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).

TYPICAL NONSTRUCTURAL LOSSES

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

Damage from the Chilean Earthquake (Jack Moehle)

70% of earthquake damage are from nonstructural elements

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 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.

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.

REFERENCES


