VDOT Pavement Type Selection

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Presentation Outlines

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

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:

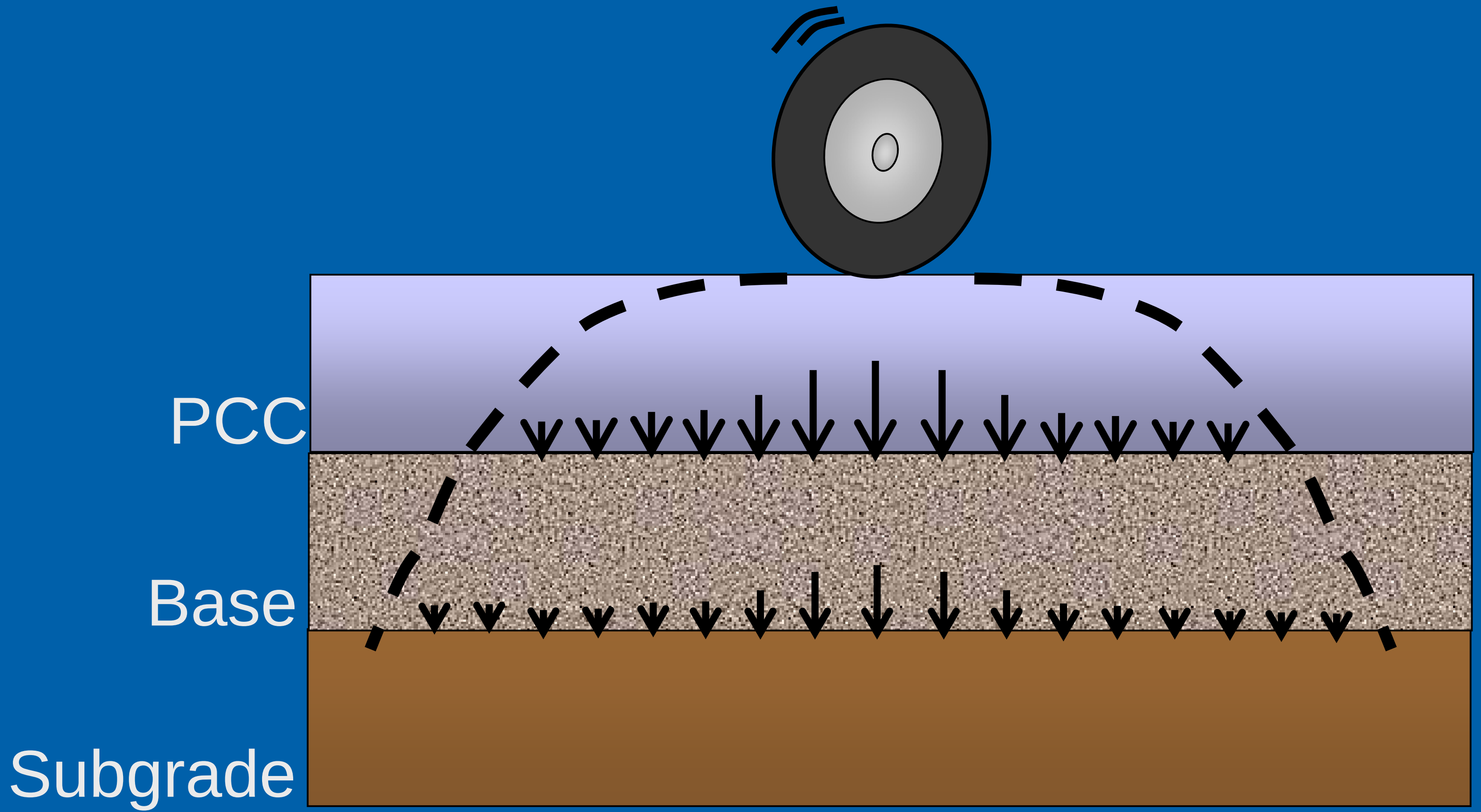
- designed differently
- perform differently
- have different maintenance/rehab cycle

