Upcoming amendments to NZS 3101:2006

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SESOC AGM
Feb 2015

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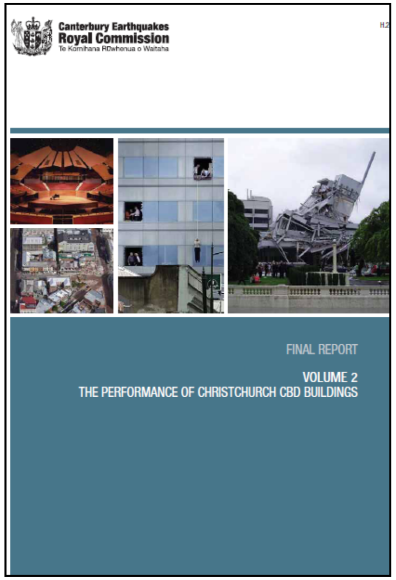
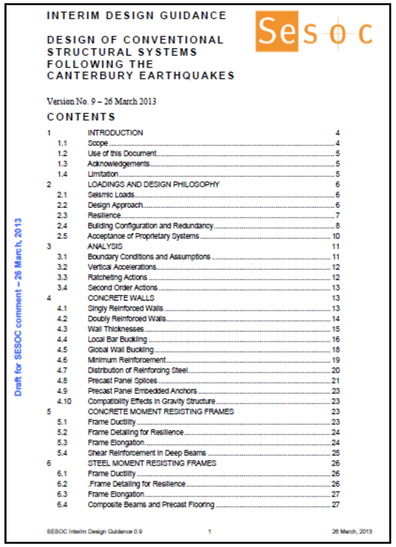
Terms of Reference

- Develop amendment to NZS3101 with due consideration of:
  - Recommendations of Canterbury Earthquake Royal Commission
  - SESOC interim design guidance
  - SNZ data base of questions/ actions

- Emphasis on big picture issues, recognise that some “judgments” will require further research




INTERIM DESIGN GUIDANCE

DESIGN OF CONVENTIONAL STRUCTURAL SYSTEMS FOLLOWING THE CANTERBURY EARTHQUAKES

Sesoc

Version No. 9 – 26 March 2013

Draft for SESOC comment – 26 March, 2013

CONTENTS

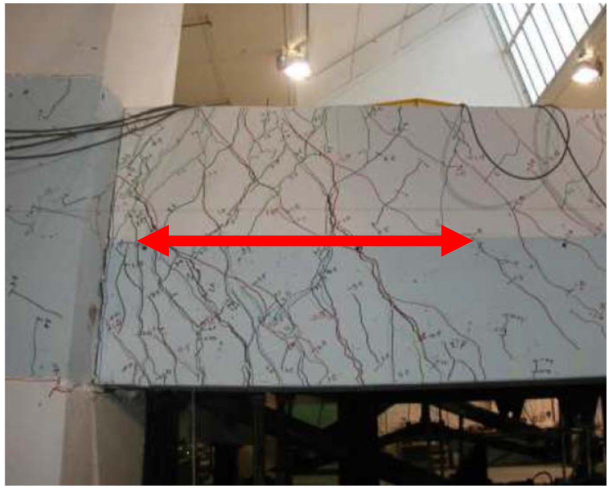
SESOC Interim Design Guidance 0.9 1 26 March, 2013

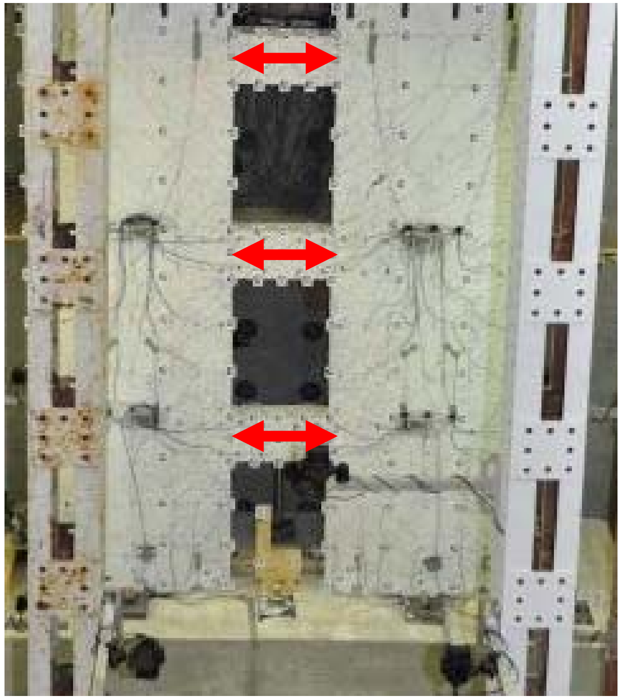
Significant changes

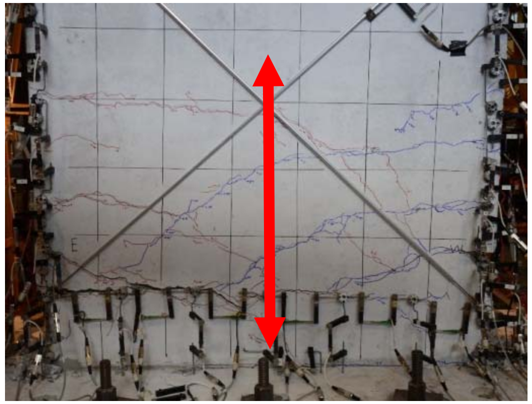
- Changes to terminology and clause order
- Member elongations
- Support details for precast floor and stair units
- Wall design and detailing
  - minimum reinforcement
  - singly reinforced walls
  - transverse reinforcement and detailing
  - axial load limits
  - coupled wall systems

