Comparative Study of Multistory Building of Flat Slab and Grid Slab System with Conventional Slab SysteM

Mohammadbhai Sadikbhai Khanushiya[1] Arjun M. Butala[2]

[1]M. Tech Student, Department of Civil Engineering, U.V. Patel College of Engineering, Gujarat, India
[2]Assistant Professor, Department of Civil Engineering, U.V. Patel College of Engineering, Gujarat, India

---

Abstract - *The demand of beam-less and column-free space structures has been increasing globally in recent years; to fulfill such an increasing demand, Flat and Grid slabs system might be used. This Comparative study is administered for Flat slab system with drop panel, Flat slab system without drop panel, Flat Slab without drop panel with periphery beam, Flat Slab with drop panel with periphery beam, Grid slab system with symmetric grid beam, Grid slab system with Asymmetric grid beam and Conventional slab system. In this study, analysis of slab system for G + 7 building for seismic zone III and having medium soil condition by using ETABS. In a present study the analysis is carried out for Flat slab system with drop panel, Flat slab system without drop panel, Flat Slab without drop panel with periphery beam, Flat Slab with drop panel with periphery beam, Grid slab system with symmetric grid beam, Grid slab system with Asymmetric grid beam and Conventional slab system as per IS-1893:2016. During this comparative study the comparison of various parameter such as, Story displacements, Story Drift, Base shear, Time period and Dead load are carried out. This study is carried out to find the most suitable slab system between Flat slab, Grid slab and conventional slab system.*

Key Words: **ETABS, Story Displacements, Story Drift, Base shear, Time period, Dead load.**

1. INTRODUCTION

A slab is a structural element, made of concrete, that is used to create flat horizontal surfaces such as floors, roof decks and ceilings. A slab is generally several inches thick and supported by beams, columns, walls, or the ground.

Some types of slab system are explained below:

1.1 Flat Slab System

The term flat slab means a reinforced concrete slab with or without drops, supported generally without beams, by columns with or without flared heads. Flat slabs are beam less structures which are very usable in these days, in flat slab structure we are only adding panels on the top of the columns and increasing the thickness of the slab, structures with flat slabs are more usable because of decreasing floor to floor height of the structure, low amount is required to be constructed and for other reasons as architectural requirements.

Types of Flat slab system:

1 Flat slab without drop panel
2 Flat slab with drop panel
3 Flat slab with periphery beam with drop panel
4 Flat slab with periphery beam without drop panel

1.2 Grid Slab System

Grid floor systems is a conventional method of construction in which beams are spaced at regular intervals in perpendicular directions and monolithic with slab. They are generally employed for architectural reasons for large rooms such as auditoriums, vestibules, theatre halls, show rooms of shops where column free space is required. Often the main requirement. The rectangular or square void formed in the ceiling is advantageously utilized for concealed architectural lighting. The sizes of the beams running in perpendicular directions are generally kept the same.

The grid slab system is used in the areas where less number of column are provided, i.e. it is basically used in the areas which has huge spaces. This type of slab is used in airports, parking garages, commercial and industrial buildings, residencies and other structures requiring extra stability.

1.3 Conventional Slab System

The slab which is rested on Beams and columns is called a conventional slab. In this kind, the thickness of the slab is small whereas the depth of the beam is large and load is transferred to beams and then to columns. It requires more formwork when compared with the flat slab. In the conventional type of slab there is no need for providing column caps. The thickness of conventional slab is 4″ or 10cm. 5″ to 6″ inches is recommended if the concrete will receive occasional heavy loads, such as motor homes or garbage trucks.

A conventional slab is classified as either:

1 **One-way slab:** Supported by beams on two opposite sides, carrying the load along one direction.
2 **Two-way slab:** Supported by beams on all four sides, carrying the load along both directions.

