Using a soft storey, seismic analysis of multi-story buildings

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ABSTRACT- Around the world, earthquakes have shown the dangerous effects and susceptibility of weak structures. The term "soft storey" refers to a level where the aggregate stiffness of the storeys above is less than 80% or less than 70%. Soft storeys are used in multi-story buildings to facilitate parking, which is an inevitable element. An earthquake might cause this open ground floor to collapse. Stiffness irregularities in a structure are caused by soft storeys. Due to urbanization and space occupancy issues, soft storey architecture is a common element of high-rise or multi-story buildings. Because of the soft story, these features make the lateral load-resisting structure less rigid, making a progressive collapse inevitable in the event of a strong earthquake. Damage and collapse are most frequently seen in soft-story structures during earthquakes because the concrete columns supporting this storey level were not able to withstand shear. Shear walls give the construction strength and durability against seismic threats. The placement of the shear wall is crucial for seismic resistance; it must be so that it does not alter the structure's overall behavior. The infill wall contributes significantly to the building's lateral rigidity. Six 3D mathematical models have been created in order to investigate the seismic performance of soft-story buildings, and an industrial building has been chosen for this paper.

INTRODUCTION:

An Earthquake is a sudden slipping or movement of a portion of the earth’s crust or plates, caused by a sudden release of stresses .Earthquake epicenter are usually less than 25 miles below the ear surface and are accompanied and followed by a series of vibrations. The earth has four major layers: The inner core, outer core, mantle and crust. The crust and the top of the mantle make up a thin layer on the surface of earth. But this layer is not a single cover, it is made up of many pieces like jigsaw covering the surface of the earth. These keep slowly moving around each other, slide past one another and bump into each other. These puzzle pieces are called tectonic plates, and the edges of the plates are called the plate boundaries. The plate boundaries are made up of many faults, and most of the earthquakes around the world occur on these faults. Since the edges of the plates are rough, they get stuck while the rest of the plate keeps moving. Finally, when the plate has moved far enough, the edges unstick on one of the faults and there is an earthquake.

1.1: TYPES OF EARTHQUAKE:

Most earthquakes in the world occur along the boundaries of the tectonic plates and are called Inter-plate Earthquakes. A number of earthquakes also occur within the plate itself away from the plate boundaries, called Intra-plate Earthquakes. Earthquakes are recorded by instrument called *seismographs*. The recording they made is called a seismogram.

The seismogram consists of two parts, a base and a weight, to held it firmly in the ground. When an earthquake causes the ground to shake, the base of the seismograph shakes too, but the hanging weight does not. Instead the spring or string that it is hanging from absorbs all the movement. Thus the difference between the moving and immovable part is recorded. The size of an earthquake depends on the size of the fault and the amount of slip on the fault, but this cannot be measured directly as faults are deep in the earth. The seismogram recordings made on the seismographs at the surface of the earth are used to determine the intensity of earthquake.

A short line with less zigzag portions represents a small earthquake and a lengthy line with a lot of zigzag sections shows a large earthquake. The length of line on the seismograph depends on the size of the fault and the wigginess of the line depends upon the amount of slip of the fault.

Earthquake Engineering is the branch of engineering devoted to mitigating earthquake hazards. Earthquake engineering covers the investigation and solution of the problems created by damaging earthquakes, and hence the work involved in the practical application of these solutions in planning, designing, constructing and managing earthquake-resistant structures and facilities.

1.2: EARTHQUAKE ENVIRONMENT EFFECTS

Earthquake environmental effects are the effects caused by an earthquake on the natural environment, including surface faulting, tectonic uplift and subsidence, tsunamis, soil liquefactions, ground resonance, landslides and ground failure, either directly linked to the earthquake source or provoked by the ground shaking. These are common features produced both in their near and far fields, routinely recorded and surveyed in recent events, very often remembered in historical accounts and preserved in the stratigraphic record (paleoearthquakes).

Both surface deformation and faulting and shaking-related geological effects (e.g., soil liquefaction, landslides) not only leave permanent imprints in the environment, but also dramatically affect human structures. Moreover, underwater fault ruptures and seismically-triggered landslides can generate destructive tsunami waves. EEEs represent a significant source of hazard, especially (but not exclusively) during large earthquakes. This was observed for example during more or less catastrophic seismic events recently occurred in very different parts of the world.

1.3: SOFT STOREY:

Reinforced-concrete framed structure in recent time has a special feature i.e. the ground storey is left open for the purpose of social and functional needs like vehicle parking, shops, reception lobbies, a large space for meeting room or a banking hall etc. Such buildings are often called open ground storey buildings or soft story buildings. Again when a sudden change in stiffness takes place along the building height, the story at which this drastic change of stiffness occurs is called a soft story.

