SEISMIC RESPONSE OF ASYMMETRIC STRUCTURES WITH BASE ISOLATION

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Abstract— The seismic response of base-isolated structures when eccentricities are set in the superstructure is presented. Linear dynamic analyses were used to study peak responses for different ratios of static eccentricities (e_s) between the centre of mass and the centre of rigidity for the superstructure. Peak dynamic response i.e., maximum isolator displacements were studied and compared to the ones obtained for symmetric systems of reference for the different ground motions under consideration, assessing the importance of the relative value of e_s on those response quantities.

The considered structure is a RC structure which is of 4 storey building. This structure is analyzed with the help of SAP2000. In order to maintain the same structural weight for different eccentricities of the whole superstructure, some of the bays are shifted towards the global positive x-direction which lead to the increase in the number of storey's and gave a constant weight. The time history analysis has been carried out for the 1940 El Centro earthquake. Finally the displacements of the nodes are compared with the displacements obtained from symmetric structure.

I.INTRODUCTION

Buildings with an asymmetric distribution of stiffness and strength in plan undergo coupled lateral and torsional motions during earthquakes. In many buildings the centre of resistance does not coincide with the centre of mass. By reducing the distance between the centre of mass and the centre of stiffness, torsional effects should be minimized. The stiffness characteristics control the dynamic response of the building structure. The choice of the stiffness characteristics of structures is an important step in the conceptual design phase. The good behaviour of the structure can be provided with a well distributed lateral load resisting system.

A lack of symmetry produces torsional effects that are sometimes difficult to assess, and can be very adverse. The preferred method of minimizing torsional effects is to select floor plans that are regular and reasonably compact. Complex plan buildings should be divided by seismic separation joints introduced between rectangular blocks. The behaviour of buildings during earthquakes will be satisfactory only if all measures are taken to provide a favourable failure mechanism. A special account must be taken so that torsional effects do not endanger or preclude the global ductile behaviour of the structure. Because of torsion, the seismic demands of asymmetric buildings increase above those required by just translational deformation. It is well-known that the larger the eccentricity between the centre of stiffness and the centre of mass, the larger the torsional effects. An important aspect of the inelastic behaviour of asymmetric structures is the considerations of the degree of control over inelastic twist. One of the design aims should be to restrain the system against unrestricted inelastic twist. In the structures, which remain elastic during an earthquake, torsional vibrations may cause significant additional displacements and forces in the lateral load resisting elements. However, the design of the majority of buildings relies on inelastic response. In that case torsional motion leads to additional displacement and ductility demands. Hence, the relevance of current code recommendations, based on elastic torsional response, is open to questions.

. The conventional analysis for torsion simply gives the force due to moment produced by an eccentric static force. It takes no account of the torsional vibrations and the associated accelerations. Quantitatively, an eccentricity between the centres of mass and stiffness is considered significant when it exceeds 10% of the horizontal plane dimensions under study. In such cases, corrective measures should be taken in the structural design of the building. Torsion may become even more complicated when there are vertical irregularities, such as setbacks. In effect, the upper part of the building transmits an eccentric shear to the lower part, which causes downward torsion of the transition level regardless of the structural symmetry or asymmetry of the upper and lower floors. Non symmetric or torsionally unbalanced buildings are prone to earthquake damage due to coupled lateral and torsional movements producing non-uniform displacement demands in building elements and concentrations of stresses and forces on structural members. Current codes fall short of providing recommendations for irregular structures. Thus, there is an apparent need to develop a simple analysis procedure based on rigorous analytical and experimental information on the inelastic seismic response of irregular structures.

A. Asymmetry of a structure would lead to many dangerous consequences in the structure during seismic action.
B. Due to asymmetry, torsional effects may significantly modify the seismic response of buildings, and they have caused severe damage or collapse of structures in several past earthquakes.

II. LITERATURE REVIEW

A. *William H. Robinson (1982)* has tried to explain the hysteretic behaviour of a lead rubber bearing isolator and has finally concluded that the lead-rubber hysteretic bearing provides an economic solution to the problem of base isolating structures in that one unit provides the three functions of vertical support and horizontal flexibility via the rubber, and hysteretic damping by the plastic deformation of the lead. The lead-rubber hysteretic bearing behaves like a bilinear solid with an initial elastic shear stiffness, $k_1 \approx 10 k_r$, a post elastic shear stiffness, $k_2 = k_r$, with the yield force being determined by the shear stress at which the lead in the bearing yields. This shear stress is found to be 10.5MPa. The area of the measured hysteresis loop is found to be 80 per cent of the loop defined by the bilinear solid model.

