Illinois DOT
From the AASHO Road Test
To
20 Years of Mechanistic Pavement Experience
......and Counting

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Illinois Department of Transportation

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Outline
- AASHO Road Test History
- Illinois Adoption of Mechanistic
- Current Updating Efforts

"AASHO Road Test"
Loading

<table>
<thead>
<tr>
<th>LOOP</th>
<th>LANE 1</th>
<th>LANE 2</th>
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<tbody>
<tr>
<td>3</td>
<td>4 1 12</td>
<td>6 24 24</td>
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<tr>
<td>4</td>
<td>6 18 18</td>
<td>9 32 32</td>
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<tr>
<td>5</td>
<td>6 22 22</td>
<td>9 40 40</td>
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<tr>
<td>6</td>
<td>9 30 30</td>
<td>12 48 48</td>
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</table>

2 Years = 1.1 Million Axle Loads

Rigid Profile

Flexible Profile

Traffic

AASHO – Static Weights – Dynamic Loading

The AASHO Road Test
Pavement Performance

PSR = 0.0?

PSR = 0.0?

<table>
<thead>
<tr>
<th>Axle Load</th>
<th>Flex Single ESAL's</th>
<th>Rigid Single ESAL's</th>
<th>Flex Tandem ESAL's</th>
<th>Rigid Tandem ESAL's</th>
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<tbody>
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<td>2,000</td>
<td>0.0002</td>
<td>0.0002</td>
<td>0.0000</td>
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<tr>
<td>6,000</td>
<td>0.010</td>
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<td>1.00</td>
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<td>0.444</td>
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<td>30,000</td>
<td>7.00</td>
<td>8.28</td>
<td>0.658</td>
<td>1.14</td>
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<td>36,000</td>
<td>13.9</td>
<td>17.1</td>
<td>1.38</td>
<td>2.43</td>
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<td>42,000</td>
<td>25.6</td>
<td>32.2</td>
<td>2.51</td>
<td>4.55</td>
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</table>
Illinois Method of Calculating ESAL’s

- Collect static weight data from enforcement scales.
- Load spectrum by axle/vehicle type.
  - Single.
  - Tandem.
  - Triple.
- ESAL factor by FHWA vehicle class & road type.
  - Class I – Interstate and multi lane.
  - Class II – Two lane over 2000 ADT.
  - Class III - 750 to 2000 ADT.
  - Class IV – Under 750 ADT.
- Summarize into PV, SU and MU groups.

PV, SU and MU

<table>
<thead>
<tr>
<th>Passenger Vehicles (PV)</th>
<th>Single Unit (SU)</th>
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<tbody>
<tr>
<td>Class 2 (Cars)</td>
<td>Class 4 (Buses)</td>
</tr>
<tr>
<td>Class 3 (Light Trucks)</td>
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</table>

Multiple Unit (MU)

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>2 Axle 5</td>
</tr>
<tr>
<td>3 Axle 6</td>
</tr>
<tr>
<td>4 Axle 7</td>
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</tbody>
</table>

Class 8 to 13

Current ESAL Factors (Flex)

<table>
<thead>
<tr>
<th>Road Class</th>
<th>PV</th>
<th>SU</th>
<th>MU</th>
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<tbody>
<tr>
<td>Class I</td>
<td>0.0004</td>
<td>0.394</td>
<td>1.908</td>
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<tr>
<td>Class II</td>
<td>0.0004</td>
<td>0.372</td>
<td>1.554</td>
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<tr>
<td>Class III</td>
<td>0.0004</td>
<td>0.355</td>
<td>1.541</td>
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<tr>
<td>Class IV</td>
<td>0.0004</td>
<td>0.350</td>
<td>1.523</td>
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</tbody>
</table>

Design Minimums:  
- Interstate – 1,500 MU, 500 SU  
- Non Interstate – 900 MU, 300 SU

Traffic Maps

PV = Total ADT – Truck ADT    SU = Truck ADT – MU ADT
AASHO Advances

- Equivalent $18^k$ Single Axle Loads (ESALs)
- Thickness Designs for both Flex & PCC
- “Equivalent” Pavements
- Cost Allocation

AASHO Limitations

- One Set of Materials.
- Two Years of Weathering.
- 1.1 Million Axles.
- Totally Empirical – need to extrapolate to 100’s of millions of axles.

Why Illinois Pursued Mechanistic

- AASHTO design produced excessively thick pavements for high volume facilities.
- New materials very difficult to relate back to road test for layer coefficient.
- Modern facility traffic well beyond road test traffic.
- Valid procedure??

1958 Materials vs. Modern Materials
Mechanistic Design

Mechanistic -

“Concerning the Relationships Between Applied Forces and Material Responses.”

