Seismic Analysis of a High-Rise Building A Case Study

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***Abstract*: Pakistan is located in a region of high seismicity. The 2005 Kashmir Earthquake near the city of Muzaffarabad, with an intensity 7.6 on Richter scale had a Death Toll 86,000–87,351 and Economy Loss of 6 Billion US Dollars. Earthquakes don't kill people, Buildings do. The aim of this research is to investigate the response of a high rise building during seismic excitations by using software ETABS. The building selected for this research work is a reinforced concrete building having three shear walls, located in Hyderabad. The research methodology includes the non-linear static analysis also known as pushover analysis. The zone of Hyderabad city is 2A having peak ground acceleration of 0.08g to 0.16g. The required data was extracted from Building code of Pakistan and various displacement and drift values for different floors were observed. The results show that basement carries zero drift and its value increases as one moves from the bottom to the top floors, it concludes that upper floors will move and vibrate for long time intervals as compared to the bottom floors. The building was analyzed for different loads i.e. Dead, Live, Wind and Earthquake Loads where the maximum values of shear force and bending moment diagrams were due to the Dead and Live Loads. However, this research work concludes that the proposed building is safe under seismic excitations because of the shear walls provided.**

***Keywords*: Earthquake, ETAB,; Pushover Analysis, Seismic Zone, Peak Ground Acceleration.**

I. INTRODUCTION

Since beginning of the world, the human beings are beneath the impact of natural hazards which have resulted usually in the loss of mankind. The National Earthquake Information Centre (NEIC) investigated that every year, an average of 20,000 earthquakes (about 50 per day) is recorded [1]. As the world is being developed day by day, the high rise buildings may not be designed with seismic analysis. The purpose of seismic analysis is that the structure remains safe due to earthquake forces. Pakistan is located in high seismic zone. There have been unbearable disasters in history of Pakistan. Example: The earthquake having intensity of 7.6 on Oct 8, 2005 in Kashmir, Pakistan, which caused more than 86,000 casualties and economy loss of 6 Billion US Dollars[2].

Considering the damage in the recent years, the current research is targeted to assess the seismic vulnerability of RCC High-Rise Building which is located in Hyderabad, Sindh. Hyderabad is located in the lower region of Sindh, Pakistan. The seismic zone of the city is 2A in which ground acceleration is 0.08 to 0.16g which is moderate zone. The building consists of G+11 floors having double basement. It consists of three shear walls. Shear walls are provided to resist the forces during earthquake and make the building safe during seismic excitations. For the analysis of building, several techniques and softwares are used. In this research, the seismic analysis of this structure is done with the help of ETABS (Extended Three-Dimensional Analysis of Building Systems).

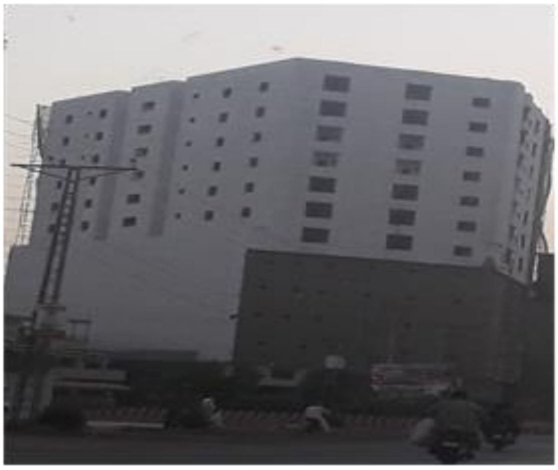

Fig. 1(a): White City Mall, Autobahn Road, Hyderabad, Sindh

Fig. 1(b) Site plan of the building

II. MATERIALS & METHODS

A. Representative Building

The building selected for this research is a high rise Reinforced Concrete Building with Double Basement+G+11 floors whereas the building has irregular plan.

1. Properties of Building

It includes all the properties of building that is type of foundation, material properties and section properties. Furthermore, the detail of the zone in which the proposed building lies is also discussed.

2. Codes Followed

The codes followed by the design engineers for the targeted building, are ACI-2002 and UBC-1997 Standards.

3. Soil pressure

The building is designed at a soil pressure of 2.75 tons/ SFT at 22 ft to 23ft depth from Exit Road Level.