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

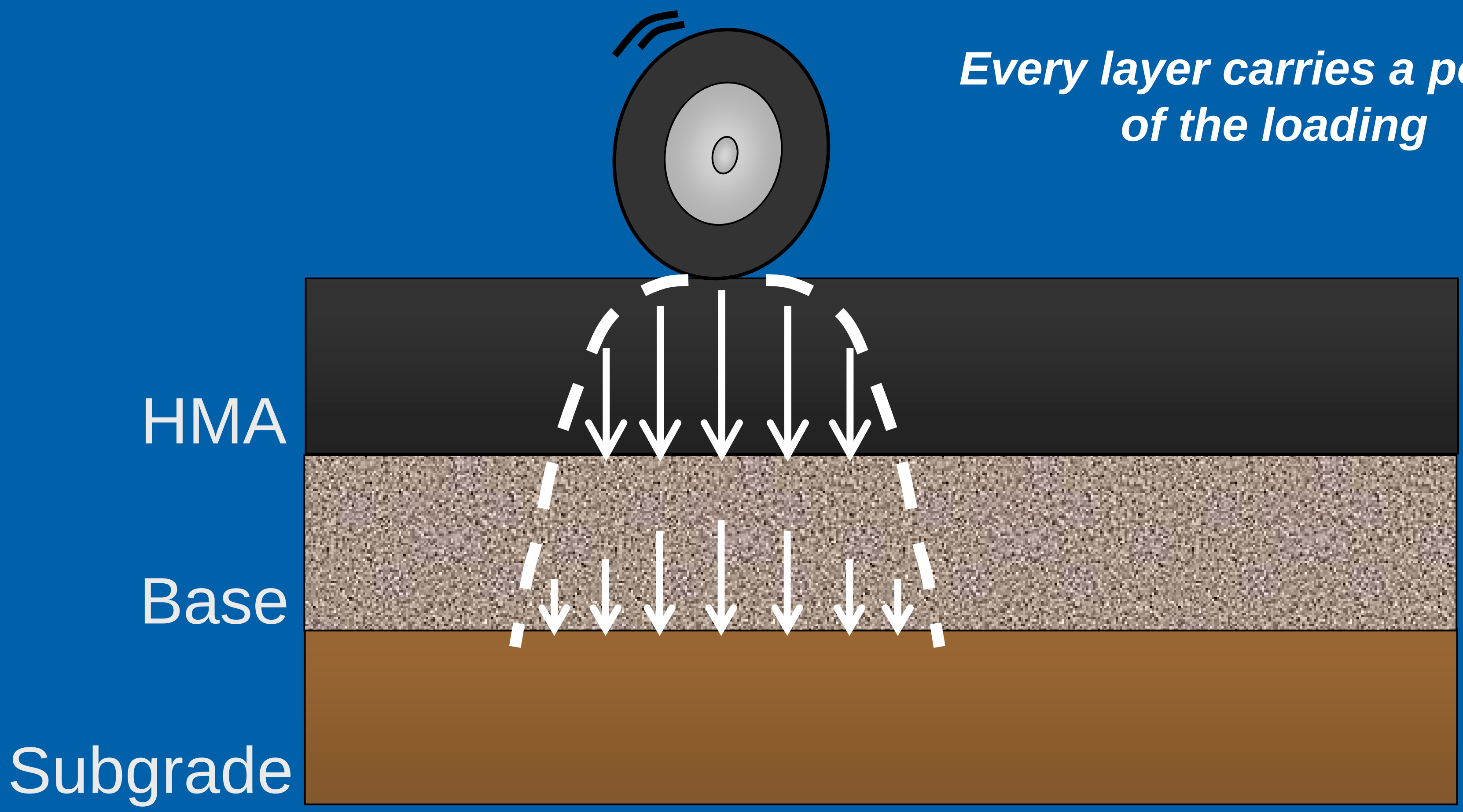


Flexible Pavement components

- 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)

Flexible Pavement Loading

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

Current Design Methods

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 and Virginia Method Design

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.**

AASHTO 93 Input parameters

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)

