WARRIP

WESTERN AUSTRALIAN ROAD RESEARCH & INNOVATION PROGRAM

WARRIP 2023-007: Dynamic Load Testing

Project Presentation

NTRO Project Team

Kenneth Lewis
Senior Professional Leader
Asset Performance
Project Leader

Anthony Germanchev
Principal Professional Leader
Asset Performance
Quality Manager

Overview

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- Background
- Project Scope and Objective
- Targeted Review
- About AutoSIM
- Review of Potential Sites
- Next Steps

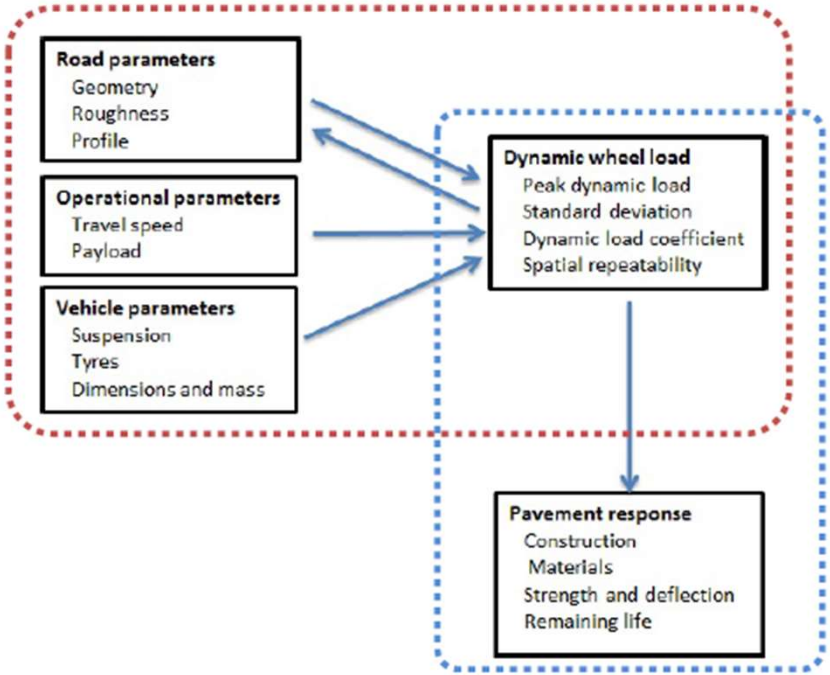
Background

- Heavy vehicles are vital to the economic prosperity, supporting industries such as mining and agriculture.
  - Road freight travels long distances
  - Mass limits from access framework is crucial for maximizing safety and productivity while reducing pavement wear.
  - Pavement wear is directly influenced by the vertical loads imparted on the road by heavy vehicles
  - Wheel loads are known to fluctuate due to factors such as road surface irregularities, vehicle speed, suspension system characteristics, and load distribution.
  - Fluctuation in wheel loads often exceed static loads.
- Impact of dynamic loading has been investigated previously
  - Most comprehensive research undertaken in the 1990s
  - Magnitude of dynamic loads and resultant pavement wear remains largely unknown

Project Scope and Objective

- **SCOPE**
  - Develop an experimental design to allow for the better understanding of dynamic axle loads and the resulting pavement wear.
- **Out of Scope**
  - Pavement damage caused by dynamic loads
  - Pore water pressure accumulation due to cyclic loading
  - Viscoelastic behaviour of asphalt pavements
  - Horizontal/shear forces on pavement surfacing damage
  - Tyre contact area and pressure
- **Objective**
  - Identify the requirements for the testing and modelling of dynamic loads applied to the pavement by restricted access vehicles.

