

## January 2024 ERRATA for *Mechanistic–Empirical Pavement Design Guide*, 3rd Edition (MEPDG-3)

January 2024

Dear Customer:

AASHTO has issued a third erratum, which includes technical revisions, for the *Mechanistic–Empirical Pavement Design Guide*, 3rd Edition (MEPDG-3).

In the event that you need to download this file again, it can be found on AASHTO’s website at:

<https://downloads.transportation.org/MEPDG-3-Errata.pdf>

This erratum should be applied after the supplement.

The new changes in this erratum are detailed in the table under the “January 2024” heading. No special type style has been used in the text so that the content is easier to read; the “October 2023” changes were extensive. Pages with the new changes have a gray box in the page header reading as follows:

### January 2024 Errata

The previous changes are detailed in the table under the “October 2023” and “August 2022” headings. These pages have a gray box in the page header reading that may read one of three ways:

October 2023 Errata

October 2023 Errata  
August 2022 Errata

August 2022 Errata

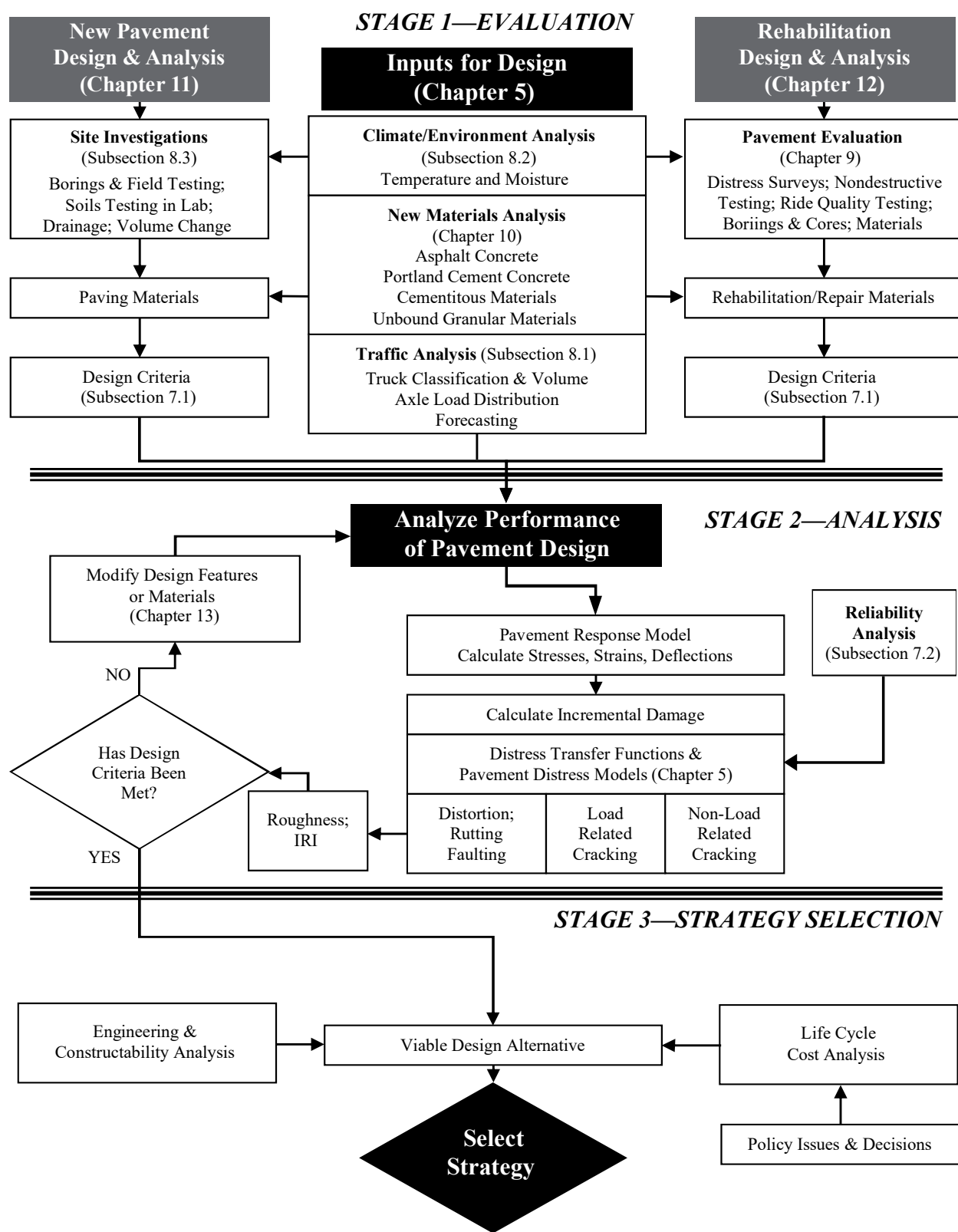
AASHTO staff sincerely apologizes for any inconvenience.

This page intentionally left blank.

List of Errata for *AASHTO Mechanistic–Empirical Pavement Design Guide, 3rd Edition (MEPDG-3)*

| Original Page       | Section           | Existing Text                                                                                                                                                                              | Corrected Text                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|---------------------|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>January 2024</b> |                   |                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 224                 | Table 13-3        | In row 1, column 2 on this page, the first bullet should be part of the note.                                                                                                              | <p>Table reads as follows:</p> <p><i>Note:</i> It is recommended to not use the surface-initiated crack prediction equation as a design criterion until the critical pavement response parameter and prediction methodology has been verified. Refer to Chapter 3.</p> <p>The cumulative damage and longitudinal cracking transfer function (Equations 5-5 and 5-8) should be used with caution when making design decisions (in terms of longitudinal cracking, or top-down cracking) regarding the adequacy of a trial design.</p> |
| <b>October 2023</b> |                   |                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| vi                  | Table P-1         | In the Coefficient of Thermal Expansion (CTE) row, AASHTOWare columns, the coefficients both are shown as 5.2.                                                                             | The coefficients both should be shown as 4.3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| viii                |                   | In the Calibration Coefficient in the Rigid Pavement Punchout Prediction Model rows, MEPDG version 1.1 column, the coefficients are shown as $A_{PO}$ , $\alpha_{PO}$ , and $\beta_{PO}$ . | The coefficients should be shown as $A_{PO}$ , $\alpha_{PO}$ , and $\beta_{PO}$ .                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| x                   | Table of Contents | Updated Chapter 5 page numbers to match corrected Chapter 5.                                                                                                                               | Section 5.3.4 is listed on page 55 and so on through 5.4.6, which is listed on page 84.2.                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| xiii–xiv            | List of Figures   | Updated Chapter 5 figure numbers and page numbers to match corrected Chapter 5.                                                                                                            | Figures 5-4 through 5-22 object and page numbers are correct.                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| xvii                | List of Tables    | Added missing Table 5-7 listing and updated Chapter 5 table page numbers to match corrected Chapter 5.                                                                                     | Table 5-2 is listed on page 54 and so on through Table 5-7, which is listed on page 64.                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| 3                   | Figure 1-1        | Under Inputs for Design, the Traffic Analysis box is missing a vertical connector line.                                                                                                    | Figure 1-1 is corrected as shown on the next page.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |

# List of Errata for AASHTO Mechanistic–Empirical Pavement Design Guide, 3rd Edition (MEPDG-3)



## List of Errata for *AASHTO Mechanistic–Empirical Pavement Design Guide*, 3rd Edition (MEPDG-3)

| Original Page       | Section   | Existing Text                                                                                                          | Corrected Text                                                                                                                                                                                                                                                                                 |
|---------------------|-----------|------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>October 2023</b> |           |                                                                                                                        |                                                                                                                                                                                                                                                                                                |
| 6                   | 1.2       | Step 3 following Figure 1-1 is missing a cautionary statement.                                                         | Step 3 has been revised to end with the following:<br><br><i>A caution to the designer</i> —Some of the input parameters are interrelated; changing one parameter may affect the value of another input parameter. The designer should use caution in making changes in individual parameters. |
| 41                  | Table 5-1 | In the Truck Traffic row, most column 1 content should be in column 2 and most column 2 content should be in column 3. | Table 5-1 has been revised as shown on the next page.                                                                                                                                                                                                                                          |
|                     |           | In the All Materials row, most column 1 content should be in column 2 and most column 2 content should be in column 3. |                                                                                                                                                                                                                                                                                                |
|                     |           | In the All Materials row, “capacitydentifce” should be “capacity, surface”.                                            |                                                                                                                                                                                                                                                                                                |

## List of Errata for *AASHTO Mechanistic–Empirical Pavement Design Guide*, 3rd Edition (MEPDG-3)

| Input Group         |                             | Input Parameter                                                            | Recalibration Input Level Used |
|---------------------|-----------------------------|----------------------------------------------------------------------------|--------------------------------|
| Truck Traffic       |                             | Axle load distributions (single, tandem, tridem)                           | Level 1                        |
|                     |                             | Truck volume distribution                                                  | Level 1                        |
|                     |                             | Lane and directional truck distributions                                   | Level 1                        |
|                     |                             | Tire pressure                                                              | Level 3, default               |
|                     |                             | Axle configuration, tire spacing                                           | Level 3, default               |
|                     |                             | Truck wander                                                               | Level 3, default               |
| Climate             |                             | Temperature, wind speed, cloud cover, precipitation, relative humidity     | Level 1 weather stations       |
| Material Properties | Unbound Layers and Subgrade | Resilient modulus—all unbound layers                                       | Level 1; backcalculation       |
|                     |                             | Classification and volumetric properties                                   | Level 1                        |
|                     |                             | Moisture-density relationships                                             | Level 1                        |
|                     |                             | Soil-water characteristic relationships                                    | Level 3, defaults              |
|                     |                             | Saturated hydraulic conductivity                                           | Level 3, defaults              |
|                     | AC                          | AC dynamic modulus                                                         | Level 3, defaults              |
|                     |                             | AC creep compliance and indirect tensile strength                          | Levels 1, 2, and 3             |
|                     |                             | Volumetric properties                                                      | Level 1                        |
|                     |                             | AC coefficient of thermal expansion                                        | Level 3, default               |
|                     | PCC                         | PCC elastic modulus                                                        | Level 1                        |
|                     |                             | PCC flexural strength                                                      | Level 1                        |
|                     |                             | PCC indirect tensile strength (CRCP only)                                  | Level 2                        |
|                     |                             | PCC coefficient of thermal expansion                                       | Level 1                        |
| All Materials       |                             | Unit weight                                                                | Level 1                        |
|                     |                             | Poisson’s ratio                                                            | Level 3, default               |
|                     |                             | Other thermal properties—conductivity, heat capacity, surface absorptivity | Level 3, defaults              |
| Existing Pavement   |                             | Condition of existing layers                                               | Levels 1 and 2                 |

