International Journal of Scientific Research in Civil Engineering
© 2019 IJSRCE | Volume 3 | Issue 6 | ISSN : 2456-6667

Seismic Analysis of a Tall Structure Considering Flat and Grid Slab Diaphragm Using Analysis Tool Staad. Pro

Paritosh Singh[1], Rajesh Joshi[2]
P.G. Scholar[1], Asst. Prof. & H.O.D.[2]
Department of Civil Engineering, R.G.P.M. Bhopal, Madhya Pradesh, India

ABSTRACT

Modern slab systems have shown great potentials in the field of conventional slab casting. Recent advances in the field of RCC Design are related to the use of Flat Slabs and Grid Floors. Flat slabs are versatile elements which are widely adopted in construction providing quick construction, minimum depth, and allowing flexible column grids. In flat slabs, the beams used in conventional slabs are taken away and the slab is made to rest directly over the columns. In case of higher loads, a drop panel or a column head may be provided to reduce the intensity of loads. They are particularly appropriate for areas where tops of partitions need to be sealed to the slab soffit for acoustic or fire reasons. On the other hand, grid floor systems consist of a large number of beams spaced at regular intervals in perpendicular directions, monolithic with slab. The rectangular or square void thus formed in the ceiling is advantageously utilized for works such as providing concealed architectural lighting. Grid floors are generally employed for architectural reasons in case of large rooms such as theatre halls, auditoriums, vestibules, and show rooms of shops where column free space is the main requirement. This study focuses on studying the behavior of conventional slab, flat slab and grid slab separately. A comparative study was done to identify the best slab system. The modeling was done in Staad.pro in which square, hexagonal and octagonal geometries were considered for the structures. The models were also developed for different number of floors taking 10, 20 and 30 storey structure designs. Seismic loadings were considered separately to evaluate the performance of all the 27 models and conclusions were drawn on the best framing system. In this structure cost analysis of all these structures are also considered.

Keywords :- Flat Slabs, Grid Floors, Monolithic and Staad.Pro, Cost Analysis, Structure.

I. INTRODUCTION

There is an increasing demand for construction of high rise buildings due to urbanization and an ever increasing population. Earthquake is the one of the biggest enemy of such tall structures. These earthquake forces are haphazard in nature & are thus unpredictable. The designers need to acuminate engineering tools for analyzing structures under the action of these seismic forces. Thus a careful modeling of such loads needs to be done, so as to evaluate the behavior of tall structures with a clear perspective of the damage that is to be expected. To analyze the structures for different earthquake intensities and then perform checks for various criteria at each level has become an essential practice for the last couple of decades.

Earthquakes cause varying shaking intensities at different locations and the damages induced in the buildings at these locations are also different. Thus, it is necessary to construct such structures which are earthquake resistant at a particular level of intensity of shaking, and assimilate the effects of earthquake.

Even though same magnitudes of earthquakes are occurring but due to its varying intensity, it results in dissimilar damaging effects for different regions. Hence, it is necessary to study the variations in seismic behavior of multistoried RC framed buildings for different seismic intensities in terms of various responses such as story drift, lateral displacements, and base shear. Hence the seismic behavior of buildings having similar layout needs to be understood under different intensities of earthquake. For determination of seismic responses, it is necessary to carry out seismic analysis of the structure using different available methods.

Flat Slab:

Flat slabs are one-way or two-way systems with thickenings in the slabs at the columns and/or load bearing walls, called 'drop panels'. These Drop panels act as T-beams over the supports, increasing the shear capacity and the stiffness of the floor system under vertical loads, and thus increasing the economical span range. This form of construction has however become less popular in recent years because of the limit on economical spans of about 9.5m for reinforced slabs and about 12m for prestressed slabs. Reinforced flat slabs may need to be sensibly pre-cambered to control deflection. The plan dimensions of the drop panels are a minimum of 1/3 of the span in the direction under consideration, rounded to the nearest 100 mm. The overall depth of the drop panel is generally taken as 1.75 to 2 times the depth of the slab, rounded to suit timber sizes or the nearest 25 mm.

