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Christchurch 2013 Post Earthquake Impact on Structural Design

Presented by
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Christchurch 22nd February 2011

Magnitude 6.3 Earthquake strikes Christchurch CBD and is a direct hit

Peak Ground Acceleration
- 1.8g Horizontal
- 2.2g Vertical

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Building Damage - Earthquake February 22nd 2011 – Christchurch

- Building stock was old and heavy and not resilient to ground shaking

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The Grand Chancellor Hotel - Big heavy and not resilient

- 1980s reinforced concrete 27 storey ductile frame building – modern capacity design damaged beyond repair

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Heavy Unreinforced Masonry

- Pre 1935 buildings don't have much chance


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Heavy Heritage

- Many strengthened heritage buildings also damaged beyond repair


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Soft storey collapse and permanent deformation

Many timber frames buildings are also destroyed from earthquake shaking


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However ….there are some survivors

A reinforced concrete castle that survived

Key design features

- No windows
- Two doors
- Its only missing a drawbridge and a moat

This is a survivor not a resilient building

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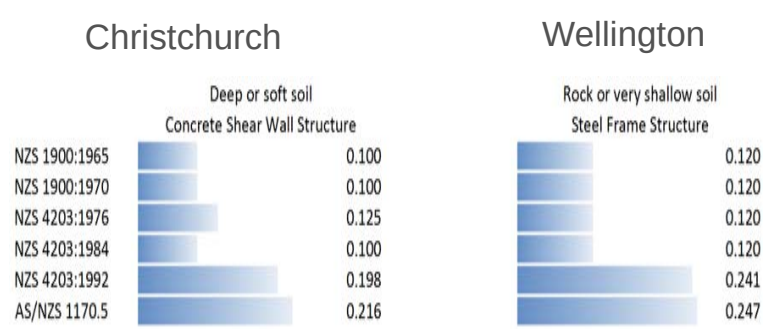
The Changing Seismic Coefficient

In the last 50 years the design loads have more than doubled



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Christchurch Seismicity Changes – The Zone Factor (Z)

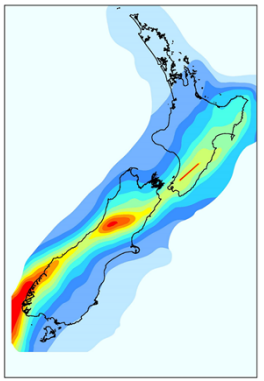
This is from the NZ design code and is effectively a map of relative seismicity across the country.

Auckland 0.13

•Wellington 0.4

• Christchurch was 0.22
now 0.3 - 37% increase in seismic loads

• Dunedin 0.13



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Emergence of Resilient Buildings

Same old same old

- **Many warehouses and 1 -2 storey commercial buildings are reverting back to same old elastic design to new load levels**

Emergence of resilient buildings - Asset protection as an owner choice

- **The boom of new technologies for building higher than 2 storey - low damage design technology takes many forms**

Focus on speed of construction

- **Move toward structural steel construction**
- **Steel sections and prefabricated steel imported from China**
- **LVL timber construction**
- **Return of the precast concrete panel**

Light weight buildings

- **Reinforced concrete and gravel raft foundations**
- **Economic and fast build foundation solutions**

600 x 600 X 20 Hollow sections made for 'The Terrace Project' awaiting export from China

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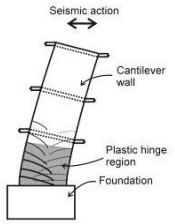
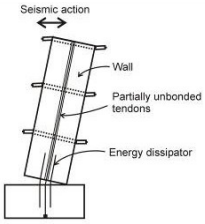
New Technology Boom – Low Damage Resilient Buildings

