Pavement Design for Practitioners - PAVEXpress

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ND DOT           Asphalt Pavement Alliance
The Asphalt Pavement Alliance (APA) is a coalition of the Asphalt Institute, the National Asphalt Pavement Association, and the State Asphalt Pavement Associations.
A Simplified Pavement Design Tool

www.PAVEXpressDesign.com
Brief Overview

• Why PaveXpress?
• What Is PaveXpress?
• An Introduction
• Overview of the System
• Recent Additions
• New Learning Module
AASHTO has been developing MEPDG for high volume roads, but a gap has developed for local roads and lower volume roads.
What Is PAVEXpress?

A free, online tool to help you create simplified pavement designs using key engineering inputs, based on the AASHTO 1993 and 1998 supplement pavement design process.

• Accessible via the web and mobile devices
• Free — no cost to use
• Based on AASHTO pavement design equations
• User-friendly
• Share, save, and print project designs
• Interactive help and resource links
What Does PaveXpress Do?

- New pavement designs - asphalt and concrete
- Asphalt overlay designs
- Initial cost estimates
- Life cycle cost analysis
- Mechanistic pavement analysis
- Porous pavement design
Verified

- Verified by Gary Sharpe, P.E. of Palmer Engineering
- Asphalt design verified by Kansas DOT
- Used by DOTs, cities, county and private engineers around the country
PAVEXpress Examples

1. Overlay
2. New Construction
PaveXpress for AC Overlay Design

• AC Overlay Design for Flexible Pavement Rehabilitation Only
• Evaluation Methods for Existing AC Pavement
  – Condition Survey
  – Non-Destructive Deflection Testing
• Includes Questions on Coring and Milling
  – Delamination/Stripping
  – Top-Down or Bottom-Up Cracking
• Adjustment to Existing Pavement
  Layer Coefficients
Overlay Example
PAVEXpress
Hwy 32
Flexible Pavement Thickness Design
(Mill and Overlay of an Existing Asphalt Roadway)
Figure 5.1. Illustration of Structural Capacity Loss Over Time and with Traffic.
Information Obtained for the Hwy 32 design

- Pavement coring
- Falling Weight Deflectometer analysis
- Linear soils survey
- Average daily traffic and Design ESAL’s
- Evaluation of present serviceability of the roadway
- Distress survey
- Ride data
- Grading Plans
- Pavement Management Data
Condition Survey Method
Pavement Coring
Overlay Design Inputs

Reliability 80%
Initial Serviceability 4.5
Terminal Serviceability 2.5
Design ESAL’s 1,000,000
Analysis Period 20 years
Subgrade Resilient Modulus ($M_r$)
  5,000 psi
Soil Type A-7-6

Layer Coefficients

- Superpave FAA 43
  0.36
- Existing HBP
  0.25
- Emulsified Base
  0.10 - 0.20
- Aggregate Base CL 5
  0.10
## My Projects > Hwy 32 Thickness Design Option 2 > Hwy 32 Mill and HBP Overlay

### Layer Coefficients

<table>
<thead>
<tr>
<th>Layers</th>
<th>Existing Thickness</th>
<th>AASHTO Recommendation</th>
<th>Layer Conf. (a)</th>
<th>Drainage Conf. (m)</th>
<th>SN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt - Dense Graded</td>
<td>7&quot;</td>
<td>0.20 to 0.30</td>
<td>0.25</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Bituminous treated base</td>
<td>3.5&quot;</td>
<td>0.15 to 0.20</td>
<td>0.2</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Aggregate Base</td>
<td>3.5&quot;</td>
<td>0.00 to 0.1</td>
<td>0.1</td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

⚠️ You have elected to remove 2 inches of pavement from the surface. This may impact the layer coefficient you select.

