ISSN 2348 – 8034
Impact Factor- 4.022

GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES

COMPARATIVE STUDY OF FAILURE CRITERIA OF A DAMAGED RC BUILDING IN NEPAL WITH FOUR OTHER MAJOR EARTHQUAKES

Syed Mubasshir*1 and Mohd Abdul Hafeez[2]

[*1]M- Tech (scholar), Nizam Institute of Engineering and Technology, Hyderabad, TS, INDIA.

[2]Assistant Professor, Moulana Azad Urdu University Hyderabad, Govt of India, TS, INDIA.

ABSTRACT

Earthquakes occurred in recent past around the world have indicated that if the structures are not analyzed and designed with adequate requirements may cause a great destruction of structures apparently resulting in human as well as financial losses. Hence, going for the study of buildings with broad and expanded considerations are needed to decide the further precautionary measures for the designers in future. In this study is the 10 storey building damaged in Nepal earthquake on 25th April, 2015.The paper was published named, "Performance of a ten story reinforced building damaged in the 2015 Nepal Gorkha Earthquake" and the resistance of the building to the seismic demands was found inadequate.

The analysis of the building model is again done with the adoption of different known time histories from the past and the comparative study was carried out on the model using the same response history analysis and inverted triangular based pushover analysis. The failure criterion of the building model is determined for different time history functions.

***Keywords*:** Response history analysis, push over analysis, Time history functions, etc.

I. INTRODUCTION

The buildings in Nepal are designed as per the Indian standards and are seen to have destroyed severely in the 2015 Nepal earthquake. Hence it becomes necessary to do the detailed analysis and to reach the core of the seismic behavior of the building with comparative study of different past earthquakes on the same model. A detailed review of the design and construction practice of RC buildings in Nepal can be found in Chaulagain et al. (2013). Firstly, the non linear response history analysis was carried out followed by an inverted triangle load pattern based push over analysis.

The time history functions called in this study were:

1. NEPAL,KATNP EARTHQUAKE,APRIL15,2015
   Magnitude: 7.8
2. CHILE,ALGAROBBO EARTHQUAKE,MARCH03,1985
   Magnitude: 8
3. EL-CENTRO EARTHQUAKE,MAY18,1940
   Magnitude: 6.9
4. UTTARKASHI
   EARTHQUAKE, OCT 20, 1991
   Magnitude: 6.6
5. BOKAJAN EARTHQUAKE,AUG06,1988

Magnitude: 6.9

Building specifications and Modeling:

It is the 3 –bay by 5-bay,10 storey reinforced concrete building comprised with a uniform floor height of 10ft(3.048m)with varying bay width. The building has a small room having a height of 13 ft (3.962 m) to house the elevator machinery on the roof. The two core shear walls are placed in the elevator shafts. The building has two floors of basement assumed to behave as a rigid body, which are not considered during the analysis.

From the available data, the design compressive strength of the concrete is 30 MPa and the nominal yield strength of reinforcement is 500 MPa. Dead load consists of member self-weight, loads due to partitions, infill clay brick walls, and floor finish. Live load on the floor and roof slabs was 2.0 kN/m2 and 1.5 kN/m 2, respectively. The other necessary parameters were adopted from the aid provided. Modeling and analysis of the building was done using ETABS 2015 Ultimate15.0.0.

The beams and columns were modeled using rectangular frame elements (rectangular sections), while the core walls of the elevator shafts were modeled using a frame element (box section) representing equivalent wall sections. To maintain the connectivity of the walls with the frame, it was connected at the floor level with rigid links.

In order to model the nonlinear behavior in the structural components, nonlinear hinges were assigned to each frame element. The default hinge property available in ETABS 2015 which is based on ASCE 41-13 is used. The PMM hinges that combine axial force and biaxial bending (i.e. axial force-moment interaction) was assigned to both ends in all the columns, while M3 hinges (representing the out-of-plane bending) were assigned to the beam ends.

