COMPARATIVE STUDY ON SEISMIC ANALYSIS OF CONVENTIONAL SLAB, FLAT SLAB AND GRID SLAB SYSTEM FOR A R.C FRAMED STRUCTURES

Dr Ramakrishna Hegde[1], Chethana[2], Nanditha Vinod Kumar[3]

[1] Head of the Department, Department of Civil Engineering, Srinivas School of Engineering, Mangalore, India
[2] Assistant Professor, Department of Civil Engineering, Srinivas School of Engineering, Mangalore, India
[3]M. Tech Student, Department of Civil Engineering, Srinivas School of Engineering, Mangalore, India

---***---

Abstract – *For the design engineers, selection of the type of the structure for a particular purpose is very important of late. Under circumstances, slab structures and grid structures proves to be more beneficial compared to the conventional RC Framed Structures. Architectural aspects and the flexibility of the space utilization inside the structures, easy form work etc., plays a major role in the selection of the design criteria even though the conventional approach naturally provides the better seismic resistance. In this project work an attempt is made to study and compare the procedure and performances of the Conventional RC frame slab, Flat Slab and Grid slab. These are studied and analyzed, under earthquake zone II. The modes are is done using E-Tabs 2015 IS Code 456-2000. G+14 storey buildings are taken and designed and analysis is done for both Gravity (D.L and L.L) and lateral (earth quake and wind) loads. The equivalent static method is used to design and analyze the structures, as categorized by Indian Standard Code for earthquake resistant structures. Study provides good information about storey drift, storey displacement, base shear, storey shear, and time period. It is observed that the seismic performance of grid slab structure was better as compared to that of flat slab structure. It is found that the Storey drift of conventional slab is 10% higher than flat slab and grid slab. The Base shear of conventional slab is 44% higher than flat slab and 37% higher compared to grid slab.*

Key Words: **story displacement, time period, story drift, story shear, base shear, ETABS.**

1. INTRODUCTION

Shelter is a very important basic need of the human being since the early civilization. Varieties of structural forms are constructed for the purpose of better living. Research are been carried out to make the building comfortable, safe and economical. Presently, there is an increase in requirement of construction of tall structures at urban areas to accommodate the population which is growing exponentially. Problem faced by the designers in the vertical growth of the cities is efficiently handling the seismic forces which are haphazard in nature & unpredictable. Hence, earthquake modeling is to be done carefully. Seismic forces cause different vibrations at different areas and the damage caused is also different. Factors like intensity of vibration, duration etc, are very important to understand the effect of seismic force. Hence, it is important to know the earthquake behavior of structure such as lateral displacements, story drift, storey shear and base shear. To determine the seismic response of structure, seismic analysis is done using various methods i.e. Response Spectrum Method and Time History method. Failure of structure occurs at the point where it is week during earthquake. Earthquake appears due to the Geotechnical aspect of the Earth bed, it is unpredictable, if it occurs in populated areas, it causes heavy loss to both life and properties. Many a times damage caused by the earth quake is enormous.

1.1 SCOPE OF WORK

The structures are modeled in 3D as commercial structures by using the E-Tabs software. In the present work, 15 storied reinforced concrete frame buildings situated in Zone II as per Indian standard code, is considered for the study. The building height is assumed as 45 m. The buildings are studied as space frames. The designed space frames are studied for dead loads, live loads and seismic loads. The analysis was done for the following three models. G+14 storied RCC structure with Conventional slabs, Flat slabs and Grid slabs in ETAB 2015 software and results are tabulated and compared. All the three models were considered for the Equivalent static analysis. From the equivalent static analysis the displacement, time period, story drift, shear in the storey and the base shear are obtained and compared. The work will help greatly in achieving the better safety, economy and comfort in the design of the multistoried building which is the need of the hour.