Basic Premise -

Low Deflections = Long Life

IL-AAHSTO vs. Mechanistic

![Graph showing IL-AAHSTO vs. Mechanistic](Image)

Illinois Mechanistic-Empirical Design

- Research completed in 1987.
- Load spectrum discussed – dismissed.
- Designs based upon 18K ESAL’s.
- Results very complex.
- Many designer inputs.
- Policy decisions needed to simplify.
Fatigue Theory

High Strain = Short Life
Low Strain = Long Life

Fatigue Cracking

18K

18,000 Pounds
80 PSI

Illinois Mechanistic Loop Pavement Model

Load Model
Why Load Spectrum Not Used

- Data reliability.
  - Calibration.
  - Maintenance of equipment.
- Limited data collection ability.
  - Expense.
  - People – Head count limits.
- Data fit into performance calibration??
- Department understanding of ESAL’s.

Inputs – Full-Depth Asphalt

- Traffic.
- Soil Support (Eri).
- Location (temperature/modulus relations).
- Asphalt grade.
- Mix air voids and gradation.
- Crack initiation at bottom of HMA.
- Reliability.

Inputs – Jointed Concrete

- Traffic.
- Soil support (k).
- Joint spacing.
- Joint load transfer.
- Edge support.
- Drainage conditions.
- Concrete strength.
- Slab cracking.
- Reliability.

Decisions, Decisions, Decisions!

- Policy decisions:
  - To simplify design.
  - To limit sophisticated data collection or testing.
  - Insure design assumptions are built into pavement.
- Maintain “off-the-shelf” or current inputs.
  - 18K ESAL and related traffic data collection.
  - Current material test.
Example:

- Simplified correlation for soil inputs.
  - Not going to run subgrade resilient modulus \((E_{ri})\) for every project.
  - Not going to determine “k” values.
  - Correlated to Corp of Engineers soil triangle (grain size analysis) to three common support levels.

### Impacts of Soil Inputs

<table>
<thead>
<tr>
<th>Soil Rating</th>
<th>Full-Depth HMA</th>
<th>Concrete</th>
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<tbody>
<tr>
<td>Granular</td>
<td>13.75</td>
<td>9.25</td>
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<tr>
<td>(k = 200)</td>
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<tr>
<td>(E_{ri}) = Stress Dependent</td>
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<tr>
<td>Fair</td>
<td>14.00</td>
<td>9.75</td>
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<tr>
<td>- 5%</td>
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<tr>
<td>(k = 100)</td>
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<tr>
<td>(E_{ri}) = 5 ksi</td>
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<tr>
<td>Poor</td>
<td>14.25</td>
<td>10.25</td>
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<tr>
<td>- 90%</td>
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<tr>
<td>(k = 50)</td>
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<tr>
<td>(E_{ri}) = 2 ksi</td>
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</table>

For 2000 trucks/day in design lane — moderate volume Interstate

### Pavement Performance

- Keys to long term performance:
  - Design.
  - Thickness.
  - Cross-section.
  - Materials.
  - Construction.
  - Maintenance.
“D” Cracked Concrete

ESAL Survival of Original Pavements – South IL
D-Cracking Comparisons

30% More Life

Keys to Pavement Performance - Illinois

Summary of Pavement Life (No DC) – Age
Summary of Pavement Life (No DC) – Cumulative ESALs

Traffic Data

Search for New Portable Equipment

- Safety of the worker
- Quality and Quantity of data collected
- Cost to the Department
- Comply with new FHWA’s Traffic Monitoring Guide (TMG)

Nu-Metrics Hi-Star 97
PV, SU and MU

Passenger Vehicles (PV)
- Class 2: Cars
- Class 3: Light Trucks

Single Unit (SU)
- Buses: Class 4
- 2 Axle: 5
- 3 Axle: 6
- 4 Axle: 7

Multiple Unit (MU)
- Class 8 to 13

Axle Classification vs. Length Classification
(data from permanent ATR locations)

Distribution of Vehicles by Length

Illinois Mechanistic Design
Minimum Designs:
Former procedure:
- Minimum thickness by facility type
- Same statewide
- Industry issues
New Minimums

- Minimums by Facility Type
  - Interstates 2 Way ADT:
    - 500 SU 1500 MU
  - Other State
    - 300 SU 900 MU
  - Unmarked
    - Actual Traffic

Mechanistic Example

Given:  
TF = 4.27  
AC = PG 58 – XX  
Location = Springfield, IL

Soil Input

- 45% Silt
- 27% Clay
- 28% Sand

“Poor”
Illinois 2008 Mechanistic Update

- **HMA**
  - New Fatigue Equation
  - PG Graded Materials for Modules
  - Limiting Strain (Max thickness)

- **PCC**
  - Relook at Joint Spacing
  - Mechanistic CRCP

- **Both**
  - New Minimum Traffic (Lower)
Implementation

- Research start 1980
  - 6 years
- Industry meetings
  - Design Procedures
  - Selection Process
  - Implementation
  - 2 years
- Issue Design 1989

Issues after Implementation

- Industry questions
- FHWA/IDOT review
- Revisions 1992

Summary/Suggestions

- Review design.
- Determine where performance gains needed in your state.
  - Durability (materials)
  - Design
  - Other
- Determine merits of each design input and worth of refinement.
- Involve industry

Challenges & Issues

Quality Data

Quantity Needed?

Simplified Inputs

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<th>Percent</th>
<th>Clay</th>
<th>Fair</th>
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<table>
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