AASHTO 93 Input parameters

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 Parameters

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

  $SN = a_1(h_1)+a_2(h_2)+a_3(h_3)(m_3)$

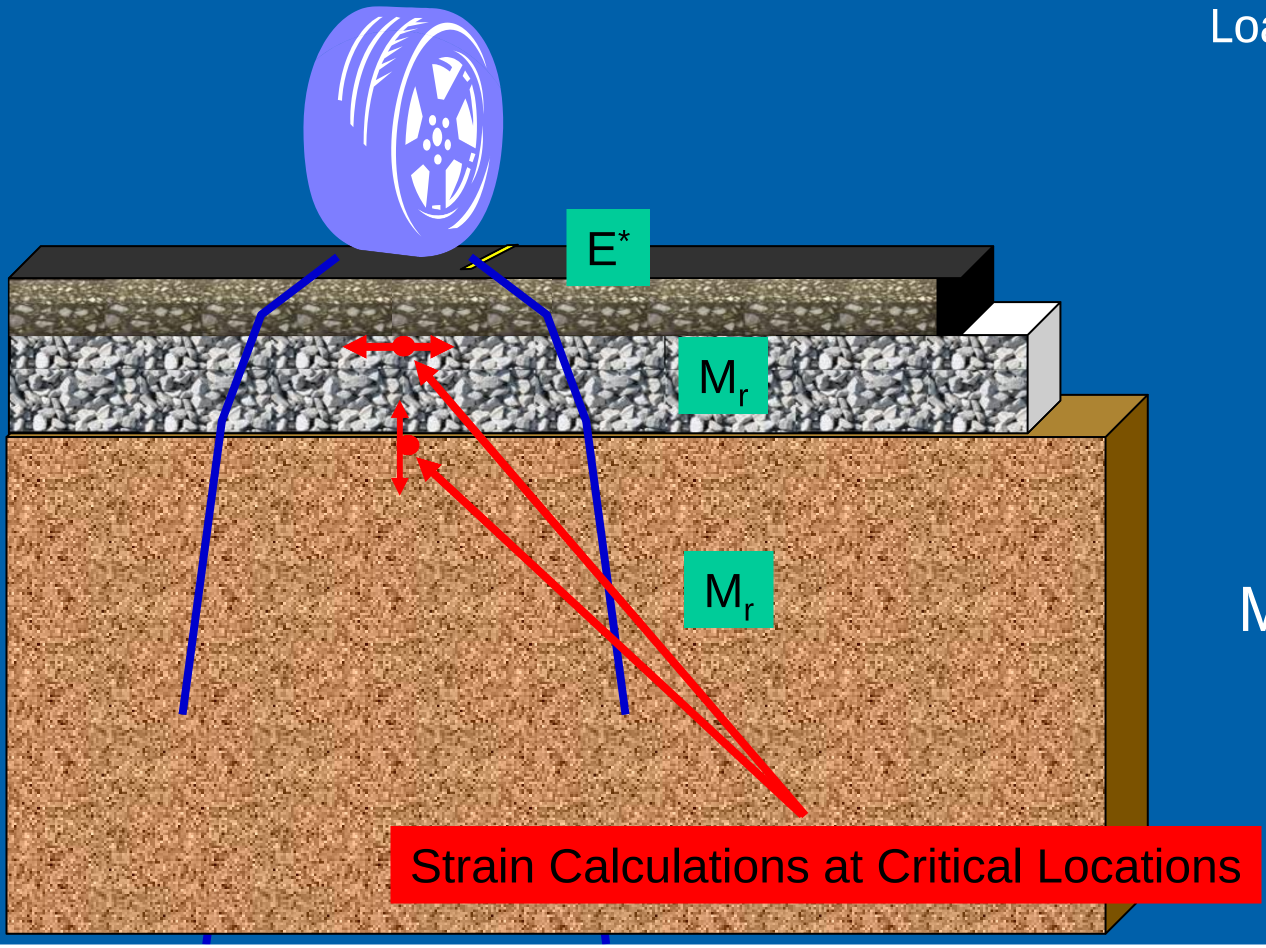
For Rigid Pavement Design AASHTO yields a slab thickness.

