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Alternative Approaches to Seismic Design in Developing Countries

Background

The purpose of seismic design is to proportion structures so that they can withstand the displacements and forces induced by ground motion [1]. It is important to keep in mind that the response of structures depends on their height. In general, multiple story buildings have a stronger response to low-frequency ground motion, while shorter buildings are more responsive towards high-frequency ground motion. Designers of earthquake prone structures are therefore faced with two options: (1) to provide adequate stiffness and strength to limit the response of the structure to stay in the elastic range, or (2) to design a lower-strength structure with the ability to withstand large inelastic deformations while maintaining their load-carrying capability [1]. In either case, to keep structures from failing it is essential for structural members to be ductile, which allows for the dissipation of energy.

Although the above technique has proven to keep structures from collapsing during earthquakes, in recent years, there has been research in seeking alternative techniques. In particular, countries that have experienced historic catastrophes due to earthquakes, have taken initiative in creating and analyzing different economical but safe approaches to seismic design. The countries I have researched are Chile, Turkey, and Mexico, which have all experienced the harsh results of inadequate seismic design.

Innovations in Chile

Chile is one specific country that is coming up with an innovative technique of preventing deformations that jeopardize the safety and serviceability of buildings. For the past six years, an isolation system has been evaluated to determine how different parameters affect its yield level. The basic concept in this type of system is the use of bearings that serve as beam-column joints. Each bearing, either rubber bearing or lead-rubber bearing allows for a specific displacement determined by its location in the building. The bearings allow for members in the building to deflect without causing deformation of the structural members.

To test the use of bearings, Chile has constructed a hospital building and an engineering faculty building. Due to the use of bearings, in the hospital building, no extra slab was required and all shear walls as well as all construction joints were eliminated. In the Engineering Faculty building, “extra costs due to the isolation were counterbalanced by (i) the elimination of the construction join in the structure (ii) a more economic design of the foundation system; and (iii) a lower density of shear walls and reinforcement [4]. Below you can find the location of the bearings for each building.

Changes in Turkey’s Design Code

In 1999 Turkey experienced a 7.4 earthquake that resulted in a death toll of over 17,200 and an economic loss of 20 billion US dollars [2]. “Many of the failures and collapses of engineered commercial construction can be attributed to the use of non-ductile details and not poor quality construction (106, Sezen)”. “Common use of 90-degree hooks for transverse reinforcement reduced the lateral strength and confinement of columns [2]”.

Turkey has established a group known as the reconnaissance team that evaluates the aftermath of earthquakes. The evaluations of this group have led to a different building code for the country. This new building code deals with the proximity each city has to the epicenter region.

I had planned to evaluate how Turkey continues to develop their code, but I’m if the sources I currently have will provide me with enough information.

Mexico City

Mexico City lies on what is known as a lake bed, where the soil conditions cause buildings to sink anywhere from ten to twenty centimeters a year. Ever since the 1985 earthquake, there has not been much initiative to construct multistory buildings. But in 1999, the construction of what would be the tallest and safest building in Latin America began.

The structural consultants, New York based Cantor Seinuk Inc., and local engineer Enrique Martinez Romero used an innovative technique consisting of fluid viscous dampers and diagonal bracing. The dampers and bracing resulted in a 55-story building that is able to resist earthquake forces nearly four times as efficiently as a conventionally damped building. This building has already resisted a 7.3 magnitude earthquake and the amount of money that was spent on all 93 dampers, was well made up for in the drastic insurance premium reductions due to the overall security ensured by the damping and bracing technique [3].

Future Work

I plan to follow up on the use of dampers and bearings in current projects. In order to see how the deflections in a lead bearing structure compare to a typical design, I will use SAP to model one of the buildings analyzed in Chile.

References

[1] Nilson, A., “Seismic Design,” *Design of Concrete Structures*, McGraw-Hill, pp.700-703, 2004.

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[3] Post, N., “Damper-Studded Diamonds in Mexico City Raises Bar on Earthquake Resistance,”http://www.construction.com/NewsCenter/Headlines/ENR/20030630eg.asp, May 2003.

[4] Llera, J., “Analysis, testing, and implementation of seismic isolation of buildings in Chile,” *Earthquake Engineering and Structural Dynamics Journal*, Vol.33, pp.543-574, 2004.