Municipal Pavement Design with StreetPave Software

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Presentation Overview

• Background / history of the design procedure
• Concrete pavement design principles
• Discussion of the primary factors (inputs) affecting concrete pavement design
• Example using StreetPave design software
Municipal Pavement Design

Thickness Design Basics
Streets and Local Roads Thickness Design Procedure

- Longitudinal joint
- Transverse joint
- Surface Texture
- Surface smoothness or rideability
- Tiebars
- Subgrade
- Subbase or base
- Concrete materials
- Dowel bars
- Thickness Design

Concrete materials

Dowel bars
Thickness Design Procedures

• **Empirical Design**
  – Based on observed performance
    • AASHO Road Test

• **Mechanistic Design**
  – Based calculated pavement responses
    • PCA Design Procedure (PCAPAV)
    • StreetPave (ACPA Design Method)

AASHO Test Road:
Ottawa, Illinois (approximately 80 miles southwest of Chicago) between 1956 and 1960
StreetPave Design Software

- Pavement design tool geared primarily for roads & streets
- Based on the PCA’s pavement thickness design methodology
- Checks adequacy of concrete thickness using both fatigue and erosion criteria
Concrete Pavement Types

- Jointed Plain
  - Undoweled
  - Doweled
- Jointed Reinforced
- Continuously Reinforced
- Prestressed
Jointed Plain

Plan

8 – 15 ft

Profile

or
SLR Pavement Design

- Street classification
- Traffic
- Geometric design
- Subgrade and subbase
- Concrete quality
- **Thickness design**
- Jointing
- Dowel Bar Recommendations
## Street Classifications

<table>
<thead>
<tr>
<th>Street Class</th>
<th>Description</th>
<th>Two-way Average Daily Traffic (ADT)</th>
<th>Two-way Average Daily Truck Traffic (ADTT)</th>
<th>Typical Range of Slab Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light Residential</td>
<td>Short streets in subdivisions and similar residential areas – often not through-streets.</td>
<td>Less than 200</td>
<td>2-4</td>
<td>4.0 - 5.0 in. (100-125 mm)</td>
</tr>
<tr>
<td>Residential</td>
<td>Through-streets in subdivisions and similar residential areas that occasionally carry a heavy vehicle (truck or bus).</td>
<td>200-1,000</td>
<td>10-50</td>
<td>5.0 - 7.0 in. (125-175 mm)</td>
</tr>
<tr>
<td>Collector</td>
<td>Streets that collect traffic from several residential subdivisions, and that may serve buses and trucks.</td>
<td>1,000-8,000</td>
<td>50-500</td>
<td>5.5 - 9.0 in. (135-225 mm)</td>
</tr>
<tr>
<td>Business</td>
<td>Streets that provide access to shopping and urban central business districts.</td>
<td>11,000-17,000</td>
<td>400-700</td>
<td>6.0 - 9.0 in. (150-225 mm)</td>
</tr>
<tr>
<td>Industrial</td>
<td>Streets that provide access to industrial areas or parks, and typically carry heavier trucks than the business class.</td>
<td>2,000-4,000</td>
<td>300-800</td>
<td>7.0 - 10.5 in. (175-260 mm)</td>
</tr>
<tr>
<td>Arterial</td>
<td>Streets that serve traffic from major expressways and carry traffic through metropolitan areas. Truck and bus routes are primarily on these roads.</td>
<td>4,000-15,000 (minor) 4,000-30,000 (major)</td>
<td>300-600 700-1,500</td>
<td>6.0 - 9.0 in. (150-225 mm) 7.0 - 11.0 in. (175-275 mm)</td>
</tr>
</tbody>
</table>
Municipal Pavement Design

Geometric Design
Geometric Design

• Increase Edge Support
  – Integral Curb
  – Tied Curb & Gutter
  – Widened Lanes (2 feet no parking)
  – Parking Lanes
  – Rural Areas – Tied Concrete Shoulders
**Edge Support**

**Concrete Shoulder**

**Curb & Gutter**
- separate
- or
- integral

**Widened Lane**
Basic Two-Lane Sections

25’ to 28’ wide

PLAN

PROFILE

No curb

25’-28’

18” min.

Integral curb Separate curb

28’ to 42’ wide

PLAN

PROFILE

No curb

28’-42’

18” min.

1/3 width (typ.)

Integral curb Separate curb

NOT TO SCALE
Three-Lane Section

34’ to 42’ wide

PLAN

PROFILE

1/3 width (typ.)

18” min.

34-42’

L

No curb

Integral curb  Separate curb

NOT TO SCALE
Subgrades and Subbases

- **Subgrade**
  - Natural ground, graded, and compacted on which the pavement is built.

- **Subbase**
  - Layer of material directly below the concrete pavement.
Design for Uniform Support

Three Major Causes for Non-Uniform Support

- Expansive Soils
- Differential Frost Heave
- Pumping (loss of support)
Subgrade Properties

Modulus of Subgrade Reaction, k-value

\[ k = \frac{\text{Plate load on subgrade}}{\text{Plate deflection on subgrade}} \]

\[ k = \frac{5.0 \text{ psi}}{0.5 \text{ in}} = 100 \text{ psi / in.} \]
### Subgrade Properties

**Subgrade Soil Types and Approximate k Values**

<table>
<thead>
<tr>
<th>Type of Soil</th>
<th>Support</th>
<th>k value range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fine-grained soils in which silt and clay-size particles predominate</td>
<td>Low</td>
<td>75 - 120 pci</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(20 - 34 MPa/m)</td>
</tr>
<tr>
<td>Sands and sand-gravel mixtures with moderate amounts of silt and clay</td>
<td>Medium</td>
<td>130 - 170 pci</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(35 - 49 MPa/m)</td>
</tr>
<tr>
<td>Sands and sand-gravel mixtures relatively free of plastic fines</td>
<td>High</td>
<td>180 - 220 pci</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(50 - 60 MPa/m)</td>
</tr>
</tbody>
</table>
# Subgrade Properties

## Resilient Modulus of the Subgrade

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Support</th>
<th>Resilient Modulus (MR), psi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fine-grained with high amounts of silt/clay</td>
<td>Low</td>
<td>1455-2325</td>
</tr>
<tr>
<td>Sand and sand-gravel with moderate silt/clay</td>
<td>Medium</td>
<td>2500-3300</td>
</tr>
<tr>
<td>Sand and sand-gravel with little or no silt/clay</td>
<td>High</td>
<td>3500-4275</td>
</tr>
</tbody>
</table>
## Subgrade Properties

Typical composite k-values for unbound granular, aggregate, or crushed stone subbase

<table>
<thead>
<tr>
<th>Subgrade k-value (pci)</th>
<th>Thickness of Unbound Granular or Crushed Stone Subbase</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4”</td>
</tr>
<tr>
<td>50</td>
<td>65</td>
</tr>
<tr>
<td>100</td>
<td>130</td>
</tr>
<tr>
<td>150</td>
<td>176</td>
</tr>
<tr>
<td>200</td>
<td>220</td>
</tr>
</tbody>
</table>
Subgrade and Subbases Design

Summary

• Subgrade strength is not a critical element in the thickness design.
  – Has little impact on thickness.

