PROGRESSIVE CALIBRATION OF THE FE MODEL OF THE ELECTRIC CABINETS IN NUCLEAR POWER PLANTS

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INTRODUCTION

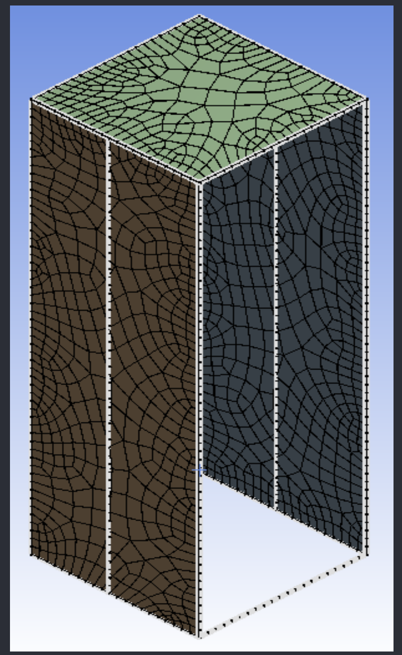
Nuclear power plants (NPPs) require the highest level of safety due to the possible danger of enormous amounts of radiation and energy they can release in the case of a critical accident.

There have been numerous studies on the seismic analysis of NPPs facilities. In general, there are three methods that can be used to assess the performance of electrical cabinets:

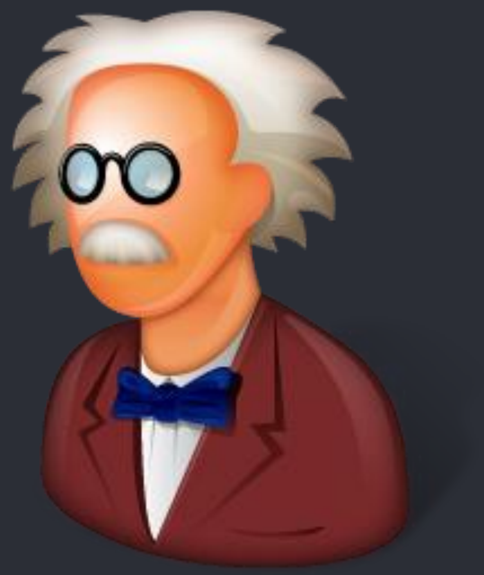
- The experimental test (e.g., shake table test)
- The analytical method (e.g., a high fidelity finite element model)
- Basing on the expert opinion: the reconnaissance surveys from the past earthquakes and observations from the past experimental tests of the cabinets.

For groups of cabinets, implementation of shake table testing becomes expensive, and interpretation of the results may be difficult. So this study proposes a generic method that can be applied to generate a simplified model of the cabinets.

