Concrete Pavement History

Seedling Miles

- One lane, 9 feet wide
- The industry built these in the hope that once motorists tried it, they would lobby for more miles of paved roads
Old IL 127
North of Greenville
Bates Road Test

- In 1920, Illinois passed a $200 million bond issue to build 9000 miles of paved roads
- To determine the best paving material, they built sections of brick, asphalt, and concrete
- Developed thickness design procedures and chose concrete for the Illinois pavements

Old WWI Army trucks with 9000# wheel loads
Source of Much of What We Know About Pavement Design

- President Eisenhower moved us into a new era
- AASHO Road Test
- Late 50’s and early 60’s
- Ottawa, Illinois
AASHO Test Traffic

Max Single Axle

Max Tandem Axle
Typical AASHO Pavement Sections

**Asphalt**
- Surface
- Base
- Subbase

**Concrete**
- Concrete
- Subbase

**Thickness**
- 5''
- 10''
- 15''
- 20''
- 25''
Keys to Quality Design
(Some things never change)

- The platform matters
  - Stable
  - Uniform
  - Not necessarily strong
Keys to Quality Design
(Some things never change)

- The platform matters
- Thickness & traffic matter
### AASHO Road Test Results

<table>
<thead>
<tr>
<th>CONCRETE THICKNESS</th>
<th>3&quot;</th>
<th>5&quot;</th>
<th>6½&quot;</th>
<th>8&quot;</th>
<th>9½&quot;</th>
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<td>REINFORCED</td>
<td>PLAIN</td>
<td>REINFORCED</td>
<td>PLAIN</td>
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</tr>
<tr>
<td>LANE 1</td>
<td>716</td>
<td>415</td>
<td>353</td>
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<td>343</td>
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<td>LOAD APPLICATIONS TO FAILURE (1,000#s)</td>
<td>4</td>
<td>4</td>
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</table>
Keys to Quality Design
(Some things never change)

- The platform matters
- Thickness & traffic matter
- Concrete cracks, so let's deal with it
Natural Crack Development

- Temperature Gradients
- Moisture Gradients
- Thermal Cycles
- Loading

Usually starts sometime after 12 hours and may take months.
Natural Crack Development

- Proper jointing early provides a series of saw cuts (joints) spaced to control crack formation
- No such thing as too many joints!
Do it Right and Concrete Pavements Provide...

- Longevity
- Low annual cost
Concrete Has Stood the Test of Time in Illinois

- Concrete on IL Interstate system has carried from 1.6 to 7.8 times its design traffic
- Hundreds of blocks of concrete city streets are in excess of 50 years old
- Some streets are over 90 years old

All were designed with a 20-year life!!!
AASHTO ’93 Guide

- Pavements Can be Compared at Roughly Equivalent Levels of Reliability
- Principles in both versions are identical for new construction
Reliability
What is it?

- Probability of “Winning”
- Factor of Safety
- Usually Expressed as %
AASHTO ’93 for Local Roads

Climatic Zones For Flexible Pavements
### AASHTO '93 Local Roads Catalog Designs

#### Table 4.7. Flexible Pavement Design Catalog for Low-Volume Roads: Recommended Ranges of Structural Number (SN) for Six U.S. Climatic Regions, Three Levels of Axle Load Traffic and Five Levels of Roadbed Soil Quality—Inherent Reliability: 75 percent

<table>
<thead>
<tr>
<th>Relative Quality of Roadbed Soil</th>
<th>Traffic Level</th>
<th>U.S. Climatic Region</th>
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<tr>
<td></td>
<td>High</td>
<td>I</td>
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<tr>
<td>Very good</td>
<td>High</td>
<td>2.6–2.7*</td>
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<tr>
<td></td>
<td>Medium</td>
<td>2.3–2.5</td>
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<tr>
<td></td>
<td>Low</td>
<td>1.6–2.1</td>
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<tr>
<td>Good</td>
<td>High</td>
<td>2.9–3.0</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>2.6–2.8</td>
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<td></td>
<td>Low</td>
<td>1.9–2.4</td>
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<td></td>
<td>Medium</td>
<td>2.8–3.1</td>
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<tr>
<td></td>
<td>Low</td>
<td>2.1–2.7</td>
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<tr>
<td>Poor</td>
<td>High</td>
<td>3.5–3.6</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>3.1–3.4</td>
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<td>Low</td>
<td>2.4–3.0</td>
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<tr>
<td>Very poor</td>
<td>High</td>
<td>3.8–3.9</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>3.4–3.7</td>
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<td></td>
<td>Low</td>
<td>2.6–3.2</td>
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*Recommended range of structural number (SN).
Table 4.9(b). Rigid Design Catalog for Low-Volume Roads: Recommended Minimum PCC Slab Thickness (Inches) for Three Levels of Axle Load Traffic and Five Levels of Roadbed Soil Quality

Inherent reliability: 75 percent.
With Granular Subbase

<table>
<thead>
<tr>
<th>Load Transfer Devices</th>
<th>No</th>
<th></th>
<th>Yes</th>
<th></th>
<th>No</th>
<th></th>
<th>Yes</th>
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<td>Edge Support</td>
<td>S'_c (psi)</td>
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<td>700</td>
<td>600</td>
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<tr>
<td>Relative Quality of Roadbed Soil</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Very good &amp; good</td>
<td>5.5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Fair</td>
<td>5.75</td>
<td>5.25</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
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<tr>
<td>Poor &amp; very poor</td>
<td>5.75</td>
<td>5.25</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

