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Non-Linear Analysis of Conventional Slab ; Flat slab and Flat Slab with Perimeter Beam.

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Abstract : Flat slab is unique technique in which slab provided without beam due to which structure becomes more economical as self-weight of structure is reduced over the conventional slab. As flat slab structure is beamless architectural requirement is meets and can provide more floors within restricted floor heights. Punching shear is more critical in flat slab because beams are absent. To reduce vulnerability of flat slab structure during an earthquake perimeter beam can provide. In present study seismic response of G+14 Story structure with conventional Slab, flat slab & flat slab with perimeter beam is compared using ETABS. Dynamic Non-Linear analysis i.e. Time history analysis for 7 different cases are done to evaluate story displacement, Maximum axial force, shear force & bending moment.

Keywords - Flat slab, Conventional Slab, Perimeter Beam, ETABS, Seismic Response, Time History Analysis.

I. INTRODUCTION

Since flat plate slabs do not have any beams, the floor height may be decreased by anywhere from 10 to 15 percent. This results in significant cost savings. In addition, the formwork is less complicated, and the structure is beautiful. As a result, the use of flat plate slab building has been common in western countries for a significant amount of time. On the other hand, the technology has just been put to use on a significant scale in the last ten years, and it is now one of the technologies that is evolving the quickest in the Indian construction sector. The fast expansion of technology in India may be attributed to a number of factors, including improvements in the quality of construction, material advancements in the quality of concrete that is accessible for building, and simpler design and numerical approaches.

A flat slab is a concrete slab made of reinforced concrete that is directly supported by concrete columns. Beams are not necessary for flat slab construction. They are propped up by the columns on which they rest. The loads are moved straight into the column storage. Through the use of this kind of construction, a flat ceiling can be produced, which results in an aesthetically pleasing look from an architectural point of view. When compared to the standard beam and slab structure, the ceiling with no beams or slabs diffuses the light more effectively and is said to be safer in the event of a fire. The flat slab needs less formwork and is simpler to build than the other two options.

Flat slab constructions tend to be flexible, it is imperative that they either be made more rigid or that their stiffness be increased by some other method. In order to get around this flaw, the perimeter beam or the edge beam is given a flat slab. This helps to increase their stiffness and allows them to better handle the lateral stresses that are present in high seismic zones. Perimeter beams and edge beams have many advantages over shear walls in flat slab construction. Shear walls raise the cost of construction and make the structure so inflexible that it splits when subjected to lateral loads. Perimeter beams and edge beams, on the other hand, have several advantage.

II. OBJECTIVE

- To study the performance of flat slab ; flat slab with perimeter beam & conventional slab structure subjected to various loads and conditions.
- To study the behaviour of both structure for the parameters like storey shear, story displacement, axial forces, shear forces, bending moment.
- Analysis of G+14 building for zone IV and seven different past earthquake data.

III. METHODOLOGY

The analysis is carried out on G+14 story RC building using ETABS 2017 software. The structure is subjected to gravity load and dynamic load which is analysed by equivalent frame method as per IS 456- 2000. Dynamic analysis is carried out by response spectrum & Time- History method. Past 7 different type of earthquake ground motion data is collected from PEER data website and matched with Indian spectrum to perform non-linear time history analysis. The past 7 different earthquake data are - 1. El centro, 2. Chichi, 3. Imperior Valley, 4. Kocaeli, 5. Loma Preta, 6. Kobe, 7. Northridge.

IV. MODELING

Typical Storey Height - 3m, Base Storey Height -1.5m, No. of Bays in X-Direction - 8, No. of Bays in Y-Direction -6, Bay Length in X-Direction -5 m, Bay Length in Y-Direction -5 m, Density of R.C.C. - 25 KN/m3, Density of Masonry -20 kN/m^3, Columns - 700 mm x 700 mm, Perimeter Beams - 300 mm x 500 mm, Slab Thickness - 200 mm, Drop Panel Size - 3 m x 3 m, Drop Panel Thickness -150 mm, Bottom Support Conditions - Fixed, Dead Load -1.5kN/m^2, 0.75 kN/m^2 for flat slab & conventional slab respectively, Live Load - 3 kN/m^2, Soil Conditions - Medium Soil (Type II), Grade of Concrete and Steel: M30; Fe 500 Steel.