The experimental test



The analytical method

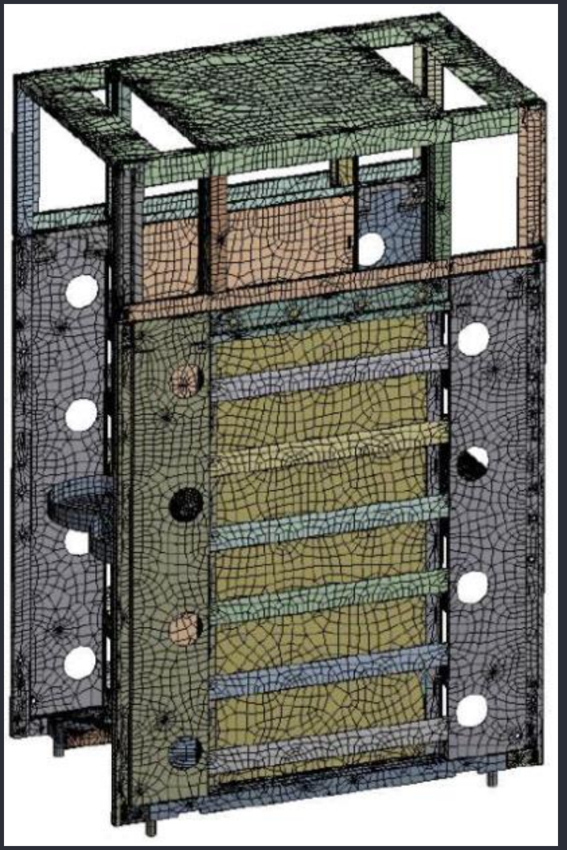


The expert opinion

Multi-electric cabinets

BACKGROUND

Budy et al. (2009) developed a numerical model and validated the natural frequencies of the model with experimental results. All members, panels, and connections were modeled using shell or brick elements.
This structure has similar structural properties to an electrical cabinet in terms of the materials and the structural system used, such as the framing system and the attached panels.

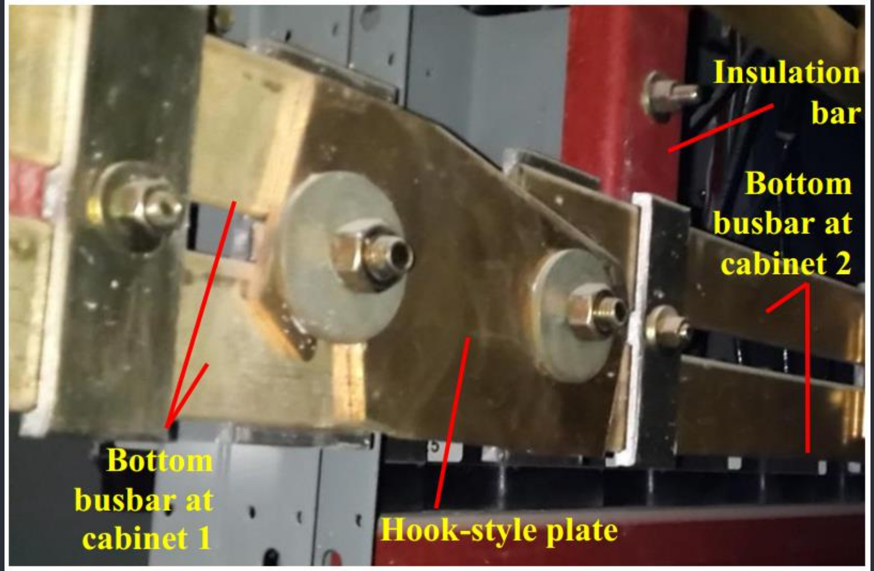


High fidelity model

In 1991, Gupta et al. developed a simplified model to predict the performance of electrical cabinets. In their study, a high fidelity finite element model was set as the benchmark for comparison to their simplified model. The results of this simplified model matched the performance results obtained using a detailed finite element analysis.

Hur (2012) developed a method to generate a simplified electrical cabinet models that consists of frame elements for framing members, shell elements for panels, and nonlinear springs for connections between framing members and for connection between panels and framing members. This approach allows a general application of the method to different configurations of cabinets.

According to Lim (2016), the structural configurations of the cabinet assembly are selected based on the observation of actual cabinets at the Sustainable Education Building in Georgia Tech.



The connection between busbars

Following that, the connector constrains to beam property rigidly, while as the connector with join property constrains the translational.

MODEL SIMULATION

The prototype and finite-element model of the cabinet are illustrated in the figure .
The Sap2000 program is used in the analysis of the cabinet.
The plates, and doors are modelled using the shell elements and the frames are modelled by the girder and column system.

