Integration into new design method, and consideration of pavement vehicle interaction, freight damage and logistics

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Topics

• Consideration of
  – Vehicle-Pavement Interaction (V-PI)
  – Freight damage
  – Freight logistics

• Design methods
  – Integration of LCA aspects
  – SA National Roads Agency Limited (SANRAL) implementation
V-PI Consideration

• Importance of V-PI in road condition established
• Various studies over many years – also at this conference
• Recent pilot study by Caltrans to evaluate possibilities of incorporation in various economic transportation models
Field Work Setting

Central Valley Region
• Mainly Agriculture – produces 1/2 of all fresh produce for US
• Unprecedented population growth fuels consumer demand, population 3.6 million
• Increases in warehousing & distribution; relocating from the Bay Area

Bay Area Region
• >37% of econ activity: manufacturing, freight transp/warehousing/distrib
• Approx $6.6 billion per year spent on freight transport services
• Trans-Pacific - Oakland over LA/Long Beach for destinations farther east
• 7.1 million people; 2.1 million jobs
V-PI Field Work

• Actual V-PI data collected
• Volunteer private firms
  – Anonymized
    – Agriculture transport and processing, “Company A”
    – Less Than Truckload (LTL), “Company B”

• US Interstate and rural routes
V-PI Maps

Roughness

Tire loads; Emissions;
Vertical acceleration; Fuel consumption

Tire wear

Repair and maintenance

Very Good

Good

Average

Poor
V-PI Environmental Links

• Various sources for relationships
  – Environmental emissions
  – Need for localized models – LCA (UC Davis)

• Linkages to economic models
  – Speed related effects
Freight Damage - Tomatoes

• Determine potential damage to tomatoes due to road conditions
• Based on measured data
• Acceleration analysis from field measurements
• Determine frequency bands of interest for different routes and locations
Freight Damage – Sensors

• Acceleration sensors (field and laboratory)
  – Measures accelerations
  – Same sensors used on trucks

• Pressure mats (laboratory)
  – Measures contact $\sigma$
  – In-between layers of tomatoes

• Video (laboratory)
  – Keeps track of changes and progress
Test Methodology – Analysis

• Analyse
  – Measured accelerations
  – $\sigma/\varepsilon$ relationship for tomatoes
  – $\sigma$ data
  – Stress-ratio calcs to determine damage / failure
Freight Damage – Lab Results

- Tomato damage and failure defined
- Typical contact $\sigma$ measurements
- Cumulative contact $\sigma$ distribution
  – 5 major freq.’s from field work (trucks)
Linking Freight Damage to VPI

- % of tomatoes at 95\textsuperscript{th} % of damage or 95% of failure stress for different roads
  - 1 location on truck
- Output agrees with field experience
- Current limitations (pilot study)
  - Tomato types, ripeness, speed, trip duration
Freight Damage Conclusions

• Can measure contact $\sigma$ in laboratory model
• Can calculate actual contact $\sigma$ as % of damage / failure $\sigma$
• Data appears representative of damage/failed % in practice (per private firm)
• May be utilized as performance measurement rating for pavement / freight system
  – Linked to maps for routes and commodities in specific area
• Follow-up studies, expanding the pilot study are needed
V-PI Conclusions

• Road roughness data + appropriate models and relationships = **evaluate economic effect of road use** (VOCs, potential vehicle and freight damage) – **Road users and owners**

• Use relationships (road roughness + various parameters) - select optimal routes where VOCs / damage are minimized – **Road users**

• Evaluate effect of different levels of construction and maintenance quality control on infrastructure condition + general transportation costs / infrastructure deterioration rates as affected by road roughness – **Road owners**
Freight Logistics Consideration

• Damaged freight results in direct and indirect losses in potential revenue through effects on logistical operations

• Potential freight damage savings accrued by road improvement must be given as input into Cal-B/C model

• Potential links to LCA
  – Effect of freight logistics costs on LCA use phase evaluations
Why Logistics Matters in Calif.

• Drivers of freight growth: Increasing ...
  Consumption (due to Population + Econ growth)
  Manufacturing output
  Inventory-pull (just-in-time) systems
  International trade

• Focused action required for California to handle forecasted freight volumes

• Concern for business AND government
  Manufacturing, Distribution, 3rd Party Logistics
  ALL levels of government (fed, state, region, local)
Freight Flow Within and Through California

- Foreign Countries
  - Kilo Tonne: 51,622
  - Domestic Truck %: 54%

- Within California
  - Kilo Tonne: 32,863
  - Domestic Truck %: 31%

- Rest of USA
  - Kilo Tonne: 1,004,527
  - Truck %: 85%

- Canada
  - Kilo Tonne: 1,567
  - Domestic Truck %: 81%

- Rest of World
  - Kilo Tonne: 80,517
  - Domestic Truck %: 42%

- Mexico
  - Kilo Tonne: 6,886
  - Domestic Truck %: 87%

- Rest of USA
  - Kilo Tonne: 1,213,333
  - Domestic Truck %: 78%

- Canada
  - Kilo Tonne: 4,115
  - Domestic Truck %: 32%

- Mexico
  - Kilo Tonne: 7,902
  - Domestic Truck %: 79%
Integration of LCA into SANRAL Design Method

• SANRAL updated Road Design Method
• Concept and objective
• Components
• LCA integration
• Beta version coming soon
• Workshop at TRB 2015
Acknowledgements

Company “A”

Caltrans Div. of Transportation Planning

Company “B”

SANRAL

Nat’l Research Foundation of South Africa

FHWA

Thank you! Questions?