2. LITRETURE REVIEW

Amit A. Sathwane studied that the among flat slab, flat slab with drop and grid slab which is economical for the nexus point opposite to vidhan bhavan and beside NMC office. The analysis of flat slab, flat slab without drop and grid slab done both manually by IS 456-2000 and by STAAD PRO V8i. It is found in the study that flat slab with drop is economical then rest of other considered slab for the nexus point. It is also revealed in the study that concrete required for grid slab is more than the flat slab with and without drop and steel required for the flat slab without drop is more than the flat slab with drop and grid slab.

D. Ramya et all,. (October 2015) analyzed the multi-story (G+10) building by both STAAD PRO V8i and ETABS software. In the study comparison between these two software is done to find out which give economy of multi storied (G+10) building. It is show that in the study STAAD PRO is much simple to work with as compare to ETABS software. It is also show that quantity of steel given by the ETABS is 9.25% less than by STAAD Pro when analyzed G+10 multistory building. The quantity of concrete show by both the software's is found same for multistory building. In the study it is revealed that the most economical section given by ETABS.

Mohana, et.al (2015) "Comparative Study of Flat Slab and Conventional Slab Structure Using ETABS for Different Earthquake Zones of India", analyzed a G+5 commercial multistoried building having flat slab and conventional slab for the parameters like base shear, story drift, axial force, and displacement. The performance and behavior of both the structures in all seismic zones of India has been studied. The story shear of flat slab is 5% more than conventional slab structure, the axial forces on flat slab building is nearly 6% more than conventional building, the difference in story displacement of flat and conventional building are approximately 4mm in each floor. The work provides reasonable information about the suitability of flat slab for various seismic zones without compromising the performance over the conventional slab structures.

3. METHODOLOGY

A RCC structure is primarily composed of beams, columns, slabs and foundation and this whole system behave as a one unit and transfer load finally to the footing. Normally the flow of load in the building is from slab to beam, beam to column and finally to footing. In the current study we have taken different type of floors for different grid size and for this purpose we have utilized the ETABS software. The different types of floors taken are conventional slab, flat slab, and grid slab having same elevation.

3.1 Analysis of structural system

ETABS software is used for the analysis of the proposed structural model. The models are analyzed by dynamic analysis method that is only response spectrum method for zone III and Soil type II (medium or stiff soil). Considering the method of analysis used for the model the lateral load calculation is made by the software itself and then this calculation are applied to carry out analysis of these models. In the present study the structure is subjected to lateral loads and analysis is carried out by using the Response spectrum method of the structure.

3.2 Response Spectrum Method

The representation of maximum response of idealized multi degree of freedom (MDOF) system expressed in terms of superposition of modal response and each model being determined to single degree of freedom during earthquake ground motion. The undammed natural period for various damping values for maximum response is plotted which is expressed as maximum acceleration value and maximum relative velocity to maximum relative displacement. For this case response spectrum analysis has been performed according to IS 1893 (part 1):2016. The behavior of flexible structures by dynamic analysis is studied. Static analysis is carried out in which inertia forces can be neglected. But if there is any change in dynamic load, the response with the help of dynamic analysis must be determined in which the inertial force cannot be neglected and is equal to mass time of acceleration (Newton's 2nd law) F=M X a Where F is inertial force, M is inertial mass and a is acceleration.

4. MODELING

G+7 story building is taken and designed and analysis is done for both Gravity (D.L and L.L) and lateral (earth quake) loads. The models are analyzed by dynamic analysis method that is response spectrum method for zone III. As categorized by Indian Standard Code 1893:2016 for earthquake resistant structures. In the present study the structure is subjected to lateral loads and analysis is carried out by using the Response spectrum method of the structure.