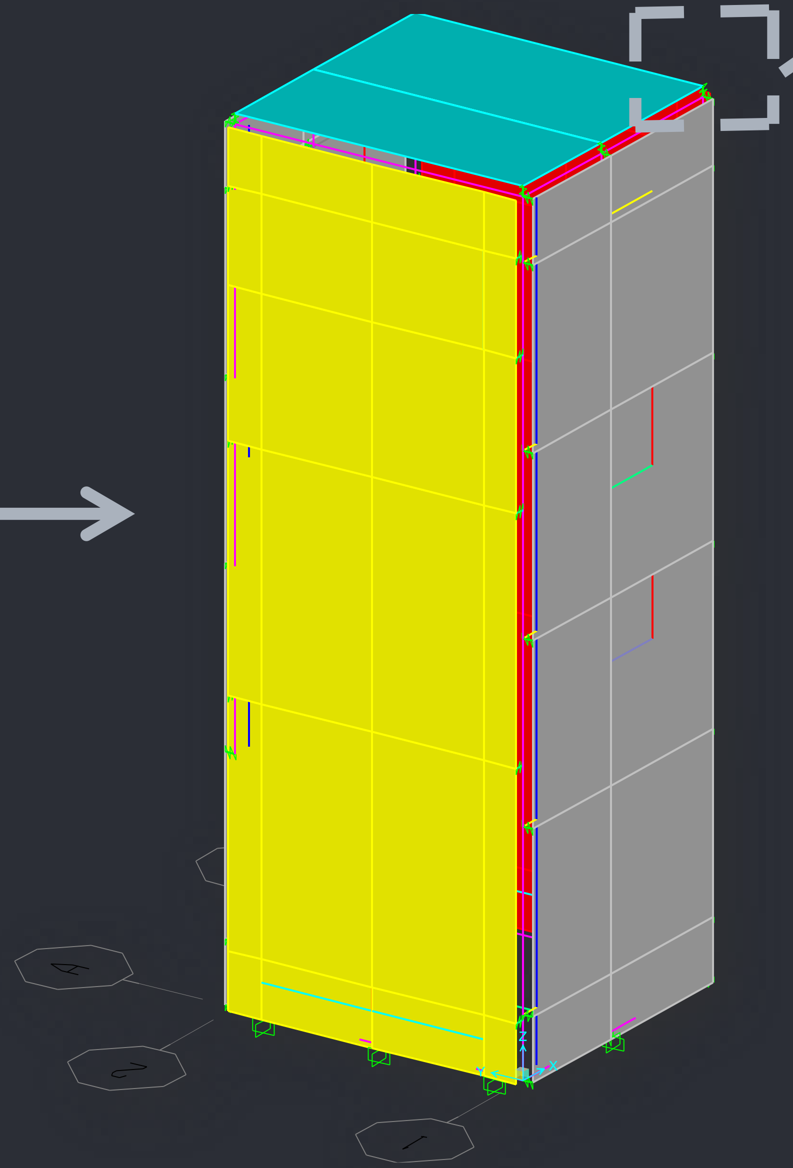
Specification

Dimensions: 800x800x2100 mm
Weight: 287.6 Kg

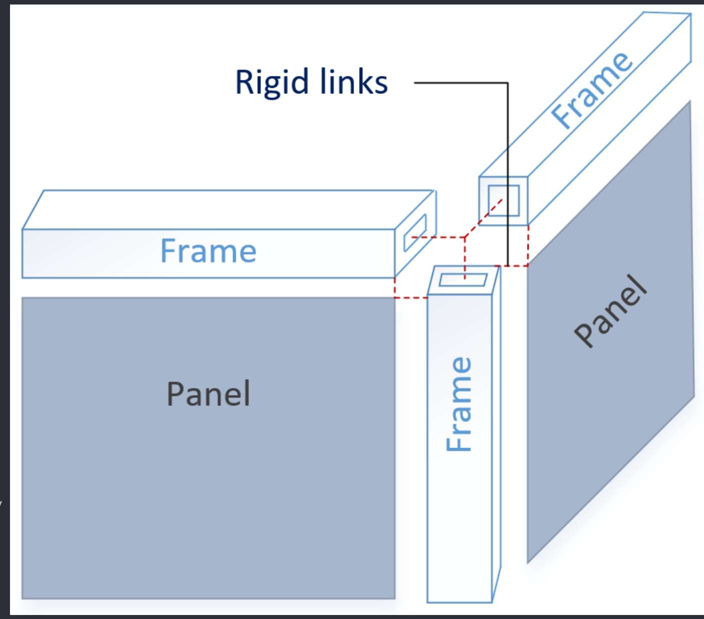
Properties

Young's modulus: 2.14x10^6 kgf/cm^2
Poisson's Ratio: 0.3
Density: 7850 kg/m^3

Real cabinet



Model



Connections

The connection between the framing members themselves and between the panels and framing members are modeled using combination of **rigid links.**

