CHARACTERIZATION AND DEVELOPMENT OF TRUCK LOAD SPECTRA FOR CURRENT AND FUTURE PAVEMENT DESIGN PRACTICES IN LOUISIANA

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OUTLINE

• BACKGROUND AND PROBLEM STATEMENT
• STUDY OBJECTIVES
• LITERATURE REVIEW
• DATA COLLECTION
• METHODOLOGY
• RESULTS AND DISCUSSIONS
• CONCLUSIONS AND RECOMMENDATIONS
BACKGROUND AND PROBLEM STATEMENT

• ESALs may produce inaccurate predictions of pavement performance
• MEPDG requires additional traffic data that may or may not be readily available
• There is a need in LA to:
  o Improve the utilization of existing traffic data for future implementation of MEPDG, as well as current pavement design practices
  o Prepare for the transition from current use of ESAL to axle load spectra
**Research Objectives**

- Review current practices by the state of Louisiana on traffic data collection
- Assess the quality of Louisiana’s traffic data
- Develop a strategic plan for traffic data monitoring program
- Estimate the truck load spectra in Louisiana using the available traffic data.
- Make recommendations on implementation of the MEPDG in Louisiana.
AASHTO PAVEMENT DESIGN GUIDE

• Based on empirical design approaches derived from the AASHO Road Test
• Limited structural sections at one location, and with limited traffic levels
• Developed from field measurements over 40 years ago
• Pavement damage caused by new vehicle characteristics and configurations may differ
• Equivalent Single Axle Loads (ESAL)
  o ESAL is the number and weight of all axle loads from the vehicles expected during the pavement design life expressed in 18-KIP
MECHANISTIC-EMPIRICAL PAVEMENT DESIGN GUIDE

- Improve design approaches
- Based on mechanistic principles (more desirable)
- Need: Substantial increase in the truck traffic volume (about 10 to 20 times more) since the 1960s
- Traffic loading and different climatic conditions have been taken into account
A TRAFFIC DATA PLAN FOR MECHANISTIC-EMPIRICAL PAVEMENT DESIGNS (VIRGINIA 2003)

• Objective:
  o Develop a plan to position Virginia Department of Transportation (VDOT) to collect traffic and truck axle weight data to support Level 2 pavement designs

• Recognized piezoelectric output changed greatly with temperature variance, pavement wear, roadway bending, site smoothness, vehicle tire type, air pressure, and piezoelectric sensor aging

• VDOT used the enforcement truck weight data
**Virginia Study (2003)**

- **Truck weight groups**
  - Interstate and arterials with high truck volumes (1,000 or more tractor-trailers per day, Group 1)
  - Interstate and arterials with low truck volume (fewer than 1,000 tractor-trailers per day, Group 2)
  - Minor arterials and major collectors

- **Single load cell was recommended for Groups 1 and 2 (interstate and principal arterials)**

- **Total cost estimated for 5 proposed WIM sites over 5 years was $3,075,000**

- **Benefits:**
  - If 10% of more than 1000 miles paved annually could be reduced by 0.5” (10 percent of 1,000 miles multiplied by $15,000 per mile), $1.5 million could be saved per year
MISSISSIPPI STUDY (2004)

- Objectives:
  - Assist MDOT in developing axle load spectra.
  - Estimating traffic inputs:
    - Directional and lane distribution factors
    - Monthly and hourly truck traffic volume adjustments

- Traffic data:
  - Long Term Pavement Performance (LTPP) database.
  - 22 Mississippi LTPP traffic sites
  - Typically formatted in accordance with the TMG
  - WIM data from 1992 through 1998
  - Truck traffic classification (TTC) groups
### TTC Group Criteria

