CRMCA approached SCDOT and NCDOT to request updated methods for low-volume concrete pavement design around 2010.

NCDOT and SCDOT staff agreed that their methodology is not ideal for low volume roads.

CRMCA prepared a streets and local roads design guide and construction specifications for NCDOT and SCDOT written by a consultant specializing in pavement engineering.

The design guide uses PCA design methodology, which is better suited for low volume roads and is the basis for ACI 330.
Background

• While SCDOT agreed in principle with the design guide changes, we had many detailed concerns with the recommendations.

• This led to multiple drafts and meetings to address their concerns.
Background

- NCDOT published a low-volume road design guide for concrete in 2016 on their website.
- Unlike NCDOT, SCDOT does not accept subdivisions and new developments into the state system.
- SCDOT declined to publish because they do not have a comparable asphalt low volume guide.
- However, pavement designed by the guide can be acceptable within the limits of the design method.
Why can’t SCDOT’s existing design method be used?

• SCDOT uses the AASHTO empirical design method.
• Was developed in the 1950s to prepare for the upcoming interstate building boom of the 1960s and 1970s.
• Most of the test pavements used for developing the design method failed due to pumping at the joints, not fatigue.
• Not really intended for low-volume roads.
Why can’t SCDOT’s existing design method be used?

• SCDOT working on implementation of new AASHTO mechanistic-empirical design methodology.
• Addresses many of the weaknesses of previous AASHTO design method.
• Has to be designed with AASHTO PavementME software – very expensive and complex.
• Still not really intended for low-volume roads.
What is a low-volume road?

• Streets and Local Roads Design Guide has specific limits on when it can be used:
  • Average Daily 2-way Truck Traffic of 200 or less.
  • Maximum slab thickness of 8 inches.
  • Normal mixed traffic, not for industrial or special haul roads.

• If these conditions do not apply, a detailed pavement design is required.
SLR pavement design methodology

(1951, first edition 1933)
Design of Concrete Pavement for City Streets

Standards established by a community for the design and construction of its streets should provide for pavements with long service life and low maintenance. Excess maintenance of inadequate pavements (such as patching chuckholes and applying periodic seal coats) is an unnecessary drain on tax dollars. An investment in adequate concrete streets needing little maintenance over a long service life—50 years or more in many communities—frees more dollars for permanent capital improvements.

Concrete pavements are designed for both economy and long service. Following are the factors involved in designing concrete pavement for the lowest possible annual cost:

1. Street classification and traffic (including axle weights and volume)
2. Thickness design
3. Design life

Residential Streets. In subdivisions these streets carry the same type of traffic as light residential, but serve more houses (60 to 140) including those on dead-end streets. In cities with a grid-type street pattern, traffic generally consists of vehicles serving the homes plus an occasional heavy truck. Traffic volumes range from 300 to 700 vpd with 1% to 2% heavy commercial traffic per day (hcvpd).

Residential Collector Streets. Residential collectors receive all the residential street traffic within an area and distribute it into the major street systems. They can be quite long, serving 140 to 300 homes or more, and have traffic volumes of 700 to 1,500 vpd with 1% to 2% heavy commercial traffic.

Collector Streets. Collectors may serve several subdivisions and may be several miles long. They may be bus routes and serve truck movements to and from an area along the arterial.
Welcome to Pavement Designer, a free web-based pavement design tool for streets, local roads, parking lots, and intermodal/industrial facilities.

Best viewed using Chrome on Windows or Safari for MacOS.

Start Designing
Project Type: Street Concrete JPCP

Calculated Minimum Thickness
- Dowelled: 4.68 in, Undowelled: 4.68 in

Recommended Design Thickness
- Dowelled: 4.75 in, Undowelled: 4.75 in

Maximum Joint Spacing
- Dowelled: 8 ft, Undowelled: 8 ft

Analysis and Guidance
- Sensitivity
- Cracking
- Erosion
- Load Transfer
- Joint Spacing
- Dowelled
- Undowelled

- K-Value
- Flexural Strength
- Design Life
Concrete Pavement - What’s Important?

- Subbase
- Concrete Strength
- Joint Placement
- Slab Thickness
- Dowels
- Steel in Slab
- Aggregates
- Drainage
Concrete Pavement Design

Four Major Design Areas:

• Geometrics
• Thickness(es)
• Joints
• Materials
Concrete Pavement Design

- Geometrics
- Thickness(es)
- Joints
- Materials

Most Often Influence Cost & Selection of Projects
Concrete Pavement Design

- Geometrics
- Thickness(es)
  - Joints
  - Materials

Most Often Influence Real-world Performance
Key design questions

- Is a subbase necessary?
- Are dowels necessary?
- How thick should the pavement be?
- How far apart should the joints be?
Non-erodible subbase material properties

- Less than 15 percent passing the #200 sieve.
- An in-place density of 95% of AASHTO T99.
- A Plasticity Index (PI) of 6 or less.
- A Liquid Limit (LL) of 25 or less.
Is a subbase necessary?