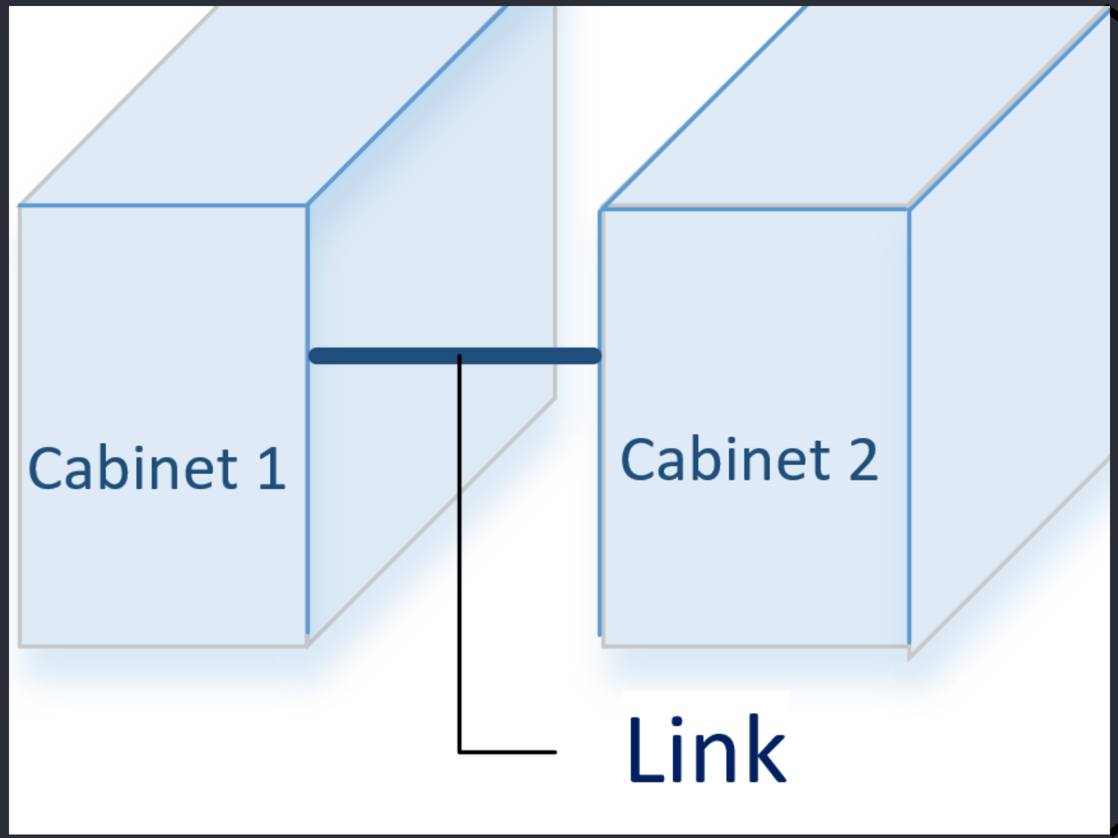
MODEL SIMULATION

This connector is selected based on the assumption that the connection will fully transfer only translational forces but does not have the capability to transfer moments.

