

Shake Table Test on a Low-Damage Concrete Wall Building

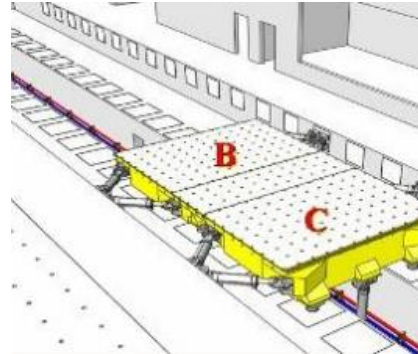
2017-7-25



NZ invited to propose an ILEE test for 2017 at Tongji University, China

Focus:

- Shake-tables
- System level verification
- Low-damage concrete systems



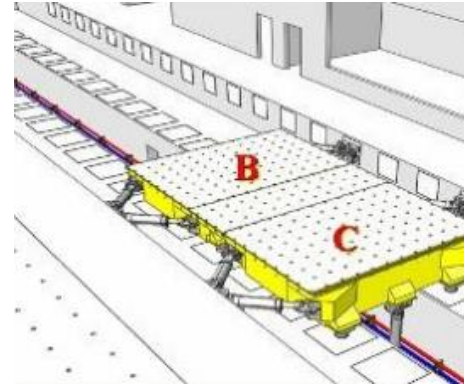
International Joint Research Laboratory of
Earthquake Engineering

- Verify seismic response of low-damage concrete wall building implementing state-of-art concepts
- Verify practical construction details used in low-damage buildings
- Investigate interaction of the structural components (gravity and lateral systems)
- Sub objectives:
 1. Compare alternative wall-to-floor connection details
 2. Compare alternative dissipating devices
 3. Torsional / bi-directional response
 4. Diaphragm design / load paths
 5. PT walls with conventional walls

- Preliminary design finalized
- Detailed design
 - Component design (wall, frame, damper)
 - Connection detailing design (wall-to-floor, wall-to-foundation, column-to-foundation, damper connections)

Table capacity

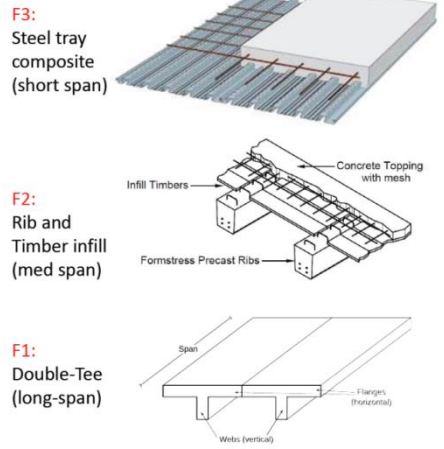
- Table dimension 10 x 6m
- 140t payload
- 500t-m weak direction, 800t-m strong axis
- Crane capacity = 50t
- Crane height = 18m
- Gate 9x9m
- Large area concrete and cutting not allowed
- Minor grouting is permitted