Model-1 G+14 Conventional slab.
Model-2 G+14 Flat Slab.
Model-3 G+14 Flat slab with Perimeter Beam.

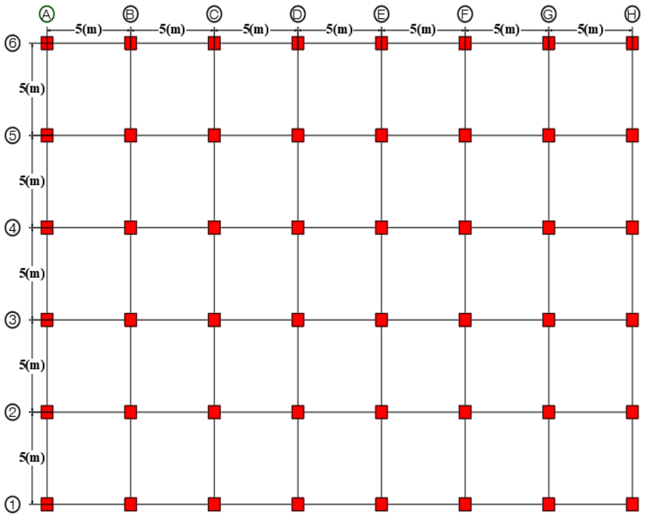


fig 1. plan of G+14 story conventional slab building

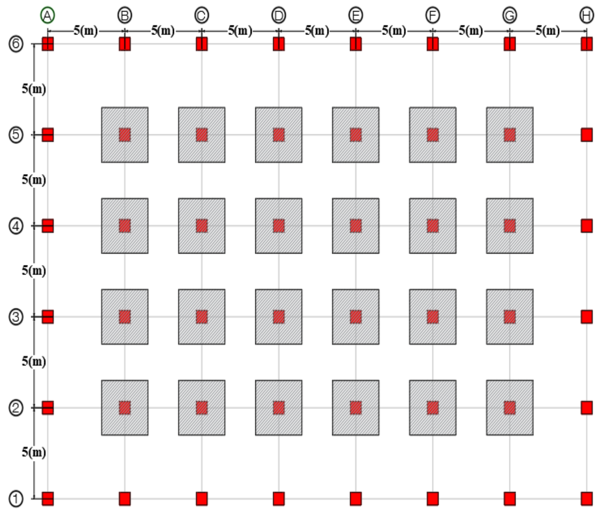


fig 2. plan of G+14 story flat slab building.

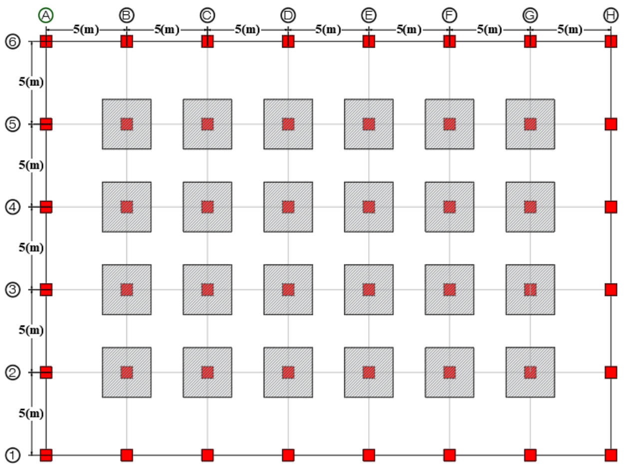


fig 3. plan of G+14 story flat slab with perimeter beam building.

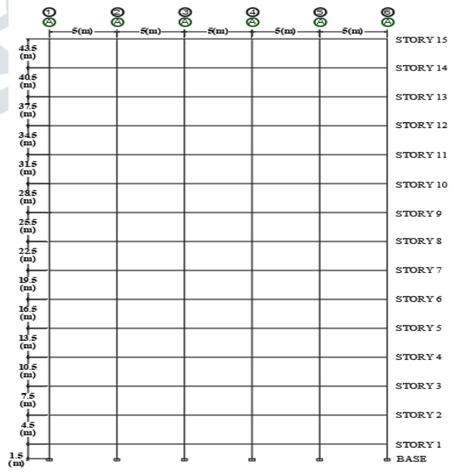


fig 4. elevation of G+14 story for all model.