1.2 DESIGN AND ANALYSIS OF STRUCTURE

Normally following methods are adopted for the analysis

- Equivalent static analysis
- Linear dynamic analysis
- Response spectrum method
- Time history analysis
- Push over analysis
- Non-linear static analysis
- Non-linear dynamic analysis

The seismic analysis is done for the structures which are prone to the seismic forces. Equivalent linear static analysis is sufficient for simple regular structures. The study is achieved for general and low rise structures and it gives good results. Dynamic analysis is carried out for the buildings mentioned in IS 1893:2002 (part I). The dynamic analysis is carried out by two methods, Response Spectrum and Time History.

2. MODELLING

The structures are modeled in 3D as commercial structure by using the E-Tabs software. In the present work, 15 storied reinforced concrete frame buildings situated in Zone II as per Indian standard code, is considered for the study. The number of horizontal lines and vertical lines are mentioned and also the floor height is given. The building height is mentioned as 45m.The buildings are studied as space frames. The designed space frames are studied for dead load, live load and seismic loads. The structures are compared for storey displacements, time period, drift of storey, shear of the storey and base of the shear. The analysis was carried to the following three models.

1. Model 1 – Flat Slab
2. Model 2 – Conventional Slab
3. Model 3 – Grid Slab

2.1 DESCRIPTION OF STRUCTURE

a. Structure details

Plan dimension	42mX25m
Number of arms in x-axis	7
Number of arms in y-axis	5
Arm length in x-axis	6m
Arm length in y-axis	5m
Height of the floor	3m

b. Material properties

Concrete grade of beam	M25	-	M25
Concrete grade of column	M25	M30	M25
Concrete grade of normal slab	M20	M20	M20
Concrete grade of drop	-	M20	-
Density of concrete	25kN/m3	25kN/m3	25kN/m3
Grade of steel	Fe500	Fe500	Fe500
Poisson's ratio	0.2	0.2	0.2
Modulus of elasticity	25kN/m2	25kN/m2	25kN/m2

c. Section properties

Structural element	Flat slab building	Conventional slab building	Grid slab building
Beam	-	300X500mm	300X500mm
Column	750X750mm	750X750mm	750X750mm
Slab thickness	200mm	150mm	100mm
drop slab thickness	300mm	-	-
Panel size	6X5m	6X5m	6X5m

Gravity loads

Dead load	Default valves taken by E-Tabs
Live load	$4kN/m^2$
Floor finish	$1.5kN/m^2$
Wall load	$14.37kN/m^2$ (0.23X(3.0 - 0.5)X25)

Lateral loads

Seismic load	
Seismic Zone Factor, Z	0.10
Importance Factor, I	1
Response Reduction Factor, R	5
Wind load	
Wind Speed, Vb	50m/s
Terrain Category	2
Structure Class	B
Risk Co-efficient, k1	1
Topography, k3	1

