# Reducing Initial and Lifetime Costs of Base Isolation Through Design

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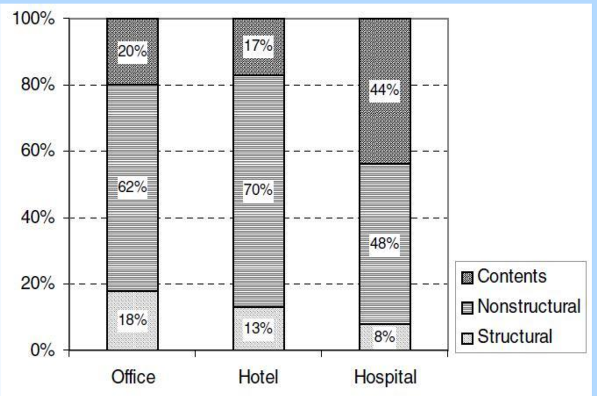
## SCOPE OF RESEARCH

The goal of this research project is to lower the initial cost of seismic isolation by finding where earthquake damage costs begin to increase substantially due to inter-story drift and acceleration, the two main causes of nonstructural damage in an earthquake. Two computer programs, PACT II and a MATLAB program by Judith Mitrani-Reiser are used to estimate these costs. Then, three building models were modeled in OPENSEES to see if any of them did not reach the points where costs due to story drift and acceleration increased.

## COST OF EARTHQUAKES

### HIGHER COSTS TODAY

•Code compliant buildings under moderate ground motion can result in large economic losses and major societal disruptions (NSF, 2008).




**70% of earthquake damage are from nonstructural elements**

**Damage from the Chilean Earthquake** (Jack Moehle)

### TYPICAL NONSTRUCTURAL LOSSES

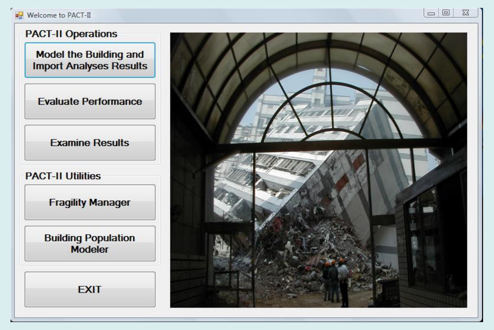
•Death
•Dollars: Loss of:
  •Content
  •Production and Operations
  •Sales and Services
  •Ongoing Research
  •Market Shares and Stock Values
•Downtime
  •Repair and Potential Demolition

## METHODS AND MATERIALS

### DAMAGE COST ANALYSIS

The following two programs allows a user to model a building and the nonstructural components in it. From there, damage costs are estimated by the programs for story drifts between 0.01 and 0.05 and acceleration between 0.1g and 0.7g. In the model building, there are 64 nonstructural components. These two programs were only able to take into account 8% and 15% of the total damage costs possible, respectively.

### PERFORMANCE ASSESSMENT CALCULATION TOOL - PACT II



•PACT II takes into account hazard levels and building response and translates them into expected damage costs..

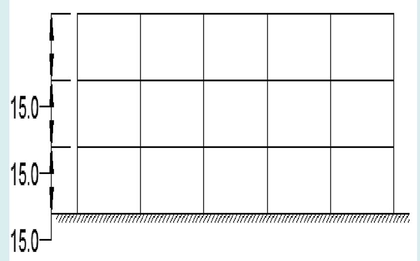
### MATLAB PROGRAM BY MITRANI-REISER

•Mitrani-Reiser was hired by ATC-58 to create a MATLAB program that is similar to PACT II except it allows users to enter more nonstructural components and to alter the program.

### THREE BUILDING MODELS

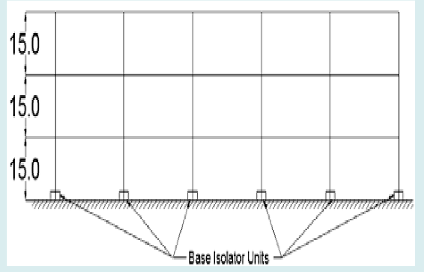
**OPENSEES**

•Open System for Earthquake Engineering Simulation (OPENSEES) allows a user to create an analytical model to find the response of a structural system subjected to an earthquake. Using OPENSEES, the following three models were constructed.