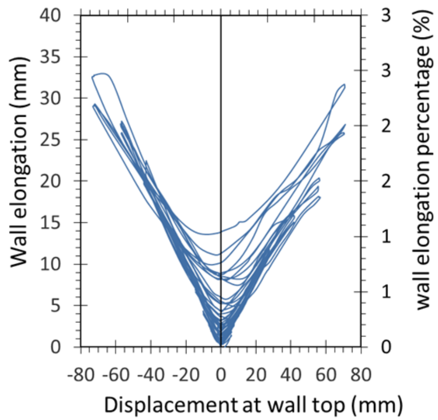
Elongation

- New guidance based on past research







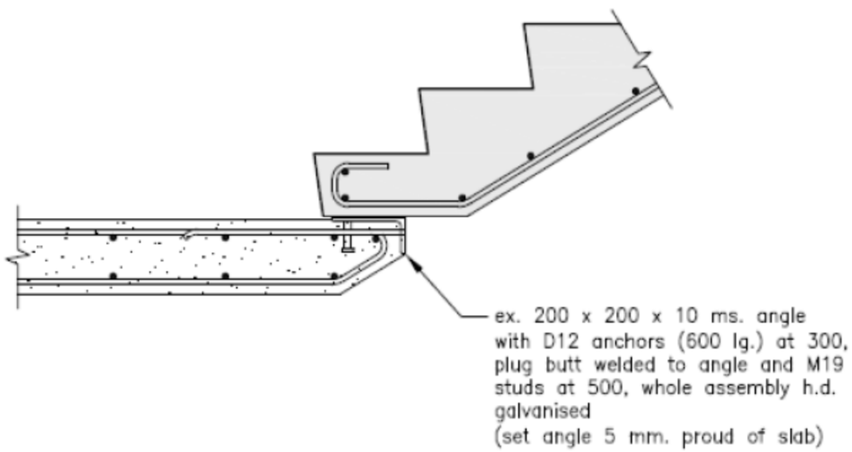


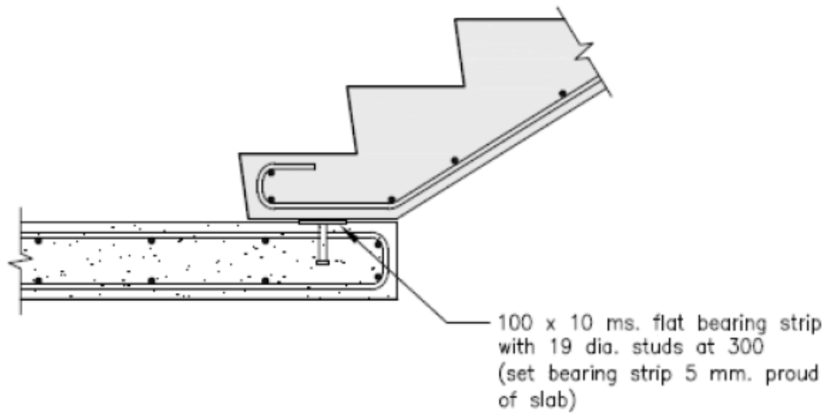
Elongation

- When elongation needs to be considered (2.6.5.10)
- Estimate the magnitude of elongation (7.8)
- Detailing for elongation:
  - Stairs and ramps (2.6.10, 18.7.6)
  - Cladding panels and fixings (17.6.2)
  - Support of floor elements (18.7.4, 18.8.1)
  - Coupling beams (11.4.9.2)
  - Axial forces induced in walls (11.4.1.4)

Stairs and ramps

- Designed for 1.5 times the peak inter-storey drift (MCE) + elongation + tolerance (18.7.6)





Floor seating lengths (low-drift)

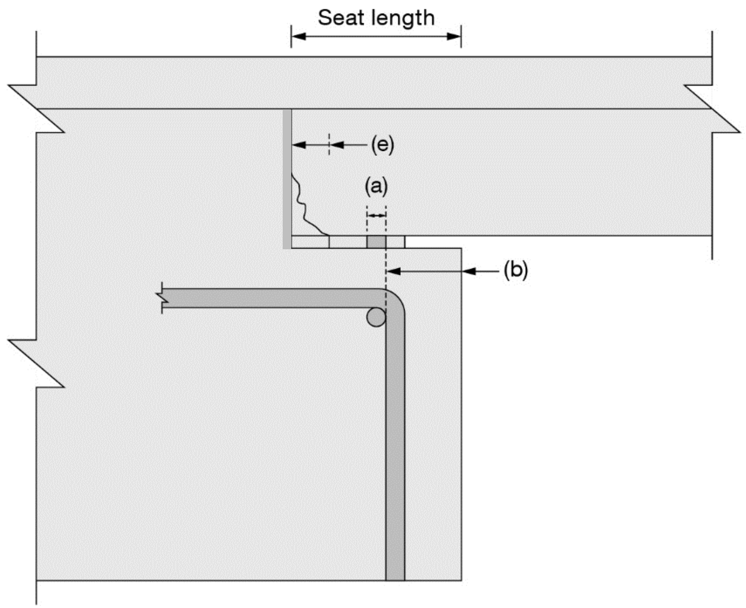
- Minimum seating lengths apply (18.7.4) when:
  - Drift less than 0.6%
  - Elongation less than 10mm

- Reduction if edge is armoured
- All use low-friction bearing strip
- More detail on bearing stress checks

Floor seating lengths (high drift)

- Larger seating (18.8.1) when:
  - Drift greater than 0.6%
  - Elongation greater than 10mm

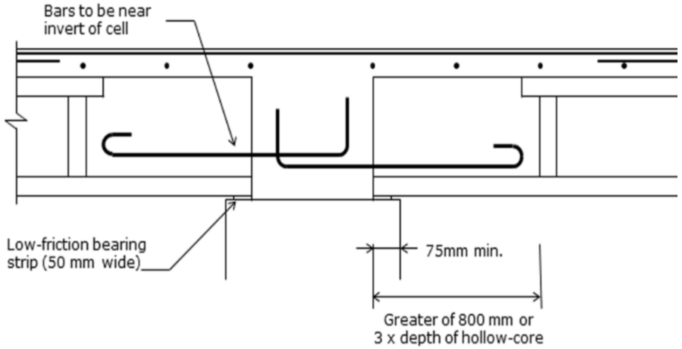
- Calculated from:
  - Bearing area
  - Cover loss
  - Elongation + support rotation
  - Unit spalling
  - Shrinkage
  - Tolerances



Seating length equals

(a)	Bearing length	10 mm
(b)	Seat spalling	40 mm
(c)	Beam centre line elongation	32.4 mm
(d)	Support rotation	6.3 mm
(e)	Precast unit spalling	20 mm
(g)	Tolerances	15 mm
		123.7 mm (round up to 125 mm)

