A New Zealand Perspective on Mitigating Surface Fault Displacement Hazard & Integrating Displacement Hazard Information in Community Planning

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3 Ministry for the Environment

PEER workshop, Berkeley 2009
New Zealand’s Active faults
Closer look near Wellington, NZ’s capital, including offshore active faults
Some historic and pre-historic NZ ruptures
Hope Fault 1888
Despite examples of historic surface rupture and lots of well-defined fault traces, surface fault displacement hazard in New Zealand is:

- Neither specifically addressed in the Building Code
- Nor specifically addressed in any other legislation (e.g. no Alquist-Priolo in NZ)
- Only covered in non-binding guidelines commissioned by Ministry for the Environment and issued in 2004

Remainder talk presents a case-study example that illustrates key aspects of the MfE Active Fault Guidelines
Kapiti Coast Case Study

Kapiti Coast District
population ~50,000
Scope of Study

- Identify all known active fault traces
- Accurately map as many fault traces as possible
- Provide fault data on
  - location certainty
  - activity (recurrence interval of surface rupture)
  - single-event displacement size
- Classify faults in terms of MfE Guidelines
  - Recurrence Interval Class
  - Fault Complexity
  - Fault Avoidance Zones
Ministry for the Environment Guidelines

- MfE Guidelines formulated by joint study group of
  - Geological Society of New Zealand
  - New Zealand Society for Earthquake Engineering
- Aim to assist planners with development near active faults
- Life-safety is the key driver
- Promote a risk-based approach
  - Type of proposed development (Building Importance Category)
  - Existing site usage (Greenfield vs. Developed site)
  - Fault activity (Recurrence Interval Class)
  - Location & complexity of fault rupture (Fault Avoidance Zones)
<table>
<thead>
<tr>
<th>Building Importance Category</th>
<th>Description</th>
<th>Examples</th>
</tr>
</thead>
</table>
| 1                           | **Temporary structures** with low hazard to life and other property | • Structures with a floor area of <30 m²  
• Farm buildings, fences  
• Towers in rural situations |
| 2a                          | **Timber-framed** residential construction | • Timber framed single-story dwellings |
| 2b                          | **Normal structures** and structures not in other categories | • Timber framed houses with area >300 m²  
• Multi-occupancy buildings accommodating <5000 people and <10,000 m²  
• Public assembly buildings, theatres and cinemas <1000 m² |
| 3                           | **Important structures** that may contain people in crowds or contents of high value to the community or pose risks to people in crowds | • Emergency medical and other emergency facilities not designated as critical post disaster facilities  
• Airport terminals, principal railway stations, schools  
• Structures accommodating >5000 people  
• Public assembly buildings >1000 m² |
| 4                           | **Critical structures** with special post disaster functions | • Major infrastructure facilities  
• Air traffic control installations  
• Designated civilian emergency centres, medical emergency facilities, emergency vehicle garages, fire and police stations |
## MfE Guidelines: a risk-based approach
### Recurrence Interval Class & Building Importance Categories

<table>
<thead>
<tr>
<th>Recurrence Interval Class</th>
<th>Average Recurrence Interval of Surface Rupture</th>
<th>Building Importance (BI) Category Limitations (allowable buildings)</th>
<th>Previously subdivided or developed sites</th>
<th>Greenfield sites</th>
</tr>
</thead>
</table>
| I                         | ≤2000 years                                   | BI Category 1  
Temporary structures only                                      | BI Category 1  
Temporary structures only                                      |
| II                        | >2000 years to ≤3500 years                    | BI Category 1 & 2a  
Temporary & Timber-framed residential structures only             | BI Category 1  
Temporary structures only                                      |
| III                       | >3500 years to ≤5000 years                    | BI Category 1, 2a, & 2b  
Temporary & Normal structures only                                 | BI Category 1 & 2a  
Temporary & Timber-framed residential structures only             |
| IV                        | >5000 years to ≤10,000 years                  | BI Category 1, 2a, 2b & 3  
Temporary, Normal & Important structures only                     | BI Category 1, 2a, & 2b  
Temporary & Normal structures only                                 |
| V                         | >10,000 years to ≤20,000 years                | BI Category 1, 2a, 2b & 3  
Temporary, Normal & Important structures only                     | BI Category 1, 2a, 2b & 3  
Temporary, Normal & Important structures only                     |
| VI                        | >20,000 years to ≤125,000 years               | BI Category 1, 2a, 2b, 3 & 4  
Critical structures with post-disaster requirements cannot be built across an active fault with a recurrence interval ≤20,000 years | BI Category 1, 2a, 2b, 3 & 4  
Critical structures with post-disaster requirements cannot be built across an active fault with a recurrence interval ≤20,000 years |

Note: Faults with average recurrence intervals >125,000 years are not considered active.
## Active Faults & Surface Rupture Hazard
### Kapiti Coast District

**MfE Guidelines**

**Recurrence Interval Class and Building Importance Categories**

### Previously developed sites

<table>
<thead>
<tr>
<th>Recurrence Interval Class</th>
<th>BIC 1 temporary</th>
<th>BIC 2 LTF houses</th>
<th>BIC 3 important</th>
<th>BIC 4 critical</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 2000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2000 ≤ 3500</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3500 ≤ 5000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5000 ≤ 10000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10000 ≤ 20000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 20000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥ 20000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Greenfield sites

