Resilience assessment of road networks in New Zealand

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Outline

1. Natural hazards and road network performance
2. Resilience metrics
3. National state highway assessment
4. Regional road network assessment
5. Resilience mapping usage and implementation
Natural hazard events & road performance

- Frequency vs impact of natural hazards
- Significant impacts can happen in frequent events
Low frequency – high impact
Medium/high frequency – high impact
Road network performance

- Damage to roads – loss of availability
- Time required to reinstate access – outage duration
Resilience

- Ability to recover quickly and resume original service after damage
Resilience metrics

### Availability State

<table>
<thead>
<tr>
<th>Level</th>
<th>State</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Full</td>
<td>Full access except condition may require care.</td>
</tr>
<tr>
<td>2</td>
<td>Poor</td>
<td>Available for slow access, but with difficulty by normal vehicles due to partial lane blockage, erosion or deformation.</td>
</tr>
<tr>
<td>3</td>
<td>Single lane</td>
<td>Single lane access only with difficulty due to poor condition of remaining road.</td>
</tr>
<tr>
<td>4</td>
<td>Difficult</td>
<td>Road accessible single lane by only 4x4 off road vehicles.</td>
</tr>
<tr>
<td>5</td>
<td>Closed</td>
<td>Road closed and unavailable for use.</td>
</tr>
</tbody>
</table>

### Outage State

<table>
<thead>
<tr>
<th>Level</th>
<th>State</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Open</td>
<td>No closure, except for maintenance</td>
</tr>
<tr>
<td>2</td>
<td>Minor</td>
<td>Condition persists for up to 1 day</td>
</tr>
<tr>
<td>3</td>
<td>Moderate</td>
<td>Condition persists for 1 day to 3 days</td>
</tr>
<tr>
<td>4</td>
<td>Short term</td>
<td>Condition persists for 3 days to 2 weeks</td>
</tr>
<tr>
<td>5</td>
<td>Medium term</td>
<td>Condition persists for 2 weeks to 2 months</td>
</tr>
<tr>
<td>6</td>
<td>Long term</td>
<td>Condition persists for 2 months to 6 months</td>
</tr>
<tr>
<td>7</td>
<td>Very long term</td>
<td>Condition persists for greater than 6 months</td>
</tr>
</tbody>
</table>
# Resilience metrics

<table>
<thead>
<tr>
<th>Disruption</th>
<th>Open</th>
<th>&lt; 1 day</th>
<th>1-3 days</th>
<th>3 days - 2 weeks</th>
<th>2 weeks - 2 months</th>
<th>2-6 months</th>
<th>&gt;6 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Poor</td>
<td>None</td>
<td>Limited</td>
<td>Limited</td>
<td>Limited</td>
<td>Moderate</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Single Lane</td>
<td>None</td>
<td>Limited</td>
<td>Limited</td>
<td>Moderate</td>
<td>High</td>
<td>Severe</td>
<td>Extreme</td>
</tr>
<tr>
<td>Difficult</td>
<td>None</td>
<td>Limited</td>
<td>Limited</td>
<td>Moderate</td>
<td>High</td>
<td>Severe</td>
<td>Extreme</td>
</tr>
<tr>
<td>Closed</td>
<td>None</td>
<td>Limited</td>
<td>Moderate</td>
<td>High</td>
<td>Severe</td>
<td>Extreme</td>
<td>Catastrophic</td>
</tr>
</tbody>
</table>
National state highway assessment
Objectives

• Assess the resilience of the whole state highway network.
• Assess at a broad brush high level, efficiently and quickly.
• Assess resilience to large natural hazard events.
  • Large earthquake
  • Large storm / flooding
  • Tsunami
  • Volcanic eruption
• Use a consistent basis applied across the country.
Methodology

- Develop resilience metrics
- Gather national data
- Identify hazard impacts of relevance
- Characterise road corridors
- Capture into GIS & prepare resilience maps
- Assessment of key resilience issues
Road characterisation

1. Characterise road corridor into categories
   • Terrain
   • Geology
   • Hydrology
   • Hazards
   • Road environment

2. Assess type & extent of potential hazard impacts for road categories, and typical duration of repair

3. Apply metrics of availability & outage to hazard impacts

4. Assign to road categories
Resilience maps – earthquake

Disruption State
- None
- Limited
- Moderate
- High
- Severe
- Extreme
- Catastrophic
Resilience maps – tsunami

Disruption State
- None
- Limited
- Moderate
- High
- Severe
- Extreme
- Catastrophic
Resilience maps – volcanic

Disruption State
- None
- Limited
- Moderate
- High
- Severe
- Extreme
- Catastrophic
Regional road network assessments
Western Bay of Plenty – storm & earthquake

Resilience and gaps identified through regional study of local and state highway routes
Wellington - earthquake

- Resilience assessments helped drive Civil Defence and Land Transport Resilience Planning
Taranaki - storm

- Resilience studies helped identify improvements at Awakino and Mt Messenger sections
Resilience assessment implementation
Resilience assessment implementation

- Identification of key vulnerabilities
- Route prioritisation
- Identifying and prioritising resilience gaps
- Interventions to improve resilience
Identification of vulnerabilities

Earthquake Availability State
- Full
- Poor
- Single Lane
- Difficult
- Closed
Identification of vulnerabilities

Earthquake Outage State
- Open (no closure)
- Minor (up to 1 day)
- Moderate (1 day to 3 days)
- Short term (3 days to 2 weeks)
- Medium term (2 weeks to 2 months)
- Long term (2 months to 6 months)
- Very long term (>6 months)
Route prioritisation & resilience gaps
Route prioritisation & resilience gaps

Wellington Land Transport Resilience Programme Business Case covers local roads and state highways
Resilience

- Ability to recover quickly and resume original service after damage

Diagram:
- Normal level of service
- Reduced level of service
- Loss of Service (Vulnerability)
- Recovery Time

Level of Service vs. Time
Improving resilience – strengthening

Strengthening of key structures to enhance resilience of key routes
Improving resilience – with safety & efficiency

SH2 Rimutaka Hill - Muldoon’s Corner – carefully chosen cut slopes and rock anchors enhance resilience
Regional network resilience assessments provided impetus to develop alternative routes.

Improving resilience – new routes

- Transmission Gully
- Petone to Grenada
Improving resilience – response planning

- Consider types & scale of potential damages
- Identify alternative routes (consider vulnerabilities)
- Identify plant, equipment & fuel requirements
- Consider other measures e.g. bailey bridges, containers
- Pre-event planning for communication/cooperation between RCAs, Kiwirail, Civil Defence etc
Summary

- Roads are vital lifelines – road availability is key
- Damage & disruption posed by hazards across the country
- Resilience mapping captured in spatial databases
- Screen and understand the resilience of the network, appreciate differences, and identify areas of concern
- Maps show sections of high vulnerability, allowing for more detailed assessment
- Maps show resilience of roads in national and regional context – vital for:
  - Understanding distribution of critical vulnerabilities
  - Emergency response planning
  - Prioritising interventions
  - Enhancing resilience
- Resilience assessments have been fundamental to enhance transport resilience