<table>
<thead>
<tr>
<th></th>
<th>Buses</th>
<th>Multi-Trailer</th>
<th>Single-Trailer and Single-Unit Trucks</th>
<th>TTC</th>
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<tr>
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<td>Relatively high amount of multi-trailer trucks (&gt;10%)</td>
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<td>High percentage of single-trailer trucks, but some single-trailer trucks</td>
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<td>Mixed truck traffic with a higher percentage of single-trailer trucks</td>
<td>Mixed truck traffic with about equal percentages of single-unit and single-trailer trucks</td>
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<tr>
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<td>Mixed truck traffic with about equal percentages of single-unit and single-trailer trucks</td>
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<td>Moderate amount of multi-trailer trucks (2-10%)</td>
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<tr>
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<td>Mixed truck traffic with about equal percentages of single-unit and single-trailer trucks</td>
<td>Predominantly single-trailer trucks</td>
<td>7</td>
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<tr>
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<td></td>
<td>Predominantly single-unit trucks</td>
<td>Mixed truck traffic with about equal percentages of single-unit and single-trailer trucks</td>
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</tr>
<tr>
<td>Low to Moderate (&gt;2%)</td>
<td>Low to None (&lt;2%)</td>
<td>Predominantly single-trailer trucks</td>
<td>Predominantly single-trailer trucks, but with a low percentage of single-unit trucks</td>
<td>1</td>
</tr>
<tr>
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<td>Predominantly single-trailer trucks with a low to moderate amount of single-unit trucks</td>
<td>Mixed truck traffic with a higher percentage of single-trailer trucks</td>
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<tr>
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<td>Major Bus Route (&gt;25%)</td>
<td>Low to None (&lt;2%)</td>
<td>Mixed truck traffic with about equal percentages of single-unit and single-trailer trucks</td>
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<tr>
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<td>Mixed truck traffic with a higher percentage of single-trailer trucks</td>
<td>Predominantly single-unit trucks</td>
<td>6</td>
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<td>Predominantly single-unit trucks</td>
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<td>Mixed truck traffic with about equal single-unit and single-trailer trucks</td>
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<td>Predominantly single-unit trucks</td>
<td>Mixed truck traffic with about equal single-unit and single-trailer trucks</td>
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</tr>
</tbody>
</table>
Mississippi Study (2004)

- Axle Load Spectra
  - Annual axle load spectra for single, tandem, tridem axles for each TTC group
  - Compared axle load spectra of each vehicle class in each of the TTC groups

- Used default values for other input data such as axles per vehicle, tire pressure, axle and tire spacing, and traffic wander

- Conclusions
  - Recommended truck traffic classification (TTC) grouping over the roadway functional class grouping because of the considerable variability in truck distribution.

- Review of the statewide data collection systems was performed in 2002
- Evaluation of the WIM program and a strategic plan for an expanded WIM program
- Bending plate and piezoelectric
- In August 2002, TxDOT had 17 WIM data sites statewide
- Proposed 133 new sites statewide across various roadway functional classifications
- Estimated total cost for additional sites was $32.6 million
- As of May 2004, twelve additional WIM data collection sites were identified
WASHINGTON STUDY (2005)

- **Objectives**
  - To develop axle load spectra for improved pavement design
  - To determine if ESALs obtained from load spectra differ from historical values.

- **WIM Data:** 2000 to 2003

- **Methodology:**
  - Screen stations with unusable data and exclude from analysis
WASHINGTON STUDY (2005)

- **Evaluation**
  - Plot class 9 vehicles gross weight (GVW) vs. frequency for accuracy
  - An ideal plot exhibits two peaks within the federal weight range under fully loaded (80,000 lbs) and empty conditions (28,000 – 35,000 lbs)
WASHINGTON STUDY (2005)

- **Consistency**
  - Plot steering axle weight for class 9 vs. frequency.
  - Check for consistency within weight range (8,500-12,000 lbs)
WASHINGTON STUDY CONCLUSIONS

• Based on historical traffic data, ESALs increased slightly throughout the years and varied per vehicle class
• WIM sites having valid data were used to develop the load spectra
• The new guide is sensitive to overestimated and underestimated load spectra (calibration required)
• Axle load spectra were similar in their overall location of peaks (empty and fully loaded trucks) when compared to new M-EPDG defaults and Minnesota values
Objective:
- Characterizing truck traffic to provide traffic inputs for the M-EPDG procedures

WIM data:
- From 1991 to 2001 through 98 WIM sites
- As of 2006, more than 110 WIM stations were installed

Analysis:
- Sampled one week’s data from each month for each WIM station
- Cluster analysis was applied to form group that had similar truck traffic characteristics
Development and Influence of Statewide Axle Load Spectra on Flexible Pavement Performance (Arkansas 2007)

