3.13 PAVEMENT DESIGN

Methodology

Generally, ADOT methodology is used for pavement structure design in Pima County. This process is outlined in the latest edition of ADOT’s Materials Preliminary Engineering and Design Manual. For simplicity, that document is referred to in this section as "the reference." An overview of the process for flexible pavement design as adapted for use within Pima County is provided below. The reference shall be consulted for guidance in the design of rigid pavement structures.

Flexible pavement structure design follows four general steps:

Step One

Determine the geotechnical properties of the in-place or borrow material that will make up the subgrade on which the pavement structure is to be placed. The geotechnical characteristic that reflects the strength of subgrade is the Resilient Modulus ($M_R$), which is derived from the mean R-Value ($R_{MEAN}$) which in turn is based on R-Value tests ($R_T$) and Pima County correlated R-Values ($R_C$) estimated from measurements of plasticity index (PI) and percent of soil by weight passing a #200 sieve (minus 200).

- All soil and subgrade sampling and testing shall be in accordance with Chapter 1 of the reference and Chapter 3.12 of this manual.
- The $R_{MEAN}$ shall be calculated using a combination of tested R-values and Pima County correlated R-values as adapted from the reference. The Pima County correlated R-value ($R_{PC}$) shall be calculated using the soil PI and minus 200 percentage as follows:
  1. Calculate the base correlated R-value ($R_{CB}$) from Table 202.02-3 in the reference or by using the following equation:
     \[
     \log R_{CB} = 2.0 - 0.006 \times \text{minus 200} - 0.017 \times \text{PI}
     \]
  2. Calculate the Pima County correlated R-value ($R_{PC}$) as follows:
     \[
     R_{PC} = x \times R_{CB}^y
     \]
     Where $x = 0.3$ and $y = 1.2$
  3. The $R_{MEAN}$ is the design R-value. Since the correlated R-value has been adjusted above, the design R-value is also the construction control R-value.

Where a site specific correlation may provide cost saving opportunities, the designer shall consult with Pima County to determine the sufficient number of actual R-value laboratory tests (typically anticipated to be 10-20 per geologic formation) in order to develop project-specific correlated R-values ($R_C$) using the power function as noted above with site-specific x and y values. When this option is used, a site specific subgrade acceptance chart must also be created.
For small development projects, a measured R-value option is acceptable in lieu of using correlations. In such cases, the design R-value is the lowest measured project R-value and the subgrade acceptance threshold is based on the mean PI and the mean minus 200 percentage.

**Step Two**

Estimate the traffic loading to which the pavement will be subjected during its design life. This is expressed as the number of equivalent 18-kip single axle loads (ESAL) in the design lane and is based on the current and projected design year average daily traffic (ADT) and the current mix of vehicle classifications.

- For determining ESAL, use the process described in Appendix A of the reference.

- The percentage of total traffic assumed in the design lane for various roadway widths is:
  - Two-lane roadway: 50%
  - Four-lane roadway: 45%
  - Six-lane roadway: 40%

**Step Three**

Combine the geotechnical and traffic information into a quantifiable measure reflecting the strength of the pavement structure needed. That measure is the Structural Number (SN) from which the thickness of various paving courses can be determined.

- The Level of Reliability and Combined Standard Error (So) values appropriate for various roadway classifications in Pima County are as follows:

<table>
<thead>
<tr>
<th>Functional Level of Classification</th>
<th>Level of Reliability</th>
<th>So</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arterials</td>
<td>95%</td>
<td>0.35</td>
</tr>
<tr>
<td>Collectors</td>
<td>90%</td>
<td>0.35</td>
</tr>
<tr>
<td>Local Streets</td>
<td>80%</td>
<td>0.35</td>
</tr>
</tbody>
</table>

- The values for change in Present Serviceability Index (△PSI), initial serviceability index (Po) and terminal serviceability index (Pt) are as follows:

<table>
<thead>
<tr>
<th>Functional Classification</th>
<th>Po</th>
<th>Pt</th>
<th>△PSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arterials</td>
<td>4.2</td>
<td>2.8</td>
<td>1.4</td>
</tr>
<tr>
<td>Collectors</td>
<td>4.1</td>
<td>2.6</td>
<td>1.5</td>
</tr>
<tr>
<td>Local Streets</td>
<td>4.0</td>
<td>2.4</td>
<td>1.6</td>
</tr>
</tbody>
</table>
Step Four

Using the criteria below, determine a pavement structure that provides the necessary SN. Typically, several possible structures are developed for a SN with the final selection being based on cost and constructability. For Pima County CIP projects, provide alternate pavement sections for a minimum of four R-values, or as directed by the project manager, based on the minimum and maximum R-values. The intent is to quantify the cost differences between removing poor soils and providing a thicker pavement section.

