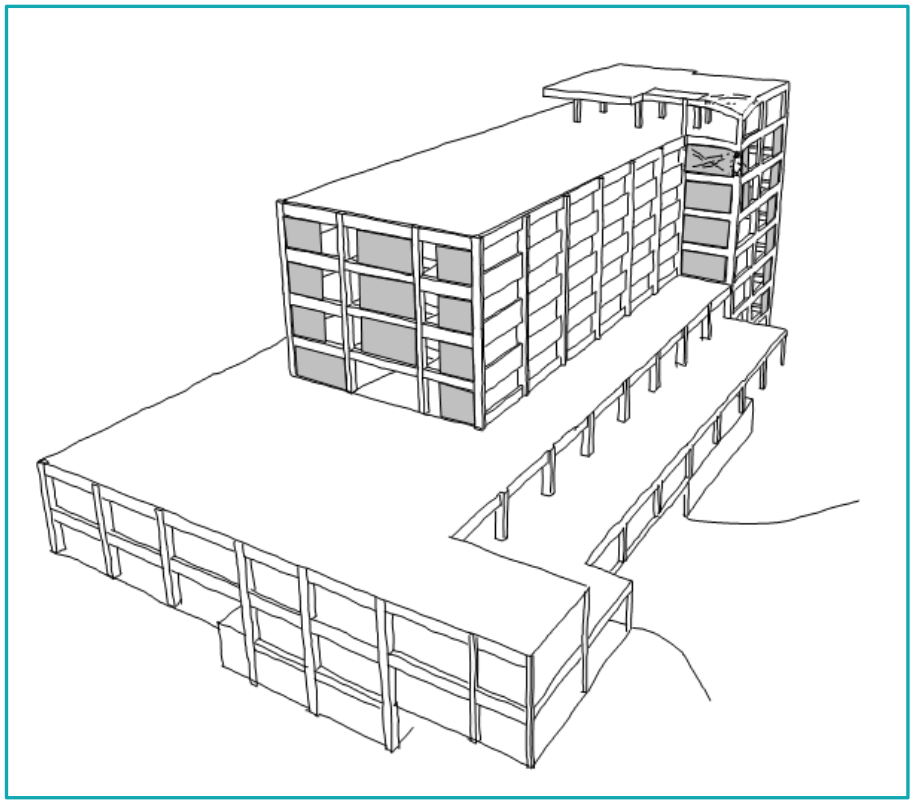
ADVANTAGES OF USING THE SIMPLIFIED LATERAL MECHANISM ANALYSIS (SLaMA) TECHNIQUE IN THE ASSESSMENT OF NEW ZEALAND 1960s REINFORCED CONCRETE FRAME BUILDINGS

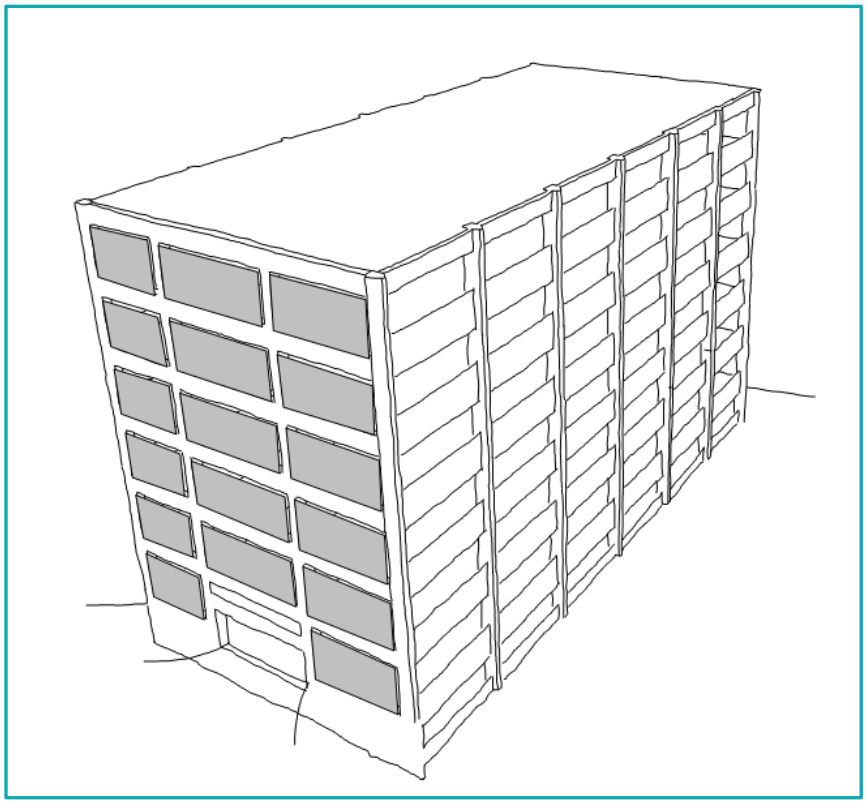
JARED KEEN & HELEN FERNER

ON ANALYSIS AND UNCERTAINTY

A REAL WORLD LABORATORY

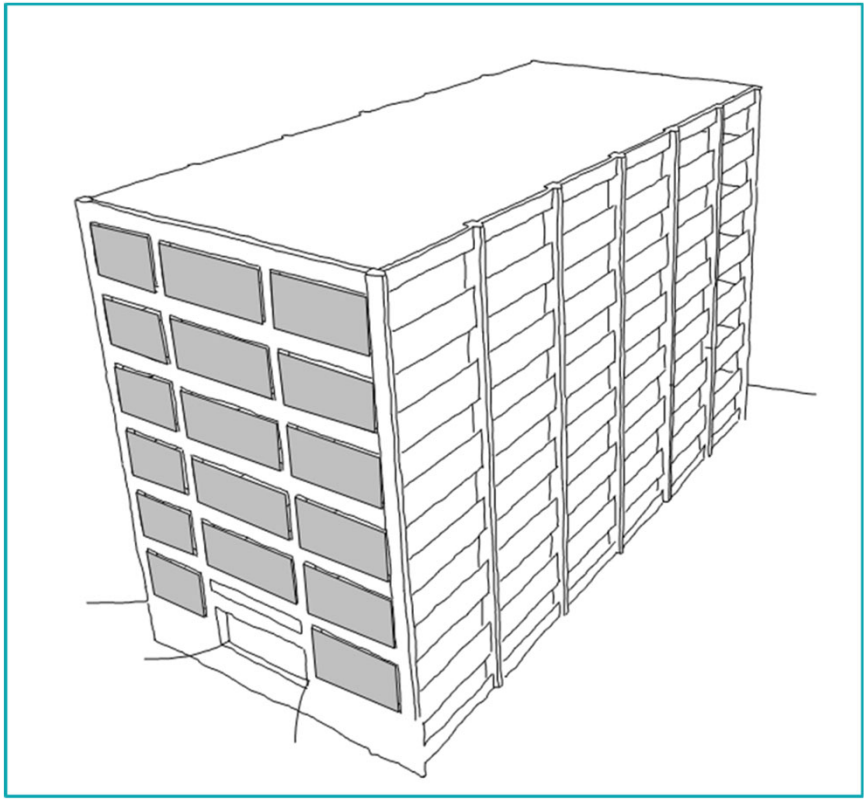
The Laboratory





The Laboratory

- Reinforced Concrete Frame
- Low Seismicity Zone
- Low Capacity
- Built in 1959
- Near textbook building…
- …with some real world twists
- Two Independent Analysis
  - NLTHA
  - SLaMA