Ductility = Damage = Repair or Demolish





Ductile Shear Wall Verse Low Damage Rocking Shear Wall

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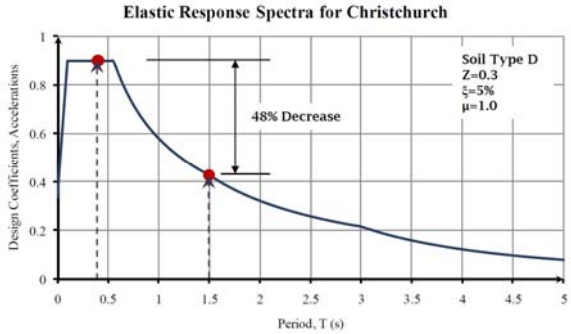
How Does It Work - A 4 Year Engineering Degree In 4 Minutes



This is how much force a building feels in an earthquake

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Low Damage Systems - All Materials Are Possible

Concrete

Timber LVL

Structural Steel

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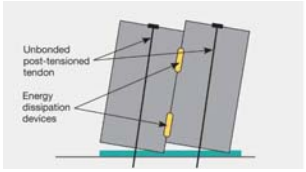
Concrete – Post Tensioned Rocking Walls

- Precast shear wall post tensioned down to foundation beam
- Shear wall can rock and return to centre under seismic loads
- Ductile shear wall damage is avoided
- Energy dissipaters absorb seismic energy and are replaceable



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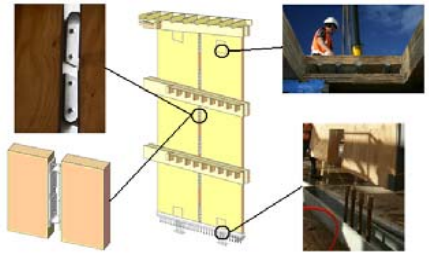
Timber – Post Tensioned Rocking Walls



- Timber shear wall post tensioned down to foundation beam
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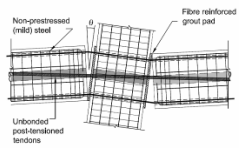
Precast Concrete or Timber – Post Tensioned Frames

- Precast concrete or Prefabricated Timber frames
- Post tensioned together to avoid damage at beam/column joints
- Frames return to centre
- Ductile frame damage to beams and columns is avoided



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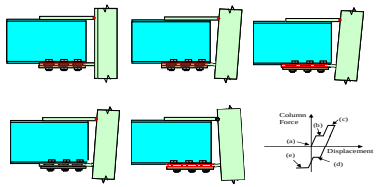
Structural Steel – Sliding Hinge Joint Frames



- Structural Steel frames with bottom flange connections that slide
- Joints slide to protect beams and columns from yielding damage
- Frames shown to 90% re-centre

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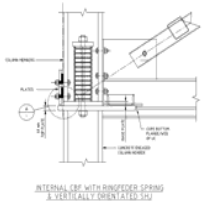
Structural Steel – Concentric K Braced Frames with Ringfedder Hold-Down Springs

- Structural Steel prefabricated frames
- Frames rock to avoid yielding damage
- Frames are returned to centre by springs at the base
- Avoids the need to post tension, keeps frames lightweight



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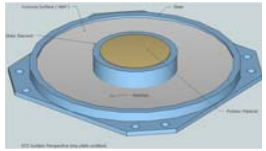
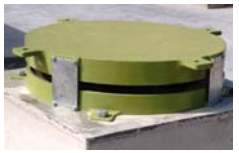
Base Isolation – Friction Pendulum and Lead Rubber Bearings



- Friction Pendulum Bearings

The building feels about
0.1g -0.2g above the isolation plane



- Lead Rubber bearings

The building feels about
0.4g - 0.5g above the isolation plane

- Non Base isolated buildings in Christchurch are designed for about 0.7g - 0.9g

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NMIT Building – Nelson 2010

Energy Dissipaters

Post tensioning tendons

Timber Rocking Walls

The worlds first post tensioned timber rocking shear wall building

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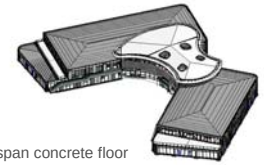
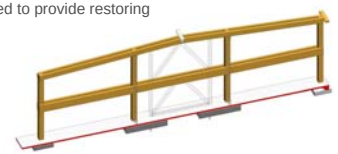
Tait Building – Christchurch 2013