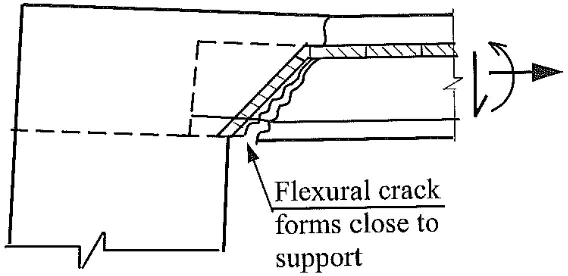
Support details

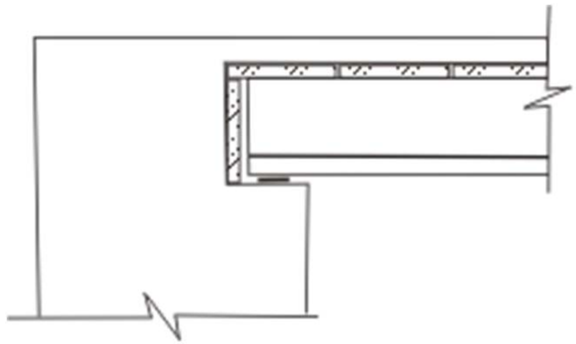


Hollowcore (no change)

Tees (armouring trigger)

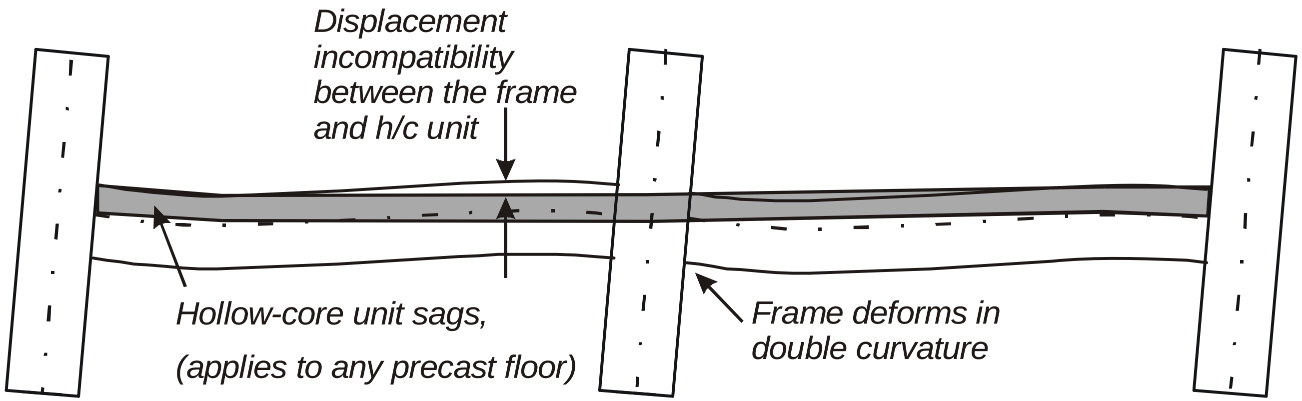
Support details - Ribs



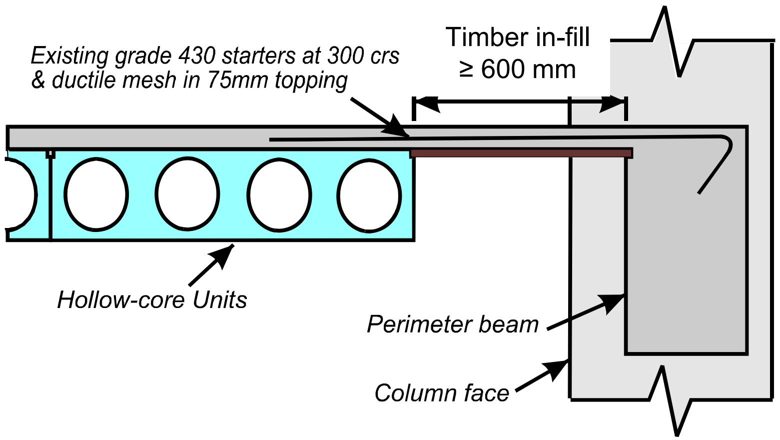


Further research and testing in progress

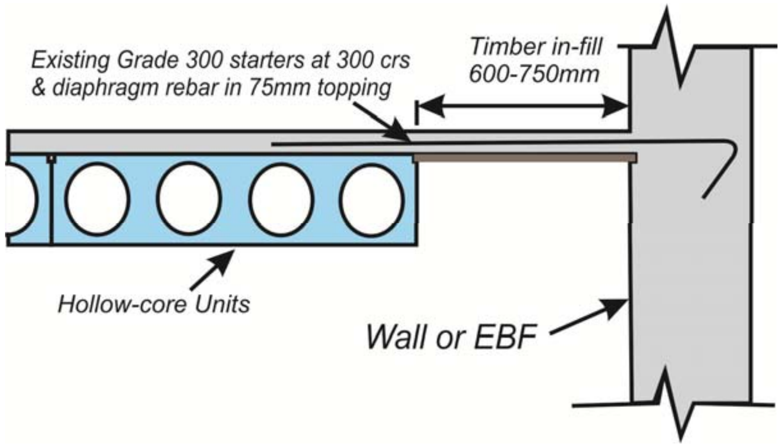
Link slabs



Displacement incompatibility between the frame and h/c unit
Hollow-core unit sags,
(applies to any precast floor)
Frame deforms in double curvature



Existing grade 430 starters at 300 crs & ductile mesh in 75mm topping
Timber in-fill ≥ 600 mm
Hollow-core Units
Perimeter beam
Column face



Existing Grade 300 starters at 300 crs & diaphragm rebar in 75mm topping
Timber in-fill 600-750mm
Hollow-core Units
Wall or EBF