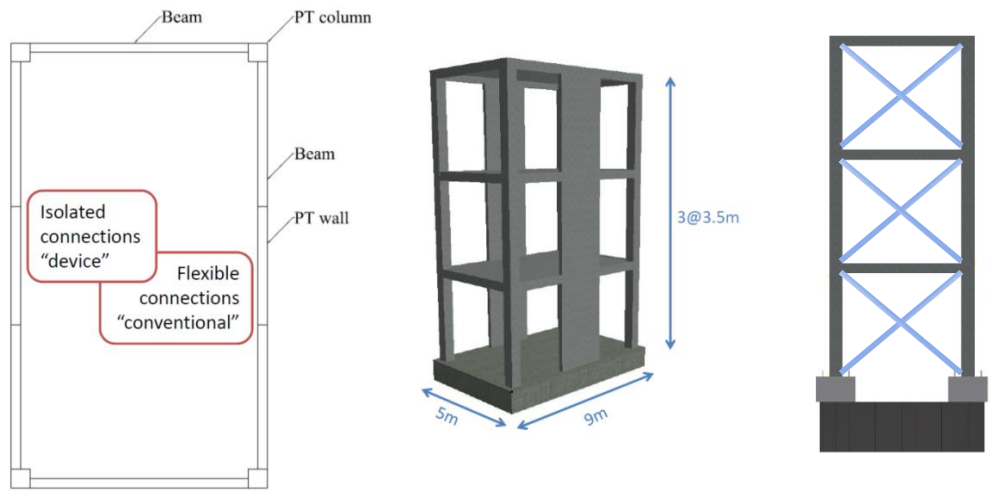
Review of previous design

- Use different floor system and configurations on each level
 - Mixture of precast and composite floor
 - Link slab on one side of double-tee
 - Tongue slotted device at center
 - Flexible floor slabs for rib and timber and comslab levels
 - Torsion induced
- Too many variables, irregularity, too complex. Torsion can still be introduced by other ways.
 - 140t payload, 500 t-m overturning moment
 - Brace hard to design, difficult to adjust stiffness at short direction

Floor system

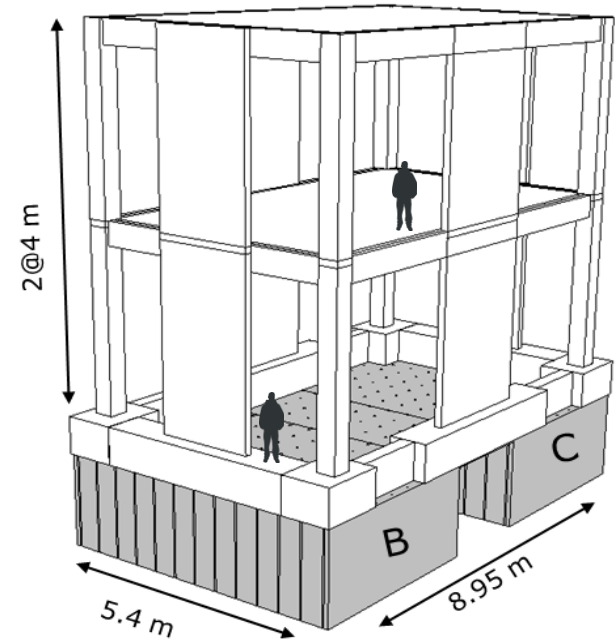
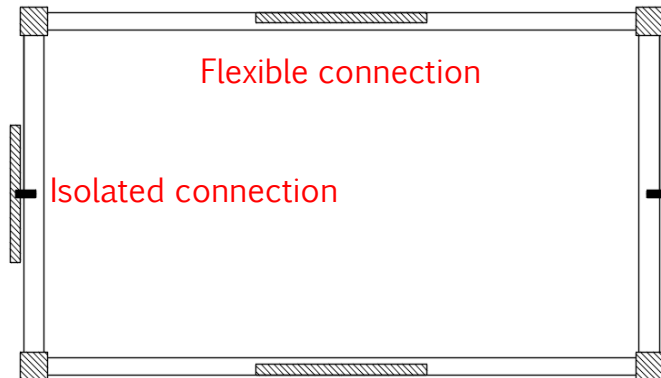
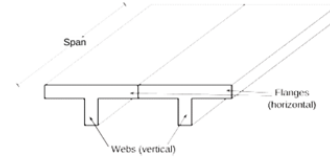
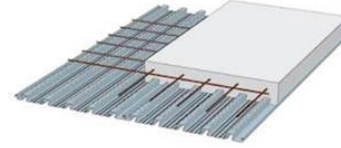