• Objective:
  • Develop statewide axle load spectra in Arkansas and their significance in MEPDG
  • Perform quality control evaluation of traffic data collected at the WIM sites
• Used 10 out of 25 selected WIM sites (Upon quality checks)
• Sample size of 270 days in each of three years from 2003 through 2005 (for 10 WIM sites)
• Analysis showed significant difference in pavement loadings (statewide vs. MEPDG default spectra)
• State-specific axle load spectra recommended for implementation in Arkansas
• Weight data from WIM stations should be carefully checked before used for pavement design
DATA COLLECTION
DATA COLLECTION

• PORTABLE WIM DATA
  o Traffic Monitoring Guide (TMG) format
  o Site specific WIM data from 2003-2006
  o Monitored for a period of 48 hours at each site
  o Piezoelectric sensors

• TRUCK ROUTE DATA
  o Officially designated truck route map in LA
  o Utilized in locating any WIM station required on a particular road section

• WEIGHT ENFORCEMENT SITES
TRUCK ROUTE MAP (SOUTH WEST REGION)
WEIGHT ENFORCEMENT SITES

• Currently 13 enforcement stations located primarily on the Interstates and other principal arterials
• Steel single load cell sensors are used for monitoring truck weights
• Accurate within a range of +/- 6% with respect to corresponding axle
• Same equipment that is being utilized by other states at most of the permanent WIM stations
• Data collected is only stored for 3 months as it is used for sorting purposes
Mainline Truck Sorting at WIM enforcement stations
(Source: International Road Dynamics Inc.)
Map showing WIM Enforcement Stations within Louisiana
METHODOLOGY
**Methodology**

- Reviewing current practices of traffic data collection by LADOTD
  - Louisiana’s traffic monitoring sampling
  - Limitations of the current practices of traffic data collection
  - Long Term Pavement Performance (LTPP) Data
- Develop strategic plan for WIM data collection program
  - Alternative Plan # 1
  - Alternative Plan # 2
- Cost estimates for the recommended WIM equipment
- Criteria for building a permanent WIM station
- Evaluation of WIM data
  - Steering axle load test
  - Gross vehicle weight test
- Comparison of truck traffic characteristics
- Implementation plan
Reviewing current practices of traffic data collection by LADOTD

• Louisiana’s traffic monitoring sampling (over a period of 3 years)
  ○ WIM sites:
    ▪ 100 sites (weight and vehicle class data)
  ○ Vehicle classification sites:
    ▪ 200 sites (only vehicle class data)

• Equipment at WIM stations: Piezoelectric cables
  ○ Temperature sensitive (variation of temperature can affect the signal readings).
  ○ Result in over-weighing light vehicles and under-weighing heavy vehicles.
LONG TERM PAVEMENT PERFORMANCE (LTPP) DATA

- **LTPP:**
  - Program that collects and processes data describing the structure, service conditions, and performance of 2,513 pavement test sections in North America in order to better understand the pavement performance
  - Used for analyzing and to make decisions that lead to more cost-effective and better performing pavements

- In Louisiana, LTPP site is located along US-171, near Moss Buff in Calcasieu Parish
- First permanent WIM site in Louisiana
- Kistler Quartz WIM equipment
DEVELOPMENT OF A STRATEGIC PLAN

• Objective: To improve the traffic data collection process for pavement design practices

• Factors considered
  o Current practices of the traffic data collection process by LA DOTD and other states.
  o Official truck route zones
  o Location of weight enforcement sites
  o Other traffic data input required by M-EPDG
  o Site selection and traffic data collection guidelines by TMG
**Strategic Plans**

- **Alternative Plan #1**
  - Assumes that WIM data from the weight enforcement stations is not available
  - 29 permanent WIM stations are proposed for the entire state, out of which 17 are allocated to interstates and the remaining 12 to principal arterials
  - 15 additional portable sites on the principal arterials to observe the traffic loading characteristics
  - Existing portable sites located in the vicinity of the proposed permanent sites could be eliminated
### Example: WIM stations in Baton Rouge region

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PMI</td>
<td>Proposed permanent WIM sites on interstates</td>
</tr>
<tr>
<td>PMA</td>
<td>Proposed permanent WIM sites on principal arterials</td>
</tr>
<tr>
<td>PR</td>
<td>Proposed portable WIM stations</td>
</tr>
<tr>
<td>Site</td>
<td>Existing portable WIM sites on interstates and principal arterials</td>
</tr>
</tbody>
</table>
STRATEGIC PLANS

