COMPARATIVE STUDY ON BEHAVIOUR OF BUILDING WITH AND WITHOUT FLAT SLAB IN DIFFERENT SEISMIC ZONES OF INDIA

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***Abstract— In today's construction activity the use of flat slab is quite common which enhances the weight reduction, speed up construction, and economical. Similarly from the beginning conventional slab has got place in providing features like more stiffness, higher load carrying capacity, safe and economical also. As the advancement era began practice of flat slab becomes quite common. In the present dissertation work a High, Medium, and Low rise commercial multi-storeyed building having flat slab and conventional slab has been analysed for the parameters like base shear, storey drift, axial force, and displacement. The performance and behaviour of both the structures in all seismic zones of India has been studied. In the present work the storey shear of flat slab is 5% more than conventional slab structure, the axial forces on flats lab building is nearly 6% more than conventional building, the difference in storey displacement of flat and conventional building are approximately 4mm in each floor. The present work provides reasonable information about the suitability of flat slab for various seismic zones without compromising the performance over the conventional slab structures*.**

Keywords— seismic zones, flat slab, conventional slab, ETABS, time period, base shear.

I. INTRODUCTION

India at present is fast growing country in economy which brings demands in increasing of infrastructure facilities along with the growth of population. The demand of land in urban areas increasing day by day, In order to counteract this demand in these urban areas vertical development is the only option. This type of development brings challenges to counteract additional lateral loads due to wind and earthquake Common practice of design and construction is to support the slabs by beams and support the beams by columns. This may be called as beam slab construction. The beams reduce the available net clear ceiling height. Hence in offices, public halls and houses, sometimes beams are avoided and slabs are directly supported by columns. These types of construction improve the aesthetic appearance. These slabs which are directly supported by columns are called Flat slabs. These flat slabs are also called as beamless slabs. The part of slab bounded on each of the four sides by center line of column is called panel. Panel may be divided into column strip and middle strip. The flat slab is thickened closed to supporting columns to provide adequate strength in shear and to reduce the amount of negative reinforcement in In 1914 Eddy and Turner were first wrote on flat slabs, The flat slabs directly rests on columns and walls over other forms of construction and advantages are better lightning, lower cost, greater neatness of appearance, rapidity of construction and increased safety is universally conceded as to render any reliable information relative to the scientific computation of stresses in flat slab construction of great interest. The research has been carried out to find the behaviour of slab column connection. The failure mode depends upon the type and extent of loading. Punching shear strength of slab column connection is of importance which depends on the gravity shear ratio. The mechanism of transfer of moments from slab to column is very complex when subjected to lateral loading and unbalanced moments. These unbalanced moments produce additional shear and torsion at the connections and then get transferred into the column which results in excessive cracking of slab leading to further reduction in the stiffness of the slab. There are several elements are modified to make work faster and economical also like introducing flat slab construction which reduces dead weight, and makes beams invisible, enhances floor area.. To know the performance of the structure it should be subjected to all type loadings, all seismic zones factors, various soil categories then only we can extract best choice or suitability parameter for the structures In the present work the performance of flat slab and Conventional slab structures for various loads all seismic zones factors have been studied.

II. FLAT SLAB

Flat slab is a reinforced concrete slab supported directly by concrete columns without the use of beams. Flat slab is defined as one sided or two-sided support system with sheer load of the slab being concentrated on the supporting columns and a square slab called 'drop panels. flat slabs are considered suitable for most of the construction and for asymmetrical column layouts like floors with curved shapes and ramps etc. the advantages of applying flat slabs are many like depth solution, flat soffit and flexibility in design layout. even though building flat slabs can be an expensive affair but gives immense freedom to architects and engineers the luxury of designing.

A. Types of Flat Slabs:

- Simple flat slab
- Flat slab with drop panels
- Flat slab with column heads
- Flat slab with both drop panels and column heads

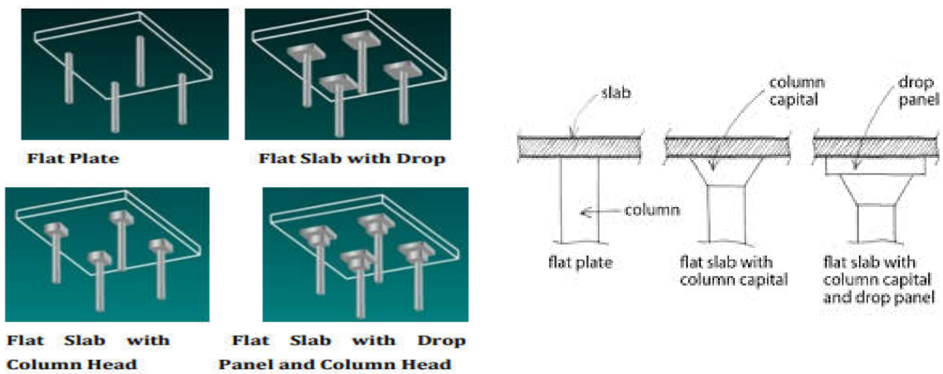


Fig. 1 Figure showing types of Flat Slabs and theire components

B. Advantages of Flat Slabs:

- Flexibility in room layout.
- Reinforcement placement is easier.
- Ease of formwork installation.
- Building height can be reduced.