TYPE – 1: Conventional slab 5 m X 5 m

TYPE – 2: Grid Slab with symmetric grid beam 5 m X 5 m

TYPE – 3: Grid Slab with asymmetric grid beam 5 m X 5 m

TYPE – 4: Flat slab without drop panel 5 m X 5 m

TYPE – 5: Flat slab with drop panel 5 m X 5 m

TYPE – 6: Flat slab with periphery beam without drop panel 5 m X 5 m

TYPE – 7: Flat slab with periphery beam with drop panel 5 m X 5 m

4.1 Methodology:

1 The Buildings are assumed to be in Zone-III.
2 Analysis of Floors using ETABS 2017.
3 The buildings are being designed as per IS 456:2000 & IS 1893:2016.

4.2 Description of structure

Table 1: - Geometrical data of G+7 Symmetric structures

SR.NO.	VARIABLE	DATA
1	Number of stories	8
2	Number of bays in X-direction	6
3	Number of bays in Y-direction	6
4	Bay length in X direction	5 m
5	Bay length in X direction	5 m
6	Height of the floor	3 m
7	Total height of building	29 m

Table 2 - Material properties for G+7 Symmetric structures

SR.NO.	MATERIAL PROPERTIES	DATA
1	Concrete grade of column	M30
2	Concrete grade of beam	M25
3	Concrete grade of slab	M25
4	Grade of steel	Fe 500
5	Density of concrete	25 kN/m^3

Table 3: - Section properties for G+7 Symmetric structures

SR.NO.	SECTION PROPERTIES	1	2	3	4	5	6	7
1	Size of column	500 X 500 mm	600 X 600 mm	600 X 600 mm	580 X 580 mm	550 X 550 mm	600 X 600 mm	550 X 550 mm
2	Size of beam	320 X 460 mm	320 X 460 mm	300 X 420	-	-	400 X 550 mm	300 X 440 mm
3	Size of grid beam	-	100 X 150 mm	100 X 150 mm	-	-	-	-
4	Drop thickness	-	-	-	-	250 mm	-	250 mm
5	Slab thickness	150 mm	120 mm	120 mm	200 mm	200 mm	200 mm	200 mm
6	Panel size	5 X 5 m	5 X 5 m	5 X 5 m	5 X 5 m	5 X 5 m	5 X 5 m	5 X 5 m

Table 4: - Gravity Loads for G+7 Symmetric structures

SR..NO.	GRAVITY LOADS	DATA
1	Dead load	Default taken by ETABS
2	Live load	2.5 kN/m^2
3	Floor finish load	1.2 kN/m^2
4	Wall load(External)	14.84 kN/m^2
5	Wall load(Internal)	8.28 kN/m^2

Table 5 - Seismic Loads for G+7 Symmetric structures

SR..NO.	SEISMIC LOADS	Conventional Slab DATA
1	Seismic Zone Factor, Z	0.16
2	Importance Factor	1
3	Response Reduction Factor	5

