Comparative Study of Equivalent Static Analysis and Response spectrum analysis on Flat Slab Using Etabs

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Abstract – *As we know that in the present scenario flat slab is gaining more popularity for the construction over the conventional beam-slab type. This is due to the fact that there are many benefits speed of constructions and availability of more clear space between floors. In this paper a residential building with G+10 floors is considered for the seismic analysis using response spectrum method. The results are compared with equivalent static method. The software used for the analysis is ETABS 2015.0.0. In this work the seismic zone is considered to be Zone II. The results generated from both the method were compared considering the parameters such as storey displacement, storey shear and storey drifts.*

Key Words: Response Spectrum, equivalent static method, ETABS, storey drift, storey shear and storey displacement.

1. INTRODUCTION

A reinforced concrete slab which is directly supported on columns is represented as flat slab, in which the beams are eliminated. Due to this the speed of construction is fast with simplified form work. In this system the floors and columns act as single two way frame. Flat slabs for spans 4m to 9m will have thickness ranging from 125mm to 300mm. By eliminating the intermediate beams and retaining perimeter beams are termed as flat plate with perimeter beam.

1.1 LITERATURE REVIEW

Mohana H.S et al (2015) [2] conducted the work of analysis of a both commercial multistoried building with flat slab and conventional slab for G+5. They compared the results for the parameters like base shear, storey drift, axial force, and displacement in all seismic zones of India. They got the results as storey shear of 5% more when compared to conventional slab type, the axial forces was found to be 6% more in flat slab. They also found out that storey displacement was differing approximately 4mm in each floor and for both flat slab and conventional slab structure.

Sumit Pahwa et al (2014) [4] carried out the study of flat slab with two way slab for comparative behavior values of various parameters using Staad Pro 2006. They created models for two-way slabs and flat slab without shear wall for each plan size of 16X24 m and 15X25m. They considered the models in the seismic Zones III, IV and V with the varying height of the above models such as 21m, 27m, 33m and 39m. After the modeling and analysis on the basis of results they concluded that the model of flat slab increases drift value in shorter plans and decreases drift in larger plans which is in the range of 0.5mm – 3mm.

Kalyan Chowdary Kodali, et al (2014) [5] carried out analysis of conventional beam slab and flat slab models. G+30 storey building model with shear walls are considered, which are subjected for different load condition. The seismic zone considered is Zone V. they concluded that, the time period of conventional beam slab is more when compared to flat slab. They found that storey drift of flat slab model is high when compared to beam slab model. Due to the higher drift ratios in flat slabs additional moments will develop. In such case the columns should be designed considering additional moments.in beam slab model base shear is more when compared to flat slab building.

Manu K V et al (2015) [6], carried out the study of characteristic seismic behavior of conventional RC frame building and flat slab buildings. They carried out the analysis using ETABS V9.7.4. They found out that lateral displacement is minimum at plinth level and maximum at terrace level, as number of stories increases lateral displacement also increases. Storey drift is minimum at plinth and 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.

1.2 Equivalent Static analysis & Response Spectrum analysis

Equivalent static analysis is used in regular structure with limited height. This method requires less computational efforts which is based on the formulation given in IS codal provision. The first step is to compute the design base shear as per IS 1893(Part 1):2002 for entire structure, and then it is distributed along the height. In case of Response spectrum analysis, with the help of smooth spectra curve which is the average of several earthquake motions, only maximum peak values of displacements and member forces in each mode of vibration are calculated in this method.

1.3 Objectives of the Present Work

- To study the parameters such as storey shear, storey displacement and storey drift of flat slab structure.
- To compare equivalent static analysis and response spectrum analysis method on flat slab for above parameters.

1.4 Model Description

The analysis of the proposed building is carried out using ETABS software. The material properties such as grade of concrete, yield strength of steel, modulus of elasticity and density of both concrete and steel are defined in the beginning. The load acting on the building such as self-weight, live loads, floor finishers, wall load, and seismic forces are defined at starting stage.
The plan considered for the present dissertation work is consisting of a ground floor and followed by ten upper floors. The plan of a typical storey is shown in Figure 1. The elevation of the building is shown in Figure 2. The total height of building is 36m consisting of 42 residential flats. The total number of 10 floor slab, one roof slab and a head room for staircase.

Concrete grade: Beams & slabs = M_{25}
Columns=M_{40}
Reinforcement Steel: Fe_{500}

Live load: 2 kN/m^2 for all floors
3 kN/m^2 for Staircase waist slab
1.5 kN/m^2 roof slab.