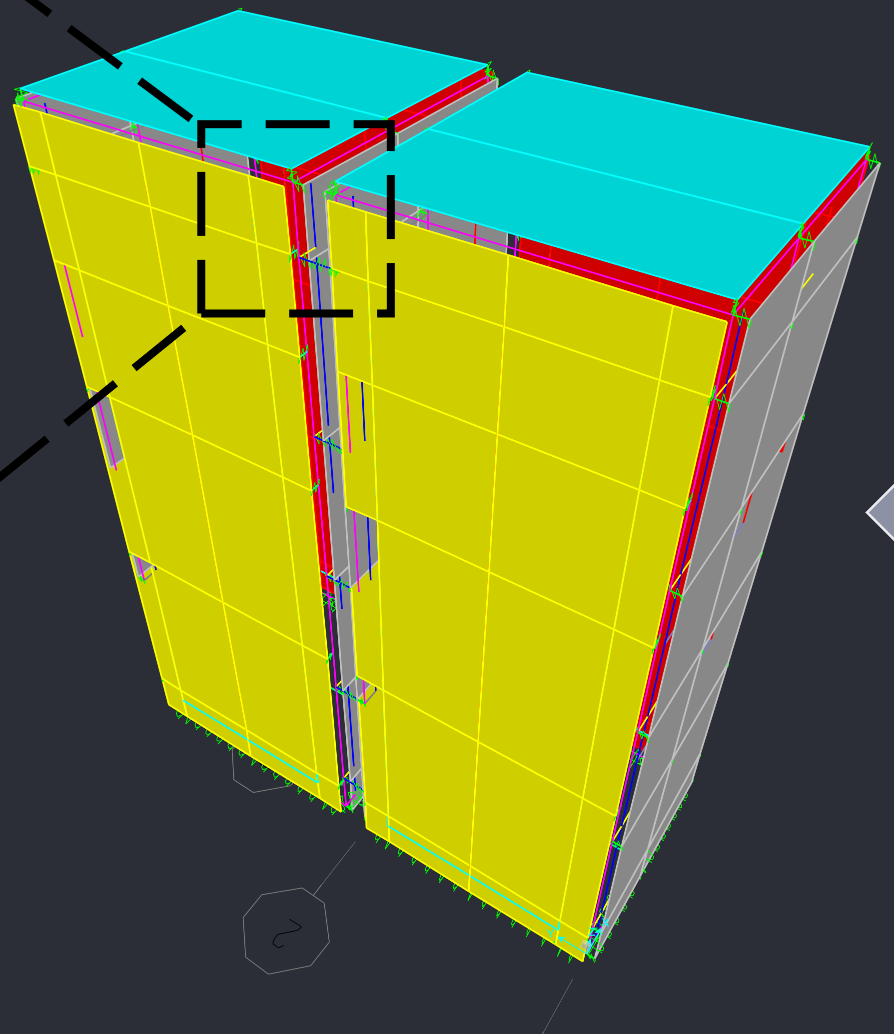
The computer model for a multi-cabinet assembly consists of a succession of single cabinet structures.

Additional links are included in the simplified cabinet assembly model to handle the connections of cabinets.

In fact, it is noticeable that the electric cabinet system has a number of single cabinets. This leads to more difficulty in modeling cabinets of NPPs.



Model



Real Multi-cabinets

RESULTS AND DISCUSSIONS

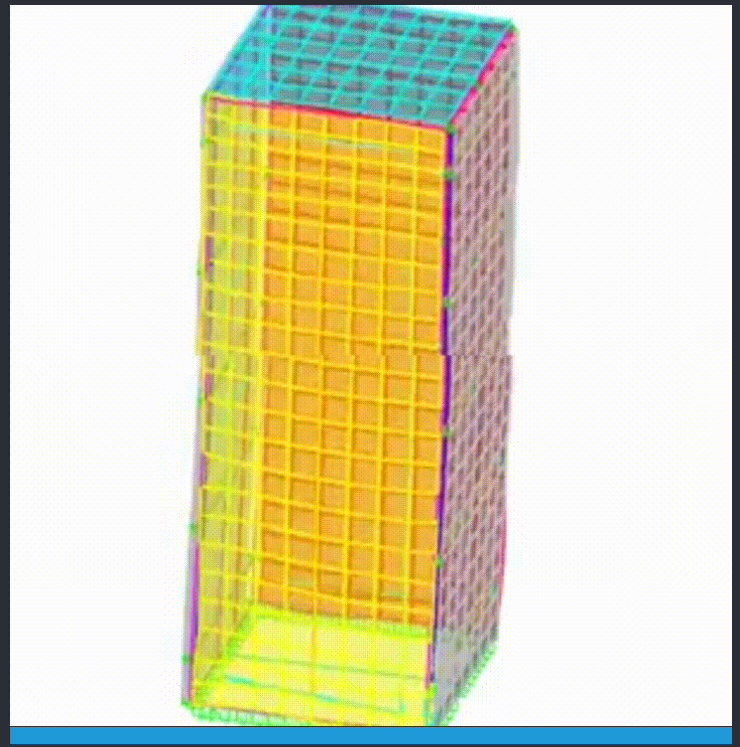
The fundamental frequencies of the FE models agree well with the fundamental frequencies of the real structure as determined from testing on the shake table in both side to side and front to back directions.