List of Errata for *AASHTO Mechanistic–Empirical Pavement Design Guide, 3rd Edition (MEPDG-3)*

| Original Page       | Section  | Existing Text                                                                                                                                                     | Corrected Text                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|---------------------|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>October 2023</b> |          |                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 45                  | Eq. 5-2d | Equation 5-2d wrongly includes “= 0.0075”.                                                                                                                        | The correct equation is as follows:<br>$C_o = Ln\left(\frac{a_1 M_r^{b_1}}{a_9 M_r^{b_9}}\right)$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| 46–54               | 5.3.3    | The “Asphalt Concrete Layers” subsection has several errors and omissions, detailed below:                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|                     |          | <ul style="list-style-type: none"> <li>The first paragraph under “Asphalt Concrete Layers” is incorrect.</li> </ul>                                               | <p>The first paragraph has been revised as follows:</p> <p>Two types of load-related cracks are predicted by the MEPDG: alligator cracking and longitudinal cracking. The MEPDG assumes that alligator, or area cracks, initiate at the bottom of the AC layers and propagate to the surface with continued truck traffic, while longitudinal cracks are assumed to initiate at the surface.</p> <p><i>For bottom-up or alligator cracking:</i></p> <p>The allowable number of axle load applications needed for the incremental damage index approach to predict bottom-up cracks is shown in Equation 5-4a.</p> |
|                     |          | <ul style="list-style-type: none"> <li>Equation 5-4a is incorrect.</li> </ul>                                                                                     | <p>The equation reads as follows:</p> $N_{f-AC} = k_{f1}(C)(C_H)\beta_{f1}(\epsilon_t)^{-k_{f2}\beta_{f2}}(E_{AC})^{-k_{f3}\beta_{f3}}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|                     |          | <ul style="list-style-type: none"> <li>Following Equation 5-4d, the notation for <math>C_H</math> is incorrect, including row 2 column 2 of the table.</li> </ul> | <p>The notation reads as follows:</p> <p><math>C_H</math> = Thickness correction term</p> <p>...</p> $1/(-0.046908H_{AC}^3 + 0.729644H_{AC}^2 - 0.635578H_{AC} - 1.555892)$                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|                     |          | <ul style="list-style-type: none"> <li>Equations 5-4e and 5-4f should not be included.</li> </ul>                                                                 | Equations 5-4e and Equation 5-4f have been deleted. The subheader between them has been moved.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|                     |          | <ul style="list-style-type: none"> <li>In the paragraph before Equation 5-6a, “and length of longitudinal cracking” should not be included.</li> </ul>            | <p>The first sentence of the paragraph reads as follows:</p> <p>The area of alligator cracking is calculated from the total damage over time (Equation 5-5) using different transfer functions.</p>                                                                                                                                                                                                                                                                                                                                                                                                               |

List of Errata for *AASHTO Mechanistic–Empirical Pavement Design Guide, 3rd Edition (MEPDG-3)*

| Original Page       | Section     | Existing Text                                                                                                                                    | Corrected Text                                                                                                                                                                                                                 |
|---------------------|-------------|--------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>October 2023</b> |             |                                                                                                                                                  |                                                                                                                                                                                                                                |
| 46–54, cont'd.      |             | <ul style="list-style-type: none"> <li>The content from just below Figure 5-3 to just before the subheader “CTB Layers” is incorrect.</li> </ul> | The content from just below Figure 5-3 to just before the subheader “CTB Layers” has been replaced. The new content includes 12 equations, 3 figures, and 2 tables. Note: For easier legibility, content was not bolded.       |
| 54–84.4             | 5.3.3–5.4.6 | Equation, figure, and table numbers and their references are incorrect to the end of Chapter 5.                                                  | Equation, figure, and table numbers and their references have been corrected to the end of Chapter 5.                                                                                                                          |
| 57                  | 5.3.4       | Equations 5-12b, 5-12d, and 5-12f (now 5-14b, 5-14d, and 5-14f) are incorrect.                                                                   | <p>The equations read as follows:</p> $S_e \text{ (Level 1; } MAAT > 57^\circ F) = 0.14(TC) + 343$ $S_e \text{ (Level 2; } MAAT > 57^\circ F) = 0.20(TC) + 343$ $S_e \text{ (Level 3; } MAAT > 57^\circ F) = 0.2386(TC) + 343$ |
| 63                  | Table 5-2   | Table 5-2 (now Table 5-4) coefficients are incorrect.                                                                                            | Table 5-4 coefficients have been corrected as shown below in red.                                                                                                                                                              |

| Calibration Coefficients | Pavement Type |                     |                                       |            |                    |
|--------------------------|---------------|---------------------|---------------------------------------|------------|--------------------|
|                          | AC over AC    | AC over Intact JPCP | AC over Intact CRCP or Fractured JPCP | Semi-Rigid | AC over Semi-Rigid |
| $k_1$                    | 0.012         | 0.012               | 0.012                                 | 0.45       | 0.012              |
| $k_2$                    | 0.005         | 0.005               | 0.0002                                | 0.05       | 0.005              |
| $k_3$                    | 1.00          | 1.00                | 0.1                                   | 1.0        | 1.0                |
| $C_1$                    | 3.22          | 3.22                | 3.22                                  | 0.1        | 3.22               |
| $C_2$                    | 25.7          | 25.7                | 25.7                                  | 0.9809     | 25.7               |
| $C_3$                    | 0.1           | 0.1                 | 0.1                                   | 0.19       | 0.1                |
| $C_4$                    | 133.4         | 133.4               | 133.4                                 | 165.3      | 133.4              |
| $C_5$                    | -72.4         | -72.4               | -72.4                                 | -5.1048    | -72.4              |

| Original Page       | Section | Existing Text                                                                             | Corrected Text                                       |
|---------------------|---------|-------------------------------------------------------------------------------------------|------------------------------------------------------|
| <b>October 2023</b> |         |                                                                                           |                                                      |
| 67                  | 5.4.1   | The second variable in the where list for Equation 5-20a (now Equation 22a) is incorrect. | The variable reads as follows:<br>$n_{i,j,k}, \dots$ |

# List of Errata for AASHTO Mechanistic–Empirical Pavement Design Guide, 3rd Edition (MEPDG-3)

| Original Page       | Section    | Existing Text                                                                                       | Corrected Text                                                                                                                                                                                                                                                                                                                                                                                    |
|---------------------|------------|-----------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>October 2023</b> |            |                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                   |
| 74                  | 5.4.2      | In the paragraph before Equations 5-28a and 5-28b (now 5-30a and 5-30b), the variable is incorrect. | The correct variable is $\Delta s$ .                                                                                                                                                                                                                                                                                                                                                              |
| 78                  | 5.4.3      | Equation 5-33 (now 5-35) is incorrect.                                                              | The equation reads as follows:<br>$CW = \text{Max} \left[ L \left( \varepsilon_{shr} + \alpha_{PCC} \Delta T_{\zeta} - \frac{c_2 f_{\sigma long}}{E_{PCC}} \right) (C_c) 1000 \right]$                                                                                                                                                                                                            |
| 81                  | 5.4.4      | Equation 5-37 (now 5-39) is incorrect.                                                              | The equation reads as follows:<br>$LCRK = \frac{1}{1 + C_4 (DI_F)^{C_5}}$                                                                                                                                                                                                                                                                                                                         |
| 84                  | 5.4.5      | Equation 5-41a (now 5-43a) is incorrect.                                                            | The equation reads as follows:<br>$IRI = IRI_t + J1 * CRK + J2 * SPALL + J3 * TFAULT + J4 * SF$                                                                                                                                                                                                                                                                                                   |
| 146                 | Table 10-3 | In rows 1 and 2, columns 1 and 2 of Table 10-3, “EHMA” and “EAC” are incorrect.                     | The table shows “ $E_{HMA}$ ” and “ $E_{AC}$ ”.                                                                                                                                                                                                                                                                                                                                                   |
| 148                 |            | In the embedded table in row 1 of Table 10-3, “ $\mu_{typical}$ ” is incorrect.                     | The table shows “ $\mu_{typical}$ ”                                                                                                                                                                                                                                                                                                                                                               |
| 153                 | Table 10-5 | In Row 1 column 2 of Table 10-5, “ $T_z$ ” is incorrect.                                            | The table shows “ $T_z$ ”.                                                                                                                                                                                                                                                                                                                                                                        |
| 155                 | Table 10-7 | In Table 10-7, “ $E = 5700(f'_c)0.5$ ” is incorrect.                                                | The table shows the following:<br>$E = 5700(f'_c)^{0.5}$                                                                                                                                                                                                                                                                                                                                          |
| 157                 | Table 10-9 | In row 1, column 2 of Table 10-9, paragraph breaks are missing between the options.                 | Table reads as follows:<br><br>Two Options:<br><br>Regression coefficients $k_1$ , $k_2$ , $k_3$ for the generalized constitutive model that defines resilient modulus as a function of stress state and regressed from laboratory resilient modulus tests.<br><br>Determine the average design resilient modulus for the expected in-place stress state from laboratory resilient modulus tests. |
| 183                 | 12.2.4     | In the second to last paragraph of the subsection, the table callout is incorrect.                  | The callout is as follows:<br><br>(refer to Table 5-4 in Subsection 5.3.5).                                                                                                                                                                                                                                                                                                                       |
| 186                 | 12.2.8     | In the first paragraph of the subsection, the table callouts are incorrect.                         | The callouts are as follows:<br><br>The global calibration model coefficients are included in Tables 5-4 and 5-5.                                                                                                                                                                                                                                                                                 |

List of Errata for *AASHTO Mechanistic–Empirical Pavement Design Guide*, 3rd Edition (MEPDG-3)

| Original Page       | Section     | Existing Text                                                                                  | Corrected Text                                                                                                                                                                                                                                                                                                                                                                         |
|---------------------|-------------|------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>October 2023</b> |             |                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                        |
| 211                 | Table 12-13 | In row 1, Faulting, column 2, a bullet point is missing.                                       | <p>The following appears as the fourth of five bullets:</p> <ul style="list-style-type: none"> <li>• <b>Decrease joint spacing.</b> This is applicable to JPCP overlays over existing flexible pavements and unbonded JPCP overlays. Shorter joint spacing generally results in smaller joint openings, making aggregate interlock more effective and increasing joint LTE.</li> </ul> |
| 235                 | Index       | Page numbers; based on the original third edition.                                             | <p>Added the following at the top of the first index page:</p> <p><b>Note:</b> Index page numbers are based on the original third edition; they have not been updated to reflect any supplement of errata repagination.</p>                                                                                                                                                            |
| <b>August 2022</b>  |             |                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                        |
| 67                  | 5.4.2       | Equation 5-23c is incorrect.                                                                   | $FAULTMAX_i = FAULTMAX_{i-1} + C_7 \times \frac{\sum_{j=1}^m DE_j}{10^6} \times \text{Log}(1 + C_5 \times 5.0^{EROD})^{C_6}$                                                                                                                                                                                                                                                           |
| 74                  | 5.4.3       | Equation 5-30 is incorrect.                                                                    | $PO = \frac{C_3}{1 + C_4 (DI_{PO})^{C_5}}$                                                                                                                                                                                                                                                                                                                                             |
| 79                  | 5.4.4       | The equation and graph in Figure 5-19 are incorrect.                                           | The equation and graph in Figure 5-19 have been revised to match Equation 5-37.                                                                                                                                                                                                                                                                                                        |
| 127                 | 9.2.7       | At the end of Table 9-8's caption, add "(21)" (citing reference 21 in Chapter 2).              | <b>Table 9-8.</b> Models Relating Material Index and Strength Properties to $M_r$ (21)                                                                                                                                                                                                                                                                                                 |
|                     | Table 9-8   | In the R-value row of Table 9-8, delete "(22)".                                                | $M_r = 1155 + 555R$ $M_r, \text{ psi}$                                                                                                                                                                                                                                                                                                                                                 |
| 127                 | Table 9-8   | In the AASHTO layer coefficient row of Table 9-8, change "3000" to "30,000" and delete "(22)". | $M_r = 30,000 \left( \frac{a_i}{0.14} \right)$ $M_r, \text{ psi}$                                                                                                                                                                                                                                                                                                                      |
|                     |             | In the PI and gradation row of Table 9-8, delete "(See Appendix CC)".                          | $CBR = \frac{75}{1 + 0.278(P_{200}PI)}$                                                                                                                                                                                                                                                                                                                                                |