4.3 ETABS Models

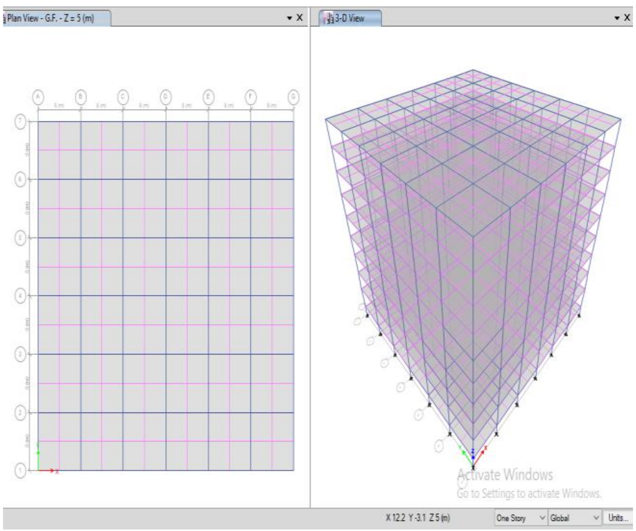

Fig -1: G+7 Symmetric Conventional Slab Model in ETABS

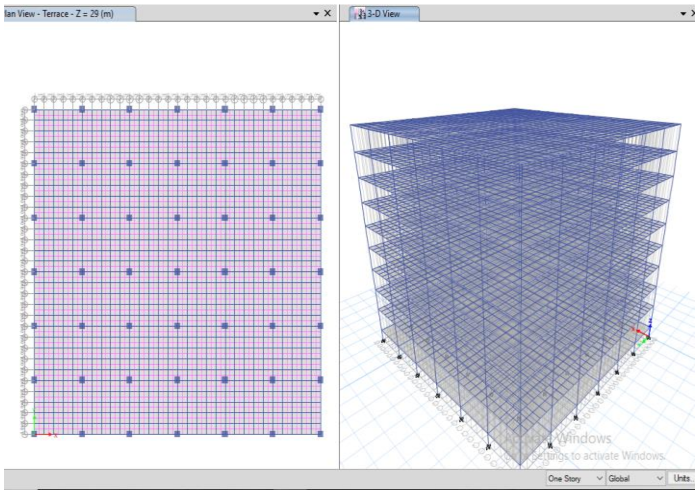

Fig -2: G+7 Grid Slab with symmetric grid beam Model in ETABS

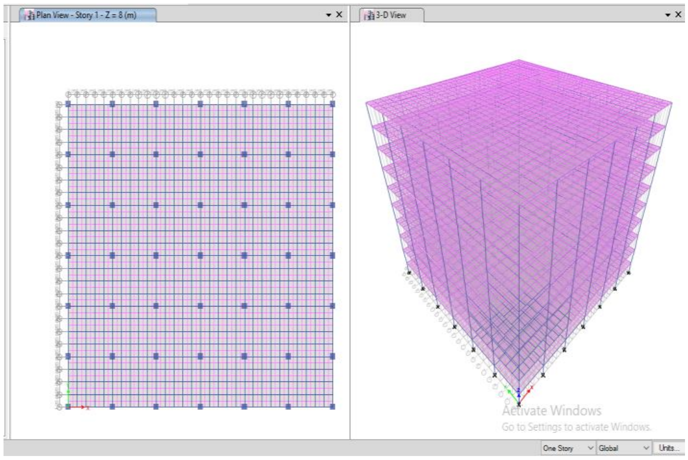

Fig.3: G+7 Symmetric Grid Slab with asymmetric grid beam Model in ETABS

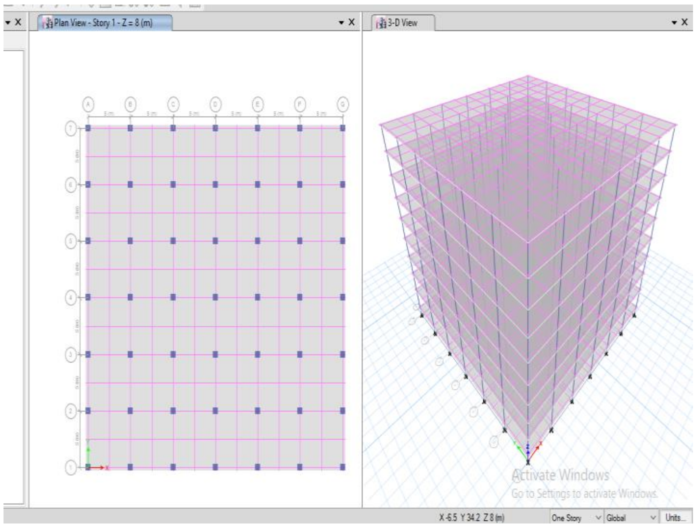

Fig.4: G+7 Symmetric Flat Slab without drop panel Model in ETABS

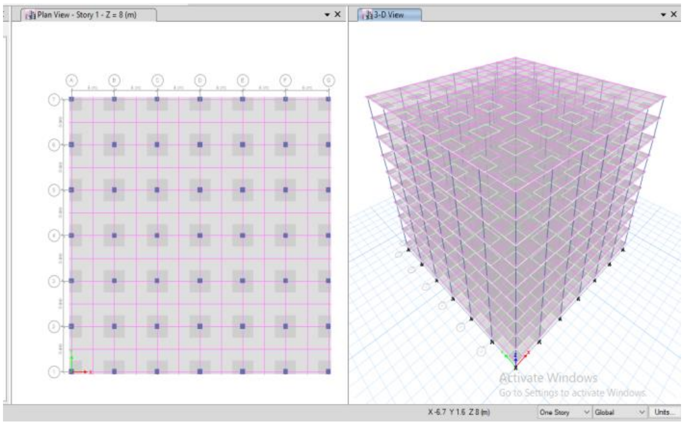

Fig. 5: G+7 Symmetric Flat Slab with drop panel Model in ETABS

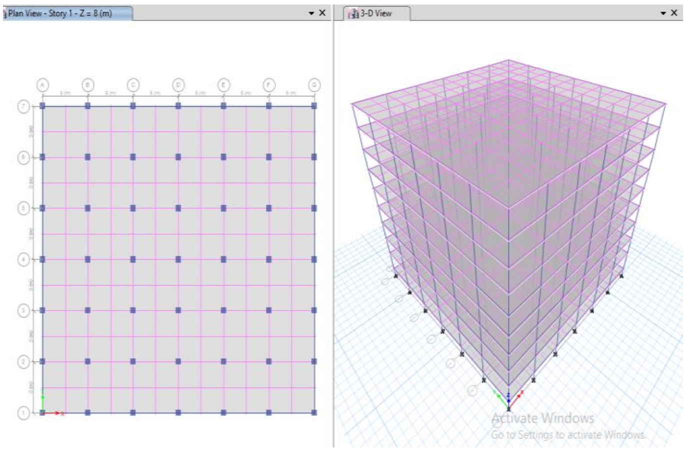

Fig. 6: G+7 Symmetric Flat Slab with periphery Beam without drop panel Model in ETABS