B. *James M. Kelly (1990)* has described the recent implementations of base isolation and approximate linear theory of isolation which can be used for design of base isolation systems that use multilayer elastomeric isolators.

C. *Anand S Arya (1994)* has briefly reviewed the concepts, techniques applicablity and bemifits of using base isolation in structures in severe seismic zones. It is a passive way for achieving seismic response control by introducing various types of isolators between the foundation and the superstructure. The system has to perform three functions; horizontal flexibility, Energy dissipation and rigidity against normal lateral loads. The Rubber-Lead bearing appears to be the best isolator so far, performing all three functions efficiently. Performance of isolated buildings during the earthquakes in Japan shows clearly the achievement of desired reduction in seismic response of buildings. Conditions favouring the choice of base isolation alternative compared to conventional elastic or elasto-plastic design are indicated. The base isolation of masonry buildings through a planned sliding joint is also described.

III. MODELLING WITH SAP 2000 V15

A. A parametric study where the torsional response of base-isolated structures when eccentricities are set in the isolation system is presented.

B. Linear dynamic analyses were used to study peak responses for different static eccentricities

C. Unidirectional and bidirectional actions of selected ground motions were used

D. The maximum isolator displacement was studied and compared to the ones obtained for symmetric structure

E. The Quick Grid Lines form is used to specify the grids and spacing in the X, Y, and Z directions. Set the number of grid lines to 6 for both X and Y directions, and to 5 for the Z direction and grid spacing as 6 for X and Y axes and 3 for Z axis.

F. Click the **OK** button to accept the changes, and the program will appear as shown in Figure 4.3. Note that the grids appear in two view windows tiled vertically, an X-Y Plan View on the left and a 3-D View on the right.