C. Disadvantages of Flat Slabs:

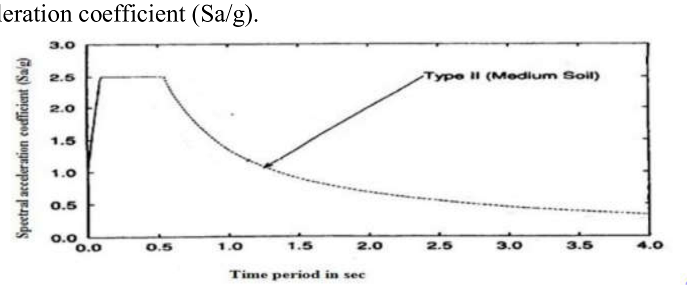
- Span length is medium.
- Not suitable for supporting brittle (masonry) partitions.
- Use of drop panels may interfere with larger mechanical ducting
- Critical middle strip deflection.

III. METHODOLOGY

The methodology adopted is to make model of a G+12 structure with and without flat slab in different seismic zones of India.(as per IS 1893-2002)

A. Analysis Method (Response spectrum Analysis)

The representation of maximum response of idealized single degree freedom system having certain period and damping, during earthquake ground motions. This analysis is carried out according to the code IS 1893-2002 (part1). The standard response spectra for type of soil considered is applied to building for the analysis in ETABS 2013 software. Following diagram shows the standard response spectrum for medium soil type and that can be given in the form of time period versus spectral acceleration coefficient (Sa/g).



Response spectrum for medium soil type for 5% damping This approach permits the multiple modes of response of a building to be taken in to account (in the frequency domain). This is required in many building codes for all except very simple or very complex structures. The response of a structure can be defined as a combination of many special shapes (modes) that in a vibrating string correspond to the “harmonic” computer analysis can be used to determine these modes for a structure. For each mode, a response is read from the design spectrum, based on the modal frequency and the modal mass, and they are then combined to provide an estimate of the total response of the structure. In this we have to calculate the magnitude of forces in all directions i.e. X, Y & Z and then see the effects on the building. Combination methods include the following:

- absolute - peak values are added together
- square root of the sum of the squares (SRSS)
- complete quadratic combination (CQC) - a method that is an improvement on SRSS for closely spaced modes

The result of a response spectrum analysis using the response spectrum from a ground motion is typically different from that which would be calculated directly from a linear dynamic analysis using that ground motion directly, since phase information is lost in the process of generating the response spectrum.

In cases where structures are either too irregular, too tall or of significance to a community in disaster response, the response spectrum approach is no longer appropriate, and more complex analysis is often required, such as non-linear static analysis or dynamic analysis. Title and Author Details

B. Modelling details:

1.	Utility of building	:	Residential building
2.	Number of stories	:	G+5,G+12, G+20
3.	Shape of building	:	Rectangular
4.	Type of walls	:	Brick wall
5.	Geometric details		
	a. Ground floor	:	3.3m
	b. floor to floor height	:	3m
6.	Material details		
	a. Concrete Grade	:	M40 (COLUMNS AND BEAMS)
	b. All Steel Grades	:	HYSD reinforcement of Grade Fe415
	c. Bearing Capacity of Soil	:	200 KN/m2
7.	Type Of Construction	:	R.C.C FRAMED structure
8.	Column	:	0.6m X 0.6m
9.	Beams	:	0.45X0.45m.
10.	Slab	:	0.150m
11.	Analysis Method	:	Response Spectrum Analysis