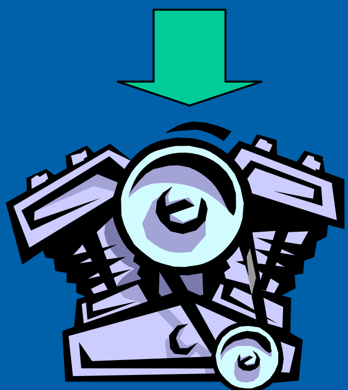
- Slab Thickness, inches

Future Method (MEPDG)

- **Mechanistic-Empirical Pavement Design Guide**

Loads and Layer Stiffness



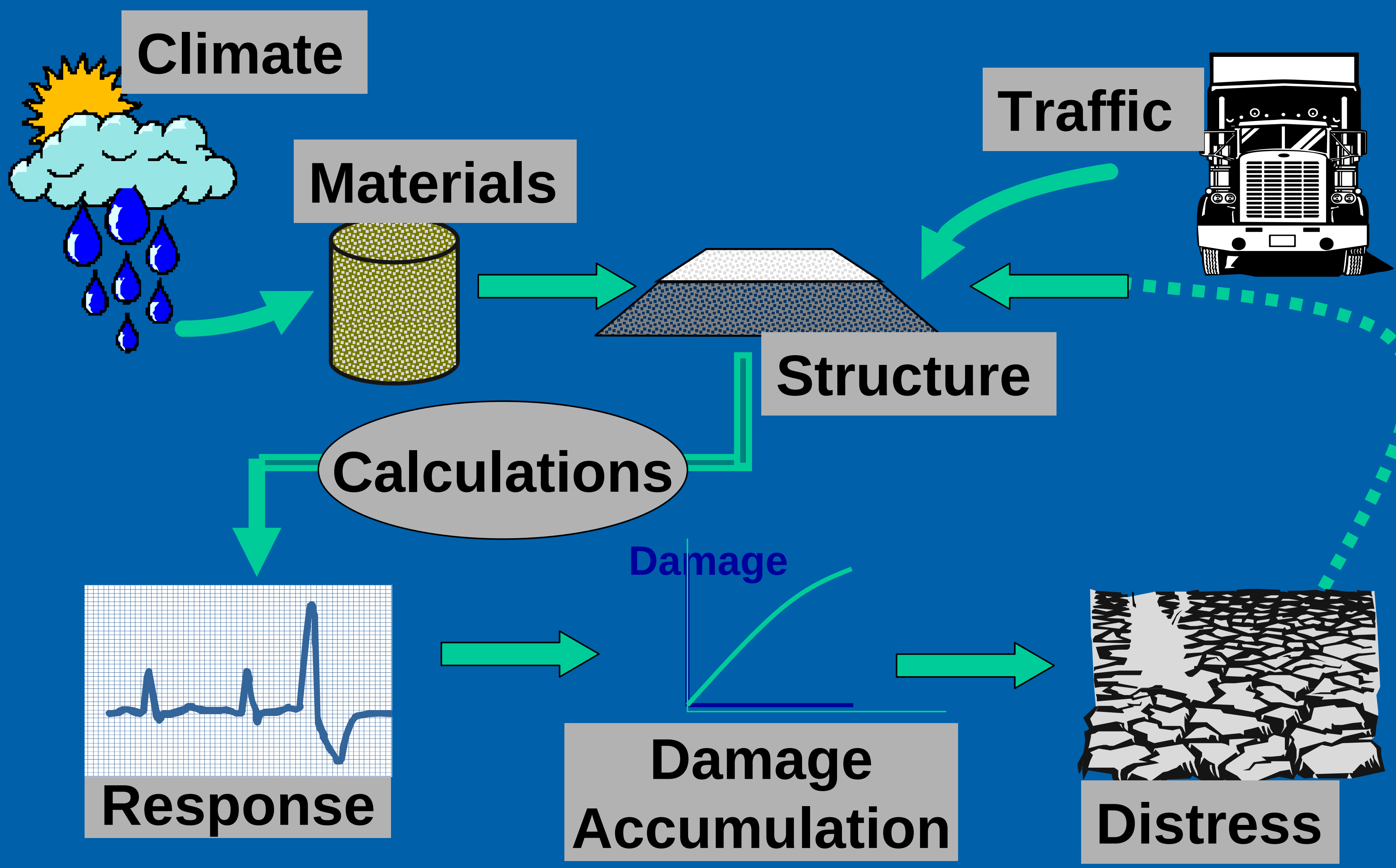


Mechanistic Analysis

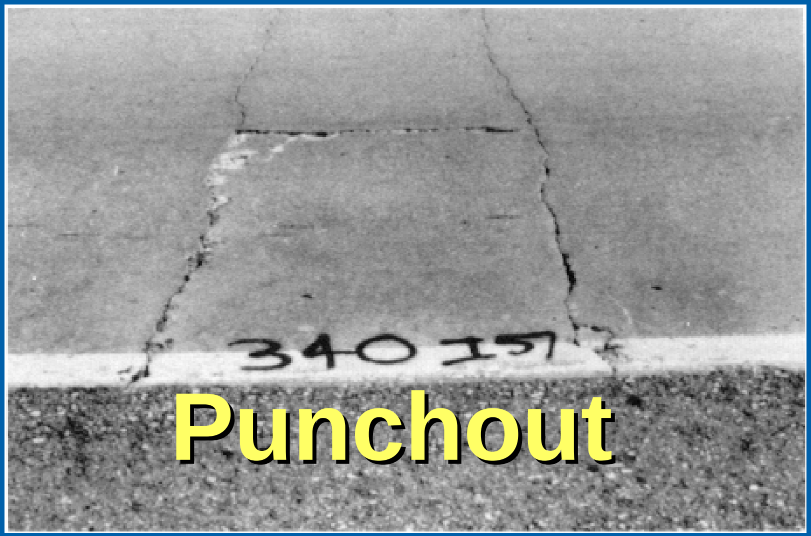
Layered Elastic Analysis

$$E = \sigma/\varepsilon$$

