A proposed numerical model for cabinets of nuclear power plants

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Contents

Introduction

1. Seismic Damage to Electrical Equipment

Seismic damage to anchored cabinets in 1985 Mexico Earthquake (Magnitude 8)

Seismic damage to unanchored cabinets in 2010 Haiti Earthquake

Failure of bolt in cabinet

2. Previous Researches

Gupta et al. (1999) developed FE models of 16 types of electrical cabinets. The FE models were generated using the ANSYS software.

Rustogi and Gupta (2004) presented the results of the analytical model and experimental data

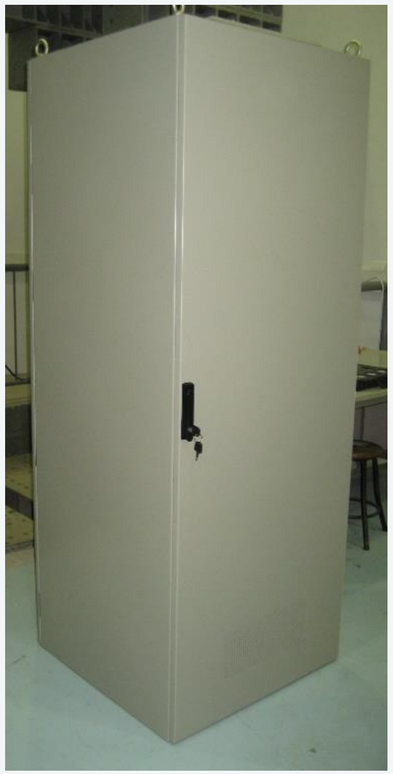
Herve et al. (2014) and Vlaski et al. (2013) studied the nonlinearity in connection of the cabinet and the floor.

3. Scope

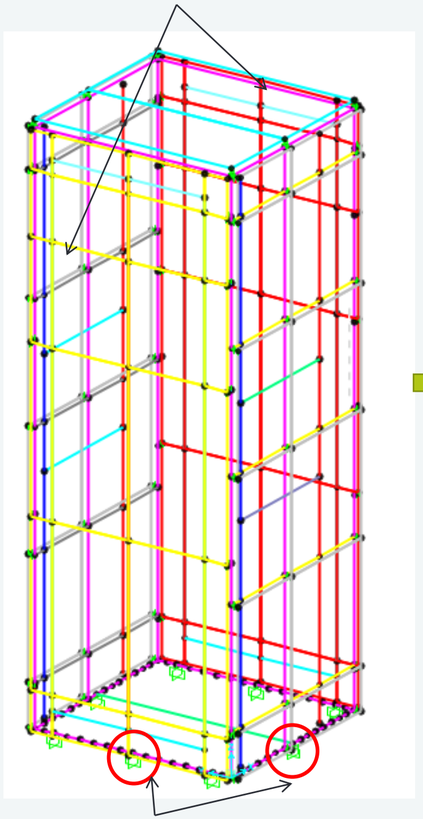
To develop nonlinear numerical models for the seismic response assessment of electric cabinet mounted on building floors.

Model and Verification

1. Model



Appearance



Beam-Column Elements

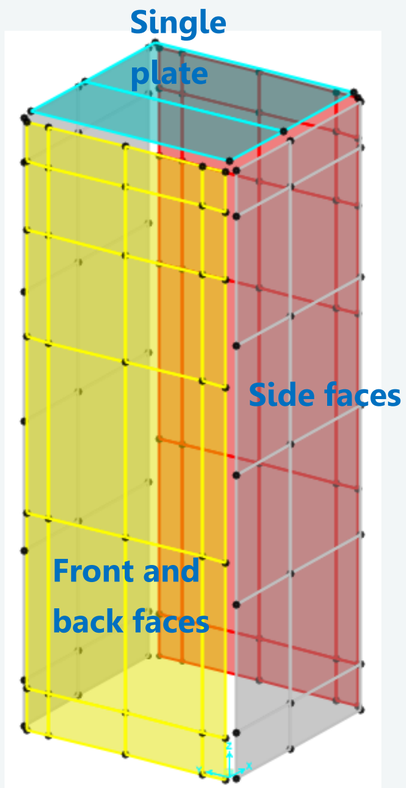
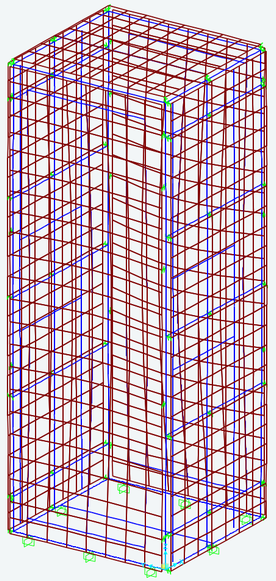