2.2 E-TABS MODELS

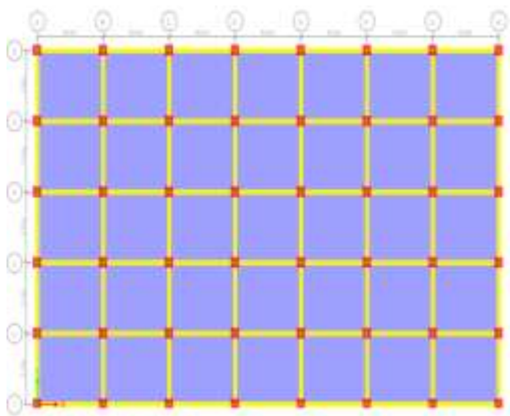

Fig 1 Plan View of Conventional Slab

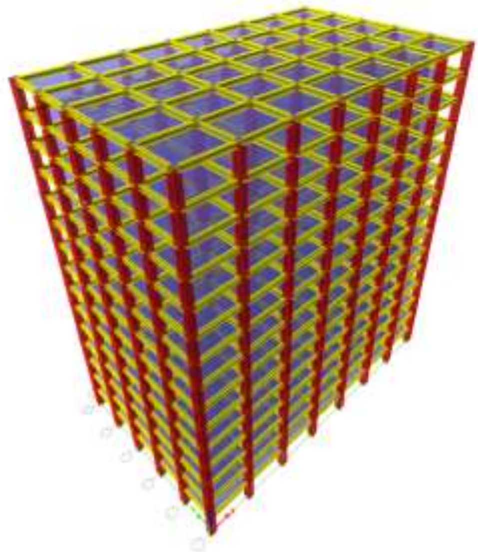

Fig 2 3D View of Conventional Slab

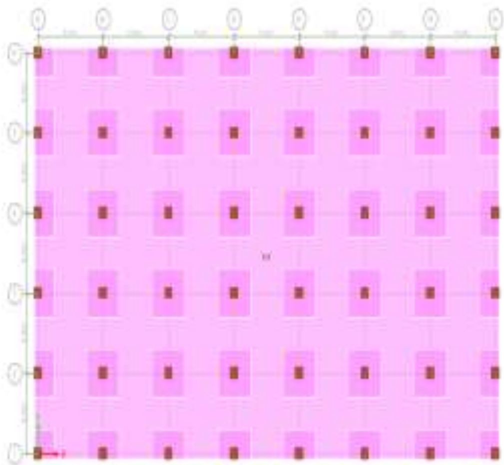

Figure 3 Plan View of Flat Slab

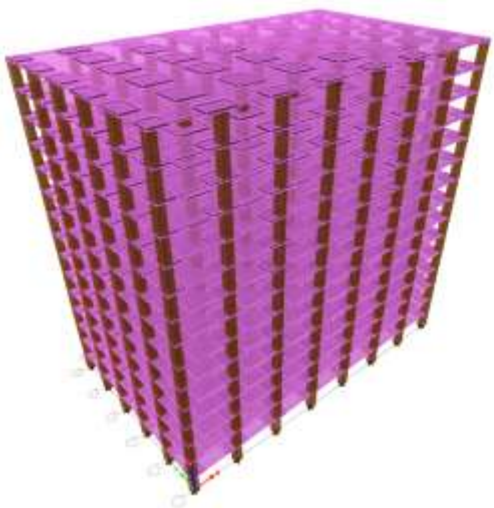

Fig 4 3D View of Flat Slab

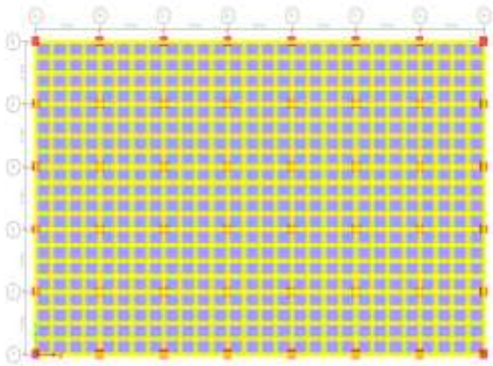

Fig 5 Plan View of Grid Slab

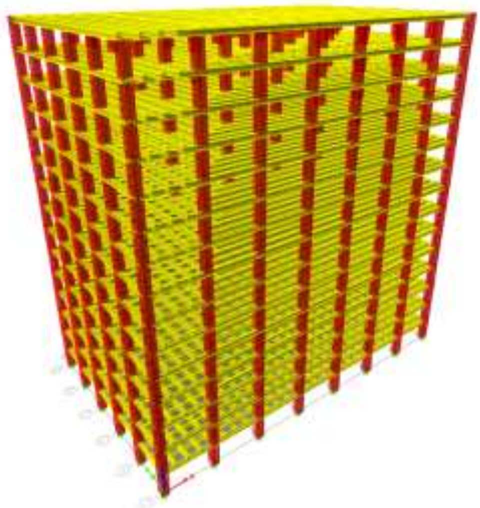

Figure 6 3D View of Grid Slab

3. RESULTS AND DISCUSIONS

3.1 LATERAL DISPLACEMENTS

3.1.1 Storey Displacement By Equivalent Static Analysis Along X- Direction

Table 1, below gives the comparison between displacement of earthquake loading in x- direction of Conventional slab structure, flat slab structure and grid slab structure .