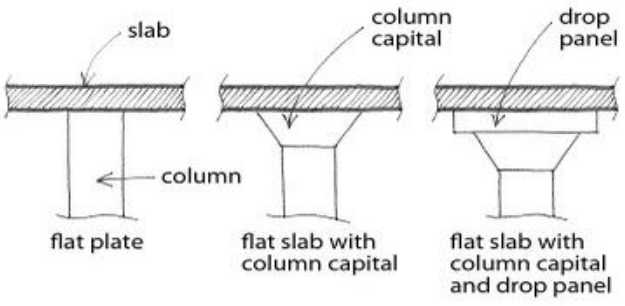


Fig 1 : Flat Slab

Grid Slab:

An assembly of intersecting beams placed at regular interval and interconnected to a slab of nominal thickness is known as Grid floor or Waffle floor. These slabs are used to cover a large column free area and therefore are good choice for public assembly halls. The structure is monolithic in nature and has more stiffness. It gives pleasing appearance. The maintenance cost of these floors is less. However, construction of the grid slabs is cost prohibitive. By investigating various parameters the cost effective solution can be found for the grid slabs, for which proper method of analysis need to be used. There are various approaches available for analyzing the grid slab system.

Fig. 2 - Grid Slabs

Objectives of the Study-

1) To perform dynamic analysis of multistoried RCC buildings with Flat slab & Grid slab (10, 20, 30 Storey) having Square, Hexagonal, Orthogonal geometry, using Response Spectrum Analysis, considering earthquake Zone II as per the Indian Standard code of practice IS 1893-2002 part-I: Criteria for Earthquake resistant structure.
2) To model different structures with aforementioned configuration and compare them using design aids like SAP2000.pro.
3) To compare seismic behavior of multistoried RCC building with Flat slab & Grid slab for different earthquake intensities in terms of

various responses such as, Beam Shear, Beam Moments and Maximum Nodal Deflection.

4) To find the relationship between earthquake intensities and responses.

II. LITERATURE REVIEW

Kaulkhere & Shete (2017) [16] Flat slabs are now a days becoming more popular and they are economical as compared to beam-column connections. RC frame buildings are commonly used for the construction. The use of flat slab building provides many advantages over RC frame building in terms of architectural tractability, use of the space, easier formwork under earthquake loads. In the present work flat slab building of G+8 storey building models are considered. The design of flat slab building with direct design method and also we have discussed the results obtained by performing Non-linear pushover analysis on flat slab building of various shapes and different types also by using software ETAB2015. To improve performance of building,it is necessary to analysis the seismic behaviour of building, provision of flat slab with drop and without drop on the performance of these two types of buildings. As per IS 456:2000 codes provisions present work gives the information on the parameters max strip moments, base shear, max storey displacement and storey drift.

Bhaduria & Chuggani (2017) [11] Structural Engineering is a branch of Civil Engineering where the study is done to know how the structure behave when building is constructed at real environment and to identify the various forces like axial force and shear force, bending moment and displacement etc. acting on the structure. When the analysis come to complex structure or multistory structure the manual calculation will be difficult to perform and hence there is various software available to perform these calculations, this software are STAAD Pro V8i, ANSYS, ETAB, SAP-2000 etc. In this study, slab system design and analysis for G+10 building for seismic zone III and having medium soil condition by using STAAD Pro V8i and these slab system analyzed for different plan area or grid size/ spacing of the column. The analysis and design of slab system is done as per IS 456-2000 and IS 1983-2002. Design of the slab system is done for different spacing/ grid size of column to find out which grid size of the column or plan area which slab is economical.

Patel &Padamwar (2017) [4] Modern slab systems have showed potentials for improvement in the conventional techniques of slab casting. Recent advances in the field of RCC Design are linked to the use of Flat Slabs and Grid Floors. Flat Slabs are highly versatile elements widely used in construction, providing minimum depth, fast construction and allowing flexible column grids. In flat slabs, the beams used in conventional slabs are done away and the slab is made to rest directly over the columns. In case of higher loads, a drop panel or a column head is provided to reduce the intensity of loads. Flat slabs are particularly appropriate for areas where tops of partitions need to be sealed to the slab soffit for acoustic or fire reasons. Grid floor systems consist of beams spaced at regular intervals in perpendicular directions, monolithic with slab. The rectangular or square void formed in the ceiling is advantageously utilized for concealed architectural lighting. 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 often the main requirement. This work focuses on studying the behavior of conventional slab, flat slab and grid slab separately. A comparative study was done to identify the best slab system.

