18 August 2016,
Avalon, Lower Hutt

Research-Informed Advancements in Guidelines and Standards of Engineering Practice for Natural Hazards

- Use NHRP-supported research to address key issues in NZ standards and guidelines that require research-based resolution and advancement
- Develop a mechanism for systematic incorporation of research into engineering standards and practice.

Research Program

Objective 1: Seismic loading and performance objectives

- Standards NZ
- MBIE

NZS1170.5 Structural Design Actions

Objective 2: Geotechnical hazards and impacts on infrastructure

- MBIE
- NZGS

MBIE-NZGS Earthquake Geotechnical Engineering Practice Design Guidelines

Objective 3: Seismic assessment and improvement of existing buildings

- NZSEE
- MBIE

Assessment and Improvement of the Structural Performance of Buildings in Earthquakes (AISPBE)

Objective 4: New buildings: system-level interactions

- Standards NZ
- MBIE

- NZ Concrete Structures Standard (NZS3101)
- NZ Steel Structures Standard (NZS 3404)
- NZ Timber Structures Standard (NZS 3603)

Objective 5: Transportation infrastructure

- NZTA (Bridges)

NZTA Bridge Design Manual

Objective 6: Tsunami hazards and impacts on costal infrastructure

- NZTA

NZTA Bridge Design Manual

Obj. 1: Seismic loading & performance objectives

Topic 1: Seismic design spectra & ground motion records (PI: Brendon Bradley, UC)

- Quantify the impact of explicitly modelling near-fault effects on probabilistic seismic hazard analysis
- Develop a new methodology for the consideration of vertical ground motion design spectra in guidelines
- Develop a practice-oriented version of the latest understanding of ground motion selection for response history analysis

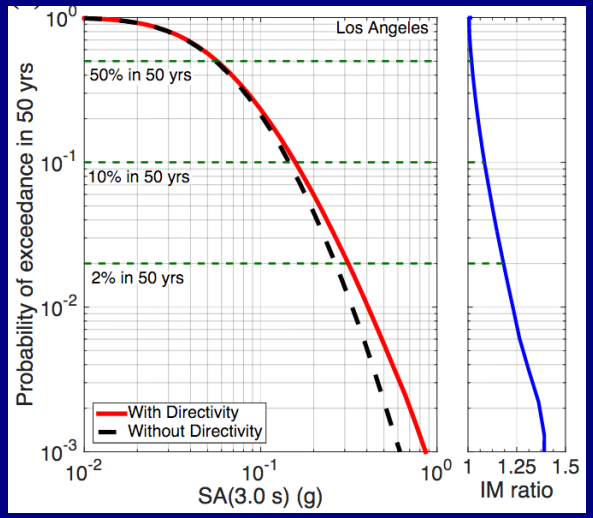
Topic 2: Natural hazard performance objectives (PI: Tim Sullivan, UC)

- Benchmark the seismic performance of new and existing structures according to NZ design standards
- Develop an improved understanding of the 'gap' between actual performance under natural hazards and societal expectations

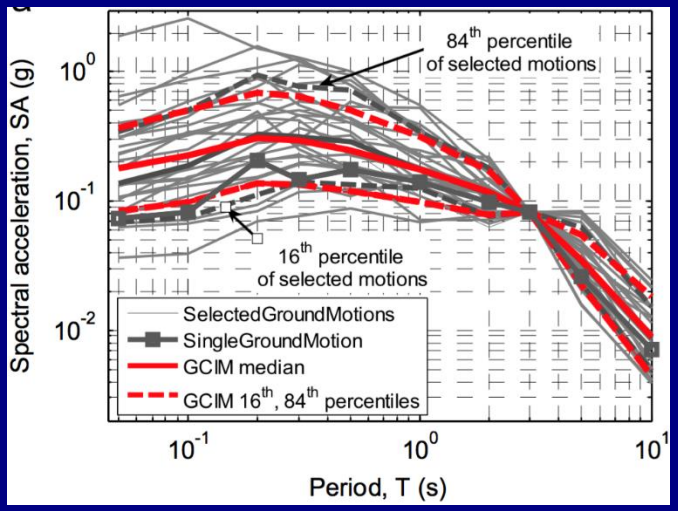
Implementation: Updates and new sections of future versions of NZS1170: New Zealand Loadings Standard