Table 1 Storey Displacement By Equivalent Static Analysis Along X- Direction

Storey No	Conventional Slab	Flat Slab	Grid Slab
0	0	0	0
1	0.5	0.4	0.6
2	1.7	1.3	1.7

3	3.2	2.4	3.1
4	4.8	3.7	4.6
5	6.5	5.1	6.1
6	8.1	6.4	7.5
7	9.7	7.7	8.9
8	11.3	9	10.3
9	12.7	10.2	11.6
10	14	11.3	12.8
11	15.2	12.3	13.8
12	16.1	13.1	14.7
13	16.9	13.8	15.4
14	17.5	14.4	15.9
15	17.9	14.8	16.2

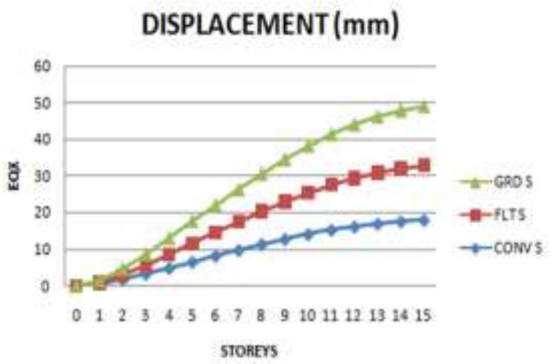

Fig 7 Storey Displacement by Equivalent Static Analysis Along X- Direction

In Figure 7 the graph is drawn for number of storey's in x axis and EQX in Y axis. The graph shows that the grid slab has highest displacement and conventional slab has lowest displacement along x- direction.

3.1.2 Storey Displacement By Equivalent Static Analysis Along X- Direction

Table 2 gives the comparison between displacement of earthquake loading in Y- direction of conventional slab, flat slab and grid slab.

Table 2 Storey Displacement By Equivalent Static Analysis Along Y- Direction

Storey No	Conventional Slab	Flat Slab	Grid Slab
0	0	0	0
1	0.5	0.4	2
2	1.7	1.2	6.1
3	3.1	2.4	11.1
4	4.6	3.6	16.3
5	6.2	4.9	21.6
6	7.8	6.1	26.8
7	9.3	7.4	31.9
8	10.8	8.6	36.8
9	12.1	9.7	41.4
10	13.4	10.8	45.6
11	14.5	11.7	49.4
12	15.4	12.5	52.6
13	16.2	13.2	55.3
14	16.8	13.7	57.2
15	17.2	14.2	58.5

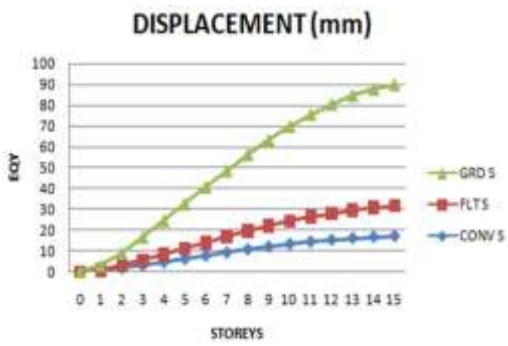

Fig 8 Storey Displacement By Equivalent Static Analysis Along Y- Direction

In Figure 8 the graph is drawn for number of storey's in X axis and EQY in Yaxis. The graph shows that the grid slab has highest displacement and conventional slab has lowest displacement along Y- direction.

3.2 TIME PERIOD

3.2.1 Time Period For Conventional Slab, Flat Slab and Grid Slab

In table 3 the Time period of Conventional Slab structure, Flat Slab structure and Grid Slab structure is given

Table 3 Time Period For Conventional Slab, Flat Slab And Grid Slab

MODAL NO	CONVENTIONA L SLAB	FLAT SLAB	GRID SLAB
1	2.759	2.252	2.882
2	2.64	2.156	2.531
3	2.42	2.088	2.519

4	0.869	0.698	0.923
5	0.834	0.671	0.811
6	0.767	0.648	0.807
7	0.474	0.371	0.515
8	0.456	0.359	0.453
9	0.421	0.345	0.449
10	0.303	0.231	0.338
11	0.294	0.225	0.298
12	0.272	0.214	0.297