Targeted Review

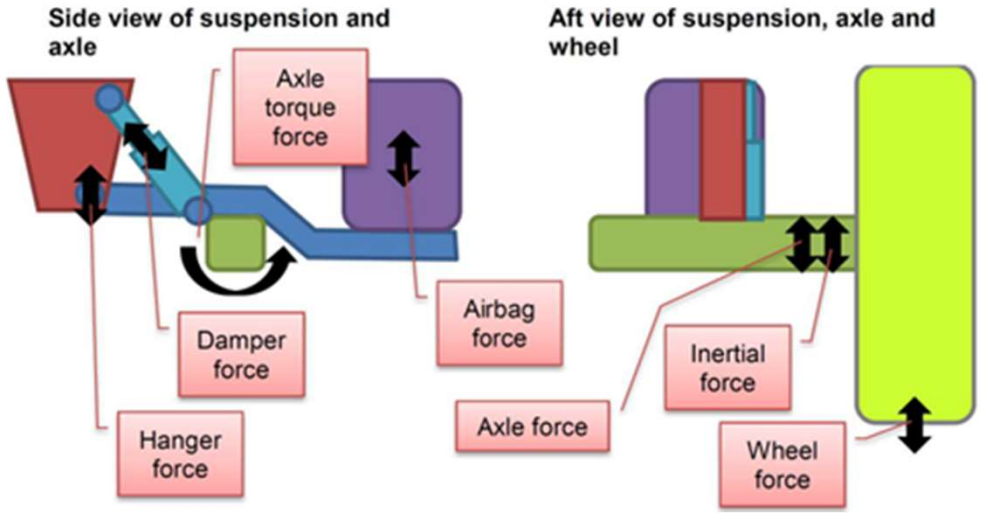


Source: Analysing dynamic wheel loading and its effects on the network (Austroads 2015).

- **Dynamic wheel loads are influenced by a number of parameters, which interact in complex ways.**
- **Vehicle components which influence load transfer to pavement (Austroads 2015):**
  - ↑ speed = ↑ dynamic force
  - ↓ suspension stiffness = ↓ dynamic force
  - Triaxle suspension < tandem axle suspensions
  - ↑ static axle load = ↑ dynamic load
  - ↓ tyre pressures = ↓ dynamic loads
  - Wide base tyres slightly lower than tandem tyres

Targeted Review

- Sensors
  - Strain gauge and accelerometer account for axle and inertial forces.
  - Comparable but less accurate results using airbag sensors, accelerometer and displacement transducer.
  - Load cells are more robust and reliable.
- Dynamic load modelling
  - Mathematical relationship between roughness and dynamic load is poor and not robust.
  - AutoSIM can be used to predict horizontal and vertical load, but not validated for dynamic vertical load.



Source: Measurement and Analysis of Dynamic Wheel Loads (Austroads 2012).

About AutoSIM

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- **Originally developed by the University of Michigan Transportation Research Institute and further refined by ARRB**
- **Widely used by ARRB for evaluating heavy vehicles performance for regulatory and safety purposes**
- **Can predict horizontal and vertical loads generated by heavy vehicles**
- **Previous work focused on horizontal loads exerted by innovative combinations**
- **Vertical loading considered in AutoSIM but not validated or reviewed in detail**
- **Limitations**
  - Calibration and validation using real world data ensures accuracy and reliability
  - Does not consider all situations (e.g. run-out)

About AutoSIM

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Vehicle configuration and dimensions

Mass
- Sprung
- Unsprung
- Static axle load

Inertia
- Sprung
- Unsprung

Centre of Gravity
- Sprung
- Axle

Suspension
- Spring vertical stiffness
- Auxiliary roll stiffness
- Damping coefficient
- Spring lateral position along axle
- Roll centre height

Axle
- Configuration (single, tandem, tri)

