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Comparative study of the Dynamic Analysis of Multi-storey Irregular building with or without Base Isolator

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Abstract—***Performance based seismic design philosophies in seismic design has become the cardinal point of interest in civil engineering structures Due to the vulnerability of Bangladesh to earthquake, base isolation system should be introduced in major earthquake zone. To see the dynamic behaviour of the structure, dynamic analysis should be performed for regular and irregular building with and without isolator. Dynamic analysis can take the form of a dynamic time history analysis or a linear response spectrum analysis. The installation of isolator in building considerably increases the time period of the structure, which means it reduces the possibility of resonance of the structure. Provision of isolator in building often increase the total cost, but as reinforcement requirement and construction material cost is reduced due to isolator. So, isolator may be incorporated at the bottom of the structure to exploit economic and structurally safe alternative. In this present study, Multi-storey irregular building of 20 stories with or without isolator has been modelled using software packages SAP2000 v15 for seismic zone of Bangladesh. Dynamic response of building under actual earthquakes, chi-chi, Taiwan, 1999 and Northridge have been investigated. This paper highlights the comparison of isolated and non-isolated building performances with Time History Analysis and Response Spectrum Analysis.***

Keywords—**Base isolator, irregular RCC building, Time history analysis, displacement, storey drift.**

I. Introduction

Historical seismic catalogues reveal that Bangladesh has been affected by earthquake since ancient times. Earthquakes occurred in 1664, 1828, 1852 and 1885 are shown to have Dhaka as epicentral area. Similarly cities like Rangpur, Sylhet, Mymensing, Chittagong, Saidpur, Sirajgong, Pabna etc. have been shown to be the epicentral area of some of the major earthquakes in the past. Although the ancient record do not specify the earthquake epicenter by giving coordinates in terms of latitude and longitude. It is difficult to figure out whether these cities were directly hit by earthquakes. However occurrence of earthquakes both inside and outside of the country and around major cities indicates that earthquake hazard exists for the country in general and the cities in particular. Consideration of earthquake forces in structural design, city planning and infrastructure development is therefore a prerequisite for future disaster mitigation.

Several earthquake of large magnitude (Richter magnitude 7.0 or higher) with epicenters within Bangladesh and India close to Indo-Bangladesh have occurred (AM and Chowdhury, 1994). **Table 1** and **Table 2** provide lists of the major earthquakes that have affected Bangladesh and its surroundings. Furthermore the country is divided into three zones determined from the earthquake magnitude for various return periods and the acceleration attenuation relationship (Ali and Chowdhury, 1994) namely zones 1,2,3 being most to least severe gradually (BNBC, 1993).

Table 1. Lists of Major Earthquakes Affecting Bangladesh

Date of occurrence	Name (Place)	Magnitude	Epicenter distance from Dhaka(Km)
10 Jan 1869	Cachar Earthquake	7.5	250
14 Jul 1885	Bengal earthquake(Bogra)	7.0	170
12 Jun 1897	Great Indian Earthquake	8.7	230
08 Jul 1918	Srimangal Earthquake (Srimangal)	7.6	150
02 Jul 1930	Dhubri Earthquake	7.1	250
15 Jan 1934	Bihar-Nepal Earthquake(Bihar)	8.3	510
15 Aug 1950	Asam Earthquake (Aasm)	8.5	780

Table 2. Recent Major earthquakes in Bangladesh (Ansary, 2005)

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Date of Occurrence	Name(Place)	Magnitude	Epicentral distance from Dhaka (Km)
08 May 1997	Sylhet Earthquake (Sylhet)	6.0	210
21 Nov 1997	Chittagong Earthquake (Chittagong)	5.5	264
22 Jul 1999	Moheskhali Earthquake (Cox's Bazar)	5.2	300
27 Jul 2003	Chittagong-Rangamati Earthquake	5.9	290

The historical seismicity data of Bangladesh and adjoining areas indicate that Bangladesh is vulnerable to earthquake hazards. As Bangladesh is the world's most densely populated area, any future earthquake shall affect more people per unit area than any other seismically active regions of the world. Both of the above factors call for evaluation of seismic hazard of Bangladesh so that proper hazard mitigation measure may be undertaken before it is too late.

The basic objective of the research is to: 1) Conduct a through literature survey on the base isolation principle and its suitability for use in irregular buildings. 2) Perform non linear dynamic analysis of buildings with isolated bearings and non-isolated one.

The investigation gives emphasis on the feasibility of incorporation of isolators and its structural implication on buildings is limited to the following extents: 1) Only buildings in Dhaka are considered in this work. 2) Only lead rubber bearing is considered in this Study.