4. Ground water table

Ground Water Table was taken as 9ft from Exit. Road Level. For this reason the foundation for the building is discussed in the later section.

5. Foundation

The foundation for the purposed building is Raft Foundation. This type of foundation is provided for the Structures that contains large number of columns and beams. The strength of concrete for foundation is 4 ksi.

6. Beams

The building consists total of 259 beams having different cross-sections. The strength of the beams is 4 ksi.

7. Columns

The building consists total of 48 columns. The strength of column is 5 ksi.

8. Slab

The slab provided for the basement and ground floor is 6” thick while the remaining floors have 5” thick slab. The strength of concrete for slab is 4 ksi.

9. Shear walls

The types of walls provided are Reinforced Cement Concrete walls. To overcome seismic loads the building has 3 shear walls (with different cross sections) having concrete ratio of 1:1:2.The Shear Wall is provided through the entire height of the building and the shear wall strength is 5000 psi. The thickness of shear walls is 12, 15 and 18 inches. Provided in three different directions to resist the seismic loadings.

10. Retaining walls

The basement floors of the building contains retaining walls having thickness of 12 in. The strength of retaining walls is 4000 psi.

11. Materials used in building structure

The mixed design M25 having strength of 4000 psi has been used in the building structure and the ingredients of mixed design are as under:

a. Cement

The type of cement used is foundation is Sulphate Resisting Cement (SRC). It is provided when the soil contains more sulphates.

b. Steel

According to ASTM-A615 the steel grade has been used of 60 ksi.

12. Seismic Zone

The zone at which building lies is 2A. It has peak ground acceleration of 0.08g to 0.16g.

B. Analysis on ETABS

ETABS is one of the most innovative and advanced tools for the modeling, analysis and design of building. ETABS is considered as multitasking software. The software has the advantage that it will assign all the dead, wind and earthquakes loads automatically. It provides plan and elevation view of building at same time and is helpful in modeling irregular buildings. It provides the Bending Moment and Shear Force Diagrams of different structural components.The method used for seismic analysis is non-linear static analysis or pushover analysis. It holds linear relations between applied forces and displacements. It has been observed from studies that the high rise-buildings are more susceptible to damage than the low and mid storey buildings during earthquakes therefore more precautions are needed during the Seismic Analysis of high rise buildings.

C. Model of the building:

The model of the purposed building after design in ETABS is as under. It contains three shear walls.

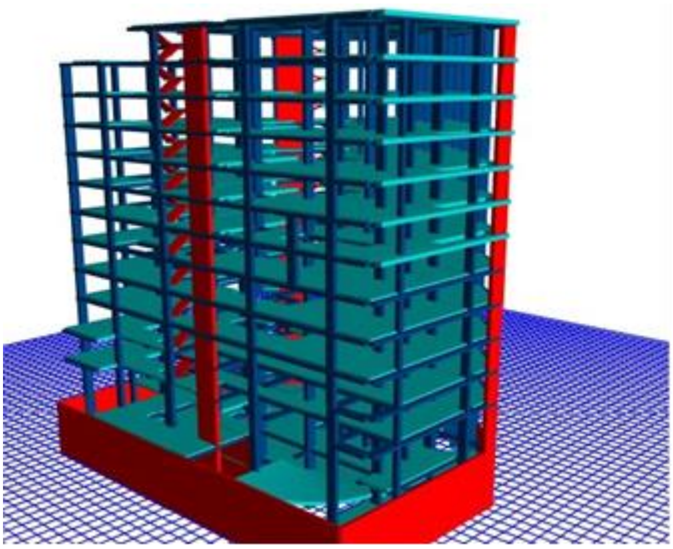

Fig. 2: 3D view of the model of building

II. RESULTS

Once the building is modeled and all the loads are assigned the next step is run analysis, a run analysis would be conducted that would clearly show the various outcomes i.e. Bending moment diagrams, Shear force diagrams of the building and the performance of building under seismic excitations.