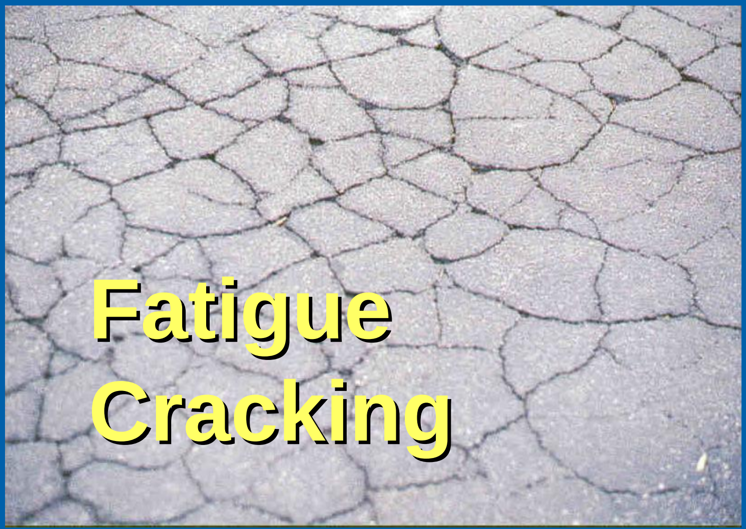
MEPDG Process

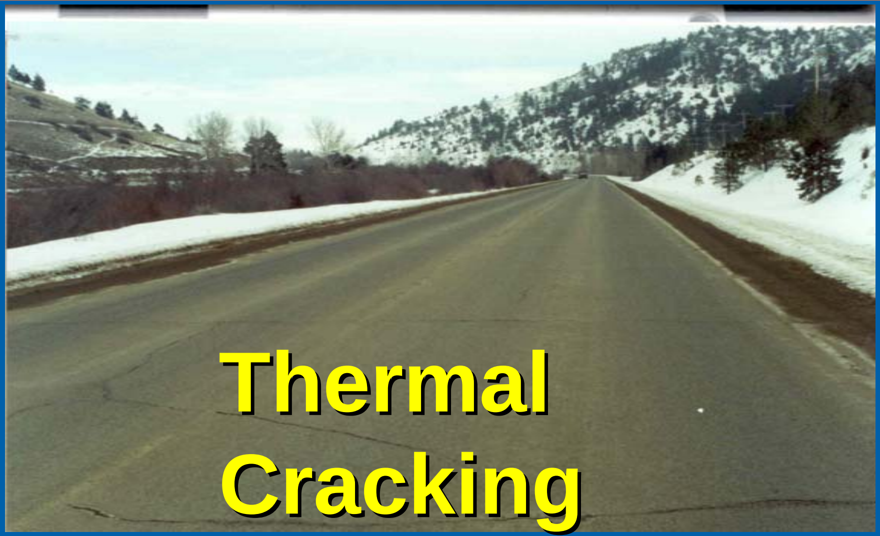


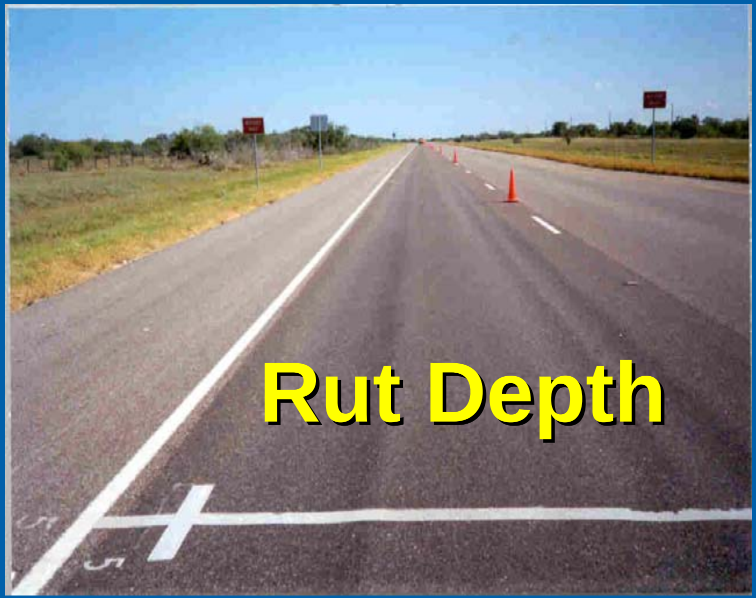
MEPDG Outputs: Rigid Pavement Performance



