Vibration Analysis of Vehicle Bump at Bridge Deck and Approach Connecting Part

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Presentation Overview

1. Introduction
2. Data Processing
3. Vibration Analysis
4. Preliminary Findings
5. Summary
Vehicle Bump at Bridge Approach

- **Reason:** The bump was caused by uneven settlement of backfill soil and abutment, and bridge expansion joints.

- **Influence:** unbalanced force to wheels, dynamic load to bridge structure.
Problem Statement

• Any standard?

AASHTO LRFD Bridge Design Specifications provide countermeasures (soil compaction standard, backfill material) aim to reduce bump

• Unsolved Problems
  • The influence of vibration caused by bump on driver behavior
  • Guide for setting speed limit at bridge approach
  • Maintenance time for bridge approach
Objective

- Figure out the influence of bump on driver at existing bridge approach and deck connecting locations
- Provide speed limit setting recommendation for bridge approach
Data Source

• Trip Information:
The Strategic Highway Research Program 2 (SHRP 2) naturalistic driving study (NDS) data.

• Bridge feature:
Related Road Information Database (RID).

• Data Size
• 83 bridges on freeway (Length>0.05 mile)
• 60 trips
• 182 passing bridge records
Speed and Acceleration Analysis

- Bump Location identification:
  Check in ArcGIS, view forward videos

- Analysis time:
  1 seconds before and after the bump

- Preliminary results
  - Small speed change (85% trips <1.0 mph)
  - Why is vertical acceleration important?

Example of Speed and Vertical Acceleration
Vibration Analysis

• Methodology

Root mean square (r.m.s) of vertical acceleration in ISO 2631-1

\[
\text{r.m.s.} = \left[ \frac{1}{T} \int_{t=0}^{t=T} a_w^2(t) \, dt \right]^{1/2}
\]

Where

- \( T \) is the measurement duration (2 seconds).
- \( a_w(t) \) is the frequency weighted acceleration at time \( t \) (vertical acceleration + 32.17 ft/s^2).

Result: average r.m.s = 1.81 ft/s^2

• Criteria

<table>
<thead>
<tr>
<th>r.m.s (ft/s^2)</th>
<th>&lt;1.033</th>
<th>1.033-2.067</th>
<th>1.64-3.28</th>
<th>2.62-5.25</th>
<th>4.1-8.2</th>
<th>&gt;6.56</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driver Feeling</td>
<td>not uncomfortable</td>
<td>a little uncomfortable</td>
<td>fairly uncomfortable</td>
<td>uncomfortable</td>
<td>very uncomfortable</td>
<td>extremely uncomfortable</td>
</tr>
</tbody>
</table>

Source: ISO 2631-1
Vibration and Speed

• How to reduce vibration?

• If speed goes down 10 mph, r.m.s of vertical acceleration will decrease 0.653.
Preliminary Findings

- The influence of bump on speed is limited (less than 1 mph).
- Decreasing driving speed can reduce vibration.
- Recommended speed for bridge is 10 mph less than connecting pavement.
Future Study

- Crash Analysis involving vibration data at bridge-related area
- Extend the sample size
- Provide maintenance time
Thank you!

Suggestions and Questions?