List of Errata for *AASHTO Mechanistic–Empirical Pavement Design Guide*, 3rd Edition (MEPDG-3)

| Original Page   | Section                                                 | Existing Text                                                                                                                                                                                                                                                                                    | Corrected Text                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                 |                                                         |          |     |        |     |         |     |        |     |         |     |        |     |          |     |           |     |           |     |           |     |                |     |
|-----------------|---------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|---------------------------------------------------------|----------|-----|--------|-----|---------|-----|--------|-----|---------|-----|--------|-----|----------|-----|-----------|-----|-----------|-----|-----------|-----|----------------|-----|
| August 2022     |                                                         |                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                 |                                                         |          |     |        |     |         |     |        |     |         |     |        |     |          |     |           |     |           |     |           |     |                |     |
| 152             | 10.4                                                    | In Table 10-5, the coefficient of thermal expansion values and the default are incorrect.                                                                                                                                                                                                        | <table><tr><th>Aggregates Type</th><th>Coefficient of Thermal Expansion (10<sup>-6</sup>/°F)</th></tr><tr><td>Andesite</td><td>4.3</td></tr><tr><td>Basalt</td><td>4.3</td></tr><tr><td>Diabase</td><td>4.6</td></tr><tr><td>Gabbro</td><td>4.4</td></tr><tr><td>Granite</td><td>4.7</td></tr><tr><td>Schist</td><td>4.4</td></tr><tr><td>Dolomite</td><td>5.0</td></tr><tr><td>Limestone</td><td>4.3</td></tr><tr><td>Quartzite</td><td>5.2</td></tr><tr><td>Sandstone</td><td>5.3</td></tr><tr><td>Expanded shale</td><td>4.5</td></tr></table> <p>Where coarse aggregate type is unknown, use MEPDG default value of 4.4*10<sup>-6</sup>/°F.</p> | Aggregates Type | Coefficient of Thermal Expansion (10 <sup>-6</sup> /°F) | Andesite | 4.3 | Basalt | 4.3 | Diabase | 4.6 | Gabbro | 4.4 | Granite | 4.7 | Schist | 4.4 | Dolomite | 5.0 | Limestone | 4.3 | Quartzite | 5.2 | Sandstone | 5.3 | Expanded shale | 4.5 |
| Aggregates Type | Coefficient of Thermal Expansion (10 <sup>-6</sup> /°F) |                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                 |                                                         |          |     |        |     |         |     |        |     |         |     |        |     |          |     |           |     |           |     |           |     |                |     |
| Andesite        | 4.3                                                     |                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                 |                                                         |          |     |        |     |         |     |        |     |         |     |        |     |          |     |           |     |           |     |           |     |                |     |
| Basalt          | 4.3                                                     |                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                 |                                                         |          |     |        |     |         |     |        |     |         |     |        |     |          |     |           |     |           |     |           |     |                |     |
| Diabase         | 4.6                                                     |                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                 |                                                         |          |     |        |     |         |     |        |     |         |     |        |     |          |     |           |     |           |     |           |     |                |     |
| Gabbro          | 4.4                                                     |                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                 |                                                         |          |     |        |     |         |     |        |     |         |     |        |     |          |     |           |     |           |     |           |     |                |     |
| Granite         | 4.7                                                     |                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                 |                                                         |          |     |        |     |         |     |        |     |         |     |        |     |          |     |           |     |           |     |           |     |                |     |
| Schist          | 4.4                                                     |                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                 |                                                         |          |     |        |     |         |     |        |     |         |     |        |     |          |     |           |     |           |     |           |     |                |     |
| Dolomite        | 5.0                                                     |                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                 |                                                         |          |     |        |     |         |     |        |     |         |     |        |     |          |     |           |     |           |     |           |     |                |     |
| Limestone       | 4.3                                                     |                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                 |                                                         |          |     |        |     |         |     |        |     |         |     |        |     |          |     |           |     |           |     |           |     |                |     |
| Quartzite       | 5.2                                                     |                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                 |                                                         |          |     |        |     |         |     |        |     |         |     |        |     |          |     |           |     |           |     |           |     |                |     |
| Sandstone       | 5.3                                                     |                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                 |                                                         |          |     |        |     |         |     |        |     |         |     |        |     |          |     |           |     |           |     |           |     |                |     |
| Expanded shale  | 4.5                                                     |                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                 |                                                         |          |     |        |     |         |     |        |     |         |     |        |     |          |     |           |     |           |     |           |     |                |     |
| 207             | 12.3.4                                                  | <i>Performance Prediction Models</i><br>The globally calibrated performance models for new pavements apply to rehabilitation design, but with one exception—the JPCP CPR faulting prediction model has slightly different coefficients than the corresponding one for new or reconstructed JPCP. | <i>Performance Prediction Models</i><br>The globally calibrated performance models for new pavements apply to rehabilitation design.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                 |                                                         |          |     |        |     |         |     |        |     |         |     |        |     |          |     |           |     |           |     |           |     |                |     |

List of Errata for *AASHTO Mechanistic–Empirical Pavement Design Guide, 3rd Edition (MEPDG-3)*

| Original Page      | Section | Existing Text                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Corrected Text                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|--------------------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>August 2022</b> |         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| 209                | 12.3.4  | <p>In the JPCP overlay over existing flexible pavement row of Table 12-12, the recommendations read as follows:</p> <p>Selection of design features for the JPCP overlay (including shoulder type and slab width) is similar to that outlined for new or reconstructed design in Chapter 10. Condition of existing flexible pavement is rated as Excellent, Good, Fair, Poor, or Very Poor, as defined in Table 12-10. These ratings will result in adjustments to the dynamic modulus, <math>E_{HMA}</math>, of the existing AC layer that now becomes the base course. Full friction should be input over the full design life of the concrete overlay.</p> | <p>The corrected recommendations read as follows:</p> <p>Selection of design features for the JPCP overlay (including shoulder type and slab width) is similar to that outlined for new or reconstructed design in Chapter 10. Condition of existing flexible pavement is characterized using one of the three hierarchical input levels:</p> <ul style="list-style-type: none"> <li>• Level 1 rehabilitation calculates the existing damage based on the FWD back-calculated modulus.</li> <li>• Level 2 calculates the damage based on the existing fatigue cracking from a visual distress survey.</li> <li>• Level 3 calculates the damage based on a condition rating as Excellent, Good, Fair, Poor, or Very Poor, as defined in Table 12-10.</li> </ul> <p>For all rehabilitation levels, the dynamic modulus, <math>E_{HMS}</math>, is adjusted to reflect the magnitude of damage within the existing asphalt layers. The existing AC layer now becomes the base course in the analysis mod. Full friction should be input over the full design life of the concrete overlay.</p> |

## Preface

This document or manual of practice describes a pavement design methodology that is based on engineering mechanics and has been validated with extensive road test performance data. This methodology is termed mechanistic-empirical (ME) pavement design, and it represents a major change from the pavement design methods in practice today.

Interested agencies have already begun implementation activities through staff training, collection of input data (materials library, traffic library, etc.), acquiring of test equipment, and preparation of field sections for local calibration. This manual, referred to as the Mechanistic-Empirical Pavement Design Guide (MEPDG), presents the information necessary for pavement design engineers to start using the ME-based design and analysis method. The software supporting this method is called Pavement ME Design® and is commercially available through AASHTOWare. The software is referred to in this document as PMED.

Multiple enhancements have been made to the AASHTOWare PMED based on completed research projects sponsored by the National Cooperative Highway Research Program (NCHRP) and the Federal Highway Administration (FHWA). In addition, revisions to the software were based on evaluations performed by State Highway Agencies and others in the Community of Practice. The third edition of the MEPDG Manual of Practice was prepared so the manual was consistent with the enhanced features and models included in the software through 2018.

The following table (Table P-1) summarizes the key differences noted between the format and calibration factors used in the MEPDG version 1.1 software, the AASHTOWare Pavement ME Design software version 2.3.1, and version 2.5.3 software.

**Table P-1.** Summary of Key Differences in Software Format and Calibration Factors

| Format, Transfer Functions, and Calibration Coefficients                                             |                     | MEPDG version 1.1                                                    | AASHTOWare Pavement ME Design version 2.3.1                                       | AASHTOWare Pavement ME Design version 2.5.3                                                                                    |
|------------------------------------------------------------------------------------------------------|---------------------|----------------------------------------------------------------------|-----------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|
| Output Format                                                                                        |                     | Excel-based                                                          | PDF- and Excel-based                                                              | PDF- and Excel-based                                                                                                           |
| Climatic Input Data and if Included in Output Summary                                                |                     | Data from Ground-Based Weather Stations; output summary not included | Data from NARR database for rigid and flexible pavements; output summary included | Data from NARR database for rigid pavements and MERRA2 database for flexible and semi-rigid pavements; output summary included |
| Axle Configuration Data in Output Summary                                                            |                     | Not included                                                         | Included                                                                          | Included                                                                                                                       |
| Special Axle Load Configuration                                                                      |                     | Included                                                             | Not included                                                                      | Not included                                                                                                                   |
| Reflection Cracking Transfer Function                                                                |                     | Empirical regression equation included                               | ME-based fracture mechanics model included                                        | ME-based fracture mechanics model included                                                                                     |
| Coefficient of Thermal Expansion (CTE)                                                               |                     | CTE for Basalt of 4.6                                                | CTE for Basalt of 4.3                                                             | CTE for Basalt of 4.3                                                                                                          |
| PCC Zero Stress Temperature                                                                          |                     | PCC Zero Stress Temperature (60°–120°F)                              | PCC Set Temperature (70°–212°F)                                                   | PCC Set Temperature (70°–212°F)                                                                                                |
| Heat Capacity of Asphalt Pavement                                                                    |                     | Default value of 0.23 BTU/lb-°F                                      | Default value of 0.28 BTU/lb-°F                                                   | Default value of 0.28 BTU/lb-°F                                                                                                |
| Thermal Conductivity of Asphalt Pavement                                                             |                     | Default value of 0.67 BTU/(ft)(hr)(F)                                | Default value of 1.25 BTU/(ft)(hr)(F)                                             | Default value of 1.25 BTU/(ft)(hr)(F)                                                                                          |
| Surface Shortwave Absorptivity                                                                       |                     | Default value of 0.95                                                | Default value of 0.85                                                             | Default value of 0.85                                                                                                          |
| Global Model Coefficient for Unbound Materials and Soils in Flexible Pavement Subgrade Rutting Model | Aggregate Base      | $k_{s1}$ of 1.673                                                    | $k_{s1}$ of 2.03                                                                  | $k_{s1}$ of 0.965                                                                                                              |
|                                                                                                      | Coarse-Grained Soil |                                                                      |                                                                                   | $k_{s1}$ of 0.965                                                                                                              |
|                                                                                                      | Sand Soil           |                                                                      |                                                                                   | $k_{s1}$ of 0.635                                                                                                              |
|                                                                                                      | Fine-Grained Soil   | $k_{s1}$ of 1.35                                                     | $k_{s1}$ of 1.35                                                                  | $k_{s1}$ of 0.675                                                                                                              |

Continued on next page.