- BIC 1 temporary
- BIC 2 LTF houses
- BIC 3 important
- BIC 4 critical
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Kapiti Coast District

MfE Guidelines
Recurrence Interval Class and Building Importance Categories

Previously developed sites

Greenfield sites

- BIC 1 temporary
- BIC 2 LTF houses
- BIC 2b normal
- BIC 3 important
- BIC 4 critical
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Kapiti Coast District

MfE Guidelines
Recurrence Interval Class and Building Importance Categories

Previously developed sites

Greenfield sites

BIC 1 temporary
BIC 2 LTF houses
BIC 2b normal
BIC 3 important
BIC 4 critical
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MfE Guidelines
Recurrence Interval Class and Building Importance Categories

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- BIC 2b normal
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Greenfield sites
Active Faults & Surface Rupture Hazard
Kapiti Coast District

MfE Guidelines
Recurrence Interval Class and Building Importance Categories

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MfE Guidelines
Recurrence Interval Class and Building Importance Categories

Previously developed sites

- 2000

\[\begin{array}{c}
\text{\textcolor{red}{BIC 1 temporary}} \\
\text{\textcolor{red!30!100}{BIC 2 LTF houses}} \\
\text{\textcolor{cyan}{BIC 2b normal}} \\
\text{\textcolor{green}{BIC 3 important}} \\
\text{\textcolor{blue}{BIC 4 critical}} \\
\end{array}\]

Greenfield sites

\[\begin{array}{c}
\text{\textcolor{red}{BIC 1 temporary}} \\
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\end{array}\]
Active Faults & Surface Rupture Hazard
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Methodology

• Identify all known active fault traces
  • authors’ first-hand knowledge of geology and faults
  • GNS & KCDC airphoto collection
  • published papers
  • unpublished GNS Science and Client reports
  • survey data from GNS clients (developers)
  • drillhole data
  • KCDC District Plan
Methodology

- Accurately map fault traces and related structures
  - two sources of error
    - location on ground (age and site)
    - capture error (airphoto, orthophoto, RTK GPS)

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Methodology

- Classifying Fault Complexity (a function of hazard & risk)
  - Well defined
  - Distributed
  - Uncertain
    - Constrained
    - Poorly constrained
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Methodology

- Defining Fault Avoidance Zones
  - faults are often a zone of deformation
  - uncertainty of location included
  - buffered 20 m as suggested in MfE guidelines
Methodology

- Defining fault activity, and assigning Recurrence Interval Class
- Based on existing data only

<table>
<thead>
<tr>
<th>Fault Name</th>
<th>Recurrence Interval Class</th>
<th>Recurrence Interval Range of Recurrence Interval Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ohariu fault</td>
<td>RI Class II</td>
<td>&gt;2000 years to ≤3500 years</td>
</tr>
<tr>
<td>Northern Ohariu fault</td>
<td>RI Class II</td>
<td>&gt;2000 years to ≤3500 years</td>
</tr>
<tr>
<td>Otaki Forks fault</td>
<td>RI Class III</td>
<td>&gt;3500 years to ≤5000 years</td>
</tr>
<tr>
<td>Gibbs fault</td>
<td>RI Class III</td>
<td>&gt;3500 years to ≤5000 years</td>
</tr>
<tr>
<td>SE Reikorangi fault</td>
<td>RI Class IV</td>
<td>&gt;5000 years to ≤10,000 years</td>
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Ohariu fault

- mapped in detail
- recurrence interval known
  - Best estimate: 2200 years
  - Uncertainty: 1300 to 3800 years
- Recurrence Interval Class II
- single event displacement known
  - expected to be between 3 and 5 metres
- expected earthquake magnitude 7.5
## OHARIU FAULT (RIC II: 2000 - 3500 years)

### Developed and/or Already Subdivided Sites

<table>
<thead>
<tr>
<th>Building Importance Category</th>
<th>1</th>
<th>2a</th>
<th>2b</th>
<th>3</th>
<th>4</th>
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<tr>
<td>Fault Complexity</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Well Defined</td>
<td>Permitted</td>
<td>Permitted</td>
<td>Non-Complying</td>
<td>Non-Complying</td>
<td>Prohibited</td>
</tr>
<tr>
<td>Distributed, &amp; Uncertain - constrained</td>
<td>Permitted</td>
<td>Permitted</td>
<td>Discretionary</td>
<td>Non-Complying</td>
<td>Non-Complying</td>
</tr>
<tr>
<td>Uncertain - poorly constrained</td>
<td>Permitted</td>
<td>Permitted</td>
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### Greenfield Sites

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<th>Building Importance Category</th>
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Mitigation of Surface Rupture Hazard in New Zealand

Conclusions

- Classify active faults in terms of MfE Guidelines
  - Recurrence Interval Class
  - Fault Complexity
  - Fault Avoidance Zones

- Define Resource Consent Categories for Fault Avoidance Zones
  - Type of proposed development (Building Importance Category)
  - Existing site usage (Greenfield vs. Developed site)
  - Fault activity (Recurrence Interval Class)
  - Location and complexity of fault rupture (Fault Avoidance Zones)
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Kapiti Coast District

Conclusions