Analysis and Design of Flat Slabs in Commercial Building by using ETABS Software

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Abstract - *With the increase in population and development of civilization the need to industrialization and construction of buildings has been rising rapidly. Especially increase in Hospitals, Auditoriums & commercial buildings demand is very high. Flat slabs are mainly used in commercial buildings, in this system of construction the slab directly rests on the column and load from the slab is directly transferred to the columns and then to the foundation. Adopting construction of Multi-storied building with Flat Slabs not only matches demand but also decrease the construction time, cost and increasing building usage space.*

The Flat slabs has got place in providing feature like more stiffness, higher capacity, safe and economical also. In this work the analysis is done for seismic analysis to check that flat slab commercial building is applicable in different zones without any failure. The analysis and design of G-2, G+7 commercial building with flat slab is designed by using ETABS software.

Key Words**: Flat Slabs, Commercial building, Earthquake, Wind load, Etabs.**

1. INTRODUCTION

There has been an increasing demand for construction of tall buildings due to an ever-increasing urbanization and increase in population. Earthquake and wind load is the bane of such tall structures. As the earthquake forces are hazardous in nature, we need to accurate engineering tools for analyzing structures under the action of these forces. Thus, a careful modelling of such earthquake and wind loads needs to be done, so as to evaluate the behaviour of the structure with a clear perspective of the damage that is expected. To analyze the structure for various earthquake and wind intensities and then perform checks for various criteria at each level has become an essential practice for the last couple of decades.

Earthquake causes different shaking intensities at different locations and the damage induced in buildings at these locations is also different. Thus, it is necessary to construct a structure which is earthquake resistant at a particular level of intensity of shaking and assimilate the effect of earthquake. Even though same magnitudes of earthquakes are occurring due to its varying intensity, it results into dissimilar damaging effects in different regions. Hence, it is necessary to study seismic behaviour of multi-storeyed RC framed building for different seismic intensities in terms of various responses such as lateral displacements, story drift and base shear. Hence the seismic behaviour of buildings having similar layout needs to be understood under different intensities of wind and earthquake. For determination of seismic responses, it is necessary to carry out seismic analysis of the structure using different available methods

The principle objective of this project is to analyze flat slabs using ETABS, to get the optimum design. The design involves load calculations and analyzing the whole structure by ETABS. The design methods used in ETABS analysis are Limit State Design conforming to Indian Standard Code of Practice. ETABS features have state-of-the-art user interface, visualization tools, powerful analysis and design engines with advanced finite element and dynamic analysis capabilities. From model generation, analysis and design to visualization and result verification, ETABS is the professional's choice. ETABS has a very interactive user interface which allows the users to draw the frame and input the load values and dimensions. Then according to the specified criteria assigned it analyses the structure and designs the members with reinforcement details for RCC frames.

1.1 Objectives of the Study:

1. To study the behavior of flat slab commercial building in various seismic zones.
   a) Displacement
   b) Shear force
   c) Storey drift
2. To study the behavior of flat slab commercial building under different terrain categories
3. To study the variations in parameters such as Shear Force, Bending moment, Displacement, percentage of steel reinforcement in different seismic zones.

2. METHODS OF ANALYSIS

The analysis can be performed on the basis of external action, the behaviour of structure or structural materials, and the type of structural model selected. Based on the type of external action and behavior of structure, the analysis can be further classified as given below-

2.1 Equivalent static analysis

All design against seismic loads must consider the dynamic nature of the load. However, for simple regular structures, analysis by equivalent linear static analysis method is sufficient. This is permitted in most codes of practice for regular, low- to medium-rise buildings. This procedure does not require dynamic analysis; however, it account for the dynamics of building in an approximate manner. The static method is the simplest one

It requires less computational efforts and is based on formulae given in the code of practice. First, the design base shear is computed for the whole building, and it is then distributed along the height of the building. The lateral forces at each floor levels thus obtained are distributed to individual lateral load resisting elements.

2.2 Nonlinear Static Analysis

It is a practical method in which analysis is carried out under permanent vertical loads and gradually increasing lateral loads to estimate deformation and damage pattern of structure. Nonlinear static analysis is the method of seismic analysis in which behaviour of the structure is characterized by capacity curve that represents the relation between the base shear force and the displacement of the roof. It is also known as Pushover Analysis.

2.3 Response Spectrum Method

Response spectrum method is the linear dynamic analysis method. In this method the peak responses of a structure during an earthquake is obtained directly from the earthquake responses. If the input used in calculating a response spectrum is steady-state periodic, then the steady-state result is recorded. Damping must be present, or else the response will be infinite. For transient input (such as seismic ground motion), the peak response is reported. Some level of damping is generally assumed, but a value will be obtained even with no damping.