Walls – EQ damage

Lack of Distributed Flexural Cracking

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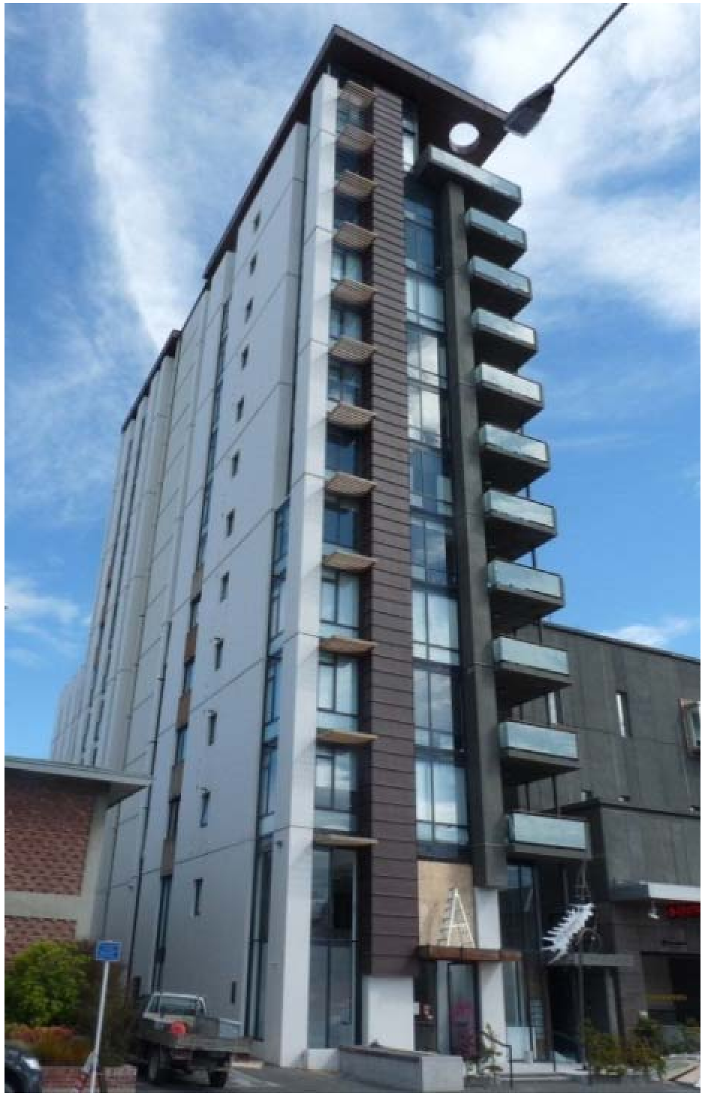
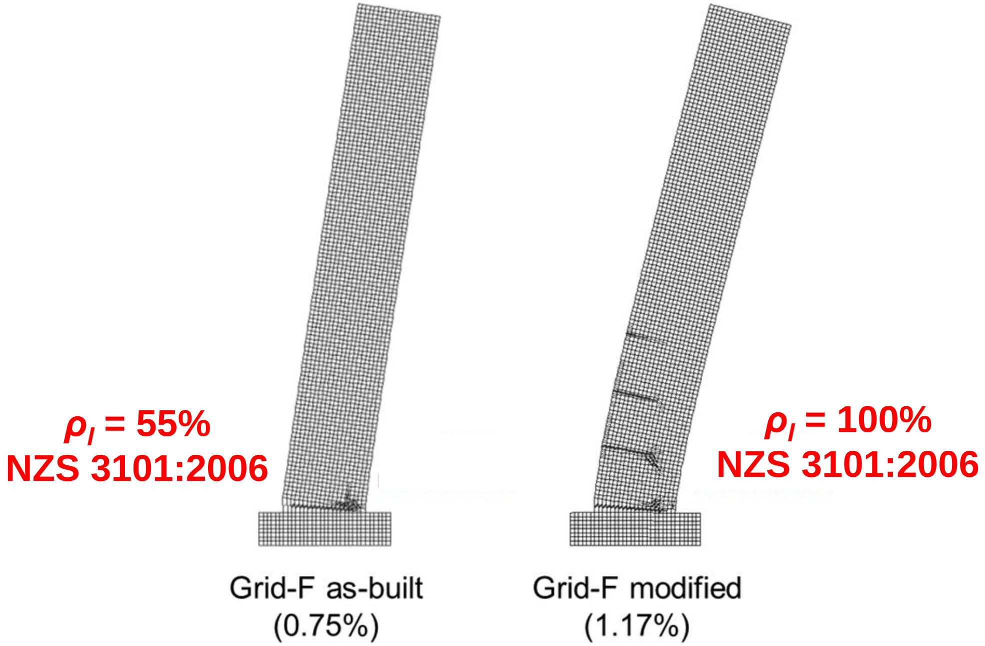


Minimum Vertical Reinforcement

- NZS 3101:1995 = 0.14-0.23%
- NZS 3101:2006 = 0.25-0.41%+ (80%+ increase)
  - Dependent on concrete strength

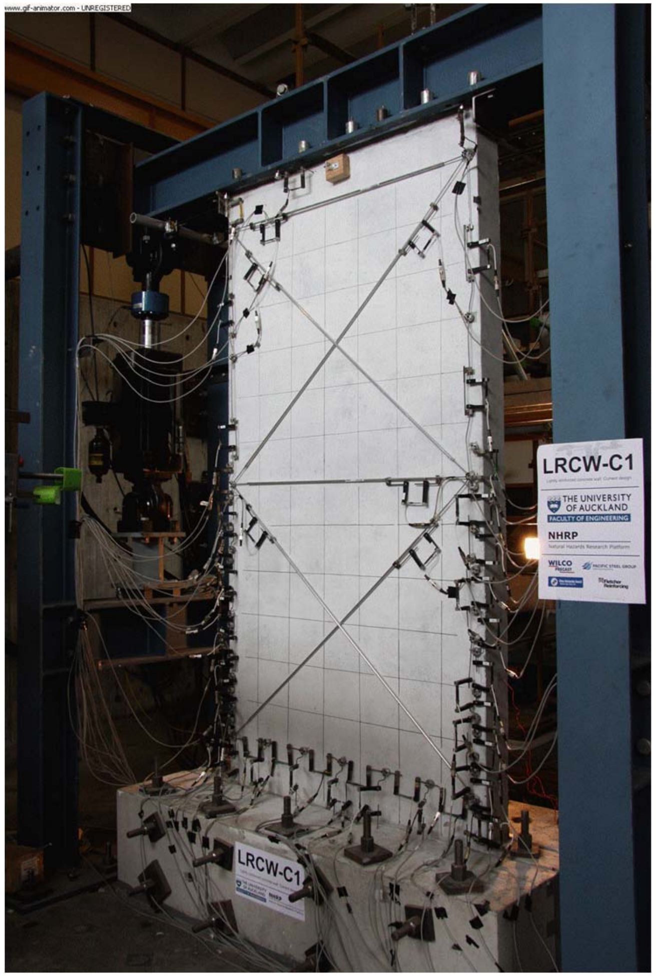


Minimum Vertical Reinforcement

- Nominally ductile (11.3.12.3)
  - Current (2006) minimum is okay for these walls
  - Commentary regarding concrete strength
  - Change from total to distributed ratio ($\rho_n \rightarrow \rho_l$)