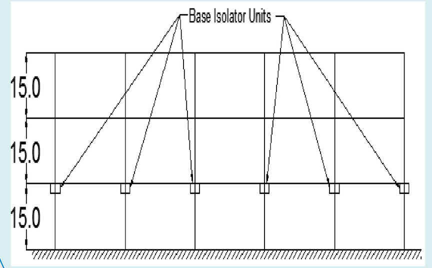

**FIXED BASE BUILDING**

•A fixed base building is how a building is normally constructed, with the foundation and superstructure connected.




**BASE ISOLATED BUILDING**

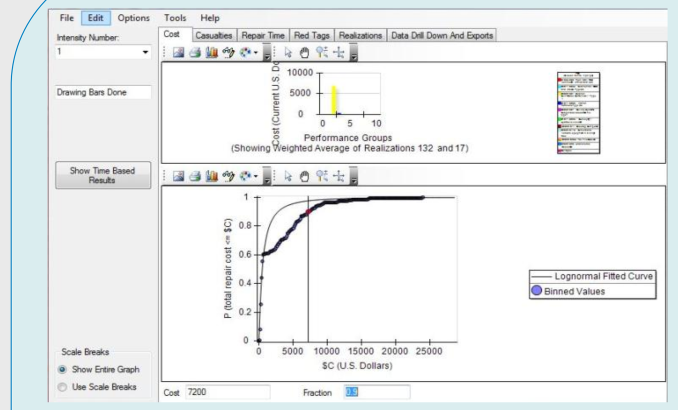
•Base isolation allows the structure to decouple from the foundation when there is an earthquake because there is a deformable isolation layer between the foundation and superstructure. This decreases the acceleration in the building and concentrates the deformations to the isolated layer. However, there is a higher initial construction cost.

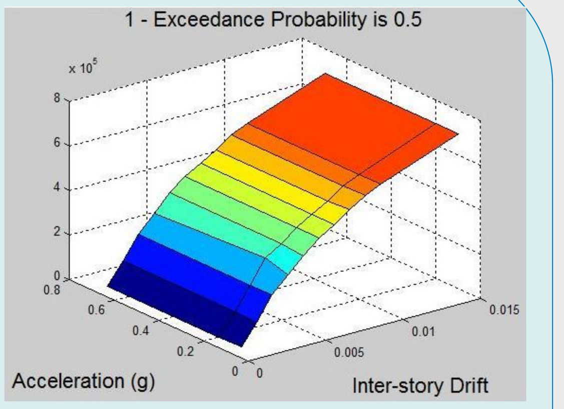



**ISOLATION ON THE 1ST STORY**

•To try and decrease the cost of isolation, isolators have been placed on the first story columns. This removes the need for a moat around the building in construction. When base isolation is used, a moat needs to be constructed around the building so when the isolated building deforms, the structure will not disturb the ground surrounding it.

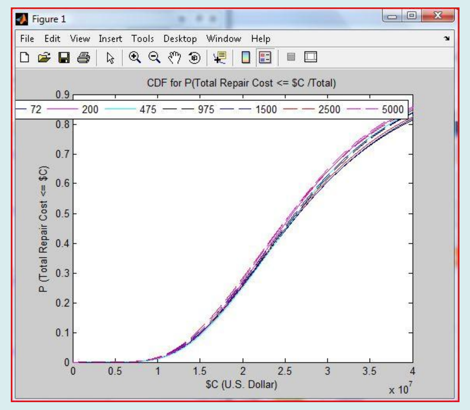
## PACT II RESULTS

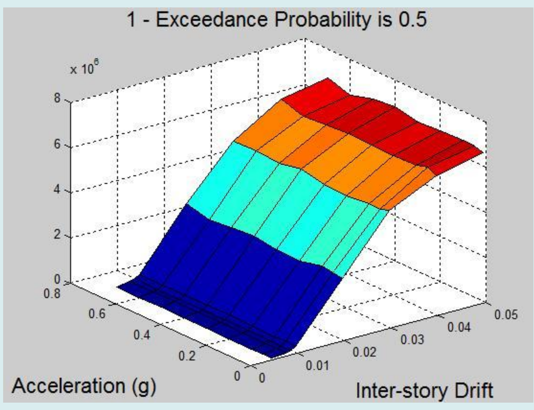





•Damage costs do not increase substantially at any point due to acceleration because the components are not acceleration dependant.
•Damages due to inter-story drift have the steepest increasing rate at 0.002, 0.003, 0.004, and 0.005.

