ABSTRACT

Earthquakes, even though they occur rarely, induce inertia force which is dynamic and complex. Moreover, they are sometimes so devastating that it is worth going into the depth of understanding them. The current work is one step towards understanding the complex effects of this dynamic force particularly on low rise RC structures which are found in almost all parts of the world. During 2001 Bhuj earthquake of India, a major damage was observed in RC framed structures at Ahemdabad which were in the range of G+3 to G+7 storey. Most of the buildings were having a normal grid of 3m x 3m column spacing with a storey height of 3m. Hence the present work, which is expected to act as a guide line for Civil and Structural Engineers in smaller towns and cities where expert advice may not be easily available, is devoted to RC framed structures ranging from G+3 to G+7 storey.

Out of the various factors affecting the earthquake and dynamic response of RC framed structures, in the current study, the shape of the column is considered to be one of the factors. The G+7 storey frame without the consideration of brick infill is subjected to push over analysis. The performance point for rectangular and equivalent square shaped cross section of columns is studied. The study incorporates two variations in the overall plan dimensions – 6m x 6m and 6m x 9m having four panes each of 3m x 3m and 3m x 4.5m respectively. The same set of models are also studied with brick infill walls modeled as 2D finite elements and equivalent strut. The performance point obtained from the push over analysis is considered as a measure of performance. Parameters like base shear, roof displacement, number of plastic hinges, severity of hinges, effective damping, etc. are compared for the mathematical models at performance point.

Another important factor affecting the seismic performance of RC frames is the rigidity of the joint. Although, in case of RC frames which are monolithically cast, the joint rigidity is usually considered as fully rigid, it however may vary depending on the size of beams and columns framing into the joint. In case of precast RC frames, the joint rigidity is always an issue especially under lateral loads. Thus, the study of RC plane frames with varying joint rigidity is considered for analysis under lateral loads. RC space frame models with varying rigidity are also developed for comparing the results under push over analysis.

The concept of joint rigidity is translated to a semi rigid joint having four different joint rigidities viz. 0%, 20%, 45% and 100% indicating fully hinged and fully rigid at the two extremes. This concept of semi rigid joints is used in conjunction with fully rigid joints in the same frame creating a hybrid frame. The seismic performance of semi rigid, hybrid and fully rigid space frames having square and rectangular columns with G+3 to G+7 storey RC structures is compared using push over analysis. The concept of hybrid frames is further extended to bigger frames of overall plan dimensions of 9m x 9m, 12m x 12m and 15m x 15m to consolidate the conclusions drawn for general applications.

Post tensioned RC framed structures have become the need of the time because of speed of construction and higher span to depth ratios. The study of these types of structures vis-a-vis the conventional RC framed structures for seismic performance is undertaken in the present study. Similar to the hybrid concept adopted for RC frames with semi rigid joints, hybrid PT frames with internal beams as PT beams and external beams as conventional beams is developed. The seismic performance of the hybrid PT frames is compared with frames having all RC beams and all PT beams. The G+3 to G+7 storey frames are again used for study under push over analysis. The Open System for Earthquake Engineering

Simulation (OpenSEES) software platform is used to do the verification of push over analysis results obtained from ETABS software.

Further, the effect of introducing a floating column in a G+7 storey RC space frame having rectangular and equivalent square column cross section when a peripheral column is removed from the first to sixth storey is studied. The storey drift obtained for each of the six cases of floating column with square and rectangular columns is considered as one of the parameters indicating the seismic performance of the structure.

Also, the dynamic response of the G+3 to G+7 storey frames is compared in the present study when the models are subjected to various analysis methods for lateral loads such as the linear static method, the response spectrum method for Bhuj earthquake, the IS 1893 specified response spectrum analysis, the non linear static (push over) analysis and the time history analysis as per the acceleration time history recorded for the Bhuj earthquake at Ahemdabad station. The comparison of the response of the space frames having rectangular and equivalent square column cross sections is done using the base shear, roof displacement and drift criteria.

It is observed that for low rise RC framed structures upto G+7 storey, the seismic performance can be enhanced to quiet an extent either by simply selecting an equivalent square shape of column as against a rectangular one without increase in the material or by using the proposed concept of hybrid frames in normal as well as post tensioned RC frames.