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Background – Earthquake Prone Buildings

Building Act 2004

Public Act 2004 No 72
Date of assent 24 August 2004
Commencement see section 2

Building (Earthquake-prone Buildings) Amendment Act 2016

Public Act 2016 No 22
Date of assent 13 May 2016
Commencement see section 2

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The Seismic Assessment of Existing Buildings

Technical Guidelines for Engineering Assessments

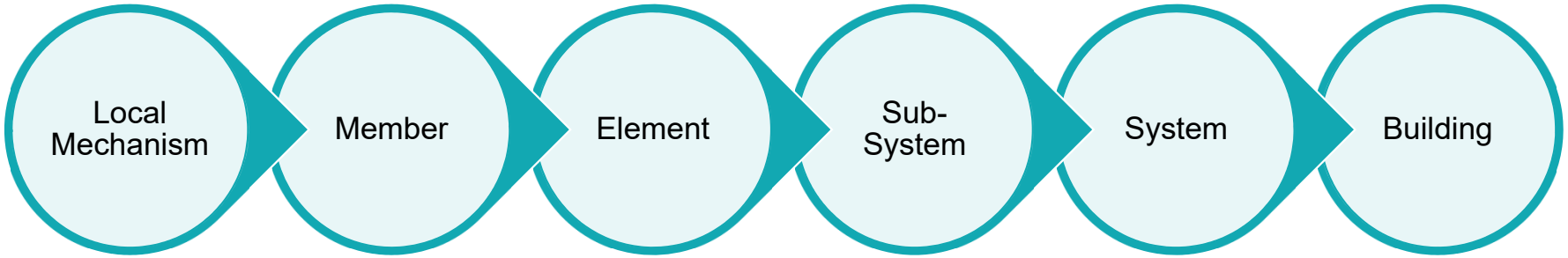
July 2017

Overview and Summary

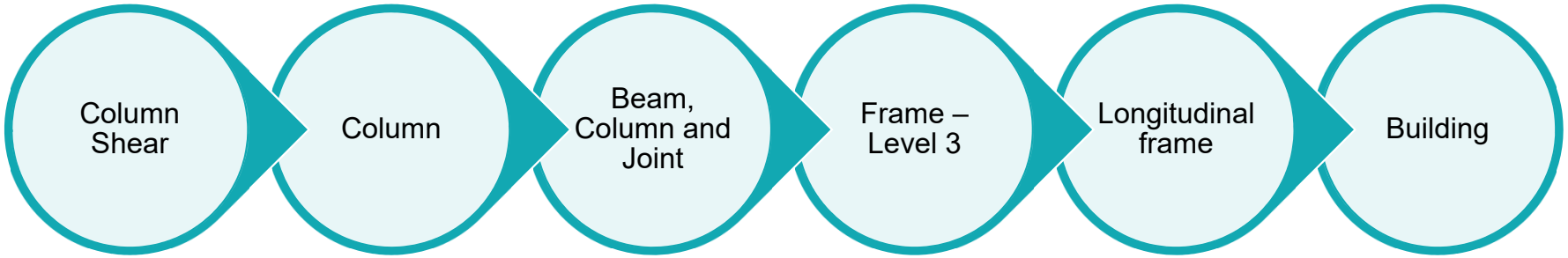
SLaMA (Simplified Lateral Mechanism Analysis)

SLaMA is a simple non-linear pushover assessment focused on assessing structures at a sub-system level. Its focus is on understanding failure hierarchies, and then translating the subassembly behavior upwards to full building behavior.

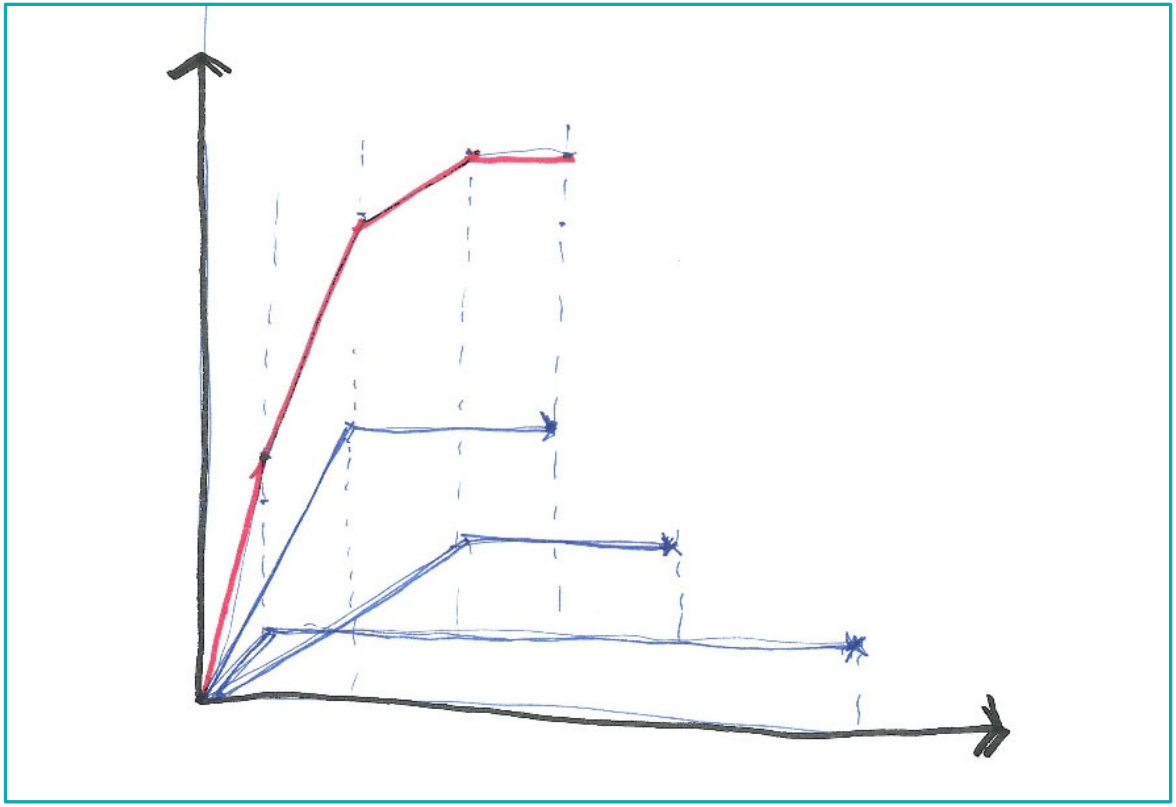
SLaMA (Simplified Lateral Mechanism Analysis)



