COLLAPSE FRAGILITY OF REINFORCED CONCRETE MOMENT FRAME BUILDING UNDER PULSE-LIKE MOTIONS

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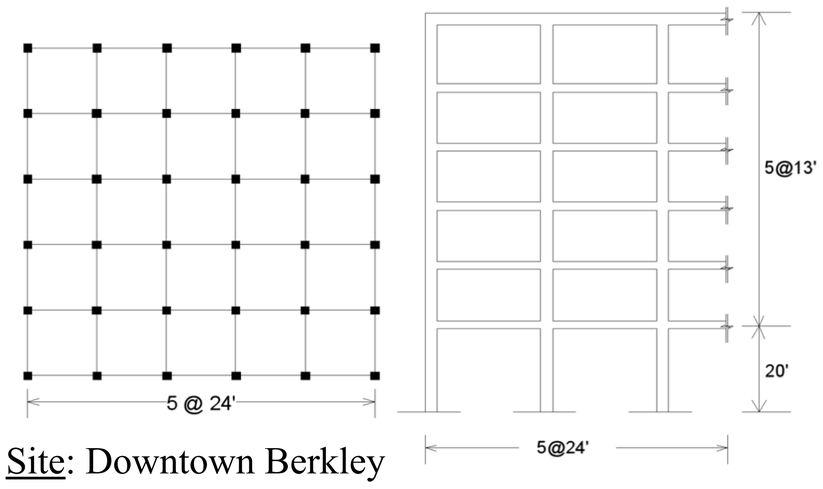
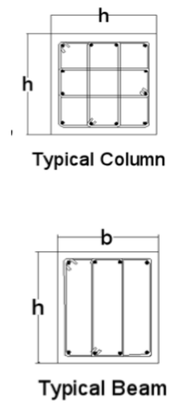
Abstract

The effect of different element and material models used to characterize the behavior of reinforced concrete components is investigated in the context of developing collapse fragilities of a typical reinforced concrete moment frame building subjected to seismic loading. Incremental Dynamic Analyses are carried out using 30 site-specific ground motions to generate demand-intensity curves. The maximum inter-story drift ratio is selected as the critical seismic demand parameter and two intensity measures were used. Findings from the study indicate that modeling choices do have a significant impact on the predicted collapse probabilities.

Building details





Site: Downtown Berkley
Codes:ASCE/SEI 7 and ACI-318
Design basis: S_s = 1.715 g; S_1 = 0.792 g.

T_1 = 1.09 sec
T_2 = 0.36 sec
T_3 = 0.20 sec

Methodology & modeling

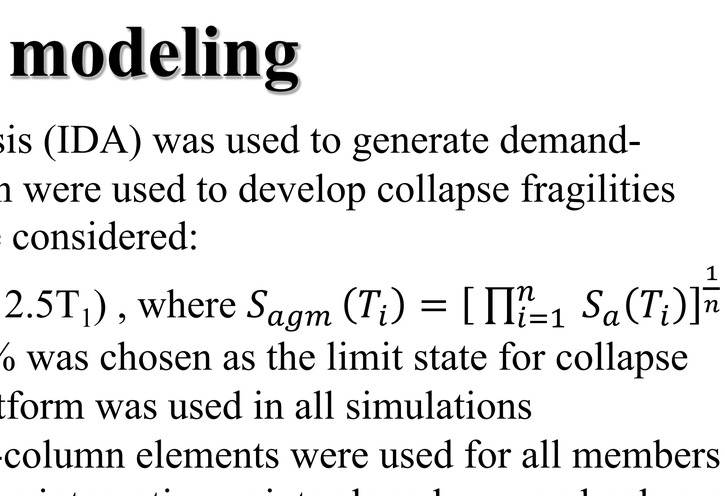
- Incremental Dynamic Analysis (IDA) was used to generate demand-intensity curves which in turn were used to develop collapse fragilities
- Two intensity measures were considered:
  - $S_a(T_1)$ and $S_{agm}(T_1, 1.5T_1, 2.5T_1)$, where $S_{agm}(T_i) = [\prod_{i=1}^{n} S_a(T_i)]^{\frac{1}{n}}$
- A peak inter-story drift of 6% was chosen as the limit state for collapse
- OpenSees computational platform was used in all simulations
- Force-based nonlinear beam-column elements were used for all members in Model A, with four and five integration points along beam and column elements, respectively.
- All members modeled as elastic elements with concentrated plastic hinges at each end in Model B.