Non-Linear Time History Analysis :

Time history analysis use for study of structure under the actual earthquake history records. Non-linear time history analysis for 7 records is performed on each model in X and Y direction. Records are downloaded from PEER data website. These downloaded records are match with response spectra for medium stiff soil of zone 4 i.e., 0.24 matching of records done by help of seismo match software. Table shows the different parameters of match spectra.

table 1 : time history records.

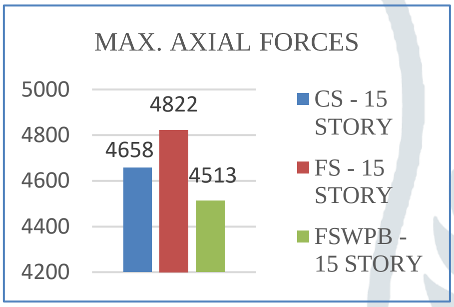
Sr. No	Name of Earthquake	PGA (g)	Time Duration	No. of Steps
1	EL CENTRO	0.3367	53	26500
2	CHICHI	0.30822	39.9	39900
3	IMPERIOR VALLEY	0.34773	39.48	39480
4	KOCAELI	0.31796	34.96	34960
5	LOMA PRETA	0.35486	39.9	39900
6	KOBE	0.34735	40.9	40900
7	NORTHRIDGE	0.31167	39.88	39880

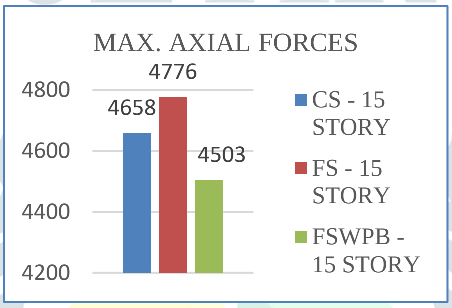
V. RESULTS

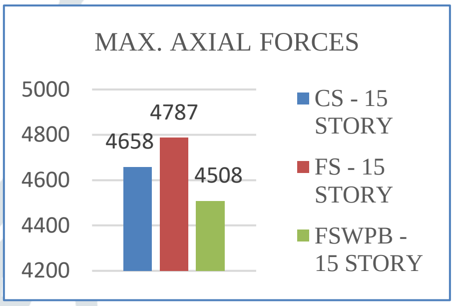
The analysis carried out on the 7 different types of earthquake data with Conventional Slab, Flat slab, Flat Slab with Perimeter Beam for G+14 story building. The results obtained from the analysis are taken into consideration based on the aim of the research. After getting the results these are compared to draw the conclusion from it.

A. *Column Axial Forces.*

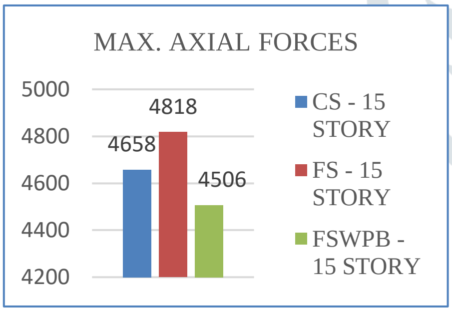
The maximum axial forces in the columns in longitudinal and transverse direction is considered for analysis in seismic zone IV and seven different earthquake data. Graphical representation of data is shown in graph 1 to 7.