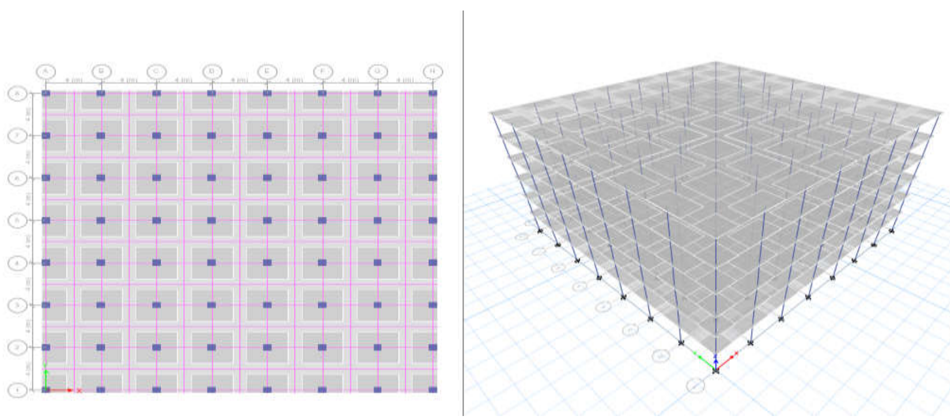


Fig. 2 Model showing G+5 structure with Flat slab

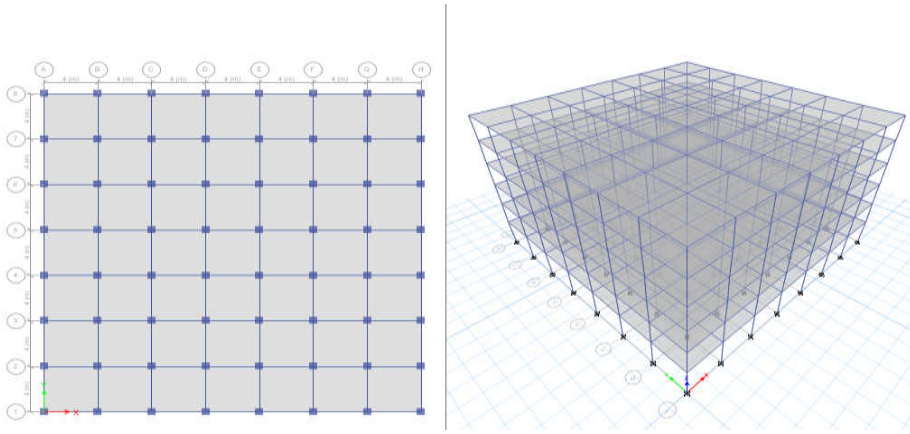


Fig. 3 Model showing G+5 structure with General slab

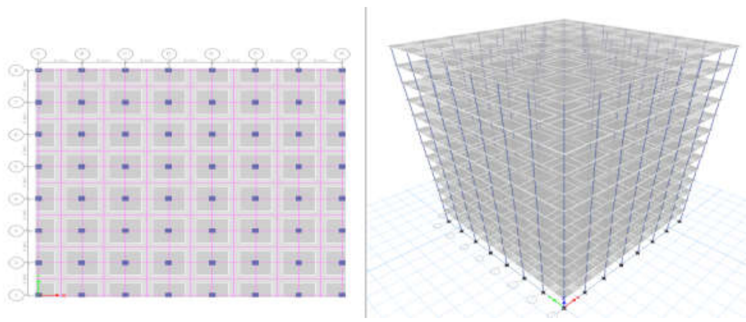


Fig. 4 Model showing G+12 structure with Flat slab

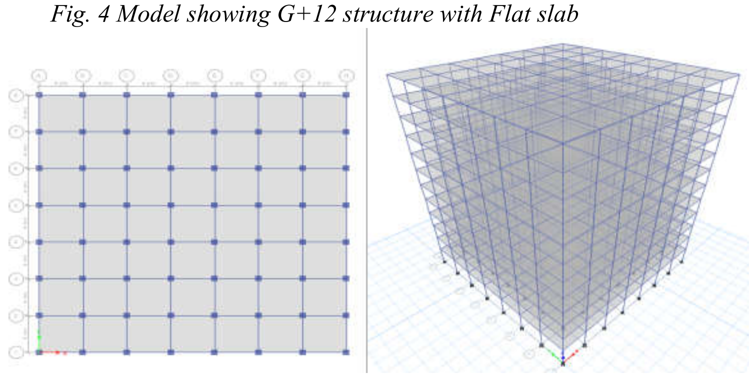


Fig. 5 Model showing G+12 structure with General slab

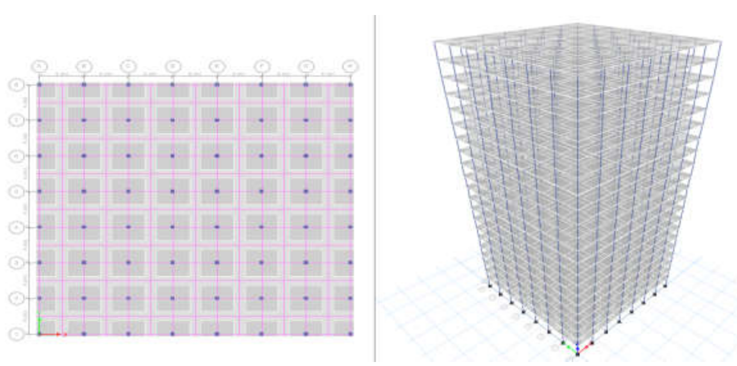


Fig.6 Model showing G+20 structure with Flat slab

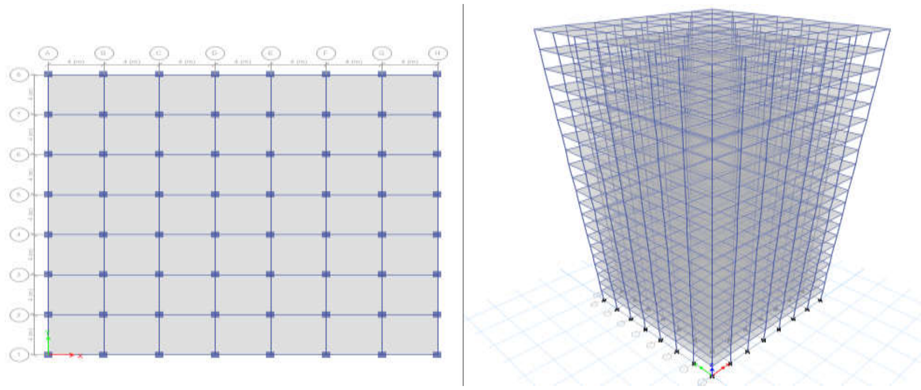


Fig. 7 Model showing G+20 structure with General slab

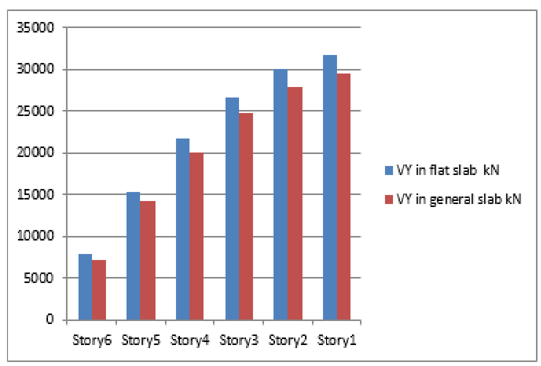
IV. RESULTS

A. Low rise building (G+5)

Zone II Results