- *Concrete02* Kent-Park material model
- *Hysteretic* model with post-peak softening for reinforcing bars

MODEL A

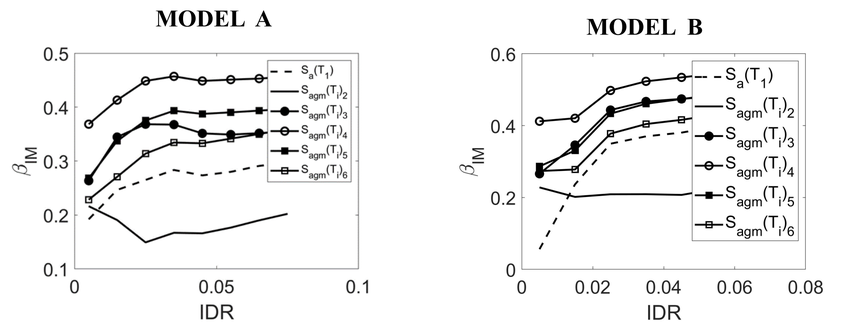
Moment-rotation behavior of the hinges modeled as uniaxial material with trilinear monotonic envelope and post-peak softening.

MODEL B



Results

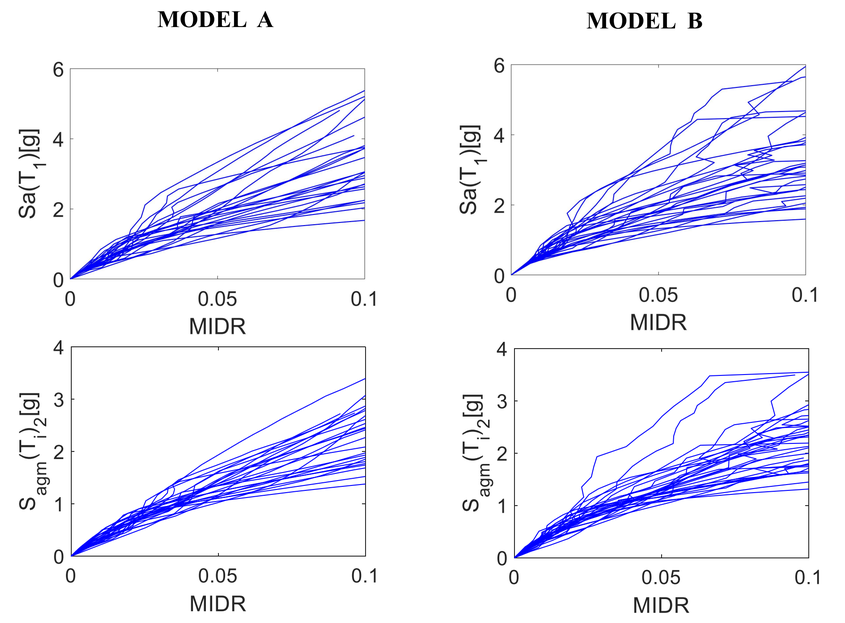
- **Dispersion of IMs for 2 models**



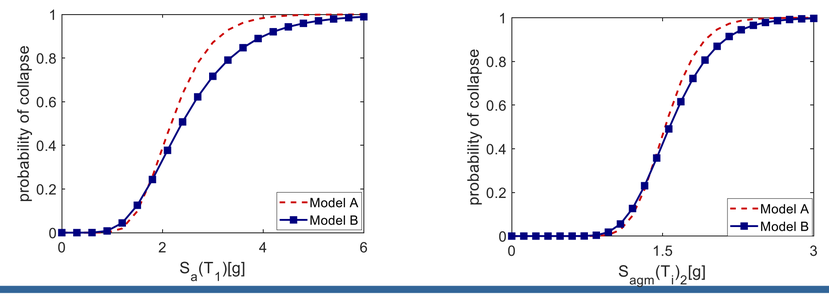
*β_{IM} is the standard deviation of the natural logarithm of IMs at target Interstory Drift Ratios (IDRs)
*$S_{agm}(T_i)_2$ is used as IM in this study, where $(T_i)_2$= [T_1, 1.5 T_1, 2.5 T_1]

Six IMs are compared:
$(T_i)_1$= [T_1], which is $S_a(T_1)$
$(T_i)_2$= [T_1, 1.5T_1, 2.5T_1]
$(T_i)_3$= [T_2, 1.5T_2, 2.5T_2]
$(T_i)_4$= [T_3, 1.5T_3, 2.5T_3]
$(T_i)_5$= [T_1, T_2, T_3]
$(T_i)_6$= [1.5T_1, 1.5T_2, 1.5T_3]

- **IDA curves for two IMs**



- **Collapse fragility functions for two IMs**



Findings

- Modeling choices have an impact in seismic collapse assessment
- Definition of collapse should be carefully evaluated
  - Has a collapse mechanism formed?
  - Non-convergence is not necessarily collapse
- Improved intensity measures can reduce dispersion in the estimated demands
- Future work: Examine relationships between IMs and dynamic properties of system; Use high fidelity models to calibrate simpler models; Extend study to range of building types; Investigate different ground motion selection methods.

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