[4059] PUSHOVER ANALYSIS FOR PERFORMANCE BASED-SEISMIC DESIGN OF RC FRAMES WITH SHEAR WALLS

Y.Fahjan[1]; B. Doran[2]; B.Akbas[1]; J.Kubin[3]

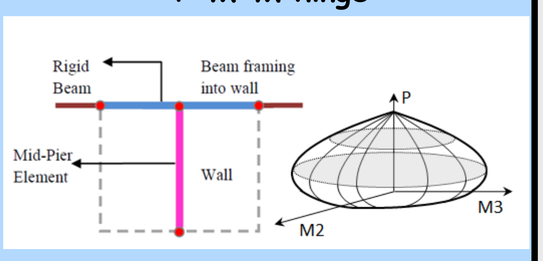
[1] Gebze Institute of Technology, Istanbul, Turkey
[2] Yıldız Technical University, Istanbul,Turkey
[4] Prota Eng.Comp., Istanbul, Turkey

SUMMARY

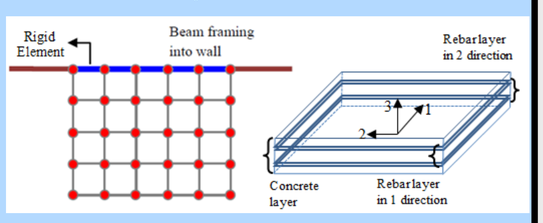
Performance-Based Design requires rigorous nonlinear analysis. Nonlinear static analysis (pushover analysis) under constant gravity loads and monotonically increasing lateral forces during an earthquake until a target displacement is reached is generally carried out as an effective tool for performance based design. For nonlinear analyses of shear walls, the nonlinear material model of mid-pier frame element is generally based on plastic hinge concept located at plastic zones towards the ends of structural elements or distributed along the member span length. The nonlinear behavior of shells is generally modeled using multi-layer shell element with layered material model. This paper evaluates and comments on the consistency of different approaches for nonlinear shear wall modeling that are used in practice. For this purpose, 3, 5 and 7-story reinforcement concrete (RC) frames with shear walls are analyzed using nonlinear two dimensional nonlinear finite element method under constant gravity loads and incrementally increased lateral loads. The analysis results for these models are compared in terms of overall behavior of the structural systems.

MODELLING TECHNIQUES FOR RC SHEAR WALLS

Mid-pier frame with plastic P-M-M hinge



Multi-layer shell elements

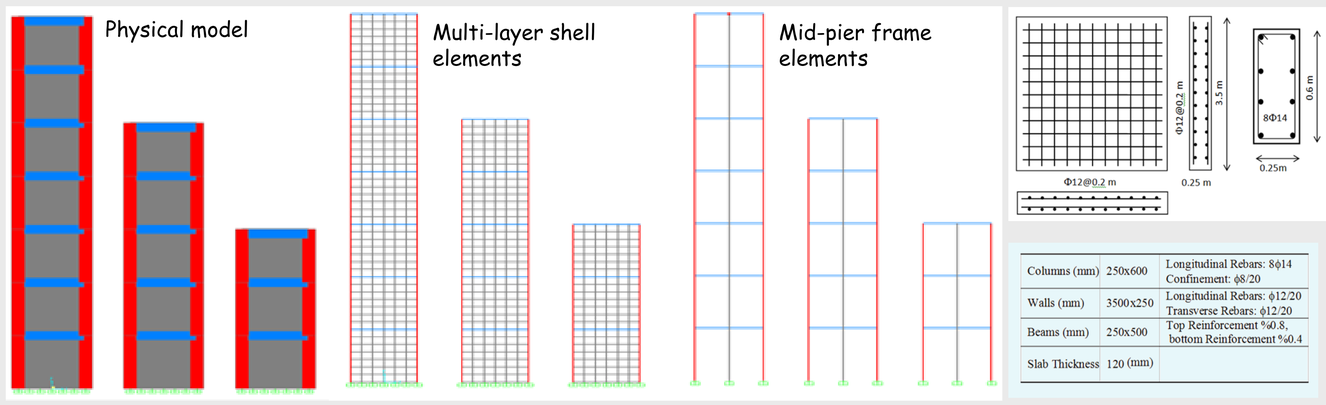


NUMERICAL EXAMPLE

Concrete and reinforcement grades used for structural members were assumed to be 14 MPa and S420, respectively. This corresponds to a modulus of elasticity value of 2.615x107 kN/m2 and 2x108 kN/m2 according to Turkish Reinforced Concrete Design Code (TS500). Three analysis models for the example building are considered using different modeling techniques of the shear walls