The difference of the deviations when comparing the frequency between these directions probably comes from the difference of front and side shell elements correspond to doors and side panels.

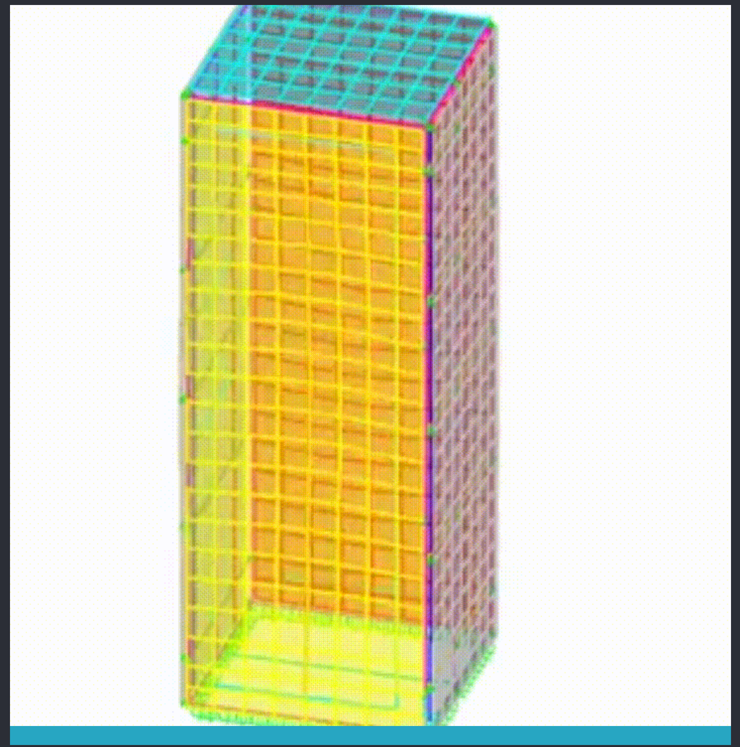
The presented model represents the dynamic characteristics of cabinet well.