• Need to know if pavement is on:
  – Subgrade \( k \approx 100 \text{ psi/in.} \ (25 \text{ MPa/m}) \),
  – Granular subbase \( k \approx 150 \text{ psi/in.} \ (40 \text{ MPa/m}) \),
  – Asphalt treated subbase \( k \approx 300 \text{ psi/in.} \ (80 \text{ MPa/m}) \)
  – Cement treated/lean concrete subbase \( k \approx 500 \text{ psi/in.} \ (125 \text{ MPa/m}) \).
Subbase Effects

At the AASHO Road Test, concrete pavements with granular bases could carry about 30% more traffic.

The current design procedures allows concrete pavements built with granular bases to carry about 5 - 8% more traffic.
Fatigue Analysis

- Allowable number of load repetitions for each axle group is determined
- % Fatigue is calculated for each axle group
- Total fatigue consumed should not exceed 100%.

Midslab loading away from transverse joint produces critical edge stresses
Pavement Design Principle #1

Stress / Fatigue

- Compressive strength: ~4000 psi
- Flexural strength: ~600 psi
Pavement Design Principle #1
Stress / Fatigue
Thickness Design Procedure
Concrete Properties

• Flexural Strength
  (Modulus of Rupture, ASTM C 78)
  – Avg. 28-day strength in 3rd-point loading

• Other Factors:
  – Concrete Strength Gain w/ Age
  – Fatigue Properties

Span Length = L

Third-point Loading

\[ d = \frac{L}{6} \]
If specify minimum flexural strength at 28-day of 550 psi & allow 10% of beams to fall below minimum:

**STEP 1**

- Estimate SDEV:
  9% for typical ready mix.
  \[
  \text{SDEV} = 550 \times 0.09 = 50 \text{ psi}
  \]

**STEP 2**

- \[ S'c_{\text{design}} = S'c_{\text{minimum}} + z \times \text{SDEV} \]
- \[ S'c_{\text{design}} = 550 + 1.282 \times 50 \]
- \[ S'c_{\text{design}} = 614 \text{ psi} \]
Design Period/Life

• 20 to 35 years is commonly used
• Shorter or longer design period may be economically justified in some cases
• High performance concrete pavements
  – Long-life pavements
  – A special haul road to be used for only a few years
  – Cross-overs
  – Temporary lanes
Reliability

- Is simply the factor of safety
- Usually expressed as %
- Is a measure of how likely the design will fail due to fatigue or erosion
- Or can be used to estimate the amount of pavement repair required at the end of design period/life
## Reliability

### Levels of Reliability for Pavement Design

<table>
<thead>
<tr>
<th>Functional Classification of Roadway</th>
<th>Recommended Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Urban</td>
</tr>
<tr>
<td>Interstates, Freeways, and Tollways</td>
<td>85 - 99</td>
</tr>
<tr>
<td>Principal Arterials</td>
<td>80 - 99</td>
</tr>
<tr>
<td>Collectors</td>
<td>80 - 95</td>
</tr>
<tr>
<td>Residential &amp; Local Roads</td>
<td>50 - 80</td>
</tr>
</tbody>
</table>
# Thickness Design

## Recommended Levels of Slab Cracking by Roadway Type

<table>
<thead>
<tr>
<th>Roadway Type</th>
<th>Recommended Percent of Slabs Cracked at End of Design Life</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Default)</td>
<td>15%</td>
</tr>
<tr>
<td>Interstate Highways, Expressways, Tollways, Turnpikes</td>
<td>5%</td>
</tr>
<tr>
<td>State Roads, Arterials</td>
<td>10%</td>
</tr>
<tr>
<td>Collectors, County Roads</td>
<td>15%</td>
</tr>
<tr>
<td>Residential Streets</td>
<td>25%</td>
</tr>
</tbody>
</table>
Effects of Combined Reliability & Slab Cracking

Table 5. Typical Values of Reliability and Percent Cracking

<table>
<thead>
<tr>
<th>Street classification</th>
<th>Specified reliability</th>
<th>Percent cracking</th>
<th>Average percent cracking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light residential</td>
<td>75%</td>
<td>15%</td>
<td>7.5%</td>
</tr>
<tr>
<td>Residential</td>
<td>80%</td>
<td>15%</td>
<td>6%</td>
</tr>
<tr>
<td>Collector</td>
<td>85%</td>
<td>10%</td>
<td>3%</td>
</tr>
<tr>
<td>Minor arterial</td>
<td>90%</td>
<td>10%</td>
<td>2%</td>
</tr>
<tr>
<td>Major arterial</td>
<td>95%</td>
<td>5%</td>
<td>0.5%</td>
</tr>
</tbody>
</table>

Average percent cracking = (100 – User-specified reliability) * Percent cracking / 50.
Erosion Analysis

• Repetitions of heavy axle loads cause:
  – pumping; erosion of subgrade, subbase and shoulder materials; voids under and adjacent to the slab; and faulting of pavement joints.

• A thin pavement with its shorter deflection basin receives a faster load punch than a thicker slab.
Pavement Design Principle #2
Deflection / Erosion / Pumping

Faulting
Design - Erosion

Conditions for Pumping:

- Subgrade soil that will go into Suspension
- Free water between slab and subgrade
- Frequent heavy wheel loads / large deflections
Concrete Pavement Design for Municipal Streets

Load Transfer = slabs ability to share its load with neighboring slabs

- Aggregate Interlock
- Dowels
- Edge Support
  - Tied curb & gutter
  - Integral curb & gutter
  - Parking lane
  - Tied concrete

\[ \Delta U = 0 \]

\[ \Delta L = \frac{x}{2} \]  \[ \Delta U = \frac{x}{2} \]

Poor Load Transfer

Good Load Transfer
Aggregate Interlock

Shear between aggregate particles below the initial saw cut
Aggregate Interlock
Dowel Recommendations

- Dowels recommendations:
  - If pavement thickness is 7” or less dowels not recommended
  - If pavement thickness is 7.0” & 7.5” use 1” dowels, stabilized subgrade, or 4-6” subbase. Note: If erosion is the failure mechanism.
  - If pavement thickness is 8” or greater use 1¼” dowels
Dowel bars

- Length 14” min.
- 6.0 in. minimum embedment length
- Diameter:
  - 1.0 in streets and roads
  - 1.25 - 1.50 in. for arterials roads
- Epoxy or other corrosion protection for harsh climates
Table 13(a). Concrete Thickness (inches), 30-Year Design WITH Concrete Curb and Gutter or Concrete Shoulders