SN = 2.8

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### Design Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Period</td>
<td>20 years</td>
</tr>
<tr>
<td>Reliability Level (R)</td>
<td>80, Z = 0.041</td>
</tr>
<tr>
<td>Combined Standard Error (%)</td>
<td>0.5</td>
</tr>
</tbody>
</table>

### Serviceability

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Serviceability Index (p)</td>
<td>4.5</td>
</tr>
<tr>
<td>Terminal Serviceability Index (p)</td>
<td>2.5</td>
</tr>
<tr>
<td>Change in Serviceability (APSI)</td>
<td>2.00</td>
</tr>
</tbody>
</table>
Guidance

Scoped Design

Overlay
Asphalt - Dense Graded
Bituminous treated base
Aggregate Base
Subgrade

Layer Thicknesses (in)

<table>
<thead>
<tr>
<th>Layer</th>
<th>Thickness (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overlay</td>
<td>4.2</td>
</tr>
<tr>
<td>Asphalt - Dense Graded</td>
<td>5</td>
</tr>
<tr>
<td>Bituminous treated base</td>
<td>3.5</td>
</tr>
<tr>
<td>Aggregate Base</td>
<td>3.5</td>
</tr>
</tbody>
</table>

Design Notes
You have removed 2 inches from the surface of the pavement prior to the overlay in this design.

Resources
Non-destructive Testing Method
### Pavement Layers

#### Existing Pavement Layers

<table>
<thead>
<tr>
<th>Layer Type</th>
<th>Thickness</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt - Dense Graded</td>
<td>7 in.</td>
<td></td>
</tr>
<tr>
<td>Asphalt stabilized base</td>
<td>3.5 in.</td>
<td></td>
</tr>
<tr>
<td>Aggregate Base</td>
<td>3.5 in.</td>
<td></td>
</tr>
</tbody>
</table>

#### Subgrade

<table>
<thead>
<tr>
<th>Subgrade Soil Type</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A-7-6</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Subgrade Modulus (M_L)</th>
<th>psi</th>
</tr>
</thead>
<tbody>
<tr>
<td>5000</td>
<td></td>
</tr>
</tbody>
</table>

### New AC Overlay

<table>
<thead>
<tr>
<th>Layer Coeff. (a)</th>
<th>0.36</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Thickness</td>
<td>0</td>
</tr>
</tbody>
</table>
### Nondestructive Testing (NDT)

#### Backcalculation Results
- **Design Subgrade Modulus** ($M_s$): 5000
- **$S_{nt}$**: 3.41

#### Cores
- **Were cores taken on the roadway?**: Yes
- **Were cores of cracks taken?**: Yes
- **Crack Type**: Entire Depth
- **Delamination/Stripping?**: No

#### Distressed Pavement
- **Mill/Remove Distressed Asphalt?**: Yes
- **Depth to remove**: 2 inches
- **Estimated Structural Coefficient** ($a_{rem}$): 0.32
Calculate Effective Strength using

**Deflection**
- Contact Pressure (p)
- Load Plate Radius (a)
- Pavement Thickness (D)

**Distressed Pavement**
- Mill/Remove Distressed Asphalt?
- Depth to remove
- Estimated Structural Coefficient (k_est)
New Design Example
## Scenario Information

<table>
<thead>
<tr>
<th>Scenario Information</th>
<th>Pavement Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario Name</td>
<td>Estimated Completion Year</td>
</tr>
<tr>
<td>NDKota</td>
<td>2019</td>
</tr>
<tr>
<td>Scenario Description</td>
<td>Roadway Classification</td>
</tr>
<tr>
<td>New Project</td>
<td>Arterials/Highway</td>
</tr>
<tr>
<td>State</td>
<td>Project Type</td>
</tr>
<tr>
<td>North Dakota</td>
<td>New - Asphalt</td>
</tr>
</tbody>
</table>

- **State**: North Dakota
### Design Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Period</td>
<td>30 years</td>
</tr>
<tr>
<td>Reliability Level (R)</td>
<td>85% - $Z_0 = -1.036433$</td>
</tr>
<tr>
<td>Combined Standard Error (S_0)</td>
<td>0.5</td>
</tr>
</tbody>
</table>

### Serviceability

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Serviceability Index (p_i)</td>
<td>4.5</td>
</tr>
<tr>
<td>Terminal Serviceability Index (p_t)</td>
<td>3</td>
</tr>
<tr>
<td>Change in Serviceability (ΔPSI)</td>
<td>1.50</td>
</tr>
</tbody>
</table>
Traffic & Loading