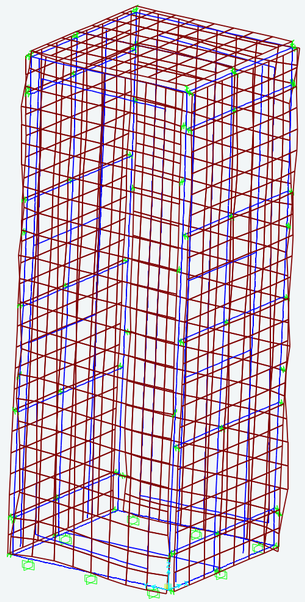
Plate Elements

2. Verification

Frequency (Hz)	Sap2000	Test
Mode 1 (Front to Back)	14.41	14.75
Mode 3 (Side to Side)	15.13	16.63

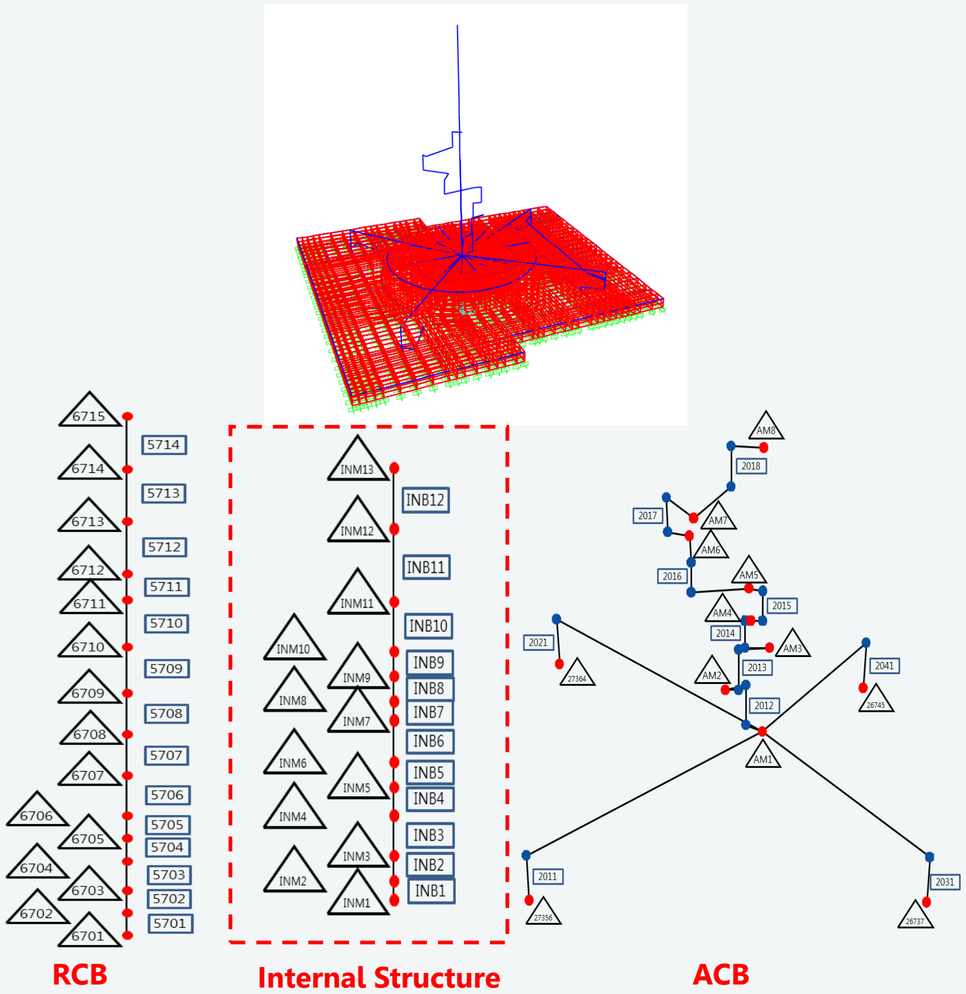


Mode 1

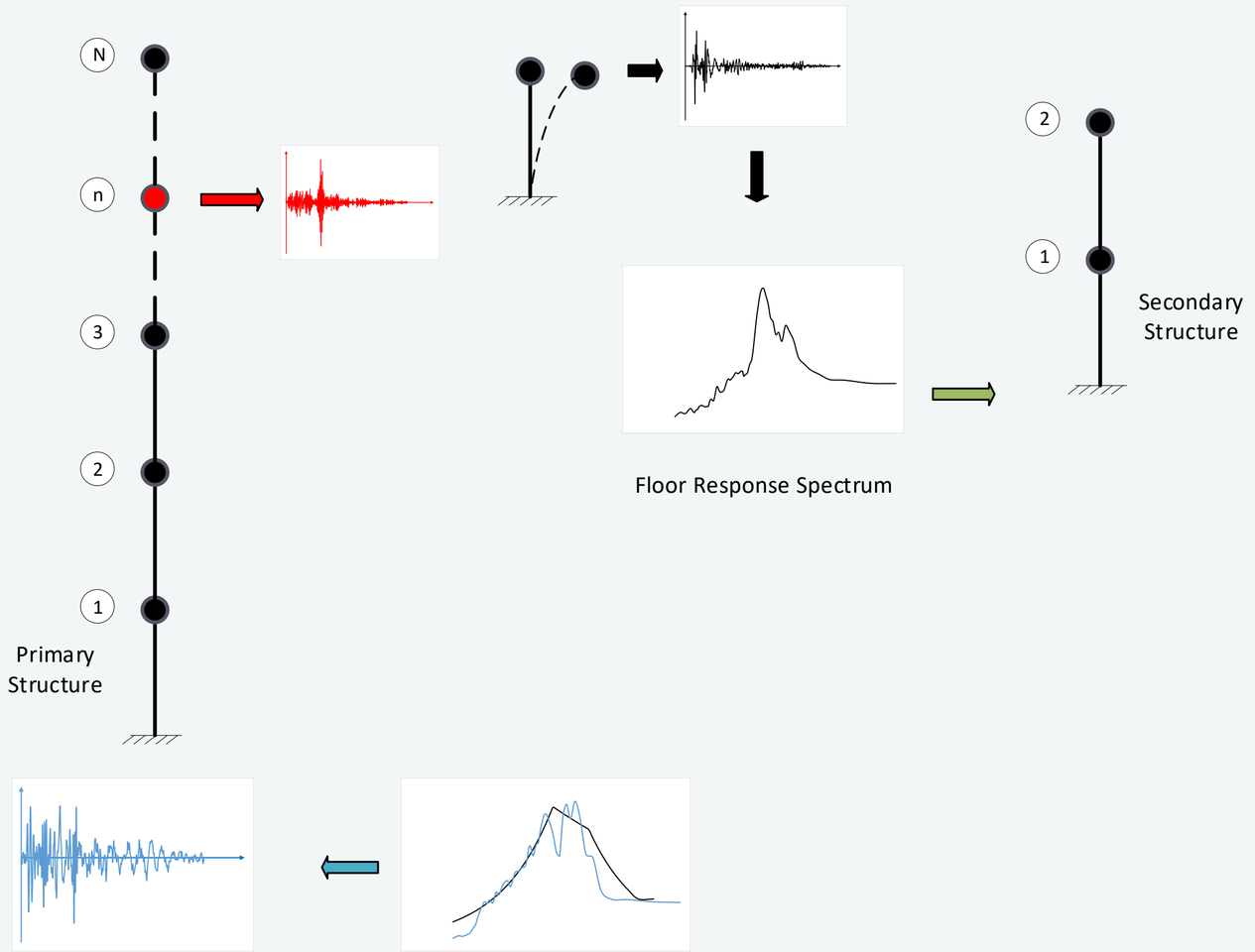


Mode 3

Methodology

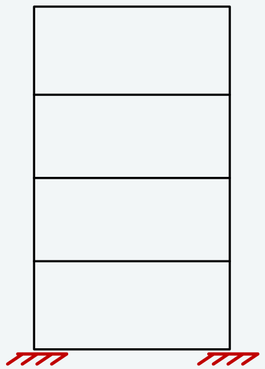


Nuclear Island of the APR1400 plant: different components of stick model



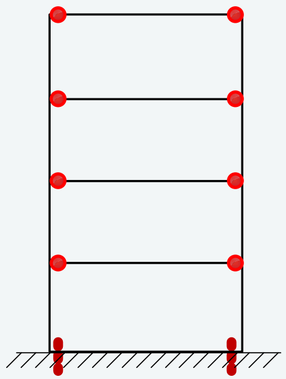
Time history method for generating floor response spectrum