<table>
<thead>
<tr>
<th>Traffic classification</th>
<th>k = 100 psi</th>
<th>k = 150 psi</th>
<th>k = 200 psi</th>
<th>k = 300 psi</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Modulus of rupture (psi)</td>
<td>Modulus of rupture (psi)</td>
<td>Modulus of rupture (psi)</td>
<td>Modulus of rupture (psi)</td>
</tr>
<tr>
<td>Light residential</td>
<td>550 600 650</td>
<td>550 600 650</td>
<td>550 600 650</td>
<td>550 600 650</td>
</tr>
<tr>
<td>2-lane ADTT = 3</td>
<td>5.0 5.0 4.5</td>
<td>5.0 4.5 4.5</td>
<td>4.5 4.5 4.0</td>
<td>4.5 4.0 4.0</td>
</tr>
<tr>
<td>Residential</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-lane</td>
<td>550 600 650</td>
<td>550 600 650</td>
<td>550 600 650</td>
<td>550 600 650</td>
</tr>
<tr>
<td>ADTT = 10</td>
<td>5.5 5.5 5.0</td>
<td>5.5 5.0 5.0</td>
<td>5.0 4.5 4.5</td>
<td>5.0 4.5 4.5</td>
</tr>
<tr>
<td>ADTT = 20</td>
<td>6.0 5.5 5.5</td>
<td>5.5 5.5 5.0</td>
<td>5.5 5.0 5.0</td>
<td>5.0 5.0 4.5</td>
</tr>
<tr>
<td>ADTT = 50</td>
<td>6.0 6.0 5.5</td>
<td>5.5 5.5 5.0</td>
<td>5.5 5.0 5.0</td>
<td>5.0 5.0 4.5</td>
</tr>
<tr>
<td>Collector</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-lane</td>
<td>550 600 650</td>
<td>550 600 650</td>
<td>550 600 650</td>
<td>550 600 650</td>
</tr>
<tr>
<td>ADTT = 50</td>
<td>6.5 6.0 6.0</td>
<td>6.0 6.0 5.5</td>
<td>6.0 5.5 5.5</td>
<td>5.5 5.5 5.0</td>
</tr>
<tr>
<td>ADTT = 100*</td>
<td>6.5 6.5 6.0</td>
<td>6.5 6.0 6.0</td>
<td>6.0 6.0 6.0</td>
<td>6.0 6.0 6.0</td>
</tr>
<tr>
<td>ADTT = 500*</td>
<td>7.0 6.5 6.5</td>
<td>6.5 6.5 6.0</td>
<td>6.5 6.0 6.0</td>
<td>6.0 6.0 6.0</td>
</tr>
<tr>
<td>Business</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2- or 4-lane</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADTT = 400*</td>
<td>7.0 6.5 6.5</td>
<td>6.5 6.5 6.0</td>
<td>6.5 6.0 6.0</td>
<td>6.0 6.0 6.0</td>
</tr>
<tr>
<td>ADTT = 700*</td>
<td>7.0 6.5 6.5</td>
<td>6.5 6.5 6.0</td>
<td>6.5 6.0 6.0</td>
<td>6.0 6.0 6.0</td>
</tr>
<tr>
<td>Minor arterial</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4-lane</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADTT = 300*</td>
<td>7.5 7.5 7.0</td>
<td>7.5 7.0 6.5</td>
<td>7.0 6.5 6.5</td>
<td>6.5 6.5 6.0</td>
</tr>
<tr>
<td>ADTT = 600*</td>
<td>8.0 7.5 7.0</td>
<td>7.5 7.0 6.5</td>
<td>7.0 6.5 6.5</td>
<td>6.5 6.5 6.0</td>
</tr>
<tr>
<td>Industrial</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4-lane</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADTT = 300*</td>
<td>8.0 8.0 7.5</td>
<td>8.0 7.5 7.0</td>
<td>7.5 7.0 7.0</td>
<td>7.0 7.0 7.0</td>
</tr>
<tr>
<td>ADTT = 800*</td>
<td>8.5 8.0 8.0</td>
<td>8.5 7.5 7.5</td>
<td>8.0 7.5 7.5</td>
<td>7.5 7.5 7.5</td>
</tr>
<tr>
<td>Major arterial</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4-lane</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADTT = 700*</td>
<td>8.5 8.0 7.5</td>
<td>8.0 7.5 7.5</td>
<td>8.0 7.5 7.5</td>
<td>7.5 7.5 7.5</td>
</tr>
<tr>
<td>ADTT = 1100*</td>
<td>8.5 8.0 8.0</td>
<td>8.0 8.0 7.5</td>
<td>8.0 7.5 7.5</td>
<td>7.5 7.5 7.5</td>
</tr>
<tr>
<td>ADTT = 1500*</td>
<td>8.5 8.5 8.0</td>
<td>8.5 8.0 7.5</td>
<td>8.0 7.5 7.5</td>
<td>7.5 7.5 7.5</td>
</tr>
</tbody>
</table>

* Dowels recommended when ADTT is greater than or equal to 80:
1. If pavement thickness is 6" or less dowels not recommended
2. If pavement thickness is 6.5" to 7.5" use 1" dowels
3. If pavement thickness is 8" or greater use 1¾" dowels

CONVERSIONS
1 in. = 25.4 mm
100 psi = 0.689 MPa
100 pci = 27.15 MPa/m
### Table 13(b). Concrete Thickness (inches), 30-Year Design WITHOUT Concrete Curb and Gutter or Concrete Shoulders