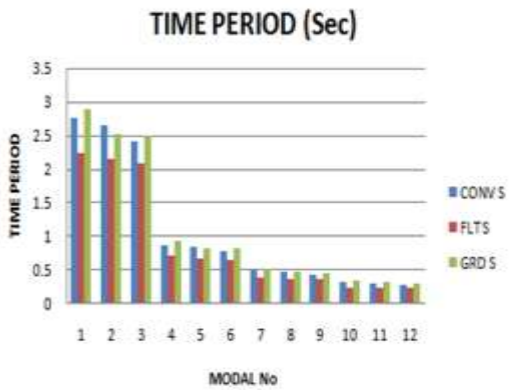

Fig 9 Time Period For Conventional Slab, Flat Slab And Grid Slab

In Figure 9 the graph is drawn of Modal No in x- axis and Time period in y- axis.

3.3 STOREY DRIFTS

3.3.1 STOREY DRIFT BY EQUIVALENT STATIC ANALYSIS ALONG X- DIRECTION

In table 4 the Storey Drift of Conventional Slab, Flat Slab and Grid Slab along x- direction is shown.

Table 4 Storey Drift By Equivalent Static Analysis Along X- Direction

Storey No	Conventional Slab	Flat Slab	Grid Slab
0	0	0	0
1	0.000181	0.000129	0.000188
2	0.000398	0.000297	0.000387
3	0.000496	0.000385	0.000463
4	0.000538	0.000428	0.00049
5	0.000552	0.000446	0.000495
6	0.000548	0.000448	0.000489
7	0.000534	0.000439	0.000475
8	0.00051	0.000422	0.000454
9	0.000477	0.000398	0.000426
10	0.000436	0.000366	0.00039
11	0.000386	0.000327	0.000346
12	0.000327	0.000283	0.000294
13	0.000262	0.000234	0.000235
14	0.000195	0.000185	0.000171
15	0.000138	0.000144	0.000115

Fig 10 Storey Drift By Equivalent Static Analysis Along X- Direction

In Figure 10 the graph is drawn for number of storey's in x axis and EQX in y axis. The graph shows that the grid slab has highest storey drift and conventional slab has lowest storey drift along x- direction.

3.3.2 STOREY DRIFT BY EQUIVALENT STATIC ANALYSIS ALONG Y- DIRECTION

In table 5 the Time period of Conventional Slab structure, Flat Slab structure and Grid Slab structure is given

Table 5 Storey Drift By Equivalent Static Analysis Along Y- Direction

Storey No	Conventional Slab	Flat Slab	Grid Slab
0	0	0	0
1	0.000178	0.000127	0.00067
2	0.000385	0.000288	0.001375
3	0.000476	0.00037	0.001648
4	0.000514	0.000409	0.001745
5	0.000525	0.000425	0.001766
6	0.000522	0.000426	0.001749
7	0.000508	0.000418	0.001703

8	0.000486	0.000402	0.001633
9	0.000457	0.000379	0.001538
10	0.000418	0.00035	0.001415
11	0.000372	0.000314	0.001263
12	0.000316	0.000272	0.001081
13	0.000255	0.000225	0.000872
14	0.000191	0.000178	0.000648
15	0.000136	0.000139	0.000452

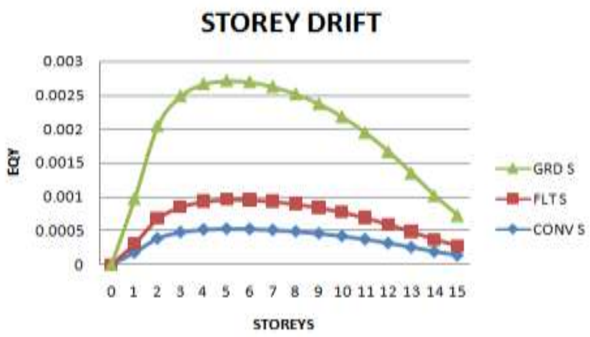

Fig 11 Storey Drift By Equivalent Static Analysis Along Y- Direction

In Figure 11 the graph is drawn for number of storey's in x axis and EQY in y axis. The graph shows that the grid slab has highest storey drift and conventional slab has lowest storey drift along y- direction.