$$\rho_l > \frac{\sqrt{f_c'}}{4 f_y}$$

[= 0.27%+]

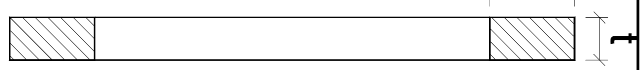


Minimum Vertical Reinforcement

- Limited ductile and ductile hinges (11.4.4.2)
  - Wall ends ($0.15L_w$):

$$\rho_{le} > \frac{\sqrt{f'_c}}{2 f_y}$$

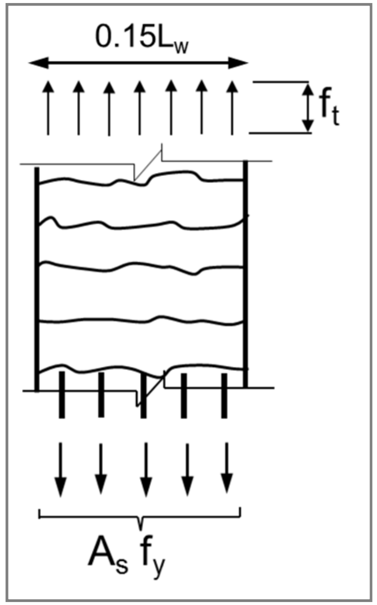
[= 0.55%+]



Rectangular wall

- Secondary crack formation:
  - Average long-term tensile strength
  - Dynamic strength enhancement
  - Shrinkage

Wall end



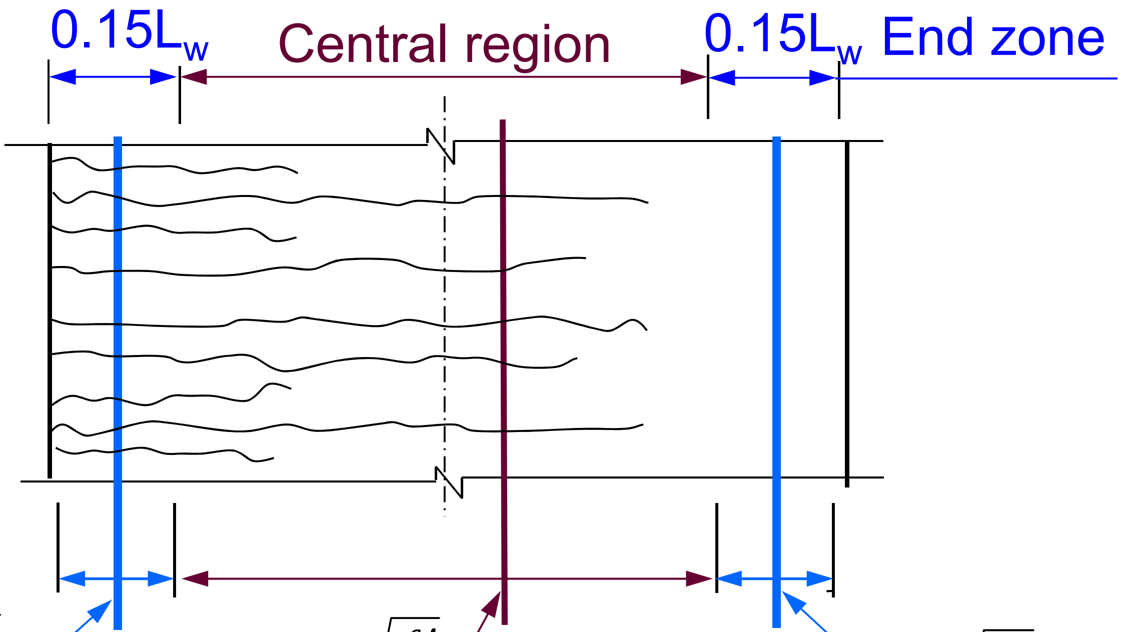
  - Middle web region:

$$\rho_l > \frac{\sqrt{f'_c}}{4 f_y}$$

[= 0.27%+]

