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NZ Centre for Earthquake Resilience

Industry Perspective

Input Ground Motions for Seismic Response Analysis

UC University of Canterbury
The University of Auckland New Zealand
Resilient Organisations
GNS Science
Massey University
Te Whare Wānanga o te Upoko o te Ika a Māui Victoria University of Wellington
The University of Waikato Te Whare Wānanga o Waikato
BRANZ

The Industry Perspective

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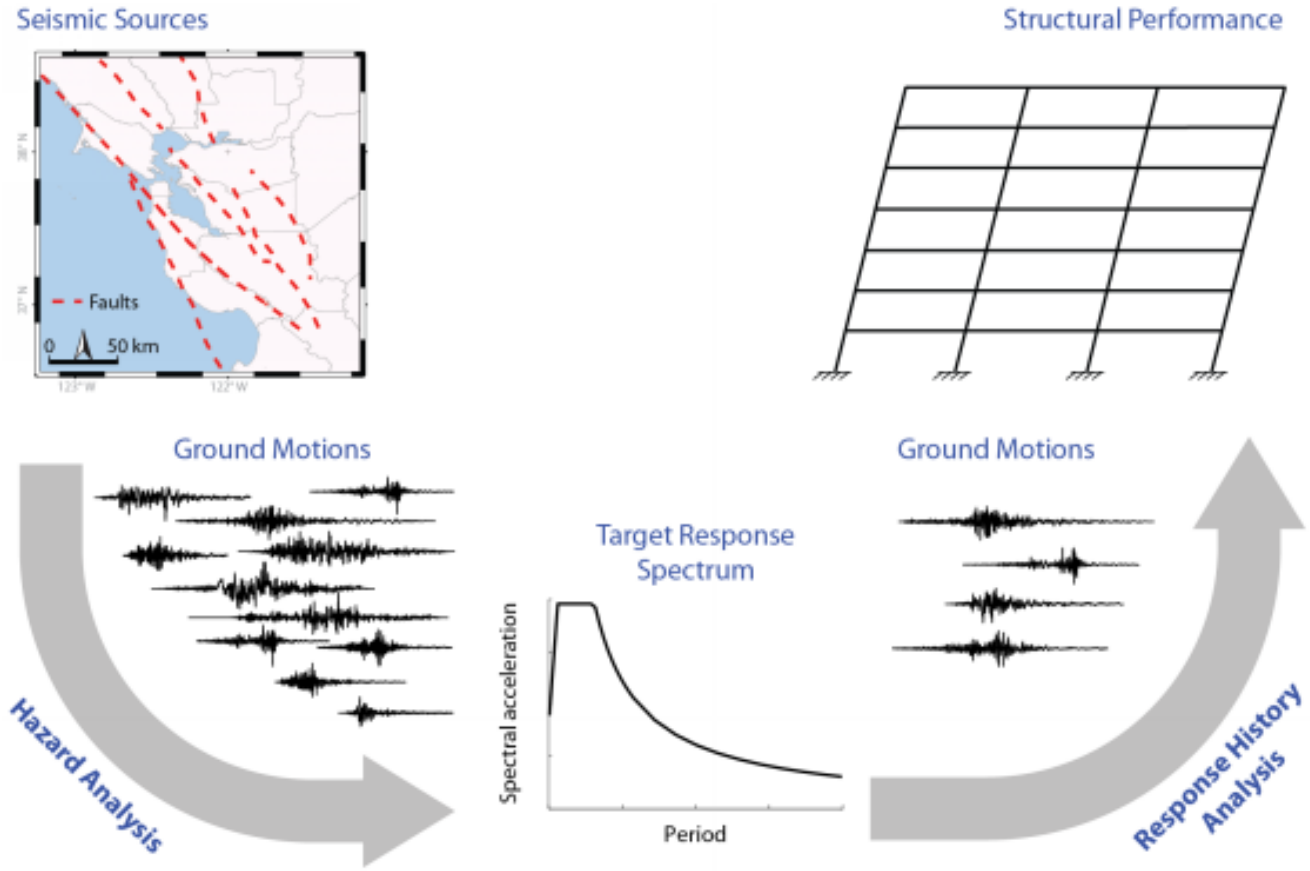