Storey Drift

Story	Load Case/Combo	Location	VX in flat slab	vx in general slab
			kN	kN
Story6	RSA Max	Bottom	7799.846	7087.785
Story5	RSA Max	Bottom	15392.41	14147.97
Story4	RSA Max	Bottom	21717.31	20051.51
Story3	RSA Max	Bottom	26670.55	24701.55
Story2	RSA Max	Bottom	30073.58	27933.98
Story1	RSA Max	Bottom	31756.09	29568.22



Shear Force

Story	Load Case/Combo	Location	VY in flat slab	VY in general slab
			kN	kN
Story6	RSA Max	Bottom	7799.846	7087.785
Story5	RSA Max	Bottom	15392.41	14147.97
Story4	RSA Max	Bottom	21717.31	20051.51
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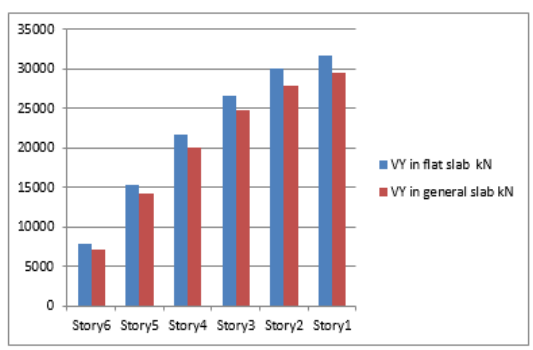
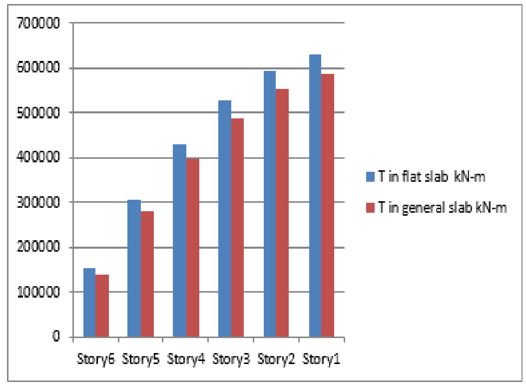