Tyres
- Tyre configuration
- Vertical stiffness

Couplings

Steering

Road
- Road profile
- Road geometry

Operational
- Travel speed

Review of Potential Sites

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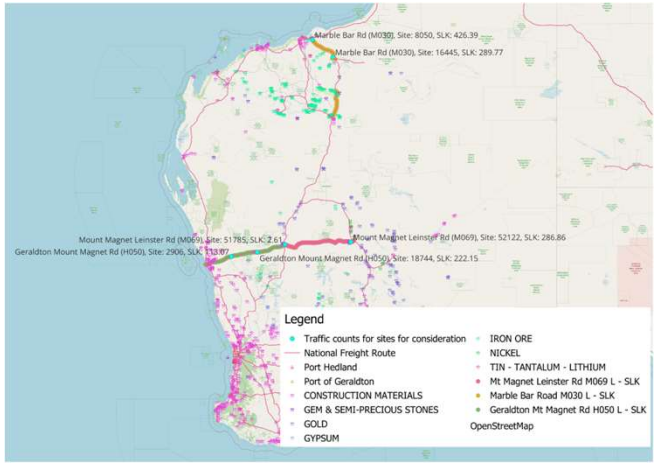
- **Road Train activity**
  - Ensures pavement wear is primarily attributed to large, heavy vehicles.
  - A consistent vehicle configuration is expected to enhance the reliability of the data for analysis.
- **Traffic volume**
  - sufficient heavy vehicle activity to cause measurable pavement wear.
- **Directionality of load**
  - Laden in one direction and unladen in the opposite direction.

Review of Potential Sites

- **MRWA Roads**
  - Marble Bar Rd
    - vital for ship to port for several iron ore mining operations.
  - Geraldton Mount Magnet Rd
    - vital east-west corridor connecting the coastal city of Geraldton to the inland mining town of Mount Magnet.
  - Mount Magnet Leinster Rd
    - a significant regional route connecting the towns of Mount Magnet and Leinster, frequented by heavy vehicles servicing the nickel mine.



- **Some additional sites were identified, but were excluded due to the following reasons:**
  - Ripon Hills Road: high % RAV, low AADT.
  - Great Northern Highway: high % RAV, high AADT, low pavement wear.
- **Advantages**
  - Have historical road survey data
  - Have historical traffic data
- **Disadvantages**
  - Dependent on identification and assistance of commercial operators using road
  - Minimal difference identified for rutting in each direction
  - Road damaged by different configuration and types
  - Road repaired as required

Review of Potential Sites

- **Private haul road**
  - NTRO currently monitoring a suitable recently built site
  - Other suitable sites may be utilised with permission from operator or through contacts from industry and technology providers.
    - This may change the advantages and disadvantages

- **The advantages and disadvantages based on site reviewed by NTRO**
- **Advantages**
  - Road condition will be monitored frequently
  - Starting with a newly built road
  - Vehicles have OBM
- **Disadvantages**
  - Permission will need to be sought
  - May take an extended period of time for road to deteriorate
  - Vehicles operating are wider and with higher loads than normally access road.
  - Installation of sensors will put vehicle out of commission for a shift.

Review of Potential Sites

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- **Accelerated Load Facility**

- **Advantages**
  - Allow for greater control of testing
  - Can develop scenarios to allow for sensitivity
- **Disadvantages**
  - Dependent on availability of site
  - Suspension not same as in vehicles
  - Operates at a speed of 20 km/h

Next Steps and Future Work

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- **Equipment**
  - Load cell
  - Accelerometer
  - GPS receiver/telematics
    - Speed
    - Position
  - On-board Mass Monitoring
  - Tyre pressure monitoring system
  - Capture frequency of 100 Hz
  - At least 1 week data capture

Next Steps and Future Work

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- **Potential challenges**
  - No discernible differences between laden and unladen wear for MRWA sites
    - Review pavement history, design and management to identify if proxy measures can be developed
  - Different parameters influence the loading
    - Test and ensure dynamic loads and wear on one vehicle can accurately be predicted
    - Test different parameters to enable confidence in predicting different vehicles

Next Steps and Future Work

- **Next Steps**

1. Confirm sites based on merit
2. Seek support from relevant mines and/or HV operators
3. Instrument RAV(s)
4. Measure the dynamic load along road link in laden and unladen direction
5. Calibrate and validate AutoSIM from field data
6. Predict laden and unladen dynamic loads.
7. Evaluate whether ESAs of RAV wear is correlated with current pavement condition

- **Considerations which will influence future work include:**
  - Need to understand the suitability for a broad range of vehicles, suspension, loading conditions, etc.
  - Suggest starting with one vehicle to confirm suitability of model and test correlation of wear.