Optimum Frame to Decrease Torsion Effects in Wood Soft Story

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Introduction & Background

Why this study conducted

- Peer review of group, indicated that current frames mandated by city of LA are over strength the weak-line and may cause either negative torsion diaphragm capacity problem.

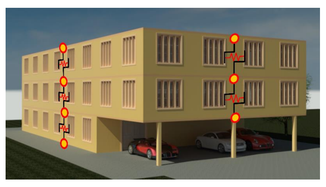
Approach

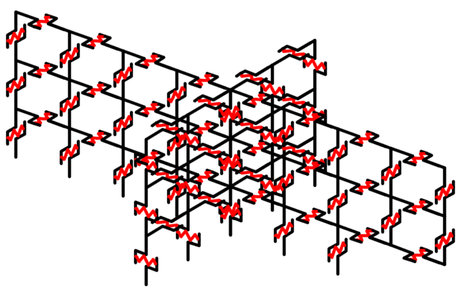
Provisions

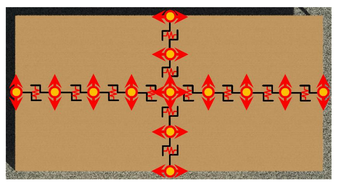
- ATC-116
- LA City Ordinance
- FEMA P-807
- FEMA P-695
- ASCE-41

Numerical model (Using OpenSees)

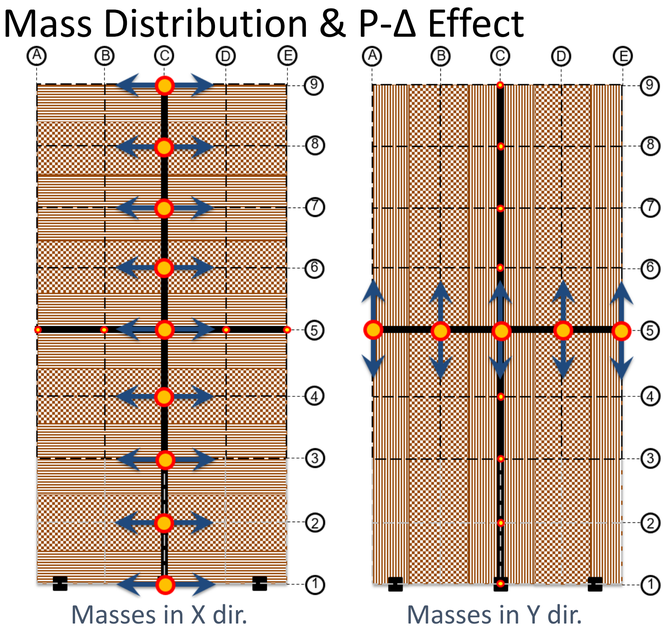
- Geometry





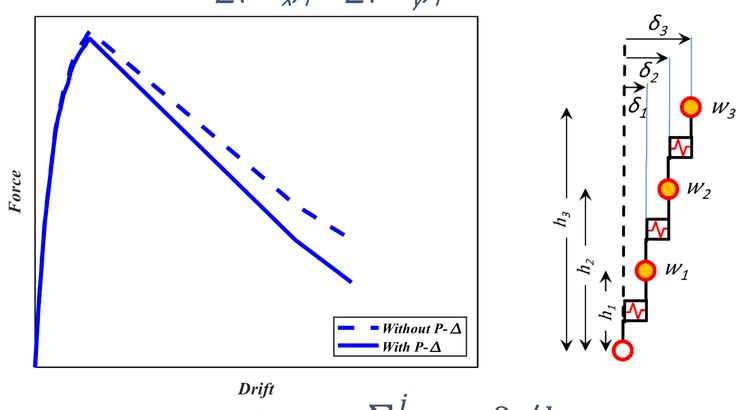


- Mass Distribution & P-Δ Effect



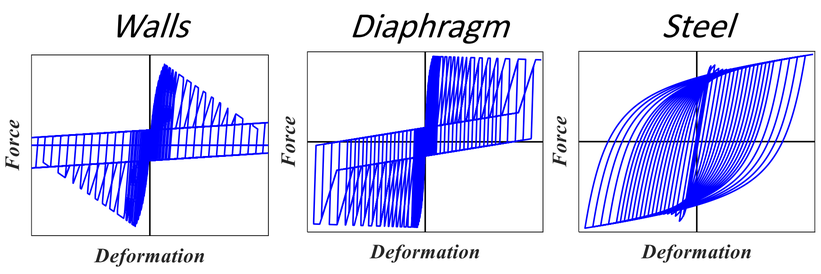
Masses in X dir. Masses in Y dir.

$\sum(M_x)_i = \sum(M_y)_i$



P-Δ Effect in j^{th} floor: $-\sum_{i=1}^{j} w_i \delta_i / h_i$

- Materials Backbone



Approach (Cont.)