To touch on…

Problems encountered using recorded ground motions

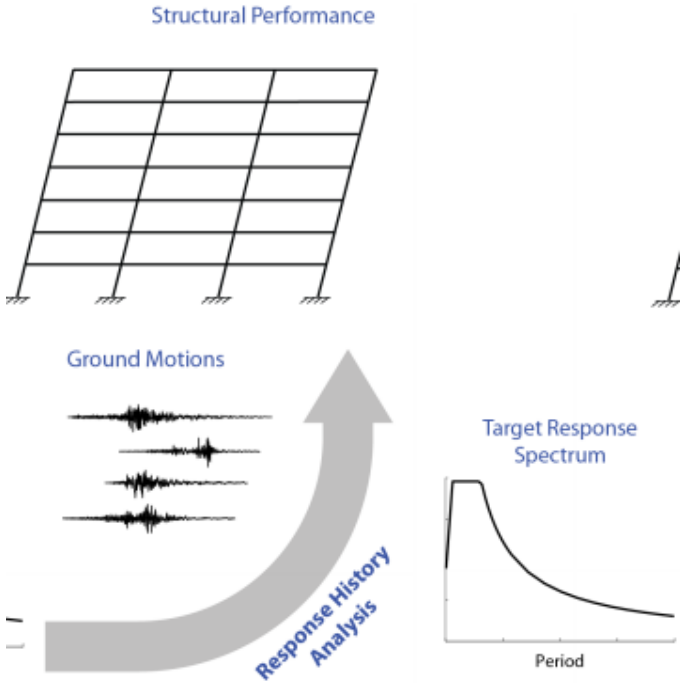
Problems we would fore-see using simulated ground motions

Potential benefits from using simulated motions

Appropriateness

Using simulations to define hazard

Using simulated motions to supplement existing databases



Current hurdles…

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Structural Engineering Perspective:

- Difficulties in compiling a suite of records from existing ground motions if we accept/follow typical constraints
  - Earthquake characteristics
  - Site characteristics
  - Quality of the content, particularly at lower frequencies with older records
  - Reviewing that the processing is consistent
- Satisfying NZS 1170.5 scaling constraints
- For non-linear time history analyses the move from three to seven records can be a challenge to find enough records that meet the above aspects
  - Currently one of the biggest challenges if NZS 1170.5 was to shift from envelope from three, to average of seven+.

Current hurdles…

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Geotechnical Engineering Perspective:

- Lack of experience in industry means lack of judgement.
  - Industry is changing quickly. There is no consensus on how to get the best fitting empirical time histories.
- Geotechnical engineers should be taking their understanding of non-linear behavior (e.g. liquefaction) and applying it to ground motions.
- Structural engineers, geotechnical engineers, geologists and seismologists need to work together to develop ground motions.
  - In typical practice, these professions still work independently.
- To select the right time histories for a project, we need to identify the right fault rupture scenario(s). Do we have the geological knowledge to select and parametrize these scenarios?
  - E.g. How many realistic scenarios are required to capture the Alpine fault earthquake?
- Unwillingness of clients to fund proper investigation and analysis.
  - Difficult to demonstrate the financial benefit of these works. Especially in a market where many practitioners (competitors) don't push to use new alternative methods.

Current hurdles…

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Perceived difficulties in using simulated ground motions:

- Perspective of presenting a design to a territorial authority and getting acceptance
  - How to get industry/authority confidence such that a structural design/verification can be based on simulated GMs?
- Understanding the means to generating – it perceived as a complex and specialized mathematical process
  - Therefore automatic reaction of "*can't understand*"
- Demonstrating that they have come from a satisfactory methodology i.e. captures physics and geological conditions at large and local scales
- The usable frequency range needs to be appropriate
- Providing one, two or three components?
- Demonstration of their appropriateness for use…is this close to reality?

A Benchmark for Reference

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For end-users of the GMs the intent of the guideline is not to leave consultants taking on more risk

- Don't have to review the simulation method or that the answer is correct
- Provide a reference for checking that the simulation method and inputs satisfy some consistent checkpoints
- Consultants use the document to confirm that the research results meet a consistent standard of documentation/verification
  - Guideline essentially acts like a performance specification
  - Similar to requirements for a device which will have prototype testing – the consultant would review the supplier design & test results against the specification to ensure the units meet the performance requirements
- Future research producing simulated GMs is put forward with consistency and transparency
  - If future revisions of NZS 1170.5 incorporate simulated GMs then that guidance draws on a consistent conglomerate of work

A Benchmark for Reference

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- Even with a move towards simulated GM usage, there are still issues associated to various consultants working independently
- Still the potential to get stuck on
  - lack of experience
  - different expertise and backgrounds (i.e. structural/geotech/seismology)
- Highlights that we still need to be fostering more interaction between the various developers and users of seismic hazard information.