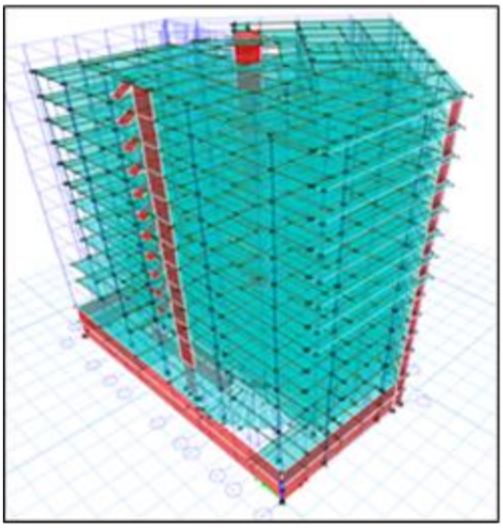

Fig.3 (a):Model before analysis

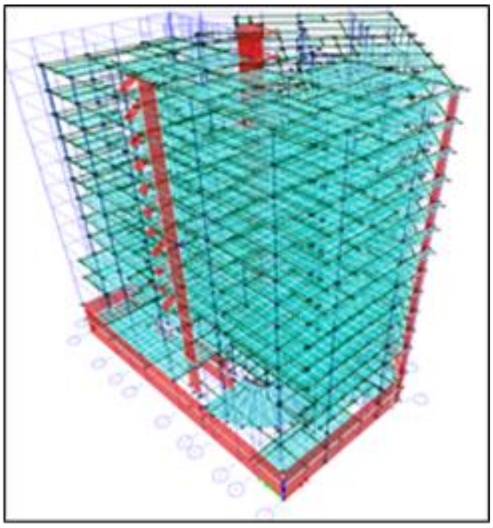

Fig.3(b): Model after analysis

1. Point Displacement and Drift

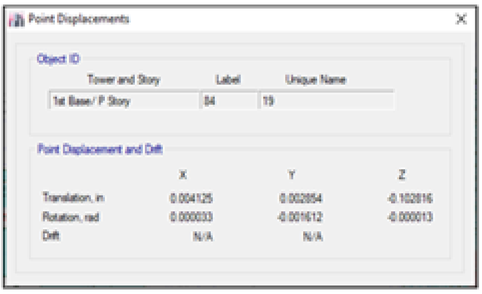

Fig.4(a) Point displacement of 1st Base

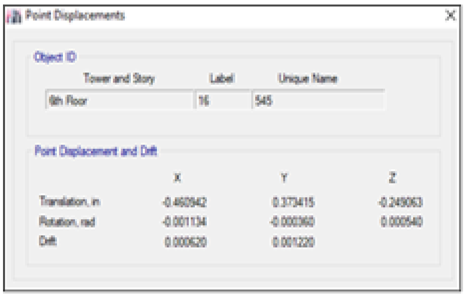

Fig. 4(b) Point displacement of 6th Floor

Fig. 4(c): Point displacement of Roof

The results obtained show that the displacement and the drift ratio increases as you move from basement to the top floor. The highest value obtained is at roof which means that under the seismic excitations, the building will move more in the lateral direction at the top floors.

2. Moment force diagram

The Moment Diagrams are obtained from Dead loads, Live loads, Wind X, Wind Y, Wind X1, Wind Y1, Wind X2, Wind Y2, EQX, EQY. While comparing the results obtained under each load, the maximum one is selected.
The bending moment and shear force diagram of all the stories is determined in the analysis. Some of them are shown below.