Harish et. al. (2017) [7] Grid floor/Ribbed floor slab consists of beams spaced at regular intervals in perpendicular directions which are monolithic with slab. These slabs are generally used for architectural purpose for large spans such as public assembly halls, auditoriums; show rooms were the slab has to cover a large column free space is required. Since gird slab offers more stiffness the rectangular voided pattern is

used in present study. In the present study G+4 building is considered, analyzed and designed for both gravity, seismic and wind loading conditions as per IS codes. The structure is analyzed using ETABS software and design has been done manually. Analysis with respect to seismic activity majorly involves Equivalent method and Response spectrum method.

Srinu & Kumar (2018) [17] An endeavour has been made to evaluate the two way rectangular orthotropic slab with interior Enclose opening with one short boundary intermittent slab using yield line theory. Keeping in view the basic principles of yield line theory, all possible yield line patterns are considered for the given configurations of the slab subjected to uniformly distributed load (udl). A computer program has been developed to solve the virtual work equations derived in this paper. Relevant tables and charts for given data and the governing admissible failure patterns of the slab for different sizes of openings are presented using the affine theorem. In this paper, the authors also present the transformation of orthotropic slab into an equivalent isotropic slab using the affine theorem. The analysis is carried out with aspect ratio of opening quite different to that the slab.

Summary of Literature Review

- It is clear that the use of flat slab and Grid slab has shown better performances as compared to the conventional two-way slabs.
- However a detailed study is required based on the structural performance of the two slab systems.
- In the past, researchers have done studied the shear behavior of grid and flat slabs extensively.
- But a model study of both these slabs for a particular site, in comparison with a conventional slab, will provide us with the exact figures.
- The present study suggests designing three frames each with conventional, grid and flat slab systems and comparing the structural performances of each.

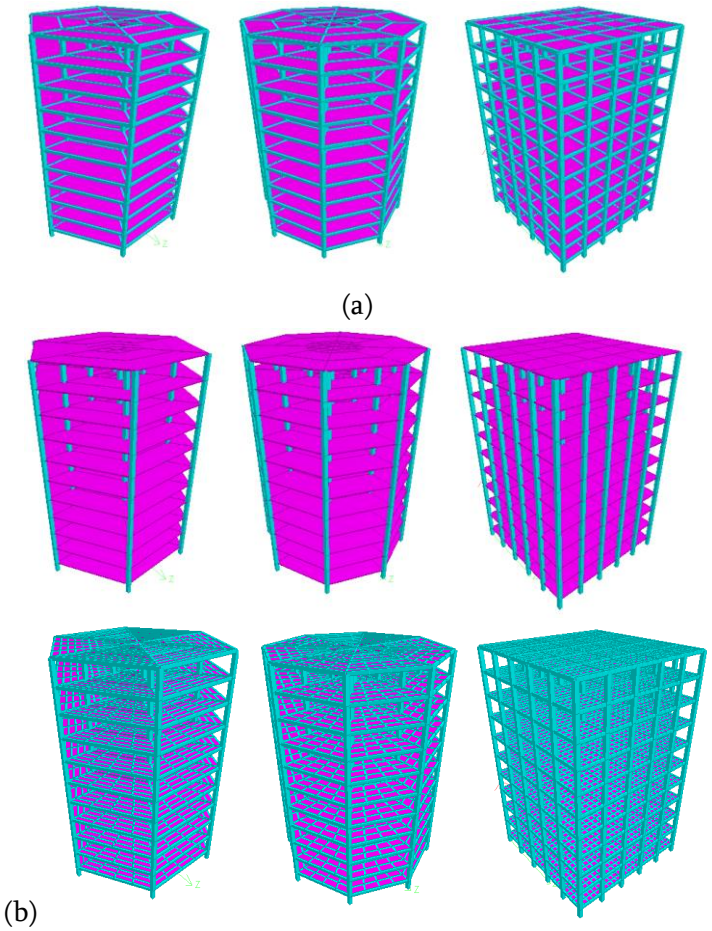
III. METHODS AND MATERIAL

10, 20 and 30 storied structures are displayed utilizing regular chunks, level pieces and matrix sections separately. These structures were given square, hexagon and octagon geometries each. These are then broke down for seismic loadings. Seismic plan was finished utilizing reaction range strategy for quake zone II of India utilizing IS: 1903-2002. Wind investigation was finished by IS: 875-1987 (Part3) however later on it was overlooked as the seismic powers were more noteworthy than wind loads. The subtleties of the displayed building are recorded underneath. Modular damping of 5% is considered with SMRF and Importance Factor (I) =1.

