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COLLAPSE PEAK GROUND ACCELERATION OF CODE COMPLAINT LOW RISE BUILDINGS

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Abstract — *The aim of this research work is to find the collapse peak ground acceleration (PGA) of code complaint low rise reinforced concrete buildings to reduce structural vulnerability of existing building stock in Pakistan. As we know that Pakistan is present in high seismic zone in the world. In past, many earthquakes occurred in Pakistan which causes many losses like Kashmir earthquake in 2005 and Quetta Earthquake in 1935.So research on earthquake is very crucial to design and assess the buildings to mitigate the seismic risk. Majority of the residential buildings in Pakistan are low rise, having three stories. After detailed discussion with professional experts and architects and based on our survey in many cities in Pakistan, like in Peshawar, Islamabad, Lahore, Karachi as well as in rural areas, many of the residential buildings are three stories. So a three story reinforced concrete residential building having two bays, 18feet span on each side has been taken for seismic assessment. The building has been designed through software ETABS according to the building code of Pakistan (BCP-2007) for soil type sb and for zone 4 and then seismic assessment has been carried out through software Seismostruct. Drawings of the building is as shown in Figure 1.Seven accelerograms are extracted from PEER data base, based on the prescribed soil and zone. By using static push over analysis, a capacity cure has been developed for the building and dynamic time history analysis has been performed for each accelerogram to determine the base shear coefficient of the building. Using base shear coefficient and capacity curve, seismic coefficient Ca has been determined which we called as collapse PGA of the building.*

Keywords*- Peak Ground Acceleration, Seismic Coefficient, Base Shear Coefficient*

I. INTRODUCTION

During Kashmir earthquake, the main affected city was Abbottabad. So, a research has been carried out for confined masonry three story buildings and for three stories reinforced concrete building as taken as case study to find out the vulnerability of existing structures. The different ground motions having an input Peak Ground acceleration were used to determine the fragility curves. The structural vulnerability was determined as probability of damage states. (Khan shahzda et al., 2011).

Another research was carried out after Kashmir earth quake to find the regional tectonic plates and seismicity regions of Pakistan. Also the behavior of the buildings during the prescribed earth quake has been discussed.Design and construction techniques is also studied. (Amjad Naseer et al, 2010)

In Pakistan, there are 10 to 15% of reinforced concrete buildings in urban areas. However this percentage is increasing day by day. Constriction of reinforced concrete structures is in early stage. So, a research is needed to mitigate the high seismic risk in the region.(Yasir Irfan badrashi et al, 2010)

A detail study was conducted by Pakistan Metrological department (PMD) and NORSAR Norway for seismic hazard analysis and zonation of Pakistan. They studied probabilistic seismic hazard analysis, strong motion attenuation models, seismology and seism tectonic interpretation and computational models how to mitigate the seismic risk in Pakistan. (al, 2007)

Another study has been carried out to find the Design Ground Motion (DGM) for Islamabad city, Federal Capital of Pakistan. With the help of Building Code of Pakistan (BCP-2007), a design response spectrum was determined and to compare the results. This study is only adopted for Islamabad city only which is present in low seismic zone 2B. (al M. S., 2012)

Summary of different types of Building performance levels observed by occupancy according to FEMA 356 is as shown in table 1.This table shows the low or poor performance of engineered and non engineered buidings. (peiris, 2008)

Table 1. Observed Pakistan building performance by occupancy class using FEMA 356

Occupancy	Dominant Construction Class	Performance Level
Residential	Unreinforced masonry (URM)	Collapse prevention or worse
Commercial	Uneinforced masonry (URM)	Collapse prevention or worse
	Reinforce concrete (RC)	Immediate occupancy or life safety
Government Administration	Uneinforced masonry (URM)	Life safety or collapse prevention
Schools	Uneinforced masonry (URM)	Collapse prevention or worse

II. DYNAMIC TIME HISTORY ANALYSIS

Residential building having three stories and two bays having length 18 feet on each axis has been designed (SMRF) using software ETABS, drawings are as shown in Figure 1. Dynamic Time History Analysis (DTHA) has been performed by using software Seismostruct to find out the Base Shear Coefficient (BSC).