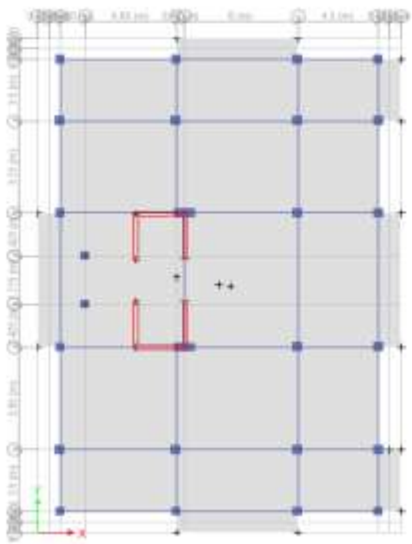

Figure1: Plan view of building model

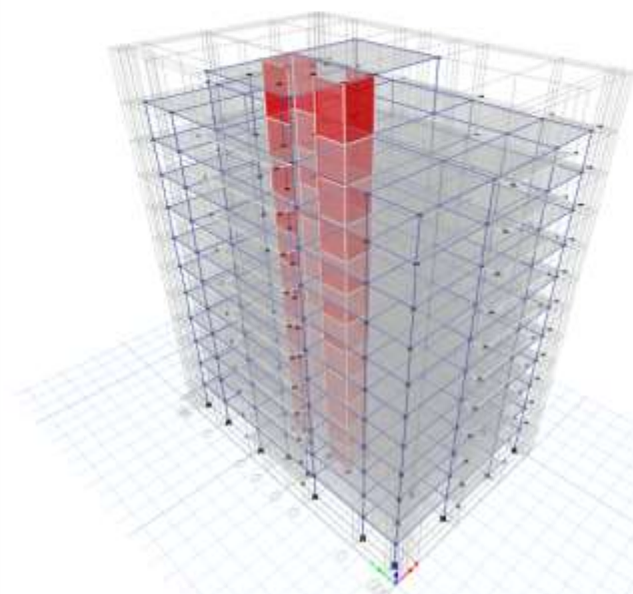

Figure2: 3-dimensional view of building model

II. Objectives of study

1. To re-analyzed the 10 storey Nepal Gorkha building and govern its performance during the 2015 Kathmandu (KATNP) earthquake.
2. To do the comparative study of failure criteria of the damaged building model with other different major earthquakes.

Methodology of analysis:

During the analysis it was observed that the effects on the Y- direction of the model were less when compared to that of in X- direction. So the study was done limiting to the X- direction due to its severity in the results.

1. Response history analysis:

The ground motion data of "KATNP" along with "BOKAJAN", "CHILE", "EL-CENTRO" and "UTTARKASHI" were applied on the building model separately and the non linear response history curves were taken out of each model representing respective ground motions. The functions were made with the aid of curves generated and response history analysis was carried out. The base shears, storey displacements, inter storey drifts, lateral forces and other relevant data was taken out.

ISSN 2348 – 8034
Impact Factor- 4.022

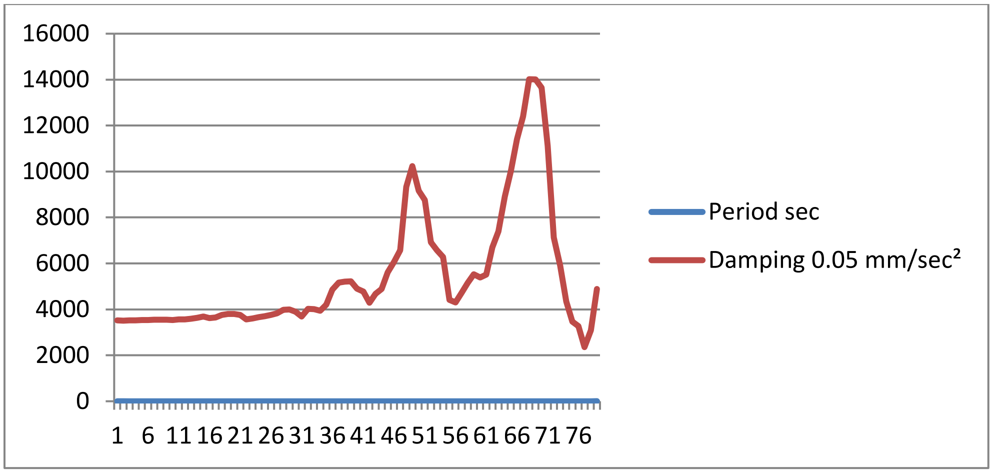

Figure3: A typical response history curve for KATNP ground motion

2. Push-over analysis:

Pushover analysis in the X-direction considering the P-delta effect was carried out for the building using an inverted triangle load pattern. The horizontal forces were applied on five models respectively on CM. Push over curve and the inverted load pattern of forces applied are shown in figures. The plastic hinge formations in the structural elements were observed in all the pushover curves. The displacement in the push over analysis was limited to 4% of total height of the building model.