**Table P-1.** Summary of Key Differences in Software Format and Calibration Factors, *continued*

| Format, Transfer Functions, and Calibration Coefficients                                                                          |                     | MEPDG<br>version 1.1   | AASHTOWare<br>Pavement ME<br>Design<br>version 2.3.1 | AASHTOWare<br>Pavement ME<br>Design<br>version 2.5.3                            |
|-----------------------------------------------------------------------------------------------------------------------------------|---------------------|------------------------|------------------------------------------------------|---------------------------------------------------------------------------------|
| Global Local Calibration or Field Adjustment Constant for Unbound Materials and Soils in Flexible Pavement Subgrade Rutting Model | Aggregate Base      | 1.0                    | 1.0                                                  | 1.0                                                                             |
|                                                                                                                                   | Coarse-Grained Soil |                        |                                                      | 1.0                                                                             |
|                                                                                                                                   | Sand Soil           |                        |                                                      | 1.0                                                                             |
|                                                                                                                                   | Fine-Grained Soil   |                        |                                                      | 1.0                                                                             |
| Global Laboratory-Derived Model Coefficients in the Fatigue Cracking Prediction Model in Flexible Pavement                        |                     | $k_{s1}$ of 0.007566   | $k_{s1}$ of 0.007566                                 | $k_{s1}$ of 3.75                                                                |
|                                                                                                                                   |                     | $k_{s2}$ of -3.9492    | $k_{s2}$ of 3.9492                                   | $k_{s2}$ of 2.87                                                                |
|                                                                                                                                   |                     | $k_{s3}$ of -1.281     | $k_{s3}$ of 1.281                                    | $k_{s3}$ of 1.46                                                                |
| Global Local Calibration or Field-Adjustment Constants for Fatigue Cracking Prediction Model in Flexible Pavement                 |                     | $\beta_1$ of 1.0       | $\beta_1$ of 1.0                                     | AC thickness dependent; see Chapter 5                                           |
|                                                                                                                                   |                     | $\beta_2$ of 1.0       | $\beta_2$ of 1.0                                     | $\beta_2$ of 1.38                                                               |
|                                                                                                                                   |                     | $\beta_3$ of 1.0       | $\beta_3$ of 1.0                                     | $\beta_3$ of 0.88                                                               |
| Global Bottom-Up Alligator Cracking Transfer Function Coefficients                                                                |                     | $C_1$ of 1.0           | $C_1$ of 1.0                                         | 1.31                                                                            |
|                                                                                                                                   |                     | $C_2$ of 1.0           | $C_2$ of 1.0                                         | AC thickness dependent; see Chapter 5                                           |
| Global Calibration or Field-Adjustment Coefficient in the Transverse Cracking Model for AC                                        |                     | $k_t$ (Level 1) of 5.0 | $k_t$ (Level 1) of 1.5                               | $k_s$ (Level 1) is Mean Annual Air Temperature (MAAT) dependent; see Chapter 5. |
|                                                                                                                                   |                     | $k_t$ (Level 2) of 1.5 | $k_t$ (Level 2) of 0.5                               | $k_s$ (Level 2) is MAAT dependent; see Chapter 5.                               |
|                                                                                                                                   |                     | $k_t$ (Level 3) of 3.0 | $k_t$ (Level 3) of 1.5                               | $k_s$ (Level 3) is MAAT dependent; see Chapter 5.                               |
| Global Laboratory Derived Model Coefficients in the Rut Depth Prediction Model                                                    |                     | $k_1$ of -3.35412      | $k_1$ of -3.35412                                    | $k_1$ of -2.45                                                                  |
|                                                                                                                                   |                     | $k_{2r}$ of 0.4791     | $k_2$ of 1.5606                                      | $k_2$ of 3.01                                                                   |
|                                                                                                                                   |                     | $k_{3r}$ of 1.5606     | $k_3$ of 0.4791                                      | $k_3$ of 0.22                                                                   |

Continued on next page.

**Documents**

Document Sharing Hub

**Table P-1.** Summary of Key Differences in Software Format and Calibration Factors, *continued*

| Format, Transfer Functions, and Calibration Coefficients                                    | MEPDG version 1.1         | AASHTOWare Pavement ME Design version 2.3.1 | AASHTOWare Pavement ME Design version 2.5.3 |
|---------------------------------------------------------------------------------------------|---------------------------|---------------------------------------------|---------------------------------------------|
| Global Local Calibration or Field Adjustment Coefficients in the Rut Depth Prediction Model | $\beta_1$ of 1.0          | $\beta_1$ of 1.0                            | $\beta_1$ of 0.40                           |
|                                                                                             | $\beta_2$ of 1.0          | $\beta_2$ of 1.0                            | $\beta_2$ of 0.52                           |
|                                                                                             | $\beta_3$ of 1.0          | $\beta_3$ of 1.0                            | $\beta_3$ of 1.36                           |
| Calibration Coefficients in the Rigid Pavement Cracking Prediction Model                    | $C_4$ of 1.0              | $C_4$ of 0.52                               | $C_4$ of 0.52                               |
|                                                                                             | $C_5$ of -1.98            | $C_5$ of -2.17                              | $C_5$ of -2.17                              |
| Calibration Coefficients in the Rigid Pavement Faulting Prediction Model                    | $C_1$ of 1.29             | $C_1$ of 1.0184                             | $C_1$ of 0.595                              |
|                                                                                             | $C_2$ of 1.1              | $C_2$ of 0.91656                            | $C_2$ of 1.636                              |
|                                                                                             | $C_3$ of 0.001725         | $C_3$ of 0.0021848                          | $C_3$ of 0.00217                            |
|                                                                                             | $C_4$ of 0.0008           | $C_4$ of 0.0008837                          | $C_4$ of 0.00444                            |
|                                                                                             | $C_6$ of 0.4              | $C_6$ of 0.47                               | $C_6$ of 0.47                               |
|                                                                                             | $C_7$ of 1.2              | $C_7$ of 1.83312                            | $C_7$ of 7.3                                |
| Calibration Coefficient in the Rigid Pavement Punchout Prediction Model                     | $A_{PO}$ of 195.789       | $C_3$ of 107.73                             | $C_3$ of 107.73                             |
|                                                                                             | $\alpha_{PO}$ of 19.8947  | $C_4$ of 2.476                              | $C_4$ of 2.475                              |
|                                                                                             | $\beta_{PO}$ of -0.526316 | $C_5$ of -0.785                             | $C_5$ of -0.785                             |
| Calibration Coefficients in the Short JPCP Overlay Longitudinal Cracking Prediction Model   | Excluded                  | $C_4$ of 0.4                                | $C_4$ of 0.4                                |
|                                                                                             |                           | $C_5$ of -2.21                              | $C_5$ of -2.21                              |

# Table of Contents

|                                                                                     |      |
|-------------------------------------------------------------------------------------|------|
| Committee on Materials and Pavement Technical Subcommittee 5d on Pavement Design .. | iii  |
| Preface .....                                                                       | v    |
| List of Figures .....                                                               | xiii |
| List of Tables .....                                                                | xvii |

|                                                                                                                                     |           |
|-------------------------------------------------------------------------------------------------------------------------------------|-----------|
| <b>1. Introduction .....</b>                                                                                                        | <b>1</b>  |
| 1.1 Purpose of Manual .....                                                                                                         | 1         |
| 1.2 Overview of the Design Procedure .....                                                                                          | 1         |
| <b>2. Referenced Documents and Standards .....</b>                                                                                  | <b>11</b> |
| 2.1 Test Protocols and Standards .....                                                                                              | 11        |
| 2.1.1 Laboratory Materials Characterization .....                                                                                   | 11        |
| 2.1.2 In-Place Materials/Pavement Layer Characterization .....                                                                      | 13        |
| 2.2 Material Specifications .....                                                                                                   | 13        |
| 2.3 Recommended Practices and Terminology .....                                                                                     | 13        |
| 2.4 Referenced Documents .....                                                                                                      | 14        |
| <b>3. Significance and Use of the MEPDG .....</b>                                                                                   | <b>17</b> |
| 3.1 MEPDG Performance Indicators .....                                                                                              | 17        |
| 3.2 MEPDG General Design Approach .....                                                                                             | 18        |
| 3.3 New Flexible Pavement and AC Overlay Design Strategies Applicable<br>to the MEPDG .....                                         | 20        |
| 3.4 New Rigid Pavement, PCC Overlay, and Restoration of Rigid Pavement Design<br>Strategies Applicable for Use with the MEPDG ..... | 23        |
| 3.5 Design Features and Factors Not Included within the MEPDG Process .....                                                         | 27        |
| <b>4. Terminology and Definition of Terms .....</b>                                                                                 | <b>31</b> |
| 4.1 General Terms .....                                                                                                             | 31        |
| 4.2 Hierarchical Input Levels .....                                                                                                 | 33        |
| 4.3 Truck Traffic Terms .....                                                                                                       | 33        |
| 4.4 Smoothness .....                                                                                                                | 34        |
| 4.5 Distresses or Performance Indicators Terms—AC-Surfaced Pavements .....                                                          | 35        |
| 4.6 Distress or Performance Indicators Terms—PCC-Surfaced Pavements .....                                                           | 36        |
| <b>5. Performance Indicator Prediction Methodologies .....</b>                                                                      | <b>39</b> |
| 5.1 Selecting the Input Levels .....                                                                                                | 39        |
| 5.2 Calibration Factors .....                                                                                                       | 40        |
| 5.3 Distress Prediction Equations for Flexible Pavements and AC Overlays .....                                                      | 40        |
| 5.3.1 Overview of Computational Methodology for Predicting Distress .....                                                           | 40        |
| 5.3.2 Rut Depth .....                                                                                                               | 43        |
| 5.3.3 Load-Related Cracking .....                                                                                                   | 46        |

|           |                                                                                              |            |
|-----------|----------------------------------------------------------------------------------------------|------------|
| 5.3.4     | Non-Load Related Cracking—Transverse Cracking .....                                          | 55         |
| 5.3.5     | Reflection Cracking in AC Overlays and AC Layers of Semi-Rigid Pavements .                   | 59         |
| 5.3.6     | Smoothness.....                                                                              | 65         |
| 5.4       | Distress Prediction Equations for Rigid Pavements and PCC Overlays .....                     | 67         |
| 5.4.1     | Transverse Slab Cracking (Bottom-Up and Top-Down)—JPCP .....                                 | 67         |
| 5.4.2     | Mean Transverse Joint Faulting—JPCP .....                                                    | 70         |
| 5.4.3     | CRCP Punchouts.....                                                                          | 77         |
| 5.4.4     | Longitudinal Slab Cracking—SJPCP on Flexible Pavements.....                                  | 80         |
| 5.4.5     | Smoothness—JPCP .....                                                                        | 84         |
| 5.4.6     | Smoothness—CRCP .....                                                                        | 84.2       |
| <b>6.</b> | <b>General Project Information.....</b>                                                      | <b>85</b>  |
| 6.1       | Design/Analysis Life.....                                                                    | 85         |
| 6.2       | Construction and Traffic Opening Dates.....                                                  | 85         |
| <b>7.</b> | <b>Selecting Design Criteria and Reliability Level .....</b>                                 | <b>87</b>  |
| 7.1       | Recommended Design-Performance Criteria .....                                                | 87         |
| 7.2       | Reliability .....                                                                            | 88         |
| 7.3       | Design Reliability Concept for Smoothness (IRI) .....                                        | 90         |
| <b>8.</b> | <b>Determining Site Conditions and Factors.....</b>                                          | <b>93</b>  |
| 8.1       | Truck Traffic.....                                                                           | 93         |
| 8.1.1     | Roadway-Specific Inputs.....                                                                 | 95         |
| 8.1.2     | Inputs Extracted from WIM Data .....                                                         | 96         |
| 8.1.3     | Truck Traffic Inputs Not Included in the WIM Data .....                                      | 101        |
| 8.2       | Climate .....                                                                                | 102        |
| 8.3       | Foundation and Subgrade Soils.....                                                           | 103        |
| 8.3.1     | Subsurface Investigations for Pavement Design.....                                           | 103        |
| 8.3.2     | Laboratory and Field Tests of Soils for Pavement Design .....                                | 105        |
| 8.4       | Existing Pavements .....                                                                     | 105        |
| <b>9.</b> | <b>Pavement Evaluation for Rehabilitation Design.....</b>                                    | <b>109</b> |
| 9.1       | Overall Condition Assessment and Problem Definition Categories.....                          | 109        |
| 9.2       | Data Collection to Define Condition Assessment .....                                         | 113        |
| 9.2.1     | Initial Pavement Assessment .....                                                            | 117        |
| 9.2.2     | Prepare Field Evaluation Plan .....                                                          | 118        |
| 9.2.3     | Conduct Condition or Visual Survey .....                                                     | 118        |
| 9.2.4     | Ground Penetrating Radar Survey .....                                                        | 122        |
| 9.2.5     | Refine Field Testing Plan .....                                                              | 122        |
| 9.2.6     | Conduct Deflection Basin Tests.....                                                          | 122        |
| 9.2.7     | Destructive Sampling and Testing—Recover Cores and Boring<br>for the Existing Pavement ..... | 124        |
| 9.2.8     | Laboratory Tests for Materials Characterization of Existing Pavements.....                   | 128        |