Wall-to-Floor connection

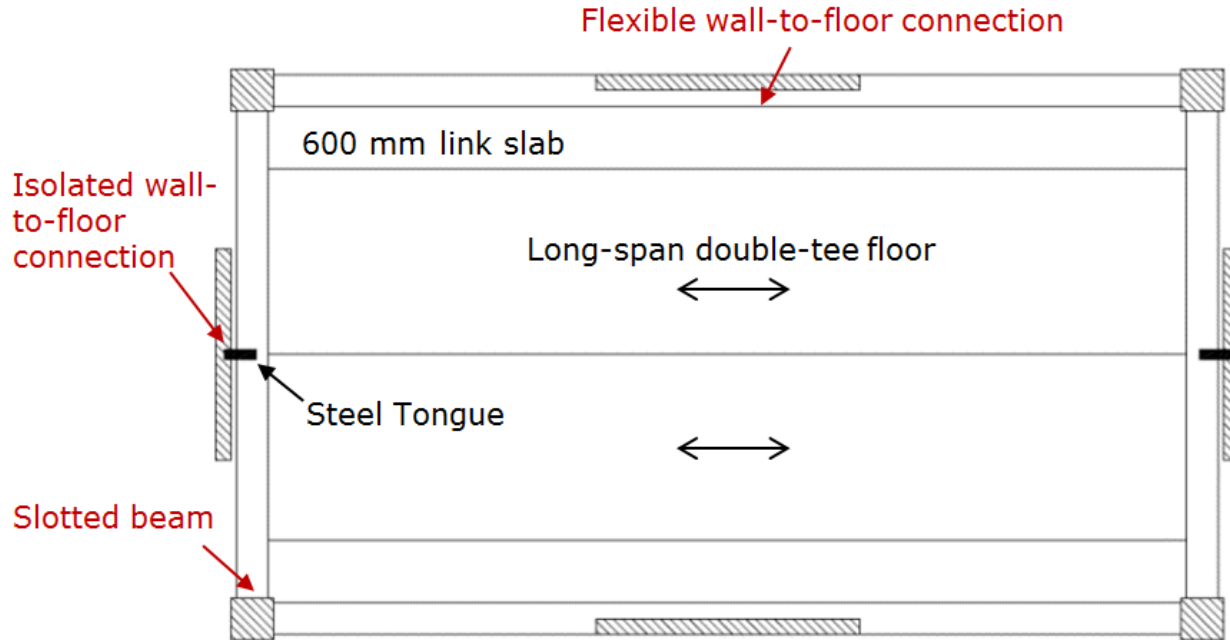


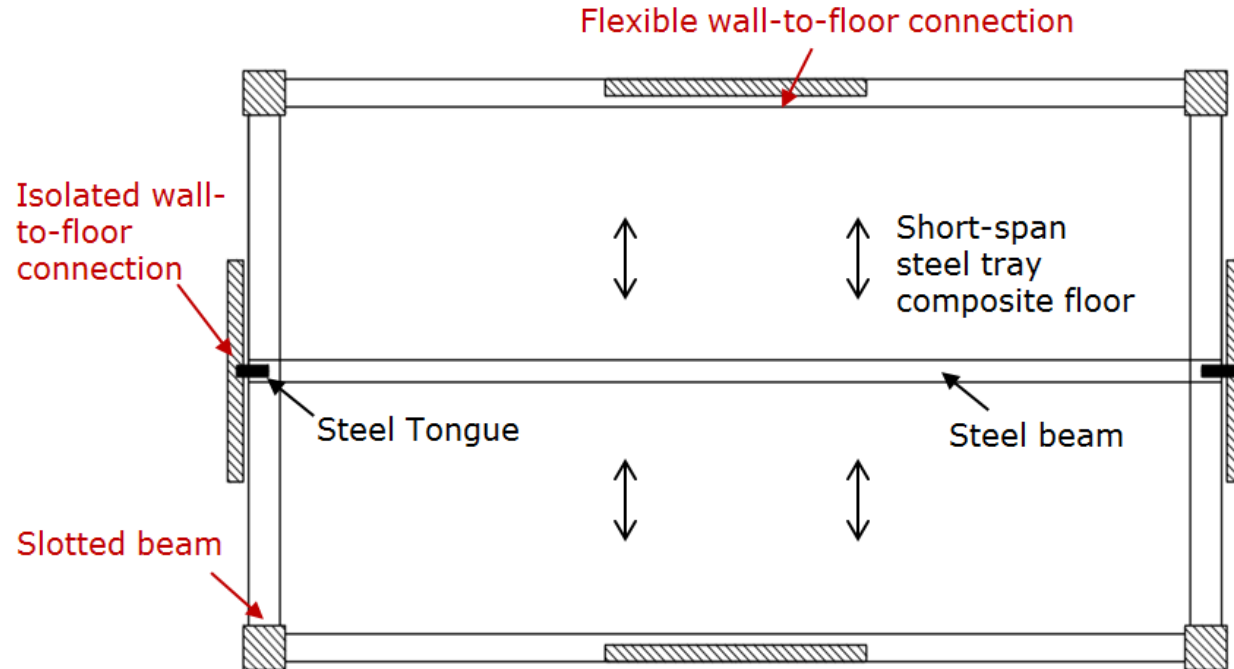
Proposed Test Building

- 2 storeys (@ full scale)
- Fit onto 2 tables joined ($10 \times 6\text{m}$)
- Post-tensioned wall system
- Gravity load resisting frames/columns
- F1 double-tee; F2 composite floor
