QuakeCoRE
NZ Centre for Earthquake Resilience
Te Hiranga Rū

2021 QuakeC0RE – NZSEE Conference Workshop

Large Scale Structural Testing – Past experiences and future research needs

Steel Buildings (heavy and light gauge)

Presentation by G Charles Clifton

13 April 2021

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Past Experiences and Ongoing Needs

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- Structural steel buildings (heavy and light steel) performed very well in Christchurch and Kaikoura earthquakes
- Therefore is further research needed?

YES!

- USA prior to Northridge 1994 thought steel buildings will always perform well in earthquakes
- We know how wrong that was for rigid moment frames

- We need to:
  - Replace luck with knowledge arising out of past earthquakes
    - eg why no column base yielding?
    - why did steel buildings self centre
  - Improve resilience of steel buildings post earthquake
  - Develop new systems, eg medium rise LSF buildings

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Scope of Talk

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- Focus on system response for earthquake
  - severe fire even more needs large scale testing
- Topics that require large scale experimental testing
  - cannot be covered by numerical modelling; or
  - requires experimental testing to validate numerical modelling
- Focus on multi-storey buildings and systems
- Heavy steel and light gauge steel

Buckling Restrained Brace Systems

- Widely used in New Zealand since 2011
- Proprietary item: performance by test
- Grout filled yielding core
- Gusset plate must remain stable in plane
- Very sensitive to accuracy of BRB construction
- Variable overstrength
- Issues over system stability
- MORE RESEARCH NEEDED

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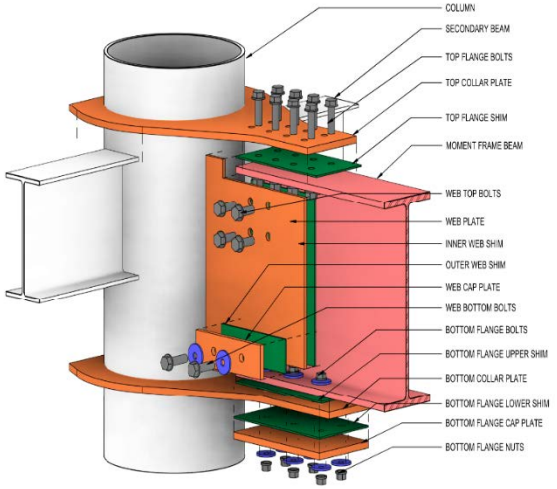
Optimised Sliding Hinge Joint Structural Systems

- Potential no damage system; first application currently in construction
- Research needs:
  - Time related changes to performance
  - Systems for external environments
  - Performance after fire
  - Manufacture of high performance disc springs
  - Measurement of installed bolt tension



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Strength and Stiffness of Composite Floor Systems

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- In-plane as diaphragms:
  - Remain elastic
  - How much cracking allowed?
  - How to model?
  - Design actions?
  - Diaphragm capacity?
- Out-of-plane in EBFs
  - Changes in brace and collector beam force
  - Influence on system performance and self centering

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Column Base Rotational Strength and Stiffness

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- Bare steel column plastic hinging at column bases leads to significant shortening
- Major repairs needed
- Need to know column base rotational strength and stiffness to keep column bases elastic
- Gravity system columns likely most critical; high compression, column shortening

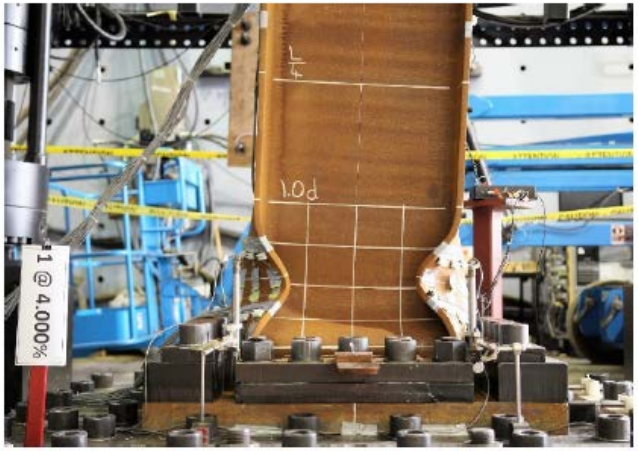
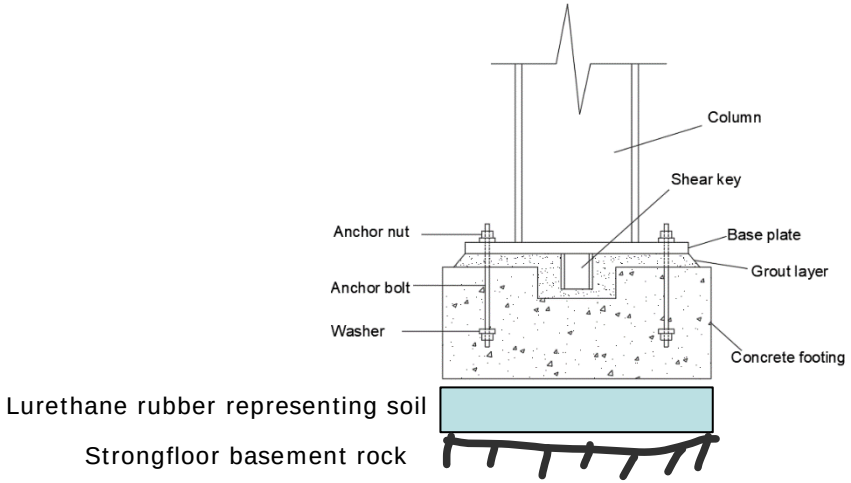