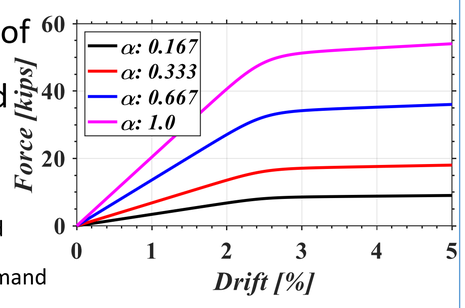
Diaphragm Capacity

- Diaphragm capacities considered in procedure
  - **100 plf:** → aged buildings
  - **300 plf:** → newly built buildings
  - **Rigid:** → extreme condition
- All types of diaphragms are assumed **axially rigid**.

Frame Property and Location

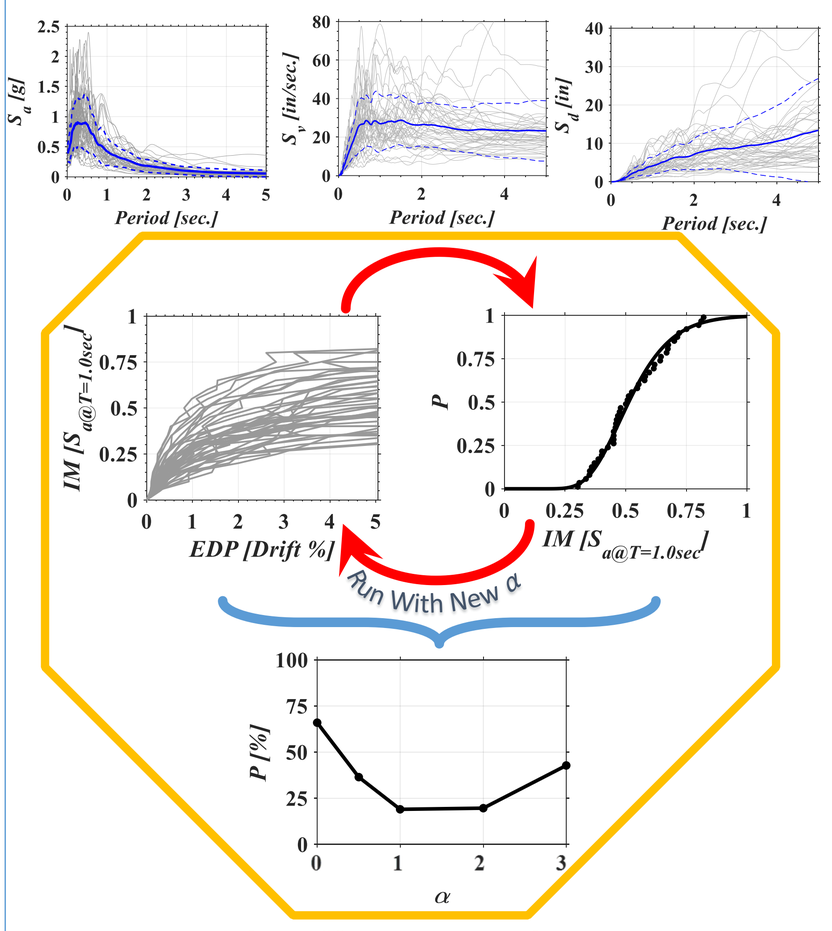
- **1-bay moment frame** located in opening line designed based on **current LA ordinance**.
- **Strength** & **Stiffness** of the frame are modified using α^* **factor**.

* α=1: base shear strength demand
* α=3: drift controlled strength demand

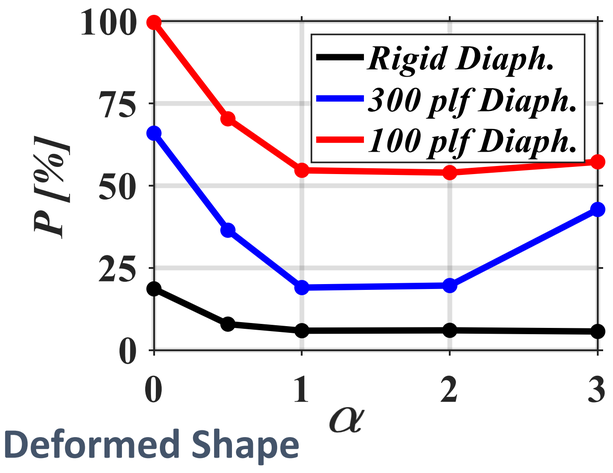


Analysis

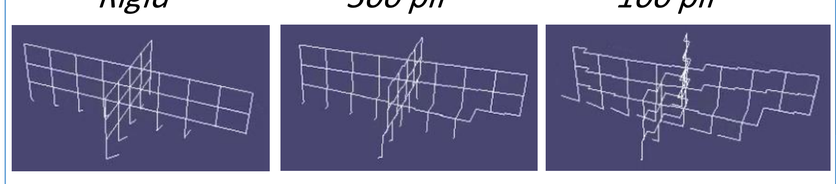
- Incremental **D**ynamic **A**nalysis **(IDA)**