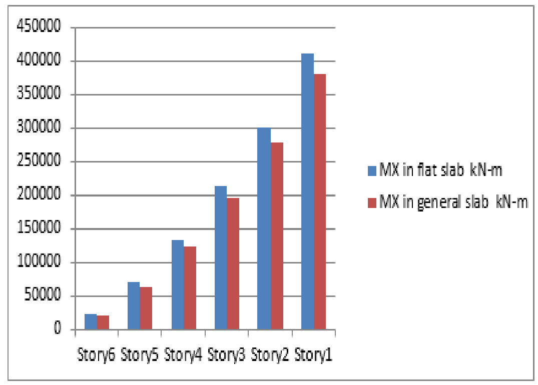
Building Torsion

Story	Load Case/Combo	Location	T in flat slab	T in general slab
			kN-m	kN-m
Story6	RSA Max	Bottom	154429.1	140331
Story5	RSA Max	Bottom	304754.2	280115.4
Story4	RSA Max	Bottom	429980.9	396999.7
Story3	RSA Max	Bottom	528049.9	489065.8
Story2	RSA Max	Bottom	595426.5	553064.6
Story1	RSA Max	Bottom	628738.5	585420.9



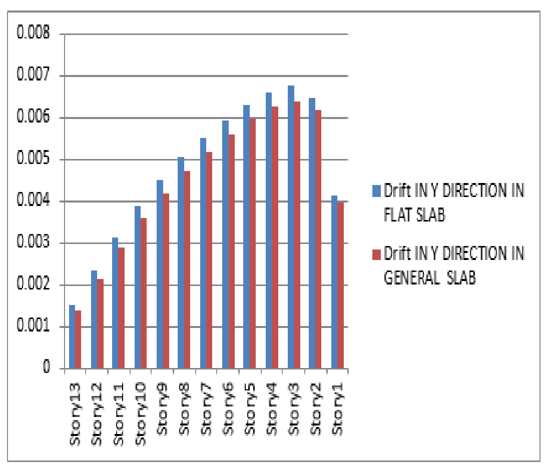
Building Momemt

Story	Load Case/Combo	Location	MX in flat slab	MX in general slab
			kN-m	kN-m
Story6	RSA Max	Bottom	23399.54	21263.36
Story5	RSA Max	Bottom	69377.93	63549.79
Story4	RSA Max	Bottom	133931	123204.6
Story3	RSA Max	Bottom	212892.4	196391.1
Story2	RSA Max	Bottom	301690	278916.8
Story1	RSA Max	Bottom	411188.3	380914.4



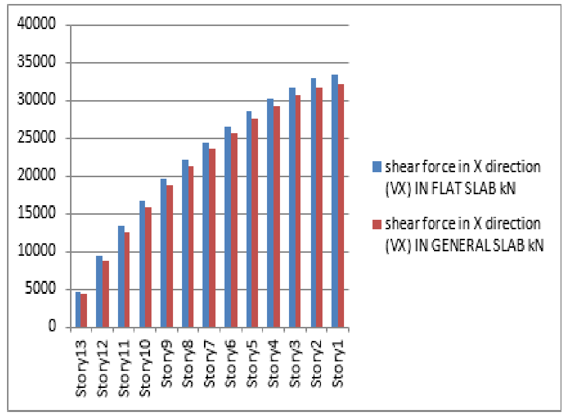
B. Medium rise building (G+12):
Zone II Results
Storey Drift

Story	Load Case/Combo	Drift IN Y DIRECTION IN FLAT SLAB	Drift IN Y DIRECTION IN GENERAL SLAB
Story13	RSA Max	0.001515	0.001365
Story12	RSA Max	0.002336	0.002124
Story11	RSA Max	0.00315	0.002891
Story10	RSA Max	0.003871	0.00358
Story9	RSA Max	0.004498	0.004185
Story8	RSA Max	0.005042	0.004715
Story7	RSA Max	0.005518	0.005181
Story6	RSA Max	0.005941	0.005594
Story5	RSA Max	0.006311	0.005955
Story4	RSA Max	0.006609	0.006245
Story3	RSA Max	0.006759	0.006395
Story2	RSA Max	0.006479	0.006162
Story1	RSA Max	0.004145	0.003958



