2009 Virginia Concrete Conference

VDOT Pavement Type Selection

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March 4 & 5, 2009
Richmond, Virginia
1. Components of Flexible and Rigid Pavements
2. VDOT Pavement Design procedures
3. Pavement Design Inputs/Output
4. Pavement Design Initial Cost
5. Life Cycle Cost Analysis
6. Pavement Type Selection/Justifications
7. How Pavement’s Typical Section Makes it to Plans
Pavement Design is the process of selecting combinations of construction materials (layer thickness and stiffness) which economically provide adequate structure to carry the traffic loading under the prevailing environment at the project site with the ultimate goal of providing safety and comfort to the traveling public.
Pavement Types

1. Rigid (Concrete) Pavement
   - Continuously Reinforced Concrete Pavement
   - Jointed Plain Concrete Pavement
   - Jointed Reinforced Concrete Pavement

2. Flexible (Asphalt) Pavement

Different pavements:
- designed differently
- perform differently
- have different maintenance/rehab cycle

Selection of pavement type requires a thorough understanding of all these..
Rigid Pavement components

- Portland Cement Concrete
  - combination of Portland cement and aggregate
  - strength from cement paste
    - aggregate, less expensive filler
  - lower stresses transferred to base and spread over larger area due to the high stiffness of Concrete
Rigid Pavement loading

- Subgrade
- Base
- PCC

Diagram showing the layers of pavement with a tire applying load.
Flexible Pavement components

- **HMA layers**
  - higher stiffness material
  - smaller particle size
  - higher stresses

- **Aggregate base layers**
  - treated or untreated
  - larger particle size
  - lower stresses

- **Subgrade**
  - natural soil (treated or untreated)
Every layer carries a portion of the loading.
Design Considerations

- Traffic (should relate to lane capacity)
- Subgrade
- Construction Materials
- Design period
- Environment
- Drainage
- Shoulder Design
- Pavement Performance in the particular location
In Virginia, two pavement design methods are generally used. For Interstate, Primary and High Volume Secondary Routes, the AASHTO 93 Pavement Design approach is required.

For Low-Volume Secondary and Subdivision streets, AASHTO and the Virginia Method are both acceptable.
AASHTO 93 Method
- An empirical method used for both flexible and rigid pavement designs; this design procedure is used mainly for high volume roadways

Virginia Method
- Used for flexible pavements only and is based on the AASHO road test, with modifications to meet Virginia’s conditions for low volume primary and Secondary roads.
Flexible Pavement

- Traffic, Cumulative ESAL’s
  - ESAL Factors
    - Cars = 0.0002, Single Unit Trucks = 0.37
    - Tractor Trailers = 1.28
  - Resilient Modulus of Subgrade Soil (psi)
  - Layer Coefficient (a_i)
  - Drainage Coefficient for unbound materials (m_i)
  - Reliability Level (%)
  - Overall Standard Deviation
  - Serviceability (Initial & Terminal)
Rigid Pavement

- Traffic, Cumulative ESAL’s
  - ESAL FACTORS
    - Cars = 0.0003
    - Single Unit Trucks = 0.56
    - Tractor Trailers = 1.92
  - Effective Mean (K Value, psi/in) of all layers below the slab
- Elastic Modulus of Concrete, (psi)
- Modulus of Rupture of Concrete, (psi)
- Load Transfer Coefficient, (J)
- Overall Drainage Coefficient, (cd)
- Reliability Level (%)
- Overall Standard Deviation
- Serviceability (Initial & Terminal)
Virginia Method Parameters

- California Bearing Ratio (CBR)
- Resiliency Factor
- Traffic in terms ADT & % truck
- Thickness Equivalency Factor, which is a relative index of strength the material contributes per inch of pavement thickness. This parameter yields a structural number or total thickness of the pavement.
Output for Flexible Pavement, whether from AASHTO or the Virginia Method, yields a structure number for total pavement and individual layer thicknesses.

- **Structural Number, SN**
  \[ SN = a_1(h_1) + a_2(h_2) + a_3(h_3)(m_3) \]

For Rigid Pavement Design AASHTO yields a slab thickness.

- **Slab Thickness, inches**
Future Method (MEPDG)

- Mechanistic-Empirical Pavement Design Guide

Loads and Layer Stiffness

Mechanistic Analysis
Layered Elastic Analysis

Strain Calculations at Critical Locations

\[ E = \frac{\sigma}{\varepsilon} \]
MEPDG Outputs: Rigid Pavement Performance

- Transverse Cracking
- Punchout
- Joint Faulting
- IRI
MEPDG Outputs: Flexible Pavement Performance

- Fatigue Cracking
- Thermal Cracking
- Rut Depth
- IRI
MEPDG (Future Analysis and Design)

- Pavement Design
- Materials Selection
- Communication
- Pavement Management
- Construction
How to make a choice among alternate pavement types?