III. RESULTS

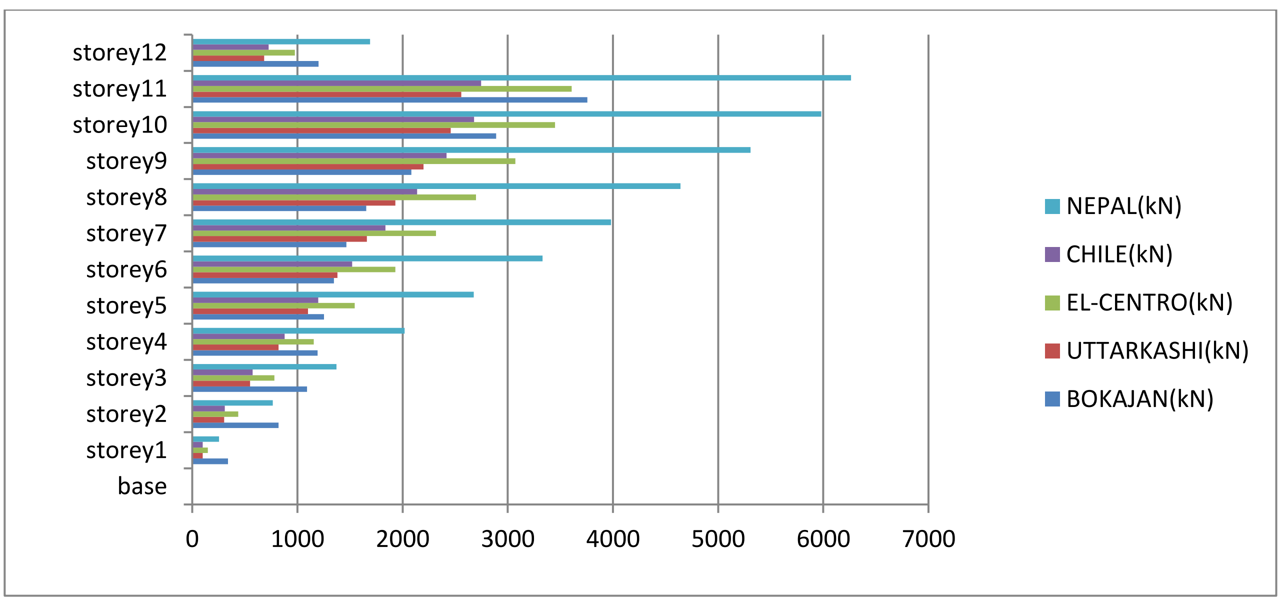

Figure4: Lateral forces on each storey for different earthquakes

ISSN 2348 – 8034
Impact Factor- 4.022

STOREY NO	NEPAL	CHILE	EL-CENTRO	BOKAJAN	UTTARKASHI
storey12	1691kN	727 kN	975 kN	1200 kN	684 kN
storey11	6263 kN	2748 kN	3607 kN	3758 kN	2554 kN
storey10	5982 kN	2679 kN	3448 kN	2891 kN	2459 kN
storey9	5308 kN	2419 kN	3072 kN	2083 kN	2199 kN
storey8	4641 kN	2138 kN	2698 kN	1655 kN	1931 kN
storey7	3983 kN	1838 kN	2317 kN	1466 kN	1659 kN
storey6	3330 kN	1520 kN	1932 kN	1347 kN	1380 kN
storey5	2676 kN	1197 kN	1544 kN	1253 kN	1100 kN
storey4	2019 kN	877 kN	1156 kN	1192 kN	820 kN
storey3	1370 kN	574 kN	781 kN	1091 kN	549 kN
storey2	766 kN	311 kN	438 kN	821 kN	303 kN
storey1	256 kN	101 kN	148 kN	341 kN	101 kN
base	0	0	0	0	0