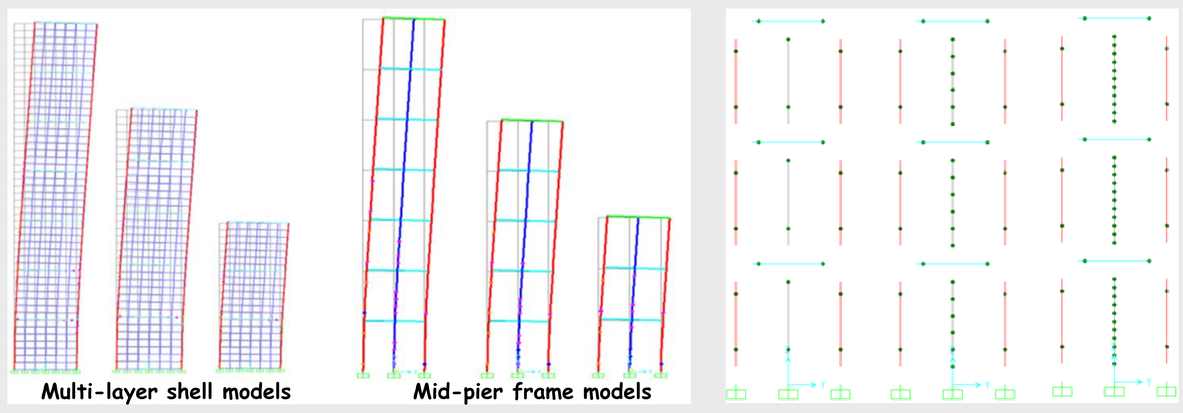
1) Shear walls are modeled by multi-layer shell elements;
2) Shear walls are modeled by mid-pier frame with plastic hinges defined according to FEMA 356;
3) Shear walls are modeled by mid-pier frame with plastic hinge computed from fiber model of the cross section.

Nonlinear Static Analyses (Pushover) are performed to explore the nonlinear behavior of proposed shear wall models using SAP2000 (CSI, 2009).

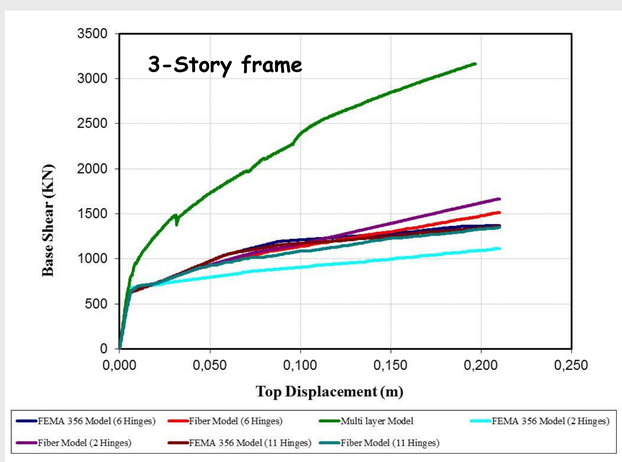


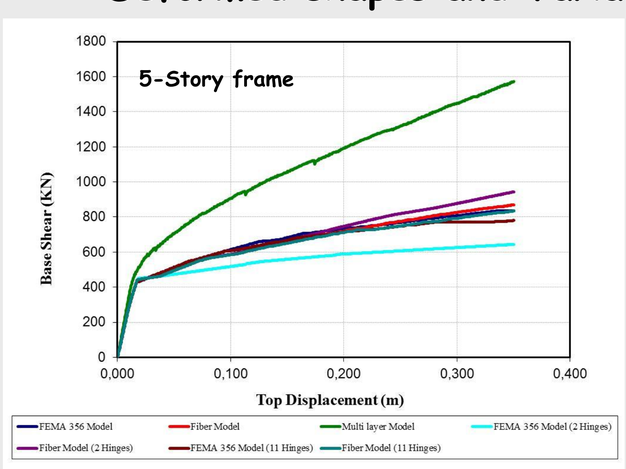
Columns (mm)	250x600	Longitudinal Rebars: 8ϕ14 Confinement: ϕ8/20
Walls (mm)	3500x250	Longitudinal Rebars: ϕ12/20 Transverse Rebars: ϕ12/20
Beams (mm)	250x500	Top Reinforcement %0.8, bottom Reinforcement %0.4
Slab Thickness	120 (mm)	