- Flip coin
- Personal preference
- Consistency with adjoining pavement
- Local experience
- Educated decision
Pavement Type Selection

- The option with least ‘cost’ should be selected
- Cost has various components
  - Initial or construction
  - Maintenance & rehab
  - User cost etc
- How to capture all these into the selection process?
  - Is it possible at all?
- The process is Life Cycle Cost Analysis (LCCA)

*LCCA is an economic method used to compare alternatives that satisfy the agency need in order to determine the lowest cost based on present worth.*
Features
- Developed by Materials Division and VTRC
- Adopted in May 2002
- Incorporated into MOI Chapter VI (Pavement Design & Evaluation)

Process
- Combines all future expected maintenance & rehab costs (over an analysis period) to initial cost
- The option with the lowest cost to be recommended
- If the difference between the options is less than 10%, a variety of other factors should be considered
Factors considered in LCCA include the following:

- Initial cost
- Analysis period
- Routine Maintenance
- Major Rehab
- User cost
- Reconstruction cost
- Salvage Value
When to Use LCCA?

- Not all projects are suitable for LCCA
  - Example: a turning lane

Typical LCCA applications
- New construction
- Reconstruction
- At least one mile long
- Costs at least $2,000,000
VDOT has identified planned maintenance & rehab activities for various pavement types

AC pavement activities

<table>
<thead>
<tr>
<th>Year-0</th>
<th>Year-12</th>
<th>Year-22</th>
<th>Year-32</th>
<th>Year-44</th>
<th>Year-50</th>
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## JCP Activities

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<th>Year-0</th>
<th>Year-10</th>
<th>Year-20</th>
<th>Year-30</th>
<th>Year-40</th>
<th>Year-50</th>
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</thead>
<tbody>
<tr>
<td>New/</td>
<td>Maintenance work:</td>
<td>Concrete Pavement</td>
<td>Asphalt overlay of min. 4 inches, pre-</td>
<td>Structural Mill and Replace: pre-overlay</td>
<td>Salvage Value</td>
</tr>
<tr>
<td>Reconst</td>
<td>Patching: 3%, Clean</td>
<td>Restoration: Patching: 10%,</td>
<td>overlay repair – patch: 5%, mill 2 inches</td>
<td>repair – patch: 10%</td>
<td></td>
</tr>
<tr>
<td>ruction</td>
<td>and Seal Joint: 100%</td>
<td>Clean &amp; Seal Joint: 100%,</td>
<td>and overlay 3.5 inches with asphalt</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>and Grinding: 100%</td>
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</table>
CRC Activities

<table>
<thead>
<tr>
<th>Year-0</th>
<th>Year-10</th>
<th>Year-20</th>
<th>Year-30</th>
<th>Year-40</th>
<th>Year-50</th>
</tr>
</thead>
<tbody>
<tr>
<td>New/Reconstruction</td>
<td>Maintenance work: Patching: 2%, Clean and Seal Joint: 100%</td>
<td>Concrete Pavement Restoration &amp; asphalt overlay: Patching: 5% and asphalt overlay 3.5 inches</td>
<td>Functional Mill &amp; Replace: patching: 5%, mill 2 inches and overlay with 2 inches of asphalt</td>
<td>Concrete Pavement Restoration &amp; asphalt overlay: Patching: 10%, mill 3.5 inches and overlay with asphalt</td>
<td>Salvage Value</td>
</tr>
</tbody>
</table>

Activities for new composite pavements are yet to develop
LCCA Process, contd.

- Analysis period: 50 years
- Discount rate: 4%
- Cost associated for each activities estimated
  - Initial construction, routine maintenance, major rehab and salvage value: all considered
- Costs are converted into
  - Present Worth and/or
  - Equivalent Uniform Annual Cost (EUAC)
- Option with least cost to be recommended
Issues to consider

For options within 10%, consider following:

- Construction consideration (time and equipment)
- Innovation (new materials or structural features)
- Performance of similar pavements in the area
- Conservation of materials and energy
- Adjacent existing pavement
- Municipal preference
- Local government preference
- Local industry

- Sensitivity to one or more parameters
  - Unit prices need to be realistic

- A combination of LCCA and engineering judgment are documented to finalize the pavement type selection.
How the Pavement typical section Makes it to Plan?

1. The Design Team writes a final pavement design report showing the selected type.

2. The report is submitted to the state Materials Engineer for concurrence and forwarding it to the Chief Engineer.

3. The Chief Engineer review, concur, and forward the report to the State Location & Design Engineer to be included in the project plans.
Thank You

Questions?

Presentation can be downloaded at:

\Coelkimage\Public\(JointQuarterlyMeeting\)PavementSelection.ppt