Implementation of Low Damage Design

Three IL3 buildings – rocking walls, slotted beams & conventional wall/frames
Rocking Walls
A Snag... Testing of Supplemental Damping Devices

- Exterior Walls
- Durability issues
- Unable to add damping elements
- Construction tolerances
Non-tearing Floors
Reinforcing Detailing

- Congestion in joints
  - very little tolerance
  - governed member sizes
- Location of bends
  - Within column to prevent bursting
- Casting of slot
Asymmetric floor loading of beams

Slotted beams have different mechanism to resist torsion

Looked at torsion induced by orthogonal drift

Pure pin gravity connection
Hysteretic Dampers

- Essentially short BRBs
- Low-cycle fatigue – calculation vs. scaled research vs. 1170.0 App B verification
- Adjustability on site
Followed ACI374 loading protocol scaled to peak drift

Failure due to inadequate embedment of core in restraining tube

Addition of a steel bush achieved approx. 15x required fatigue life
Testing of Supplemental Damping Devices

- Prototype testing of full-scale devices (or as close as practicable) is a must if similar units have not been rigorously tested previously.

- EN15129:2009 Anti-Seismic Devices (and similarly ACI 374) provides a logical and comprehensive approach to demonstrating performance.

- The articulation and kinematic behaviour often associated to LDD systems removes many of the secondary load-paths that have provided stability in ‘typical’ systems.

- It is important because devices do not necessarily scale from the lab to practice, particularly relative to end fixings which can be comparatively oversize at lab-scale and provide partial fixity at the ends.

- Trying to incorporate details to accommodate 3D deformation of a joint region can result in significantly worse behaviour!
A Snag...Testing of Supplemental Damping Devices

- The prototype testing represents:
  - Potential time delays – solved by accelerating that part of the design so that a specification for Tender can be sent-out ahead of time
  - Direct costs associated to fabrication of the prototype units and the testing
  - An opportunity to assure the client that they are getting a reliable and proven component that is fundamental to the structure performing well
  - Also furnishes key information for verification of building performance through modelling such as NLTHA often needed to demonstrate BC compliance
Reinforcing Detailing

Note that an extension of the column is required above the slab level at top floor
Other points to check with Des

Things that make the design difficult
- Construction – getting the contractor to recognise the instability of the partially built structure (particularly before installation of dampers or stressing of PT)
- Secondary effects
  - beam torsion due to asymmetric floor loading
  - axial force in the beams due to diaphragm actions but limited/reduced connection to the column
  - Design for exterior exposure both architectural and durability of damping components such as BRF, friction interfaces (life-span and construction weathering)
- Supplemental Dampers
  - Designing for low-cycle fatigue vs. completing testing of a sufficient number of samples via Appendix B NZS1170.0 to demonstrate otherwise from calculation

Things that went well
- Contractor enthusiasm for a ‘special’ project generally overcomes perceived difficulties or unusual details/methodologies...just needs a lot of communication at kick-off
  - Presenting an example sequence of construction helps