2.4 Time History Method

It is the non-linear dynamic analysis & is the most complicated of all. Time History analysis is a step by step analysis of the dynamic response of the structure at each increment of time when its base is subjected to specific ground motion time history. To perform such an analysis, a representative earthquake time history is required for a structure being evaluated. It is used to determine the seismic response of a structure under dynamic loading of representative earthquake.

3. FLAT SLAB FLOOR SYSTEM

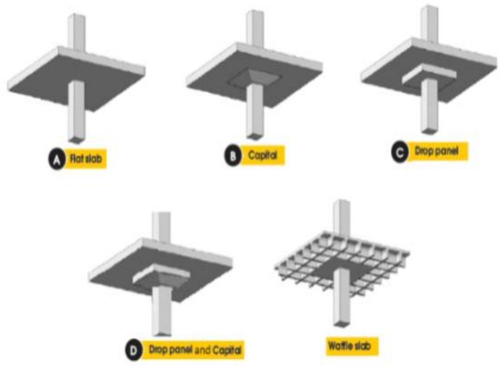
Flat slabs system of construction is one in which the beams used in the conventional methods of constructions are done away with. The slab directly rests on the column and load from the slab is directly transferred to the columns and then to the foundation. To support heavy loads the thickness of slab near the support with the column is increased and these are called drops, or columns are generally provided with enlarged heads called column heads or capitals.

Components of Flat Slabs

a. Column or capital Heads: Certain amount of negative moment is transferred from the slab to the column at the support. To resist this negative moment the area at the support needs to be increased. This is facilitated by providing column capital/heads.

b. Drop panels: To resist the punching shear which is predominant at the contact of slab and column Support, the drop dimension should not be less than one -third of panel length in that direction.

c. Drop panel and column head: In some rare cases flat slabs with drop panel and column or capital head is provided to resist the shear failure which is predominant at the slab and column.



Types of Flat Slabs

Flat slabs are highly versatile elements widely used in construction, providing minimum depth, fast construction & allowing flexible column grids, offering the following benefits:

- Construction of flat slabs is one of the quickest methods available. Lead times are very short as this is one of the most common forms of construction.
- Because this is one of the most common forms of construction, all construct members and many other concrete frame contractors can undertake this work.
- Flat slabs provide the most flexible arrangements for services distribution as services do not have to divert around structural elements.

4. MODELLING

ETABS features a state-of-the-art user interface, visualization tools, powerful analysis and design engines with advanced finite element and dynamic analysis capabilities. From model generation, analysis and design to visualization and result verification, ETABS is the professional's choice for steel, concrete design of low and high-rise buildings, ETABS consists of the following:

- The ETABS Graphical Interface: It is used to generate the model, which can then be analyzed. After analysis and design is completed. Once design completed graphs are plotted in storey response plots
- The ETABS Analysis and Design: It is a general-purpose calculation engine for structural analysis and integrated Steel, Concrete design.

To start with we have solved some sample problems using ETABS and checked the accuracy of the results with manual calculations. The results were to satisfaction and were accurate. In the initial phase of our project we have done calculations, regarding loadings on buildings and also considered seismic and wind loads. Structural analysis comprises the set of physical laws and mathematics required to study and predicts the behaviour of structures. Structural analysis can be viewed more abstractly as a method to drive the engineering design process or prove the soundness of a design without a dependence on directly testing it.

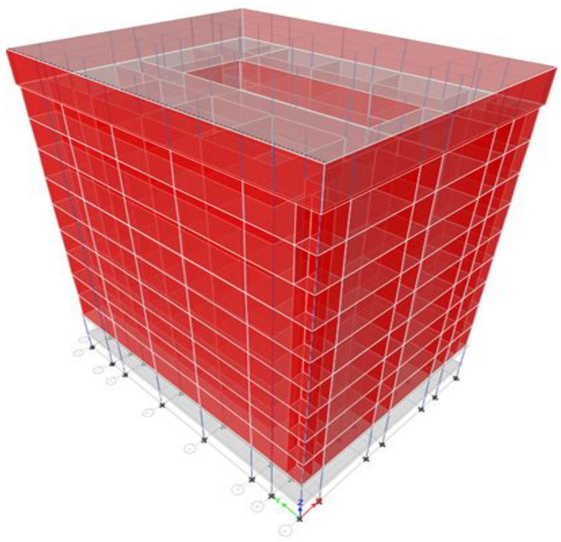
Project Statement

Commercial building with Flat slabs is taken for analysis. The salient feature of the building is:

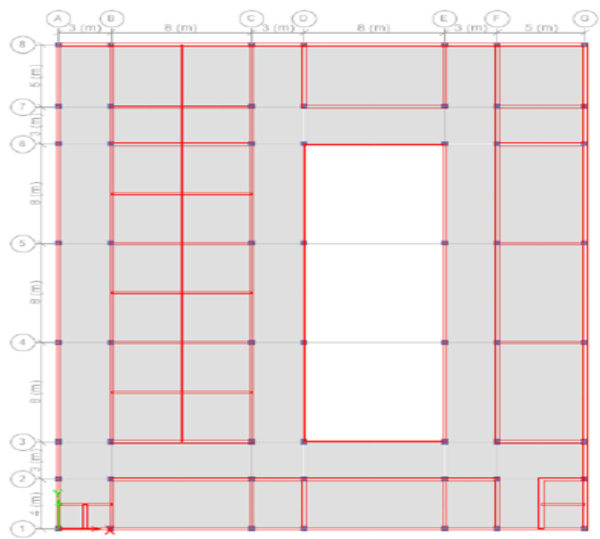
Type of slab	Flat Slab
No. of stories	G-2, G+7
Shape of the building	Asymmetrical
Depth of the slab	150 mm
Seismic zone	II, III, IV
Imposed load	4.5 kN/m^2
Floor finishes	1.5 kN/m^2
Grade of concrete	M25
Grade of steel	Fe 415
Unit weight of RCC	25 kN/m^3
Column	400 x 400 mm 750 x 750 mm
Wall thickness	230 mm for ordinary wall 115 mm for parapet wall
Total height	47m
Floor height	4m
Base height	3m

Assigned Story Data

Story	Height	Elevation	Master Story	Similar to
Story12	4	47	Yes	None
Story11	4	43	Yes	None
Story10	4	39	No	Story 11
Story9	4	35	Yes	None
Story8	4	31	No	Story 9
Story7	4	27	No	Story 9
Story6	4	23	No	Story 9
Story5	4	19	No	Story 9
Story4	4	15	No	Story 9
Story3	4	11	No	Story 9
Story2	4	7	Yes	None
Story1	3	3	No	Story 2
Base		0		



3D view of building



Plan view

Seismic zones and z factor

Seismic Zone	Z
II	0.10
III	0.16
IV	0.24
V	0.36

Type of soil

Type	Soil
I	Hard or Rocky
II	Medium
III	Soft

Wind Terrain Categories

Category	Height in meters
I	< 3
II	3 - 10
III	> 10
IV	> 40

Important Terminology:

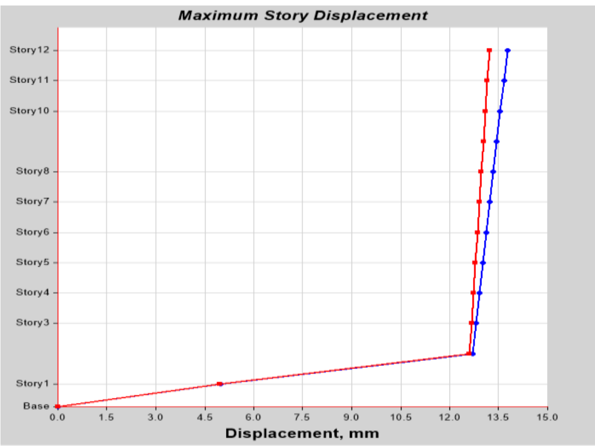
Storey displacement: It is total displacement of the storey with respect to ground and there is maximum permissible limit prescribed in IS codes for buildings.

Storey drift: Storey drift is the drift of one level of a multi-storey building relative to the level below. Inter story drift is the difference between the roof and floor displacements of any given story as the building sways during the earthquake, normalized by the story height.

Storey shear: It is the lateral force acting on a storey, due to the forces such as seismic and wind force. It is calculated for each storey, changes from minimum at the top to maximum at the bottom of the building.