- The structural coefficients to be used for various pavement structure courses are as follows:
  - Asphalt Rubber Asphalitic Concrete (ARAC) 0.44
  - Asphalitic Concrete (AC) 0.44
  - Cement or Bituminous Treated Base 0.28
  - Cement or Bituminous Subgrade 0.23
  - Aggregate Base (AB) 0.12

- The value for AB shall be adjusted by a drainage coefficient of 0.92 for projects in the Tucson area. Table 202.02-7 (p. 102 of the reference) shall be consulted for projects in other areas.

- The minimum thickness of paving courses for various roadway classifications and pavement types is as follows:

<table>
<thead>
<tr>
<th>Arterial (Greater than 10,000 ADT)</th>
<th>Major Collector (2,500 to 10,000 ADT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top Lift (AC) 2.5&quot;</td>
<td>Single Lift AC 3.0&quot;</td>
</tr>
<tr>
<td>Bottom Lift (AC) 2.5&quot;</td>
<td>AB 6.0&quot;</td>
</tr>
<tr>
<td>AB 4.0&quot;</td>
<td>Minimum SN 1.98</td>
</tr>
<tr>
<td>Minimum SN 2.64</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Collector (1,000 to 2,500 ADT)</th>
<th>Local Street (Less than 1,000 ADT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Lift AC 3.0&quot;</td>
<td>Single Lift AC 2.5&quot;</td>
</tr>
<tr>
<td>AB 4.0&quot;</td>
<td>AB 4.0&quot;</td>
</tr>
<tr>
<td>Minimum SN 1.75</td>
<td>Minimum SN 1.49</td>
</tr>
</tbody>
</table>
Driveways shall be 2.5 inches AC on a minimum of 4 inches AB, subject to local conditions.

Cement or bituminous treatment of the subgrade can be considered in lieu of removing and replacing poor native soil. The minimum thickness of these courses is 6 inches. Lime stabilization and the use of geotechnical membranes may also be considered in lieu of removing and replacing poor native soil.

The ratio of AB to AC generally shall be between 1:1 and 1.75:1.

If minimum thickness of the AC and AB courses together does not provide the necessary SN, increasing the thickness of AC is preferable to specifying deeper sections of AB.

**Pavement Design Report**

The data, procedures, and design recommendations shall be documented in a pavement design report in conformance with Appendix C of the reference and the following:

**Introduction**

Describe the location and limits of the project, and the proposed improvements with emphasis on the pavement design aspects.

**Geotechnical Data**

Summarize the general geotechnical characteristics of the soils on which the roadway will be constructed. Provide in tabular form all the geotechnical data and test results used in designing the pavement structure. Identify the limits of unsuitable subgrade material, including those soils susceptible to collapse or swelling.

**Traffic Data**

State the traffic data used in developing the pavement structure such as current and design year traffic volumes, percentage of vehicle types, percentage of total traffic in the design lane, reliability factors, and ESAL calculations.

**Pavement Structure Design & Subgrade Acceptance**

- Discuss the results of the pavement structure design. Provide in tabular or other appropriate form the calculations used to determine the structural number (SN) for the various portions of the project.

- Provide pavement section design(s) based on the required structural number(s) (SN). Present the data used and the calculations made in a manner that is straight forward and easily repeated for verification.

- The subgrade acceptance chart, Appendix 3-W, is based on the Pima County correlated R-values. If a project specific correlated R-value power function other than the Pima County...
correlated R-value power function is used, a separate subgrade acceptance chart must be prepared.

**Recommendations**

Identify the recommended structural sections, including sub-base and subgrade treatment. Include cost, construction considerations, limits of various pavement sections and other factors taken into account in developing the recommendations.

**Appendix 3-W: Subgrade Acceptance Chart**

(follows on next page)
Note: For any chosen Design R-value, if the tested plasticity index and percent fines of a soil plot below that R-value line, the soil is considered to be acceptable. If the plasticity index and percent fines of a soil plot above that R-value line, the soil is considered to be unacceptable and shall not be used as subgrade material. Also, the X-value shown in the legend for each R-value represents the maximum X-value for each Design R-value based on the equation, \( X = (\text{Percent Fines}) + [2.83(\text{PI})] \).