<table>
<thead>
<tr>
<th>Traffic classification</th>
<th>k = 100 pci</th>
<th>k = 150 pci</th>
<th>k = 200 pci</th>
<th>k = 300 pci</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Modulus of rupture (psi)</td>
<td>Modulus of rupture (psi)</td>
<td>Modulus of rupture (psi)</td>
<td>Modulus of rupture (psi)</td>
</tr>
<tr>
<td></td>
<td>550</td>
<td>600</td>
<td>650</td>
<td>550</td>
</tr>
<tr>
<td>Light Residential</td>
<td>ADTT = 3</td>
<td>6.0</td>
<td>5.5</td>
<td>5.5</td>
</tr>
<tr>
<td>Residential 2-lane</td>
<td>ADTT = 10</td>
<td>6.5</td>
<td>6.5</td>
<td>6.0</td>
</tr>
<tr>
<td></td>
<td>ADTT = 20</td>
<td>7.0</td>
<td>6.5</td>
<td>6.0</td>
</tr>
<tr>
<td></td>
<td>ADTT = 50</td>
<td>7.0</td>
<td>7.0</td>
<td>6.5</td>
</tr>
<tr>
<td>Collector 2-lane</td>
<td>ADTT = 50</td>
<td>7.5</td>
<td>7.0</td>
<td>7.0</td>
</tr>
<tr>
<td></td>
<td>ADTT = 100*</td>
<td>8.0</td>
<td>7.5</td>
<td>7.0</td>
</tr>
<tr>
<td></td>
<td>ADTT = 500*</td>
<td>8.0</td>
<td>8.0</td>
<td>7.5</td>
</tr>
<tr>
<td>Business 2- or 4-lane</td>
<td>ADTT = 400*</td>
<td>8.0</td>
<td>8.0</td>
<td>7.5</td>
</tr>
<tr>
<td></td>
<td>ADTT = 700*</td>
<td>8.5</td>
<td>8.0</td>
<td>7.5</td>
</tr>
<tr>
<td>Minor Arterial 4-lane</td>
<td>ADTT = 300*</td>
<td>9.0</td>
<td>8.5</td>
<td>8.0</td>
</tr>
<tr>
<td></td>
<td>ADTT = 800*</td>
<td>9.5</td>
<td>9.0</td>
<td>8.5</td>
</tr>
<tr>
<td>Industrial 4-lane</td>
<td>ADTT = 300*</td>
<td>9.5</td>
<td>9.0</td>
<td>8.5</td>
</tr>
<tr>
<td></td>
<td>ADTT = 800*</td>
<td>10.0</td>
<td>9.5</td>
<td>9.0</td>
</tr>
<tr>
<td>Major Arterial 4-lane</td>
<td>ADTT = 700*</td>
<td>10.0</td>
<td>9.5</td>
<td>9.0</td>
</tr>
<tr>
<td></td>
<td>ADTT = 1100*</td>
<td>10.0</td>
<td>9.5</td>
<td>9.0</td>
</tr>
<tr>
<td></td>
<td>ADTT = 1500*</td>
<td>10.0</td>
<td>9.5</td>
<td>9.0</td>
</tr>
</tbody>
</table>

* Dowels recommended when ADTT is greater than or equal to 80:
1. If pavement thickness is 6" or less dowels not recommended
2. If pavement thickness is 6.5" to 7.5" use 1" dowels
3. If pavement thickness is 8" or greater use 1 1/4" dowels

**CONVERSIONS**

1 in. = 25.4 mm
100 pci = 0.689 MPa
100 pci = 27.15 MPa/m
Thickness Design Procedure

Design controlled by:

• Fatigue usually controls design of light-traffic pavements, light residential, collector, minor arterial
  – Single-axles usually cause more fatigue damage

• Erosion usually controls design of undoweled medium- and heavy-traffic pavements, minor and major arterials
  – Tandem-axles usually cause more erosion damage
  – Tridem-axles usually cause more erosion damage
Jointing

- Control natural transverse and longitudinal crack from internal slab stresses
- Divide pavement into construction lanes or increments
- Accommodate slab movements
- Provide load transfer
- Provide uniform sealant reservoir

**Longitudinal Joints**
Divides pavement lanes (8-12 ft.)
Depth ¼ - 1/3 pavement thickness

**Transverse Joints**
Transverse Contraction Joints (8-15 ft.)
Depth ¼ - 1/3 pavement thickness
Municipal Pavement Design

StreetPave Example
StreetPave User Inputs & Outputs

- Global Settings
  - Region
  - Units (English or Metric)
  - Terminal Serviceability
  - Percent Slabs Cracked at end of design Life
- Design Life
- Reliability
- Traffic
- Pavement Properties
- Thickness/Dowel/Jointing Recommendations
Design Example – Inputs

- Design life = 30 years
- k-value = 100 pci
- Concrete flexural strength = 600 psi
- Load transfer (dowels) = No/yes
- Edge support = yes
- Traffic category = Collector
- 2-way ADTT = 100
- Reliability = 80%
- Percent Slabs Cracked = 15%
Edit your global settings below.

1. Region (refer to map)
   - MAAT = 45°F
   - MAAT = 60°F
   - MAAT = 75°F

2. Units
   - English
   - Metric

3. Terminal Serviceability
   - 2

4. Percent of Concrete Slabs Cracked at End of Design Life
   - 15%

Save and Close
Terminal Serviceability is a measure of pavement condition. It was devised for the AASHO Road Test, which occurred from 1958 to 1960 in Ottawa, Illinois. The serviceability of a pavement is rated on a scale from 0 (completely impassable) to 5 (perfect pavement condition). Terminal serviceability is the point at which the pavement needs rehabilitation of some sort, such as restoration, resurfacing, or reconstruction.

StreetPave uses terminal serviceability to calculate the equivalent single axle loads (ESALs) carried by the pavement structure over the design life. The calculation of ESALs is not very sensitive to terminal serviceability, so an estimate of the desired terminal serviceability is adequate.

Typical terminal serviceability values include:

<table>
<thead>
<tr>
<th>Terminal Serviceability</th>
<th>Road or Street Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.50</td>
<td>Interstates, Tollways, Major Highways, Major Arterials</td>
</tr>
<tr>
<td>2.25</td>
<td>Primary Roads, Minor Arterials, Industrial and Commercial Streets</td>
</tr>
<tr>
<td>2.00</td>
<td>Secondary Roads, Collector Residential Streets</td>
</tr>
<tr>
<td>1.50</td>
<td>Complete Pavement Failure</td>
</tr>
</tbody>
</table>
This input should reflect the allowable percent of concrete slabs that are cracked at the end of the design life of the pavement. This number could correspond to the percent of slabs that are intended to be replaced in determining future rehabilitation of the pavement for life cycle cost analysis. Recommended percentages are as follows:

<table>
<thead>
<tr>
<th>Type</th>
<th>Recommended Percent of Concrete Slabs Cracked at End of Design Life</th>
</tr>
</thead>
<tbody>
<tr>
<td>Default</td>
<td>15%</td>
</tr>
<tr>
<td>Interstate Highways, Expressways, Tollways, Turnpikes</td>
<td>5%</td>
</tr>
<tr>
<td>State Roads, Arterials, Collectors, County Roads</td>
<td>15%</td>
</tr>
<tr>
<td>Residential Streets</td>
<td>25%</td>
</tr>
</tbody>
</table>

The asphalt fatigue equation (or relationship) on which the asphalt design procedures are based was obtained from laboratory fatigue data which had been adjusted to provide an indication of approximately 20 percent or greater fatigue cracking (based on total pavement area) in selected sections of the AASHO Road Test. Therefore, asphalt designs are essentially cracked at 20 percent cracking or greater (45 percent in the wheel path) while concrete pavements are typically designed for less than that amount.

Step 1. Choose the Design/Analysis Type(s) you would like to perform and then click the Confirm button.

**Project Information:**

- **Project Name**
- **Project Description**
- **Route**
- **Owner / Agency**
- **Location**
- **Design Engineer**

**Design/Analysis Type:**

- [ ] Determine Concrete Thickness and
- [ ] Determine Equivalent Asphalt Thickness
- [ ] Determine Life-Cycle Costs
- [ ] Analyze Existing Concrete Pavement

**Project-Level Inputs:**

- **Design Life**: 20 years
- **Reliability**: 85 %
Step 2. Enter Project Information and Project-Level inputs then click the Next button.