• Alternative Plan #2
  o Assumes that WIM data from the weight enforcement stations is available
  o 17 permanent WIM stations are proposed for the entire state, out of which 7 are allocated to interstates and the remaining 10 to principal arterials
  o 12 weight enforcement stations
  o This plan offers lower cost than plan 1
## Cost estimates for the proposed plans

<table>
<thead>
<tr>
<th>Plans</th>
<th>Equipment</th>
<th>Initial Costs</th>
<th>Installation Costs</th>
<th>Annual Recurring costs/lane</th>
<th>Quantity</th>
<th>Amount</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternative # 1 ( without enforcement sites)</td>
<td>29 Permanent sites with single load cell</td>
<td>$50,500 (Single Load Cell)</td>
<td>$23,400</td>
<td>$8,800</td>
<td>29</td>
<td>$2,398,300</td>
<td>$2,398,300</td>
</tr>
<tr>
<td></td>
<td>17 Permanent sites (interstate) with single load cell and remaining 12 with bending plate</td>
<td>$50,500 (Single Load Cell)</td>
<td>$23,400</td>
<td>$8,800</td>
<td>17</td>
<td>$1,405,900</td>
<td>$1,951,900</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$21,500 (Bending Plate)</td>
<td>$16,100</td>
<td>$7,900</td>
<td>12</td>
<td>$546,000</td>
<td></td>
</tr>
<tr>
<td>Alternative # 2 ( with enforcement sites)</td>
<td>17 Permanent sites with single load cell</td>
<td>$50,500 (Single Load Cell)</td>
<td>$23,400</td>
<td>$8,800</td>
<td>17</td>
<td>$1,405,900</td>
<td>$1,405,900</td>
</tr>
<tr>
<td></td>
<td>7 Permanent sites (interstate) with single load cell and remaining 10 sites with bending plate</td>
<td>$50,500 (Single Load Cell)</td>
<td>$23,400</td>
<td>$8,800</td>
<td>7</td>
<td>$578,900</td>
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<td>$21,500 (Bending Plate)</td>
<td>$16,100</td>
<td>$7,900</td>
<td>10</td>
<td>$455,000</td>
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</table>
EVALUATION OF WIM DATA

• Steering axle load test
  • Objective: To eliminate WIM sites with erroneous data
  • Data: Portable WIM sites from 2004 to 2006
  • Procedure: To check whether 60% of the steering axle weight for class 9 trucks falls within a practical range of 8,000 lbs – 12,000 lbs
Example: Steering axle weight (Class 9 vehicle) versus frequency for Site #38

- WIM site # 53 passed steering axle test (89.68% of the steering axle weight inside the practical range)
Example: Steering axle weight (Class 9 vehicle) versus frequency for Site #53

- WIM site # 53 failed steering axle test (79.52% of the steering axle weight outside the practical range)
GROSS VEHICLE WEIGHT TEST

• Objective: To eliminate WIM sites with erroneous data
• Data: Portable WIM sites from 2004 to 2006
• Procedure: To check whether 60% of gross vehicle weight for class 9 trucks falls within a practical range of 28,000 - 36,000 lbs for unloaded trucks and 72,000 – 80,000 lbs for loaded trucks
Example: Gross vehicle weight (Class 9 vehicle) versus frequency for site #107

- WIM site #107 passed gross vehicle weight test
- Two peaks: (Practical, TMG)
  - A represents the peak for unloaded trucks
  - B represents the peak for loaded trucks
Example: Gross vehicle weight (Class 9 vehicle) versus frequency for site #20

• WIM site # 20 failed GVW test (50% of the GVW outside the upper limit of 80,000 lbs)
• Out of 96 WIM sites, only 51 sites passed steering and GVW tests
COMPARISON OF TRUCK TRAFFIC CHARACTERISTICS

- **Objective:** To compare the truck traffic characteristics from portable WIM sites and reduce the number of proposed WIM sites.
- **Procedure:** Determine the sum of squared differences between the axle load spectra for each pair of sites:
  \[ \sum_{i}^{j} (X_i - Y_i)^2 \]
- **Dominant vehicle class:** Class 5, 6, and 9.
Example: Group of 3 sites having similar truck characteristics