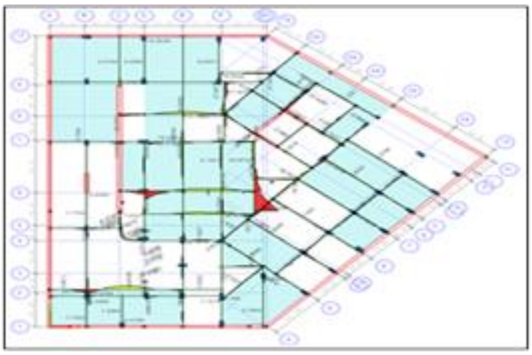

Fig.5(a): 1st Base bending moment diagram due to dead load

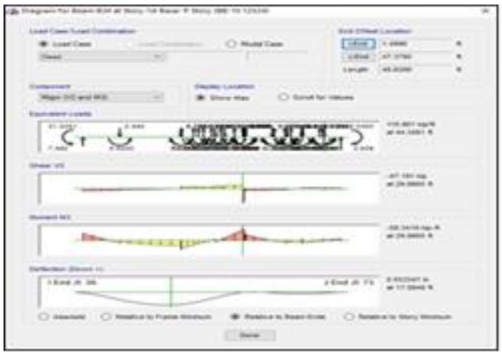

Fig. 5(b) Max. Shear Force and Bending Moment

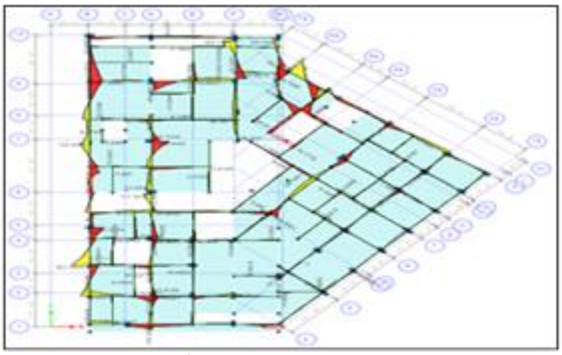

Fig. 5(c): 6th Floor bending moment diagram

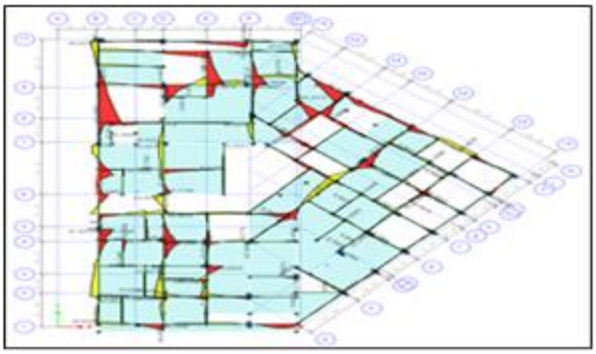

Fig. 5(d): 9th Floor bending moment diagram

3. Shear Force and Bending Moment Diagram

The shear force and bending moment diagrams for all the all stories is given under the following table. It is observed from the results that the building is safe under seismic excitations. The shear walls provided in building resist the seismic loads making the structure safe.

Table 4.1 Shear Force and Bending Moment of All Stories

Floor	Load Case	Beams	Shear Force (kips)	Bending Moment (kip-ft)	Deflection (inches)
1st Base	Dead Load	BB10 12X24	-47.2	-58.3	0.55
Ground Floor	Live Load	BB50 15X24	3.5	21.95	0.87
1st	Dead Load	FB-29	-29.8	118.00	2.183
2nd	Dead Load	TB20B 12X63	5.175	178956.97	1024.0
3rd	Dead Load	TB20A 12X63	31.1	-305.8	-15.1
4th	Dead Load	B-7A	26.435	-50.6	-0.21
5th	Dead Load	B-7A	67.8	-664.2	-36.9
6th	Dead Load	TB20A 12X63	81.14	289.7	-1.75
7th	Live Load	TB20A 12X63	15.05	-93.2	-0.39
8th	Dead Load	TB20A 12X36	50.05	-200.2	-8.2
9th	Dead Load	TB20A 12X36	50.8	-191.3	-7.7
10th	Dead Load	TB20A 12X36	49.5	-189.7	-7.84
11th	Dead Load	TB20A 12X36	54.6	-191.0	-7.83
Roof	Dead Load	TB16B	75.3	-467.08	-1.5

III. CONCLUSIONS

1. The results show that under the seismic excitations, the 1st Base storey will carry zero drift.The value of drift increases as one moves from the bottom to the top storey that shows that the upper floors will move and vibrate for long time intervals as compared to the bottom floors.
2. As the time period increases, the lateral movement will also increase. While comparing the force diagrams, the basement carries a min value of member force and the roof carries the max value.
3. The Bending Moment and Shear Force Diagrams were observed under each load i.e. Dead loads, Live loads, Wind X, Wind Y,EQX, EQY and it was observed that the max values were basically due to Dead Loads or Live Loads.
4. Only a beam to column joints were studied as a mode of failure against seismic loadings, it can be extended to other type of failures as well e.g. shear failure of columns etc.

IV. RECOMMENDATIONS

- In order to make the structure safe during seismic loading, the seismic resisting structures must be provided.
- The codes must be followed before designing any building because with the implementation of seismic codes, the level of damage would be far less and thousands of lives could be saved.
- Further research can be done by keeping this research as a foundation.

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