**Project Information:**

- **Project Name:** Virginia Concrete Pavement Conference
- **Project Description:** 2-Lane Collector
- **Route:** Route 1
- **Owner/Agency:** City of Richmond
- **Location:** Richmond, VA
- **Design Engineer:** Scott Haislip

**Design/Analysis Type:**
- Determine Concrete Thickness and
- Determine Equivalent Asphalt Thickness
- Determine Life-Cycle Costs
- Analyze Existing Concrete Pavement

**Project-Level Inputs:**
- **Design Life:** 30 years
- **Reliability:** 80 %
Step 3. Define Traffic by filling in and making choices for all inputs.

Traffic category:
- Residential
- Collector
- Minor Arterial
- Major Arterial
- User Defined

Total Number of Lanes: Choose Number
- 2
- 4
- 6
- 8
- 10

Directional Distribution:
- 2
- 4
- 6
- 8
- 10

Design Lane Distribution:
- 2
- 4
- 6
- 8

ADTT (average daily truck traffic, two-way):
- 100

ADT (average daily traffic, two-way):
- 2000

% trucks:
- 1

Truck traffic growth:
- 2 % per year

Traffic Category:
- Single Axles
- Tandem Axles
- Tridem Axles (User Defined Only)
Step 3. Define Traffic by filling in and making choices for all inputs.

Traffic category:
- Residential
- Collector
- Minor Arterial
- Major Arterial
- User Defined

Total Number of Lanes: 2
Directional Distribution: 50%
Design Lane Distribution: 100%

ADTT (average daily truck traffic, two-way): 100
ADT (average daily traffic, two-way): 2000
% trucks: 1

Truck traffic growth: 2 % per year

Traffic Category:

<table>
<thead>
<tr>
<th>Traffic Category</th>
<th>Collector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Axles</td>
<td>Axles / 1000 trucks</td>
</tr>
<tr>
<td>26</td>
<td>0.07</td>
</tr>
<tr>
<td>24</td>
<td>1.8</td>
</tr>
<tr>
<td>22</td>
<td>2.6</td>
</tr>
<tr>
<td>20</td>
<td>6.63</td>
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<tr>
<td>18</td>
<td>16.61</td>
</tr>
<tr>
<td>16</td>
<td>23.88</td>
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<tr>
<td>14</td>
<td>47.76</td>
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<tr>
<td>12</td>
<td>116.76</td>
</tr>
<tr>
<td>10</td>
<td>142.7</td>
</tr>
<tr>
<td>8</td>
<td>233.6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tandem Axles</th>
<th>Axles / 1000 trucks</th>
</tr>
</thead>
<tbody>
<tr>
<td>44</td>
<td>1.18</td>
</tr>
<tr>
<td>40</td>
<td>7.76</td>
</tr>
<tr>
<td>36</td>
<td>38.79</td>
</tr>
<tr>
<td>32</td>
<td>54.76</td>
</tr>
<tr>
<td>28</td>
<td>44.43</td>
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<tr>
<td>24</td>
<td>30.74</td>
</tr>
<tr>
<td>20</td>
<td>45</td>
</tr>
<tr>
<td>16</td>
<td>59.25</td>
</tr>
<tr>
<td>12</td>
<td>91.15</td>
</tr>
<tr>
<td>8</td>
<td>47.01</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tridem Axles (User Defined Only)</th>
<th>Axles / 1000 trucks</th>
</tr>
</thead>
<tbody>
<tr>
<td>62</td>
<td>0</td>
</tr>
<tr>
<td>56</td>
<td>0</td>
</tr>
<tr>
<td>50</td>
<td>0</td>
</tr>
<tr>
<td>44</td>
<td>0</td>
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<tr>
<td>38</td>
<td>0</td>
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<tr>
<td>32</td>
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<td>26</td>
<td>0</td>
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<tr>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>0</td>
</tr>
</tbody>
</table>
CONCRETE PAVEMENT

Resilient Modulus of the Subgrade (MRSG)

Design subbase layer system and use calculated kvalue
- Add Layers: 100 pci
- User-defined kvalue for existing subbase layer system: 161 pci

Select Concrete Properties
- 28-Day Flexural Strength (MR): 600 psi
- Modulus of Elasticity (E): 4050000 psi

Select Load Transfer Dowels
- yes  no

Select Edge Support (tied concrete shoulder, curb and gutter, or widened lane)
- yes  no

ASPHALT PAVEMENT

Adjust Support for Asphalt Design Reliability
- Coefficient of Variation (COV): 38 %
- Design MRSG: 1319.56 psi

Select Asphalt Pavement Type
- Design Type: Choose Type
- Asphalt with 6" Granular Base
- Asphalt with 12" Granular Base

*Full-depth design type not available due to MRSG [design] value. Click MRSG help for details.
The asphalt design procedure used in this program incorporates reliability of the asphalt design section as a function of the subgrade resilient modulus. To accomplish this adjustment, a coefficient of variation of the supporting soils is needed. Also, seasonal variation is not considered as part of this procedure. Average conditions should be used.

The equation used is as follows:

$$ MRSG \text{ [design]} = MRSG \text{ [user-entered]} \times (1 - ZR \times COV) $$

Where:
- $MRSG \text{ [design]}$ = the value of subgrade resilient modulus to use in the asphalt design equation
- $MRSG \text{ [user-entered]}$ = the subgrade resilient modulus value that is entered (or calculated) by the user
- $ZR$ = standard normal variate, calculated from user-entered reliability ($R$)
- $COV$ = coefficient of variation typical of the project type and soils for the project

Typical values to use for coefficient of variation, if the value is unknown for a particular project:

<table>
<thead>
<tr>
<th>Range</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.28-0.38</td>
<td>Projects with extremely high levels of quality control and very homogenous soils throughout the project. Projects characteristic of research sections and special projects.</td>
</tr>
<tr>
<td>0.38-0.45</td>
<td>Projects with typical levels of quality control and typical variation of soils within the project. Typical mainline highway construction.</td>
</tr>
<tr>
<td>0.46-0.50</td>
<td>Projects with typical levels of quality control in variable soils. Typical mainline roadway construction or high-quality municipal construction.</td>
</tr>
<tr>
<td>0.59-0.70</td>
<td>Projects with little quality control of soils. Sections typical of municipal paving or industrial sections built with little or no inspection.</td>
</tr>
<tr>
<td>0.38</td>
<td>Note: The coefficient of variation for soils on the flexible sections at the AASHO Road Test, 1958-1960, Ottawa, Illinois, USA</td>
</tr>
</tbody>
</table>

Note: This guidance is based largely on experience in looking at field data as well as reports and data from state highway agencies.
Consistent with asphalt industry procedures, the asphalt design equations used in StreetPave are not calibrated to subgrade resilient moduli lower than 3000 psi. However, values less than 3000 psi can be used in StreetPave, if a base course is specified under the asphalt. On softer soils, a base (or subbase) course of crushed stone or other quarried material becomes a construction platform to aid asphalt compaction. In order to obtain the required density in the asphalt during construction, the asphalt lifts need to be placed against a material that can provide adequate support. If a specific soil has a resilient modulus lower than 3000 psi, it can also be improved through the use of chemical stabilization or modification agents such as cement, cement kiln dust, fly ash, lime, or lime kiln dust.

