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Investigation on the Stability of Flat Slab Structure with Perimeter Beams against Seismic Loading

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Abstract: In present era, flat slab structure is becoming a new trend, this type of construction has several advantages over conventional slab structure such as fast construction, architectural flexibility, easier form works etc. A rather new concept was come in picture, providing flat slab with perimeter beams including drop panel is coming in which beams are only provided on the end or perimeter of the slab. In the present work the performance and behaviour of flat slab with perimeter beams against conventional slab under seismic zones III, IV & V as per IS: 1893:2002. In this research three models of storey 10m, 12m and 15m are considered in three seismic zones along with conventional slab in all the zones respectively and their structural behaviour is studied.
Keywords: Flat slab, Seismic Analysis, Zone, Perimeter Beams and Symmetric building.

I. INTRODUCTION

A flat slab is a two-way R.C.C. slab that usually have lack of beams and girders and the loads are transferred directly to the supporting concrete columns. Flat slab structures are one of the most popular floor systems in commercial buildings, residential buildings and many other structures. The Flat slab framed structures are favoured by both architecture and client. Flat slabs are economical and due to the absence of beams floor height is also reduced to get appropriate height we can also use flat slab with perimeter beams. In flat slab construction there are a plain ceiling is obtained and hence it offers attractive appearance from architectural point of view. The construction of flat slab is easy and economical compare to other beam slabs and requires less formwork. And also required less time for construction compare to other beam slabs.

History of flat slab **-** C.A.P. Turner constructed flat slabs in U.S.A. in 1906 mainly by conceptual ideas, which was the origin of this type of construction. Later in 1914, Nicholas proposed a method of analysis of flat slabs based on simple statics. This method is used even today for the design of flat slabs and flat plates and is known as the direct design method. Structural engineers commonly use the equivalent frame method with equivalent beams such as the one proposed by Jacob S. Grossman in practical engineering for the analysis of flat plate structures. 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. Flat slabs are used mainly in office buildings due to reduced formwork cost, fast excavation, and easy installation. Some of the researchers done his work in this field, those are: Hanamanagouda and Pallavi (2018) analysed a G+3 RCC residential building with conventional and flat slab using ETABS, they studied stresses developed in column in both the conditions. Their study concluded that flat slab produces more stress in structural elements that conventional one yet flat slab was cheaper they also concluded that storey displacement increases in medium soil than hard soil for seismic zones and conventional slab case shows more stiffness as it is a framed structure but in flat slab case it is less stiff so it produces more displacement. Sohan, Vinay and J.P. Gupta (2018), deals with comparative study of high rise building under seismic and wind loading conditions by using different geometries. Analysis is done by considering flat and conventional slab of different geometries (Hexagonal, Octagonal and Rectangular) and evaluation of maximum lateral displacement, storey drift, beam shear and axial forces were evaluated on STAAD PRO V8i for seismic zone III. In the analysis different floor height is also taken as G+9, G+15 and G+ 23 storeys for all above said geometries and the best slab system is to be found for seismic zone III. They found that Flat slabs in octagonal geometry are better preference when compared to other geometries, flat slab frames are cost effective, in flat slab system more clearance height between two floors is obtained hence overall height of structure is reduced, conventional slabs showed greater values of beam shear and beam moments as compared to flat slab and from aesthetics point of view flat slab should be preferred. Gaurav and S.N. Tande (2016) used SAFE software, equivalent frame method direct design method and for analysing flat slab. They concluded that both the methods i.e. Equivalent frame and direct design are approximate but the former one is more precise but hand calculations are time consuming so use of software is adopted. Mohana and Kavan (2015) carried out relative study of conventional and flat slab structure using ETABS for different seismic zones of

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India. They studied the performance and behaviour of both structures along with storey shear, design axial forces and storey displacement and concluded that as the seismic level increases all parameters like axial force, displacement, storey shear intensities increases. Mohit, Sudhir and Danish (2016) observed behaviour of flat slab and wide beam system in comparison to conventional moment resisting frame, they have considered a G+3 model of a building and analysed for gravity loads and seismic loads and linear static and linear dynamic methods were used by them. Their research concluded that by linear static analysis structure shows less deformations in case of flat slab than conventional slab and wide beam system because of reduced weight of structure and from seismic analysis a large amount of lateral deformation is observed in case of flat slab case because of less amount of lateral stiffness of flat and wide beam system.

II. METHODOLOGY

This study presents the impact of seismic loads on high rise R.C.C structures having flat slab with perimeter beams as per IS-norms. The seismic analysis is carried out to evaluate the structural behaviour of high rise building having Flat slab with perimeter beams considering geometrical plan with semi-rigid diaphragm conditions under seismic zones III, IV & V. Results has been compared on the basis of base shear, support reaction, joint displacement, elapsed time, maximum value of S.F & B.M in a sample member and story drift. Following procedure is adopted for analysis of high rise structures.