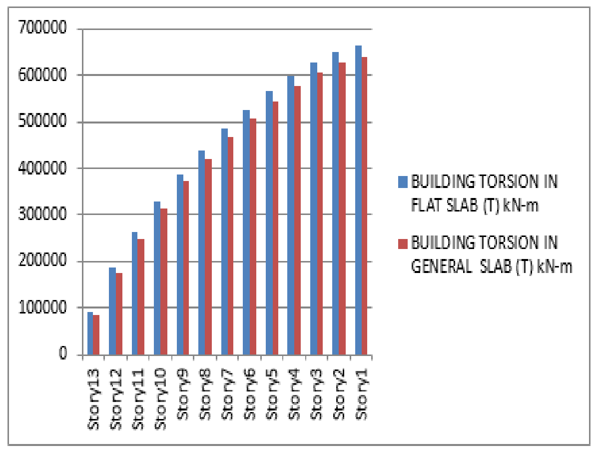
Shear Force

Story	Load Case/Combo	Location	shear force in X direction (VX) IN FLAT SLAB	shear force in X direction (VX) IN GENERAL SLAB
			kN	kN
Story13	RSA Max	Bottom	4689.962	4345.775
Story12	RSA Max	Bottom	9379.577	8797.038
Story11	RSA Max	Bottom	13334.57	12602.17
Story10	RSA Max	Bottom	16699.17	15881.41
Story9	RSA Max	Bottom	19627.6	18764.21
Story8	RSA Max	Bottom	22189.71	21305.31
Story7	RSA Max	Bottom	24470.67	23571.32
Story6	RSA Max	Bottom	26570.16	25641.98
Story5	RSA Max	Bottom	28506.48	27528.83
Story4	RSA Max	Bottom	30243.47	29197.88
Story3	RSA Max	Bottom	31745.32	30616.97
Story2	RSA Max	Bottom	32890.02	31682.05
Story1	RSA Max	Bottom	33473.81	32222.19



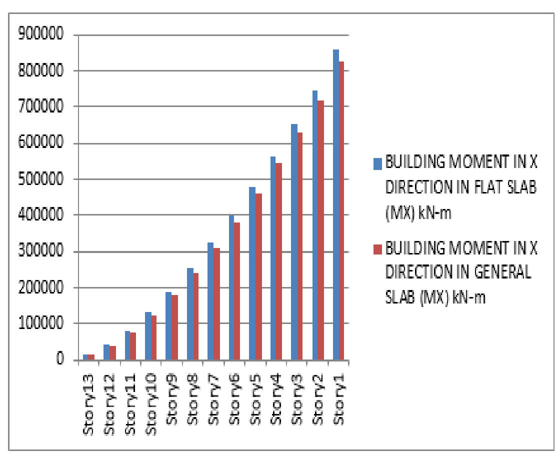
Storey Torsion

Story	Load Case/Combo	Location	BUILDING TORSION IN FLAT SLAB (T)	BUILDING TORSION IN GENERAL SLAB (T)
			kN-m	kN-m
Story13	RSA Max	Bottom	92856.5	86041.99
Story12	RSA Max	Bottom	185706.1	174172.4
Story11	RSA Max	Bottom	264011.1	249510.2
Story10	RSA Max	Bottom	330626.7	314436
Story9	RSA Max	Bottom	388606.6	371512.3
Story8	RSA Max	Bottom	439333.8	421823.6
Story7	RSA Max	Bottom	484494.5	466688.4
Story6	RSA Max	Bottom	526062.2	507685.4
Story5	RSA Max	Bottom	564399.4	545043.1
Story4	RSA Max	Bottom	598790.1	578088.5
Story3	RSA Max	Bottom	628525.3	606185.1
Story2	RSA Max	Bottom	651189.1	627272.6
Story1	RSA Max	Bottom	662747.6	637966.8



Storey Moment

Story	Load Case/Combo	Location	BUILDING MOMENT IN X DIRECTION IN FLAT SLAB (MX)	BUILDING MOMENT IN X DIRECTION IN GENERAL SLAB (MX)
			kN-m	kN-m
Story13	RSA Max	Bottom	14069.88	13037.33
Story12	RSA Max	Bottom	42163.54	39388.96
Story11	RSA Max	Bottom	81903.61	76965.06
Story10	RSA Max	Bottom	131246	123951.1
Story9	RSA Max	Bottom	188700.5	179002.9
Story8	RSA Max	Bottom	253118	241057.8
Story7	RSA Max	Bottom	323566.3	309222.5
Story6	RSA Max	Bottom	399364.8	382801.2
Story5	RSA Max	Bottom	480022.3	461243.7
Story4	RSA Max	Bottom	565082	544016.1
Story3	RSA Max	Bottom	654037.1	630531.7
Story2	RSA Max	Bottom	746244.6	720085
Story1	RSA Max	Bottom	856673.2	827134.2