StreetPave uses the MRSG [design] value as opposed to the MRSG [user-entered] value for calculations and analysis. This is consistent with asphalt industry practice, which incorporates reliability into pavement design by directly adjusting the resilient modulus of the subgrade (MRSG Design). The MRSG [design] equation is provided below.

Your current values:

MRSG [user-entered]: 1940 psi

MRSG [design]: 1319.6 psi

The equation used is as follows:

MRSG [design] = MRSG [user-entered] x (1 - ZR x COV)

Where:

MRSG [design] = the value of subgrade resilient modulus to use in the asphalt design equation

MRSG [user-entered] = the subgrade resilient modulus value that is entered (or calculated) by the user

ZR = standard normal variate, calculated from user-entered reliability (R)

COV = coefficient of variation typical of the project type and soils for the project

*Design Limitation*

The full depth asphalt design type is not available because your current MRSG [design] value is less than 3000 psi. If full-depth asphalt designs are desired, the user-entered subgrade resilient modulus, reliability, and/or coefficient of variation must be modified in order to obtain a design subgrade resilient modulus greater than 3000 psi.
CONCRETE PAVEMENT

Resilient Modulus of the Subgrade ($M_{RS}$)
(used for both concrete and asphalt designs)

Composite Modulus of Subgrade Reaction ($k$)

- Design subbase layer system and use calculated $k$ value
  - Add Layers 100 psi
  - Help
- User-defined $k$ value for existing subbase layer system
  - 161 psi

Select Concrete Properties

- 28-Day Flexural Strength ($MR$) 600 psi
- Modulus of Elasticity ($E$) 4050000 psi

Select Load Transfer Dowels

- yes
- no

Select Edge Support (tied concrete shoulder, curb and gutter, or widened lane)

- yes
- no

ASPHALT PAVEMENT

Adjust Support for Asphalt Design Reliability

- Coefficient of Variation (COV) 38%
- Design ($M_{RS}$) 1319.56 psi
  - Info*

*Full-depth design type not available due to MRSG [design] value. Click MRSG help for details.

Select Asphalt Pavement Type

- Design Type: Asphalt with 6" Granular Base

[Diagram of HMAC 9" granular base subgrade]
CONCRETE PAVEMENT

Resilient Modulus of the Subgrade \( (M_{RSG}) \)
(used for both concrete and asphalt designs)

Composite Modulus of Subgrade Reaction \( (k) \)
- Design subbase layer system and use calculated k value
  - Add Layers 100 psi
  - Help
- User-defined k value for existing subbase layer system
  - 161 psi

Select Concrete Properties
- 28-Day Flexural Strength \( (MR) \) 600 psi
- Modulus of Elasticity \( (E) \) 4050000 psi

Select Load Transfer Dowels
- yes
- no

Select Edge Support (tied concrete shoulder, curb and gutter, or widened lane)
- yes
- no

Your current Resilient Modulus of Subgrade value \( (M_{RSG}) \) is: 1940 psi

The corresponding k-value before adding subbase layer(s) is: 100 psi

To determine the k-value for a subbase layer system, use the calculator tool below. First input the subbase(s) resilient modulus and thickness. Next, click the calculate k-value button.

Step 1 - From the Top Down, Input Subbase(s) Resilient Modulus and Thickness

Number of subbase layers between subgrade and concrete pavement:
- 1 Layer

Top Layer: Unbound Compacted Granular Materials (sand/gravel, crushed stone)

Resilient Modulus of Subbase \( (M_{RSB}) \)
- Allowable Range: 15,000 - 45,000 psi
- Thickness of Subbase 6 in.

Layer 2 Choose Layer
Resilient Modulus of Subbase \( (M_{RSB}) \)
- Allowable Range: Choose Layer Type
- Thickness of Subbase

Layer 3 Choose Layer
Resilient Modulus of Subbase \( (M_{RSB}) \)
- Allowable Range: Choose Layer Type
- Thickness of Subbase

Step 2 - Calculate K

K Value Run Calculation

Close Window and Save K
CONCRETE PAVEMENT

Resilient Modulus of the Subgrade ($M_{\text{RSG}}$) (used for both concrete and asphalt designs)

- **Composite Modulus of Subgrade Reaction ($k$)**
  - Design subbase layer system and use calculated $k$ value
    - Add Layers: 131 psi
  - User-defined $k$ value for existing subbase layer system
    - 161 psi

- **Select Concrete Properties**
  - 28-Day Flexural Strength (MR): 600 psi
  - Modulus of Elasticity ($E$): 405,000 psi

- **Select Load Transfer Dowels**
  - yes
  - no

- **Select Edge Support** (tied concrete shoulder, curb and gutter, or widened lane)
  - yes
  - no

ASPHALT PAVEMENT

Adjust Support for Asphalt Design Reliability

- Coefficient of Variation (COV): 38%
- Design ($M_{\text{RSG}}$): 1319.56 psi

*Full-depth design type not available due to MRSG design value. Click MRSG help for details.

Select Asphalt Pavement Type

- Design Type: Asphalt with 6" Granular Base
Composite Modulus of Subgrade Reaction \( (k) = \) \( \text{pci} \)

Resilient Modulus of the Subgrade:
- MRSG [user-entered] = \( \text{psi} \)
- MRSG [design] = \( \text{psi} \)

Base =

Flexible ESALs =

Design Concrete Thickness = \( \text{in.} \)

Design Asphalt Thickness = \( \text{in.} \)

Concrete Recommendations:
- Concrete Thickness = \( \text{in.} \)
- Maximum Transverse Joint Spacing = \( \text{ft.} \)
- Dowel Bars:

View and Print Reports
- Design and Analysis Summary

Sensitivity Analysis of:
- k-value
- Reliability
- Concrete Strength
- % Slabs Cracked
- Design Life

Progress Bar
Concrete Pavement

Composite Modulus of Subgrade Reaction \( (k) = 100 \text{ psi} \)

Design Concrete Thickness = 6.17 in.

Concrete Recommendations:
- Concrete Thickness = 6.50 in.
- Maximum Transverse Joint Spacing = 13 ft.
- Dowel Bars: Dowel bars not chosen and not recommended.