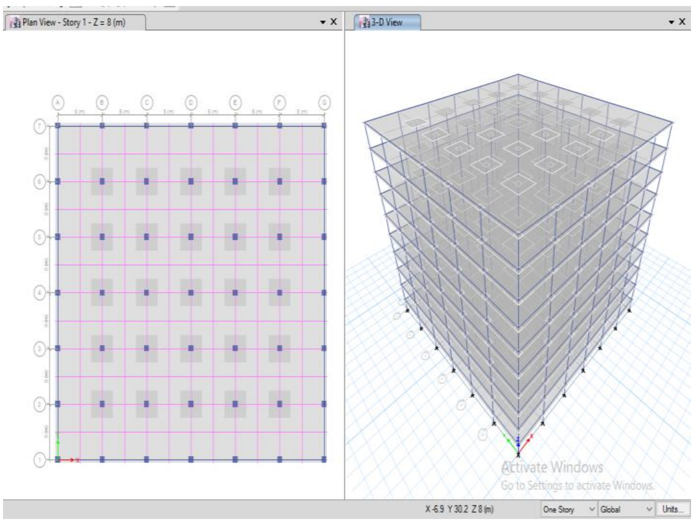

Fig. 7: G+7 Symmetric Flat Slab with periphery Beam with drop panel Model in ETABS

5. RESULTS

5.1 Story Displacement

Table 6 – G+7 Symmetric models Story Displacement in X & Y Direction

DISPLACEMENT (MM)							
STORY	**Type 1**	**Type 2**	**Type 3**	**Type 4**	**Type 5**	**Type 6**	**Type 7**
Base	0	0	0	0	0	0	0
Plinth lvl	4	1	1	1	1	1	1
G.F.	14	5	5	8	6	5	4
Story1	21	11	11	16	12	10	8
Story2	27	16	16	24	18	15	11
Story3	32	21	21	32	23	19	14
Story4	37	25	26	39	28	23	16
Story5	41	29	30	45	32	26	18
Story6	45	32	33	50	35	28	20
Story7	47	34	35	54	37	30	21
Terrace	48	35	37	56	38	31	22

Note: Here due to square Geometry the result in both X & Y directions are same.