- Web ratio must be at least 30% ratio in end region

Ductile walls



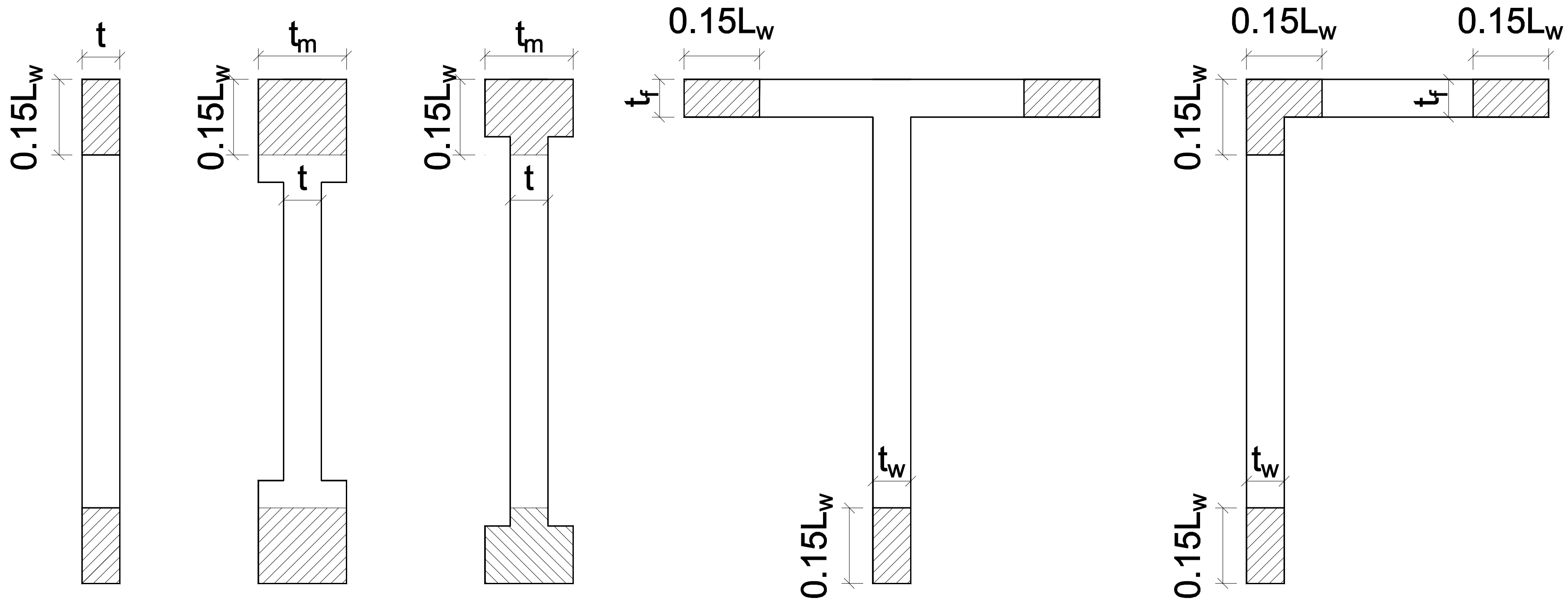
$$p_{le} = \frac{\sqrt{f'_c}}{2f_y}$$

$$p_l = \frac{\sqrt{f'_c}}{4f_y}$$

$$p_{le} = \frac{\sqrt{f'_c}}{2f_y}$$

1. Minimum end zone reinforcement (p_{le}) ensures close spacing of cracks spread of yielding.
2. Minimum central region reinforcement (p_l *or* $0.3p_{le}$) ensures cracks extend through the tension zone.

Location of end zones of walls



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Singly reinforced walls

- Lack of robustness
  - Connections and bar anchorage
  - Shear and stability
  - Fracture of reinforcement
  - Bi-direction loading?

- Changes:
  - Strength reduction factor
    - $\phi = 0.7$ (2.3.2.2)
    - Essentially elastic during MCE EQ
  - Clarify maximum reinforcement content
    - $p_l < 1\%$ (11.3.1.5)

Figure 5.106. Unit 5 at end of test. Note buckled longitudinal bars.

Figure 5.51: Unit 2: Out-of-plane displacement on the East edge at $\mu_\Delta = -4 \times 1$

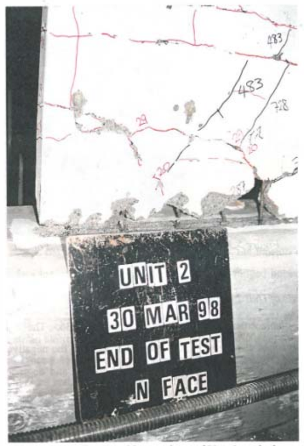
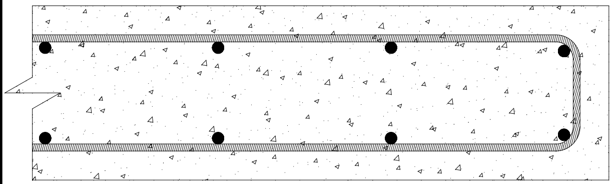
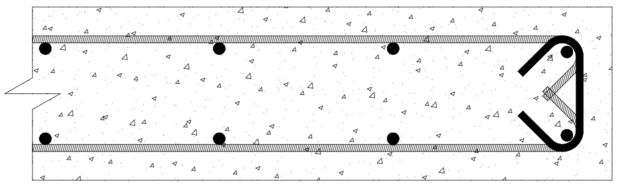


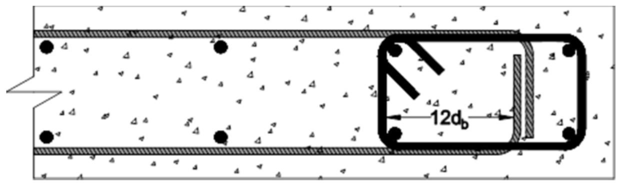
Figure 5.34. Fractured bars at base of Unit 2, end of test.

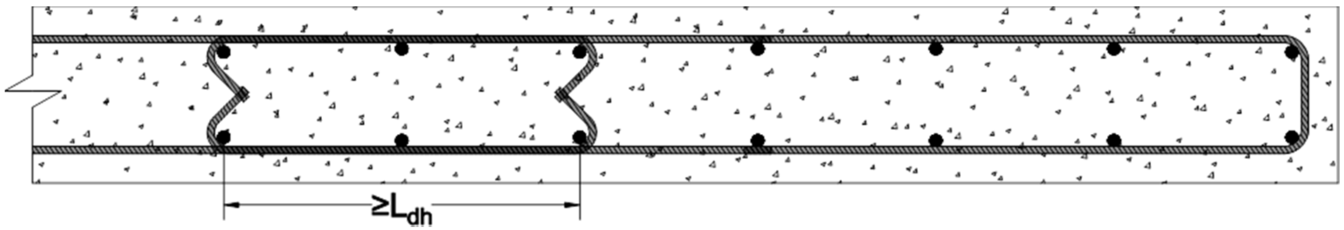
Anchorage of horizontal reinforcement

- Singly reinforced walls (essentially elastic → OK)
- Doubly reinforced walls (11.3.12.5)



