Streets and Local Roads
Concrete Pavement Design Guide

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Southeast Cement Promotion Association

Durham, NC
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Barriers to concrete pavement usage

• Concrete pavement often gets no opportunity to compete on private work and low volume roads in NC. Why?
Barriers to concrete pavement usage

• Designers want to use DOT methodology for their pavement designs, either to ensure that the DOT will accept their road or to protect themselves from design liability.

• Because the DOT uses concrete mostly for very high volume roads, their design methods and specifications for concrete pavement are not necessarily appropriate to lighter duty pavement.
Barriers to concrete pavement usage

• Consequently, when a designer tries to produce alternate pavement sections the concrete option ends up being wildly over-designed compared to the asphalt alternative. Often the concrete section is thicker than the “comparable” asphalt section.

• This leads to concrete being priced out of consideration.
Barriers to concrete pavement usage

• If concrete does get selected, the designers also want to use DOT construction specifications.
• DOT specifications for concrete are also optimized for major highways and not for smaller facilities with less traffic.
• This can drive up prices without any real benefit.
Barrier removed...

• NCDOT 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.
• While NCDOT agreed in principle with the design guide changes, both agencies had many detailed concerns with the recommendations.

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

• The proposed construction specifications were not compatible with state standard specifications.
• Ultimately, in NC we started with the Standard Specifications related to concrete pavement and rewrote the sections that were incompatible with low volume concrete pavement construction.
North Carolina Low Volume Concrete Design

• NCDOT has added the following items to their Secondary Roads and Subdivisions Manual:
  • Design Guide for Concrete Local Roads and Streets
  • Specifications for Concrete Local Roads and Streets
  • Standard Plan Notes for Concrete Local Roads and Streets
  • Various details for drop inlets, joints, and other items in various CAD formats
Secondary Roads and Subdivisions
Manuals and guidance.

Subdivision Construction Manual
- Subdivision Manual Jan 2010_Revised May 2016

Concrete Pavement for Local Roads & Streets
- Design Guide for Concrete Local Roads and Streets_V1_NCDOT.pdf
- Inlet Detail 1.zip
- Inlet Detail 2.zip
- Inlet Detail 3.zip
- Integral Curb.zip
- Isolation Joint.zip
- Keyway Joint.zip
- Manhole Detail 1.zip
- Manhole Detail 2.zip
- Manhole Detail 3.zip

State Maintenance Operations Content
- Disaster Recovery
  - Internal and external agency support for declared and non-declared state disasters.
- Interstate Maintenance Preservation Program (IMPP)
  - Extends the service life of existing interstates, bridges and roadside features through strategies designed to prevent deterioration.
  - Manuals
  - Outdoor Advertising
    - Resources for outdoor advertising and roadways signs.
  - Posted Roads
    - Complete database of weight-restricted roads in North Carolina.
  - State Maintenance Operations
    - Maintenance, management, and restrictions of North Carolina's state roads.

Secondary Roads Information
North Carolina Low Volume Concrete Design

• Items currently at:
  https://connect.ncdot.gov/resources/Asset-Management/Pages/subdivisions.aspx

• Should provide a turnkey set of documents for designing and constructing concrete pavement.

• Allows for pavement as thin as 5 inches.

• Dowels not required for pavement less than 7.5 inches thick.

• Provides for use of lower strength PCC where appropriate.
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 with other traffic.
StreetPave is the latest in thickness design technology for streets and local road pavements. This software utilizes new engineering analyses to produce optimized concrete pavement thicknesses for city, municipal, county, and state roadways.
CONCRETE PAVEMENT DESIGN

Rigid ESALs = 6,602

Composite Modulus of Subgrade Reaction (Static k-Value) = 100 psi/in.

<table>
<thead>
<tr>
<th></th>
<th>Min. Required Thickness</th>
<th>Design Thickness</th>
<th>Max Joint Spacing</th>
<th>Failure Controlled By</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>in.</td>
<td>in.</td>
<td>ft</td>
<td></td>
</tr>
<tr>
<td>Doweled</td>
<td>5.27</td>
<td>5.50</td>
<td>11</td>
<td>Cracking</td>
</tr>
<tr>
<td>Undoweled</td>
<td>5.27</td>
<td>5.50</td>
<td>11</td>
<td>Cracking</td>
</tr>
</tbody>
</table>

*Because the doweled thickness is less than 8 in. and cracking is the predicted cause of failure, dowel bars typically would not be recommended for the design details you provided.
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

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

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<th>Load Transfer</th>
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Key design questions

- Is a subbase necessary?
- Are dowels necessary?
- How thick should the pavement be?
- How far apart should the joints be?
North 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.
# North 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>
</thead>
<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><strong>Medium</strong></td>
<td>130 - 170</td>
<td>4-8</td>
<td>2500 - 3300</td>
<td><strong>150</strong></td>
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<tr>
<td>Sand and sand-gravel with low silt and/or clay content</td>
<td>High</td>
<td>180 - 220</td>
<td>9-13</td>
<td>3500 - 4275</td>
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Table 3. Typical Range of Soil Characteristics and Support Values for Subgrade Soils.
North Carolina Design Examples

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

Residential Traffic, MR = 650 psi, 85% Reliability, With Edge Support

Figure 11. Design Chart E.
North Carolina Design Examples

Residential Traffic, MR = 550 psi,
85% Reliability, With Edge Support

Figure 7. Design Chart A.
## North Carolina Design Examples

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<tr>
<th>Slab Thickness (inches)</th>
<th>Maximum Recommended Joint Spacing (feet)</th>
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<tr>
<td>5.0</td>
<td>10</td>
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</tr>
<tr>
<td>6.0</td>
<td>12.5</td>
</tr>
<tr>
<td>6.5</td>
<td>12.5</td>
</tr>
<tr>
<td>7.0 or greater</td>
<td>15</td>
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Table 6. Maximum Recommended Transverse Joint Spacing
North Carolina Design Examples

• Design Recommendation:
  • 5” Plain Jointed PCC Pavement  
    • MR=550 psi, Compressive Strength=3500 psi  
  • No dowels
  • 10’ transverse joint spacing
  • 6” Soil-Cement Subbase
North Carolina Design Examples

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

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

![Graph showing Composite k Value with Unbound Granular Base](image)

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

Collector Traffic, MR = 550 psi, 85% Reliability, No Edge Support

Figure 10. Design Chart D.
North Carolina Design Examples

Collector Traffic, $MR = 650$ psi, 85% Reliability, No Edge Support

Figure 14. Design Chart H.
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Table 5. Recommended Load Transfer Options
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Table 6. Maximum Recommended Transverse Joint Spacing
• Design Recommendation:
  • 7” Plain Jointed PCC Pavement
    • MR=650 psi, Compressive Strength=4500 psi
  • No dowels
  • 15’ transverse joint spacing
  • 6” Aggregate Base Course
Resources

• 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......
Concrete Streets and Local Roads

Design Guide for Concrete Local Roads & Streets

North Carolina Department of Transportation

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connect.ncdot.gov/resources/Asset-Management/Pages/subdivisions.aspx
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Questions?