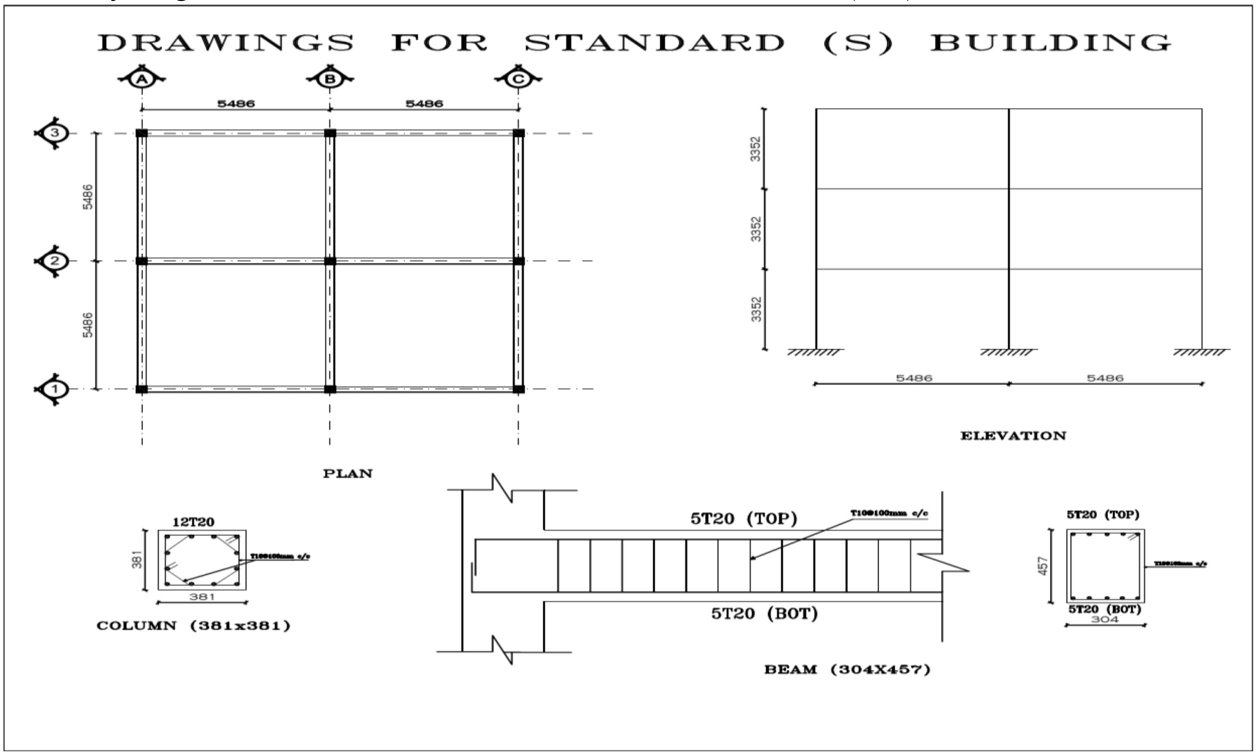
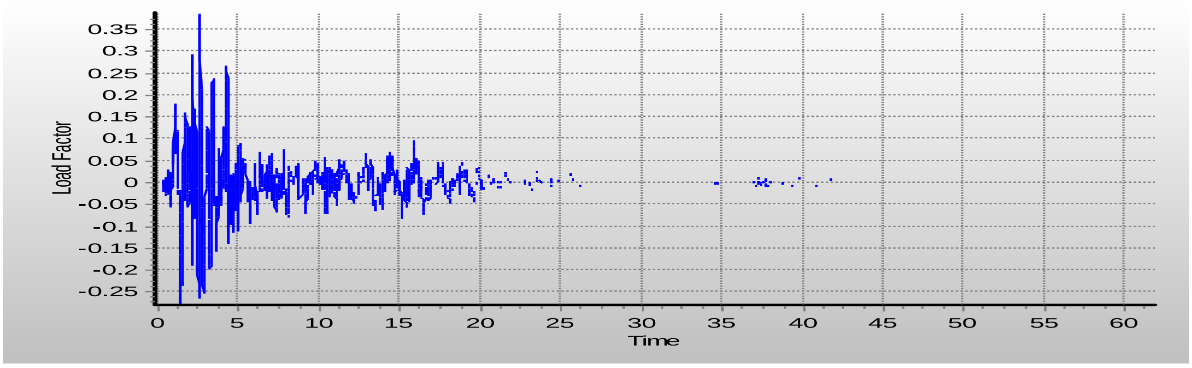


Figure 1: Three Story Building

Input ground motions are extracted from PEER data base using soil type B and Seismic zone 4 as shown in figure 2 and 3. BSC has been determined as shown in Table 2.