SLaMA (Simplified Lateral Mechanism Analysis)

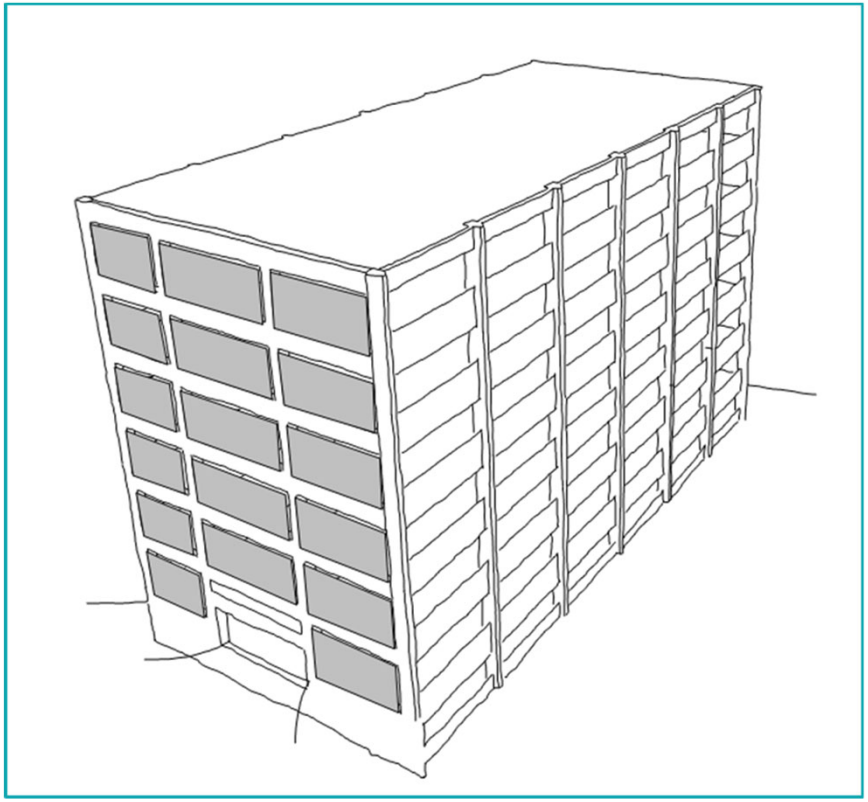


SLaMA (Simplified Lateral Mechanism Analysis)



Two Examples of Uncertainty

- Infill Wall
  - Uncertain of Capacity
- Moment Frames
  - Uncertainty of Extent



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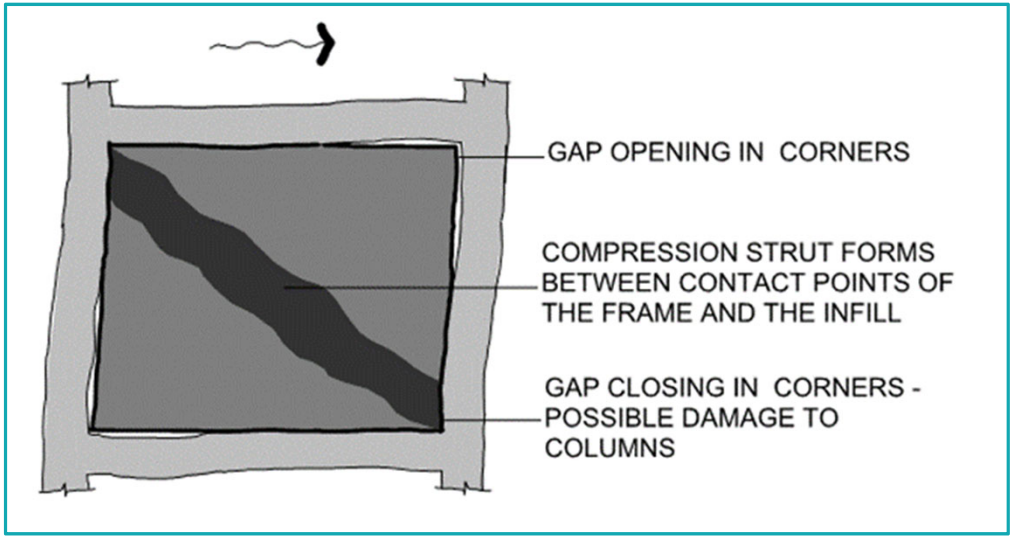
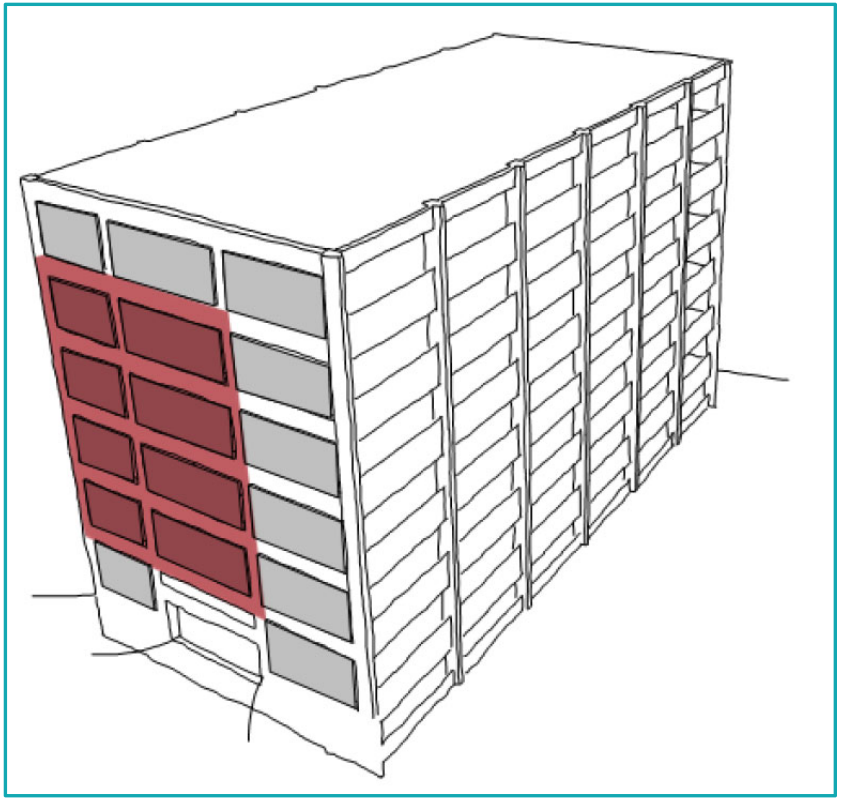
Infill Walls





