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Seismic Response of Flat Slab Buildings with Shear Wall

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Abstract - *In the present study, the seismic behavior of flat slab building is carried out. For this purpose response spectrum analysis and static pushover analysis of flat slab building and regular frame structure has been carried out for study. All the models are analyzed using Etabs 2016 software. Different parameters like performance point, base shear, roof displacement etc. have been compared. The comparison shows that the flat slab building have low base shear capacity and large deflection. Also linear and nonlinear analysis of flat slab building with shear wall and regular framed structure building has been carried out. It is found that the performance of flat slab building under seismic load improves much better with the use of shear wall.*

***Key Words*: Flat slab, Response spectrum analysis, Pushover analysis, Etabs2016 etc.**

1. INTRODUCTION

Flat slab system is being adopted in many buildings as they have major advantages over traditional slab-beam-column structures such as speedy construction, reduced floor heights to meet the economical and architectural demands, less loss of energy in cold storage buildings, simple formwork and more unobstructed space etc.

Flat slab system also known as a beamless slab is one in which RCC slabs directly rests on columns without the agency of beams or girders and load from slab is directly transferred to column and then to the foundation. To take care of heavy shear and bending moment the portion of slab around the column is thickened. This thickened portion which is usually square or rectangular in plan is called as drop or Drop panel. Also for this, columns are generally provided with enlarge head called as column heads or capitals. IS 456:2000 gives following two methods of analysis and design for flat slab system. One is direct design method and other is equivalent frame method.

The devastating social and economic impacts of recent earthquakes in the world have resulted in increased awareness of the potential seismic hazard and the corresponding vulnerability of the built environment. Greater effort has been given to reasonable estimates, predictions and mitigation of the risk associated with these potential losses. In order to be successful in mitigation efforts; the expected damage and associated loss in urban areas caused by severe earthquake should be proper estimated. It is also appropriate to consider the expected damage as a measure of seismic vulnerability. The determination of such vulnerability measures requires the assessment of the systemic performances of all types of building structures typically constructed in an urban region when subjected to a variety of potential earthquakes

Modern concrete construction in high systemic zones of India has traditionally been done using Special Moment Resisting Frame (SMRF)-(ref 1893-2002), with or without shear walls. The columns are designed to be stronger than the beams. Ductile detailing provisions of IS13920-1993 insurance this. Generally flat slabs are designed in lower seismic zone areas for gravity loads and due to absence of deep beams, flat slab structural system is significantly more flexible for lateral loads than traditional slab-beam-column frame system. Also the provision of ductile detailing of flat slab in IS code is not given separately. This makes the flat slab more vulnerable during seismic events. For this purpose the study of flat slab building under seismic load is very important.

2. Scope of the present study

1) To study and compare flat slab building and regular frame building using equivalent static method.
2) To study and compare flat slab building and regular frame building using Non-linear Pushover analysis.
3) To study and compare flat slab building and regular frame building with different locations of shear wall using equivalent static method.
4) To study and compare flat slab building and regular frame building with different locations of shear wall using Pushover analysis.

3. Methodology

The methodology adopted for achieving the above-mentioned objectives is as follows.

1) Six building models are modelled having approximately similar weight one with regular frame structure and other with different location of shear wall for flat slab building.
2) The buildings are analysed with bare frames without any infill load. The structures are analysed using static analysis and using non-linear static pushover analysis.

3) The performance point and hinge formation in the structure is studied.