## List of Figures

|              |                                                                                                                                                 |    |
|--------------|-------------------------------------------------------------------------------------------------------------------------------------------------|----|
| Figure 1-1.  | Conceptual Flow Chart of the Three-Stage Design/Analysis Process for AASHTOWare PMED .....                                                      | 3  |
| Figure 1-2.  | Typical Differences between Empirical Design Procedures and an Integrated ME Design System, in Terms of AC Mixture Characterization .....       | 4  |
| Figure 1-3.  | Typical Differences between Empirical Design Procedures and an Integrated ME Design System, in Terms of PCC-Mixture Characterization. ....      | 5  |
| Figure 1-4.  | Flow Chart of the Steps That Are More Policy Decision Related and Needed to Complete an Analysis of a Trial Design Strategy .....               | 7  |
| Figure 1-5.  | Flow Chart of the Steps Needed to Complete an Analysis of a Trial Design Strategy. ....                                                         | 8  |
| Figure 3-1.  | New (Including Lane Reconstruction) Flexible Pavement Design Strategies That Can Be Simulated with the AASHTOWare PMED .....                    | 21 |
| Figure 3-2.  | AC Overlay Design Strategies of Flexible, Semi-Rigid, and Rigid Pavements That Can Be Simulated with the AASHTOWare PMED .....                  | 21 |
| Figure 3-3.  | New (Including Lane Reconstruction) Rigid Pavement Design Strategies That Can Be Simulated with the AASHTOWare PMED .....                       | 25 |
| Figure 3-4.  | PCC Overlay Design Strategies of Flexible, Semi-Rigid, and Rigid Pavements That Can Be Simulated with the AASHTOWare PMED .....                 | 26 |
| Figure 5-1.  | Graphical Illustration of the Five Temperature Quintiles Used in the MEPDG to Determine AC Mixture Properties for Load Related Distresses. .... | 42 |
| Figure 5-2.  | Comparison of Measured and Predicted Total Rutting Resulting from Global Calibration Process. ....                                              | 46 |
| Figure 5-3.  | Comparison of Cumulative Fatigue Damage and Alligator Cracking Resulting from Global Calibration Process. ....                                  | 49 |
| Figure 5-4.  | Mechanisms of Thermally Induced Reflective Cracks of Asphalt Overlays .....                                                                     | 50 |
| Figure 5-5a. | Measured versus Predicted Number of Days to Crack Initiation .....                                                                              | 53 |
| Figure 5-5b. | Measured versus Predicted Area of Top-Down Cracking. ....                                                                                       | 53 |
| Figure 5-6.  | Comparison of Measured and Predicted Transverse Cracking Resulting from Global Calibration Process. ....                                        | 58 |
| Figure 5-7.  | Response Mechanisms Used in Reflection Cracking Prediction Methodology ....                                                                     | 59 |
| Figure 5-8.  | Mechanisms of Thermally Induced Reflective Cracks of AC Overlays .....                                                                          | 60 |
| Figure 5-9.  | Mechanisms of Traffic Induced Reflective Cracks of AC Overlays .....                                                                            | 60 |

|              |                                                                                                                                                                                                                                                          |      |
|--------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| Figure 5-10. | Comparison of Measured and Predicted IRI Values Resulting from Global Calibration Process of Flexible Pavements and AC Overlays of Flexible Pavements .....                                                                                              | 66   |
| Figure 5-11. | Comparison of Measured and Predicted IRI Values Resulting from Global Calibration Process of AC Overlays of PCC Pavements and Semi-Rigid Pavements .....                                                                                                 | 66   |
| Figure 5-12. | Comparison of Measured and Predicted Percentage JPCP Slabs Cracked Resulting from Global Calibration Process.....                                                                                                                                        | 69   |
| Figure 5-13. | Comparison of Measured and Predicted Transverse Cracking of Unbounded JPCP Overlays Resulting from Global Calibration Process .....                                                                                                                      | 69   |
| Figure 5-14. | Comparison of Measured and Predicted Transverse Cracking for Restored JPCP Resulting from Global Calibration Process.....                                                                                                                                | 70   |
| Figure 5-15. | Comparison of Measured and Predicted Transverse Joint Faulting for New JPCP Resulting from Global Calibration Process.....                                                                                                                               | 76   |
| Figure 5-16. | Comparison of Measured and Predicted Transverse Joint Faulting for Unbound JPCP Overlays Resulting from Global Calibration Process .....                                                                                                                 | 76   |
| Figure 5-17. | Comparison of Measured and Predicted Transverse Joint Faulting for Restored (Diamond Grinding) JPCP Resulting from Global Calibration Process .....                                                                                                      | 77   |
| Figure 5-18. | Comparison of Measured and Predicted Punchouts for New CRCP Resulting from Global Calibration Process.....                                                                                                                                               | 80   |
| Figure 5-19. | Illustration of Proper Location of Longitudinal Joints to Avoid Overlap with Truck Wheel Paths (to Avoid Corner Cracking) and the Resulting Critical Bending Stresses at Bottom of Slab That Are Considered to Limit Longitudinal Fatigue Cracking ..... | 81   |
| Figure 5-20. | Measured Longitudinal Fatigue Cracking (LCRK) versus PCC Fatigue Damage (DIF) at Bottom of PCC Slab .....                                                                                                                                                | 83   |
| Figure 5-21. | Comparison of Measured and Predicted Percentage SJPCP Overlay Slabs Longitudinally Cracked Resulting from Global Calibration Process.....                                                                                                                | 83   |
| Figure 5-22. | Comparison of Measured and Predicted IRI Values for New JPCP Resulting from Global Calibration Process.....                                                                                                                                              | 84.2 |
| Figure 7-1.  | Design Reliability Concept for Smoothness (IRI).....                                                                                                                                                                                                     | 89   |
| Figure 8-1.  | Comparison of the Five NALS Defaults for Vehicle Class 9 Tandem Axles—Entire Range of Axle Loads.....                                                                                                                                                    | 98   |
| Figure 8-2.  | Comparison of the Five NALS Defaults for Vehicle Class 9 Tandem Axles—Axle Loads between 32,000–50,000 lb.....                                                                                                                                           | 98   |
| Figure 9-1.  | Steps and Activities for Assessing Condition of Existing Pavements for Rehabilitation Design (Refer to Table 9-2).....                                                                                                                                   | 114  |

## List of Tables

|            |                                                                                                                                                               |     |
|------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| Table P-1. | Summary of Key Differences in Software Format and Calibration Factors . . . . .                                                                               | vi  |
| Table 5-1. | Typical Input Levels Used in the Global Calibration of the AASHTOWare<br>PMED Models and Transfer Functions . . . . .                                         | 41  |
| Table 5-2. | Calibration Parameters $\alpha_1$ and $\alpha_2$ ; Global Coefficients . . . . .                                                                              | 54  |
| Table 5-3. | Calibration Parameters for Crack Initiation Time, $t_0$ ; Global Coefficients . . . . .                                                                       | 54  |
| Table 5-4. | Global Calibration Coefficients for the Reflection Cracking Transfer Functions<br>for Transverse Cracks . . . . .                                             | 63  |
| Table 5-5. | Global Calibration Coefficients for the Reflection Cracking Transfer Functions<br>for Fatigue Cracks . . . . .                                                | 64  |
| Table 5-6. | Standard Deviation Equations for the Transverse Cracks . . . . .                                                                                              | 64  |
| Table 5-7. | Standard Deviation Equations for the Fatigue Cracks . . . . .                                                                                                 | 64  |
| Table 5-8. | Assumed Effective Base LTE for Different Base Types . . . . .                                                                                                 | 73  |
| Table 7-1. | Design Criteria or Threshold Values Recommended for Use in Judging the<br>Acceptability of a Trial Design . . . . .                                           | 88  |
| Table 7-2. | Suggested Minimum Levels of Reliability for Different Functional<br>Classifications of the Roadway . . . . .                                                  | 91  |
| Table 8-1. | Minimum Sample Size (Number of Days per Year) to Estimate the Normalized<br>Axle Load Distribution—WIM Data . . . . .                                         | 94  |
| Table 8-2. | Minimum Sample Size (Number of Days per Season) to Estimate the<br>Normalized Truck Traffic Distribution—Automated Vehicle Classifier<br>(AVC) Data . . . . . | 94  |
| Table 8-3. | Normalized Axle Load Distribution Included with the AASHTOWare PMED<br>Software . . . . .                                                                     | 97  |
| Table 8-4. | TTC Group Description and Corresponding Truck Class Distribution Default<br>Values Included in the AASHTOWare PMED Software . . . . .                         | 100 |
| Table 8-5. | Definitions and Descriptions for the TTC Groups . . . . .                                                                                                     | 101 |
| Table 8-6. | Summary of Soil Characteristics as a Pavement Material . . . . .                                                                                              | 106 |
| Table 9-1. | Checklist of Factors for Overall Pavement Condition Assessment and Problem<br>Definition . . . . .                                                            | 111 |
| Table 9-2. | Hierarchical Input Levels for a Pavement Evaluation Program to Determine<br>Inputs for Existing Pavement Layers for Rehabilitation Design . . . . .           | 115 |
| Table 9-3. | Field Data Collection and Evaluation Plan . . . . .                                                                                                           | 119 |

|              |                                                                                                                                                           |     |
|--------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| Table 9-4.   | Guidelines for Obtaining Non-Materials Input Data for Pavement Rehabilitation .....                                                                       | 120 |
| Table 9-5.   | Use of Deflection Basin Test Results for Selecting Rehabilitation Strategies and in Estimating Inputs for Rehabilitation Design .....                     | 123 |
| Table 9-6.   | Summary of Destructive Tests, Procedures, and Inputs for the MEPDG .....                                                                                  | 125 |
| Table 9-7.   | Models/Relationships Used for Determining Level 2 $E$ or $M_r$ .....                                                                                      | 126 |
| Table 9-8.   | Models Relating Material Index and Strength Properties to $M_r$ .....                                                                                     | 127 |
| Table 9-9.   | Distress Types and Severity Levels Recommended for Assessing Rigid Pavement Structural Adequacy.....                                                      | 131 |
| Table 9-10.  | Distress Types and Levels Recommended for Assessing Current Flexible Pavement Structural Adequacy.....                                                    | 132 |
| Table 9-11.  | LTE Values for Rehabilitation Design.....                                                                                                                 | 136 |
| Table 9-12.  | LTE Default Values for Input Level 3 Tied to Crack Severity Level.....                                                                                    | 136 |
| Table 10-1.  | Major Material Types for the MEPDG.....                                                                                                                   | 140 |
| Table 10-2.  | Asphalt Materials and the Test Protocols for Measuring the Material Property Inputs for New and Existing AC Layers, Input Level 1.....                    | 141 |
| Table 10-3.  | Recommended Input Parameters and Values; Limited or No Testing Capabilities for AC (Input Levels 2 and/or 3) .....                                        | 146 |
| Table 10-4.  | PCC Material Input Level 1 Parameters and Test Protocols for New and Existing PCC.....                                                                    | 150 |
| Table 10-5.  | Recommended Input Parameters and Values; Limited or No Test Capabilities for PCC Materials (Input Levels 2 or 3) .....                                    | 151 |
| Table 10-6.  | Chemically Stabilized Materials Input Level 1 Requirements and Test Protocols for New and Existing Chemically Stabilized Materials .....                  | 154 |
| Table 10-7.  | Recommended Input Levels 2 and 3 Parameters and Values for Chemically Stabilized Material Properties.....                                                 | 155 |
| Table 10-8.  | C-Values to Convert the Calculated Layer Modulus Values to an Equivalent Resilient Modulus Measured in the Laboratory.....                                | 156 |
| Table 10-9.  | Unbound Aggregate Base, Subbase, Embankment, and Subgrade Soil Input Level 1 Material Requirements and Test Protocols for New and Existing Materials..... | 157 |
| Table 10-10. | Recommended Levels 2 and 3 Input Parameters and Values for Unbound Aggregate Base, Subbase, Embankment, and Subgrade Soil Material Properties...          | 158 |
| Table 11-1.  | General IRI Recommendations .....                                                                                                                         | 167 |
| Table 11-2.  | Friction Coefficient Values for CRCP Design .....                                                                                                         | 172 |
| Table 12-1.  | Definitions of Surface Condition for Input Level 3 Pavement Condition Ratings and Suggested Rehabilitation Options .....                                  | 180 |