II. Methodology

A 20 storied residential building is modelled to analyse under Time History and Response Spectrum method. The storey plan is changing in different floors as shown in figure 1. The height of each floor is 10ft. the plan of first five floor of the problem is given in figure 2, other floors are shown in figure 3 and 4. Number of Bays in X direction is five an Loading which is applied to the structure is according to BNBC. Number of Bays in Y direction is four. Loading applied to the structure including dead load and live load are given according to BNBC. The section of column is used as 750mm the x750mm. and the beam section is taken as 300mmx600mm. Grade beams are taken as 300mmx750mm. For isolated structure lead rubber bearing(LRB) is used which were connected to all column and foundation of the building. Material properties are chosen as f'c=28MPa, fy=414MPa, Live load=2.4KPa, Slab thickness=150mm.

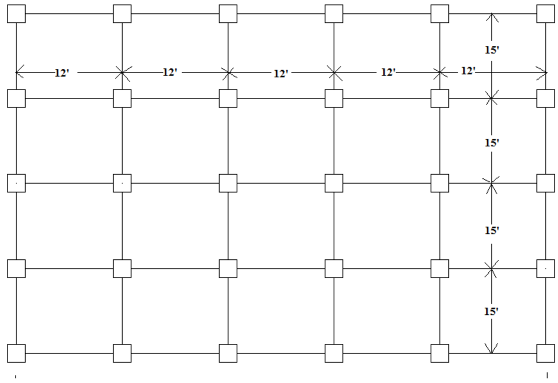

Figure 1: 1st to 5th floor plan

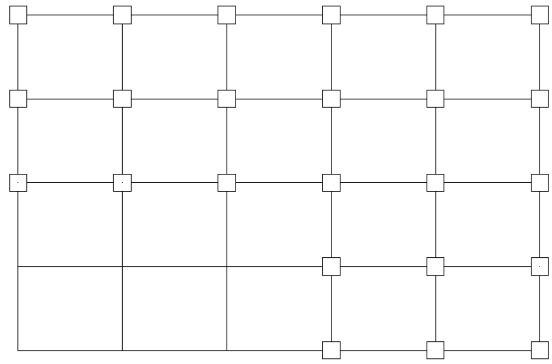

Figure 2: 6th to 10th floor plan

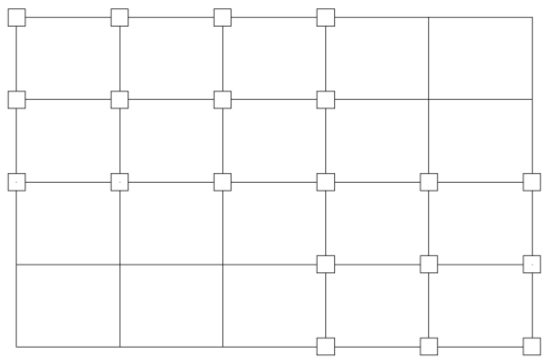

Figure 3: 11th to 15th floor plan

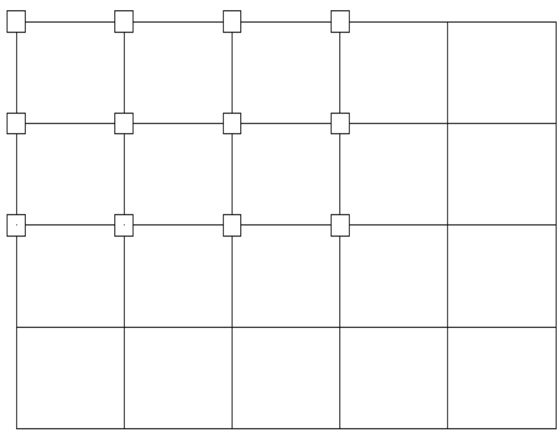

Figure 4: 16th to 20th floor plan

III. Results and Tables

The maximum displacements of building in different stories in both X and Y direction for all method of analysis have been compared and shown in Figure 6-10.

From the diagram below, it is observed that , displacement is significant in first five stories and difference between displacement is dicreasing with the increasing storey height. It is observed that the relative displacement between storis after using isolator is much less than before. This clearly indicates that the axial force on column will be reduced which will reduce the design reinforcement for column. So, Base isolation is economical under design consideration.

Finally, we can say that incorporation of base isolation is necessary for design load reduction and structural safety.