Methodology



- Cabinet is modelled using the frames and plates
- Fixed boundary condition at base

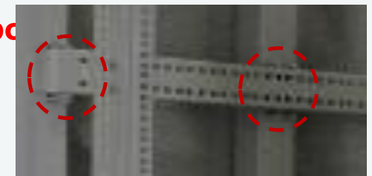
Linear Model



- Inelastic material of steel frame and plate
- Various type of boundary condition at base
- Nonlinear force-deformation relationship of joint connections

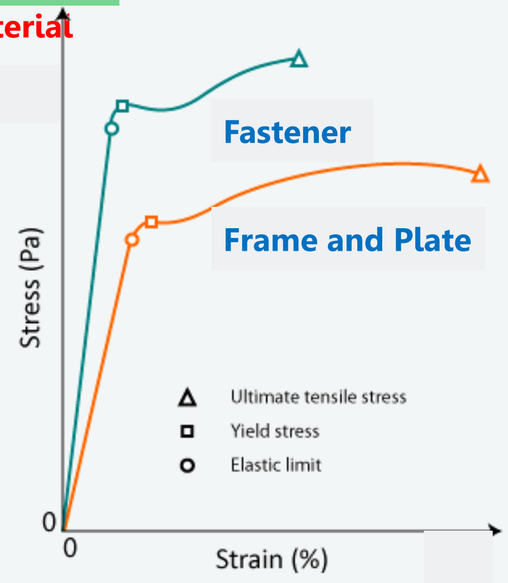
Nonlinear Model

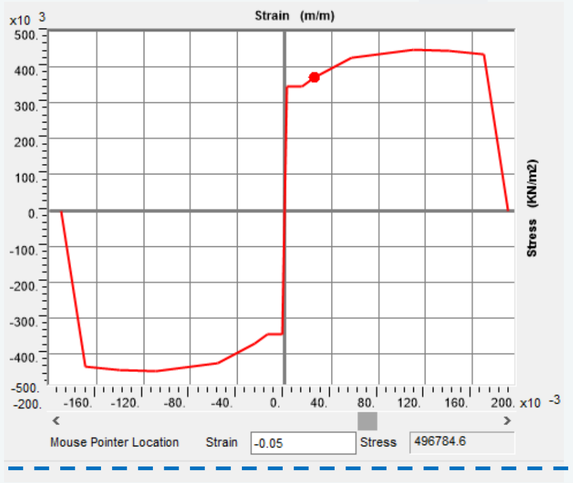
- **1. Nonlinear Material**
- **2. Force-deformation of connection**
  - **Plate to Frame (welded connection)**
  - **Frame to Frame**
    - **Main Frame (welding)**
    - **Added Frame (bo**
- **3. Nonlinear Support Boundary Condition**



Methodology

1. Material



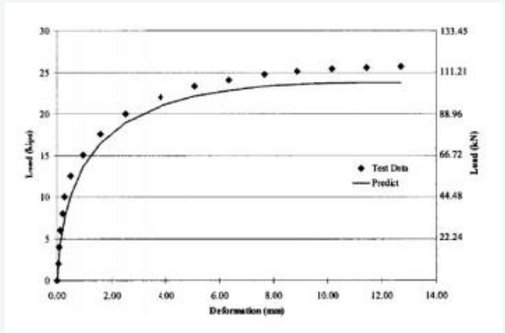


2. Connection

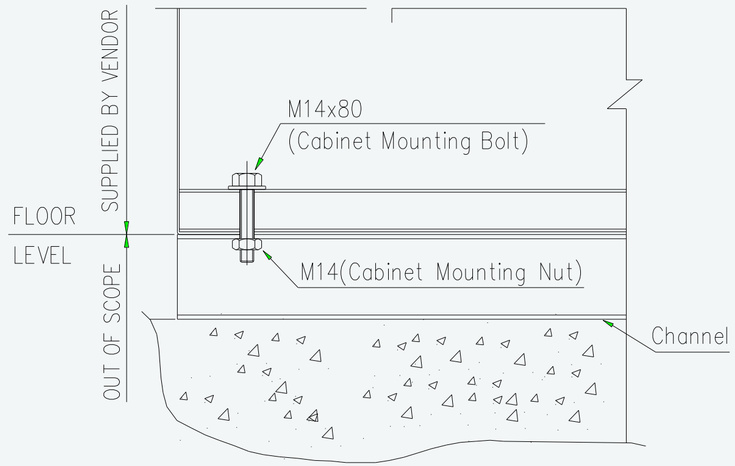
- Slip and Bearing deformation due to shear force in horizontal directions (Rex and Easterling, 2010)