- Interchangeable connections (wall-to-floor, beam-to-column, wall-to-foundation dissipaters)

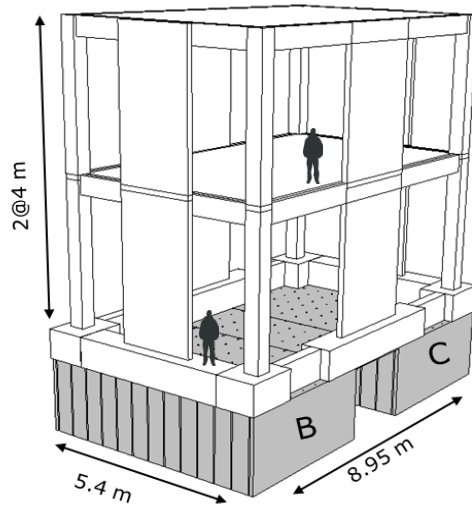


Plan – level 1

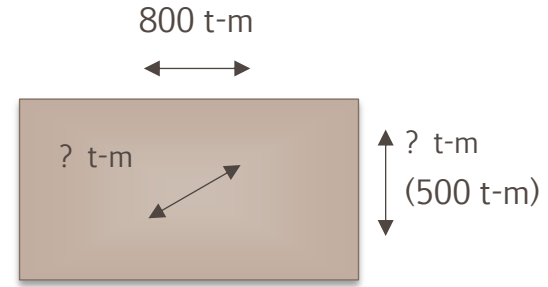




Proposed Test Building



| | 2 storeys |
|---------------|-----------|
| Weight | 135.7 t |
| Height | 8 m |
| Design moment | 328 t-m |