Table 1 : Geometrical details

SN	Specifications	Type of Building Geometry		
		Square	Hexagonal	Octagonal
1	Plan dimensions	25m × 25m (X×Z)	15 m (Radius)	15 m (Radius)
2	Length in X- direction	25 m	30 m	30 m
3	Length in Z- direction	25 m	26 m	30 m
4	Floor to floor height	4.0 m	4.0 m	4.0 m
5	No. of Stories	10, 20 & 30	10, 20 & 30	10, 20 & 30
6	Plinth Level	2 m	2 m	2 m

7	Total height of Building	42, 82 & 122 m	42, 82 & 122 m	42, 82 & 122 m
8	Spacing of Ribs	1 m	1.5 m	1.5 m
9	Size of Ribs	0.3 m x 0.3 m	0.3 m x 0.3 m	0.3 m x 0.3 m
10	Slab Thickness for flat slab	200 mm	200 mm	200 mm
11	Soil Type	Hard	Hard	Hard
12	Grade of concrete	M 25	M 25	M 25
13	Grade of Steel	Fe 415	Fe 415	Fe 415
14	Beam = 10 storey structure	0.5 m x 0.3 m	0.5 m x 0.3 m	0.5 m x 0.3 m
	= 20 storey structure	0.6 m x 0.3 m	0.6 m x 0.3 m	0.6 m x 0.3 m
	= 30 storey structure	0.7 m x 0.3 m	0.7 m x 0.3 m	0.7 m x 0.3 m
15	Column =10 storey structure	0.6 m x 0.6 m	0.6 m x 0.6 m	0.6 m x 0.6 m
	=20 storey structure	0.8 m x 0.8 m	0.8 m x 0.8 m	0.8 m x 0.8 m
	=30 storey structure	1.0 m x 1.0 m	1.0 m x 1.0 m	1.0 m x 1.0 m
16	Location	Seismic Zone II	Seismic Zone II	Seismic Zone II
17	Live Load on Slabs	3 kN/m^2	3 kN/m^2	3 kN/m^2



(a)

(b)

(c)

Fig. 3 : Generated models of Hexagonal, Octagonal and Square Structures (10 storey) with : (a) Conventional, (b) Flat & (c) Grid Floor Systems

IV. RESULTS AND DISCUSSION

Analysis Result:

Deflection in mm

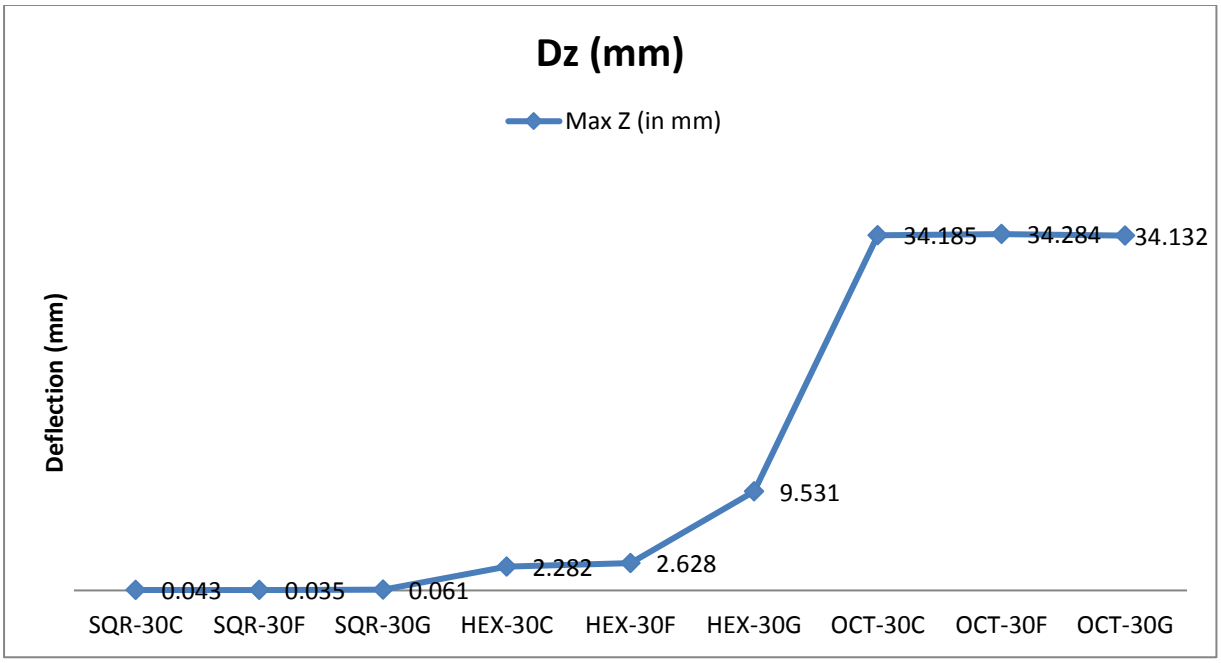


Fig 4 : Deflection

Shear Force kN

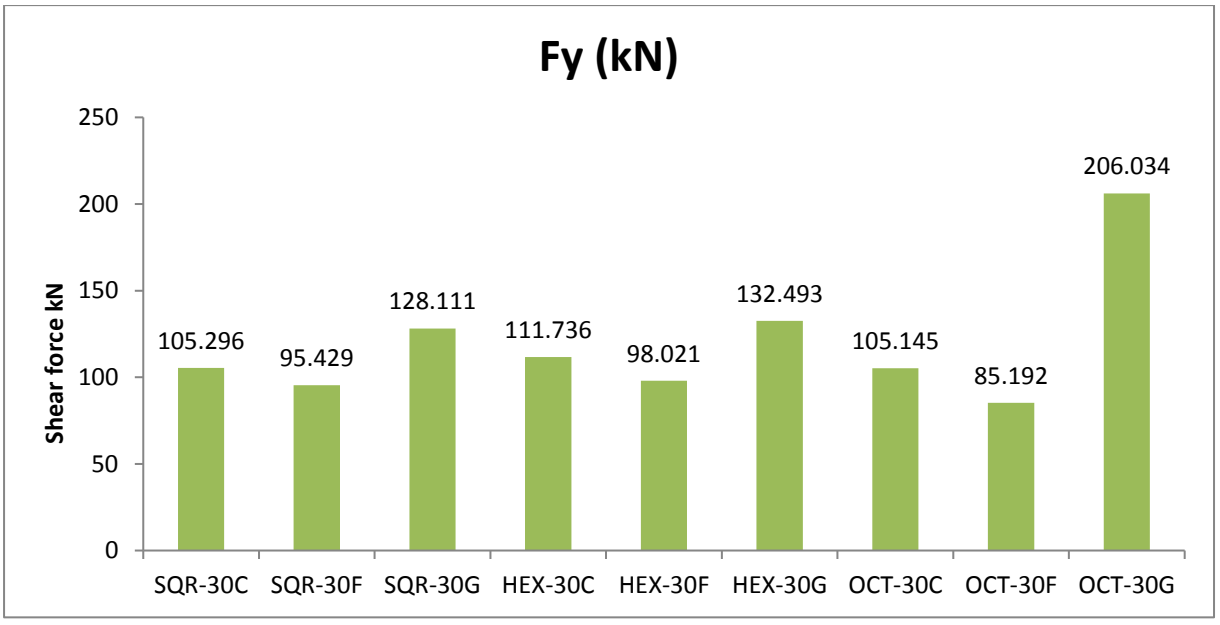


Fig 5 : Shear Force

Axial Force KN

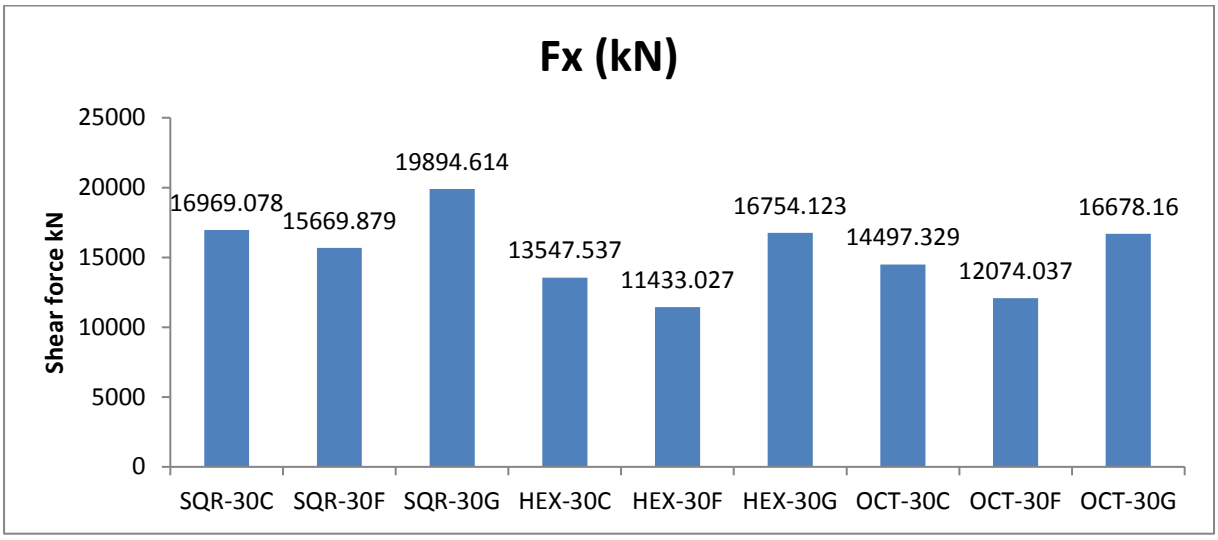


Fig 6 : Axial Force

Bending Moment kN-m

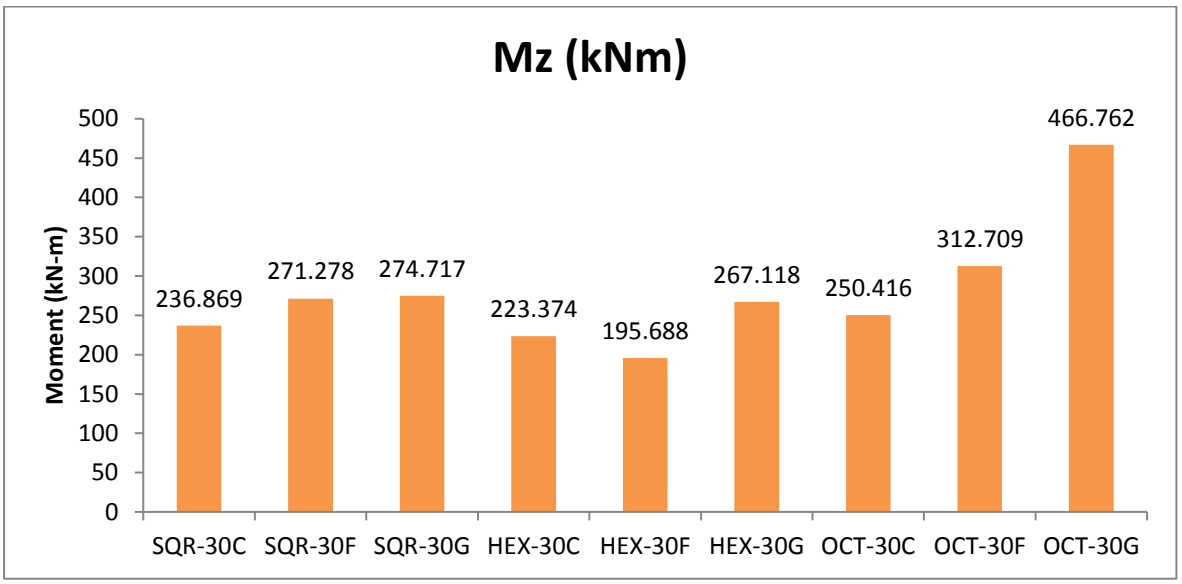


Fig 7 : Bending Moment

V. CONCLUSION

It is obvious to all that the seismic peril must be cautiously assessed before the development of vital and elevated structure structures. In view of the above scientific examination did on 3 structures, the accompanying perceptions are made:

1. In G+10, G+20 and G+30 structure it is observed in above chapter that unbalance forces in X, Y, Z direction in grid slab is comparatively 17.5% approximate higher than conventional type whereas flat slab results in most balanced type. In terms of shapes octagonal flat shape is comparatively the most suitable whereas hexagonal grid shape results in worst result in terms of forces.
2. In terms of moment flat slab observed as the most economical section as in all three different heighted structures flat slab is resulting least moment whereas grid is observed as worst. In terms of shapes square is best whereas octagonal is second best in resisting moment.

3. In terms of deflection it is observed in above chapter deflection is maximum in X direction whereas in comparison flat slab results in most convenient type of structure resulting in most stable structure. In comparison it is resulting in 15% less displacement.