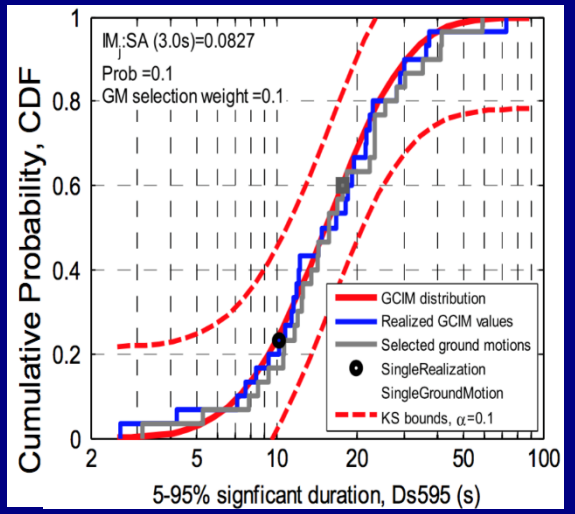
Obj. 1: Seismic loading & performance objectives

Near-fault effects on hazard

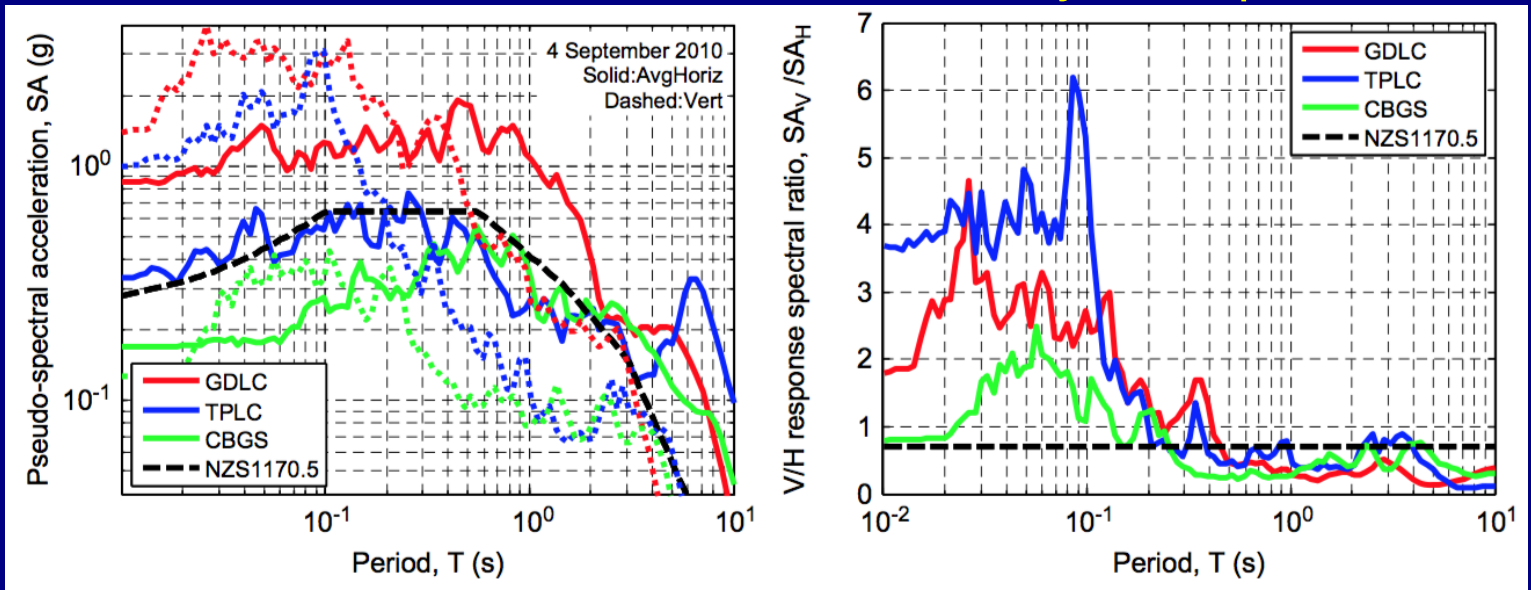


GM selection with multiple intensity measures





Vertical accelerations in the Canterbury earthquakes



Objective 2: Geotechnical Hazards

Topic 1: Liquefaction-Induced Lateral Spreading (Lead PI: Misko Cubrinovski, UC)

- Internationally recognized as one of the key issues in liquefaction assessment that requires major improvement of methodology
- Develop a step-by-step procedure for evaluation of lateral spreading using an original methodology and data from CES.

Topic 2: Geotechnical Characterization of Volcanic (Pumiceous) Soils (Lead PI: Rolando Orense, UA)

- One of the 'problematic' NZ soils; lack of guidance for geotechnical characterization and evaluation of pumiceous soils (e.g. NZTA projects)
- Develop methodology for engineering assessment of pumiceous soils based on field and laboratory tests.

Implementation: Updates and new sections of MBIE-NZGS Earthquake Geotechnical Engineering Practice Design Guidelines: Module 3 – Identification, assessment and mitigation of liquefaction hazards

Objective 3: Seismic assessment and improvement of existing buildings