Traffic Data

- Method of Determining ESALs:
  - Using AADT
  - Annual ESALs
  - Design ESALs

- Completion Year Traffic (vehicles):
  - 350,000
  - Calculate from AADT

- Load Equivalency Factor:
  - 0.14
  - Calculate LEF

- Completion Year ESALs:
  - 49,000

Traffic Growth

- Design Period:
  - 30 Years

- Future Traffic Growth Rate:
  - 2%

- ESAL Growth Rate:
  - 1%

- Total Design ESALs ($W_{1:6}$):
  - 2,339,000

Save
Treating Multiple Asphalt Layers Differently

PAVEXpress allows the designer to input for each lift of asphalt a different:

- layer coefficient
- drainage coefficient
- thickness

The designer can either specify individual inputs for the surface, intermediate (binder) course, and base (leaving the program to calculate the base thickness), or input all asphalt info as a single lift and split it into separate lifts afterward.

Optimum Lift Thickness = 4 × NMAS
Pavement Structure (Flexible) (Asphalt)

- **Use Multiple Lifts (No)**
- **Layer Coefficient (a):** 0.44
- **Drainage Coefficient (m):** 1
- **Minimum Thickness:** 2

Pavement Diagram:
- Asphalt Layer
- Base Layers
- Subgrade
Layer Coefficient Considerations

Average values of layer coefficients for materials used in the AASHO Road Test were as follows:

- Asphalt Surface Course 0.44
- Crushed Stone Base Course 0.14
- Sandy Gravel Subbase 0.11

Keep in mind that these values were empirically derived from a road test with one climate, one soil type, and one asphalt mix type.

The asphalt layer coefficient used for the Road Test was actually a weighted average of values ranging from 0.33 to 0.83.

More recent studies at the NCAT Test Track found that for Alabama, an asphalt layer coefficient of 0.54 better reflected actual performance.
Pavement Sub-Structure

<table>
<thead>
<tr>
<th>Base Layers</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Layer Type</td>
<td>Layer Coef.</td>
<td>Drainage Coef.</td>
<td>Thickness</td>
<td>Resilient Mod</td>
<td>Action?</td>
</tr>
<tr>
<td>Aggregate Base</td>
<td>0.12</td>
<td>1</td>
<td>6 in.</td>
<td>26000</td>
<td>☑ ☑</td>
</tr>
<tr>
<td>Aggregate Subbase</td>
<td>0.065</td>
<td>1</td>
<td>2 in.</td>
<td>21000</td>
<td>☑ ☑</td>
</tr>
</tbody>
</table>

Add Layer

Subgrade

Resilient Modulus (M_r)

15000 psi

Calculate MR

Pavement Diagram

Asphalt Layer

Base Layers

Subgrade

Save
Subgrade Considerations

The most common methods of classifying the subgrade for pavement design are:

- California Bearing Ratio (CBR)
- Resistance Value ($R$)
- Resilient Modulus ($M_R$)
Guidance

Scoped Design

Required minimum design SN: 3.15

Layer Thicknesses (in)

- Surface: 6.00
- Aggregate Base: 6.00
- Aggregate Subbase: 2.00

Total SN: 3.49

⚠️ The Design SN exceeds the Required SN due to the layer protection check. A base layer thickness can be reduced; however, the reduction may create issues with construction. Therefore, care must be taken before adjusting the fixed or minimum thickness.

Design Notes

Resources

Dakota Asphalt Pavement Association
**Recommendation:**

Perform multiple iterations of the design with different plausible input values to get a sense of the range of pavement structures needed to carry the anticipated loads in various scenarios.

Use engineering judgment to select the optimum pavement structure.
Additional PAVEXpress Functions
Life Cycle Cost Analysis
Layered Elastic Analysis
Parking Lot Design Guidance

www.PAVExpressDesign.com
Porous Pavement Design
PAVEInstruct.com Learning Module

complement to PAVEXpress

- Available on-demand via web
- Flexible and rigid pavement design
- Detailed use of PAVEXpress
- Leading industry expert instructors
- No cost to user
- PDHs available
Pavement Design Learning Modules
PAVEInstruct.com
So What Is Coming Next?
Next Version Features

• ME Design with PerRoad Embedded
• Simplified LCCA
• Metric Units
PaveXpress

A Simplified Pavement Design Tool

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Thank you!
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