3.3 STOREY SHEAR AND BASE SHEAR

3.4.1 STOREY SHEAR BY EQUIVALENT STATIC ANALYSIS ALONG X- DIRECTION

In the table 6 the Storey shear of Conventional slab, Flat slab and Grid slab along x- direction is shown

Table 6 Storey Shear By Equivalent Static Analysis Along X- Direction

STOREY NO	CONVENTIONAL SLAB	FLAT SLAB	GRID SLAB
1	1187.31	747.4	1558.126
2	1186.28	746.79	1556.79
3	1182.16	744.32	1551.44
4	1172.89	738.78	1539.42
5	1156.41	728.91	1518.049
6	1130.66	713.51	1484.65
7	1093.58	691.32	1436.56
8	1043.11	661.11	1371.1
9	977.19	621.67	1285.6
10	893.75	571.74	1177.4
11	790.75	510.11	1043.81
12	666.12	435.53	882.17
13	517.79	346.77	689.8
14	343.72	242.61	464.04
15	141.83	121.8	202.2

Fig 12 Storey Shear By Equivalent Static Analysis Along X- Direction

In Figure 13 the graph is drawn for number of storey's in x axis and EQX in y axis. The graph shows that the grid slab has highest storey shear and conventional slab has lowest storey drift along x- direction.

3.4.2 Storey Shear by Equivalent Static Analysis along Y- Direction

In the table 7 the Storey shear of Conventional slab, Flat slab and Grid slab along x- direction is shown.

Table 7 Storey Shear By Equivalent Static Analysis Along Y- Direction

Storey No	Conventional Slab	Flat Slab	Grid Slab
1	1240.79	780.69	5637.12
2	1239.71	780.04	5632.29
3	1235.4	777.47	5612.95
4	1225.72	771.67	5569.46
5	1208.49	761.37	5492.13
6	1181.58	745.28	5371.307
7	1142.83	722.1	5197.31
8	1090.09	690.55	4960.49

9	1021.2	649.35	4651.18
10	934.01	597.2	4259.7
11	826.36	532.82	3776.39
12	696.12	454.92	3191.6
13	541.11	362.21	2495.64
14	359.2	253.41	1678.85
15	148.22	127.22	731.57

Fig 13 Storey Shear By Equivalent Static Analysis Along Y- Direction

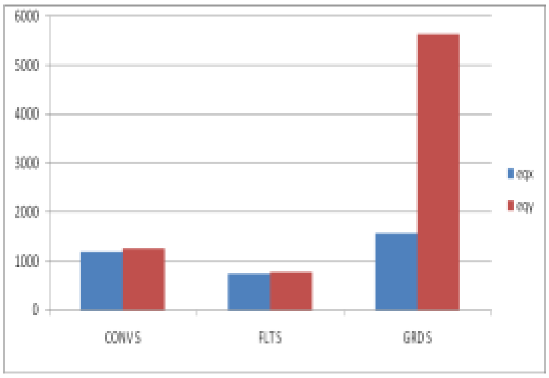

Fig 14 Base Shear By Equivalent Static Analysis

In Figure 14 the graph shows that the grid slab has highest base shear and flat slab has lowest storey drift along x and y- direction.

4. CONCLUSIONS

This chapter represents the summary of the study, for Conventional slab, Flat slab and Grid slab structure. The effect of seismic forces have been analysed and studied. Depending on the work and the conclusion formed during the study are as follows,

1. The storey displacement of conventional slab is 3% higher than the flat slat and grid slab.
2. The Time period of conventional slab is 0.5% higher than flat slab and grid slab.
3. The Storey shear of conventional slab is 0.3% higher than flat slab and 31.6% higher than grid slab.
4. The Storey drift of conventional slab is 10%heigher than flat slab and grid slab.
5. The Base shear of conventional slab is 44% higher than flat slab and 37% higher than grid slab.

