Effect of Podium Interferences on the shear force distribution in RC walls supporting buildings

Mehair Yacoubian,
Department of Infrastructure Engineering, The University of Melbourne

Nelson Lam,
Department of Infrastructure Engineering, The University of Melbourne

Elisa Lumantarna,
Department of Infrastructure Engineering, The University of Melbourne

John L. Wilson
Centre for Sustainable Infrastructure, Swinburne University of Technology
Podium-tower building configuration is an attractive alternative that is widely used in contemporary constructions.

Wide podium structures can cater for multiple towers.

The seismic performance of podium-tower buildings has not been widely covered in the literature.

Few recommendations have been set-forth by the PEER/ATC in the advent of performance-based earthquake engineering of tall buildings.
Backstay effect
Results in high shear reversals at (and below) the interface level

High torsional moments imposed on the podium by towers
Other issues.....
Incompatible (unequal) wall displacement is the direct result of the asymmetric podium restraint on the tower walls/cores.
Incompatible wall displacements

Generation of In-plane strutting forces in the connecting floors/beams

Local increase in shear forces and bending moments on tower walls
Analyses on 2D Planar Podium-Tower Sub assemblages

Significant shear force redistribution occurs when tower walls are offset from the centre of the podium by virtue of the slab in-plane compatibility forces....
Effect of rigid-diaphragm constraint

Rigid diaphragm constraint: All horizontal displacement of nodes (at a specific level) are **Identical**

Rigid diaphragm: Displacements of the walls are compatible

Explicitly modelled connecting diaphragms
Parametric studies on representative 2D sub-assemblage models

- Podium-Building height ratio
- Tower eccentricity
- In-plane stiffness of the main back-stay slab
- Relative stiffness of connected walls
- Podium-Building height ratio
Validation-3D Case study buildings
With rigid diaphragm constraints assigned at each level

≈ 40% increase in shear demands

Explicitly modelled slabs
Floor slabs were modelled as inelastic beam elements with effective width.
Influence of Rigid-diaphragm assumption on the inelastic response of the building

High shear concentrations in the interior core due to slab-wall interaction
Interaction between primary and secondary Lateral load resisting systems

At first yield of coupling beams

At maximum base shear
Discrete Modelling of Shear Failure in Interior Walls

- Equivalent material representing podium stiffness
  - Inelastic (case-1)
  - Elastic (case-2)

Modelling Validation

- Link elements representing in-plane stiffness of main backstay floors

(a) L1W2 [29]
(b) M4 [30]
Axial collapse proceeding shear failure of the **interior** wall.

**Graph 1:**
- **Elastic Podium**
- **Inelastic Podium**
- 25% increase in displacement capacity

**Graph 2:**
- **I**
- **II**
- **III**
- **IV**

**Graph Key:**
- **Inelastic Podium**
Several key recommendations for practitioners are summarised as follows:

1- Explicit modelling of the floor slabs in between these two height limits: (i) two stories above the podium and (ii) 60% of the height of the podium.

2- Alternative design procedures to reduce podium restraints on the tower walls by the use of properly detailed expansion or settlement joints at the podium-tower interface.

3- Use of procedures stipulated in PEER/ATC 72-1 for the design and detailing of floor slabs in locations where high strutting forces are expected.

4- Consideration of interactions between primary and secondary gravity systems in the lateral analysis of the type of buildings considered in this study.
Thank you

Questions?