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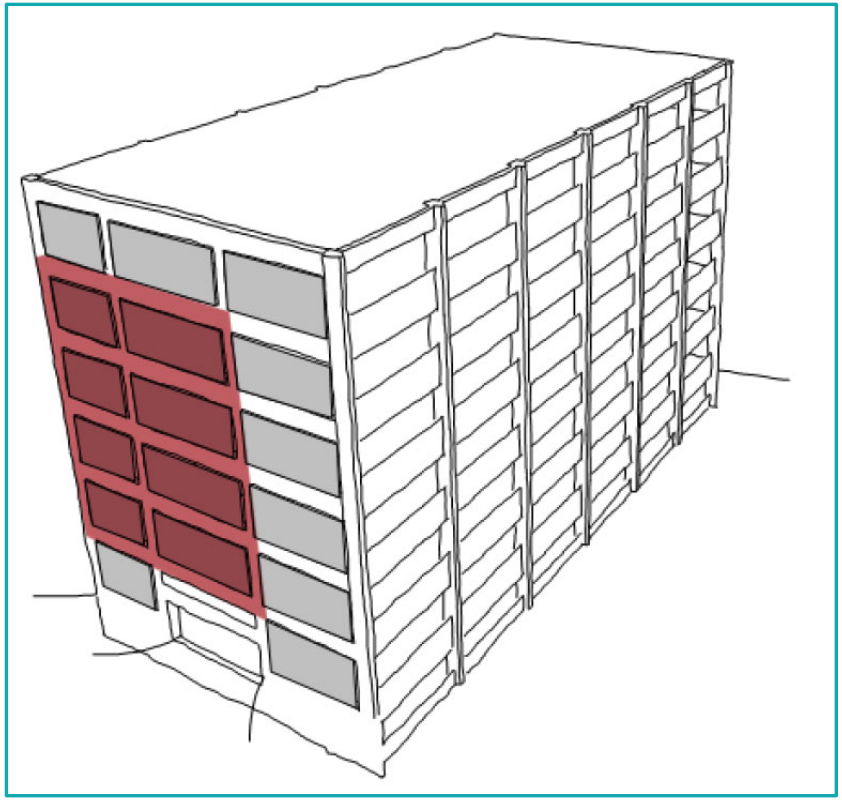
Infill Walls

SLaMA

- Input
  - Plasterboard thickness
  - Construction regularity
  - Plasterboard compressibility (after 50 years)
- Outputs
  - Drift before lock-up
  - Estimated earthquake at failure



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Infill Walls

SLaMA

- Input
  - Plasterboard thickness
  - Construction regularity
  - Plasterboard compressibility (after 50 years)
- Outputs
  - Drift before lock-up
  - Estimated earthquake at failure

NLTHA

- Input
  - Many hundreds or thousands
  - Includes SLaMA inputs
- Outputs
  - Critical failure location (somewhere)
  - Estimated earthquake at failure

Infill Walls

SLaMA

- 20% - 40% NBS(IL4)
- Or maybe 10% - 50% NBS(IL4)

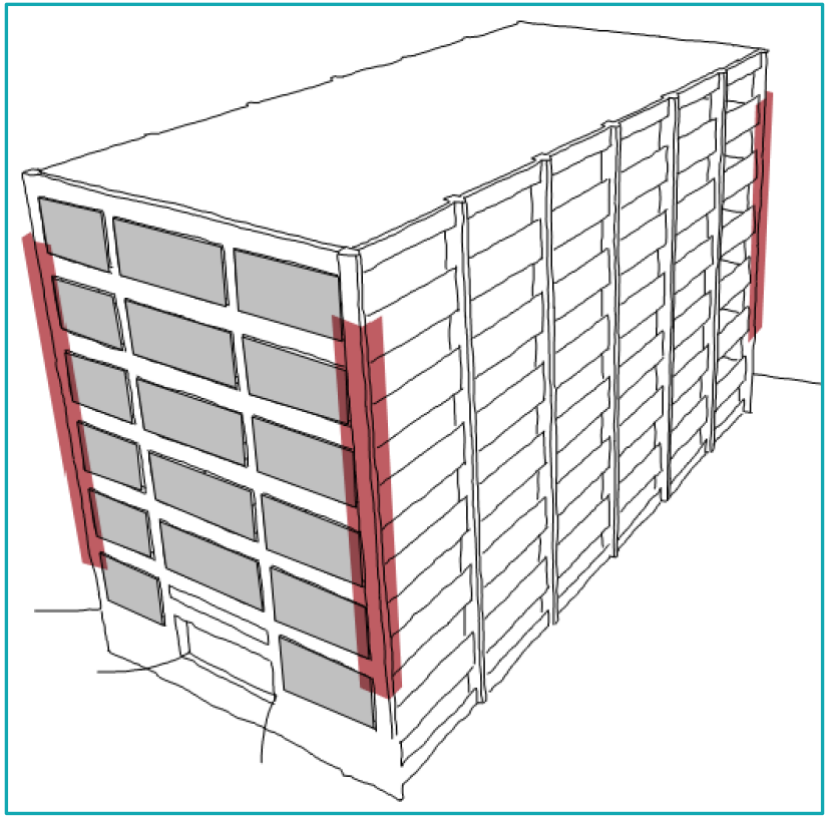
NLTHA

- 50% NBS (IL4)

Moment Frames

SLaMA

- Likely area of first failure
- 35% – 40%NBS(IL4)