Table 2: Base shear Coefficient (BSC)

S	W=	6146
Top Drift(m)	Base Shear(KN)	
0.170	1194.15	
0.274	1215.00	
0.127	1197.72	
0.178	1186.27	
0.167	1179.92	
0.189	1169.11	
0.106	980.11	
BSC	0.19	



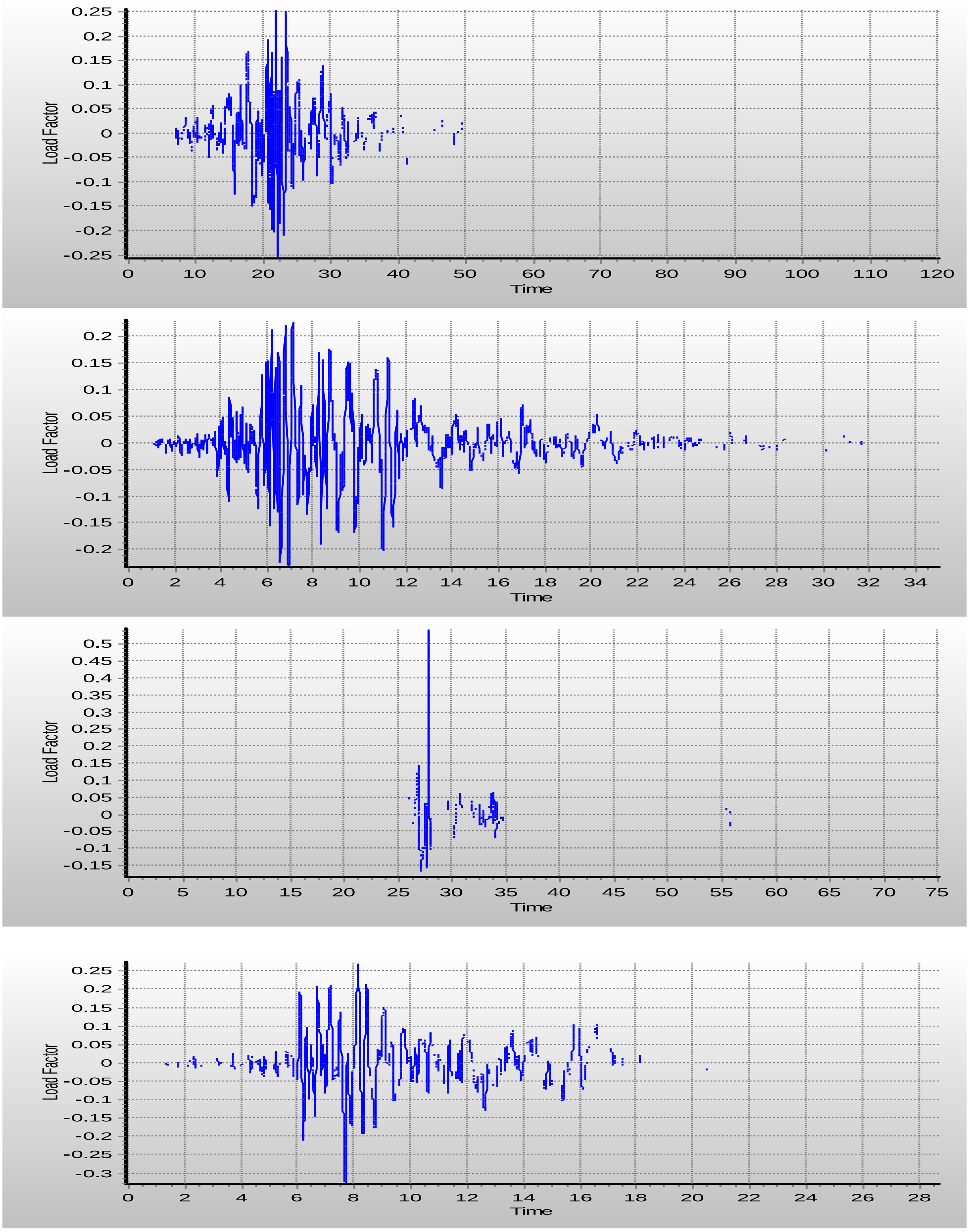
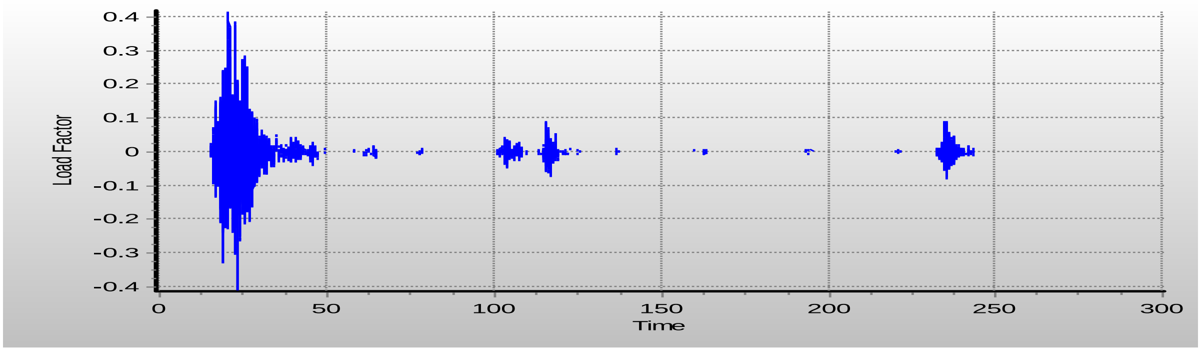