• Exclude subbase if:
  • Non-pumpable subgrade soil
  • Existing soils, when compacted, provide stable construction platform
  • Residential traffic

• Include subbase for other cases
## To dowel or not to dowel

<table>
<thead>
<tr>
<th>Slab Thickness</th>
<th>Load Transfer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 7.5 inches</td>
<td>Dowel bars are not required</td>
</tr>
<tr>
<td>7.5 inches or greater</td>
<td>1.00 inch dowel bars required</td>
</tr>
</tbody>
</table>
Key design questions

- Is a subbase necessary?
- Are dowels necessary?
- How thick should the pavement be?
- How far apart should the joints be?
South Carolina Design Examples

• Residential Street:
  • Assume 5 trucks per day for 30 years, 2% compound growth.
  • Soil support conditions are assumed to be “Medium”.
  • Will use 6 inch cement modified subbase.
  • Edge support is present.
## South Carolina Design Examples

<table>
<thead>
<tr>
<th>Soil Type Description</th>
<th>Relative Level of Soil Support</th>
<th>Typical Range for k (psi/in or pci)</th>
<th>Typical Range for CBR</th>
<th>Typical Range for Resilient Modulus (psi)</th>
<th>Average k Value used in Development of the Guide (pci)</th>
</tr>
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<tbody>
<tr>
<td>Fine-grained soil with high silt and/or clay content</td>
<td>Low</td>
<td>75-120</td>
<td>1-3</td>
<td>1455 - 2325</td>
<td>100</td>
</tr>
<tr>
<td>Sand and sand-gravel with moderate silt and/or clay content</td>
<td>Medium</td>
<td>130 - 170</td>
<td>4-8</td>
<td>2500 - 3300</td>
<td><strong>150</strong></td>
</tr>
<tr>
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<td>High</td>
<td>180 - 220</td>
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<td>3500 - 4275</td>
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</tbody>
</table>

Table 3. Typical Range of Soil Characteristics and Support Values for Subgrade Soils.
South Carolina Design Examples

Figure 3. Composite k Value for Cement Treated Base.
South Carolina Design Examples

40-Year Residential Traffic with Edge Support

Figure 7. Design Chart A. (For k greater than 150, use 5 inches.)
South Carolina Design Examples

<table>
<thead>
<tr>
<th>Slab Thickness (inches)</th>
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<td>10</td>
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</tr>
<tr>
<td>6.5</td>
<td>12.5</td>
</tr>
<tr>
<td>7.0 or greater</td>
<td>15</td>
</tr>
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</table>

Table 6. Maximum Recommended Transverse Joint Spacing
South Carolina Design Examples

• Design Recommendation:
  • 5” Plain Jointed PCC Pavement
    • Compressive Strength=4000 psi
  • No dowels
  • 10’ transverse joint spacing
  • 6” Soil-Cement Subbase (?)
South Carolina Design Examples

• Collector Road
• 200 trucks per day, 2% annual growth, 30 years
• Subgrade support condition – “Low”
• No edge support
• 6 inch aggregate base
South Carolina Design Examples

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Table 3. Typical Range of Soil Characteristics and Support Values for Subgrade Soils.
South Carolina Design Examples

Figure 2. Composite k Value for Unbound Aggregate Base.
South Carolina Design Examples

40-Year Collector Traffic without Edge Support

Figure 10. Design Chart D.
## South Carolina Design Examples

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Table 5. Recommended Load Transfer Options
## North Carolina Design Examples

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<td><strong>7.0 or greater</strong></td>
<td><strong>15</strong></td>
</tr>
</tbody>
</table>

*Table 6. Maximum Recommended Transverse Joint Spacing*
South Carolina Design Examples

- Design Recommendation:
  - 7.5” Plain Jointed PCC Pavement
    - Compressive Strength=4000 psi
  - 1” dowels
  - 15’ transverse joint spacing
  - 6” Aggregate Base Course
Resources

• DOT folks: Contact OMR if you have a low-volume road that might work for concrete.

• Others: Let the Design Assistance Team know if you have any questions.
  • Southeast Cement Promotion Association
  • Carolinas Concrete Paving Association
  • Carolinas Ready Mixed Concrete Association

• Look at both asphalt and concrete!
  • Remember....when materials compete, owners win......
Questions?