Single axle load spectra for class 9
### WIM site groups

<table>
<thead>
<tr>
<th>Group # under class 9</th>
<th>Existing WIM site #</th>
<th>Proposed WIM site #</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group # 1</td>
<td>139, 163, 33</td>
<td>PMA 7 is next to 139</td>
</tr>
<tr>
<td>Group # 2</td>
<td>154, 156, 38, 67, 168, 102, 155</td>
<td>PMI 2 is next to 154, PMI 7 is next to 156, PMI 14 is next to 67, PMI 15 is next to 168, PMI 11 is next to 102</td>
</tr>
<tr>
<td>Group # 3</td>
<td>150, 106</td>
<td>PMI 4 is next to 150</td>
</tr>
<tr>
<td>Group # 4</td>
<td>16, 162</td>
<td>PMA 2 is next to 16</td>
</tr>
<tr>
<td>Group # 5</td>
<td>77, 123</td>
<td>PMA 1 is next to 123</td>
</tr>
<tr>
<td>Group # 6</td>
<td>22, 108</td>
<td>---</td>
</tr>
<tr>
<td>Group # 7</td>
<td>49, 105</td>
<td>---</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Group # under class 5</th>
<th>WIM site #</th>
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</thead>
<tbody>
<tr>
<td>Group # 8</td>
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<td>---</td>
</tr>
<tr>
<td>Group # 9</td>
<td>24, 148, 144</td>
<td>---</td>
</tr>
<tr>
<td>Group # 10</td>
<td>14, 27, 50</td>
<td>---</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Group # under class 6</th>
<th>WIM site #</th>
<th>Proposed WIM site #</th>
</tr>
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<tr>
<td>Group # 11</td>
<td>59, 135</td>
<td>---</td>
</tr>
<tr>
<td>Group # 12</td>
<td>138, 31</td>
<td>---</td>
</tr>
</tbody>
</table>
IMPLEMENTATION PLAN

• Pilot Study
  • Step 1: Perform a pilot study scheduled on all the proposed permanent sites for a time period of 7 days a week in every quarter for a year (TMG)
  • Step 2: Repeat the analysis such as, perform the sum of squared differences for truck traffic characteristics, compare the sites with each other and find similarities between them
  • Step 3: Cluster them into different groups and make a list of the permanent WIM sites within each group in a prioritized order that LA DOTD could follow to build
DAYS REQUIRED IN COMPLETING THE PILOT STUDY

• Assumed that portable WIM is required for 10 days at one site (7 days for monitoring truck traffic and the remaining 3 days for uninstalling and installing at the next site)

• Number of proposed sites = 29

<table>
<thead>
<tr>
<th>No. of WIM equipment employed</th>
<th>No. of days required (For Alternative # 1)</th>
<th>No. of days required (For Alternative # 2)</th>
</tr>
</thead>
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<tr>
<td>1</td>
<td>((\frac{29 \times 10}{1}) = 290)</td>
<td>((\frac{17 \times 10}{1}) = 170)</td>
</tr>
<tr>
<td>2</td>
<td>((\frac{29 \times 10}{2}) = 145)</td>
<td>((\frac{17 \times 10}{2}) = 85)</td>
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<tr>
<td>3 (Existing Equipment)</td>
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<td>((\frac{17 \times 10}{3}) = 57)</td>
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<td>4</td>
<td>((\frac{29 \times 10}{4}) = 73)</td>
<td>((\frac{17 \times 10}{4}) = 43)</td>
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<tr>
<td>5</td>
<td>((\frac{29 \times 10}{5}) = 58)</td>
<td>((\frac{17 \times 10}{5}) = 34)</td>
</tr>
<tr>
<td>6</td>
<td>((\frac{29 \times 10}{6}) = 49)</td>
<td>((\frac{17 \times 10}{6}) = 29)</td>
</tr>
</tbody>
</table>
PRIORITIZED PROPOSED WIM SITES

• Provides a list of prioritized recommended WIM sites that LA DOTD can follow
• Based on the analysis of current truck volume frequencies, truck routes, geographic zones, current axle load spectra and vehicle class distribution
• Factors considered for prioritizing:
  o Interstates should be given first priority
  o Sites having truck traffic characteristics similar to other WIM sites should be built first
  o Two WIM sites proposed each year should not be in the same region
  o Sites proposed near the state border should be given least priority
# WIM Site Construction Schedule