Floor finishers: 1.5 kN/m^2

Sunken load: Balcony 50mm sunk = 0.3925 kN/m^2
Toilet 100mm sunk = 0.785 kN/m^2
Seismic load data: Seismic zone = II
Zone factor = 0.1
Importance factor = 1
Response reduction factor =3
Soil type = Medium
Total height of building = 38m
Sectional properties:
Columns = 230 X 750 mm
Perimeter beams = 230 X 450 mm
Flat slab = 200mm thickness.

[NOTE:
EQX = Seismic load in X direction
EQY = Seismic load in Y direction
RSPX = Response spectrum load case in X direction
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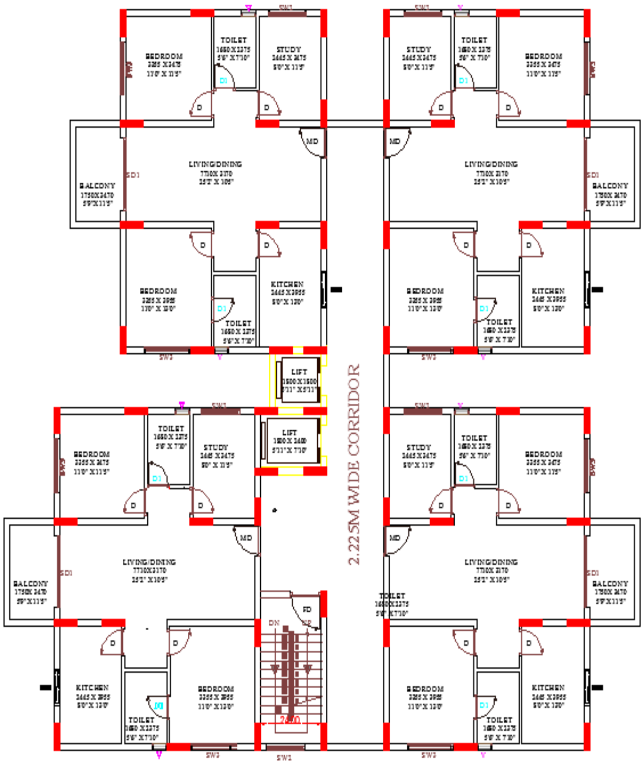

Figure 1: Typical Floor Plan of G+10 Building

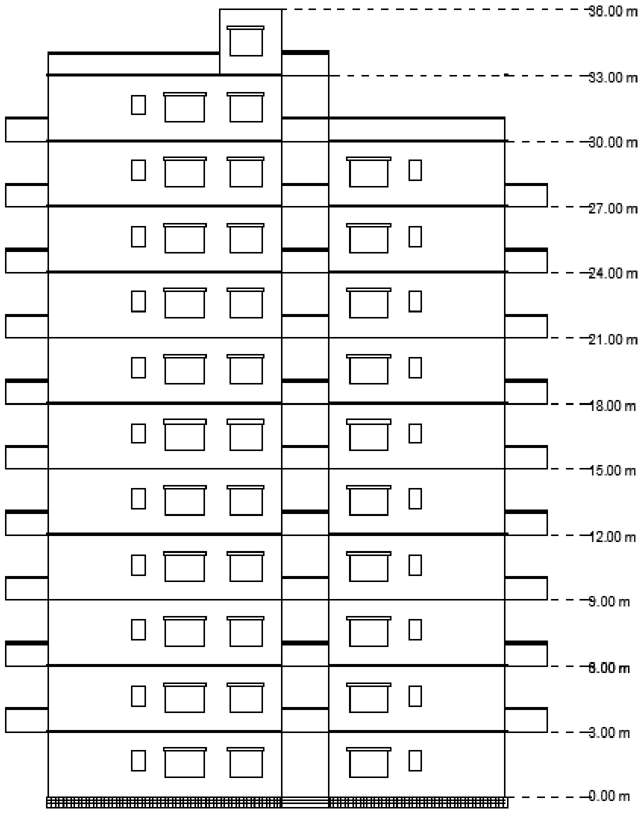

Figure 2: Elevation of Proposed Building

2. RESULTS AND DESCUSSION

The results obtained from the ETABS analysis of G+10, model for ESA and RSA methods are tabulated and discussed for the parameters such as storey shear, storey drift, storey displacement. The comparison between ESA and RSA methods are shown and reported.

