalent 18,000-lb Single Axle Load (EAL)

Design Chart A-30

Total Asphalt Thickness

3 in. minimum

4 in. minimum

5 in.

6 in.

8 in.

9 in.

10 in.

12 in.

14 in.

16 in.

20 in.

10^0

10^1

10^2

10^3

10^4

10^5

10^6

10^7

10^8

10^9

10^10

10^11