VI. REFERENCES

[1]. Pradeep kumar, Shashank dutt (2016), Analysis of a tall structure considering seismic force under rigid frame structure, Journal of Engineering Research and Application, ISSN : 2248 9622, Vol. 7, Issue 7, (Part 1) July 2016, pp.29 34.

[2]. Rahul Chourasiya, Rashmi Sakalle (2015), Seismic analysis of multi-storey R.C. structure using bracing system and floor diaphragm, International Journal of engineering sciences & research technology, ISSN: 2277-9655.

[3]. Sanjaya Kumar Patro, Sandeep jain (2013), Effect of slab stiffness on seismic response of building structures, Proceedings of The Eight World Conference on Earthquake Engineering, pp. 735-742.

[4]. Avinash patel and seema padamwar, "studying the response of flat slabs & grid slabs systems in conventional rcc buildings", Indian journal scientific research". 14 (2): 516-521, 2017

[5]. T. Öztürk and Z. Öztürk (2008) the effects of the type of slab on structural system in the multi-storey reinforced concrete buildings, World Conference on Earthquake Engineering.

[6]. D.R. Gardiner , D.K. Bull , A.J. Carr, (20018) Trends of Internal Forces in Concrete Floor Diaphragms of Multi-storey Structures During Seismic Shaking , World Conference on Earthquake Engineering.

[7]. Harish M K., Ashwini B T, Chethan V R and Sharath M Y, "Analysis and Design of Grid Slab in Building Using Response Spectrum Method ", "International Journal for Research Trends and Innovation", ISSN: 2456-3315, Volume 2, Issue 6, 2017.

[8]. Joel M. Barron and Mary Beth D. Hueste (2004), Efficient seismic analysis of high-rise building structures with the effects of floor slabs, Engineering Structures, 24(5), pp. 613-623.

[9]. Amit A. Sathawane and R.S. Deotale, "Analysis And Design of Flat Slab And Grid Slab And Their Cost Comparison", "International Journal of Advanced Technology in Civil Engineering", ISSN: 2231 –5721, Volume-1, Issue-2, 2012

[10]. M.D. bari, P.B. Kodag, (2004), "Analysis of reinforced structure with slab effect using computer program and compared it with conventional method",International Journal of Modern Engineering researchvol.3, Issue.3, pp-1428-1434.

[11]. Sudhir Singh Bhaduria and Nitin Chhugani (2017) "Comparative Analysis and Design of Flat and Grid Slab System With Conventional Slab System", "International Research Journal of Engineering and Technology", ISSN: 2395-0056, Volume: 04 Issue: 08

[12]. Andreas j. Kappos , D.k. Bull (2002) Seismic analysis of asymmetric multistorey buildings structure with the effect of slab and comparing it with structure without slab in 2-d & 3-d frame, 16(8), Pages 609–624.

[13]. Hawary (1994), Seismic Response of RC Buildings with Inelastic Floor Diaphragms, Journal of Structural Engineering 117(4).

[14]. Sashi K. Kunnath, Nader panashahi (1994), Effect of slab consideration in RC structure considering P-delta analysis, elsevier, Computers and structure.

[15]. Goutam Mondala and Sudhir K. Jain, "Seismic Analysis of irregular shaped building considering slab effect with walls", Earthquake Engineering Research Institute, , Earthquake Spectra, Volume 24, No. 3, pages 701–723.

[16]. Kaulkhere R.V and G. N. Shete, "Analysis and Design of Flat slab with various shapes",

"iinternational Journal of Scientific Development and Research" 365 052022 doi:10.1088/1757-899X/365/5/052022, 2017.

[17]. Srinu, p., & kumar, s. A. (n.d.). "Analysis and design of two way rectangular orthotropic slab with interior enclose opening with one short boundary intermittent slab using yield line theory". "International journal of engineering sciences & research technology", 7(3), 2018, 514-518.

Cite this article as :

Paritosh Singh, Rajesh Joshi, "Seismic Analysis of a Tall Structure Considering Flat and Grid Slab Diaphragm Using Analysis Tool Staad. Pro", International Journal of Scientific Research in Civil Engineering (IJSRCE), ISSN : 2456-6667, Volume 3, Issue 6, pp.35-43, November-December.2019
URL : http://ijsrce.com/IJSRCE19361