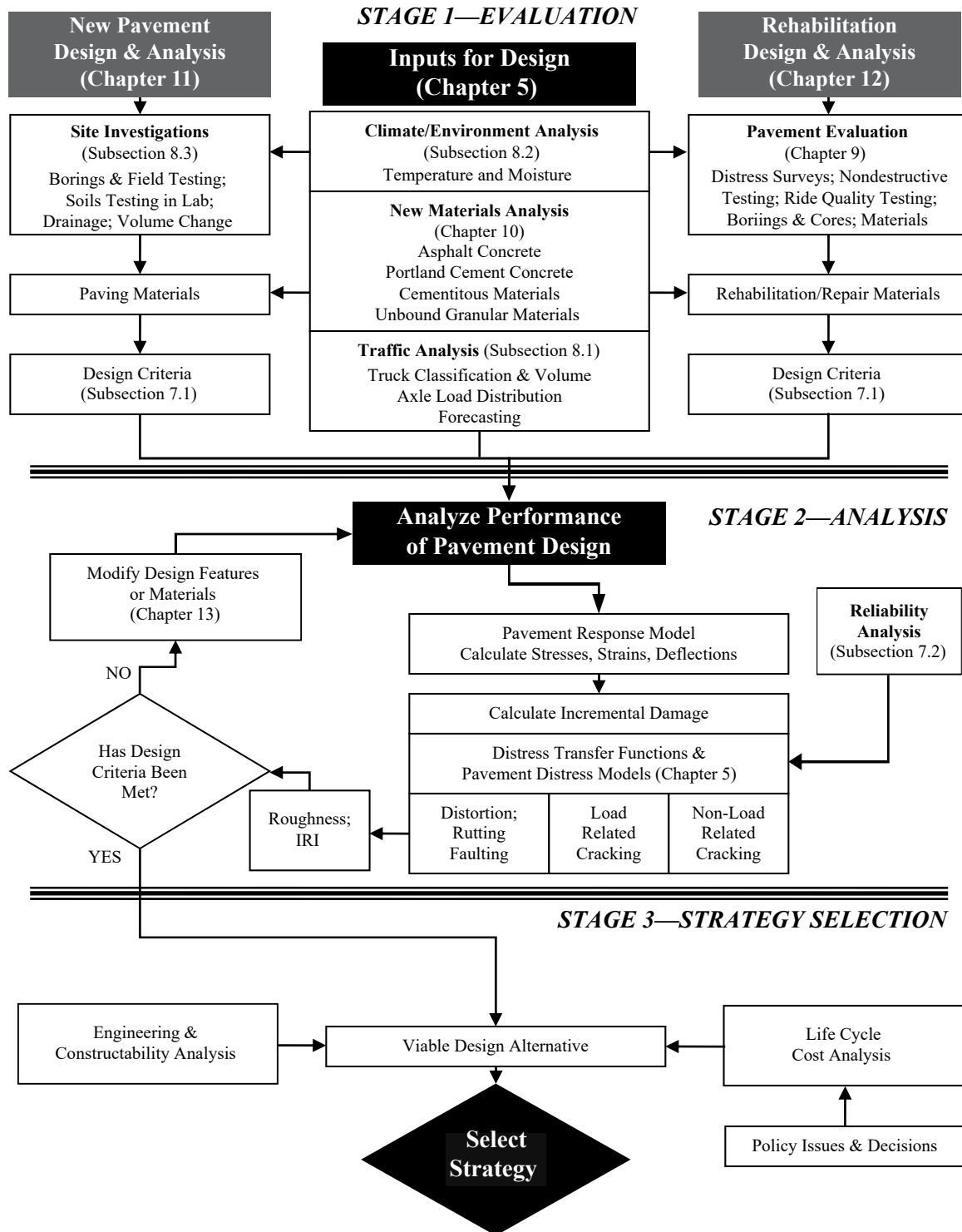


**Figure 1-1.** Conceptual Flow Chart of the Three-Stage Design/Analysis Process for AASHTOWare PMED

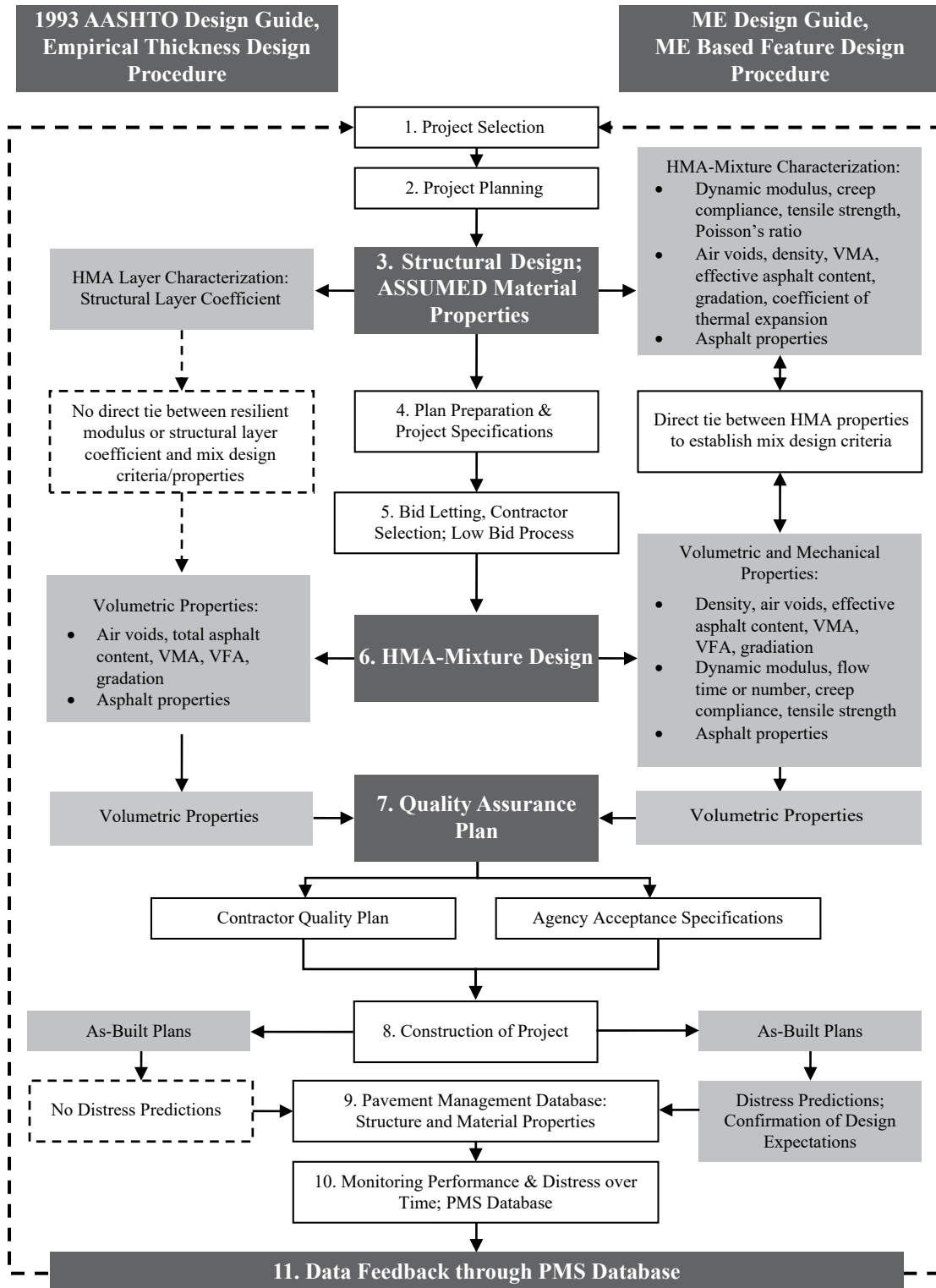


**Figure 1-2.** Typical Differences between Empirical Design Procedures and an Integrated ME Design System, in Terms of AC Mixture Characterization

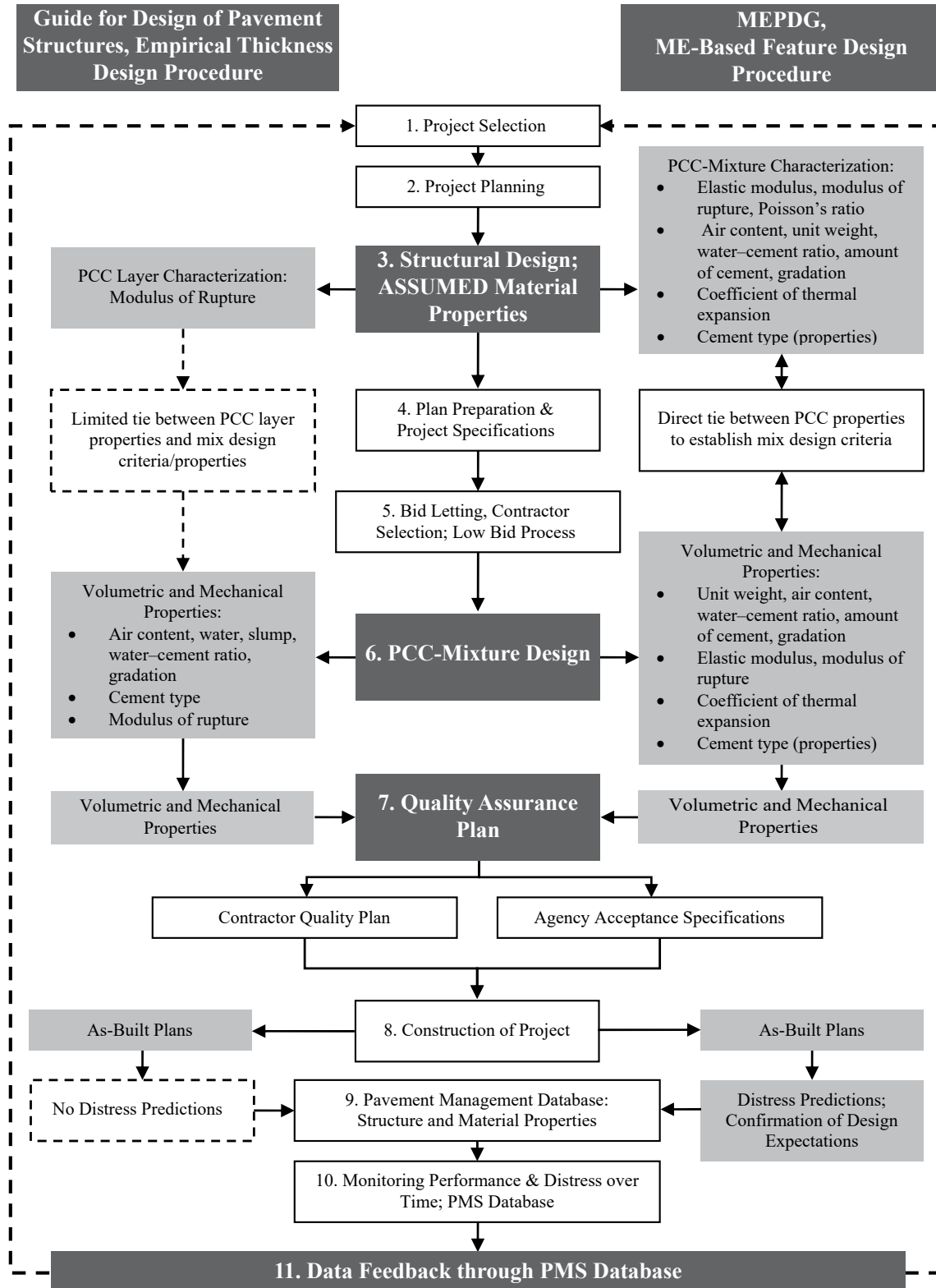


**Figure 1-3.** Typical Differences between Empirical Design Procedures and an Integrated ME Design System, in Terms of PCC-Mixture Characterization

The ME approach makes it possible to optimize the design and to fully verify that specific distress types will be limited to values less than the failure criteria within the design life of the pavement structure. The basic steps included in the MEPDG are listed below and presented as flow charts in Figures 1-4 and 1-5. The steps shown in Figures 1-4 and 1-5 are referenced to the appropriate sections within this manual of practice.