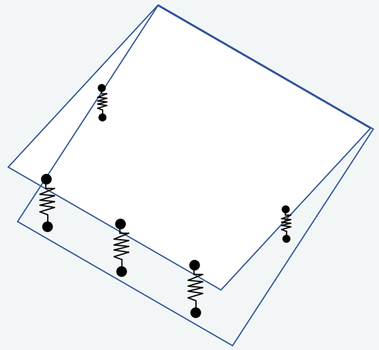
The force-deformation behavior:

$$\frac{P_{bearing}}{R_{n,bearing}} = \frac{1.74\bar{\Delta}}{(1+\bar{\Delta}^{0.5})^2} - 0.009\bar{\Delta}$$

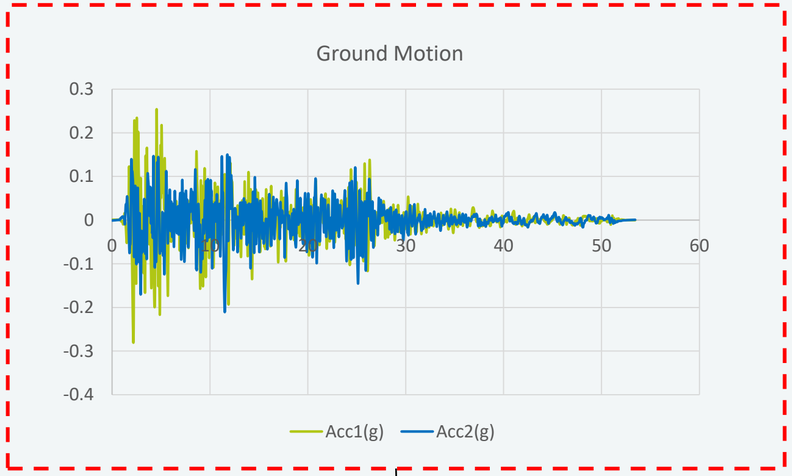


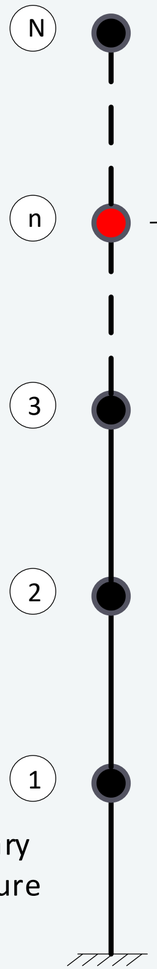
3. Boundary Condition

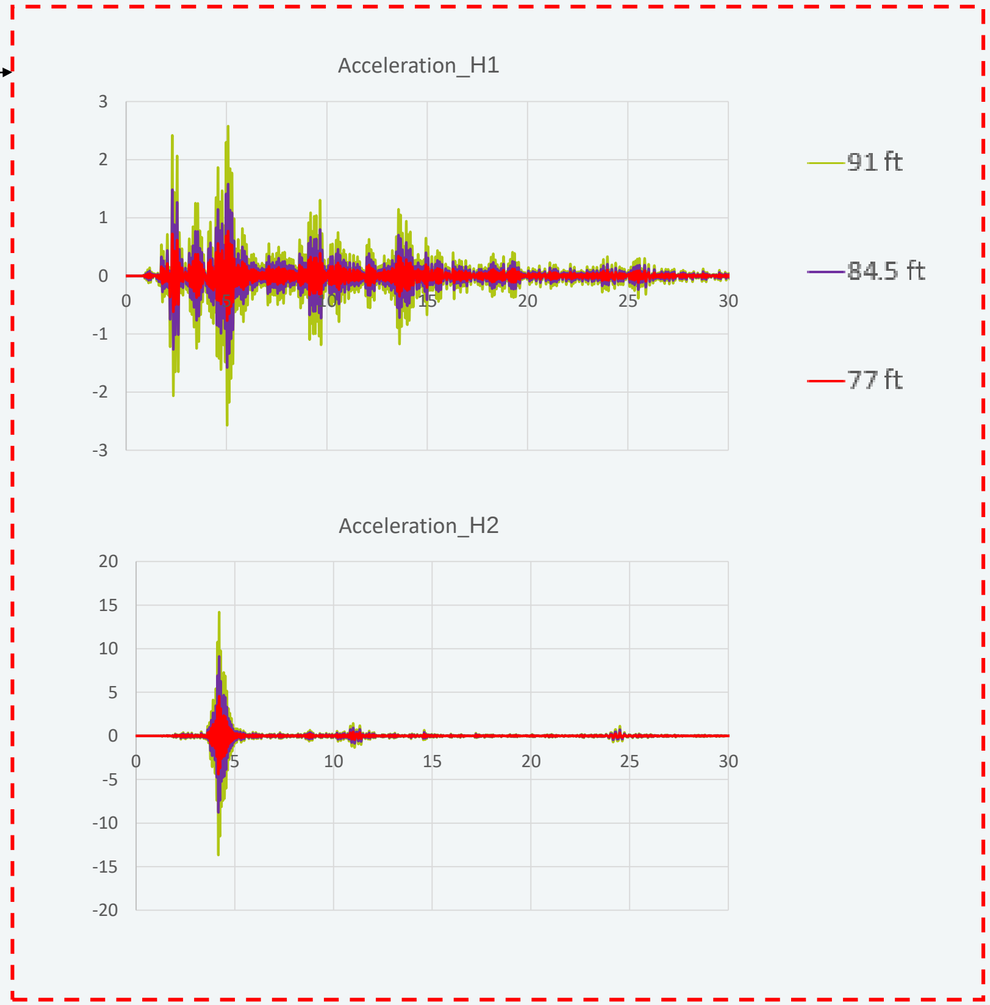




Ground Motion







Result

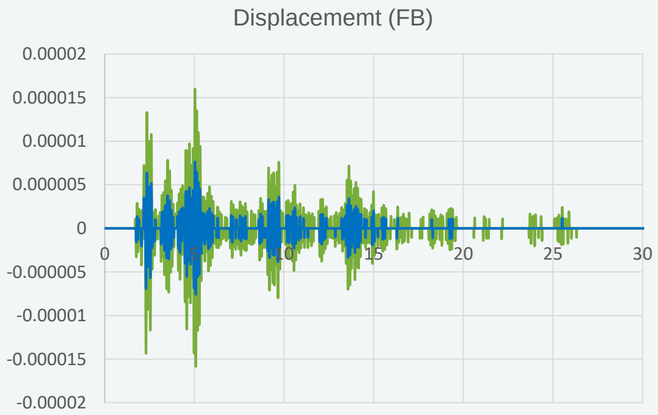
1. Different Model