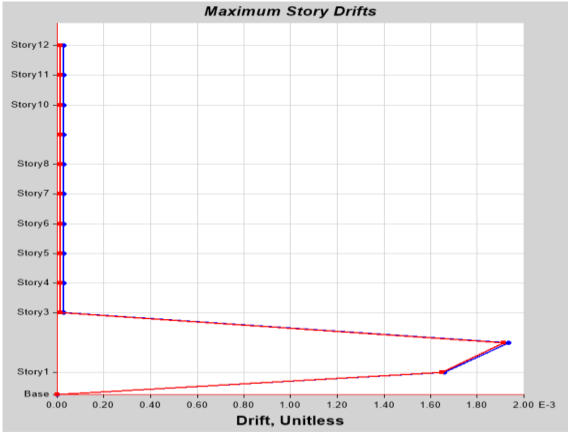
5. RESULTS

Maximum Story Displacement (mm)



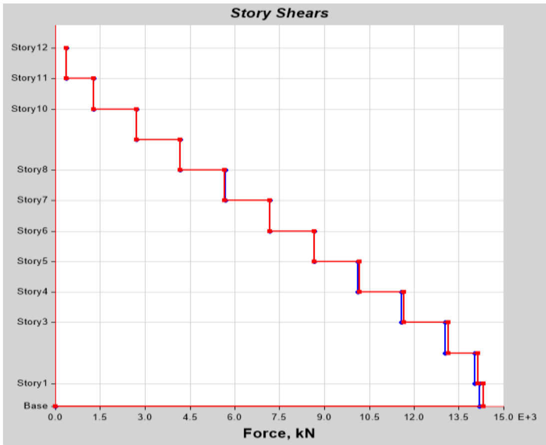
Maximum Story Displacement (mm)			
Direction	Zone II	Zone III	Zone IV
X	4.2	11.3	13.8
Y	4	10.8	13.2

Maximum Story Drifts (mm)



Maximum Story Drifts (mm)			
Direction	Zone II	Zone III	Zone IV
X	0.00008	0.000027	0.000027
Y	0.00005	0.000015	0.000015

Maximum Story shear (kN)



Maximum Story shear (kN)			
Direction	Zone II	Zone III	Zone IV
X	4296.6654	14186.4	14186.406
Y	4353.71	14315.7	14315.7276

6. CONCLUSIONS

Form the data revealed by the software analysis for the structure using various load combinations tried following conclusions are drawn:

1. Seismic analysis was done by using ETABS software as per IS 1893 – 2002.

2. There is a gradual increase in the values of lateral forces from bottom floor to top floor.

3. The maximum story displacement is increased as the seismic zone goes from II to IV.

4. As the seismic zone increases from II to IV, the storey shear increases.

5. As the seismic zone increases from II to IV, the storey drift increases.

6. As the seismic zone increases from II to IV, the lateral force increases.

7. Results are compared for all zones.

8. Hence the designed flat slab in commercial building is able to with stand earth quake in II to IV zones which are analyzed in this work.

7. SCOPE FOR FUTURE STUDY

Flat slabs system of construction is one in which the beams used in the present study is limited to response spectrum analysis this flat slab commercial building for 3 different zones. This can be further continued for analysis through flat slab with drop panels in different zones even with time history analysis. Even waffle slab can be continued for further analysis through different zones.

REFERENCES

[1] R.S.More, V. S. Sawant . "Analysis of flat slab" International Journal of Science and Research (IJSR) ISSN (Online): 2319-7064 Index Copernicus Value (2013): 6.14 | Impact Factor (2013): 4.438

[2] Mohan H.S, kavan M.R "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) e-ISSN: 2395-0056 Volume: 02 Issue: 03 | June-2015

[3] Dhanaji r. Chavan, Mohite D. D., dr. C. P. Pise, Pawar Y. P., kadam S. S., Deshmukh C. M. "Analysis of flat slab building with and without shear wall" Dhanaji R. Chavan.et al. Int. Journal of Engineering Research and Application ISSN : 2248-9622, Vol. 6, Issue 10, (Part -4) October 2016, pp.35-43

[4] R. P. Apostolska , G. S. Necevska-Cvetanovska , J. P.Cvetanovska and N. Mircic "Seismic Performance Of Flat-Slab Building Structural Systems" The 14th World Conference on Earthquake Engineering October 12-17, 2008

[5] Uttam v Chothani, Jashmin Gadhiya, Hitesh k Dhameliya."Comparative study of seismic behaviour and cost comparison of multi-storey flat slab and conventional reinforced concrete framed structure" 2016 IJSRSET | Volume 2 | Issue 3 | Print ISSN : 2395-1990 | Online ISSN : 2394-4099

[6] Ramachandra , Vijay Gehlot –Limit state of Design concrete structure

IS Codes

The code books referred for this project are

- IS 456:2000 (Reinforced concrete for general building construction).
- IS 800:2007 (Limit state design).
- IS 875 part 1, (Dead Loads for building and structures).
- IS 875 part 2, (Imposed Loads for building and structures).
- IS 875 part 3, (Wind Loads for building and structures).
- IS 1893:2002 (Earthquake Resistant Design of Structures).