The Indian code (clause no. 4.20) classifies a soft storey as, It is one in which lateral stiffness is less than 70 percent of that in the storey above or less than 80 percent of the average lateral stiffness of the three storey above (IS 1893:2002). Soft storey can form at any level of a high rise building to fulfill required functional necessity and serve various.

Moreover, typical multistoried construction in India comprises RC frames with brick masonry infill. Unreinforced masonry panels may not contribute towards resisting gravity loads, but contribute significantly, in terms of enhancement in stiffness and strength in case of earthquake (or wind) induced lateral loading. The effect of infill may be positive or negative depending on large number of influential factors.

II. Literature Survey:

Robin Davis, discussed two buildings are located in moderate seismic zone Structurally symmetric (bare frame) is compared to the building with plan and vertical irregularity (soft Storey) Infill wall on the upper floor are modelled using equivalent stiffness strut approach. Equivalent static analysis, response spectrum and Non-linear pushover analysis is performed to determine the structural response of building to earthquake. This study concludes that presence of masonry infill panel considerably increases total storey shear bending moment in the ground floor column and failure occurs due to soft storey mechanism. Hence present structures with soft storey need to be retrofitted.

F. Hejazil (2011), The writer studied seismic behavior of multi-storied building with soft storey by adding bracings to the soft storey. He concluded that, location and number of bracings plays an important factor for soft storey structure to displace during earthquake The displacement will be smaller of the storey provided with bracings. Also provision of bracing reduces the effect of soft storey and vulnerability to collapse.

Mohammad H. Jinya, V. R. Patel (2014), In this paper seismic behavior of RC frame building is analyzed by performing multi-model static and dynamic analysis. The results of bare frame, masonry infill panel with outer wall opening, and soft storey are discussed. The conclusions made in this study is infill wall(diagonal strut) change the seismic performance of RC building. Storey drift and displacement were decreased. It is suggested that at least soft storey should be provided with outer masonry infill panel to increase stiffness of soft storey.

Md Rihan Maaze, The writer performs equivalent static and response spectrum analysis on infill frame and solid concrete block and compared to bare frame. Also, non-linear pushover analysis is carried out for hinge properties. He concluded that SMRF building models are found more resistant to earthquake loads as compared to OMRF in terms of performance level point and hinge variation. Hence ductile detailing is must for building under high seismic zone.

Dhadde Santosh (2014), The writer carried out the performance evaluation on non-retrofitted buildings. Soft storey is located at ground, intermediate and top and compared to retrofitted model. The performance evaluation was based on lateral deformation, storey shear, and hinge formation From the study, he had concluded that storey drift is maximum at soft storey and it decreases gradually up to the top. Plastic hinge formation, base reaction and roof displacement is more in existing soft storey building but less in retrofitted models.

Hiten L. Kheni, Anuj K.Chandiwala, said collapse mechanism of different buildings damaged under earthquakes are assessed and makes a design concept of strong column weak beam such that during earthquake, beam yield before column collapse. Based on this concept, different building models were analyzed using software. Writer concluded that estimation of displacement of codal lateral load pattern are smaller for lower stories and larger for upper stories and are independent of total number of stories of the model.

SuchitaHirde and Ganga Tepugade, Discussed the performance of a building with soft storey at different level with at ground level. The nonlinear static pushover analysis is carried out Concluded it is observed that plastic hinges are developed in columns of ground level soft storey which is not acceptable criteria for safe design Displacement reduces when the soft storey is provided at higher level.

Conclusion:

In comparison to the other five models, Model 1 exhibits the lowest base shear and the longest time period, indicating the least amount of stiffness. Soft storeys are dangerous at lower levels, so any necessary provisions should be made to prevent a catastrophic or abrupt collapse. The model with the bottom soft storey exhibits the highest storey drift at ground level when compared to other models. It also demonstrates that the bottom soft storey has less stiffness than the above stories. The top storey of the bare frame model exhibits the largest storey displacements when compared to other models; however, the displacement of the planar or L-shaped shear wall is significantly decreased; thus, the presence of a shear wall minimizes storey displacements and makes the structure strong. Since Model-II exhibits the least amount of stiffness when compared to the other four models, the addition of shear walls will strengthen and stabilize the structure against seismic threats. Core walls should be included in models that are closest to the center of mass point because models without core walls behave similarly to models with central core walls. The location of the shear wall is crucial for seismic resistance; it must be such that it does not interfere with the structure's overall behavior. According to a study on mode forms, Model-II exhibits greater torsion at the ground floor when compared to other models. The overall behavior is significantly impacted when modeling and designing without taking into account the significance of brick infill panels.

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