## MATLAB RESULTS

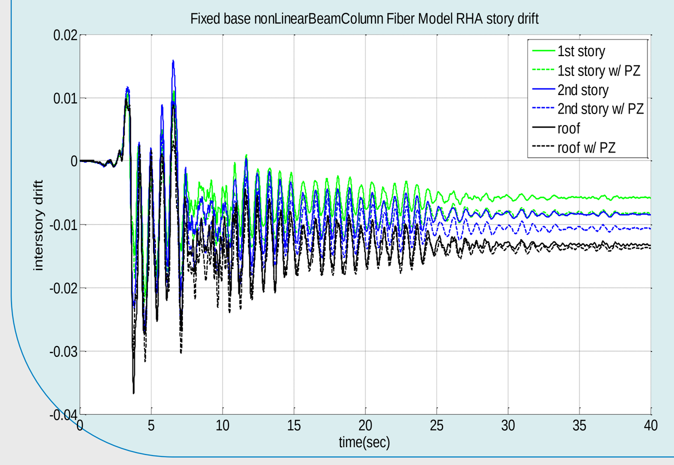


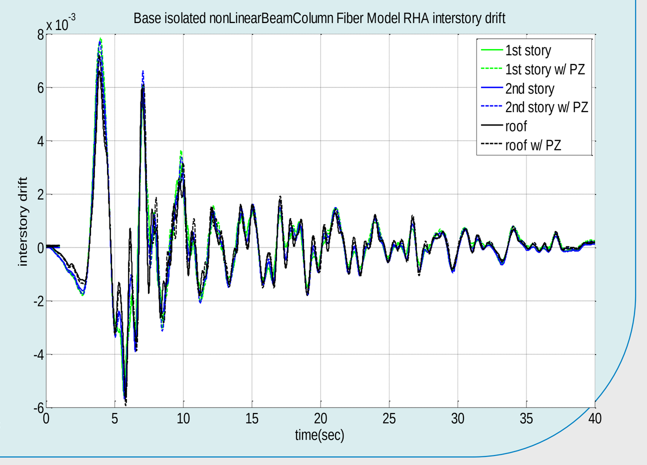



•The increase in damage costs due to inter-story drift is substantially greater than those due to acceleration
•No data can be collected in accordance to where acceleration costs increase because the damage costs decrease at 0.1g, 0.2g, and 0.6g when the exceedance probability is greater than 0.8.
•Inter-story drift increases at 0.008, 0.010, and 0.020.

## OPENSEES ANAYSIS AND CONCLUSION

The results from PACT II and MATLAB were compared to those found from the OPENSEES evaluation of the three model buildings. For a fixed base structure, the inter-story drift almost reaches 4%. For an isolated structure with isolators under the first floor, it is 0.8%. The isolated structure does not need to be redesigned if values from the MATLAB program are used. When isolators are placed on the first-story columns of the buildings, the maximum inter-story drift is less than 0.88%. This design cannot be used to reduce costs.




## LIMITATIONS

**PACT II**

The results from PACT II are unreasonably low. This analysis only serves as a means by which one may see how PACT II is able to show variations in costs for future use..

**MATLAB**

Although the MATLAB program provides results that reveal the limitations designers have, they are not adequate yet. In reality the damage costs can reach $17,776,263 while the program is only able to have 15% of this cost in this analysis.

**OTHERS**

This analysis only applies to this model building. For every building, an analysis like this must be conducted to limit costs.

## FUTURE WORK

PACT II is currently an alpha program. Once it is complete, it will have more performance groups so that it will be able to analyze 85% of the total damage cost possible.

MATLAB needs to have more performance groups inputted, all users can do this. Finding fragility curves for all the performance groups may prove to be difficult.

Once this is completed, engineers can redesigning buildings with isolators to reduce costs. This will be done using OPENSEES to analyze different buildings models.

## REFERENCES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