ABSTRACT

The objective of the present study is to examine the influence of the effective stiffness of isolators regarding the torsional response of base isolated structures under lateral forces. Consider the three-storey reinforced concrete asymmetric building with rigid floor diaphragms, base isolated with elastometallic lead rubber bearings. For the above mentioned building the following two cases were considered: model (b) which consists of bearings of identical horizontal stiffness, whose fundamental period is less than three times that of the fixed base building [model (a)] and model (c) which consists of three types of bearings which differ in their horizontal stiffness. The criterion upon which the properties of the isolators and their arrangement in plan were chosen, is the coincidence of optimum torsion axis (O.T.A.) with the vertical mass axis. The total horizontal and torsional stiffness remain constant between the two models, (b) and (c).

In the first chapter, a description of the structural system of the three–storey base isolated building is given. Due to the fact that multi–storey asymmetric buildings do not have real elastic axis, the methodology used for the determination of the fictitious elastic axis (optimum torsion axis) and the principal directions is presented. The methodology used was proposed by Marino and Rossi (2004) in order to define the exact location of the O.T.A. and was expanded by Athanatopoulou and Doudoumis (2005). The only restrictions for the application of the above procedure are the linear elastic behavior and the existence of rigid floor diaphragms. These assumptions are also valid in many cases of base isolated buildings as long as they can be represented as linear models for analyses purposes. The application of seismic isolation in the above mentioned building causes the movement of the O.T.A. towards the theoretical center of mass.

In the second chapter all the linear analyses are presented. Simplified Linear Method and the Response Spectrum Analysis are performed as the Seismic Codes suggest and they are widely used. The application of these methods is based on the provisions of E.A.K. 2003. Although the diaphragm rotations are almost in all cases decreased, the resultant displacements, calculated by the Simplified Linear Method and the Response Spectrum Analysis, are sometimes reduced and other times increased, depending on the location of the design forces and the masses respectively. The above mentioned methods are approximate and they do not offer clear and evident results. For the comparative study between the two models [(b) and(c)] Linear Time History Analysis is performed. The two models (b) and (c) were subjected to five unscaled seismic base excitations, represented by the accelerograms of the El Centro, Kobe, Lefkada, Aigio and Kozani earthquakes. The maximum response of the building due to seismic excitations was determined through analytical formulae developed by A.M. Athanatopoulou. These formulae determines the critical angle of seismic incidence and the corresponding maximum value of response quantity of structures subjected to three correlated seismic components. From the analyses results the following conclusions are drawn:

- The same earthquake records have different critical angles for different response quantities.

- Different earthquake records have different critical angles for the same response quantity.

In the third chapter NonLinear Time History Analyses are performed, assuming that the displacements are concentrated on the isolation level and, therefore, the superstructure behaves elastically. The accelerograms used were those of the El Centro, Kobe and Lefkada earthquakes, which were considered as the strongest. Since superposition is not valid for NonLinear Analyses the proposed methodology by A.M. Athanatopoulou cannot be applied. In order to determine the maximum value of horizontal displacements and diaphragm rotations analyses were carried out for several angles of seismic incidence.

The results of NonLinear Time History Analyses are similar to those of Linear Time History Analyses according to which the displacements of the elements located at the flexible side of the building reduced significantly. The resultant displacements of model (c) are up to 46% in comparison to the respective displacements of model (b). NonLinear Time History Analyses gave a decrease of approximately 27%. The displacements calculated for the elements located at the stiff side of the building with Linear Time History Analyses were decreased, while the same displacements produced by the NonLinear Time History Analyses were either reduced or had a negligible increase about 8%. The diaphragm rotations of model (c) reduce significantly despite that this model had a torsional stiffness 1,4% less than the model (b). On the basis of the above study one can make the following observation. The isolators located at the perimeter of the building can prevent undesirable torsional response with the proper selection of their horizontal stiffness. In addition proper selection of the isolators' characteristics so that the O.T.A. coincides with the center of mass leads to uniform displacements of all vertical resisting elements. Peak displacements produced by NonLinear Time History Analyses are more unfavorable: 42% for the El Centro earthquake, 20% for the Kobe earthquake and 42% for the Lefkada earthquake.

All of the above conclusions verify the importance of proper selection of the isolators' stiffness in order to achieve the optimum behavior of the isolated building under earthquake ground motion.