2.1 Storey Displacement

It is the important factor, when the structure is affected by seismic forces and wind force. It mainly depends on the height of the structure, tall structures are more flexible for lateral loads. Displacement values will be higher at the top storey and less at bottom storey.

The storey displacement for ESA and RSA methods are given in the Table 1 and the graphical representation is shown in Chart 1.

Table -1: Storey displacement for ESA & RSA methods.

Storey no.	Storey Displacement (mm)			
	Load case			
	ESA		RSA	
	EQX	EQY	RSPX	RSPY
HEADROOM	61	48.1	46.1	36.1
TERRACE	57.6	47.8	44.7	34.4
10TH	54.7	45.1	42.8	34.1
9TH	51.3	41.9	40.4	33.4
8TH	47.1	38.9	37.6	31.3
7TH	42.1	35	34.1	28.8
6TH	36.5	30.6	30.1	25.6
5TH	30.4	25.6	25.7	22
4TH	23.9	20.4	20.8	18
3RD	17.3	14.9	15.5	13.6
2ND	11	9.6	10.1	9
1ST	5.3	4.7	5	4.5
GF	1.2	1.1	1.1	1

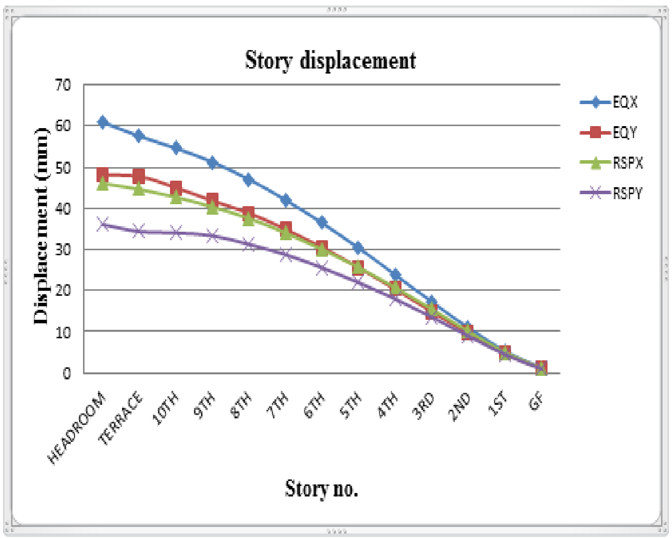

Chart -1: Storey displacement for ESA & RSA methods.

From the Table 1 and Chart 1, the value of displacement is maximum at top storey in both the methods, the maximum value is seen in ESA method than RSA that is because the results from RSA is accurate than ESA. The maximum displacement is 61 mm for load case EQX. The storey displacement value is 14.9mm more in case of ESA method

2.2 Storey Drift

It is nothing but the difference between storey displacements of one storey with respect to the other storey. As per codes its value should not exceed the limit of 0.004 of height of the storey. Its value is usually maximum at mid stories.

The storey drift for ESA and RSA methods are given in the Table 2 and the graphical representation is shown in Chart 2.

Table -2: Storey drifts for ESA & RSA methods.

Storey no.	Storey drift			
	Load case			
	ESA		RSA	
	EQX	EQY	RSPX	RSPY
HEADROO	0.00093	0.00049	0.00095	0.00045
TERRACE	0.00096	0.00062	0.00081	0.00048
10TH	0.00116	0.00086	0.00100	0.00066
9TH	0.00144	0.00113	0.00122	0.00093
8TH	0.00171	0.00137	0.00142	0.00118
7TH	0.00193	0.00156	0.00157	0.00138
6TH	0.00210	0.00171	0.00169	0.00153
5TH	0.00221	0.00181	0.00179	0.00167
4TH	0.00225	0.00186	0.00188	0.00178
3RD	0.00218	0.00185	0.00189	0.00183
2ND	0.00194	0.00175	0.00178	0.00177
1ST	0.00146	0.00140	0.00136	0.00141
GF	0.00061	0.00061	0.00056	0.00049