## List of prioritized proposed WIM sites for Alternative Plan 1

<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Proposed WIM #</td>
<td>PMI 11</td>
<td>PMI 8</td>
<td>PMI 3</td>
<td>PMI 9</td>
<td>PMI 6</td>
<td>PMI 1</td>
<td>PMA 7</td>
<td>PMA 4</td>
<td>PMA 5</td>
<td>PMA 12</td>
<td>PMA 3</td>
<td>PMA 8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PMI 4</td>
<td>PMI 12</td>
<td>PMI 13</td>
<td>PMI 17</td>
<td>PMI 16</td>
<td>PMA 1</td>
<td>PMA 2</td>
<td>PMA 9</td>
<td>PMA 11</td>
<td>PMA 10</td>
<td>PMA 6</td>
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</tbody>
</table>

## List of prioritized proposed WIM sites for Alternative Plan 2

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<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Proposed WIM #</td>
<td>PMI 8</td>
<td>PMI 10</td>
<td>PMI 3</td>
<td>PMA 7</td>
<td>PMA 4</td>
<td>PMA 12</td>
<td>PMA 8</td>
<td>PMA 6</td>
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<tr>
<td></td>
<td>PMI 4</td>
<td>PMI 5</td>
<td>PMA 1</td>
<td>PMA 2</td>
<td>PMA 9</td>
<td>PMA 11</td>
<td>PMA 10</td>
<td>---</td>
</tr>
</tbody>
</table>
RESULTS AND DISCUSSIONS
VEHICLE CLASS DISTRIBUTION FOR FUNCTIONAL CLASS

Vehicle Class Distribution for Functional Class 1
TRUCK TRAFFIC CLASSIFICATION GROUPS

Vehicle Class Distribution for TTC 1

Vehicle Class Distribution for TTC 3
AXLE LOAD SPECTRA FOR TTC GROUPS

Single axles per vehicle class for TTC 1

Single axle load spectrum for combined vehicle classes (X 1,000 lbs)

Single axle load spectrum for combined vehicle classes for TTC 1
Single axle load spectrum for class 8 (X 1,000 lbs)

Single axle load spectrum for vehicle class 8 for TTC 1

Single axle load spectrum for class 9 (X 1,000 lbs)

Single axle load spectrum for vehicle class 9 for TTC 1
Single axle load spectrum for vehicle class 9 for TTC groups

Frequency in %

Single axe load spectrum for class 9 for TTC groups (X 1,000 lbs)
Tandem axle load spectrum for vehicle class 9 for TTC groups
Tridem axle load spectrum for vehicle class 10 for TTC groups (X 1,000 lbs)
CONCLUSIONS AND RECOMMENDATIONS
CONCLUSIONS

• There exists a significant increase in truck traffic data characterization to be utilized in pavement design

• Reviewing these entire current and anticipated practices, two alternative plans are proposed. 29 permanent WIM sites are proposed in alternative #1, and 17 permanent WIM sites are proposed in alternative #2

• Out of 96 portable WIM stations, 51 sites passed the quality control tests and comprised valid weight data.
CONCLUSIONS

- Forty-five WIM sites that were not included for developing axle load spectra showed the piezoelectric sensors were out of calibration or failed.
- Underestimated and/or overestimated data were eliminated (using Steering and GVW tests).
- Single, tandem, and tridem axle load spectra and vehicle class distributions were developed in this study with truck traffic classification procedure.
- WIM sites when grouped with truck traffic classification procedure had good agreement with vehicle class distribution and single axle load spectra default values.
CONCLUSIONS

• Default tandem and tridem axle load spectrum was entirely different when compared to the TTC groups.
• There exists a significant variability in vehicle class distribution within the same functional classification.
RECOMMENDATIONS

• Existing portable WIM sites (excluded for developing axle load spectra) - be calibrated

• The traffic data from weight enforcement stations should be collected and stored periodically

• A pilot study is recommended for implementing proposed permanent WIM sites. Proposed sites should be monitored for seven continuous days in every quarter of the year with calibrated piezoelectric sensors

• Proposed and existing portable WIM sites should have piezoelectric sensors

• A monitoring period of seven continuous days for portable WIM sites is recommended
RECOMMENDATIONS

• Existing portable WIM sites (close proximity to proposed permanent WIM sites) be eliminated
• Single load cell equipment for interstates
• Bending plate for principal arterials
• Not recommended to group highways based on functional classification
• Truck traffic classification (TTC) system is recommended for grouping highways for existing conditions
• Default values for general traffic inputs should be used unless specific information is obtained
THANKYOU