The Potential Benefits

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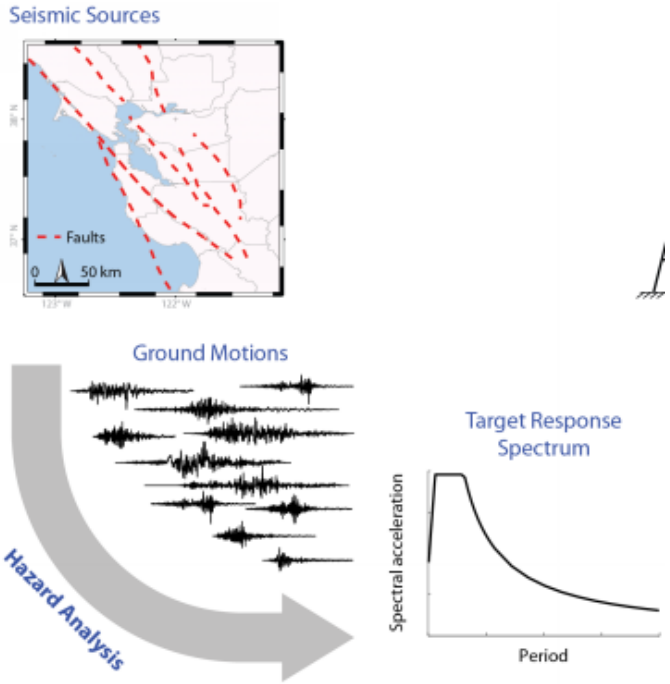
A more complete definition of seismic hazard:

- Often we are using a Code defined spectrum
  - Missing site- and region-specific features
  - Missing secondary signature information on duration and significant cycles
- Site Specific evaluations using empirical models provide little guidance on site effects
  - Simulated GMs can help provide this key information
  - Studies from Christchurch have highlighted that recorded motions deviate from empirical approaches – so we have seen that there is something missing in the empirical models
- Pick up known limitations of our current hazard definition
  - Realistic Alpine Fault scenarios



The Potential Benefits

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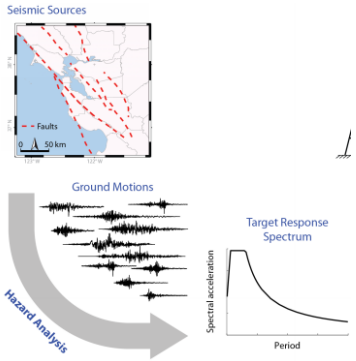
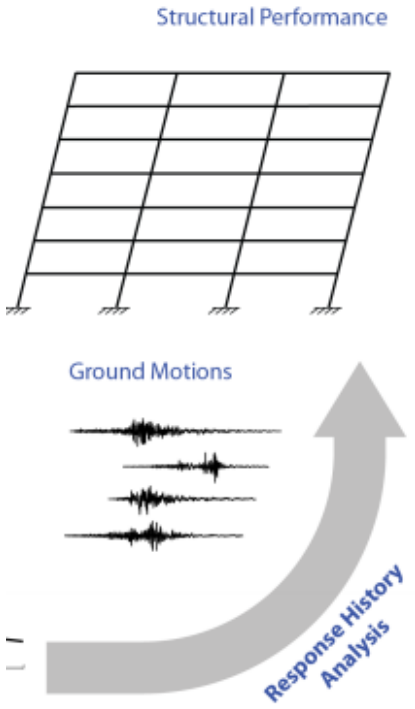
- Using simulated GMs we can review/re-develop the hazard analysis with appropriate input and output
  - Capture the site specifics
  - Retrieve information & communication on what these secondary aspects could look like
- Provide an accurate means to generating spectra that account for damping (/ductility) influences
  - Can deal with the persistence of spectrum particulars such as long period “bumps” that otherwise remain if simple reduction scaling is applied for damping above 5%
  - Inelastic spectra not often understood/used by structural engineers
- Supply of a suite of simulated GMs processed to correctly capture these changes will provide a more consistent approach to design decisions when negotiated these characteristics



Supplementing the databases

The second beneficial aspect is that the simulated GMs will augment record databases for NZ locations

- Offers a pathway to using more records for non-linear time history analysis work
- The output of the simulations will include the actual time series
  - Provides inputs for both geotechnical and structural analysis
- Can confidently capture and incorporate into a record suite
  - Duration i.e. Alpine Fault events
  - Directivity
  - Basin effects
- Currently the process of scaling records is cumbersome and difficult to satisfy for larger numbers of records



Supplementing the databases

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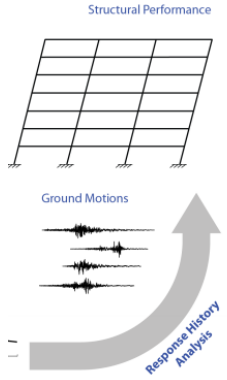
- The additional records can be beneficial if supplied and matched to the seismic hazard developed from empirical models
- If the target spectrum is based on the inclusion of simulated GMs then the scaling procedure is greatly simplified and/or removed as the GMs will inherently be within the bounds used to form the spectrum



Discussion…

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From the opening sections, what else should be considered in developing the guidelines?

- Key information that should be required *by* the guideline document?
- Disadvantages with development of simulated GMs?
- Disadvantages in application in practice?
- Other advantages from application?
- Risks if we apply them in practice?
- How/can this guideline provide an adequate pathway to deal with problems such as lack of experience?