IMPACT OF OVERLOADED VEHICLES ON LOAD EQUIVALENCY FACTORS AND SERVICE PERIOD OF FLEXIBLE PAVEMENTS

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Background of research

Growth of heavy traffic in National Roads of Poland 1990-2015

Vehicle classes:
- Truck with trailer or semi-trailer
- Single trucks units
- Buses
Problem of overloaded vehicles

- There are set legal limitations of gross weight and axle loads of vehicles
- Some vehicles exceed this legal limit
- Overloaded vehicles have much higher detrimental effects on pavement structure than properly loaded vehicles

\[
\begin{align*}
\text{max 40 tons} & \quad \text{max 100 kN} \\
\text{max 18 tons} & \quad \text{max 115 kN (or 100 kN)}
\end{align*}
\]
System of weigh in motion (WIM)

Weigh in motion station

- Weighing of all vehicles
- Preselecting
- Providing the statistical data

Control on static weight

- Weighing of preselected vehicles on static, legal weights.
- Imposition of punishment
Data delivered from weigh in motion

Data include:

- gross weight
- axle loads
- distance between axles
- speed
- vehicles class
Data used in the analysis

10 WIM stations

Measurement period from 1 to 6 whole years

More than 12 millions heavy vehicles after data validation
Average percentage of overloaded vehicles – different stations

\[
OV = \frac{\text{Number of overloaded vehicles}}{\text{Total number of trucks}} \times 100 \% 
\]
Variations in the percentage of overloaded vehicles – an example

Intensivity of vehicle overloading can be reduced by improving enforcement
Structure of vehicles overloading

- Lot of vehicles exceed axle loads limits despite having proper gross weight
- Result of wrong charge distribution
Load equivalency factors

Number of trucks or axles \times \text{Load equivalency factors } F_j = \text{Number of equivalent standard axle loads}

- Fourth power equation – general level

\[ F_j = \left( \frac{Q_j}{Q_s} \right)^4 \]

- \( Q_j \) – actual axle load
- \( Q_s \) – standard axle load
Load equivalency factors

Number of trucks or axles \times \text{Load equivalency factors } F_j = \text{Number of equivalent standard axle loads}

- Mechanistic-empirical approach – site specific level

\[ F_j = \frac{d_j}{d_s} \]

- \( d_j \) – fatigue damage caused by actual axle load \( Q_j \)
- \( d_s \) – fatigue damage caused by standard axle load \( Q_s \)
Truck factors

- Truck factor characterize detrimental effect of particular vehicles on pavement structure

\[
TF_v = \sum_{j=1}^{n} F_j
\]

- Calculated separately for each vehicle (more than 12 million vehicles included)
The contribution of overloaded vehicles in the fatigue damage of pavement structure
How the reduction of overloaded vehicles will contribute to increase of service period of pavement structure
Effect of overloaded vehicles on truck factors

- Linear regression between monthly percentage of overloaded vehicles OV and average truck factors TF
- Determinated for particular 11 WIM stations
- High coefficient of determination $R^2$ from 0.76 to 0.99
Fatigue life of pavement structure: \[ N_{100} = NT_0 \cdot TF_0 = NT_{OV} \cdot TF_{OV} \]

Decrease of Fatigue Life: \[ DFL = 1 - \frac{TF_0}{TF_{OV}} \]
Example:
Residual Service Period $\text{RSP}$ at $\text{OV} = 20\%$ equals **10 years**
Higher enforcement causes reduction of $\text{OV}$ from 20% to 5%

$$
RSP_{\text{OV-\Delta OV}} = RSP_{\text{OV}} \frac{1-\text{DFL}_{\text{OV-\Delta OV}}}{1-\text{DFL}_{\text{OV}}} = 10 \frac{1-0,29}{1-0,60} = 18 \text{ [years]}
$$
Conclusions...

1) Vehicle overloading is a serious problem. The percentage of overloaded vehicles in Poland range from 7% to 23%

2) Percentage of overloaded can be decreased by improvement of enforcement

3) Truck Factor which characterizes the fatigue damage of pavements structure caused by an average vehicle is very well correlated with percentage of overloaded vehicles

4) Increase of the percentage of overloaded vehicles from 0% to 15% will cause Decrease of Fatigue Life approximately twice

5) Decreasing of the percentage of overloaded vehicles will cause the significant extension of pavement service period
Thank you for attention...