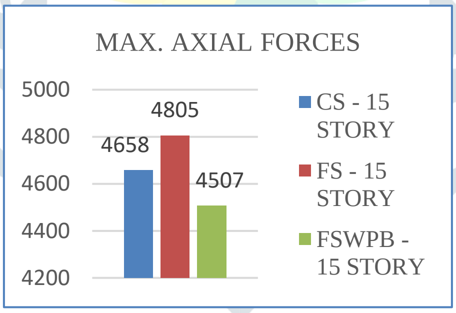


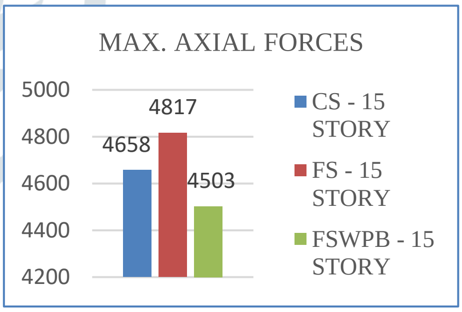




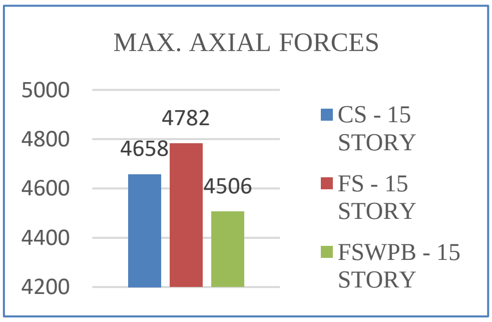
graph 1, 2 & 3 : max axial force for el centro ; chichi ; imperior valley.







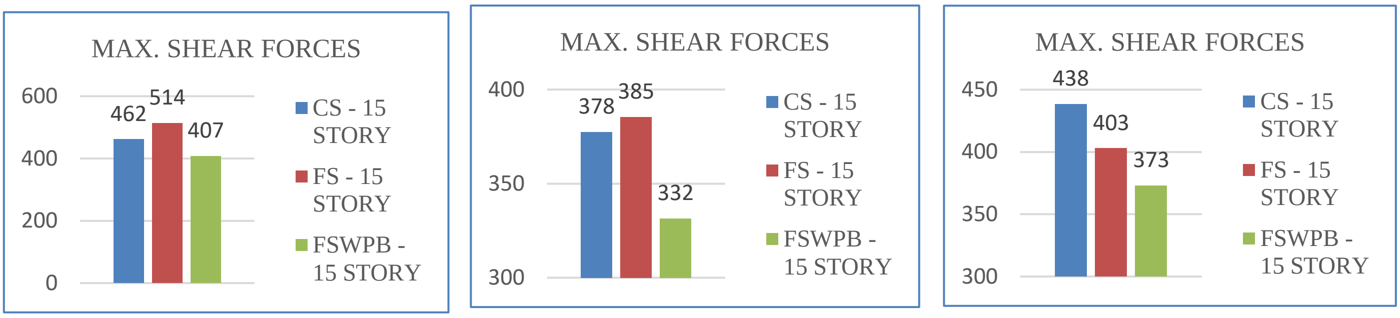
graph 4, 5 & 6 : max axial force for kocaeli ; loma preta ; kobe.



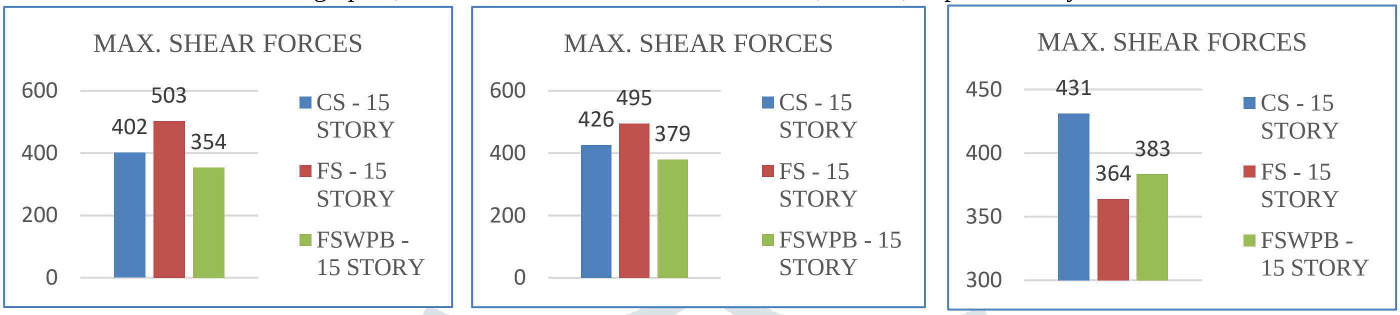
graph 7: max shear force for northridge.

