Recommendations for Dynamic Allowance in Bridge Assessment

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1. Introduction
2. Dynamic Allowance for All Bridges
3. Recommendations for Site-Specific Assessment of Dynamic Allowance
4. Conclusions
1. Finding Characteristic Static Load Effect, i.e., Load Effect with acceptably low probability
   • previous speaker (WIM measurements and computer simulations)

2. Or use a notional load model for assessment

3. Adding an allowance for dynamic amplification
   • this is what I will address
We have reason to believe that allowances for dynamics are quite conservative.
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Previous studies considered dynamics for common trucks (2-axle or 5-axle)

We found in ARCHES that critical loading events involve big cranes or low loaders
In ARCHES, we compared dynamic amplification for cranes & 5-axle trucks
• Beam Model
  - Euler-Bernoulli beam
  - Inaccurate
  - Conservative
  - Faster calculations

• Plate Model (FEM)
  - Finite Element Plate
  - More accurate
  - Slower calculations
• Vehicle fleet
  - Woerden Weigh-In-Motion site (The Netherlands)
  - 77 daily maxima
  - 5-axle truck vs. Crane type vehicles

• Random variability (Monte Carlo scheme)
  - Road profiles, ISO Class A & B
  - Vehicle properties (Speed, suspension and tyre stiffness, …)

• Results
  - Over 300 000 Beam model simulations
  - Over 50 000 Plate model simulations
  - Class A and B profiles analyzed separately
Assessment and Rehabilitation of Central European Highway Structures

Same trend for Plate model

Recommendation Beam Model: Cranes and 5-axle trucks (95% confidence interval for Class A profiles)
Class A Recommendation for

- 1 Lane Moment
- 1 Lane Shear
- 2 Lanes
Class B Bending Moment & Recommendations
Class B Shear &
Recommendations
• This study was for 1-Lane bridges
  • (But would be conservative for 2-lane bridges)

Next Steps

• Study of 2-Lane scenario
  - Critical events (2 or more vehicles meeting on the bridge)

• Estimation of calculation time
  - Critical events using traffic model = 40 PC-days
  - Dynamic evaluation of events = Another 60 PC-days

• Expect reduced allowances for dynamics
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Site-specific measurement of Dynamic Amplification:

- Directly measure total strain
- Use Bridge WIM system to measure truck weight
- Hence estimate the static strain

- Estimate of DAF = Total/(Est. of Static)
Bridge Weigh-In-Motion Data was analysed from 4 locations:

<table>
<thead>
<tr>
<th>Location</th>
<th>Length</th>
<th>Events</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trebnje</td>
<td>8m</td>
<td>50,937 events</td>
<td>34 days</td>
</tr>
<tr>
<td>Vransko</td>
<td>24.8m</td>
<td>112,339 events</td>
<td>58 days</td>
</tr>
<tr>
<td>Blagovica</td>
<td>12m</td>
<td>50,770 events</td>
<td>33 days</td>
</tr>
<tr>
<td>The Netherlands</td>
<td>7.3m</td>
<td>52,694 events</td>
<td>15 days</td>
</tr>
</tbody>
</table>
Trebnje

Trabnje Data

- Data
- Mean
- Mean + 1.28 Std Dev (90%)

Static (micro) Strain

DAF
Vransko Data

- Data
- Mean
- Mean + 1.28 Std Dev (90%)
The Netherlands

The Netherlands Data

- Data
- Mean
- Mean + 1.28 Std Dev (90%)

DAF

Static (micro) Strain
Definition of Dynamic Amplification Factor (DAF):

\[
DAF = \frac{\text{Dynamic stress}}{\text{Static stress}} \quad \text{for a given loading scenario}
\]
We have developed a new factor for dynamics, Assessment Dynamic Ratio (ADR):

\[
ADR = \frac{\text{What we want to know}}{\text{What we already know}}
\]

\[
ADR = \frac{\text{Characteristic total stress (all scenarios)}}{\text{Characteristic static stress (all scenarios)}}
\]
50 years...

Estimate of Max Static Bending Moment

Assessment Dynamic Ratio (ADR)
Recommendation – we need about 3 months of data to predict the ADR for a 50-year return period.
Conclusions

• There is a great deal of conservatism in the general EC1 allowances for dynamic amplification
• Recommendations for single vehicle events (1-lane bridges):
Conclusions (continued)

- For particular bridges, it is often possible to prove that allowances are much too conservative

- Recommend using Bridge WIM to estimate static
- And measure total strain directly
- 3 months of data enough for good estimate of Assessment Dynamic Ratio