- Timber gravity structure with inter-span concrete floor system
- Steel concentric braced rocking frames for seismic bracing
- Ringfedder springs used to provide restoring



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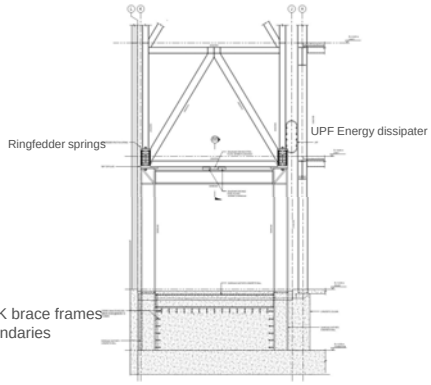
141 Cambridge Tce - Christchurch 2013



- Low damage rocking K Brace frames
- Ringfedder restoring springs at base of K brace frames
- Elastic Precast shear wall along the boundaries

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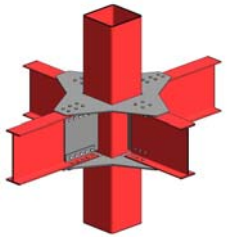
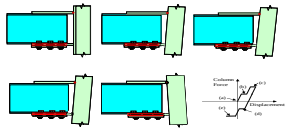
The Terrace Redevelopment – Christchurch 2013



- Low Damage - Structural Steel Two Way Sliding Hinge Joint Frame
- Sliding Hinge Joints each way using 600 x 600 steel SHS columns



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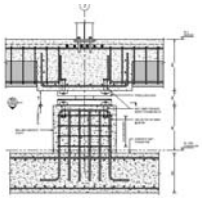
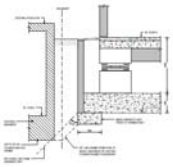
53 Victoria St - Christchurch 2013

- Base isolated using friction pendulum bearings
- ULS (500yr) EQ 0.17g
- Bearing Movement at ULS 165mm





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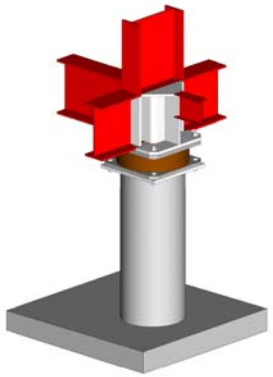
151 Cambridge Tce - Christchurch 2013



- Structural steel frame building
- Base isolated
- Friction Pendulum bearings

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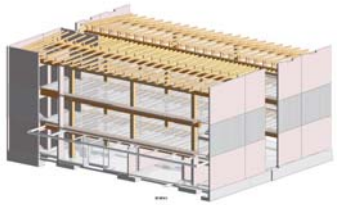
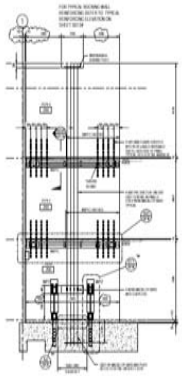
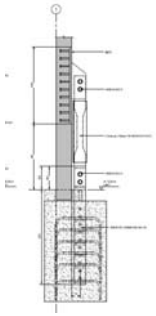
Halifax St - Nelson 2013







•Seismic bracing walls allowed to rock

• Plug and play energy dissipaters are replaceable post earthquake – tension compression yielding device

•Walls are post tensioned to provide stability and restoring

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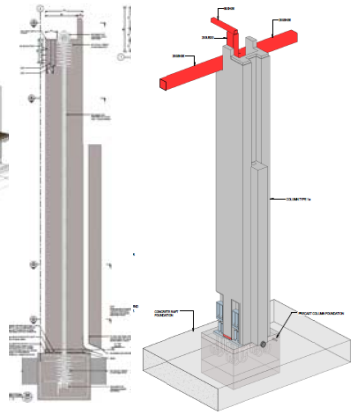
Knox Church - Christchurch 2013



•Seismic bracing piers allowed to rock

•Plug and play energy dissipaters are replaceable post earthquake – tension compression yielding device

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Thankyou

Presented By:

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