Topic 1: Detailed seismic assessment (Lead PI: Jason Ingham, UA)

- Recruiting new doctoral students:
  - Advanced methods for complex URM (2)
  - Methods for stone masonry
  - Assessment of concrete buildings (2)
  - Performance based assessment

Topic 2: Residual capacity (Lead PI: Ken Elwood, UA)

- 6 out of 14 tests completed on ductile RC beam specimens
- Developing methods for post-EQ detailed assessment of damaged plastic hinges
- Aim to quantify effects of repair by epoxy injection and mortar patching

Topic 3: Seismic improvement (Lead PI: Stefano Pampanin, UC)

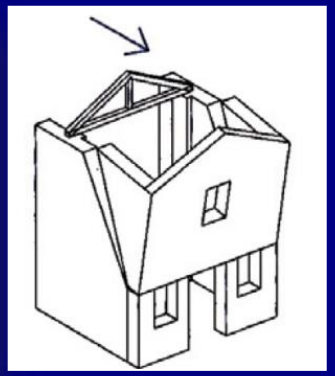
- Actual vs forecast repair cost for L'Aquila eq
- Benefit-cost analysis
- Foundation deformation and soil-structure interaction

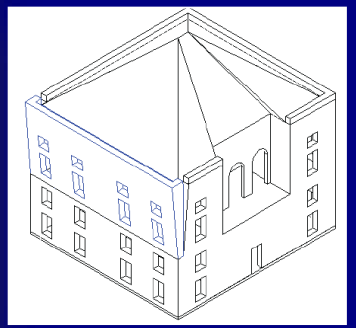
Topic 4: Protection and damping devices (Lead PI: Geoff Rodgers , UC)

- System level testing at UA
- Two devices being tested: Tension-only brace; novel design viscous damper
- Linked with Royal Society Rutherford Scholarship

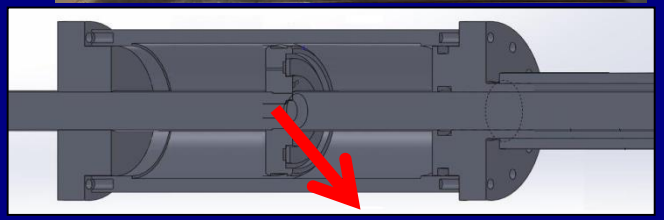
Implementation: Latest guidance documents recently released in Eq-Assess website. Current projects to inform next generation of documents