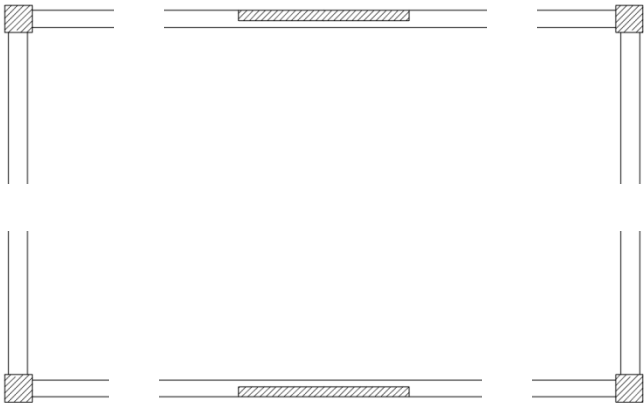
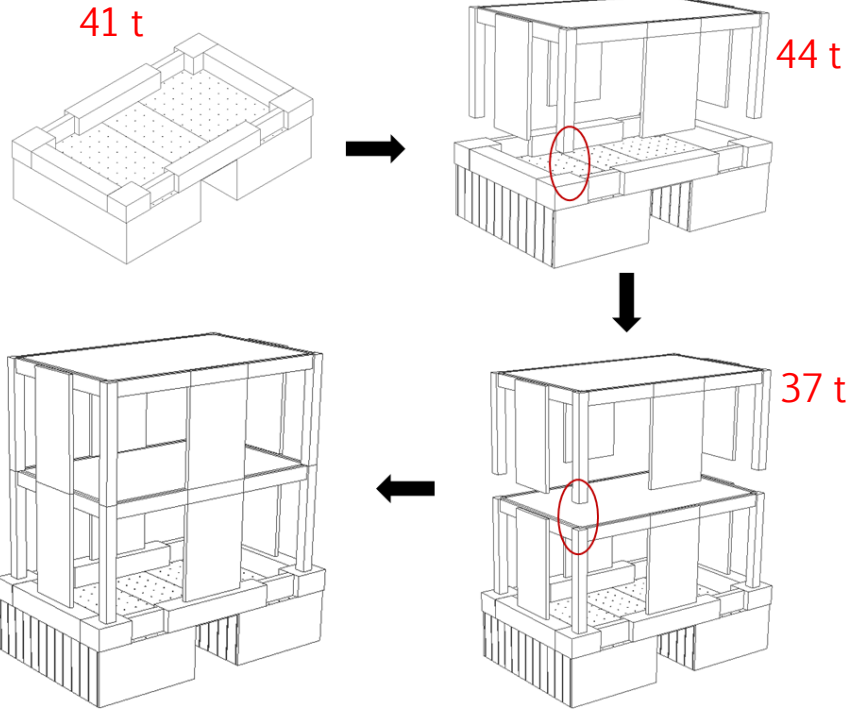
Dimension and weight

| Member | Size (mm) |
|-----------------------|----------------|
| Columns in all levels | 400 x 400 |
| Beams in all levels | 400 x 300 |
| Walls at x direction | 150 x 2500 |
| Walls at y direction | 150 x 2000 |
| Double-Tee floor | 300TT |
| Composite floor | Ultra-span 130 |