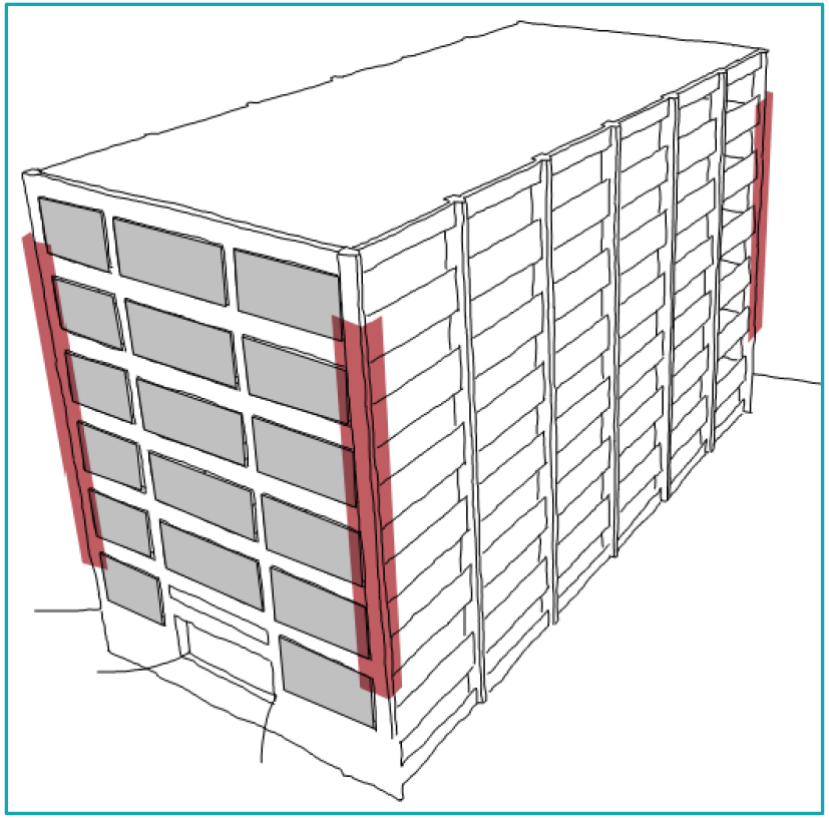
Moment Frames

SLaMA

- Likely area of first failure
- 35% – 40%NBS(IL4)

NLTHA

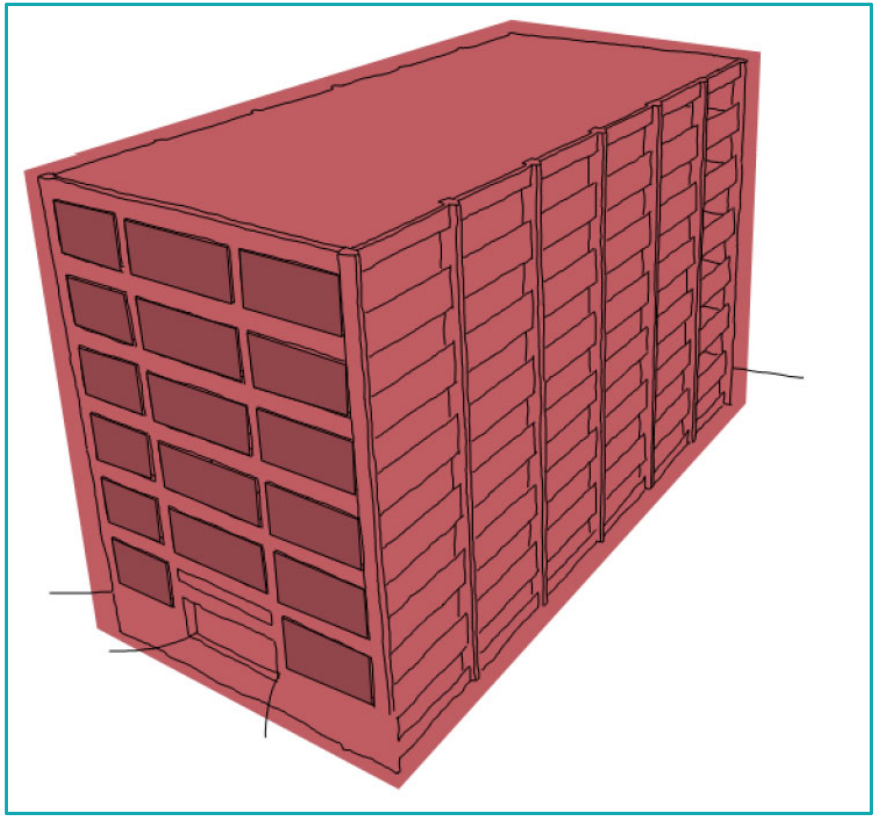
- 35%NBS(IL4)



Moment Frames

SLaMA

- Subsequent failure areas
- 40% – 50%NBS(IL4)



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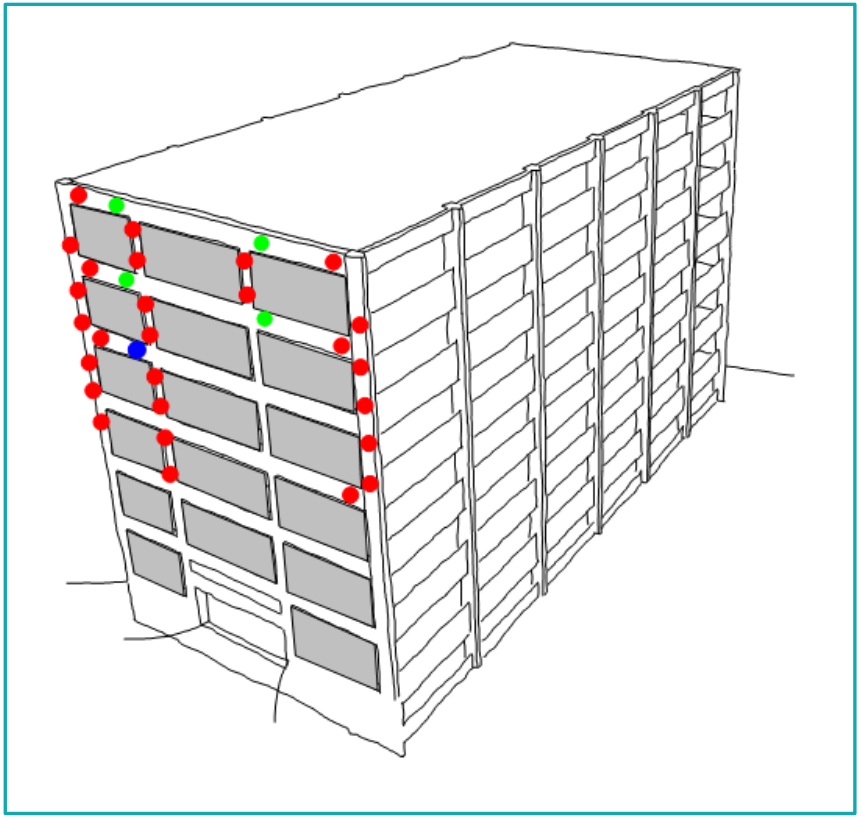
Moment Frames