B. *Column Shear Forces.*

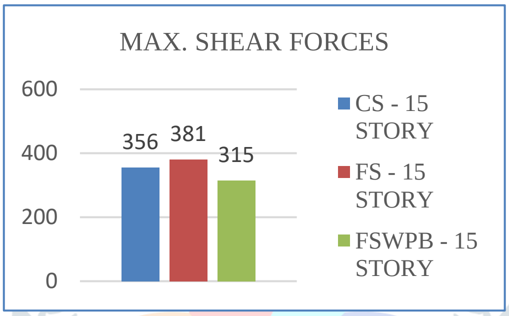
The maximum shear forces in the columns in longitudinal and transverse direction is considered for analysis in seismic zone IV and seven different earthquake data. Graphical representation of data is shown in graph 8 to 14.



graph 8, 9 & 10 : max shear force for el centro ; chichi ; imperior valley.



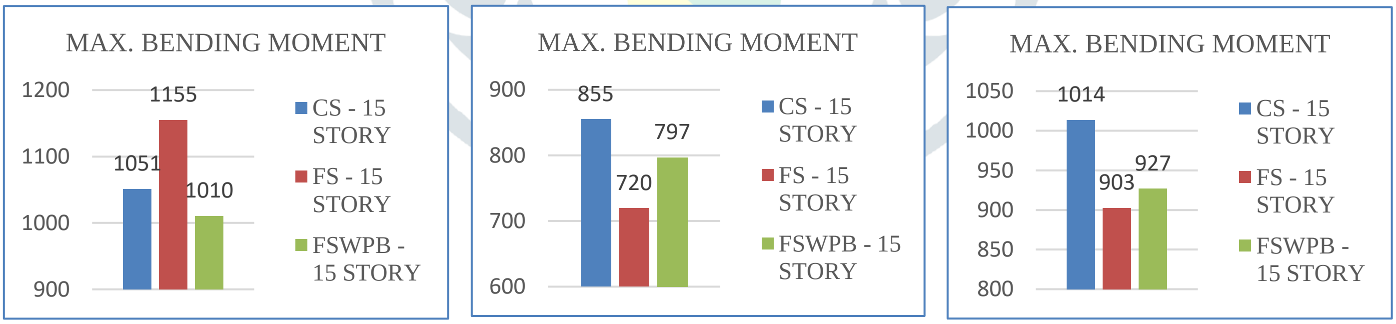
graph 11, 12 & 13 : max shear force for kocaeli ; loma preta ; kobe.



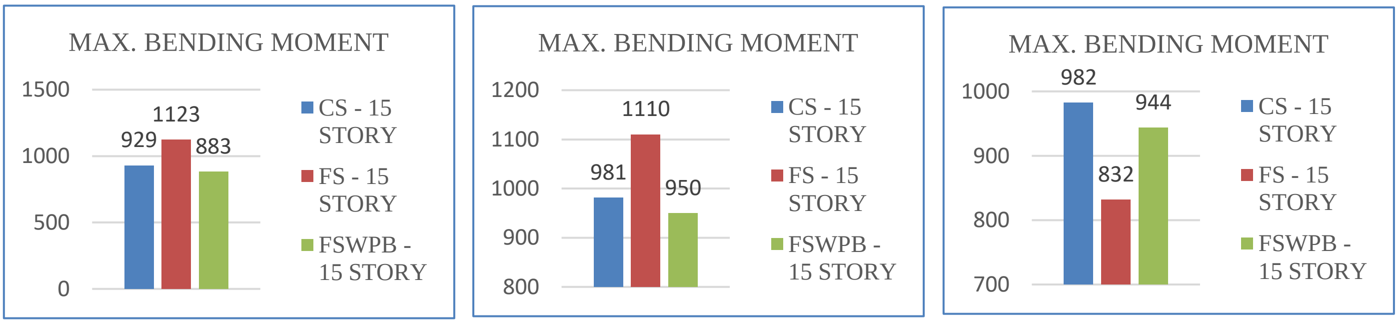
graph 14: max shear force for northridge.

C. *Column Bending Moment*

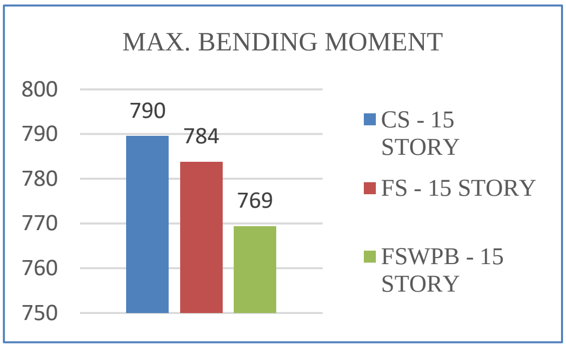
The maximum bending moment in the columns in longitudinal and transverse direction is considered for analysis in seismic zone IV and seven different types of earthquake data. Graphical representation of data is shown in graph 15 to 21.



graph 15, 16 & 17 : max bending moment for el centro ; chichi ; imperior valley.