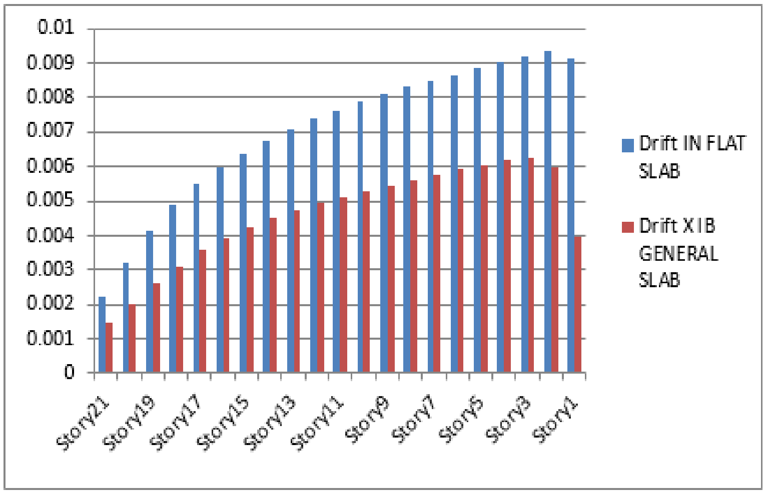


C. High rise building (G+20):

Zone II Results

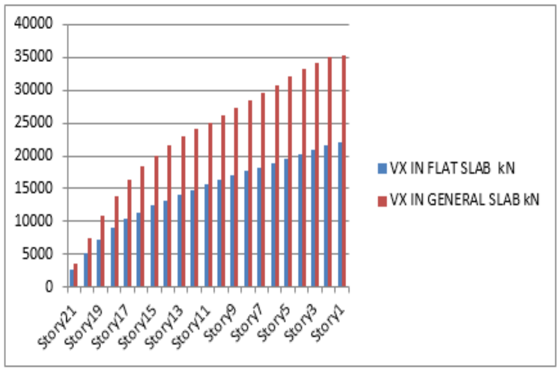
Storey Drift

Story	Load Case/Combo	Drift IN FLAT SLAB	Drift X IB GENERAL SLAB
Story21	RSA Max	0.002253	0.001442
Story20	RSA Max	0.003235	0.002002
Story19	RSA Max	0.004134	0.002589
Story18	RSA Max	0.004879	0.003115
Story17	RSA Max	0.00548	0.003564
Story16	RSA Max	0.005972	0.003942
Story15	RSA Max	0.00639	0.00426
Story14	RSA Max	0.006759	0.004528
Story13	RSA Max	0.007088	0.004752
Story12	RSA Max	0.00738	0.004944
Story11	RSA Max	0.007642	0.005114
Story10	RSA Max	0.007885	0.005275
Story9	RSA Max	0.008111	0.005434
Story8	RSA Max	0.008319	0.005594
Story7	RSA Max	0.008507	0.005755
Story6	RSA Max	0.008679	0.005914
Story5	RSA Max	0.00885	0.006066
Story4	RSA Max	0.009027	0.006193
Story3	RSA Max	0.009195	0.006236
Story2	RSA Max	0.009365	0.005998
Story1	RSA Max	0.009125	0.003991



Shear Force

Story	Load Case/Combo	Location	VX IN FLAT SLAB	VX IN GENERAL SLAB
			kN	kN
Story21	RSA Max	Bottom	2609.068	3631.561
Story20	RSA Max	Bottom	5120.738	7498.792
Story19	RSA Max	Bottom	7252.649	10920.78
Story18	RSA Max	Bottom	8967.206	13838.88
Story17	RSA Max	Bottom	10321.74	16283.49
Story16	RSA Max	Bottom	11428.15	18336.78
Story15	RSA Max	Bottom	12392.94	20082.77
Story14	RSA Max	Bottom	13276.12	21580.51
Story13	RSA Max	Bottom	14094.19	22873.48
Story12	RSA Max	Bottom	14852.26	24015.19
Story11	RSA Max	Bottom	15567.52	25078.79
Story10	RSA Max	Bottom	16263.89	26138.09
Story9	RSA Max	Bottom	16951.83	27238.63
Story8	RSA Max	Bottom	17622.6	28388.24
Story7	RSA Max	Bottom	18267.96	29574.56
Story6	RSA Max	Bottom	18904.52	30785.59
Story5	RSA Max	Bottom	19571.21	32005.49
Story4	RSA Max	Bottom	20290.55	33185.91
Story3	RSA Max	Bottom	21022.65	34223.77
Story2	RSA Max	Bottom	21656	34978.72
Story1	RSA Max	Bottom	22051.97	35347.84