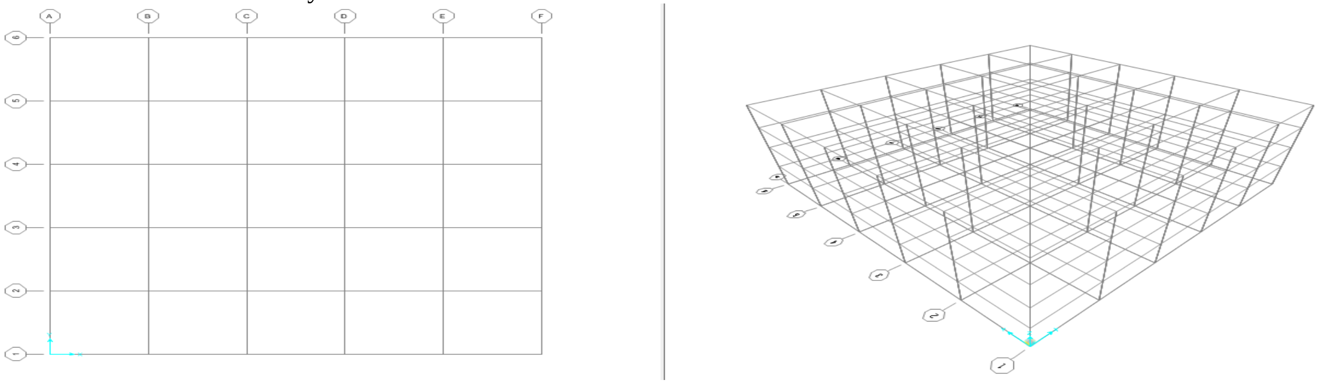


Figure 1: Grid Lines in Plan and 3D

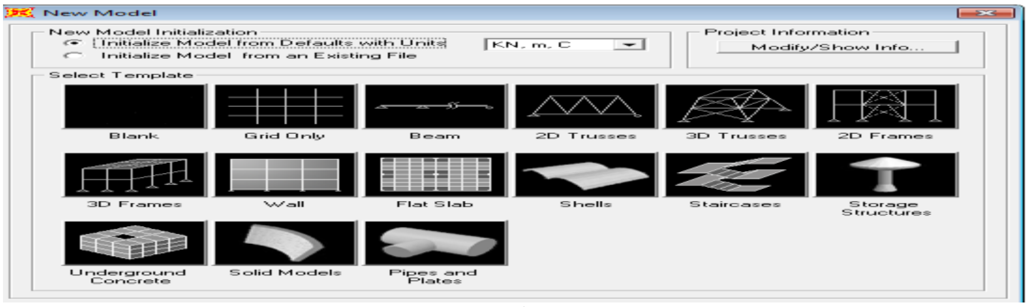


Figure2: Selection of Grid View to Begin the Mode

IV.FINAL MODELLED STRUCTURES

A. Finally the modelled structures model 1, model 2 and model 3 are shown in figures 3 and 4.

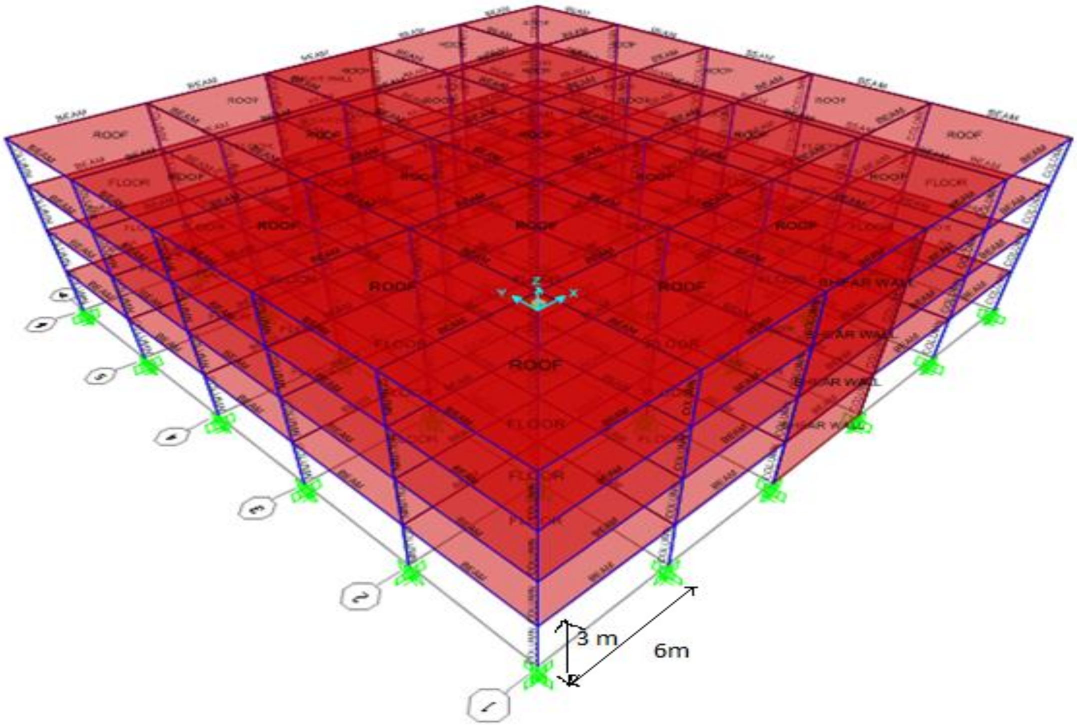
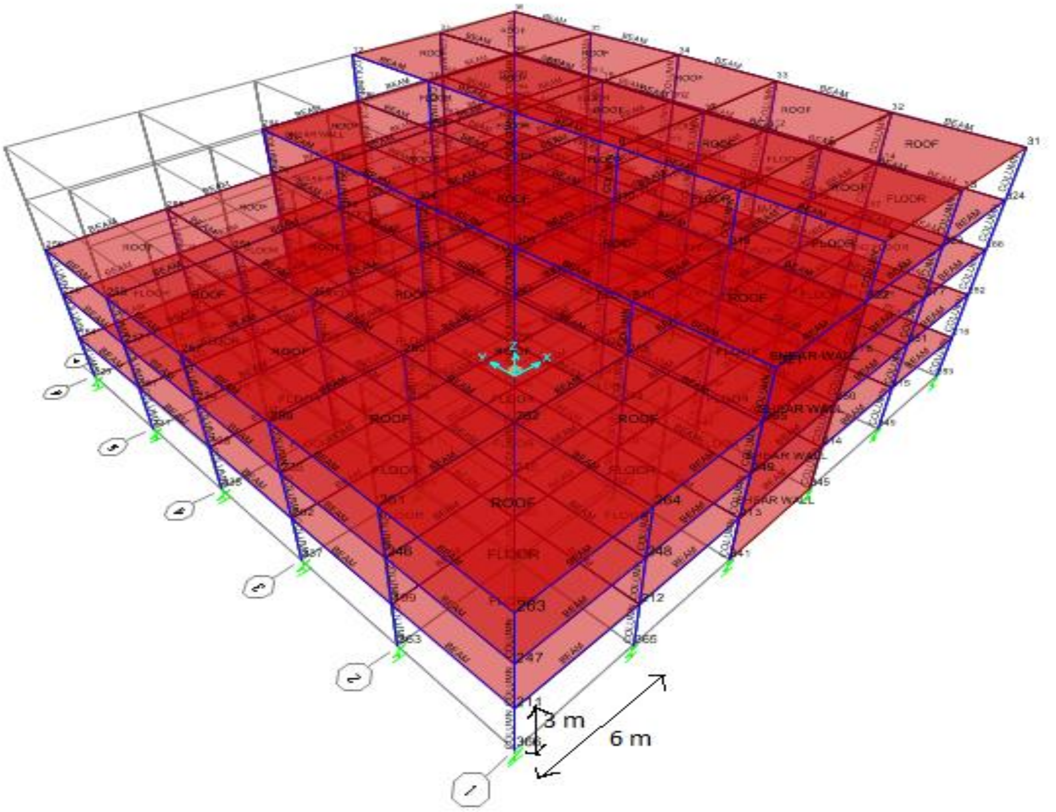


