The Impact of Overloaded Heavy Vehicles

Submitted by: Australian Road Research Board
The impact of overloaded heavy vehicles
The demanding freight task
Working together to deliver freight

Freight task

Vehicles

Roads
Matching the vehicle to the road

Freight task

Measure

Classify

Vehicles + Roads

Classify

Measure

Road Access
EU vs US vs AUS

Europe

USA

Australia
Road levels in Australia

Vehicle performance

Best

Level 1

Level 2

Level 3

Level 4

Worst

Least

Access to the road network

Most
Road levels in Australia

• The road network is assessed for each Level 1, 2, 3 & 4.

  • L1
  • L2
  • L3
  • L4
Increasing mass and length

Vehicle performance

Level 1
- > 19 m > 42.5 t
- > 20 m > 50.0 t

Level 2
- > 26 m > 68.0 t
- > 30 m > 85.0 t

Level 3
- > 36.5 m > 80 t
- > 42 m > 110 t

Level 4
- > 53.5 m > 110 t
- > 60 m > 150 t

Access to the road network

Least

Most
Level 1 vehicle (unrestricted access)

Rigid truck
Length: 12.5 m
Gross mass: 23 tonnes

16.5 t
6.5 t
Level 1 vehicle (unrestricted access)

Payload: Building materials
Length: 19.0 m
Gross mass: 48.5 tonnes
Level 2 vehicle (major highways)

Payload: Grain
Length: 23 m
Gross mass: 63 tonnes
Level 2 vehicle (major highways – port precinct)

Load: Containers
Length: 30.0 m
Gross mass: 77.5 tonnes
Access: Level 2

27.0 t  27.0 t  17.0 t  6.5 t
Level 2 vehicle (major highways – cotton harvest)

Load: Containers
Length: 30.0 m
Gross mass: 79.5 tonnes
Access: Level 2
Level 4 vehicle (remote areas)

- **Load:** Mineral sands
- **Length:** 37.5 m
- **Gross mass:** 130 tonnes
- **Access:** Level 4
Level 4 - Quad road train

Load: General freight
Length: 53.5 m
Gross mass: 130 tonnes
Access: Level 4
Level 3 – AAB Quad road train

**Load:** Sulphuric Acid

**Length:** 53.5 m

**Gross mass:** 160 tonnes

**Access:** Level 4
Axle group limits
Vertical loading of pavement

6.5 t

ESA = 5.4 t
### ESA method – standard axles

<table>
<thead>
<tr>
<th>Axle</th>
<th>Axle type</th>
<th>Reference load (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="I" /></td>
<td>Single axle (single tyres)</td>
<td>5.40</td>
</tr>
<tr>
<td><img src="image2" alt="I" /></td>
<td>Single axle (dual tyres or super singles)</td>
<td>8.20</td>
</tr>
<tr>
<td><img src="image3" alt="II" /></td>
<td>Tandem axle (single tyres)</td>
<td>9.18</td>
</tr>
<tr>
<td><img src="image4" alt="II" /></td>
<td>Tandem axle (dual tyres or super singles)</td>
<td>13.80</td>
</tr>
<tr>
<td><img src="image5" alt="III" /></td>
<td>Triaxle (dual tyres or super singles)</td>
<td>18.50</td>
</tr>
<tr>
<td><img src="image6" alt="III" /></td>
<td>Quad axle (dual tyres or super singles)</td>
<td>22.50</td>
</tr>
</tbody>
</table>
ESA calculation method

Steer axle ESA = \( \left( \frac{5.4}{5.4} \right)^4 = 1 \)

Drive axle ESA = \( \left( \frac{13.8}{13.8} \right)^4 = 1 \)

Triaxle ESA = \( \left( \frac{18.5}{18.5} \right)^4 = 1 \)

Steer axle ESA = \( \left( \frac{6.0}{5.4} \right)^4 = 1.52 \)

Drive axle ESA = \( \left( \frac{16.5}{13.8} \right)^4 = 2.04 \)

Triaxle ESA = \( \left( \frac{20.0}{18.5} \right)^4 = 1.36 \)
Conventional Australian heavy vehicles

6.0  16.5  20.0

3.0  2.06  1.11 tonnes per tyre
Conventional Australian heavy vehicles

- 6.5 m
- 16.5 m
- 20.0 m

Each diagram illustrates a different configuration of the conventional Australian heavy vehicles, showing the length of each section in meters.
Conventional Australian heavy vehicles
Conventional Australian heavy vehicles

16 axles

13.5 axles

12 axles
## Conventional Australian heavy vehicles

<table>
<thead>
<tr>
<th>6.5</th>
<th>16.5</th>
<th>20.0</th>
<th>16.5</th>
<th>20.0</th>
<th>16.5</th>
<th>20.0</th>
<th>16.5</th>
<th>20.0</th>
</tr>
</thead>
</table>