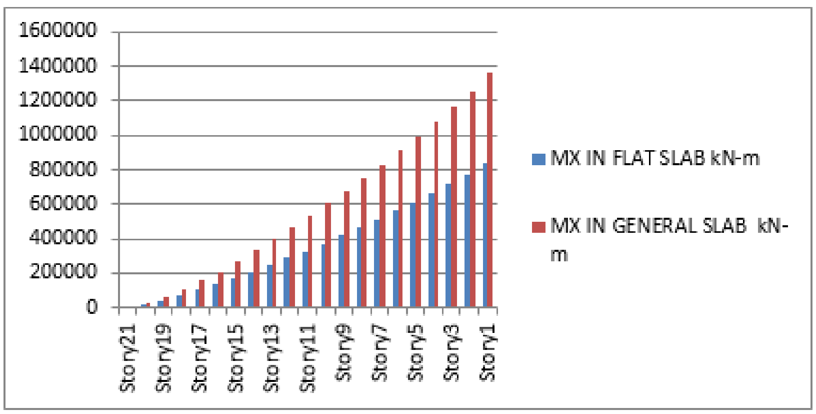


Building Torsion

Story	Load Case/Combo	Location	T IN FLAT SLAB	T IN GENERAL SLAB
			kN-m	kN-m
Story21	RSA Max	Bottom	51656.87	71901.34
Story20	RSA Max	Bottom	101385.5	148468.5
Story19	RSA Max	Bottom	143595.1	216220.4
Story18	RSA Max	Bottom	177541.6	273995.8
Story17	RSA Max	Bottom	204360.2	322396.6
Story16	RSA Max	Bottom	226265.8	363049.8
Story15	RSA Max	Bottom	245367.6	397618.6
Story14	RSA Max	Bottom	262853.8	427272.2
Story13	RSA Max	Bottom	279050.8	452871.8
Story12	RSA Max	Bottom	294059.7	475476.6
Story11	RSA Max	Bottom	308221.1	496534.7
Story10	RSA Max	Bottom	322008.6	517507.7
Story9	RSA Max	Bottom	335629.1	539297.3
Story8	RSA Max	Bottom	348909.7	562058.5
Story7	RSA Max	Bottom	361687.2	585546.5
Story6	RSA Max	Bottom	374290.5	609523.6
Story5	RSA Max	Bottom	387490.3	633676.5
Story4	RSA Max	Bottom	401732.5	657047.5
Story3	RSA Max	Bottom	416227.3	677596.1
Story2	RSA Max	Bottom	428767	692543.2
Story1	RSA Max	Bottom	436606.7	699851.4

Building Moment

Story	Load Case/Combo	Location	MX IN FLAT SLAB	MX IN GENERAL SLAB
			kN-m	kN-m
Story21	RSA Max	Bottom	7827.203	10894.71
Story20	RSA Max	Bottom	23184.59	33384.79
Story19	RSA Max	Bottom	44902.95	66102.17
Story18	RSA Max	Bottom	71643.46	107447.8
Story17	RSA Max	Bottom	102162.3	155846.1
Story16	RSA Max	Bottom	135496	209926.4
Story15	RSA Max	Bottom	171017.3	268583
Story14	RSA Max	Bottom	208373.8	330941.9
Story13	RSA Max	Bottom	247375.8	396302.4
Story12	RSA Max	Bottom	287908.1	464109.3
Story11	RSA Max	Bottom	329895.3	533969.1
Story10	RSA Max	Bottom	373303.2	605673.6
Story9	RSA Max	Bottom	418134.8	679194.9
Story8	RSA Max	Bottom	464406.4	754640.2
Story7	RSA Max	Bottom	512123.8	832194.3
Story6	RSA Max	Bottom	561286	912075.7
Story5	RSA Max	Bottom	611918.9	994509.6
Story4	RSA Max	Bottom	664103.2	1079691
Story3	RSA Max	Bottom	717952.3	1167709
Story2	RSA Max	Bottom	773526.1	1258450
Story1	RSA Max	Bottom	840383.2	1367242



V. Conclusions

Upon the results of investigations the following conclusions were made:

- Lateral displacement is minimum at plinth level and maximum at terrace level, as the number of stories increases lateral displacement also increases.
- Storey drift is minimum at plinth, top stories and maximum at middle stories, thus extra stiffness of column requires at middle stories compared to other stories.
- The Natural period increases as number of Stories increases. The Base shear value is maximum at plinth level and minimum at terrace level, as total number of stories increases base shear increases.
- The base shear is maximum at plinth level. The base shear will increase drastically as the height increases. Base shear of conventional beam slab building is less than the flat slab building.
- The displacement of structures increased as the seismic zone increase in both conventional beam slab and flat slab building
- Displacement increases as the height increases for all the structure. Displacement of flat slab building is more than conventional beam slab building
- Storey drift in buildings with flat slab construction is significantly more as compared to the conventional beam slab building.

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