Figure 3: Model 1 (Symmetric Structure with e1 = 0)

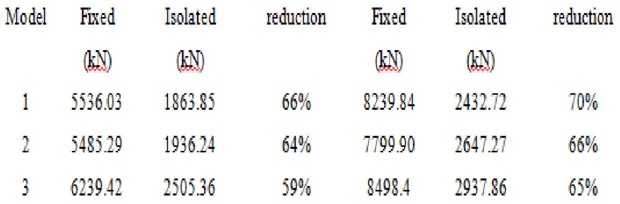


V. RESULTS AND DISCUSSIONS

a.The results based on analysis are presented in tables and the results were discussed with respective graphs. The modelling of the structures with different eccentricities are carried out by shifting the bays towards the direction of eccentricity. These all models are analysed to attain the base reactions, and the maximum possible reaction at the supports among all the structures has been attained. Thus a base isolator with such reaction capacity is designed using UBC-1997and after designing the final results K_r = 1551.4 kN/m and the thickness t_r = 300mm are obtained.

B.BASE SHEAR

Table 1: base shear along X and Y directions



Model	Fixed (kN)	Isolated (kN)	reduction	Fixed (kN)	Isolated (kN)	reduction
1	5536.03	1863.85	66%	8239.84	2432.72	70%
2	5485.29	1936.24	64%	7799.90	2647.27	66%
3	6239.42	2505.36	59%	8498.4	2937.86	65%

VI. CONCLUSION

A. Analysis has shown significant reduction of the story accelerations with isolation. Accelerations have been reduced from 3.589 m/sec2 to 1.779m/sec2 (50%) in model 1, from 3.656 m/sec2 to 1.767 m/sec2 (52%) in model 2and from 4.285 m/sec2 to 1.664 m/sec2 (61%)

B. With implementation of base isolation 98% and 93% amplification of displacements are observed along X direction and Y direction.

C. The obtained peak absolute displacements after performing linear time history analysis were 207mm, 216mm and 220mm for model 1, model 2, and model 3 respectively at node 324 after 2.6sec in Y direction.

D. The peak relative displacements (i.e., the offset between the corresponding solid and dotted lines of the models) of node 324 with respect to node 353 are 42mm, 45mm, 47mm for model 1, model 2, and model 3 respectively.

E. Because of providing the base isolators, the relative displacements are almost equal, as they reduce the seismic force transferred to the super structure.

F. This work could be continued by modifying the technique of energy dissipating objects like frictional dampers, viscous dampers instead of base isolation technique as incorporated in this project.

G. We can also consider other seismic response quantities like inter storey drifts, stresses and energy dissipation mechanism induced at the joints etc.

ACKNOWLEDGEMENT

We would like to thank Mr.Dr.K.S.R.Murthy,(Professor)Department of Civil Engineering, Sree Dattha Institute of Engineering and Science (SDES).

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