![Diagram showing conventional Australian heavy vehicles](image-url)
Impacts on bridges – shear force

Impacts on bridges – bending moment

Close proximity of axle groups increases bending on span

Methods – Bridge formula

Access to the PBS Level 1 road network

\[ M = 3L + 12.5 \] for \( M \leq 42.5 \) t; and
\[ M = L + 32.5 \] for \( M \geq 42.5 \) t

Access to the PBS Level 2 road network

\[ M = 3L + 12.5 \] for \( M \leq 46.5 \) t; and
\[ M = 1.5L + 29.5 \] for \( M \geq 46.5 \) t

Access to the PBS Level 3 and Level 4 road networks

\[ M = 3L + 12.5 \] for all \( M \)

Source: NTC (2007)
Bridge formula

Axles 1 to 3

Axles 1 to 6

Axles 2 to 6

Axles 4 to 9

Axles 2 to 9

Axles 1 to 9
Bridge formula check

Efficiency gain = new payload/old payload

= 50.0 t / 45.0 t

= ~10% increase
## Load calculations

<table>
<thead>
<tr>
<th>Axle group mass (t)</th>
<th>Axle group mass (t)</th>
<th>Axle group mass (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.5 t</td>
<td>16.5 t</td>
<td>20 t</td>
</tr>
<tr>
<td>2.1</td>
<td>2.06</td>
<td>1.38</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5.5 axles</td>
</tr>
<tr>
<td>7.5 t</td>
<td>20.5 t</td>
<td>25 t</td>
</tr>
<tr>
<td>3.7</td>
<td>4.9</td>
<td>3.4</td>
</tr>
<tr>
<td>7.0</td>
<td>26.0</td>
<td>3.4</td>
</tr>
</tbody>
</table>

- **Axle group mass**
  - 5.64 t
  - 12.58 t
  - 18.25 t
  - 24.5 t
  - 32.1 t

- **Load**
  - +10%: 7.0 t 18.5 t 42.0 t
  - +35%: 7.5 t 20.5 t 25 t 47.5 t
  - +50%: 7.0 t 26.0 t 42.0 t

- **Steerable**
  - 6.5 t 16.5 t 20 t 43.0 t
  - 2.1 2.06 1.38 5.5 axles
  - 7.5 t 20.5 t 25 t 53.0 t
  - 3.7 4.9 3.4 12 axles

- **Axle group mass**
  - 26.0 t
  - 42.0 t
  - 34.0 t

- **Steerable**
  - 6.7 t 24.5 t 32.1 t
## Vehicle Manufacturer ratings

<table>
<thead>
<tr>
<th>Specification</th>
<th>Vehicle 1</th>
<th>Vehicle 2</th>
<th>Vehicle 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Application</strong></td>
<td>Road train (tandem drive)</td>
<td>B-double</td>
<td>Truck and trailer</td>
</tr>
<tr>
<td><strong>Make</strong></td>
<td>Scania</td>
<td>Volvo</td>
<td>Mercedes</td>
</tr>
<tr>
<td><strong>GVM</strong></td>
<td>28,500 kg</td>
<td>27,700 kg</td>
<td>26,000 kg</td>
</tr>
<tr>
<td><strong>GCM</strong></td>
<td>130,000 kg</td>
<td>70,000 kg</td>
<td>55,000 kg</td>
</tr>
<tr>
<td><strong>Steer axle capacity</strong></td>
<td>7500 kg</td>
<td>6700 kg</td>
<td>7500 kg</td>
</tr>
<tr>
<td><strong>Suspension capacity</strong></td>
<td>7500 kg</td>
<td>6700 kg</td>
<td>7100 kg</td>
</tr>
<tr>
<td><strong>Steer tyre capacity</strong></td>
<td>8500 kg</td>
<td>7100 kg</td>
<td>7100 kg</td>
</tr>
<tr>
<td><strong>Steer rims capacity</strong></td>
<td>8500 kg</td>
<td>7300 kg</td>
<td>7300 kg</td>
</tr>
<tr>
<td><strong>Front axle assembly rated capacity</strong></td>
<td>7500 kg</td>
<td>6700 kg</td>
<td>7100 kg</td>
</tr>
</tbody>
</table>
Effect on vehicle Performance

- Engine power
- Rollover stability
- Braking power
- Vehicle Ride and Handling
- Infrastructure Standards

- Startability
- Gradeability
- Acceleration Capability
- Static Rollover Threshold
- Stopping distance
- Ride comfort
- Pavement Vertical Loading
- Pavement Horizontal Loading
- Tyre Contact Pressure Distribution
- Bridge Loading