Objective 3: Seismic assessment and improvement of existing buildings





Macro-element approach for advanced assessment of URM buildings



Provide one way flow valves

Initial damage

Repair

Retesting

Objective 4: New Buildings

Overarching theme: System level issues (i.e. shift from components to buildings)

Topic 1: Concrete – NZS 3101 (Lead PI: Rick Henry, UA)

- Design of coupled-wall systems
- Interaction between walls, floor diaphragms, and frames
- Load rate (bond → member → system)

Topic 2: Steel – NZS 3404 + SCNZ (Lead PI: Greg MacRae, UC)

- Design of BRB systems
- Design of steel-concrete composite structural systems

Topic 3: Timber – NZS 3603 + BRANZ (Lead PI: Minghao Li, UC)

- Timber-steel shear wall systems
- CLT or LVL core wall systems
- Post-tensioned timber frames with chevron braces

Implementation: Updates to NZS material design standards as well as industry guidelines (e.g. SCNZ, BRANZ)

Objective 5: Transportation Infrastructure

Topic 1: Design detailing optimization and cost effectiveness of low-damage rocking precast concrete bridge piers (Lead PIs: Palermo / Scott)

- Post-earthquake repairable bridges are internationally recognised as the next generation of systems especially for high urban dense networks. Cost effective detailing and constructability still requires major improvements such that the initial costs of constructions are the similar to conventional systems.

- Refer to the last four year experimental campaign and Wigram-Magdala bridge link and develop a step-by-step procedure (supported by FEM numerical modelling) for design optimization of the bridge piers' connections. Industry workshops will also be held.

Topic 2: Performance Based Design Methods for low-damage rocking precast concrete bridges (Lead PI: Palermo / AI: John Wood)

- Performance Based Design is widely adopted in standards but no research on design methods has been conducted on bridge systems which minimize post-earthquake reparability.