4. Problem data

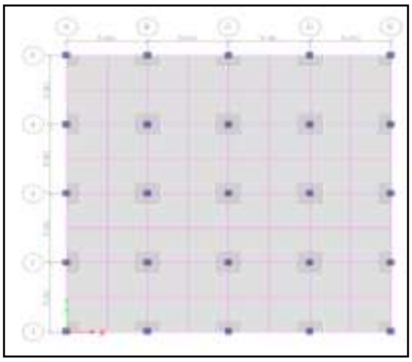
Type of frame:	Ordinary moment resisting frame.
Seismic zone:	III
Story No.	4(G+3) and 10 (G+9)
Size of bay:	5m X 5m
Plan area:	20m X 20m
Storey height:	3.5m
Plinth height:	2.0m
Column:	450mm X 450mm
Plinth beam:	300mm X 450mm
Floor Finish:	$1KN/m^2$
Live load:	$3KN/m^2$
LL on terrace:	$1.5\ KN/m^2$
Materials:	Concrete M20, Steel Fe415
Density:	$25KN/m^3$
Type of Soil:	Medium
Damping of structure:	5%

Table-1: Problem statement for analysis.

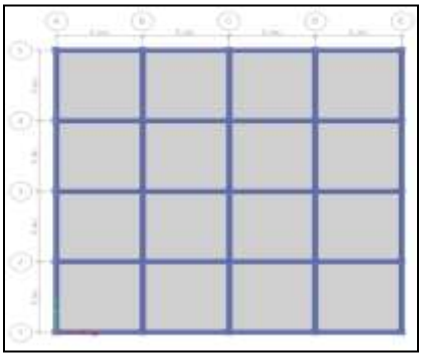
5. DESCRIPTION OF BUILDING

A four storied and ten storied flat slab building situated in zone III, is taken for the purpose of study. The plan area of a building is 20mX20m with 2.0m as height of plinth above top of footing and remaining stories having height as 3.5m. It consists of 4 bays of 5m each in X-direction and Y-direction. The building is considered as an ordinary Moment resisting frame. Damping of structure is assumed as 5% of critical damping.

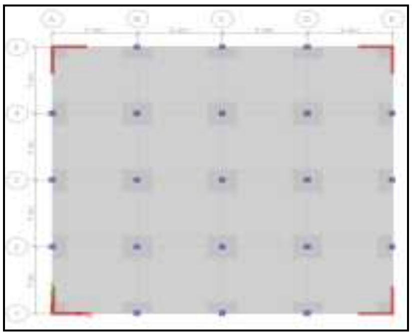
The various models of flat slab building that are modelled are as follows.



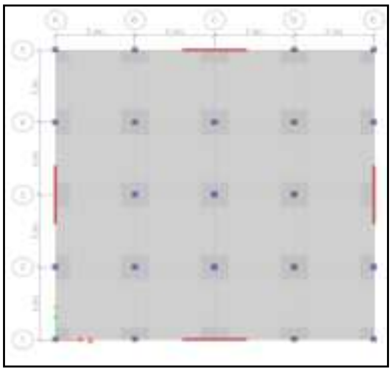
FS-Flat slab building



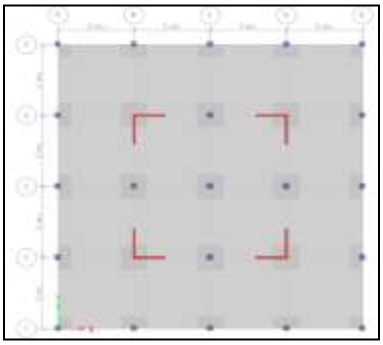
RFB-1- Regular frame building.



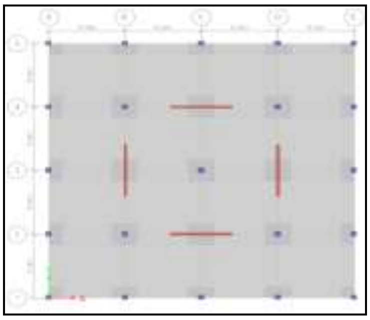
FS-S1- Flat Slab Building with Shear wall at exterior corner location.



FS-S2- Flat Slab Building with Shear wall at exterior mid location.



FS-S3- Flat Slab Building with Shear wall at interior corner location.



FS-S4- Flat Slab Building with Shear wall at interior mid location.