Asphalt Pavement

Resilient Modulus of the Subgrade:
- MRSG [user-entered] = 1940 psi
- MRSG [design] = 1319.6 psi
- Base = 6 inch Granular Base
- Flexible ESALs = 405,148

Design Asphalt Thickness = 11.03 in.
<table>
<thead>
<tr>
<th>Traffic Category</th>
<th>Collector</th>
<th>Fatigue Analysis</th>
<th>Erosion Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Axles per 1000 Trucks</td>
<td>Expected Repetitions</td>
<td>Stress Ratio</td>
</tr>
<tr>
<td><strong>Axle Load, kips</strong></td>
<td><strong>Single Axles</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>0.07</td>
<td>52</td>
<td>0.745</td>
</tr>
<tr>
<td>24</td>
<td>1.6</td>
<td>1185</td>
<td>0.691</td>
</tr>
<tr>
<td>22</td>
<td>2.6</td>
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<tr>
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<td>6.63</td>
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<td>0.582</td>
</tr>
<tr>
<td>18</td>
<td>16.61</td>
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<tr>
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<td>23.88</td>
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<td>47.76</td>
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<td>12</td>
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<td>10</td>
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<td>0.303</td>
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<tr>
<td>8</td>
<td>233.6</td>
<td>172350</td>
<td>0.246</td>
</tr>
<tr>
<td><strong>Tandem Axles</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>44</td>
<td>1.16</td>
<td>859</td>
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<tr>
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<td>47.01</td>
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<td>0.109</td>
</tr>
<tr>
<td><strong>Tridem Axles</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>62</td>
<td>0</td>
<td>0</td>
<td>0.455</td>
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<td>0.157</td>
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<td>0.112</td>
</tr>
<tr>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0.066</td>
</tr>
</tbody>
</table>

**Total Fatigue Used:** 98.88  **Total Erosion Used:** 23.13
StreetPave recommends rounding the exact design thickness up to the nearest 0.5 inch (12.7 mm). Rounding up will increase both the reliability and theoretical life of the pavement. The effects of rounding up or down on both the reliability and theoretical life of the pavement are shown below.

<table>
<thead>
<tr>
<th>Specified Design Life</th>
<th>Recommended Thickness</th>
<th>Specified Reliability</th>
<th>Rounded-Down Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>6.50</td>
<td>80</td>
<td>6.00</td>
</tr>
<tr>
<td>Design Thickness</td>
<td>6.17</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Theoretical Life of Recommended Concrete Design
- 59 years @ 80 % reliability
Reliability of Recommended Concrete Design
- 90.1 % reliability for 30-year design

Theoretical Life of Rounded-Down Concrete Design
- 17 years @ 80 % reliability
Reliability of Rounded-Down Concrete Design
- 71.2 % reliability for 30-year design
Design and Analysis Summary Replace with PDF Desktop

StreetPave
Pavement Design & Analysis Software
American Concrete Pavement Association

Report for Asphalt Pavement Design
Project Name: Municipal Concrete Pavement
Route: Route 401
Location: Toronto, Ontario
Owner/Agency: Cement Association of Canada
Design Engineer: Scott Halslo

Recommended Asphalt Pavement Design
Asphalt Thickness: 10.13 in

Cross-Section

Sheet: 1

5/14/2017 8:31:44 AM
Engineer: Scott Halslo
Page 4 of 6
Sensitivity Charts

Effect of k-value on Thickness

Effect of Reliability (at 15% Slabs Cracked) on Thickness

Effect of Flexural Strength on Thickness

Effect of Design Life on Thickness
Life-Cycle Cost Analysis

Combines all present and future costs (benefits)
### Concrete Pavement Inputs

- **Concrete and Asphalt**
  - Project length: 1 mile
  - Lane width: 12 ft
  - Analysis Period: 30 year

- **Discount Rate Applied to Future Maintenance Items**
  - Interest Rate: 5.00 %
  - Inflation Rate: 3.00 %
  - Discount Rate: 1.84 %

- **Asphalt Only**
  - Design thickness: 10.13 in
  - Amount of design thickness which is surface course: 0 in
  - Remaining base amount: 10.13 in

- **Concrete Only**
  - Composite aggregate base density: 120 lb/ft²

### Concrete Pavement Initial Costs

- Use concrete pavement (material) AND concrete placement (cure, saw, seal): $75.00/yd², $5.00/yd³
- Use single concrete cost: $16.25/yd²

### Concrete Pavement Maintenance Costs

- **Joint sealant**:
  - No seal: $1.75/lf
  - Hotpour filler in single sawcut: $2.00/lf
  - Hotpour sealant (w/backer rod): $3.00/lf
  - Silicone sealant (w/backer rod): $5.00/lf

- **Concrete annual maintenance**: $0.00/yd²
- **Full-depth repairs**: $90.00/yd²
- **Partial-depth repairs**: $150.00/yd²
- **Diamond grinding**: $5.50/yd²

### Asphalt Pavement Inputs

- **Surface course**: 42.00 $/ton
- **Base**: 40.50 $/ton
- **Aggregate base**: 12.00 $/ton

### Asphalt Pavement Initial Costs

- **Asphalt annual maintenance**: $0.15/yd²
- **Crack sealing**: $0.75/lf

### Asphalt Pavement Maintenance Costs

- **Milling**: $1.00/yd²
- **Seal coat**: $1.50/yd²
### Project Level Inputs

**Concrete and Asphalt**
- Project length: 1 mile
- Lane width: 12.0 feet
- Analysis Period: 30 years

**Discount Rate Applied to Future Maintenance Items**
- Interest Rate: 5.00%
- Inflation Rate: 3.00%
- Discount Rate: 1.94%

**Asphalt Only**
- Design thickness: 11.03 inches
- Amount of design thickness which is surface course: 1.5 inches
- Remaining base amount: 9.53 inches

**Concrete Only**
- Composite aggregate base density: 120 lb/ft³

### Concrete Pavement Initial Costs

- Use concrete pavement (material) AND concrete placement (cure, saw, seal): $94.00 / yd²
- Use single concrete cost: $16.25 / yd²
- Aggregate base: 12.00 $/ton

### Concrete Pavement Maintenance Costs

- Joint sealant:
  - No seal
  - Hotpour filler in single sawcut: $1.75 / ft
  - Hot-pour sealant (w/backer rod): $2.00 / ft
  - Silicone sealant (w/backer rod): $3.00 / ft
  - Preformed neoprene compression seal: $5.00 / ft

- Concrete annual maintenance: 0.00 $/yd²
- Full-depth repairs: 100.00 $/yd²
- Partial-depth repairs: 150.00 $/yd²
- Diamond grinding: 5.50 $/yd²

### Asphalt Pavement Initial Costs

- Surface course: 65.00 $/ton
- Base: 55.00 $/ton
- Aggregate base: 12.00 $/ton

### Asphalt Pavement Maintenance Costs

- Asphalt annual maintenance: 0.15 $/yd²
- Crack sealing: 0.75 $/ft
- Milling: 1.00 $/yd²
- Seal coat: 1.50 $/yd²
- Chip seal: 3.00 $/yd²
### Concrete Pavement

<table>
<thead>
<tr>
<th>Year</th>
<th>Item</th>
<th>Available Quantity</th>
<th>Amount Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Reseal joints</td>
<td>100</td>
<td>13728 if</td>
</tr>
<tr>
<td>20</td>
<td>Reseal joints</td>
<td>100</td>
<td>13728 if</td>
</tr>
</tbody>
</table>

### Asphalt Pavement

<table>
<thead>
<tr>
<th>Year</th>
<th>Item</th>
<th>Amount Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>Rout &amp; seal cracks</td>
<td>500, If</td>
</tr>
<tr>
<td>12</td>
<td>Asphalt Overlay</td>
<td>1.5, If</td>
</tr>
<tr>
<td>20</td>
<td>Rout &amp; seal cracks</td>
<td>1000, If</td>
</tr>
<tr>
<td>24</td>
<td>Asphalt Overlay</td>
<td>1.5, If</td>
</tr>
</tbody>
</table>

Note: The available quantity is 100% in all cases.
Note: Life cycle cost reports and graphs are only available after running a new pavement analysis and proceeding directly to the life cycle cost section.