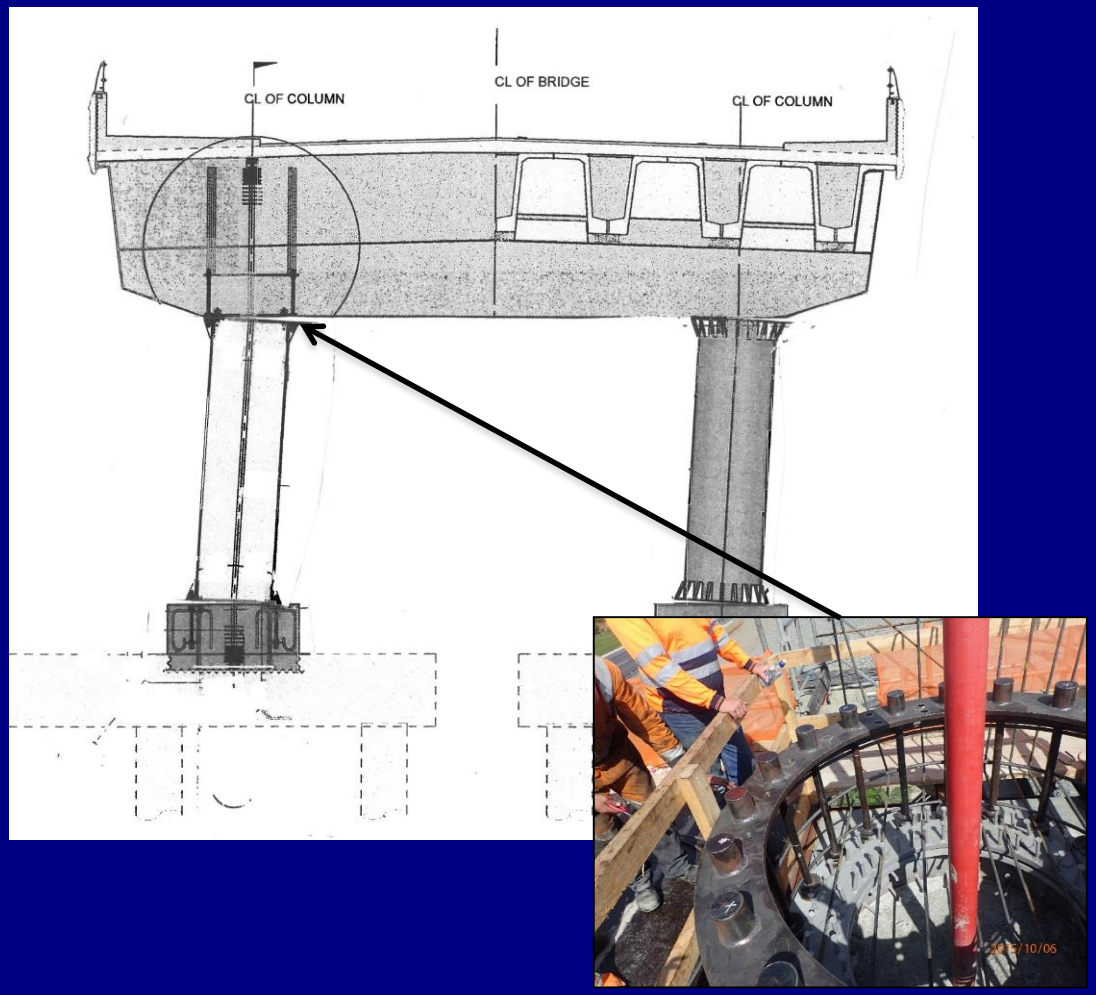
- Focused will be given to Displacement Based Design which will be introduced in the next Bridge Manual update. A step-by-step procedure for typical short-medium span New Zealand Bridges is proposed and validated throughout Non Linear Time History

Implementation: Updates and new paragraphs of Bridge Manual, section 5 with support of NZTA co-funded Design Guideline.

Objective 5: Transportation Infrastructure

First Bridge in the World: Wigram Magdala Bridge with dissipative post-tensioned rocking technology (minize post-earthquake damage)

Transverse Behaviour



Objective 6: Tsunami and Coastal Infrastructure

Topic 1: Modelling Tsunami Effects on New Zealand Port Infrastructure (Lead PI: Asaad Shamseldin, UA)

- The vast majority of wharves in New Zealand are pile supported, the most critical tsunami loads are less known.
- Development of guidelines for tsunami loading on New Zealand wharf structures and mitigation strategies for wharf design based on physical and numerical modelling.

Topic 2: Modelling Tsunami Effects on New Zealand Bridges (Lead PI: Bruce Melville, UA)

- Tsunami loading characteristics on typical New Zealand's bridges are not available.
- Development of guidelines for tsunami loading on New Zealand bridges based on physical and numerical modelling.

Objective 6: Tsunami and Coastal Infrastructure

Topic 3: Modelling Tsunami Mitigation Effects of Coastal Protection Structure (Lead PI: Bruce Melville and Nak Nandasena UA)

- New Zealand coastal protection structures are not tested against tsunami loads.
- Development of guidelines for the use of coastal protection structures in reducing tsunami loads based on physical and numerical modelling.

Topic 4: Development of Fragility Models for New Zealand Bridge and Wharf Structures (Lead PI: Liam Wotherspoon, UA)

- Initial assessment of the performance of bridges and wharves under tsunami loading is important prior to detailed assessments.
- Development of fragility models (functions) of the port infrastructure and bridges for tsunami loading from results of Topics 1-3 and other interdisciplinary research conducted.

Implementation: Recommendations to NZTA and port authorities/engineering consultants for guidelines on tsunami loading on bridges and wharves and mitigation strategies.