1. **Select a trial design strategy.** The pavement designer may use an agency-specific procedure to determine the trial design cross section.
2. **Select the appropriate performance indicator criteria (threshold value) and design reliability level for the project.** Design or performance indicator criteria include magnitudes of key pavement distresses and smoothness that may trigger major rehabilitation or reconstruction. These criteria could be a part of an agency's policies for deciding when to rehabilitate or reconstruct. AASHTOWare PMED allows the user to select the performance indicator criteria to be considered. The user can uncheck the box next to the criteria that do not need to be considered. (See Chapter 4.1 for definitions.)
3. **Obtain all inputs for the pavement trial design under consideration.** This step may be a time-consuming effort, but it is what separates the MEPDG from other design procedures. The MEPDG allows the designer to determine inputs using a hierarchical structure in which the effort to quantify a given input is selected based on the importance of the project, importance of the input, and available resources. The required inputs to run the software are obtained using one of three levels of effort that need not be consistent for all of the inputs for a given design. This permits the user to use the "best available" data for all inputs. The hierarchical input levels are defined in Chapters 4 and 5, and are grouped under six broad topics: (1) general project information, (2) design criteria, (3) traffic, (4) climate, (5) structure layering, and (6) material properties (including the design features). *A caution to the designer—Some of the input parameters are interrelated; changing one parameter may affect the value of another input parameter. The designer should use caution in making changes in individual parameters.*
4. **Run AASHTOWare PMED and examine the inputs and outputs for engineering reasonableness.** The software calculates changes in layer properties, damage, key distresses, and the International Roughness Index (IRI) over the design life. The substeps for step 4 include:
  - a. Examine the input summary to verify the inputs are correct. This step should be completed after each run, until the designer becomes more familiar with the program and its inputs.
  - b. Examine the outputs that comprise the intermediate process—specific parameters (such as climate values), monthly load transfer efficiency (LTE) values for rigid pavement analysis, monthly layer modulus values for flexible and rigid pavement analysis to determine their reasonableness, and calculated performance indicators (pavement distresses and IRI). This step may be completed after each run or

until the designer becomes more familiar with the program. Review of important intermediate processes and steps is presented in Chapter 13.

- c. Assess whether the trial design has met each of the performance indicator criteria at the design reliability level chosen for the project. As noted above, IRI is an output parameter predicted over time and a measure of surface smoothness. IRI is calculated from other distress predictions (refer to Figure 1-1), site factors, and initial IRI.
- d. If any of the criteria are not met, determine how this deficiency can be remedied by altering the materials used, the layering of materials, layer thickness, or other design features.

5. **Revise the trial design, as needed.** If the trial design has input errors, material output anomalies, or has exceeded the failure criteria at the given level of reliability, revise the inputs/trial design and rerun the program. An automated process to iterate to an optimized thickness is done by AASHTOWare PMED to produce a feasible design.

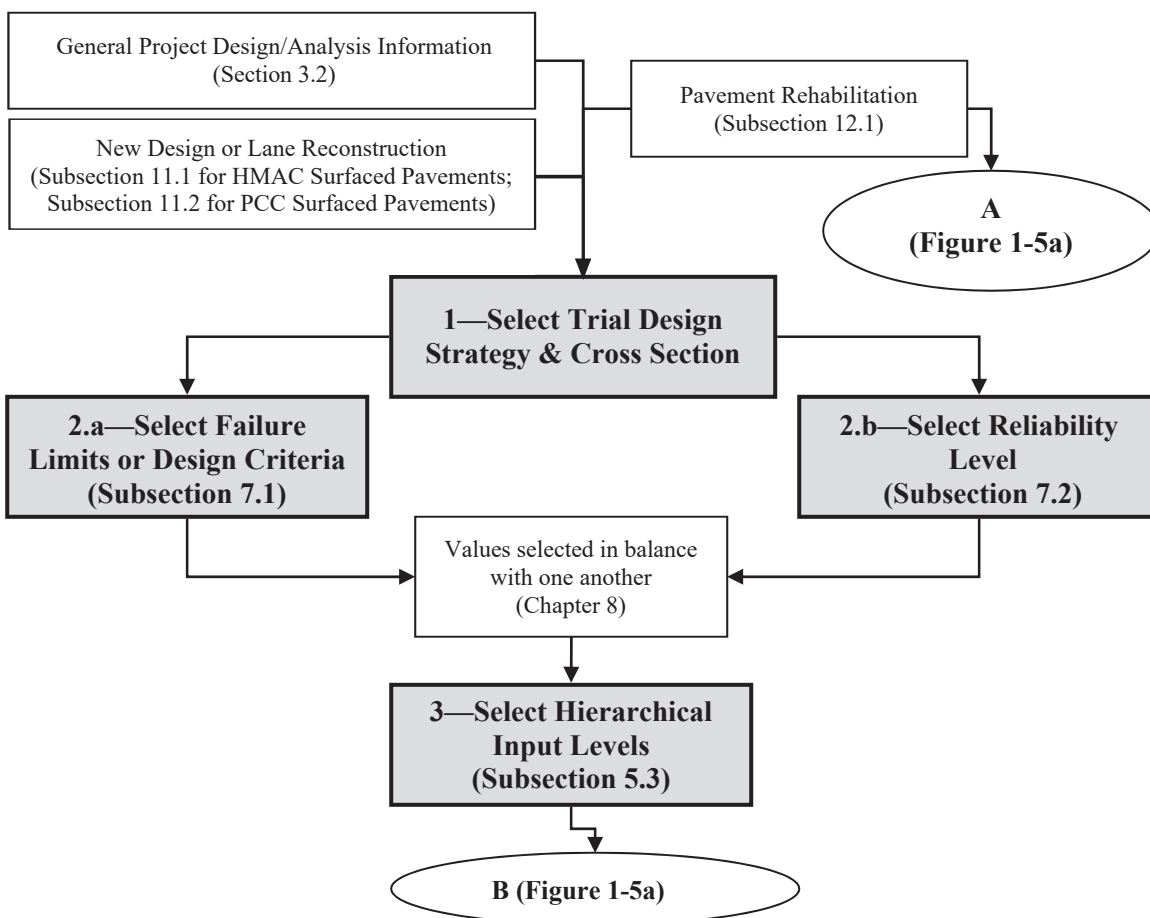


**Figure 1-4.** Flow Chart of the Steps That Are More Policy Decision Related and Needed to Complete an Analysis of a Trial Design Strategy

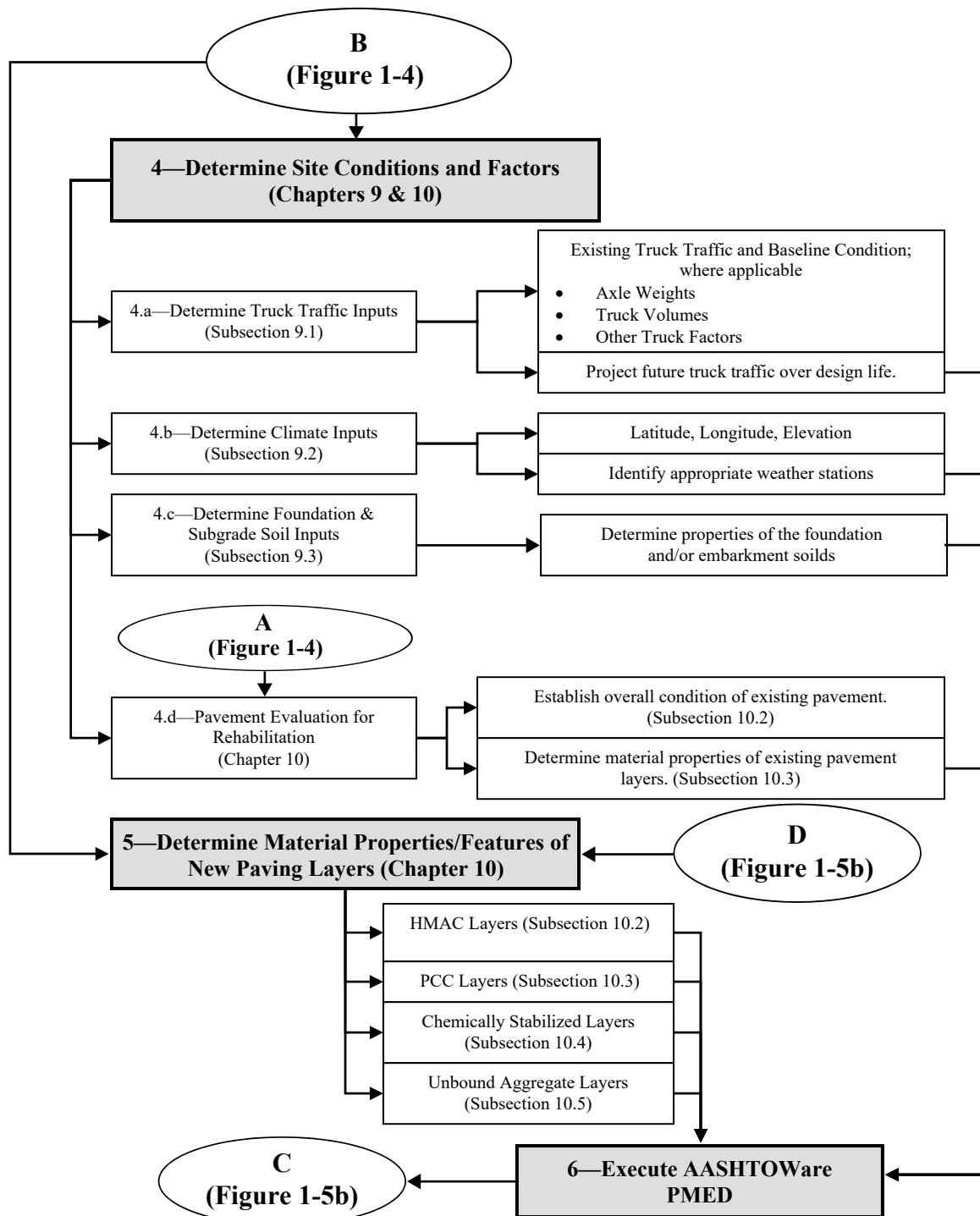


Figure 1-5a. Flow Chart of the Steps Needed to Complete an Analysis of a Trial Design Strategy