4.1 SCOPE FOR FUTURE WORK

1. The earthquake resisting structures like shear wall, base isolation and bracing systems can be used for analysis to increase the effectiveness of the structure.
2. Wind analysis can be carried out for all models to check the stability of the structure.
3. The analysis of the building can be carried out with the development of the shear wall.
4. The building structure taken in this can be taken as rectangular, L-shape, C- shape with eccentricity.
5. The design and analysis of building structures can be done by using Response spectrum method or Time history methods.

REFERENCES

[1] Sandesh D Bothara, Dr. Valsson Varghese (2012), "Dynamic Analysis Of Special Moment Resisting Frame Building With Flat Slab And Grid Slab", International Journal of Engineering Research and Application, Vol. 2, Issue 4, pp.275-280.

[2] Muniraju K.S, Subramanya K.G (2015)," Comparative Study of Seismic Analysis between Conventional RC Frame and Flat Slab with Drop", International Journal for Scientific Research & Development, Vol. 3, Issue 09.

[3] R.S.More, V. S. Sawant, Y. R. Suryawanshi (2015)," Analytical Study of Different Types of Flat Slab Subjected to Dynamic Loading", International Journal of Science and Research (IJSR) , Volume 4 Issue 7.

[4] Archana Shaga, Satyanarayana Polisetty (2016)," Seismic Performance of Flat Slab with drop and Conventional Slab Structure", International Journal of Latest Engineering Research and Applications (IJLERA), Volume 01, Issue 09, PP 79-94.

[5] Chintha Santhosh, Venkatesh Wadki, S.Madan Mohan, S.Sreenatha Reddy (2016), "Analysis and Design of Multi-storey Building with Grid Slab Using E-Tabs", International Journal of Innovative Research in Science, Engineering and Technology, Vol. 5, Issue 9.

[6] Miss. S. N. Utane, Prof. H. B. Dahake (2016)," Effect of Shape Irregularity on Flat slab Industrial Building under Lateral Loading", International Journal of Modern Trends in Engineering and Research (IJMTER), Volume 03, Issue 03.

[7] Navjot Kaur Bhatia, Tuhsar Golait (2016)," Studying the Response of Flat Slabs & Grid Slabs Systems in Conventional RCC Buildings", International Journal of Trend in Research and Development (IJTRD), Volume 3(3).

[8] Virendra P. Patil and Vikram (2016), "Analytical Study on Effective Width of Equivalent Frame Flat Plate Structural System Subjected to Seismic Loads", Bonfring International Journal of Man Machine Interface, Vol. 4, Special Issue.

[9] Vishesh P. Thakkar, Anuj K. Chandiwala, Unnati D. Bhagat (2016)," A Review on Comparative Study of Seismic behaviour of Flat slab and Conventional RC Framed Structure", International Journal of Advance Engineering and Research Development, Volume 3, Issue 12.

[10] Abhijit Salunkhe, S.B.Mohite (2017), "A Comparative Study of Seismic Behaviour of Flat Slab Structure and Conventional Framed Structure ", International Journal of Research and Scientific Innovation (IJRSI) | Volume V, Issue I, Page 132.

[11] Ch.Rajkumar, Dr.D.Venkateswarlu (2017)," Analysis and Design of Multi-storey Building with Grid Slab Using ETABS", International Journal of Professional Engineering Studies, Volume VIII, Issue 5.

[12] Md Abdul Muntaqim, Noor Mohammed and Syed Farrukh Anwar (2017), "Seismic Performance on Flat Slabs and Beam Slab in Multi Storey Building", Global Journal of Engineering Science and Researches.

[13] Sohan Lal (2018), "Comparison between Flat and Conventional Slab of High Rise Buildings with Varying Geometry under Seismic Loading Condition", Journal of Structural Technology, Volume 3, Issue 1.