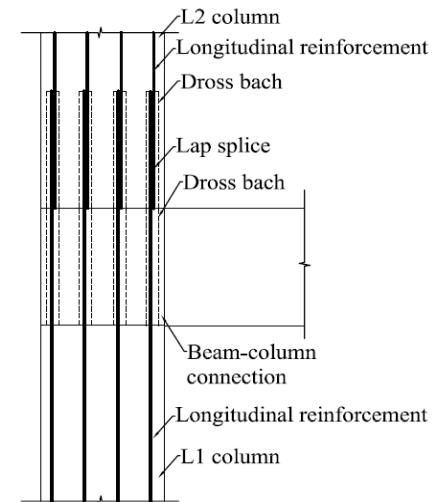
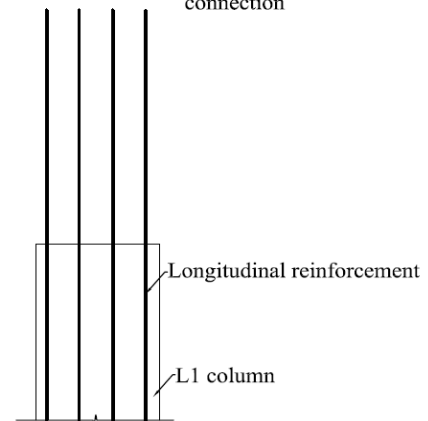
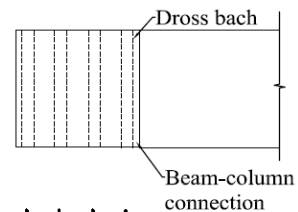
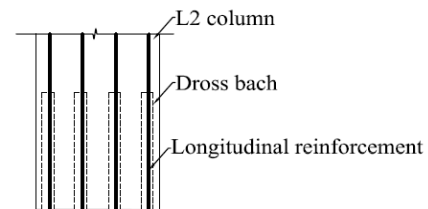
| Level | Self - Weight (t) | | | | | Added mass (t) | Total (t) |
|--------------|-------------------|--------|-------|-------|--------------|----------------|--------------|
| | Wall | Column | Beam | Floor | Total | | |
| Foundation | | | | | 41.20 | | |
| Level 1 | 12.96 | 6.14 | 7.08 | 17.32 | 43.50 | 7 | |
| Level 2 | 12.96 | 6.14 | 7.78 | 10.07 | 36.95 | 7 | |
| Total | 25.92 | 12.28 | 14.86 | 26.49 | 121.7 | 14 | 135.7 |

Construction method

- Crane capacity = 50t
- Gate 9x9m
- Large area concrete and cutting not allowed
- Minor grouting is permitted



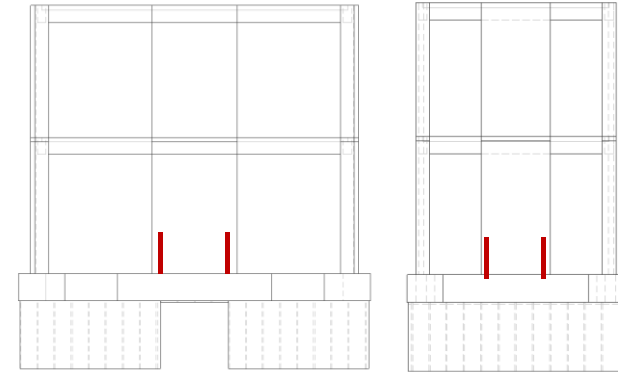
Frame – column joints



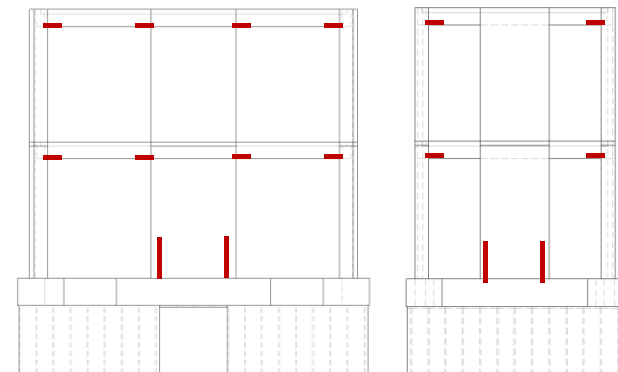
Test variations

| Design case | Test Variation | Design drift | Energy dissipating device | | Deliberate torsion |
|-------------|----------------|--------------|---------------------------|--------------------|--------------------|
| | | | Wall base | Beam-column joints | |
| I | #1 | 2% | Steel fuse | N/A | No |
| II | #2 | 1% | Steel fuse | N/A | No |
| III | #3 | 1% | Steel fuse | Steel fuse | No |
| | #4 | 1% | Viscous damper | Steel fuse | No |
| | #5 | 1% | Viscous damper | HF2V | No |
| | #6 | 1% | Viscous damper | HF2V | Yes |
| | #7 | 1% | Viscous damper | HF2V | Yes |
| | | | | | |