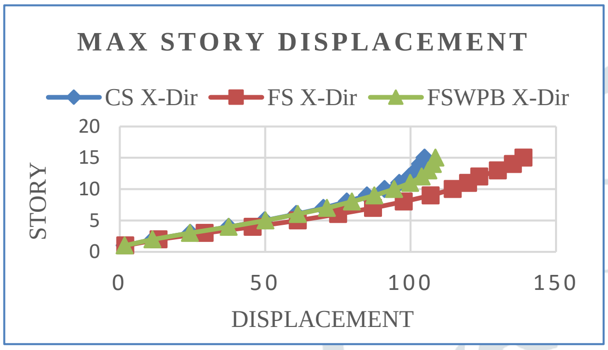
graph 18, 19 & 20 : max bending moment for kocaeli ; loma preta ; kobe.

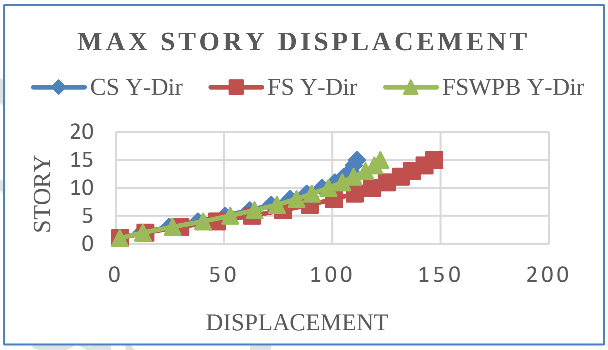


graph 21: max bending moment for northridge.

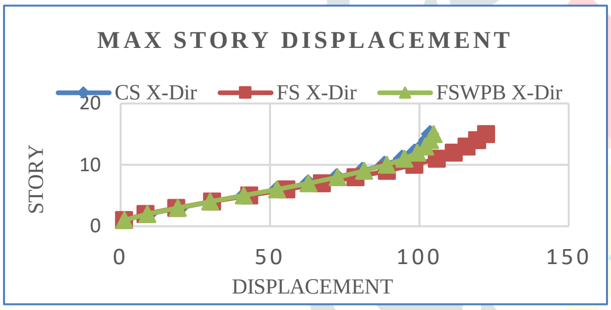
D. ***Story Displacement***

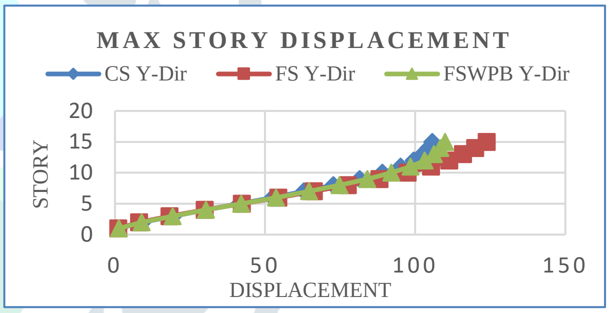
The maximum story displacement in longitudinal and transverse direction is considered for analysis in seismic zone IV and seven different data. Graphical representation of data is shown in graph 22 to 35.



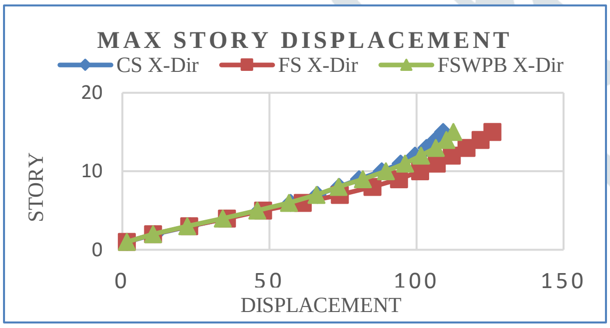


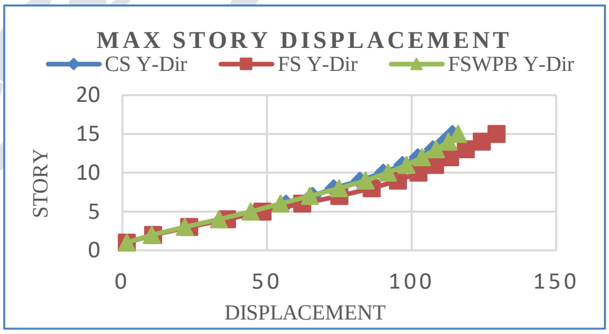
graph 22 & 23 : maximum story displacement for el centro.