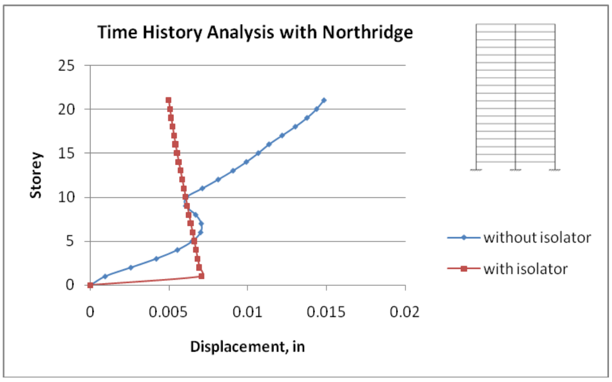

Figure 5: Maximum displacement in U1 direction

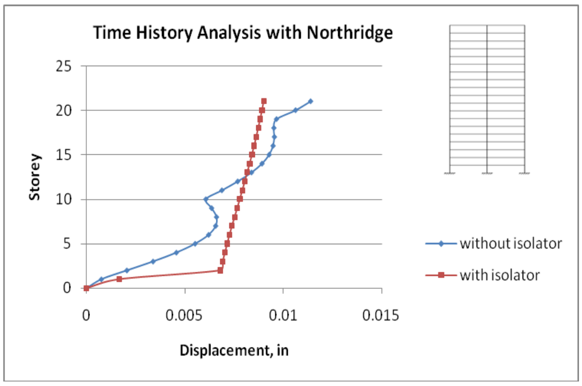

Figure 6: Maximum displacement in U2 direction

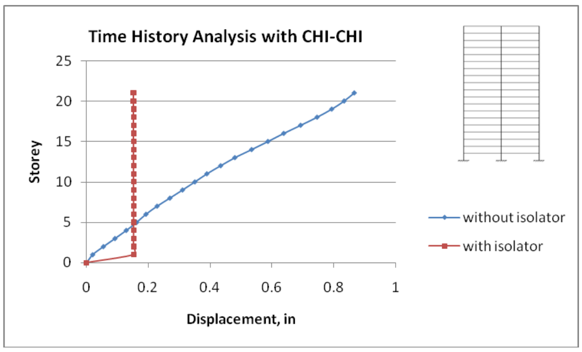

Figure 7: Maximum displacement in U1 direction

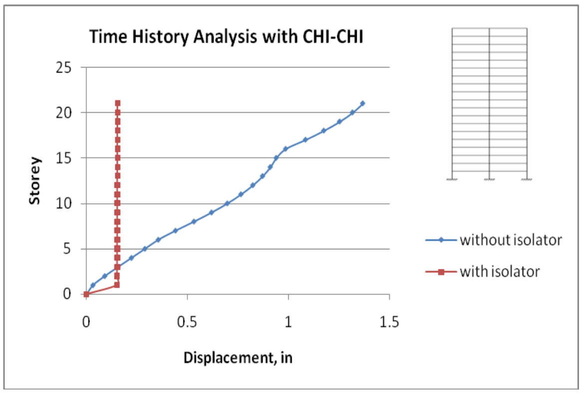

Figure 8: Maximum displacement in U2 direction

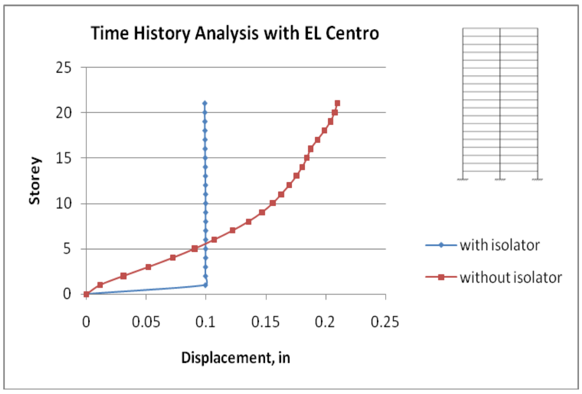

Figure 9: Maximum displacement in U1 direction

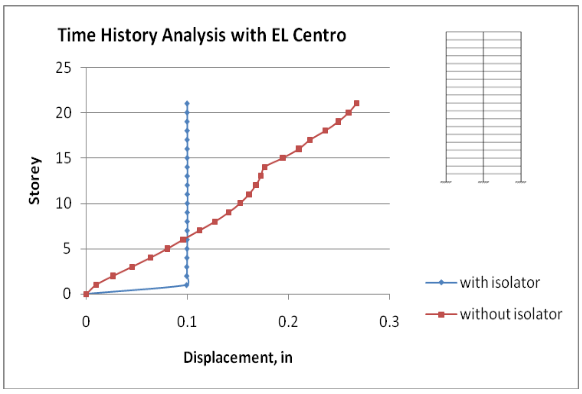

Figure 10: Maximum displacement in U2 direction

IV. Conclusion

From the above work the following conclusion can be drawn out

[1] Results of comparison between isolated and non-isolated building under different earthquake show that the displacement obtained by non-isolated building is much higher than isolated structure.

[2] Time history analysis is an important and effective tool to visualize the performance level of building under different earthquake.

[3] Seismic performance of structure can be obtained by selecting an adequate recorded ground motion for time history analysis.

[4] Static analysis is not sufficient for high rise buildings and it is necessary to provide dynamic analysis (because of specific and non-linear distribution of force)

[5] For irregular structure time history analysis should be performed to see the non-linear behaviour of the structure.

[6] The displacement difference between the isolated and non isolated structure is significant in irregular building. So, base isolation can be incorporated in this type of structure.

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