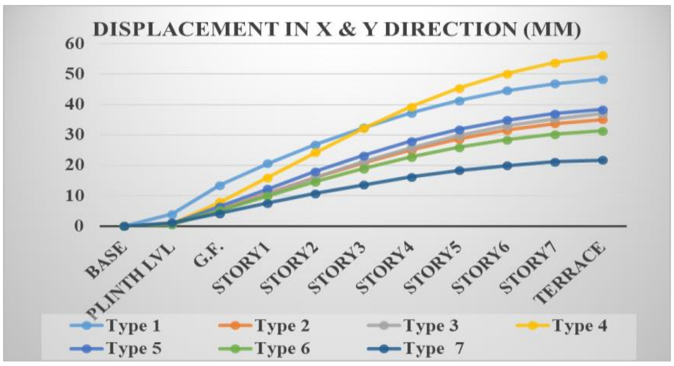

Fig. 8: G+7 Symmetric models Story Displacement Graph in X & Y direction

Table 7 – G+7 Symmetric models Story Drift in X & Y Direction

STORY DRIFT							
STORY	**Type 1**	**Type 2**	**Type 3**	**Type 4**	**Type 5**	**Type 6**	**Type 7**
Base	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Plinth	0.003	0.000	0.001	0.001	0.001	0.000	0.001
G.F.	0.003	0.001	0.001	0.002	0.002	0.001	0.001
Story1	0.002	0.002	0.002	0.003	0.002	0.002	0.001
Story2	0.002	0.002	0.002	0.003	0.002	0.002	0.001
Story3	0.002	0.002	0.002	0.003	0.002	0.001	0.001
Story4	0.002	0.001	0.002	0.002	0.002	0.001	0.001
Story5	0.002	0.001	0.001	0.002	0.001	0.001	0.001
Story6	0.001	0.001	0.001	0.002	0.001	0.001	0.001
Story7	0.001	0.001	0.001	0.001	0.001	0.001	0.000
Terrace	0.001	0.001	0.001	0.001	0.000	0.000	0.000

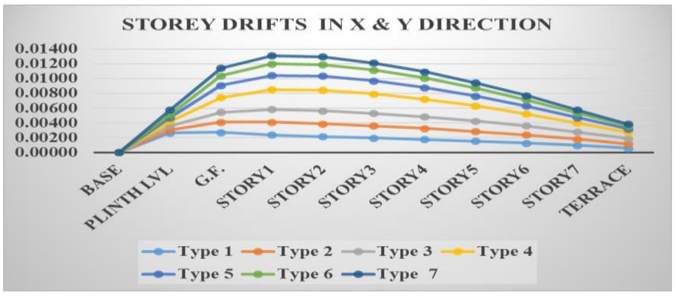

Fig. 9: G+7 Symmetric models Story Drift Graph in X & Y direction

Table 8 – G+7 Symmetric models Base shear in X & Y Direction

BASE SHEAR							
STORY	**Type 1**	**Type 2**	**Type 3**	**Type 4**	**Type 5**	**Type 6**	**Type 7**
Plinth	2839	2318	2030	2348	2443	2728	2578
G.F.	2773	2302	2003	2340	2433	2717	2551
Story1	2589	2180	1888	2271	2354	2629	2459
Story2	2390	2019	1740	2147	2216	2476	2308
Story3	2188	1846	1589	1970	2024	2262	2103
Story4	1983	1668	1443	1742	1783	1993	1849
Story5	1753	1478	1296	1469	1498	1674	1550
Story6	1462	1244	1110	1153	1171	1309	1210
Story7	1086	940	859	797	806	900	832
Terrace	586	520	489	401	403	449	414