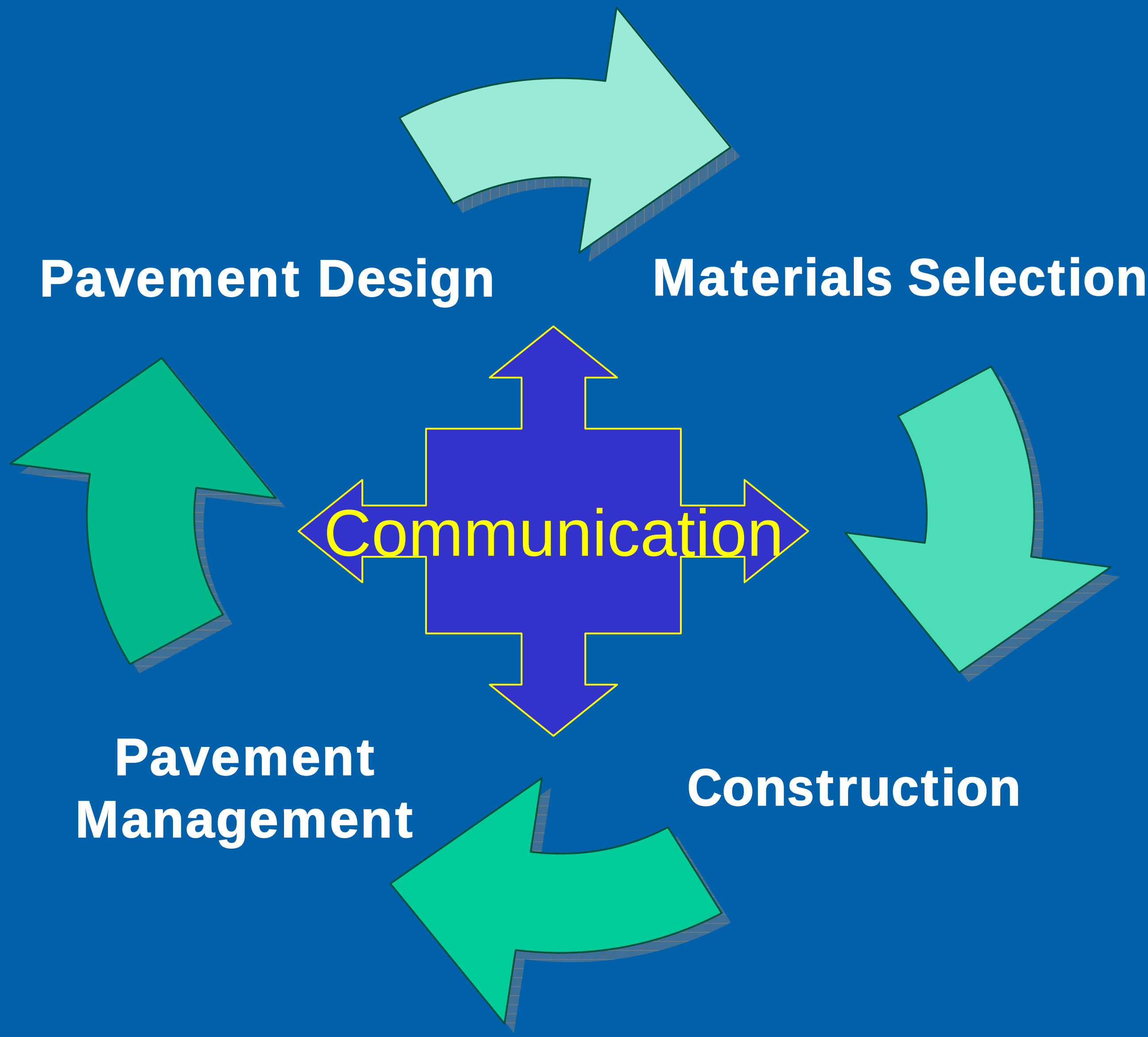
MEPDG Outputs: Flexible Pavement Performance







MEPDG (Future Analysis and Design)



Pavement Type Selection

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.

Highlights of VDOT LCCA

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

Life Cycle Cost Analysis (LCCA)

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

LCCA Process

VDOT has identified planned maintenance & rehab activities for various pavement types

AC pavement activities

Year-0	Year-12	Year-22	Year-32	Year-44	Year-50
New/ Reconstruction	Functional Mill & Replace: pre-overlay repair – patch: 1%, mill 2 inches and overlay with 2 inches of asphalt.	Structural mill & Replace: pre-overlay repair-patch: 1%, mill 2 inches and replace with 3.5 inches of asphalt.	Major Rehabilitation: pre-overlay repair – patch: 5%, Deep mill & replace with new thicker asphalt layer.	Functional Mill & Replace: pre-overlay repair – patch: 1%, mill 2 inches and overlay with 2 inches of asphalt.	Salvage Value

LCCA Process, contd.

JCP Activities

Year-0	Year-10	Year-20	Year-30	Year-40	Year-50
New/ Reconstruction	Maintenance work: Patching: 3%, Clean and Seal Joint: 100%	Concrete Pavement Restoration: Patching: 10%, Clean & Seal Joint: 100%, and Grinding: 100%	Asphalt overlay of min. 4 inches, pre-overlay repair – patch: 10%	Structural Mill and Replace: per-overlay repair – patch: 5%, mill 2 inches and overlay 3.5 inches with asphalt	Salvage Value

LCCA Process, contd.

CRC Activities

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

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.**

VDOT

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:

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