Figure 2: Different Accelerograms



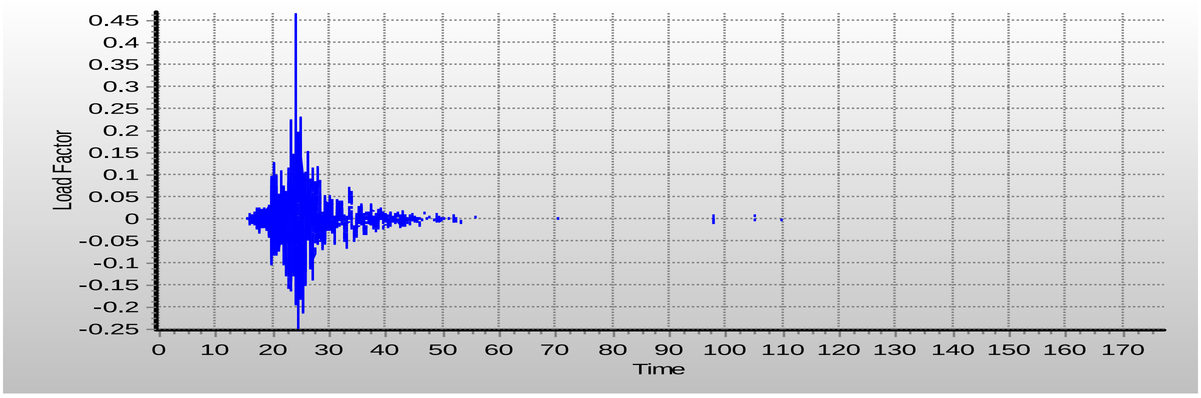


Figure 3: Different Accelerograms

III. STATIC PUSHOVER ANALYSIS

Static Pushover Analysis has been performed by using Sesimostruct to develop capacity curve for the building as shown in figure 4.Using equal energy principal and from idealized curve, ductility capacity, yield base shear, yield elastic displacement, maximum displacement, ductility reduction factor, over strength reduction factor and response modification factor has been determined as shown in table 3. Natural time period T has been determined by using model analysis. By using BSC and response modification factor, seismic coefficient Ca has been determined which we called as Collapse PGA of the building with the help of the equation I as follows:

Ca= BSC x R/2.5 x I (Tb/T)…………………… (I)