Low Traffic

| Relative Quality of Roadbed Soil | | | | | | | |
| Very good & good      | 6.25 | 5.75 | 5.75 | 5.25 | 6 | 5.5 | 5.5 | 5 |
| Fair                  | 6.5 | 5.75 | 6 | 5.5 | 6.25 | 5.5 | 5.5 | 5 |
| Poor & very poor      | 6.5 | 6 | 6 | 5.5 | 6.25 | 5.75 | 5.5 | 5.25 |

Medium Traffic

| Relative Quality of Roadbed Soil | | | | | | | |
| Very good & good      | 7.25 | 6.5 | 6.5 | 6 | 6.75 | 6 | 6 |
| Fair                  | 7.25 | 6.5 | 6.5 | 6 | 6.75 | 6 | 6 |
| Poor & very poor      | 7.25 | 6.75 | 6.75 | 6 | 6.75 | 6.25 | 6.75 | 6.25 |
Equivalent Sections for a Given Level of Fully Loaded Semi-Tractor Trailers Under Typical Illinois Conditions

(Based on 1993 AASHTO Guide for Design of Pavement Structures - 80 % Reliability)

---

10 Trucks Per Day

5.1 in. PCC

3 in. Class I Surf.

6 in. Class I Binder

4" Granular Subbase

4" Granular Subbase

---

50 Trucks Per Day

6.8 in. PCC

3 in. Class I Surf.

9 in. Class I Binder

4" Granular Subbase

4" Granular Subbase
Rockford
5” Concrete
Built ’84
About the same time as the asphalt

January 24, 2013

Summer 1996
Alternates with Approximate Costs

10 Trucks Per Day

- 5.1 in. CONCRETE
  - 4” Granular Subbase
  - Approximate Costs/sq. yd.
    - CONCRETE: $26.18
    - ASPHALT*: $37.30

- 3 in. BIT. Surface
  - 6 in. BIT. Binder
  - 4” Granular Subbase

50 Trucks Per Day

- 6.8 in. CONCRETE
  - 4” Granular Subbase
  - Approximate Costs/sq. yd.
    - CONCRETE: $30.56
    - ASPHALT*: $49.73

- 3 in. BIT. Surface
  - 9 in. BIT. Binder
  - 4” Granular Subbase
Recommendations for Peoria

- **The 7-inch recommendation**
  - Conservative for subdivisions
  - Probably light for collectors
  - Should be doweled for anything greater than 85 trucks/day

- **Jointing**
  - Panel lengths < 15 feet, shorter is better
  - Widths < 13 feet
  - Tied curb and gutter enhances performance

- **Granular subbase**
  - Test data indicate it is worth about 30 percent increase in performance compared to no subbase
  - But 9 inches is no better than 3 inches
  - Point of diminishing returns reached quickly for concrete
5F-1 Crack Control and Load Transfer

A. General Information

A good jointing plan will ease construction by providing clear guidance. The development of a jointing plan requires the designer to think about not only the specific project requirements but also the entire project jointing system. Jointing layouts in some parts of a project can have a substantial impact on other parts. In order to control concrete pavement cracking and subsequently maintain structural integrity, designers need to develop an understanding of how to complete jointing layouts of mainline pavements and intersections to obtain a comprehensive jointing system. This will allow a check on the pattern, type of joints, and the matching joints to their purpose.

This subsection of the pavement design section deals primarily with plain jointed pavements (tie bars or dowels only at specified joints). The primary function plain jointed pavements is to provide for load transfer across the joint, either through tie bars that hold the adjacent slabs together and allows for aggregate interlock to be maintained, or dowel bars that provide for mechanical load transfer even with slab movement.

Some cities in Iowa utilize jointed reinforced (JR) pavements, sometimes referred to as distributed steel reinforcing pavements. Section 5F-2, F discusses joint reinforced pavements. Joint reinforced pavements are used primarily to control cracking of a concrete pavement, to provide for load transfer, and to maintain the structural integrity of the slab between transverse joints. Joint reinforced pavements should not be confused with continuously reinforced pavement, which has very few or no joints.

The primary benefits of jointing are as follows:

1. Crack control. Cracking results from stress caused by concrete drying shrinkage, subgrade restraint, temperature-moisture differentials and applied traffic loads, and the combined effects of restraint curling and warping. It is highly desirable to control the location and geometry of transverse and longitudinal cracking in pavements. Without this control, cracking occurs in a random pattern similar to Figure 1, which results in increased distress of the joints.

   **Figure 1**: Effect of sawing on crack control.

   ![Random Cracking without Sawing](image1.png)  ![Controlled Cracking with Sawing](image2.png)

2. Accommodating slab movements.
3. Providing desirable load transfer.
Other Benefits of Concrete

- Durable rut resistant surface
- Reduce interim maintenance
- Environmentally Friendly
  - Light Reflective - Day and Night
  - Reduces Urban Heat Island Effects
- In today’s environment, it may even cost less!
Thanks for your time!

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