Repeat with Different Diaphragm Capacity



Deformed Shape

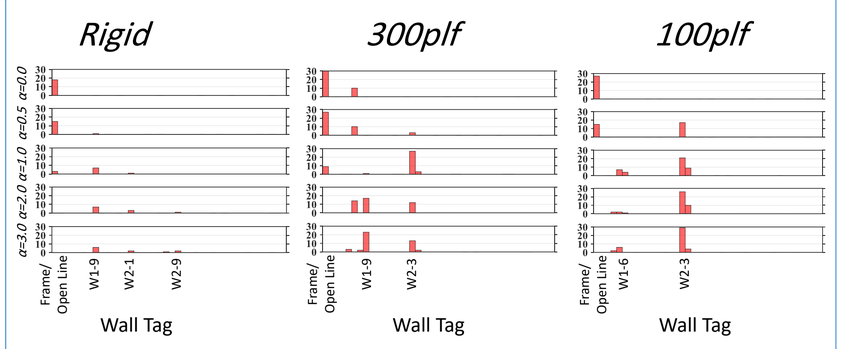


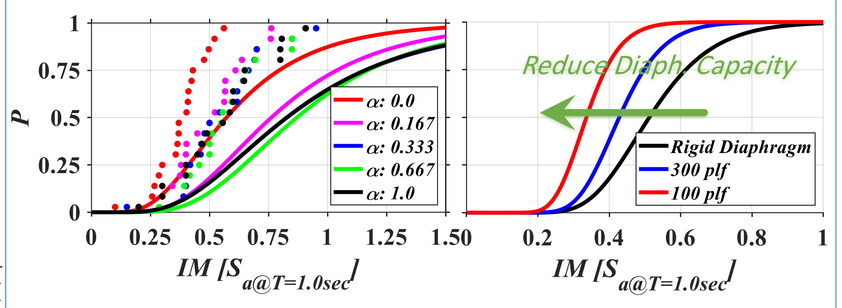
Whole story goes off and cause collapse

In Between

Collapse occur due to punching through diaphragm

Results

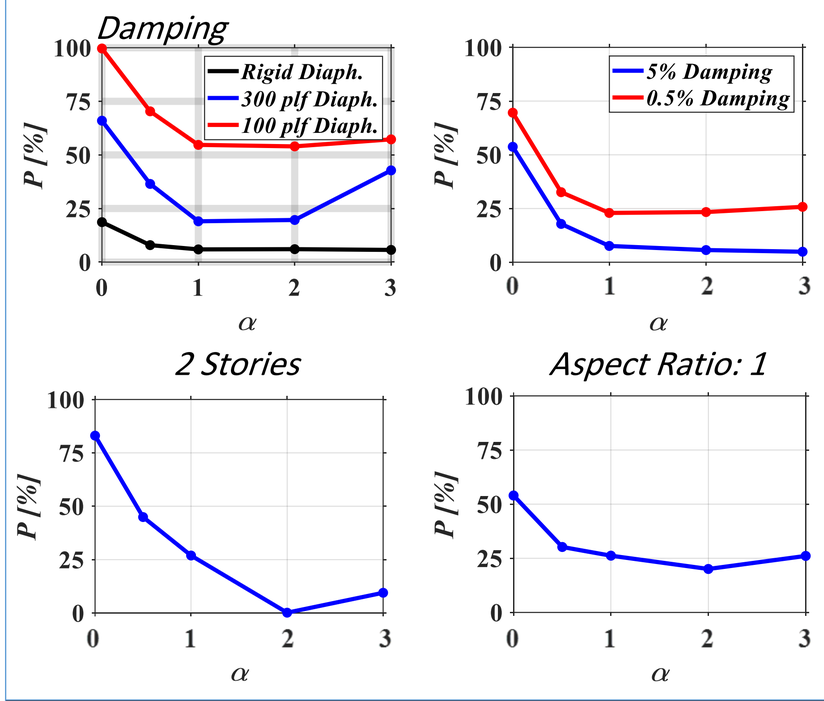




Adjusted Fragilities Parameters

Diaph.	α=0		α=0.5		α=1.0		α=2.0		α=3.0	
	S_{CT}	β	S_{CT}	β	S_{CT}	β	S_{CT}	β	S_{CT}	β
Rigid	0.82	0.40	0.86	0.41	0.87	0.43	0.88	0.43	0.88	0.42
300 plf	0.69	0.37	0.75	0.39	0.81	0.41	0.81	0.41	0.79	0.44
100 plf	0.54	0.37	0.68	0.39	0.71	0.37	0.72	0.38	0.72	0.38

Sensitivity Study



Conclusions

- One third of current recommended stiffness is enough and optimal stiffness for frame in the opening line.
- Diaphragm capacity can affect the collapse mode severely.
- Although the considered damping ratio can affect the probability of collapse, the optimal frame will remain the same.

Acknowledgements

- **Degenkolb Engineers**
- **Mehrain Naeim International Inc.**