SLaMA

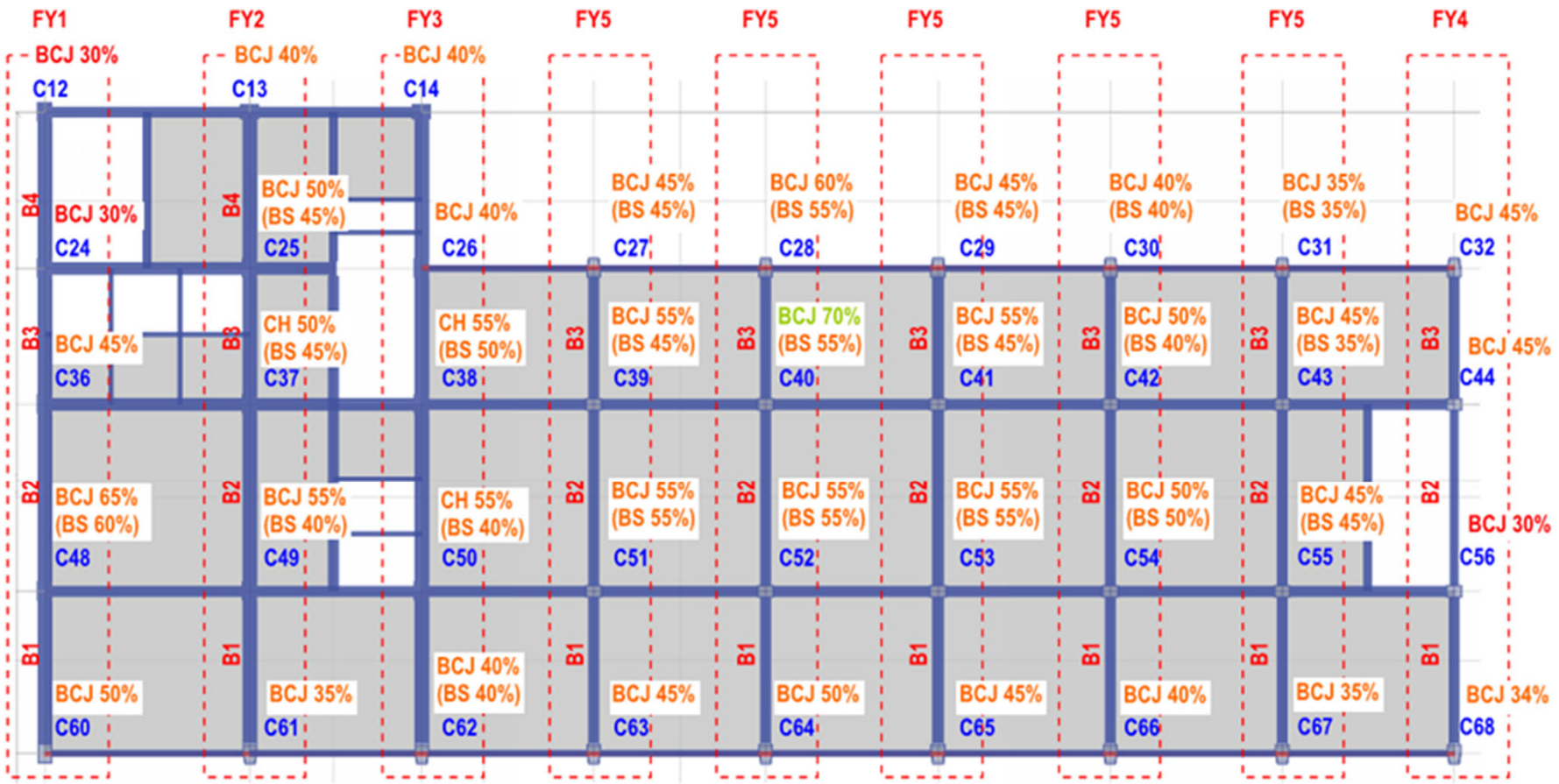
- Subsequent failure areas
- 40% – 50%NBS(IL4)