Table-2: Weight of G+ 3 Structures

Model	Slab thickness (mm)	Drop wall thickness (mm)	Shear wall thickness (mm)	Weight of building (KN)
FS-1	200	350	NA	61013.750
RFB-1	150	NA	NA	59626.000
FS-S1	200	300	150	60979.200
FS-S2	200	300	150	60984.800
FS-S3	200	300	150	60990.400
FS-S4	200	300	150	60997.150

Model	Slab thickness (mm)	Drop wall thickness (mm)	Shear wall thickness (mm)	Weight of building (KN)
FS-1	200	350	NA	61013.750
RFB-1	150	NA	NA	59626.000
FS-S1	200	300	150	60979.200
FS-S2	200	300	150	60984.800
FS-S3	200	300	150	60990.400
FS-S4	200	300	150	60997.150

Table-3: Weight of G+ 9 Structures

6. Analysis and Results:

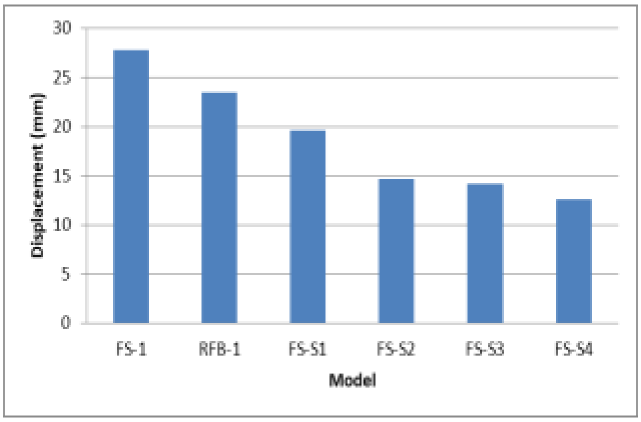
The models of flat slab buildings and regular frame buildings are analyzed by equivalent lateral forces method as per IS 1893 part-1 using ETAB 2016.

The results obtained are for G+ 3 structures. The comparison of Base Shears and Roof displacement shows that-

1. Base shear of Flat slab building is more than base shear of Regular frame building. For example, for Model FS-1 Vb = 1382.70KN and for Model RFB-1 Vb = 1345.82KN.
2. Roof displacement of Flat slab building is more than roof displacement of Regular frame building. For example, for Model FS-1 displ. = 27.76mm and for Model RFB-1 displ. = 23.45mm. So there is 15.52% reduction in roof displacement.
3. Flat Slab building with Shear wall at its core (S4 location) gives minimum displacement than Shear wall at exterior corners (S1 location), Shear wall along periphery at central (S2 location) and Shear wall at interior corners (S3 location).

Table-4: Roof displacement of buildings.

Model No.	Model	Base Shear (KN)	Disp.(mm)
1	FS-1	1382.70	27.76
2	RFB-1	1345.82	23.45
3	FS-S1	1378.00	19.57
4	FS-S2	1379.01	14.63
5	FS-S3	1379.32	14.21
6	FS-S4	1379.47	12.54



Graph-1: Variation of roof displacement by equivalent static analysis for G+ 3 structures.

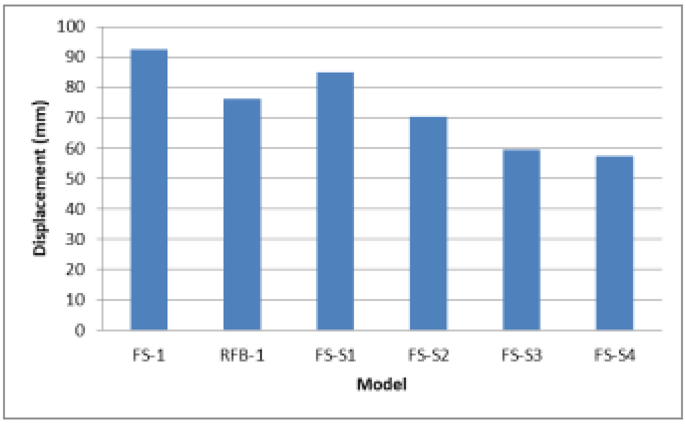
The results obtained for flat slab buildings and regular frame buildings are shown below for G+9 structure.