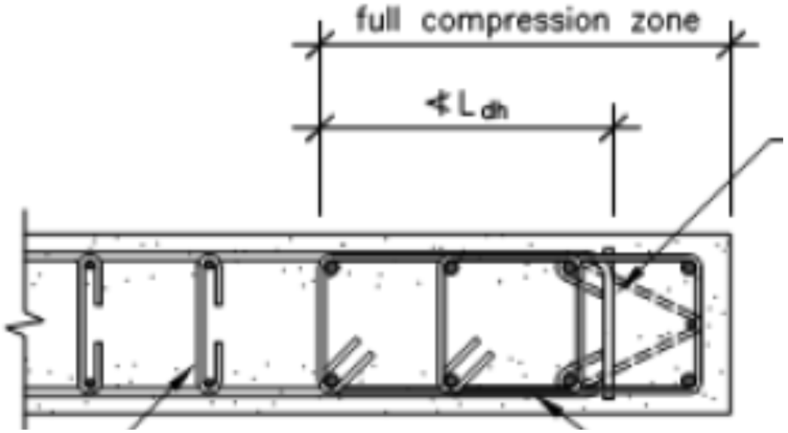


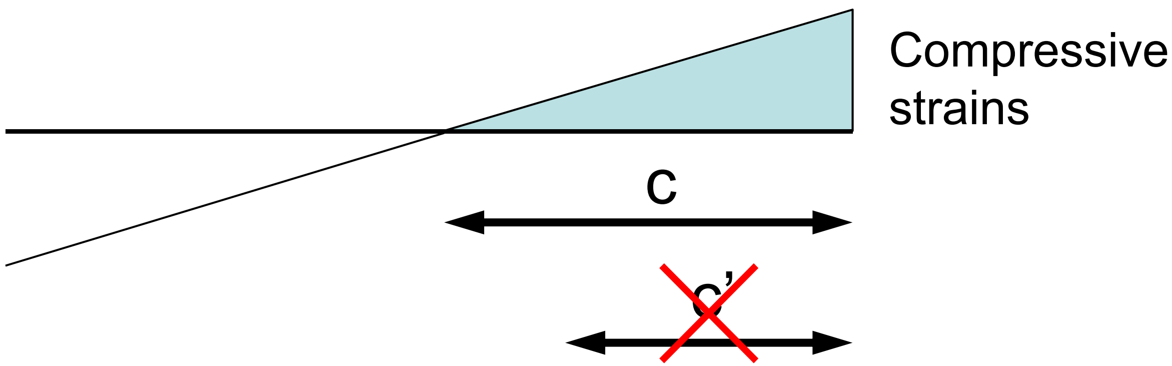




Confinement (plastic hinge regions)

- Confinement over entire compression zone (11.4.5.5)





Transverse ties (plastic hinge regions)

- In compression region (11.4.5.2)
  - Always required for every bar
  - Removed clause that permitted no ties when ρ_l < 1%

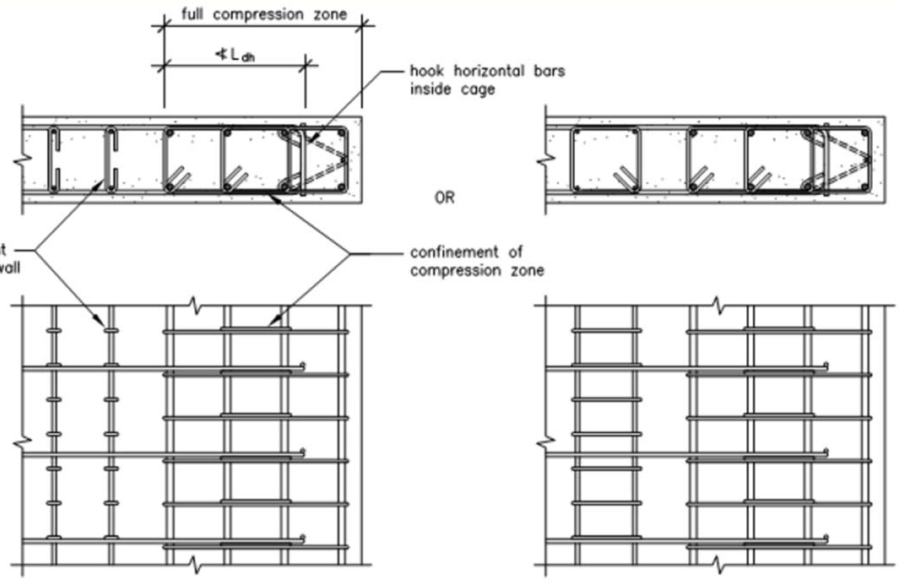


Figure 5: Confinement requirements for doubly reinforced walls

Transverse ties (plastic hinge regions)

- In central region, when triggered by (11.4.5.3):
  - High shear
  - Low cover
  - Large curvatures (large tensile reinforcement strains)