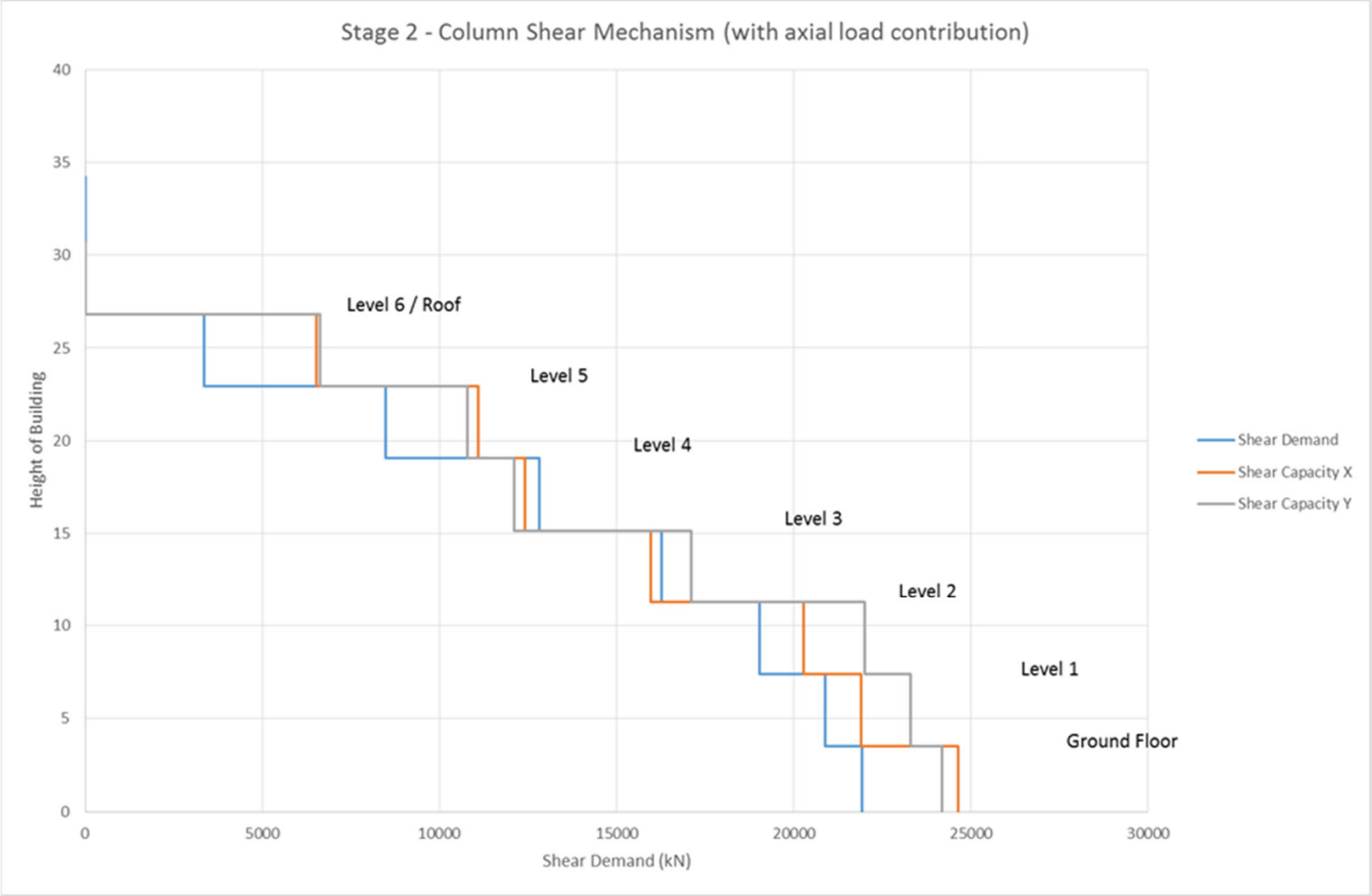
NLTHA

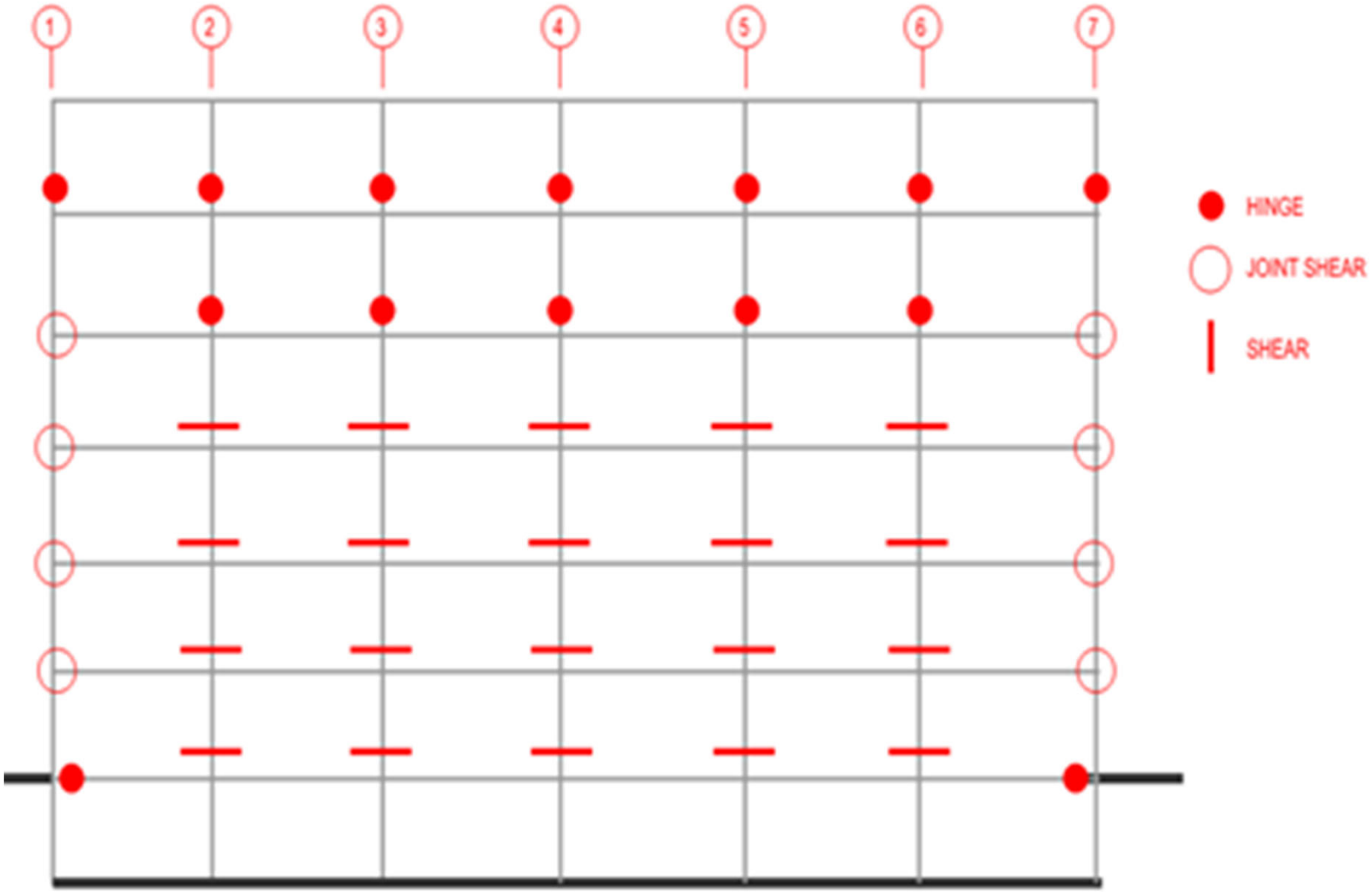
- Difficult to discern in analysis



LEVEL 3 - Y-DIRECTION

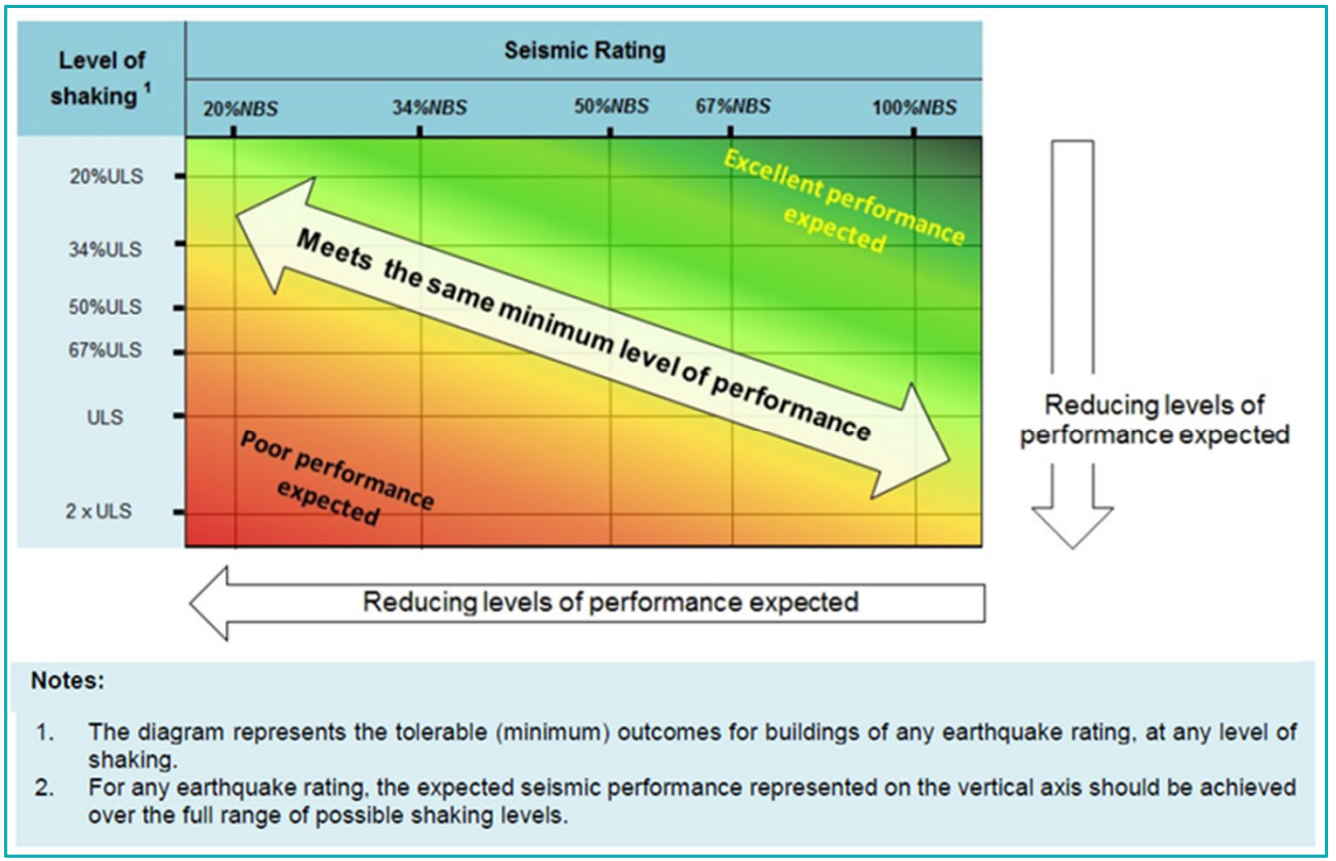



Stage 2 - Column Shear Mechanism (with axial load contribution)
Height of Building
Shear Demand (kN)
0
5
10
15
20
25
30
35
40
0
5000
10000
15000
20000
25000
30000
Level 6 / Roof
Level 5
Level 4
Level 3
Level 2
Level 1
Ground Floor
Shear Demand
Shear Capacity X
Shear Capacity Y


1
2
3
4
5
6
7
HINGE
JOINT SHEAR
SHEAR

How uncertain are our inputs?

Explaining uncertainty to others



Notes:

1. The diagram represents the tolerable (minimum) outcomes for buildings of any earthquake rating, at any level of shaking.