Run a life cycle cost report to view initial pavement costs, present value maintenance costs, and cumulative costs over the analysis period.

Life Cycle Cost Report

The life cycle cost graph depicts cumulative costs over the analysis period.

Life Cycle Cost Graph
StreetPave
Pavement Design & Analysis Software
American Concrete Pavement Association

Life Cycle Cost Analysis

- **Project Name:** Municipal Pavement Design Webinar
- **Location:** Skokie, IL
- **Project Description:** 2-Lane Collector
- **Owner/Agency:** American Concrete Pavement Association
- **Design Engineer:** Scott Haislip

**Initial Cost**

**Concrete Pavement Details**
- **Project Length:** 1.0 miles
- **Number of Lanes:** 2
- **Lane Width:** 12.0 feet
- **Design Thickness:** 6.00 in. *StreetPave Recommended Value*
- **Aggregate Base Thickness:** Top Layer = Not Selected
  - **Thickness:** 0 in.
  - **Layer 2 = Not Selected**
  - **Thickness:** 0 in.
  - **Layer 3 = Not Selected**
  - **Thickness:** 0 in.

**Composite Aggregate Base Density:** 120 lb/ft³

**Cost Inputs**
- **Concrete Pavement (material):** $94.00 / yd³
- **Concrete Placement (cure, saw, seal):** $5.00 / yd³
- **Aggregate Base:** $12.00 / ton

**Calculations**

- **Calculated Initial Cost for Concrete =** $309,369
- **Calculated Initial Cost for Aggregate Base =** $0
- **Total Initial Cost for Concrete Pavement Design =** $309,369

**Asphalt Pavement Details**
- **Project Length:** 1 miles
- **Number of Lanes:** 2
- **Lane Width:** 12.0 feet
- **Design Thickness:** 11.03 in. *StreetPave Recommended Value*
- **Surface Course Thickness:** 1.5 in.
- **Remaining Base Thickness:** 9.53 in.
- **Aggregate Base Thickness:** 8 inch Granular Base
- **Surface Course Density:** 145 lb/ft³
- **Base Density:** 140 lb/ft³
- **Aggregate Base Density:** 120 lb/ft³

**Cost Inputs**
- **Asphalt Surface Course:** $65.00 / ton
- **Asphalt Base:** $55.00 / ton
- **Aggregate Base:** $12.00 / ton

**Calculations**

- **Calculated Initial Cost for Asphalt Surface Course =** $74,846
- **Calculated Initial Cost for Asphalt Base =** $307,452
- **Calculated Initial Cost for Aggregate Base =** $45,519
- **Total Initial Cost for Asphalt Pavement =** $507,717

4/18/2008 6:51:12AM Engineer: Scott Haislip

4/26/2008 4:24:22PM Engineer: Scott Haislip
Life Cycle Cost Analysis

Cost $ vs. Year

- Blue line: Concrete
- Red line: Asphalt

Year:
1  3  5  7  9  11  13  15  17  19  21  23  25  27  29

Cost:
300K  350K  400K  450K  500K  550K  600K  650K
### Project Level Inputs

**Concrete and Asphalt**
- **Project length**: 1 miles
- **Lane width**: 12.0 feet
- **Analysis Period**: 40 years

**Discount Rate Applied to Future Maintenance Items**
- **Interest Rate**: 5.00%
- **Inflation Rate**: 3.00%
- **Discount Rate**: 1.94%

**Asphalt Only**
- **Design thickness**: 11.03 in
- **Amount of design thickness which is surface course**: 1.5 in
- **Remaining base amount**: 9.53 in

**Concrete Only**
- **Composite aggregate base density**: 120 lb/ft³

### Concrete Pavement Initial Costs

- **Use concrete pavement (material) AND concrete placement (cure, saw, seal)**: 94.00 $/yd³
- **Use single concrete cost**: 16.25 $/yd³
- **Aggregate base**: 12.00 $/ton

### Concrete Pavement Maintenance Costs

**Joint sealant**:
- No seal
- Hotpour filler in single sawcut: 1.75 $/lf
- Hot-pour sealant (w/backer rod): 2.00 $/lf
- Silicone sealant (w/backer rod): 3.00 $/lf
- Preformed neoprene compression seal: 5.00 $/lf

**Concrete annual maintenance**: 0.00 $/yd³
- Full-depth repairs: 100.00 $/yd³
- Partial-depth repairs: 150.00 $/yd³
- Diamond grinding: 5.50 $/yd³

### Asphalt Pavement Initial Costs

- **Surface course**: 65.00 $/ton
- **Base**: 55.00 $/ton
- **Aggregate base**: 12.00 $/ton

### Asphalt Pavement Maintenance Costs

- **Asphalt annual maintenance**: 0.15 $/yd³
- **Crack sealing**: 0.75 $/lf
- **Milling**: 1.00 $/yd³
- **Seal coat**: 1.50 $/yd³
- **Chip seal**: 3.00 $/yd³
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<td>Reseal joints</td>
<td>100</td>
<td>%</td>
</tr>
<tr>
<td>28</td>
<td>Full-depth repairs</td>
<td>6</td>
<td>%</td>
</tr>
<tr>
<td>28</td>
<td>Partial-depth repairs</td>
<td>2</td>
<td>%</td>
</tr>
<tr>
<td>28</td>
<td>Diamond grinding</td>
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<td>%</td>
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</tr>
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<td>Asphalt Overlay</td>
<td>1.5</td>
</tr>
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Summary

• StreetPave program incorporates reliability and slab cracking into fatigue for concrete pavement design

• Can be used to compare the outcome of altering design inputs to obtain cost-effective pavement sections

• Principles can also be applied to concrete overlays
StreetPave Software Availability

Available from:

Bob Long
Executive Director
Mid-Atlantic Chapter ACPA

Patch v1.3:  www.pavement.com
Questions?
Thank You!!!

Please contact PRESENTER with questions or comments:
Shaislip@ConcreteLot.com