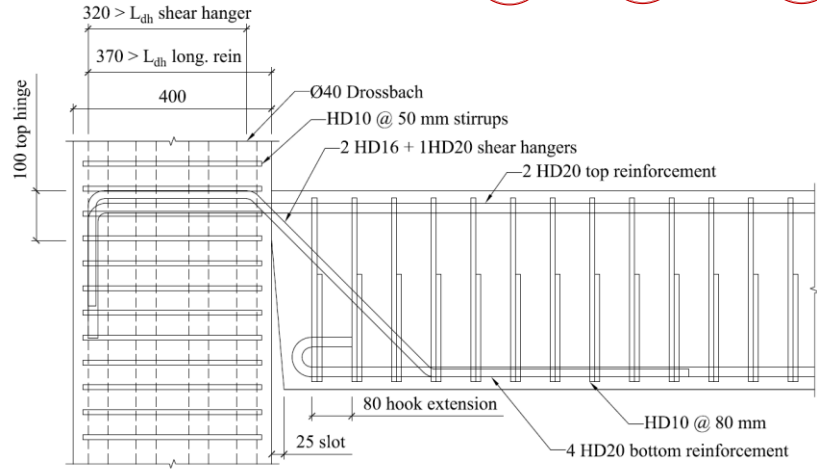
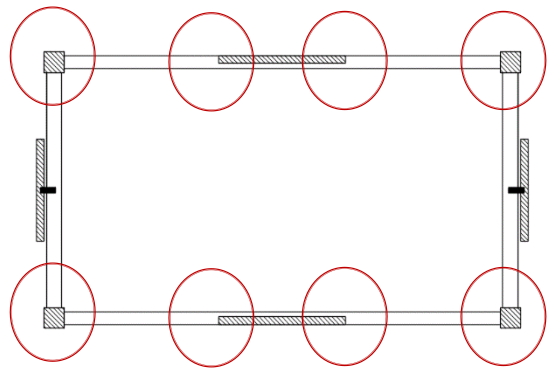
Drift = 2% & 1%, damping 5%