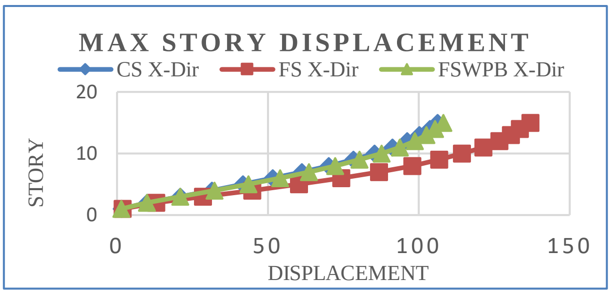


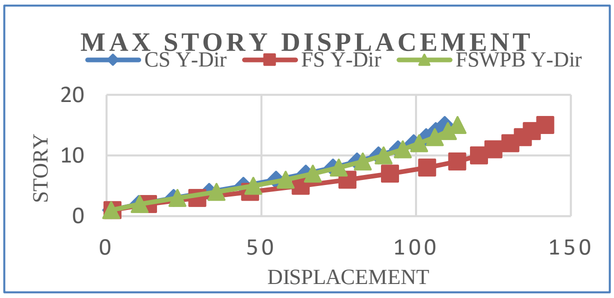
graph 24 & 25 : maximum story displacement for chichi



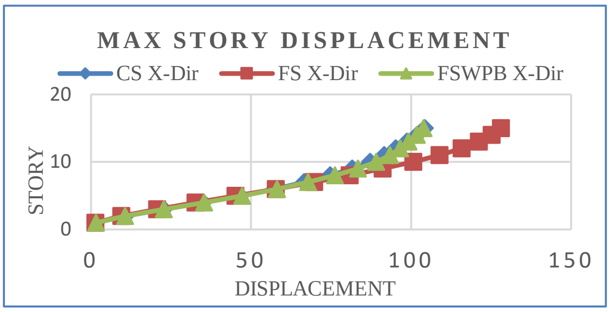


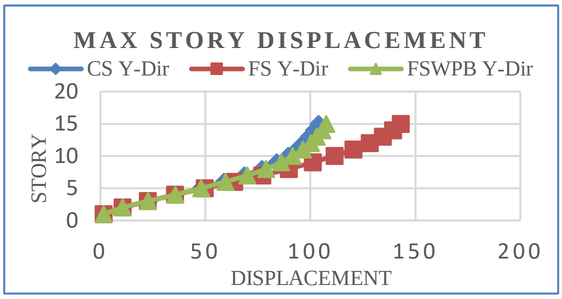
graph 26 & 27 : maximum story displacement for imperior valley.



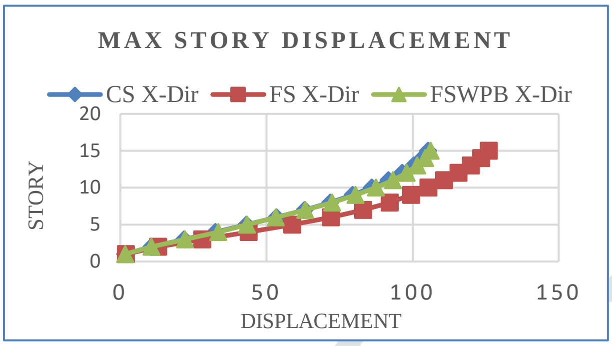


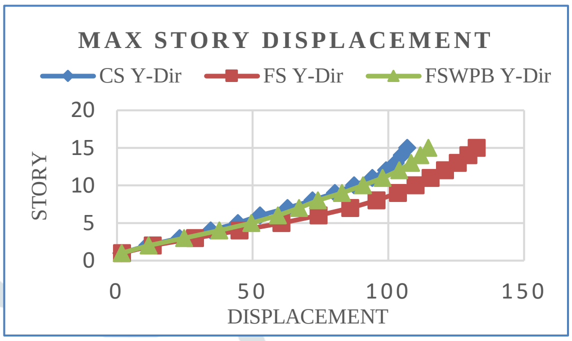
Graph 28 & 29 : maximum story displacement for kocaeli.