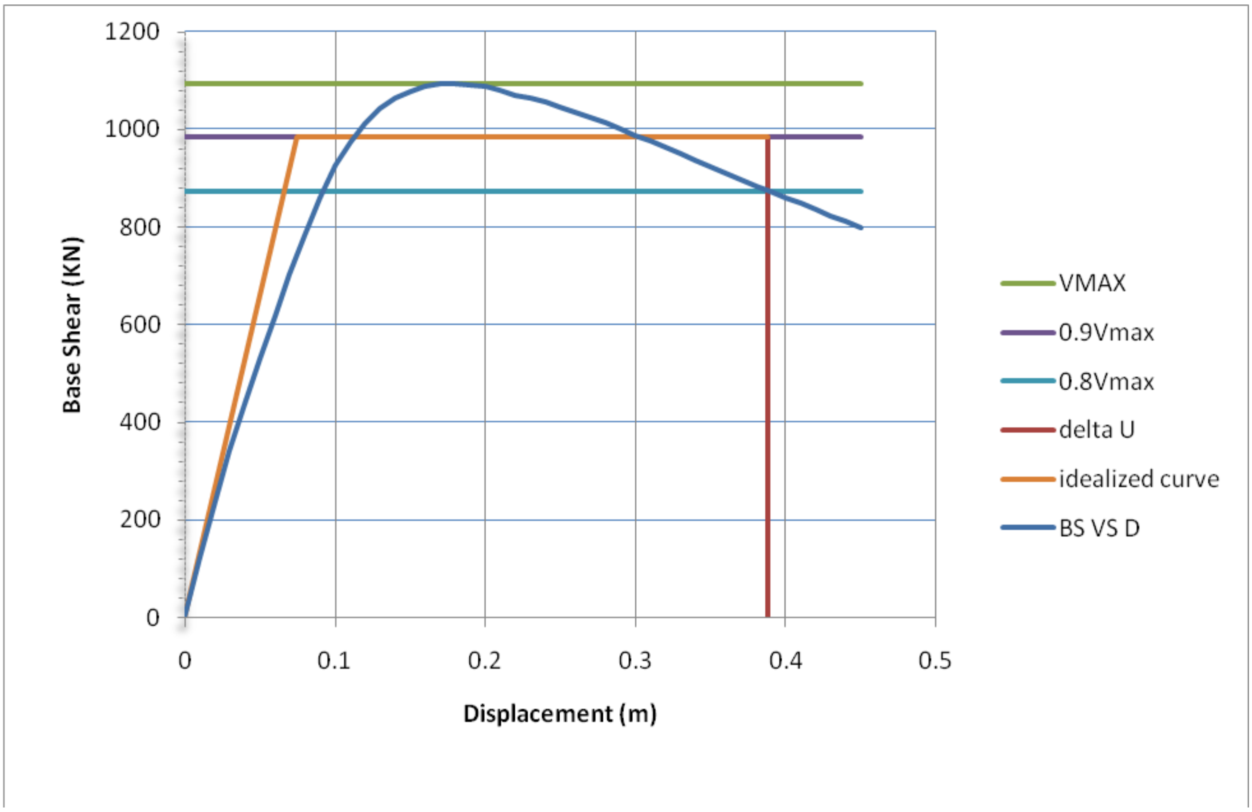


Figure 4: Capacity curve

IV. RESULTS AND DISCUSSION

Ductility capacity μ has been determined from top displacements. With the help of model analysis T is obtained. Ductility reduction factor Rμ has been determined. Response modification factor R is determined which is close to the valve as per Building code of Pakistan which is 8.5 for SMRF.

Table 3: Determination of Seismic Coefficient Ca

Vy	983.34KN
Δ	0.08m
Δu	0.39m
Vmax	1092.60KN
μ	5.17
T	0.32sec
Rμ	5.17
Vd	705.42KN
Rs	1.39
R	7.21
BSC	0.19
Ca	**1.25**

V. CONCLUSIONS

Conclusions made after the research study:

- Ductility Capacity has been obtained as 5.17, which is very close as shown by other researchers. (Taner Ucar et al, 2015)
- Reduction factor due to ductility Rμ has been determined which is 5.17
- Over strength reduction factor Rs has been found as 1.39 which is close to the valve as per BCP-2007
- Over all Response Modification Factor R has been determined which is very close to the valve given in BCP-2007 which 8.5 for SMRF.
- A base shear coefficient has been obtained which is very close to as shown by other researchers.
- Collapse Peak Ground Acceleration has been determined as 1.25g which is reasonable valve for such a stiff building.
- It means that this type of buildings can be easily constructed in zone 4.
- Using Collapse PGA, Vulnerability of existing structures may be determined.
- This study can help to reduce structural vulnerability of existing buildings in construction industry in Pakistan according to zonation, soil type and construction techniques.
- With the help of this study, One can find the capacity of a building in terms of collapse PGA and demand can be found from soil type, seismic zone and fault type. By comparing capacity and demand, an engineer can find the structural vulnerability of a building.
- Future study should be made to find the structural vulnerability of buildings having seismic deficiencies.

VI. RECOMMENDATIONS

- It is recommended that valve of Response Modification factor R should be taken as 7.5 for SMRF buildings in the design.
- The valve of R should be revised in code for low rise, mid rise and high rise buildings.
- This is limitation of this study that it has only performed for three story building. This study should be extended for mid rise and high rise buildings.
- Based on collapse PGA, It is recommended to find out the seismic structural vulnerability of mid rise low rise and high rise buildings having seismic deficiencies which cause vulnerability.

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