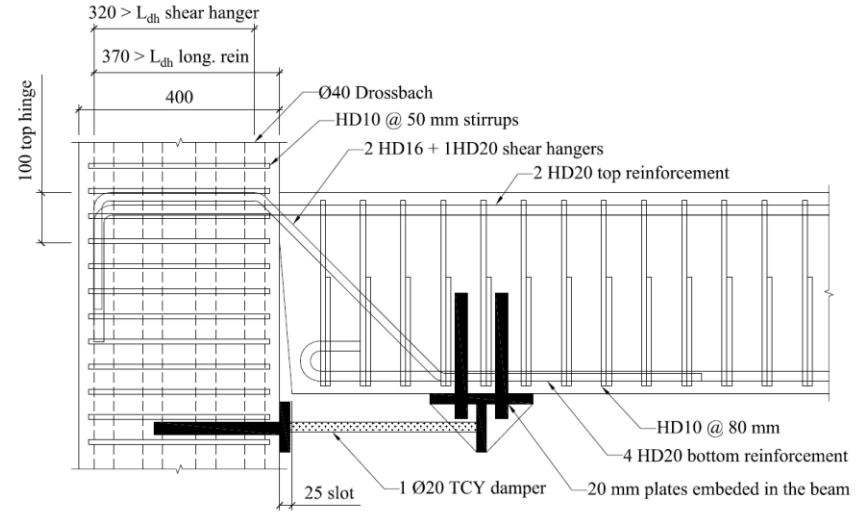
Drift = 1%, damping 10-12%



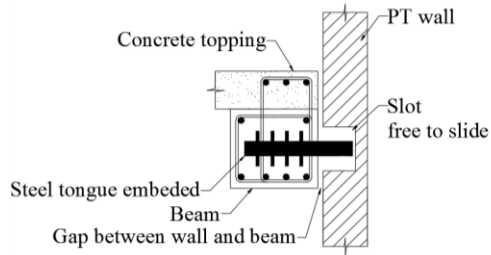
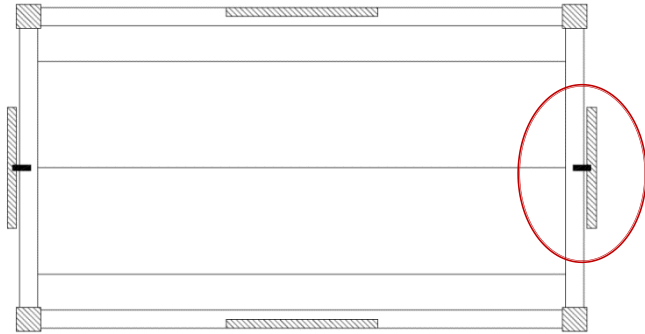
Frame – slotted beam joints



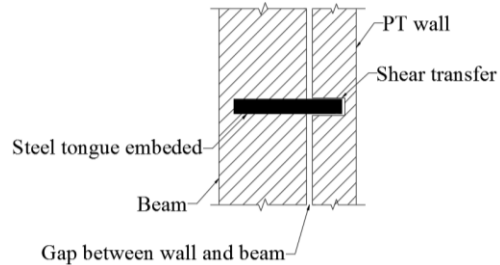
- With energy dissipation devices
- Without energy dissipation devices



Wall-to-floor connection - Isolated



(a) Elevation



(b) Plan



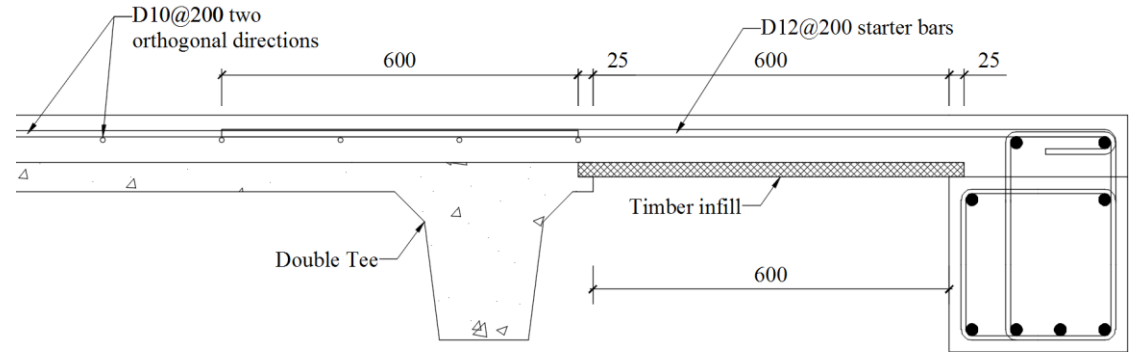
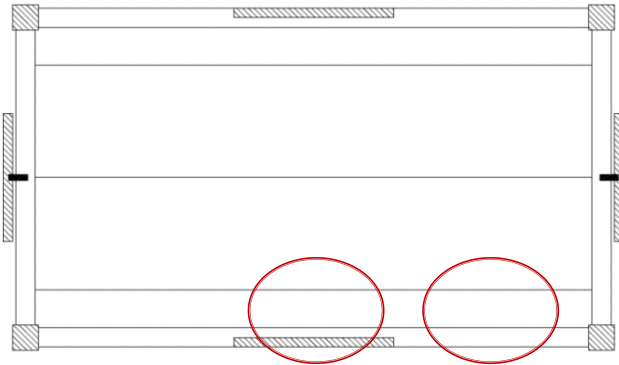
Steel tongue attached to floor unit

Armoured slot in wall



- Transfer of horizontal forces in bearing
- Free to slide vertically to eliminate displacement incompatibility

Wall-to-floor connection - Link slab flexible



THANK YOU! QUESTIONS?