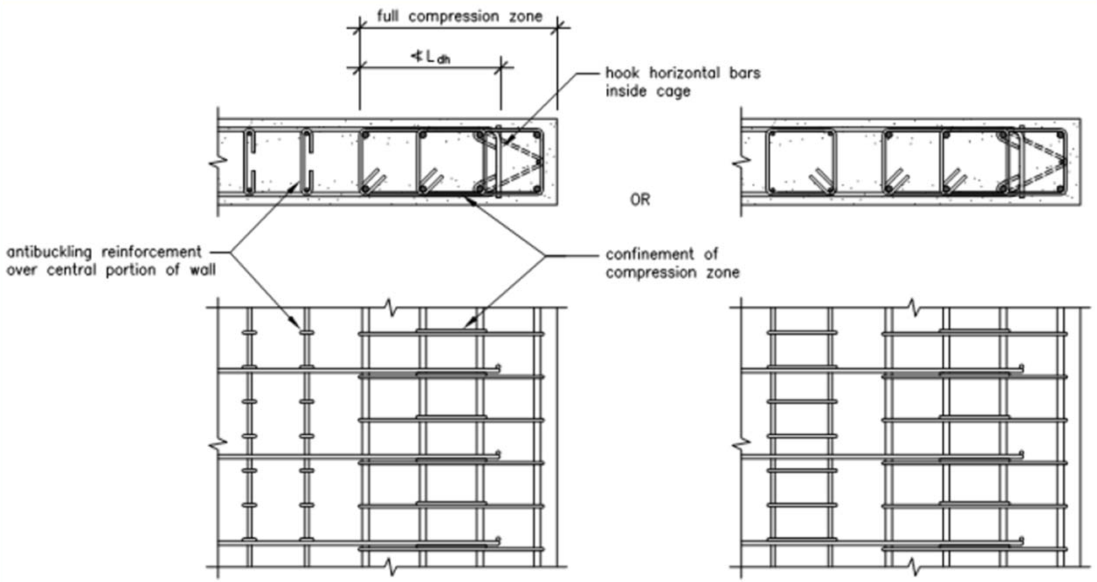


Figure 5: Confinement requirements for doubly reinforced walls

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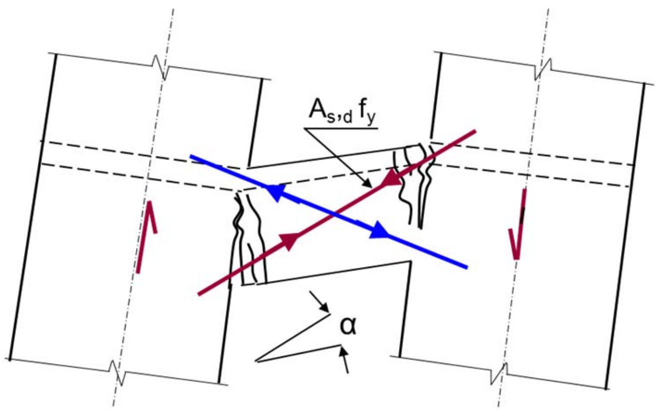
Axial load and slenderness

- Issues:
  - Wall elongation can significantly increase wall axial loads
  - Instability and buckling are complicated…
- Design axial load < $0.3\phi f'_c A_g$ (11.3.1.6)
  - Additional commentary added regarding elongation
- Slenderness:
  - $L_n/t < 20$ when $N^* > 0.2\phi f'_c A_g$ (11.3.7)
- Further Research required

Coupled Wall systems

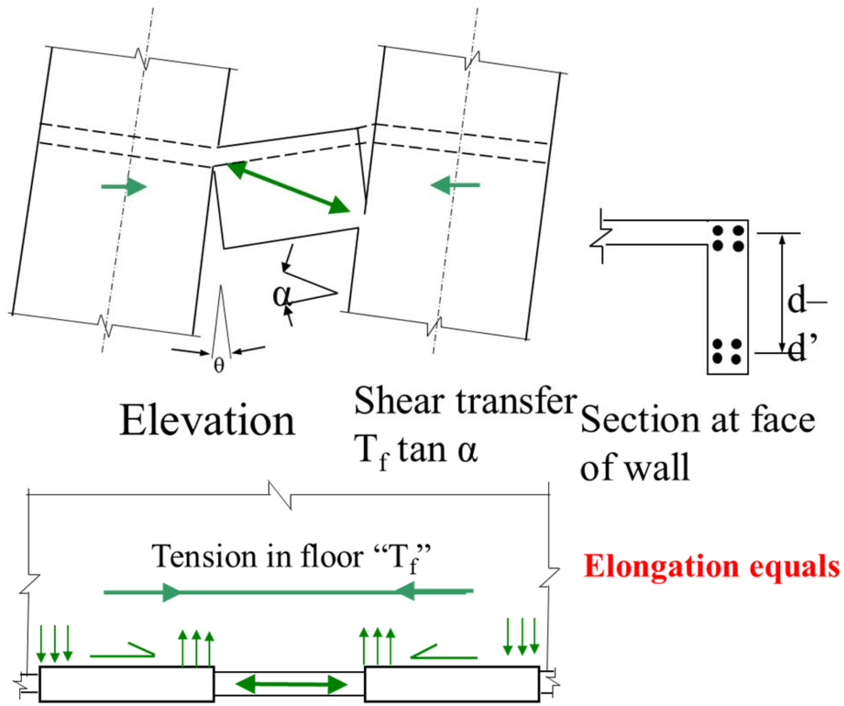
- Coupling beam elongation/deformation restrained by floor diaphragms and wall piers



Elevation on coupled walls

Conventional design assumption no axial load in coupling beam

Shear transfer = $2\,A_{s,d}\,f_y \sin\alpha$



Elongation equals θ (d-d')

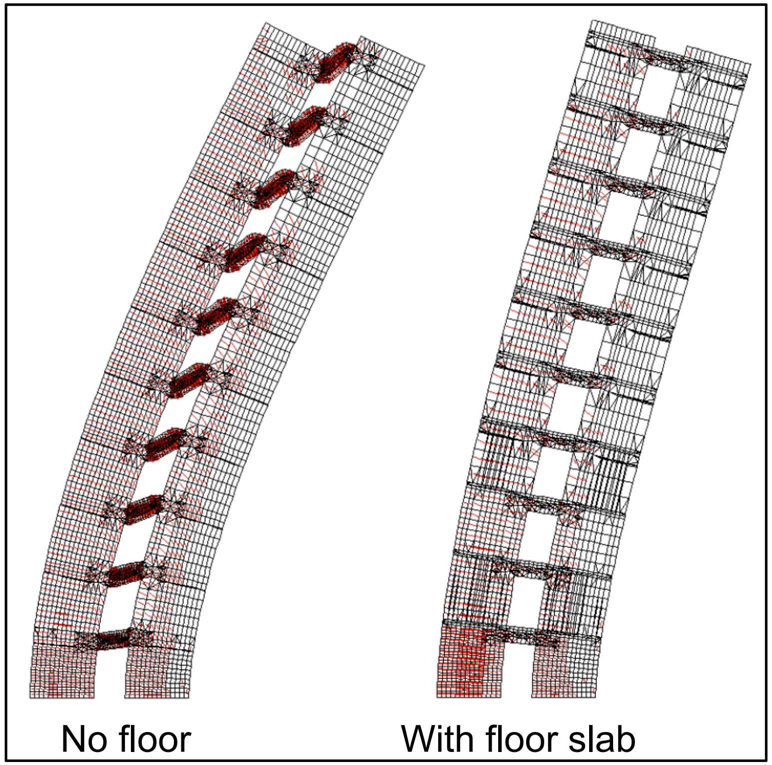
Plan on floor

Actions due to restraint from floor

Coupled Wall systems

- Coupling beam over-strength calculated with axial restraint force provided by floor (11.4.9.2)
  - Similar to floor slab contribution to beam over-strength already in NZS 3101

➢ **Ongoing research on this topic**



Questions?

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