Collapse Simulations of Buildings Under Earthquake Conditions

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Introduction

Reliable structural modeling requires analytical tools that can accurately predict the strength and stiffness deterioration of structural elements in response to earthquake conditions. Computer simulations allow engineers to test different structural ideas and concepts to find a balance between cost-effective design and structural integrity. The goal of this research project is to explore the applications of Particle Swarm Optimization to calibrate the IMK deterioration model parameters and the corresponding uncertainty quantifications of structural models under earthquake conditions.

Background

Earthquakes are one of the most destructive natural disasters known to plague urban structures in seismically active regions. Between 12,000 and 14,000 earthquakes occur annually worldwide ranging between a magnitude of less then 2.0, to surpassing 5.0 on the Richter Scale.

Northridge Earthquake

Date: January 17, 1994
Location: San Fernando Valley
Magnitude: 6.7
Damage Cost: 20 Billion
Casualties: More than 60 fatalities, 9,000 injures

Objective

- Create photo collection of building collapse by earthquakes
- Create structural models in Opensees
- Calibrate the modified IMK parameters using PSO
- Create uncertainty quantifications using MCMC

Structural Model Frames

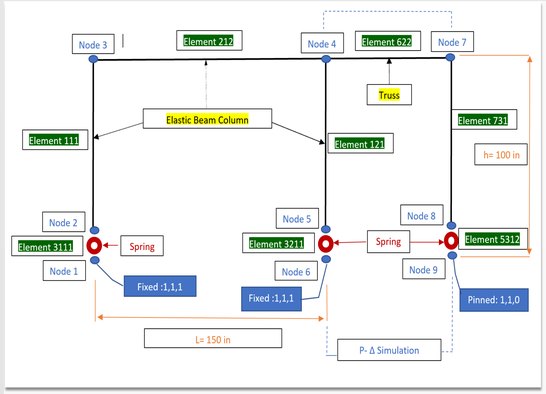


Figure 1: 1 Story, 1 Bay Frame Model

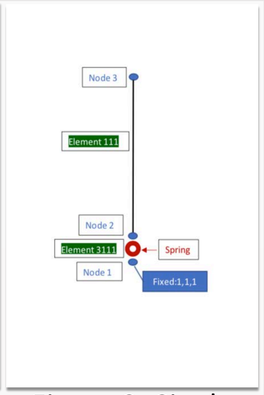
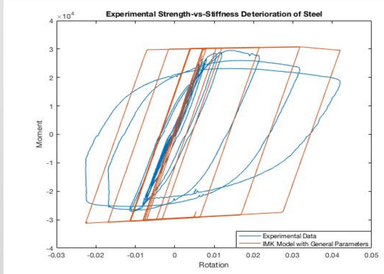
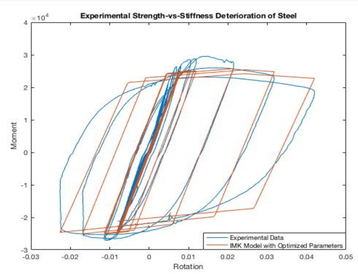


Figure 2: Single Column Model

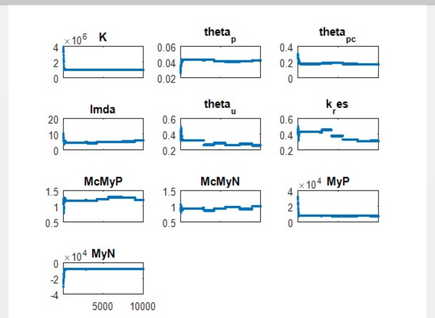
IMK and Particle Swarm Optimization





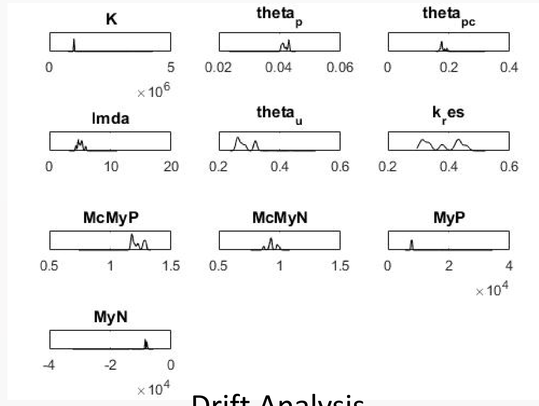
	General Parameters	Optimized Parameters
McMyP	1.15	1.73347
McMyN	1.05	1.28276
MyP	30350	23377.6
MyN	-30350	-23377.6
K	4E+06	3.22736E+06
th_p	0.025	0.0222353
th_pc	0.25	0.275686
LS	10	1.17218
ResP	0.4	0.571738
th_u	0.4	0.425687

Markov Chain Monte Carlo Uncertainty

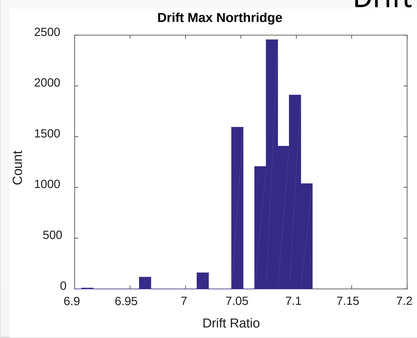


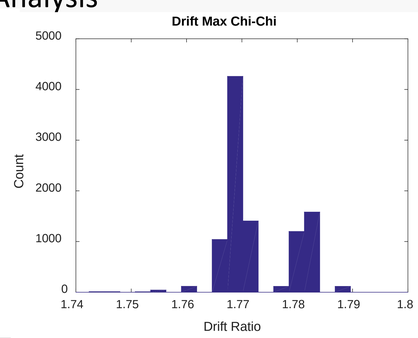
Results

IMK Parameters



Drift Analysis





Conclusions and Future Study

- Computational simulations provided a cost-effective and time-effective provision before an Earthquake takes place
- Produce reliable simulations for structural collapse under earthquake conditions.
- Multidiscipline mastery for Civil Engineering
- Given more time and computational freedom to produce more iterations could produce a more precise simulation for structural response under earthquake conditions

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