Development of a Roll-Coupled Hitch for Truck/trailers

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Background

- Truck/Full Trailer
- Truck/Pony Trailer

Less dynamically stable relative to semi-trailers
Background

- Truck-trailers incorporated into Canadian provincial transportation memorandum of understanding (MOU) in 1991
- Trailer capacities downgraded below axle capacities due to dynamic concerns
- MOU not universally applied across all provinces
Background

MOU 31 000 kg MAX

MOU 21 000 kg MAX
Objectives

• To improve truck-trailer dynamic performance and thereby improve safety
• To improve configuration productivity by utilizing full axle load capacity
Research

• Roll coupling hardware deemed optimal solution to improve performance:
  – will meet performance criteria under current dimensional allowances
  – will facilitate straightforward regulatory enforcement
  – Simulations showed significant improvement in Load Transfer Ratio (LTR), meeting the TAC performance measure (LTR <0.60)
Research

• Proposed strength requirements were developed from existing C-dolly specifications (Transport Canada Standard 903).

• Increased for higher payloads
  – The proposed requirements specified:
    • Hitch axial strength (400 kN pull; 130 kN vertical; 40 kN lateral)
    • Hitch torsional strength (60 kN-m)
    • Hitch torsional stiffness (4 kN-m/deg)
Prototype Design- Full-Trailer Drawbar

• Feric cooperated with Arctic trailers to design and build drawbar to meet prescribed requirements
Prototype Design- Wolf Trailer Company Roll-Coupled Drawbar

• Larry Wulff (Wolf Trailer Company) designed & manufactured a prototype hitch to meet these requirements for the Pony Trailer
Hitch/drawbar Torsional Testing

- Torsional requirements:
  - torsional strength of at least 60 kN·m
  - torsional stiffness of at least 4 kN·m/deg
Torsional Testing - Results

OVERALL STIFFNESS: 14.4 kN-m/deg
Hitch Torsional Testing - Conclusions

• Torsional strength
  – Both the full-trailer hitch & the pony trailer hitch were able to sustain over the 60 kN•m of torque required

• Torsional stiffness
  – Both the full-trailer hitch & the pony trailer hitch had a torsional stiffness over 3 times the required 4 kN•m/deg
Performance Measures - Definitions

• Static Rollover Threshold (SRT)
  – the maximum lateral acceleration (in g’s) a vehicle can sustain without rolling over

• Load Transfer Ratio (LTR)
  – ratio of difference between sum of right wheel loads & left wheel loads to the sum of all wheel loads
Vehicle Stability Testing

- Vehicle stability testing undertaken to quantify the effect of roll-coupling
- Tilt table test
Configuration Stability Testing

- Two conditions evaluated:
  - Truck free to roll: steady state stability
  - Truck fixed to table: dynamic stability (phase shift)

<table>
<thead>
<tr>
<th>Drawbar Type</th>
<th>Pony trailer loads (kg)</th>
<th>Full-trailer loads (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a standard</td>
<td>21 000</td>
<td>31 000</td>
</tr>
<tr>
<td>1b standard</td>
<td>24 000</td>
<td>34 000</td>
</tr>
<tr>
<td>2a roll-coupled</td>
<td>21 000</td>
<td>31 000</td>
</tr>
<tr>
<td>2b roll-coupled</td>
<td>24 000</td>
<td>34 000</td>
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</tbody>
</table>
Stability Testing - Pony Trailer

Trailer Load = 24,000 kg
Truck fixed to Table

Equivalent Lateral Acceleration @ trailer (g)
Stability Testing - Pony Trailer

Roll coupling enables increased load (24 000 kg) to be carried without sacrificing stability.
Stability Testing - Pony Trailer

Roll coupling reduces roll unit LTR

Roll unit LTR @ 0.3 g trailer lateral acceleration
Configuration Stability Testing - Conclusions

- Roll-coupling demonstrated improved stability for truck/pony trailer
- A roll-coupled pony trailer with 24 000 kg load showed improved stability relative to a non-roll coupled unit with 21 000 kg trailer load
- Supplementary testing required to complete testing for truck/full trailer
Next Steps - Pony Trailer

• Recommend full axle weight allowances for “roll-coupled” pony trailers
• Roll-coupled hitch requirements (and certification):
  – Minimum roll torque capacity of 60 kN-m
  – Minimum roll stiffness of 4 kN-m per degree
Next Steps - Full Trailer

- Supplementary Tilt Table tests
- Completion of in-service evaluation
- Dynamic testing
Questions?