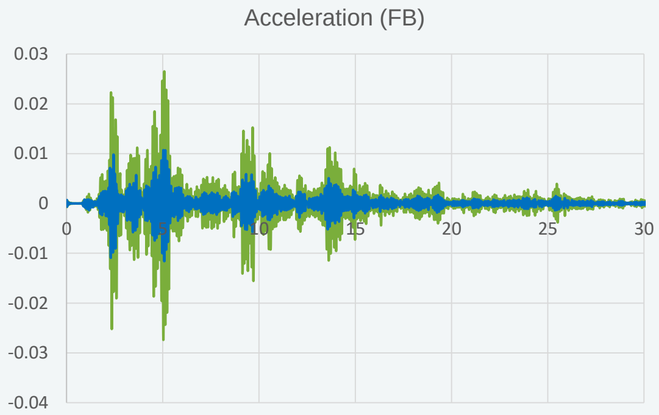
Displacement at Top

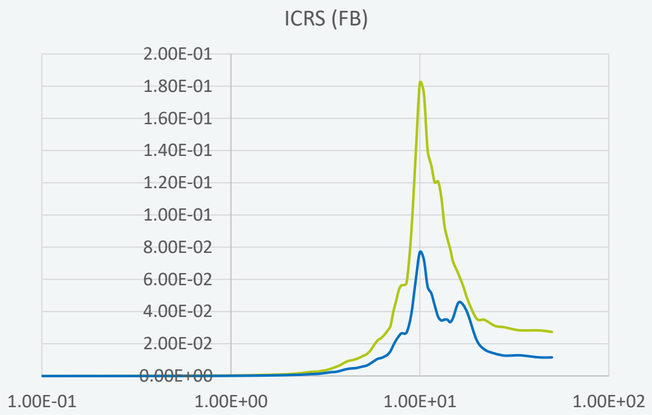
Acceleration at Top

ICRS for various model

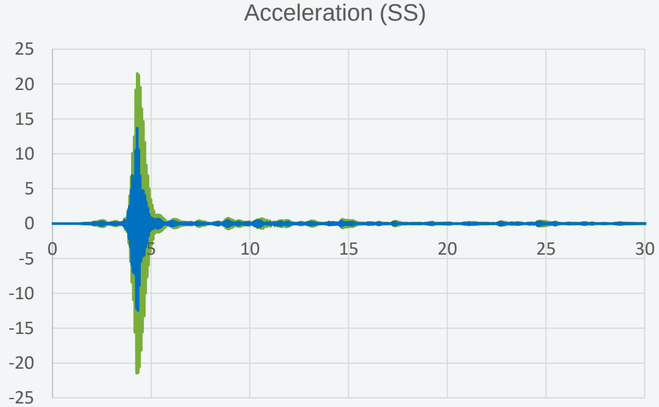
Front to Back

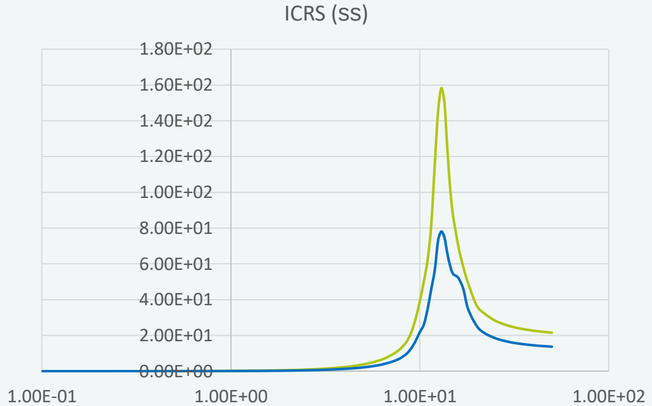






Side to Side





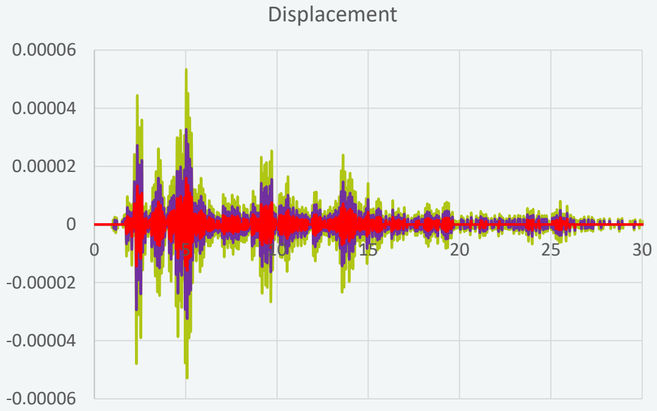
Nonlinear Linear

Result

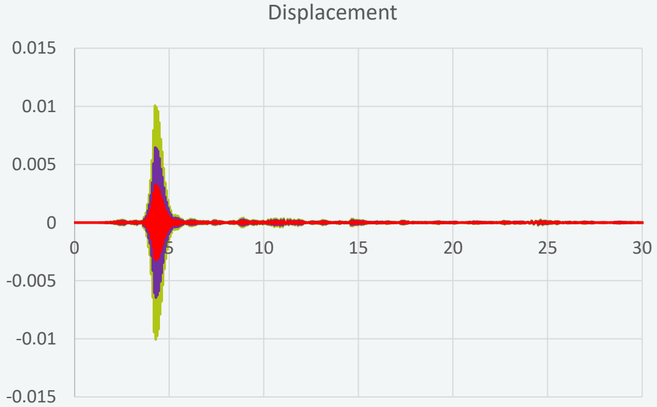
2. Different locations

Displacement at Top

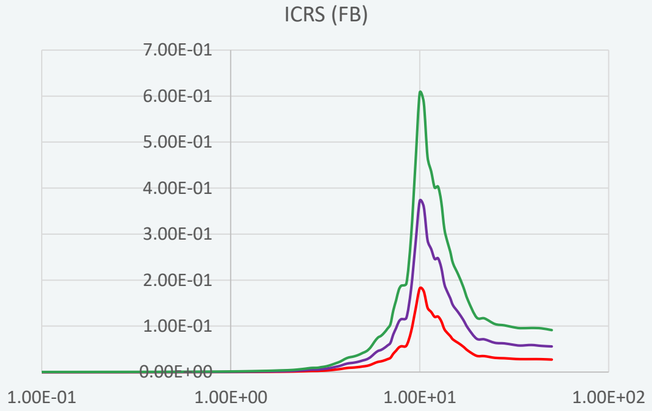