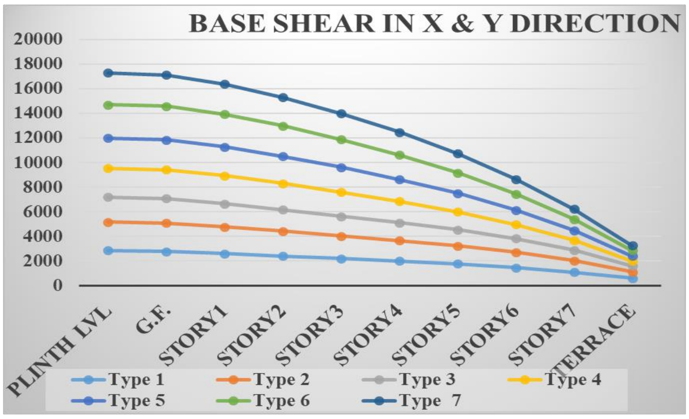

Fig. 10: G+7 Symmetric models Base Shear Graph in X & Y Direction

Table 9 – G+7 Symmetric models Time period Table

TIME PERIOD							
MODE	**Type 1**	**Type 2**	**Type 3**	**Type 4**	**Type 5**	**Type 6**	**Type 7**
1	1.62	1.49	1.61	1.81	1.52	1.36	1.16
2	1.62	1.49	1.60	1.81	1.52	1.36	1.16
3	1.51	1.37	1.47	1.69	1.44	1.05	1.12
4	0.52	0.46	0.50	0.55	0.48	0.43	0.38
5	0.52	0.46	0.49	0.55	0.48	0.43	0.38
6	0.48	0.43	0.45	0.52	0.45	0.34	0.37
7	0.29	0.25	0.26	0.29	0.26	0.24	0.21
8	0.29	0.25	0.26	0.29	0.26	0.24	0.21
9	0.27	0.23	0.24	0.27	0.25	0.19	0.21
10	0.19	0.15	0.16	0.18	0.17	0.15	0.15
11	0.19	0.15	0.16	0.18	0.17	0.15	0.14
12	0.17	0.14	0.15	0.16	0.16	0.13	0.14

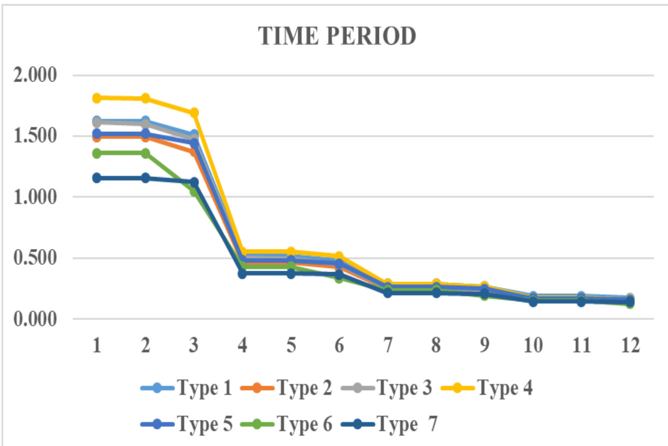

Fig. 11: G+7 Symmetric models Time Period Graph

Table 12– G+7 Symmetric models Dead Load Table

Dead load							
DATA	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6	Type 7
Column	8879	12785	12785	11947	10743	12785	12179
Beam	13906	18455	15720	0	0	8314	3523
Floor	33740	26992	26992	46804	46804	45891	46804
Drop	0	0	0	0	15206	0	9763
Total load (kN)	56525	58232	55497	58751	72753	66990	72269

