Earthquake Resistant Buildings

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Situation

- Over 1 million lives have been lost over the past short period of 40 years due to earthquakes [1]
- Most earthquakes result from rapid movement along the plane of faults within the earth's crust.
- Sudden movement of the fault releases great energy that travels through Earth in the form of seismic waves.
- It is difficult to inform people of the occurrence of an earthquake before it happens.

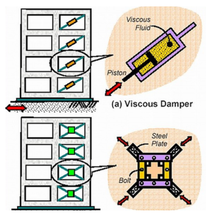
Energy Dissipation

Seismic Waves:
- Earthquakes are seismic waves carrying a huge amount of energy.
- When these waves strike, all the energy is absorbed by the structural elements, causing it to collapse.

Solution:
- Components in the building called seismic dampers, which absorb the moments and accelerations [2]
- Installing dampers instead of structural elements.
- Three types of dampers, yielding, friction, and viscous dampers (figure 1) to absorb the seismic energy [2]

Evaluation:
- Seismic dampers reduce seismic vibration, are easy to install
- Require no maintenance
- Must be replaced due to plastic deformation of the materials used in the dampers

Fig. 1 www.iitk.ac.in



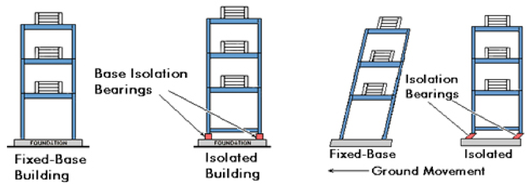
Base Isolation

Inertia and its Hazards:
- During an earthquake the inertia of the building acts against the direction of the earthquake's force trying to keep the building in its place (figure 2)

Solutions :
- Isolating the building and its foundations from the ground below it
- Placing rollers between the building's foundations and the ground below [2]
- Placing flexible pads in between the building and its foundation, to create resistance against lateral movements [2]

Evaluation:
- The method requires a high initial cost due to the rollers and other materials used in construction
- Specialized labor has to be employed to know how to implement the techniques used

Fig. 2 www.iitk.ac.in



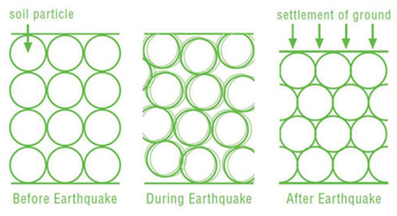
Liquifaction

Soil Stabilty:
- Liquefaction causes the soil to behave like a liquid, turning the soil temporarily into quicksand. As a result, even the most structurally sound buildings may sink into the earth

Solutions:
- Stabilizing the soil by either removing the water from it or adding a dense agent [3]
- Constructing foundations with steel columns which go as deep as 40meters below the ground surface
- Concentrating mainly on stabilizing the soil to eliminate liquefaction or to control its effects

Evaluation:
- Stabilizing the soil changes its properties into one that is more packed and less porous than the original one
- Reinforcing with specially chosen deep foundations like steel rods or concrete slabs [3]

Fig. 3 www.eeri.org



Earthquake Detection

Sudden Occurence of Earthquakes & False Alarms:
Early earthquake warning systems can trigger false, and missed alarms, causing public panic for no reason.

Solutions
- Designing an earthquake warning system that uses primary waves to detect the magnitude of earthquakes
- Using primary waves to estimate the intensity of S-Waves [4]
- Combining data from several seismometers to obtain an average estimate of the earthquake's magnitude [4]

Evaluation
- Arrival of S-waves shortly after P-waves, making it difficult for the people to react in time
- Implementing an earthquake early warning systems will require a very high initial investment
- Trade-off between accuracy of prediction & warning time available

Alarm System (REWS)

Delayed Alerts:
In case of major earthquakes, delayed warning causes huge human losses and material damages.

Solution
Providing Rapid Early Warning System (REWS) that consists the following elements:
- An earthquake monitoring network that is made of seismic stations with different types of sensors [5]
- A data communication network to transmit seismic information from sensors to analyzing center [5]
- Dedicated programs to evaluate Earthquake's parameters and warning lever

Evaluation
- Implementing REWS will require a high initial cost
- In the long run it will be cost efficient

References

[1] "Number of Earthquakes by Year", USGS Earthquake Hazards Program Nov. 17, 2012. [Online]. Available: http://earthquake.usgs.gov/earthquakes/eqarchives/year/eqstats.php.

[2] How to Reduce Earthquake Effects on Buildings. October. 13, 2009. [Online]. Available http://www.iitk.ac.in/nicee/EQTips/EQTip24.pdf.[Accessed Nov 26, 2013].

[3] Liquefaction, what it is and what to do about it. (1994, January). Retrieved from http://www.eeri.org/cds_publications/earthquake_basics_series/LIQ1.pdf

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[5] "Seismic Rapid Early Warning System for dangerous facilities", Nuclear Industry Evaluation Program 2010. [Online] Available: http://www.infp.ro/real-time/ews [Accessed Dec 4, 2013]