1. Base shear of Flat slab building is more than base shear of Regular frame building having same mass as that of Flat slab building. For example, for Model FS-1 Vb = 1769.976KN and for Model RFB-1 Vb = 1729.709KN.
2. Roof displacement of Flat slab building is more than roof displacement of Regular frame building. For example, for Model FS-1 displ. = 92.403mm and for Model RFB-1 displ. = 76.250mm. So there is 17.48% reduction in roof displacement.
3. Flat Slab building with Shear wall at its core (S4 location) gives minimum displacement than Shear

wall at exterior corners (S1 location), Shear wall along periphery at central (S2 location) and Shear wall at interior corners (S3 location).

Model No.	Model	Base Shear (KN)	Disp.(mm)
1	FS-1	1769.976	92.403
2	RFB-1	1729.709	76.250
3	FS-S1	1768.965	84.768
4	FS-S2	1769.1278	70.263
5	FS-S3	1769.290	59.530
6	FS-S4	1769.486	57.280

Table-5: Data for G+ 9 Structures



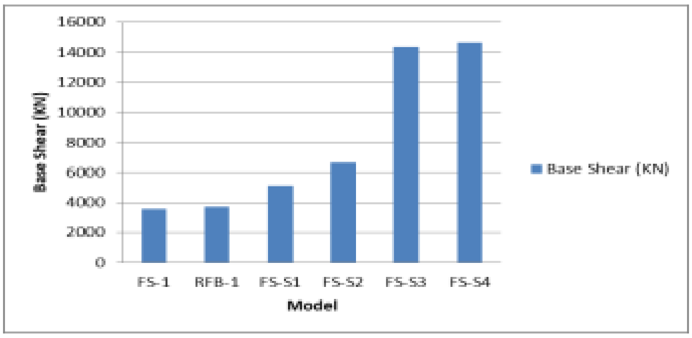
Graph-2: Variation of roof displacement by equivalent static analysis for G+ 9 structures.

The comparison shows that, Performance of regular frame building is better than flat slab building i.e. Base Shear capacity of regular building is more compared to flat slab building.

The result obtained shows that, Performance of flat slab building increases with the use of Shear wall. The Shear wall at core (S4 location) of a flat slab building gives better performance than shear at exterior corners (S1 location), Shear wall along periphery at central (S2 location) and Shear wall at interior corners (S3 location).

Table-6: OBSERVATIONS OF FLAT SLAB BUILDING AND REGULAR FRAME BUILDING WITH SHEAR WALL (G+3) BY PUSHOVER ANALYSIS

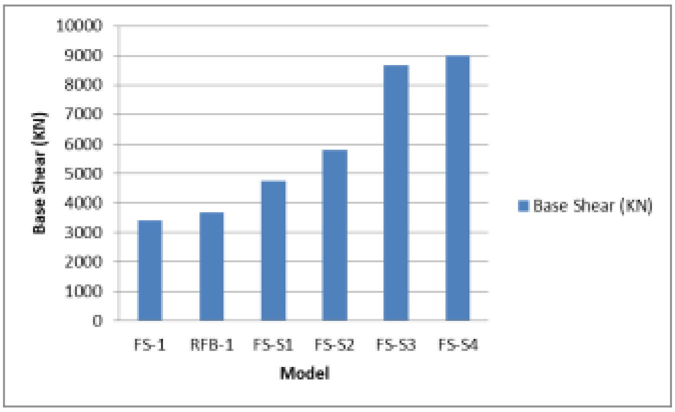
Models	Base Shear (KN)	Roof displacement (mm)
FS-1	3554.7809	85.4770
RFB-1	3718.0716	90.5840
FS-S1	5095.0221	95.4150
FS-S2	6680.6427	112.385
FS-S3	14373.2875	115.755
FS-S4	14627.9500	99.5980



Graph-3: Variation of Base shear by Pushover analysis.