Table1: Lateral force on each storey for different earthquakes

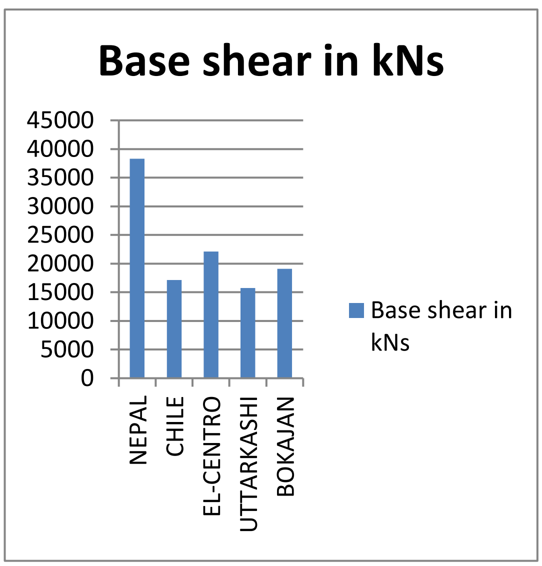

Figure5: max base shear

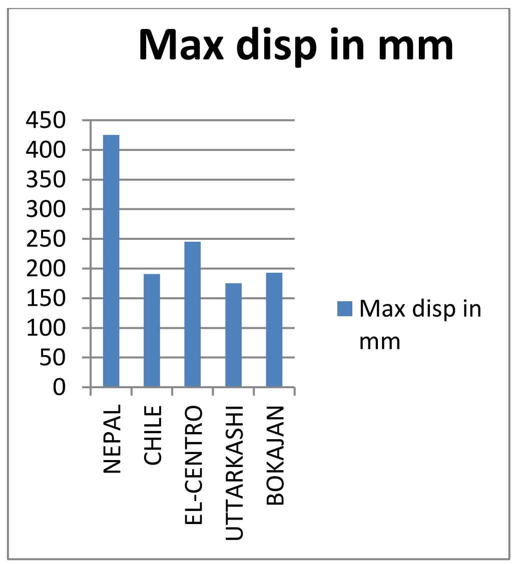

Figure6: max lateral displacement

THOMSON REUTERS
ENDNOTE
[Mubasshir, 3(9): September 2016]
DOI- 10.5281/zenodo.155084
ISSN 2348 – 8034
Impact Factor- 4.022