Table 1: The frequencies of single cabinet

Frequency (Hz)	Side-Side	Front-Back
Sap2000	14.36	14.75
Test	16.63	14.64



Side-Side



Front-Back

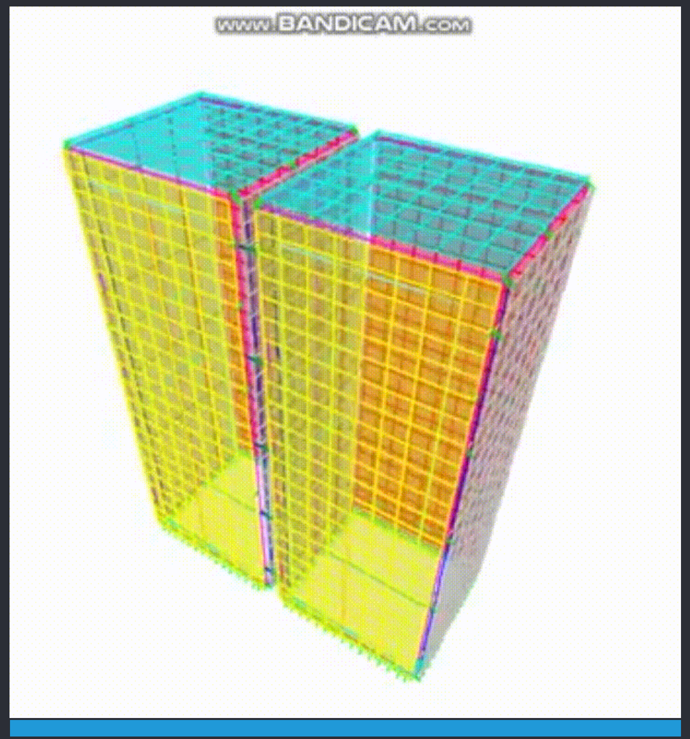
RESULTS AND DISCUSSIONS

The natural frequency only change a little, so we get the knowledge that the structural natural vibration characteristic does not change evidently and the mechanical structure is good.

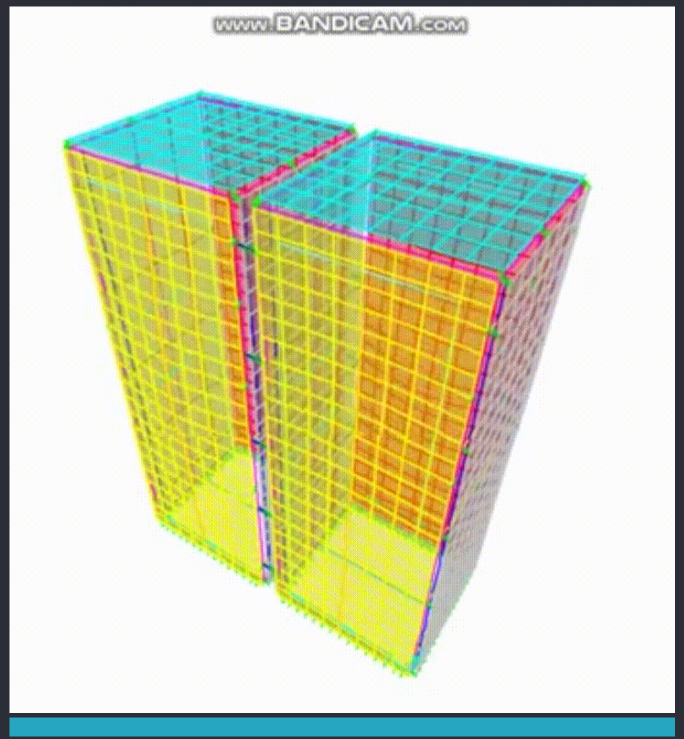
The effect of connectors which hold the link tasks between the cabinets following the side to side direction is more significant than that in the front to back direction.

Table 2: The frequencies of cabinets

Frequency (Hz)	Side-Side	Front-Back
Single	14.36	14.75
Double	18.10	14.64



Side-Side



Front-Back

CONCLUSIONS

The dynamic characteristics of the cabinet were evaluated via modal analysis, and the results were compared with those of the experimental test of the prototype. Results of the analysis and the test agree fairly well with each other in terms of the major modes.

The results of modeling double cabinets show that the assumed connection between cabinets themselves are acceptable. So that the simplified cabinet models are able to predict nonlinear behaviors of properly electrical cabinets generally.

When developing a new cabinet system for NPPs, the present model for the dynamic analysis of the cabinet may be efficiently applied to reduce time and costs.

FUTURE WORKS

Conduct time history analyses using finite element models that account for nonlinear material, force deformation and evaluate the dynamic characteristics of simplified nonlinear numerical models for switchboard cabinets to provide enhanced understanding of their behavior during seismic events.

Some of the challenges in modeling the electrical cabinet are related to the variability of the configuration of the cabinets. So that the features of the connections between cabinets are diverse. Therefore, there is a need to have further studies about the connectors such as: types, positions, … Furthermore, it is important to analysis **the behavior of the connectors in seismic events**.

Thank You