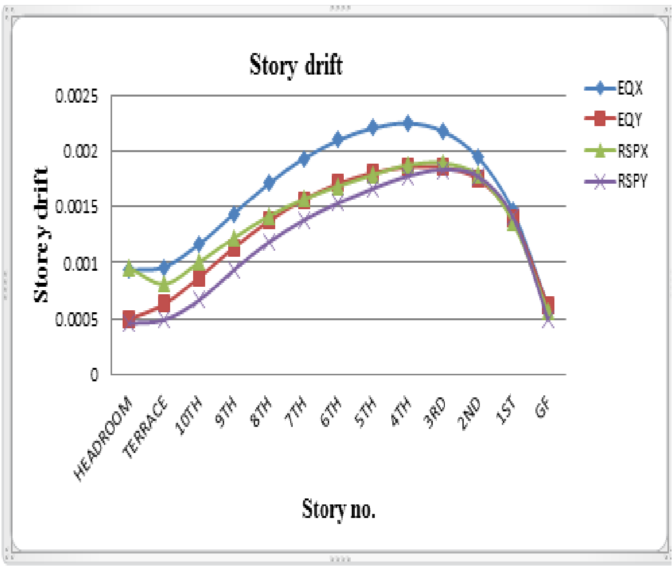

Chart -2: Storey drift for ESA & RSA methods.

From the Table 2 and Chart 2, it can be seen that drift is maximum for ESA method for EQX load case in 4^{TH} storey. In case of RSA method the maximum storey drift was seen in 3^{RD} storey. Obtained value states that in ESA method the drift ratio is maximum than RSA method, because in RSA method it gives accurate results. The maximum storey drift of 0.002254 is seen in 4^{TH} storey for EQX load case.

2.2 Storey Shear

The cumulative sum of lateral forces at every level above the storey considered is called as storey shear. This value is always maximum at bottom storey and minimum at top storey. The storey shear at the base is considered as base shear.

The storey shear for ESA and RSA methods are given in the Table 3 and the graphical representation is shown in Chart 3.

Table -3: Storey shears for ESA & RSA methods.

Storey no.	Storey shear (kN)			
	Load case			
	ESA		RSA	
	EQX	EQY	RSPX	RSPY
HEADROO	65.065	65.065	87.2374	79.9345
TERRACE	232.239	232.239	258.701	241.343
10^{TH}	535.090	535.090	536.26	505.918
9^{TH}	852.916	852.916	782.127	759.855
8^{TH}	1105.93	1105.93	948.505	942.414
7^{TH}	1305.85	1305.85	1073.83	1078.70
6^{TH}	1457.01	1457.01	1182.48	1189.02
5^{TH}	1566.23	1566.23	1284.81	1293.88
4^{TH}	1640.33	1640.33	1386.95	1398.48
3^{RD}	1686.13	1686.13	1501.40	1509.07
2^{ND}	1710.41	1710.41	1623.44	1625.46
1^{ST}	1719.93	1719.93	1710.88	1710.81
GF	1720.56	1720.56	1720.24	1720.01

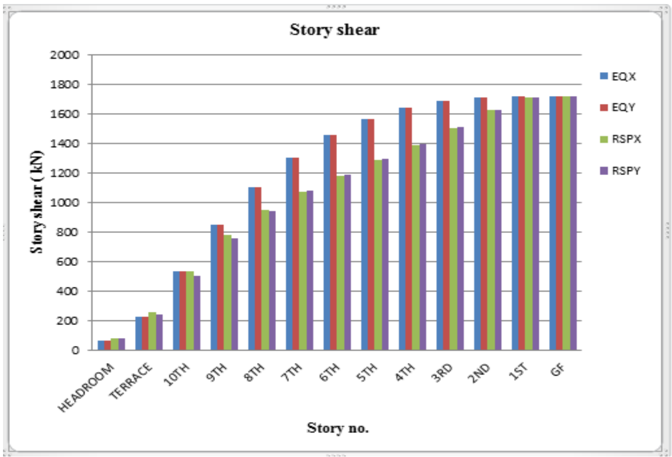

Chart -3: Storey shear for ESA & RSA methods.

From the Table 3 and Chart 3, the maximum storey shear value of FS model from both ESA and RSA methods is seen in bottom storey. The maximum storey shear value of 1720.5626 kN is seen in ESA method.

[NOTE:
ESA = Equivalent Static Analysis
RSA = Response Spectrum Analysis]

3. CONCLUSIONS

- The storey displacement values obtained from both the analysis is evident that the displacement is more in top storey.
- From the analysis results for both ESA and RSA the storey displacement and storey drift is more along the shorter span i.e., in X-direction.
- In ESA the storey drift is maximum at fourth storey where as in RSA it is maximum at third storey.
- Storey shear is maximum at base.
- Drift and displacement results obtained by ESA are greater than the results obtained by RSA.

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