2. For any earthquake rating, the expected seismic performance represented on the vertical axis should be achieved over the full range of possible shaking levels.

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Living with uncertainty ourselves

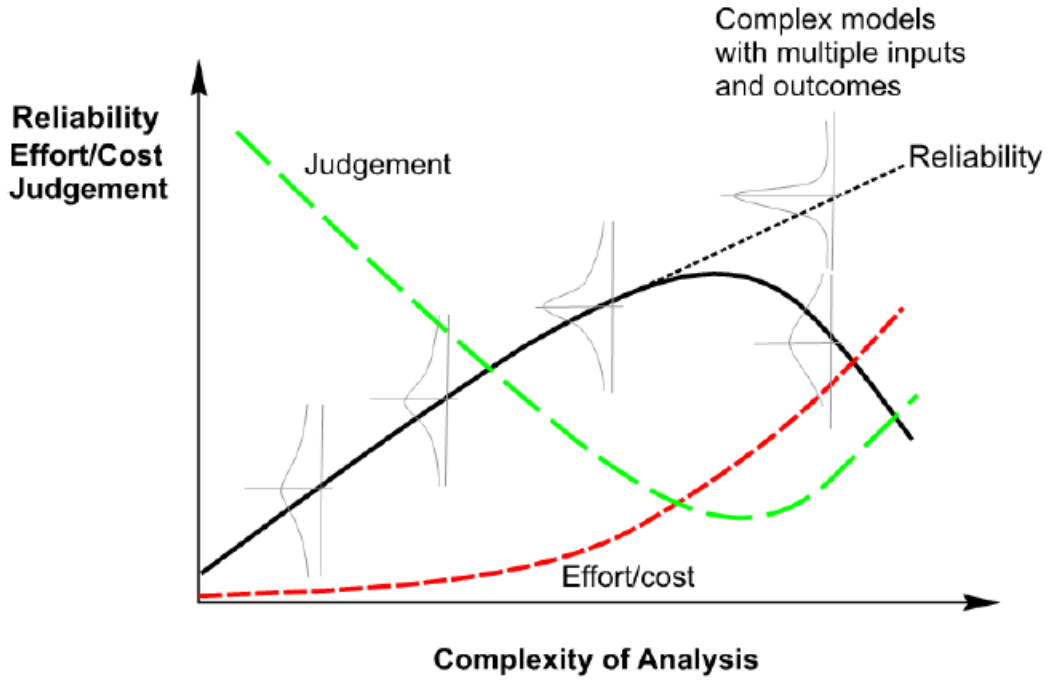

Figure C2.10: Trade-off between reliability, engineering judgement, cost and complexity of structural analysis (modified from Kam and Jury, 2015)

Conclusions

- In assessment, our inputs are highly uncertain
- Complex analysis can lead to that uncertainty being difficult to visualise
- SLaMA provides clarity of causality, and
- SLaMA provides enhanced understanding of building behaviour, particular after first failure

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