Figure 1: Column base yielding. Winston He Conference Paper



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Steel Plate Shear Walls

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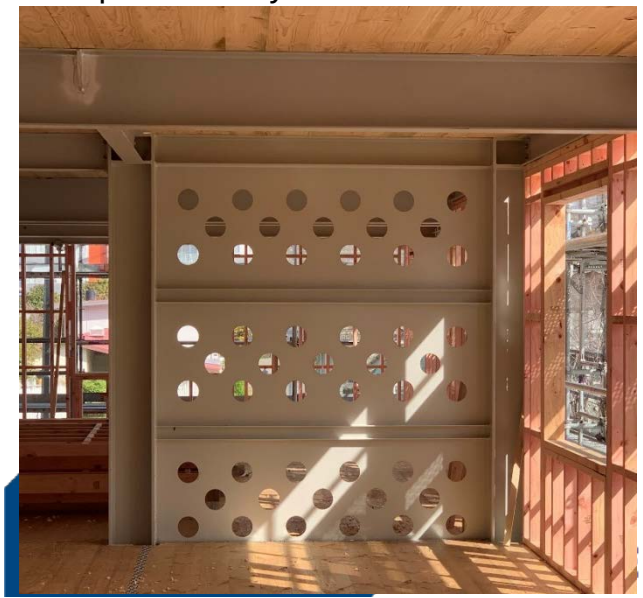
- Good solution for medium rise buildings
- Perforated plates to reduce strength
- Research needs around:
  - Enhanced self centering
  - Rapid replacement of shear wall panels after earthquake
  - Floor effects on wall

Figures from 2021 NZSEE Conference Paper No 4 by Lee



Light Steel Frame Seismic Resisting Systems

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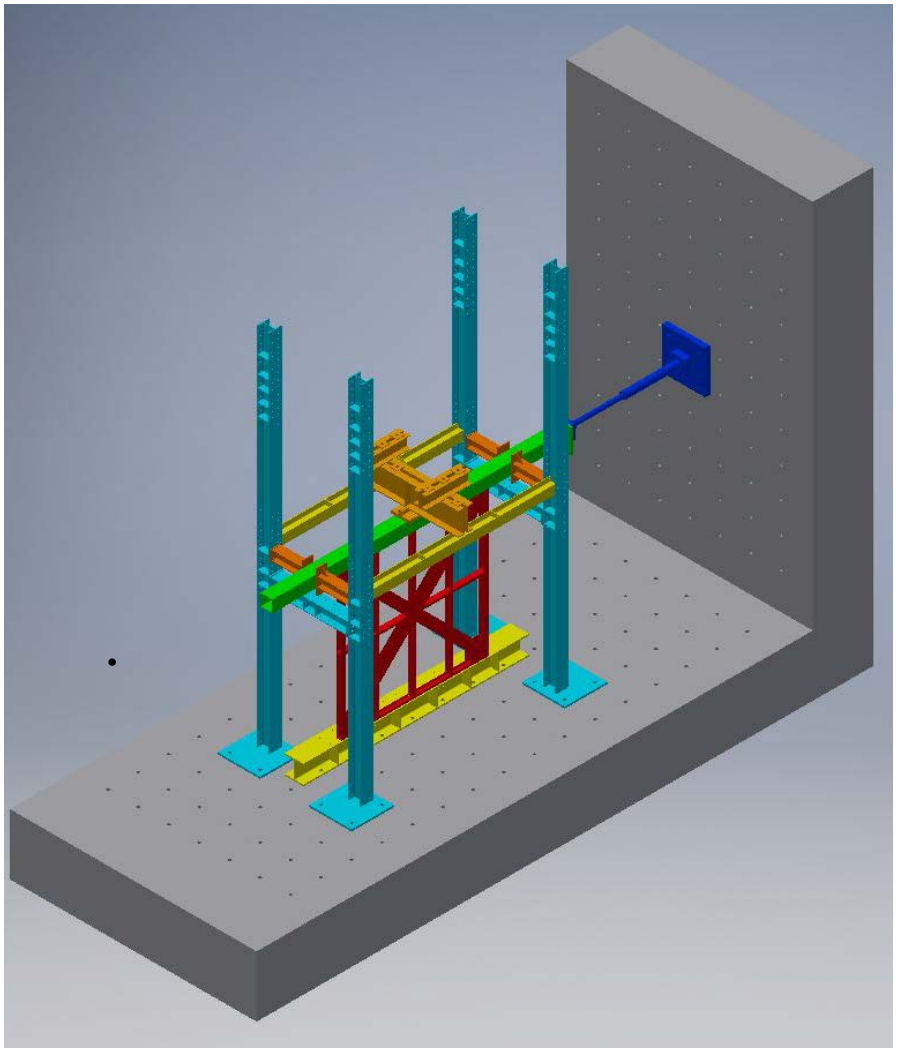
- Stacked X braced shear walls
- Medium rise
- Aim to make self centering up to around 1.5% drift
- Research just getting underway
- Includes weight of supported floors
- 1 storey and 2 storey options with floors between