Front to Back

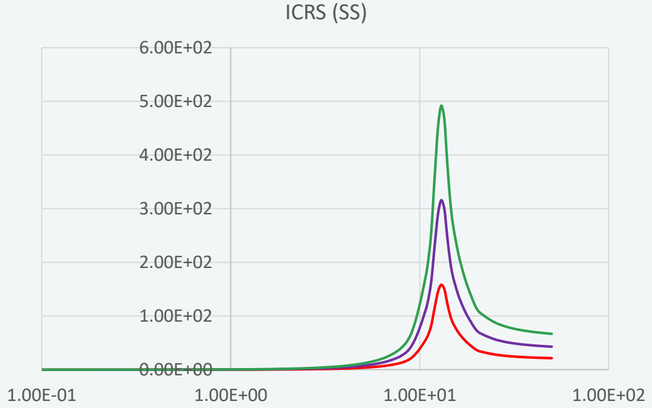


Side to Side



ICRS for various model





Discussion

The anchored model appear to have larger responses than the fixed model in terms of horizontal acceleration responses.

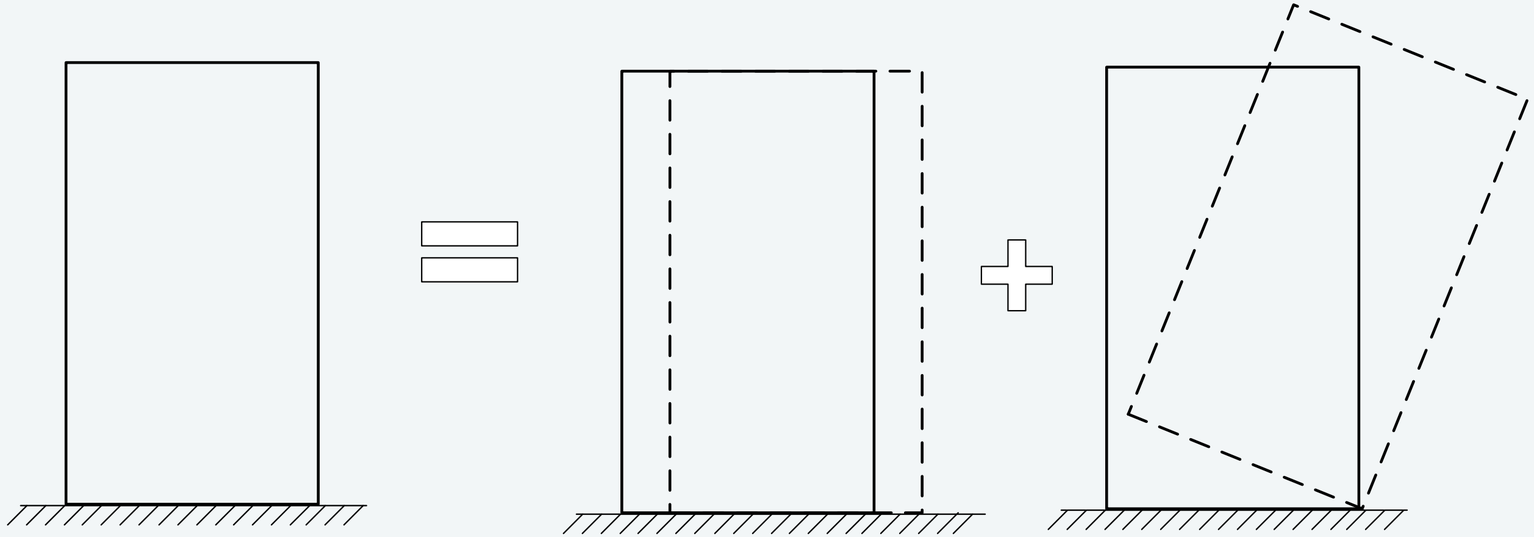
The perfectly constrained models, fixed at the base, appear to have smaller responses than the other in all displacement and acceleration response measures.

The ICRS depend on the locations to which to the cabinet and the relationship between them are proposed.

The FE modeling approach presented in this study yields additional insights into cabinet responses during earthquakes. This is achieved by properly capturing the nonlinear behavior of the cabinet as well as the boundary conditions at the base.

Future work

Unrestrained Condition



Sliding

Rocking


Thank
you