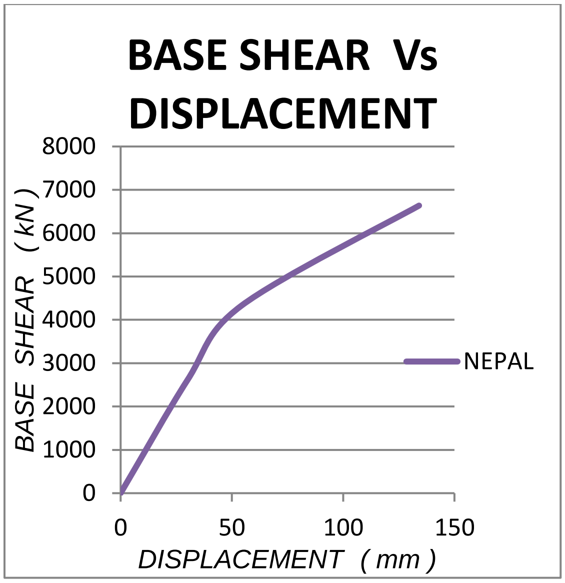

Figure7: Push-over curve for Nepal

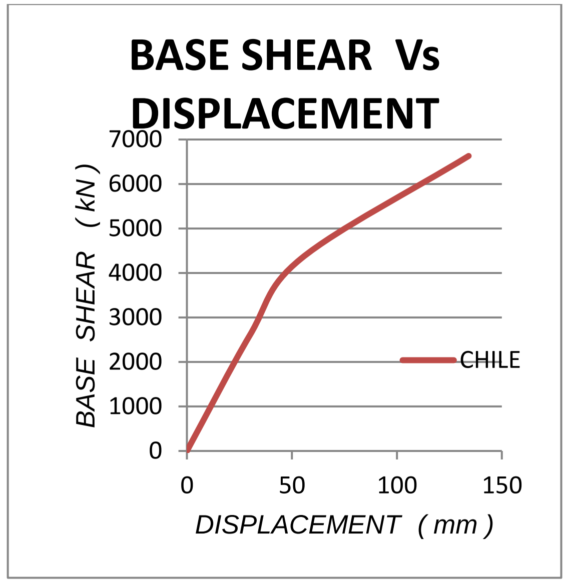

Figure8: Push-over curve for Chile

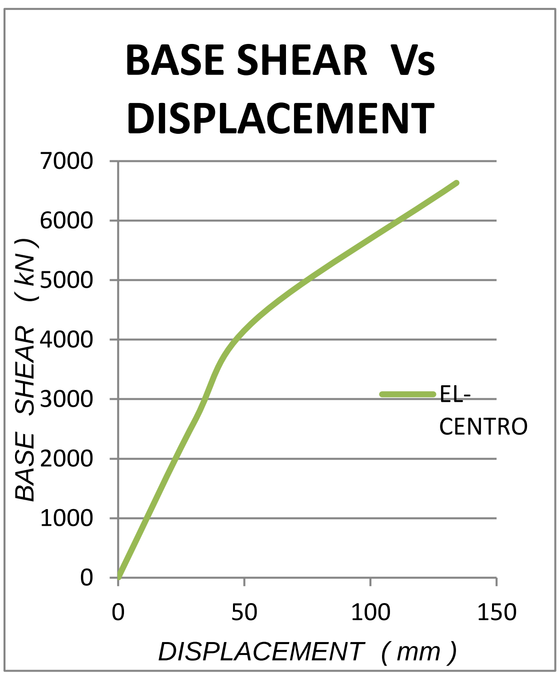

Figure9: Push-over curves for El-Centro

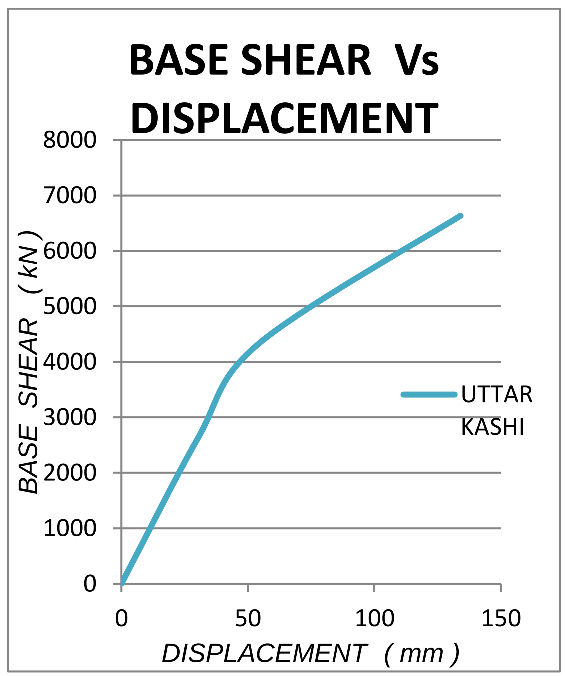

Figure10: Push-over curves for Uttarkashi

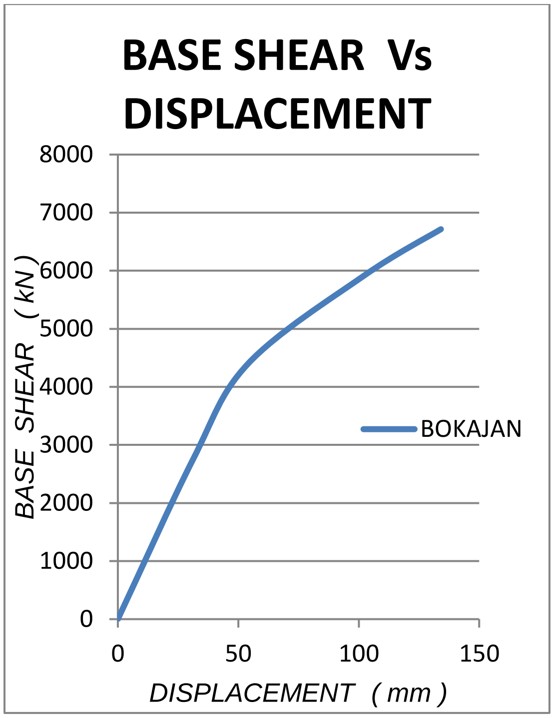

Figure11: Push-over curve of Bokajan

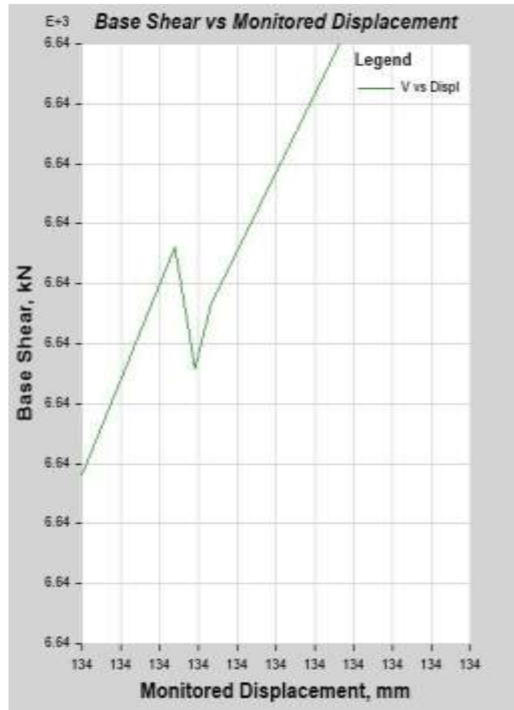

Figure12: Typical saw tooth observed

IV. CONCLUSION

After carrying out the non-linear response history and pushover analysis of the building model with Nepal Gorkha 2015 KATNP and four other major earthquakes it was observed and concluded that:

* The seismic resistance of the building was found to be inadequate against the past considered ground motions as well as the Nepal KATNP ground data since the formation of plastic hinges are observed in push over curves of all the models studied.

* The lateral stiffness of the building would have been higher if one among the past studied ground motions would have been adopted by the designer in its pre- designed stage, resulting in less damage to the structure.

* In this study it has been clearly observed that outcome analytical data from the “KATNP” measured 7.8 Ritcher magnitude was higher than that of others Including “CHILE” measured 8 magnitude which is greater than that of Nepal “KATNP” ground motion data.

* The base shear, max lateral displacements and the lateral load pattern due to all the ground motions has justified the above conclusion.

* It can be further concluded that KATNP ground motion data due to its critical amplitude and immense effects can be taken as time history considerations for the buildings to be designed in future.

V. ACKNOWLEDGEMENTS

I would like to thank:

[Mubasshir, 3(9): September 2016] ISSN 2348 – 8034
DOI- 10.5281/zenodo.155084 Impact Factor- 4.022

- Almighty for everything I am in my life today and ever will be.
- My parents and family for co-operating and always being there for me.