**Table 5-1.** Typical Input Levels Used in the Global Calibration of the AASHTOWare PMED Models and Transfer Functions

| Input Group         |                             | Input Parameter                                                            | Recalibration Input Level Used |
|---------------------|-----------------------------|----------------------------------------------------------------------------|--------------------------------|
| Truck Traffic       |                             | Axle load distributions (single, tandem, tridem)                           | Level 1                        |
|                     |                             | Truck volume distribution                                                  | Level 1                        |
|                     |                             | Lane and directional truck distributions                                   | Level 1                        |
|                     |                             | Tire pressure                                                              | Level 3, default               |
|                     |                             | Axle configuration, tire spacing                                           | Level 3, default               |
|                     |                             | Truck wander                                                               | Level 3, default               |
| Climate             |                             | Temperature, wind speed, cloud cover, precipitation, relative humidity     | Level 1 weather stations       |
| Material Properties | Unbound Layers and Subgrade | Resilient modulus—all unbound layers                                       | Level 1; backcalculation       |
|                     |                             | Classification and volumetric properties                                   | Level 1                        |
|                     |                             | Moisture-density relationships                                             | Level 1                        |
|                     |                             | Soil-water characteristic relationships                                    | Level 3, defaults              |
|                     |                             | Saturated hydraulic conductivity                                           | Level 3, defaults              |
|                     | AC                          | AC dynamic modulus                                                         | Level 3, defaults              |
|                     |                             | AC creep compliance and indirect tensile strength                          | Levels 1, 2, and 3             |
|                     |                             | Volumetric properties                                                      | Level 1                        |
|                     |                             | AC coefficient of thermal expansion                                        | Level 3, default               |
|                     | PCC                         | PCC elastic modulus                                                        | Level 1                        |
|                     |                             | PCC flexural strength                                                      | Level 1                        |
|                     |                             | PCC indirect tensile strength (CRCP only)                                  | Level 2                        |
|                     |                             | PCC coefficient of thermal expansion                                       | Level 1                        |
| All Materials       |                             | Unit weight                                                                | Level 1                        |
|                     |                             | Poisson's ratio                                                            | Level 3, default               |
|                     |                             | Other thermal properties—conductivity, heat capacity, surface absorptivity | Level 3, defaults              |
| Existing Pavement   |                             | Condition of existing layers                                               | Levels 1 and 2                 |

makes extensive use of the EICM for adjusting the pavement layer modulus values with temperature and moisture. The EICM calculates the temperature and moisture conditions throughout the pavement structure on an hourly basis (16).

The frequency distribution of AC temperatures using the EICM is assumed to be normally distributed. The temperatures in each AC sublayer are combined into five quintiles. Each quintile represents 20 percent of the frequency distribution for each month of the analysis period for the load related distresses (see Figure 5-1). This is accomplished by computing pavement temperatures corresponding to accumulated frequencies of 10, 30, 50, 70 and 90 percent within a given month. The average temperature within each quintile of a sublayer for each month is used to determine the dynamic modulus of that sublayer. The truck traffic is assumed to be equal within each of the five temperature quintiles. Thus, the flexible pavement procedure does not tie the hourly truck volumes directly to the hourly temperatures.

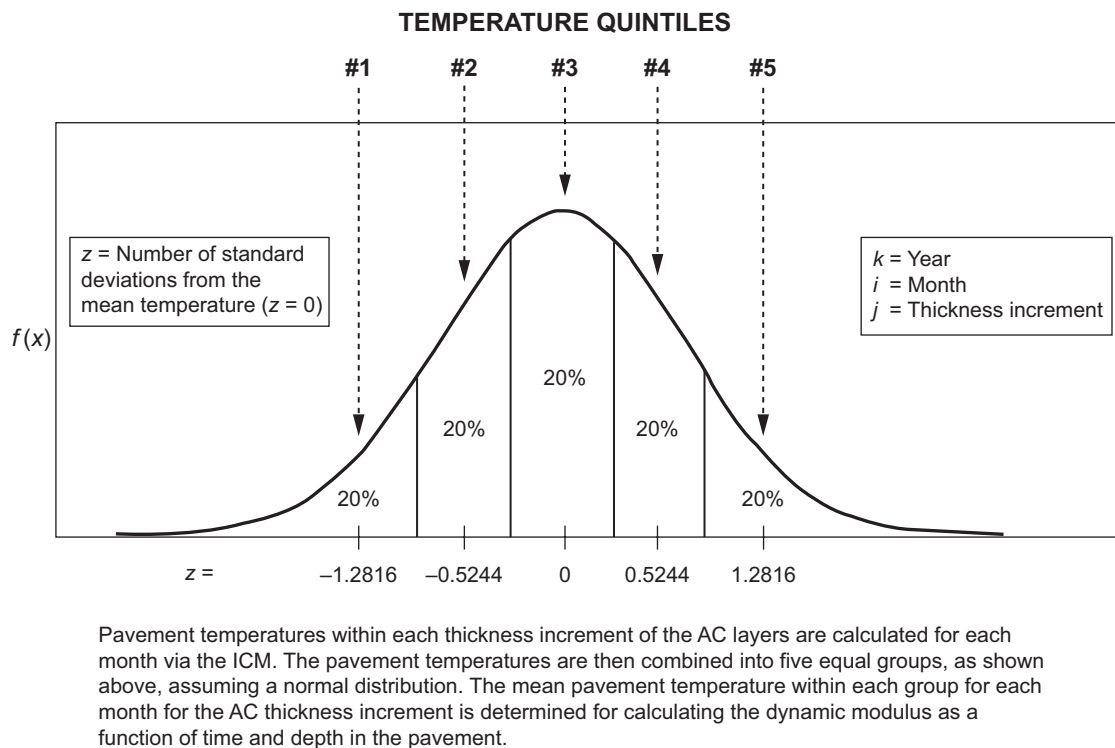


**Figure 5-1.** Graphical Illustration of the Five Temperature Quintiles Used in the MEPDG to Determine AC Mixture Properties for Load Related Distresses

The dynamic modulus is used to compute the horizontal and vertical strains at critical depths on a grid to determine the maximum permanent deformation within each layer and location of the maximum fatigue damage in the asphalt concrete layers. For transverse cracks (non-load related cracks), the EICM calculates the AC temperatures on an hourly basis and uses those hourly temperatures to estimate the AC properties (creep compliance and indirect tensile strength) to calculate the tensile stress throughout the AC surface layer.

The EICM also calculates the temperatures within each unbound sublayer and determines the months when any sublayer is frozen. The resilient modulus of the frozen sublayers is then increased

$$\rho = 10^9 \left\{ \frac{C_o}{\left[ 1 - (10^9)^\beta \right]} \right\}^{\frac{1}{\beta}} \quad (5-2c)$$

$$C_o = \ln \left( \frac{a_1 M_r^{b_1}}{a_9 M_r^{b_9}} \right) \quad (5-2d)$$

where:

$W_c$  = Water content, %

$M_r$  = Resilient modulus of the unbound layer or sublayer, psi

$a_{1,9}$  = Regression constants;  $a_1 = 0.15$  and  $a_9 = 20.0$

$b_{1,9}$  = Regression constants;  $b_1 = 0.0$  and  $b_9 = 0.0$

Figure 5-2 shows a comparison between the measured and predicted total rut depths, including the statistics from the global calibration process. The standard error ( $s_e$ ) for the total rut depth is the sum of the standard error for the AC and unbound layer rut depths and is a function of the average predicted rut depth. Equations 5-3a–5-3c show the standard error (standard deviation of the residual errors) for the individual layers—AC and unbound layers for coarse and fine-grained materials and soils.

$$s_{e(AC)} = 0.24(\Delta_{AC})^{0.8026} + 0.001 \quad (5-3a)$$

$$s_{e(AggrBase)} = 0.1235(\Delta_{AggrBase})^{0.5012} + 0.001 \quad (5-3b)$$

$$s_{e(Subgrade)} = 0.1477(\Delta_{Subgrade})^{0.6711} + 0.001 \quad (5-3c)$$

where:

$\Delta_{AC}$  = Plastic deformation in the AC layers, in.

$\Delta_{AggrBase}$  = Plastic deformation in the aggregate or granular base layers, in.

$\Delta_{Subgrade}$  = Plastic deformation in the subgrade or embankment layers and soils, in.

These equations for the standard errors of the predicted rut depths within each layer were not based on actual measurements of rutting within each layer, because trenches were unavailable for all LTPP test sections used in the global calibration process. The so-called “measured” rut depths within each layer were only estimated by proportioning the total rut depth measured to the different layers using a systematic procedure.

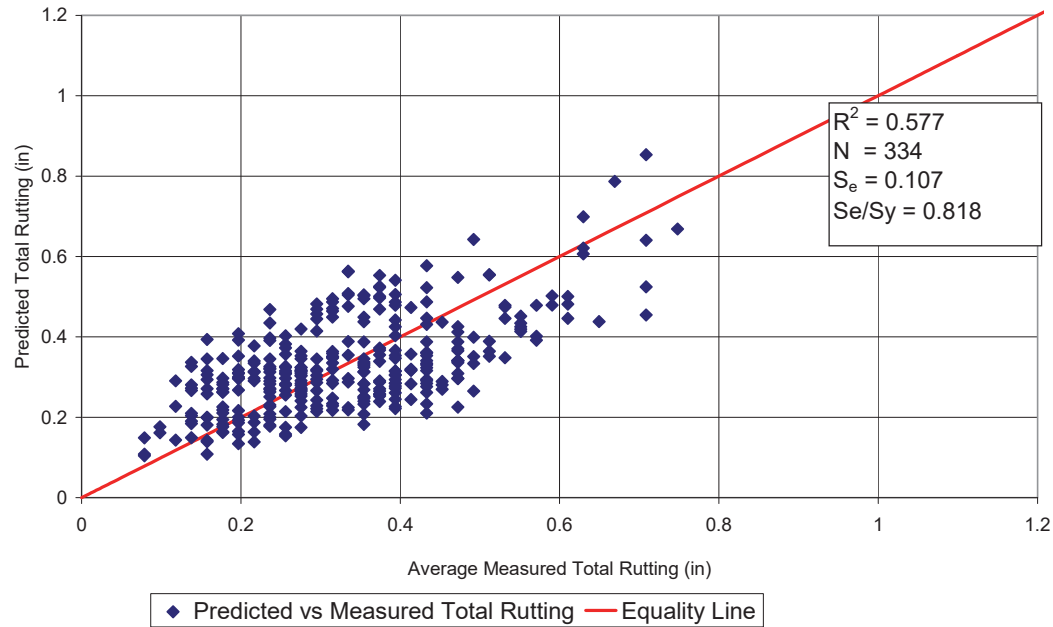


**Figure 5-2.** Comparison of Measured and Predicted Total Rutting Resulting from Global Calibration Process

### 5.3.3 Load-Related Cracking

#### Asphalt Concrete Layers

Two types of load-related cracks are predicted by the MEPDG: alligator cracking and longitudinal cracking. The MEPDG assumes that alligator, or area cracks, initiate at the bottom of the AC layers and propagate to the surface with continued truck traffic, while longitudinal cracks are assumed to initiate at the surface.

*For bottom-up or alligator cracking:*

The allowable number of axle load applications needed for the incremental damage index approach to predict bottom-up cracks) is shown in Equation 5-4a.

$$N_{f-AC} = k_{f1}(C)(C_H)\beta_{f1}(\epsilon_t)^{-k_{f2}\beta_{f2}}(E_{AC})^{-k_{f3}\beta_{f3}} \quad (5-4a)$$

where:

$N_{f-AC}$  = Allowable number of axle load applications for a flexible pavement and AC overlays

$\epsilon_t$  = Tensile strain at critical locations and calculated by the structural response model, in/in.

$E_{AC}$  = Dynamic modulus of the AC measured in compression, psi

$k_{f1}, k_{f2}, k_{f3}$  = Global laboratory-derived model coefficients for dense-graded neat AC mixtures ( $k_{f1} = 3.75, k_{f2} = 2.87$ , and  $k_{f3} = 1.46$ )

$\beta_{f1}, \beta_{f2}, \beta_{f3}$  = Local or mixture specific field shift or adjustment constants; for the global calibration effort, these constants are:  $\beta_{f1}$  is AC thickness dependent,  $\beta_{f2}$  is 1.38, and  $\beta_{f3}$  is 0.88