Structural Considerations in Moving Mega Loads on Idaho Highways

By:
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Focus:

Overview *mechanistic-empirical procedures* used to determine the impact of oversize and overweight vehicles on flexible pavement performance in Idaho.
1. Examples for Using Mechanistic-Empirical Based Pavement Design-Analysis Procedures
Example: Analysis & design of designated routes for hauling overloads for pavement & rehabilitation design.

Photo: Courtesy of Jim Scherocman.
Example: Analysis of special loading configurations for pavement design.
Example: Determine impact from transporting overweight/oversize commodities on pavement deterioration and maintenance.

Photo: Courtesy of Ken Fults.
Example: Determine damage from special loading configurations for transporting oversize commodities.

\[
\text{Damage} = \sum \frac{\text{ActualCycles}, n}{\text{AllowableCycles}, N}
\]

Photo: Courtesy of Ken Fults.
Higher loads, more axles, higher tire pressures:

Result in higher bending or strains in the pavement:

Causing increased pavement damage & shorter service life.

But, how much more damage?

Photo: Courtesy of Ken Fults.
2. How Much More Damage?
Determined from Pavement Responses to Estimate Allowable Load Cycles, N
Pavement Evaluation Procedures.

M-E Based Procedures

- Climate
- Foundation
- Traffic
- Structure
- Materials

Pavement Responses:
- Deflections
- Stresses
- Strains

MECHANISTIC PART TO DETERMINE DAMAGE

Transfer Functions:
- Alligator Cracks
- Rut Depths
- Roughness

EMPIRICAL PART TO CALCULATE DISTRESS
Effect of Mega Loads on Pavement Distress

M-E Based Procedures to Determine Allowable Load Cycles (ESALs):

- Tensile strain bottom of HMA layer; **FATIGUE CRACKING**.
- Vertical compressive strain in HMA; **HMA RUTTING**.
- Subgrade vertical compressive strain; **STRUCTURAL RUTTING**.

ESAL = Equivalent Single Axle Load.
3. How Much More Damage or Distress Specific to Idaho Mega Vehicles – Kearl Oil Sands Project?
Idaho Mega Vehicle Loading Details

Gross Vehicle Weight
556,300 lbs.

Pull Vehicle:
- One Steering Axle
- One Tandem Axle

Push Vehicle:
- One Steering Axle
- One Tandem Axle

Trailer:
- Fourteen axles or seven tandem axles.

Frequency:
- 200 annual operations.
Idaho Mega Vehicle Loading Details

- Trailer Weight per Tire = 7,720 lbs.
- Tractor Steer Axle Weight per Tire = 8,050 lbs.
- Tractor Drive Axle Weight per Tire = 5,738 lbs.
- Dual Tire Spacing = 30 inches
- Tandem Axle Spacing = 59 inches
- Vehicle speed = 5 mph
- Tire pressure = 125 psi

Gross Vehicle Weight
556,300 lbs.
Effect of Multiple Axles – Tensile Strain

Two strain applications for a tandem axle.
Threshold Values Used to Determine Allowable Load Applications

- Rut Depth – 0.5 inches
- Alligator Fatigue Cracking – 10%
- Roughness – 160 in./mi.
### Allowable Number of Load Applications for Threshold Values

<table>
<thead>
<tr>
<th>Pavement Structure</th>
<th>18-kip ESALs</th>
<th>Mega Vehicle/Loads</th>
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<tr>
<td></td>
<td></td>
<td>Steering Axle</td>
</tr>
<tr>
<td>Thin Pavement</td>
<td>1,661,000</td>
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<tr>
<td>Thick Pavement</td>
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Good subgrade support conditions assumed: A-1-b Soil; R-Value – 40 to 50
## Equivalent Number of Single Axles Per Mega Vehicle

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<tr>
<th>Pavement Structure</th>
<th>Number of ESALS</th>
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<td>Tractor Steering Axle</td>
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<tr>
<td>Thick Structure</td>
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Number of ESALs for Mega Vehicle = 30
Annual ESALs = 6,000
4. What does this mean in terms of pavement distress or performance?
MEPDG Design Process

Distresses Predicted for the Idaho Mega Vehicles Versus Roadway without Mega Vehicles:

1. Bottom-Up Alligator Cracking
2. Total Rut Depth
3. Roughness
Expanding the Realm of Possibility

FHWA Vehicle Classifications

1. Motorcycles
2. Passenger Cars
3. 2-Axle, 4-Tire, Single Units
4. Buses
5. 2-Axle, 6-Tire, Single Units
6. 3-Axle Single Units
7. 4-Axes or More, Single Units
8. 4-Axes or Less, Single Trailers
9. 5-Axle Single Trailers
10. 6-Axes or More, Single Trailers
11. 5-Axes or Less, Multi-Trailers
12. 6-Axle Multi-Trailers
13. 7-Axes or More, Multi Trailers
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<th>Truck Class</th>
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Note: AADTT distribution must total 100%.

Truck Class Distribution:
Truck Class #7 used to represent the mega vehicles.
### Monthly/Seasonal Adjustment Factors

#### Monthly Adjustment Factors

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</table>
Truck Growth: No growth used for mega vehicle.
### Axle Load Distribution Factors

**Axle Load Distribution**
- Level 1: Site Specific
- Level 2: Regional
- Level 3: Default

**View**
- Cumulative Distribution
- Distribution

**Axle Types**
- Single Axle
- Tandem Axle
- Tridem Axle
- Quad Axle

#### Axle Factors by Axle Type

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Expanding the Realm of Possibility
Truck Tandem Axle Load Distributions

- Default Distribution
- Northbound, Loaded Truck Direction
- Southbound, Unloaded Truck Direction
General Traffic Inputs

Lateral Traffic Wander
Mean wheel location (inches from the lane marking):
18
Traffic wander standard deviation (in):
10
Design lane width (ft): (Note: This is not slab width)
12

Number Axles/Truck
Axle Configuration
Wheelbase

<table>
<thead>
<tr>
<th>Class</th>
<th>Single</th>
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<th>Tridem</th>
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General Traffic Inputs

Expanding the Realm of Possibility
Distresses or Performance Indicators Predicted with the MEPDG:
Increased Fatigue Damage

\[ \text{Damage} = \sum \frac{n}{N} \]
Increased Fatigue Cracking

**Thin Structure**
- No Mega Load, Thin Structure
- Mega Load, Thin Structure

**Thick Structure**
- No Mega Load, Thick Structure
- Mega Load, Thick Structure

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Increased Rutting

**Thin Structure**

**Thick Structure**

![Graph showing comparison between No Mega Load and Mega Load for Thin and Thick Structures.](image-url)
Increased Roughness

**Thin Structure**

**Thick Structure**
5. Summary or Findings

M-E Based Analysis:

1. Each mega vehicle applies about 30 ESALs per operation.

2. Pavement will exhibit slightly higher levels of alligator cracking, rutting, and roughness.

3. Mega vehicle more damaging over weaker soils.
5. Summary or Findings

4. Expect service lives to decrease no more than about 2 years in comparison to pavements without these mega vehicles *that were properly designed*.

5. New designs or rehabilitation strategies will require no more than about 0.5 inch of HMA.
QUESTIONS?

Photo: Courtesy of Ken Fults.