Table-7: OBSERVATIONS OF FLAT SLAB BUILDING AND REGULAR FRAME BUILDING WITH SHEAR WALL (G+9) BY PUSHOVER ANALYSIS

Models	Base Shear (KN)	Roof displacement (mm)
FS-1	3422.7275	169.206
RFB-1	3666.0354	181.293
FS-S1	4733.2659	188.486
FS-S2	5783.5259	196.763
FS-S3	8659.8096	209.502
FS-S4	9010.3524	207.227



Graph-4: Variation of Base Shear by Pushover analysis

3. CONCLUSIONS

Pushover analysis of Flat slab building and Regular frame building gives,

1) Performance of regular frame building is better than flat slab building.
2) Performance of flat slab building improves much more with the use of shear wall.
3) Shear wall at core of a building gives minimum lateral displacement.
4) It is encountered from non-linear analysis, that the reserve strength of structure without shear wall buildings is less in comparison to buildings with shear wall.

REFERENCES

[1] C.S Garg, Yogendra Singh and Pradeep Bhargava "Seismic Performance of Flat-Slab Shear Wall System" Journal of Structural Engineering Vol.37 No.3 August-September 2010 pp.203-207.

[2] Dr. Uttamasha Gupta, Shruti Ratnaparkhe, Padma Gome – "Seismic Behavior of Buildings having Flat Slabs with Drops" International Journal of Emerging Technology and Advanced Engineering (ISSN 2250-2459, Volume 2, Issue 10, October 2012)

[3] Ema Coelho, Paulo Candeias, Giorgios Anamateros, Raul Zaharia, Fabio Taucer, Artur V. Pinto 2004 – "Assessment of the seismic behavior of RC Flat slab building structures" Proc. Of the 13th World Conference of Earthquake Engineering, (13WCEE), Vancouver, B.C., Canada, August 2004.

[4] K. Soni Priya, T. Durgabhavani, K. Mounika, M. Nageswari, P. Poluraju- Non-Linear Pushover Analysis of Flat slab Building by Sap2000. - ANALELE UNIVERSITĂłII "EFTIMIE MURGU" RESIłAANUL XIX, NR. 1, 2012, ISSN 1453 – 7397.

[5] Mohana H.S, Kavan M.R. - Comparative Study of Flat Slab and Conventional Slab Structure Using ETABS for Different Earthquake Zones of India. International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056, Volume: 02 Issue: 03 June-2015 www.irjet.net p-ISSN: 2395-0072.

[6] IS: 1893:2002, Criteria for earthquake resistant design of structures Indian Standards, New Delhi.

[7] IS: 456-2000, Plain Reinforced Concrete- code of practice, Bureau of Indian Standards, India.

[8] Thimmayapally dileep kumar, A. Mownika Vardhan - Analysis and design of regular and irregular flat slab for Multi- storied building under two seismic zones using ETABS and SAFE - International journal of professional engineering studies Volume VIII /Issue 3 / MAR 2017.

[9] R.S.More, V. S. Sawant, Y. R. Suryawanshi - Analytical Study of Different Types of Flat Slab Subjected to Dynamic Loading. International Journal of Science and Research (IJSR) ISSN (Online): 2319-7064 Index Copernicus Value (2013): 6.14, Impact Factor (2013): 4.438.

[10] B.Anjaneyulu, K Jaya Prakash - Analysis And Design Of Flat Slab By Using Etabs Software International Journal of Science Engineering and Advance Technology, IJSEAT, Vol. 4, Issue 2 ISSN 2321-6905.