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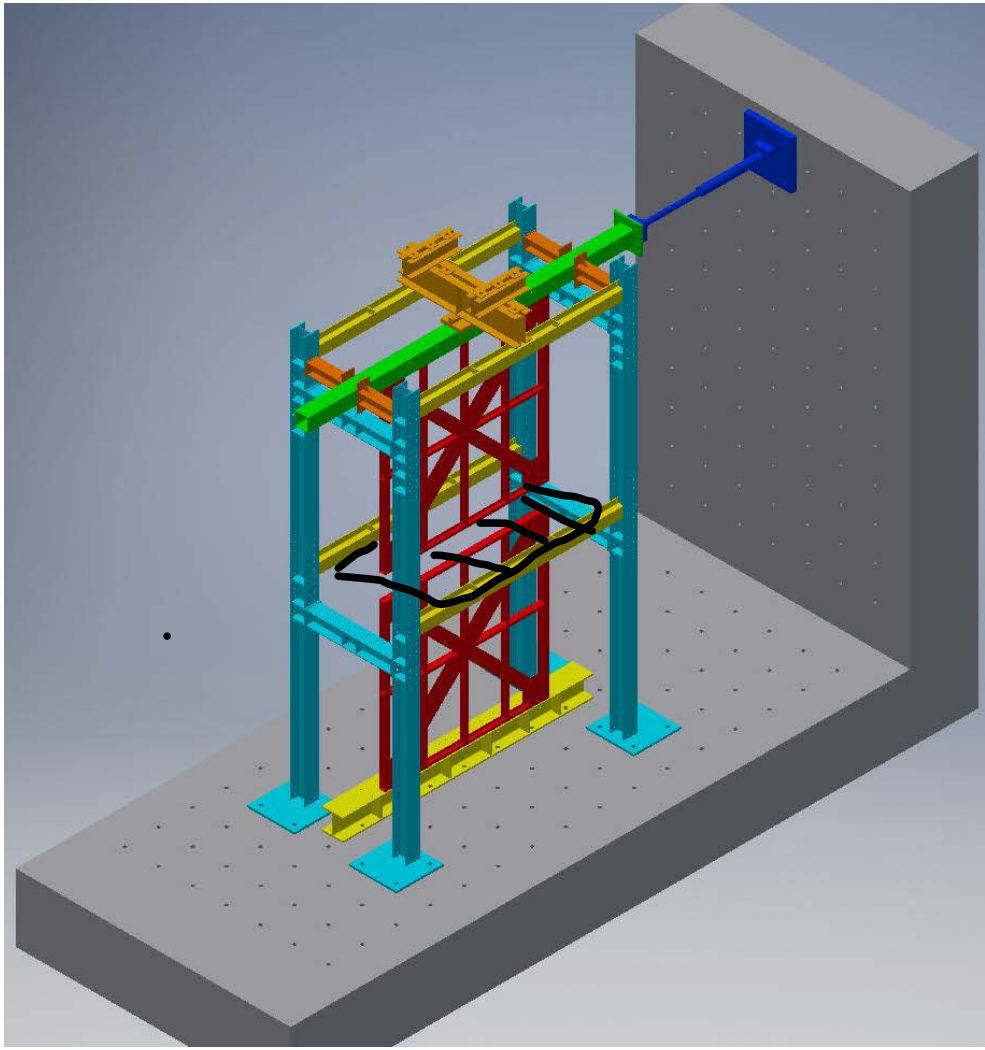

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Pallet Racking Systems

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- Friction slipper system developed for cross-aisle direction seismic resilience
- Now working on similar system for down-aisle direction seismic resilience
- Requires full scale shake table testing following component testing to confirm properties

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