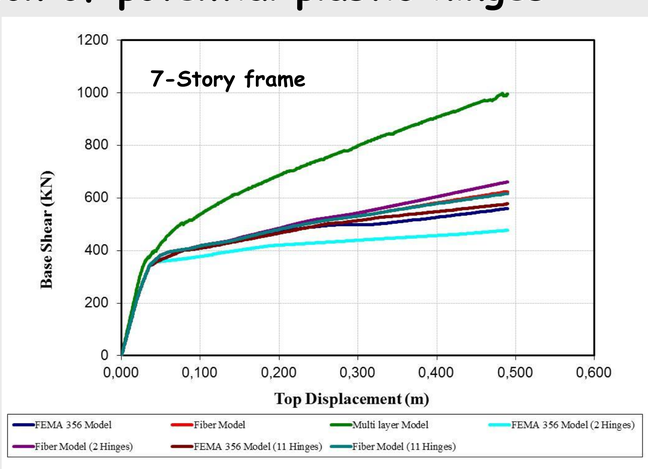
Two dimensional 3, 5 and 7-story frames FE model of RC shear wall



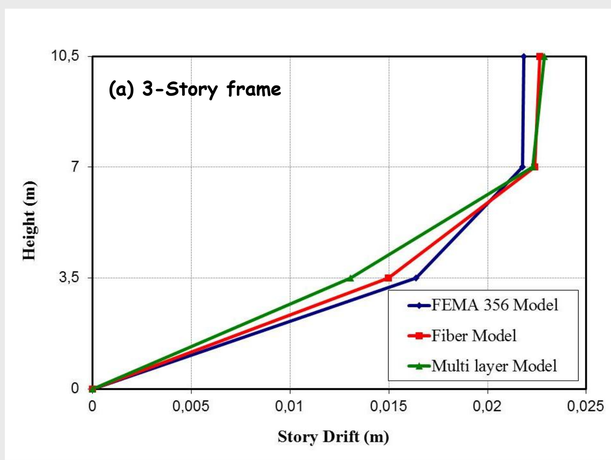
Deformed shapes and Variation of potential plastic hinges

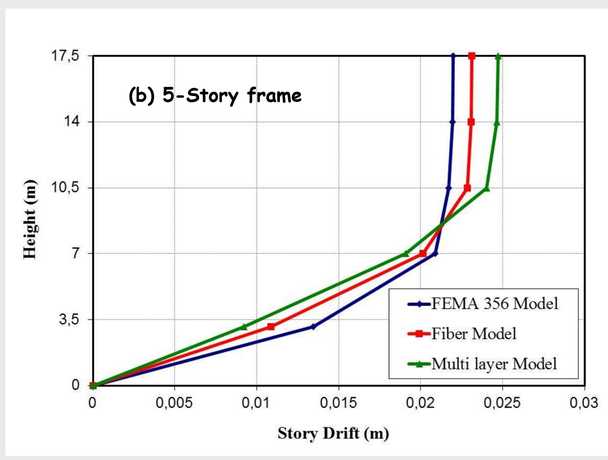


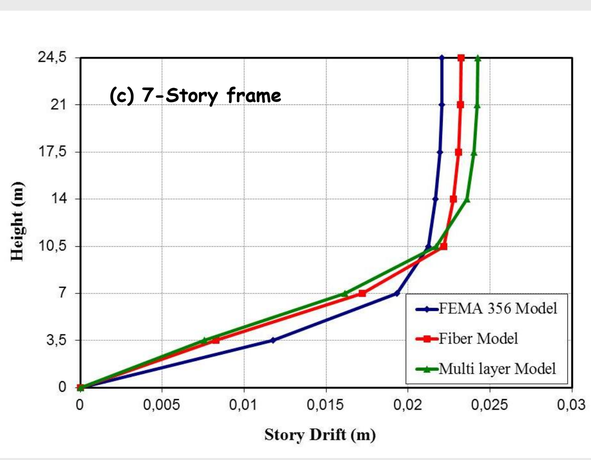




Pushover curves for different shear wall models







Inter-story drift ratios for different shear wall models

CONCLUSIONS

Based on numerical results for different frame models with shear wall, the following conclusions can be drawn.

1. The shear wall with two layers of longitudinal and transverse reinforcement bars could be modeled with multi-layer shell and mid-pier frame with plastic hinges to reflect the material nonlinearity. The plastic hinge properties of the shear wall could be defined using FEMA 356 recommendation or fiber-based hinge property. The pushover analysis based on FEMA 356 model and fiber model produced identical top displacement-base shear curves for the sample frames. These curves are approximately similar except multi-layer shell model for all cases.
2. Number of plastic hinge locations is a major key for the accurate representation of the inelastic phenomenon for the RC shear walls. FEMA 356 model with 2 plastic hinges overestimates the capacity of the structure for all cases as depicted in Figure 8.
3. Since the capacity curves for mid-pier frames with plastic hinges defined using FEMA 356 recommendation and fiber-based hinge property are identical with each other, shear walls can be modeled using mid-pier frame with plastic hinges defined using FEMA 356 recommendation.