- Guide, Mr. Mohd Abdul Hafeez, for supporting and guiding me through out.
- For providing me with the necessary parameters and being a humble professional, Mr. Satish Bhagath, Tokyo Institute of Technology, Japan.
- For the aid in my academics, Sri K. Chandrashekar Rao, Honorable Chief Minister, Govt of Telangana.

REFERENCE

1. Satish BHAGATH, Susumu KONO, Anil C.WIJEYEWICKREMA, Koichi KUSUNOKI, Seitaro TAJIRI and Hisatoshi KASHIWA, "Performance of a ten-story reinforced concrete building damaged in the 2015 Nepal Gorkha Earthquake", October 2015,Kathmandu,Nepal.

2. Chaulagain, H., Rodrigues, H., Jara, J., Spacone, E., and Varum, H., 2013. Seismic response of current RC buildings in Nepal: a comparative analysis of different design/construction. Engineering Structures 49, 284-294.

3. The Japan Building Disaster Prevention Association, 2002. Guidelines for post earthquake damage evaluation and rehabilitation for buildings.

4. Rahman, M. K., Ajmal, M., Baluch, M. H., and Celep, Z., 2012. Nonlinear static pushover analysis of eight storey RC frame shear wall building in Saudi Arabia. 15th World Conference on Earthquake Engineering, Lisboa, Portugal, Paper No. 4.

5. Rana, R., Jin, L., and Zekioglu, A., 2004. Pushover analysis of a 19 story concrete shear wall building, 13th World Conference on Earthquake Engineering, Vancouver, Canada Paper No. 133.

6. IS 13920:1993. Ductile detailing of reinforced concrete structures subjected to seismic force – code of practice, Bureau of Indian Standards, ManakBhavan, 9 Bahadur Shah Zafar Marg, New Delhi.

7. IS 1893:2002. Criteria for earthquake resistant design of structures, 5th revision, Bureau of Indian Standards, ManakBhavan, 9 Bahadur Shah ZafarMarg, New Delhi.

8. ASCE 41-13: Seismic Evaluation and Retrofit of Existing Buildings

9. CSI, E-TABS 2015 Ultimate 15.0.0 Computers and structures Inc., Berkeley, CA.

10. Earthquake Resistant Design of Structures, Pankaj Agarwal, Manish Shrikhande.

11. Earthquake Resistance Design of Structures, Dr. S.K. Duggal.

12. Source: Ground data

http://www.strongmotionceter.org/