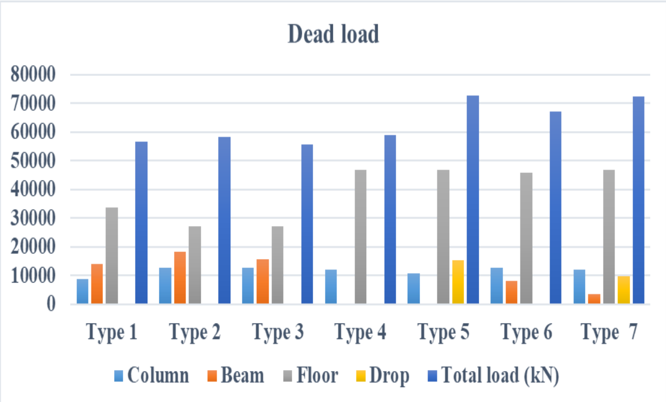

Fig. 11: G+7 Symmetric models Dead Load Graph

6. CONCLUSIONS

- The maximum displacement is found to be maximum for Flat slab system without drop panel for same plan area of the structure and it is followed by conventional slab system, flat slab system with drop panel, Grid slab with asymmetric grid beam, grid slab with symmetric grid beam, Flat slab with periphery beam without drop panel and minimum for Flat slab with periphery beam with drop panel in all direction of the structure.

- The maximum drift is found to be maximum for Flat slab system without drop panel for same plan area of the structure and it is followed by conventional slab system, flat slab system with drop panel, Grid slab with asymmetric grid beam, grid slab with symmetric grid beam, Flat slab with periphery beam without drop panel and minimum for Flat slab with periphery beam with drop panel in all direction of the structure.

- The maximum Base shear is found to be maximum for Conventional slab system for same plan area of the structure and it is followed by, Flat slab with periphery beam without drop panel, Flat slab with periphery beam with drop panel, flat slab system with drop panel, Flat slab system without drop panel, Grid slab with symmetric grid beam, and minimum for Grid slab with asymmetric grid beam in all direction of the structure.

- The maximum Time period is found to be maximum for Flat slab system without drop panel for same plan area of the structure and it is followed by conventional slab system, Grid slab with asymmetric grid beam, Flat slab system with drop panel, Grid slab with symmetric grid beam, Flat slab with periphery beam without drop panel and minimum for Flat slab with periphery beam with drop panel in all direction of the structure.

- The maximum Dead load is found to be maximum for Flat slab system with drop panel for same plan area of the structure and it is followed by Flat slab with periphery beam with drop panel, Flat slab with periphery beam without drop panel, Flat slab system without drop panel, Grid slab with symmetric grid beam, Grid slab with asymmetric grid beam and minimum for conventional slab system in all direction of the structure.

REFERENCES

[1] H.J Shah "Reinforced concrete Vol. II" Advanced reinforced concrete, pp 26-62.
[2] Plain & Reinforced Concrete Code of Practice" Fourth Revision IS: 456:2000.
[3] IS 1893-2016: Indian Standard Code of Practice for Criteria for Earthquake Resistance Design of Structures.
[4] K.N. Mate, Volume 4 Issue 6, June 2015 Study of Flat Slab, International journal of science and research (IJSR), pp.1106-1110.
[5] Techi Tata, Volume 03 Issue 09, Sep-2016 Study of Behaviors of Building with Flat Slab, International Research Journal of Engineering and Technology (IRJET), pp.1333-1339.
[6] Mohana H.S, Volume 02 Issue 03, June-2015 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). pp.1931 – 1936.
[7] Navjot Kaur Bhatia, Volume 3 May 2016 Studying the Response of Flat Slab & Grid Slabs System in Conventional RCC Buildings, International Journal of Trends in Research and Development (IJTRD), pp.335 - 337.
[8] Navyashree K, Sahana T. S (2014), Use of flat slabs in multi-story commercial building situated in high seismic zone, IJRET: International Journal of Research in Engineering and Technology,
Volume: 03 Issue: 08 / Aug 2014.