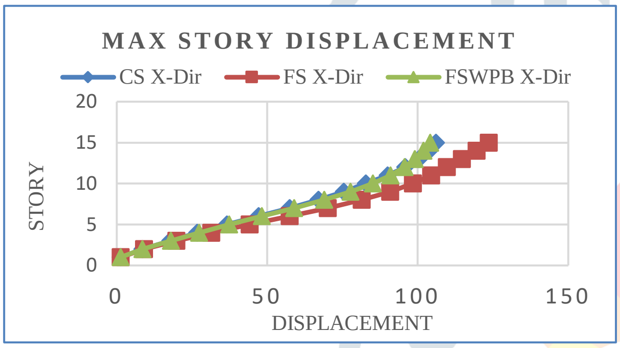


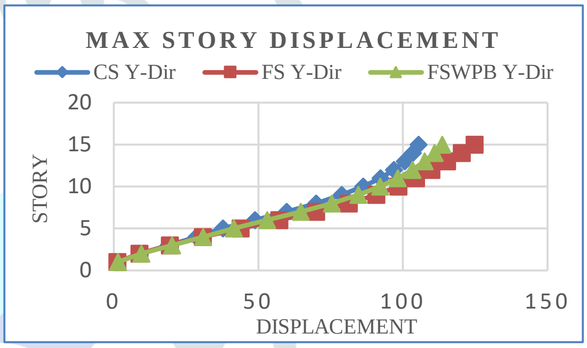
graph 30 & 31 : maximum story displacement for loma preta.





graph 32 & 33: maximum story displacement for kobe.





graph 34 & 35 : maximum story displacement for northridge.

E. Base Shear

Base shear is an estimate of the maximum expected lateral force that will occur due to seismic ground motion at the base of a structure.

table 2 : base shear.

SR NO	DATA TYPE	CONVENTIONAL SLAB		FLAT SLAB		FLAT SLAB WITH PERIMETER BEAM	
15TH STORY BUILDING		TH-X	TH-Y	TH-X	TH-Y	TH-X	TH-Y
		Fx (kN)	Fy (kN)	Fx (kN)	Fy (kN)	Fx (kN)	Fy (kN)
1	ELCENTRO	14781	14693	9440	9255	12699	12364
2	CHICHI	10643.58	10319.94	6451.02	6154.36	9026.27	8609.18
3	IMPERIOR VALLEY	12626.10	12040.74	7101.34	7035.92	10490.04	8937.63
4	KOCAELI	11036.62	10707.45	8014.51	7986.48	9460.30	9451.99
5	LOMA PRETA	12380.22	12690.36	9985.54	10087.94	10895.36	11343.35
6	KOBE	12000.30	11894.55	7126.91	7024.01	10435.69	9857.59
7	NORTHRIDGE	9904.43	10351.59	7116.08	6803.79	8818.51	9375.96

VI. CONCLUSION

This is the summary of project work for conventional slab, flat slab, flat slab with perimeter beam building in seismic zone IV with type II medium soil. From the above graphs following conclusion have been drawn :

- It is seen that axial force of column is less for conventional slab building compared to flat slab & flat slab with perimeter beam building. This is the same for all types of earthquake data.
- We have observed that shear force & bending moment value is different on each time history data and different location. This is happen due to the building time period and modal analysis.
- Storey displacement is high at top storey and least at the base of the structure. With the increase in height of structure displacement is also goes on increasing. If joints are highly stiff then the displacement is less. In this case the max story displacement for conventional slab is observed to be less as compared to flat slab and flat slab with perimeter beam building. The displacement of flat slab is slightly higher and it is within the permissibility (height/250).
- Base shear increases with increases in mass and stiffness of building and hence the base shear is maximum in conventional slab building in both x and y direction.
- Flat slab with perimeter beam value of base shear is more when compared with model of flat slab building because the beam is added in perimeter of flat slab with perimeter beam building.

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