Step1: Selection of building geometry, bays and story.
Step2: Select the property of frame sections for building frame
Step3: Select the support conditions for different loading conditions:
Step4: Selection of semi-rigid diaphragms model.
Step5: Select loading condition such as dead load, live load, Seismic loads and combination of loads.
Step6: Structural analysis of building frames for above loading conditions.
Step7: Analysis results in terms of maximum moments in columns and beams, base shear, displacements, support reactions at the ends, story drift and CPU time ratings.
Step8: Critical study of results.

III. STRUCTURAL MODELLING AND ANALYSIS

A: Modelling Of Building Frames

In this study, high rise structure and their geometrical plan is considered for the analysis:

Table: Cases under consideration

Software used	Configuration	Model	Storey	Remarks
ETABS 2016	Symmetric	40m x 30m	10	Seismic load of ZONE III, IV & V as per IS: 1893:2002.
			12	
			15	

All these cases are analysed for different seismic zones (which must be zone III, zone IV & zone V) and for diaphragm condition (semi-rigid diaphragm). Structural modal including plan, 3-D and Elevation view for the above two cases as shown in figure 1, figure 2 & figure 3.

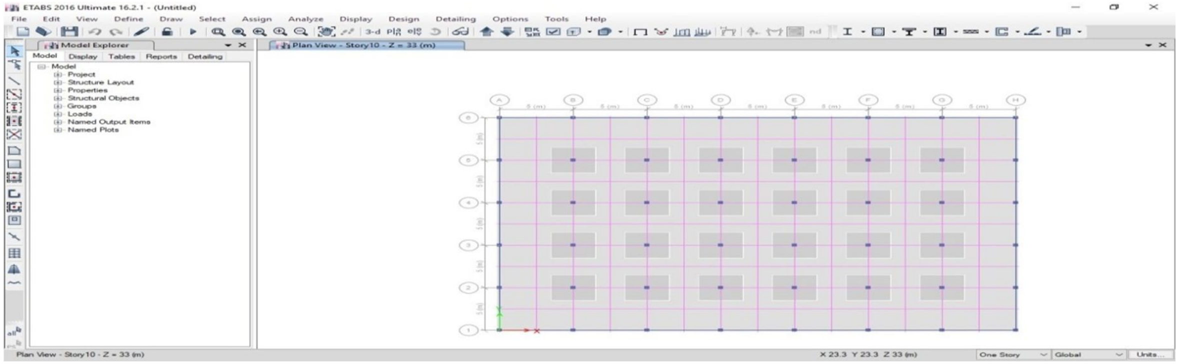

Fig.1 – Top View (Plan) of flat slab with perimeter beams

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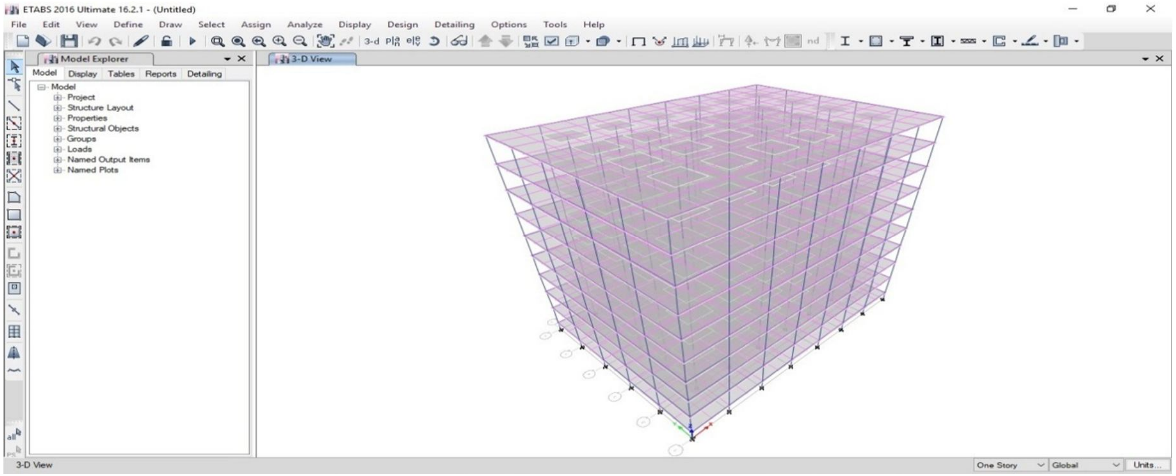

Fig. 2 – 3D View of flat slab with perimeter beams

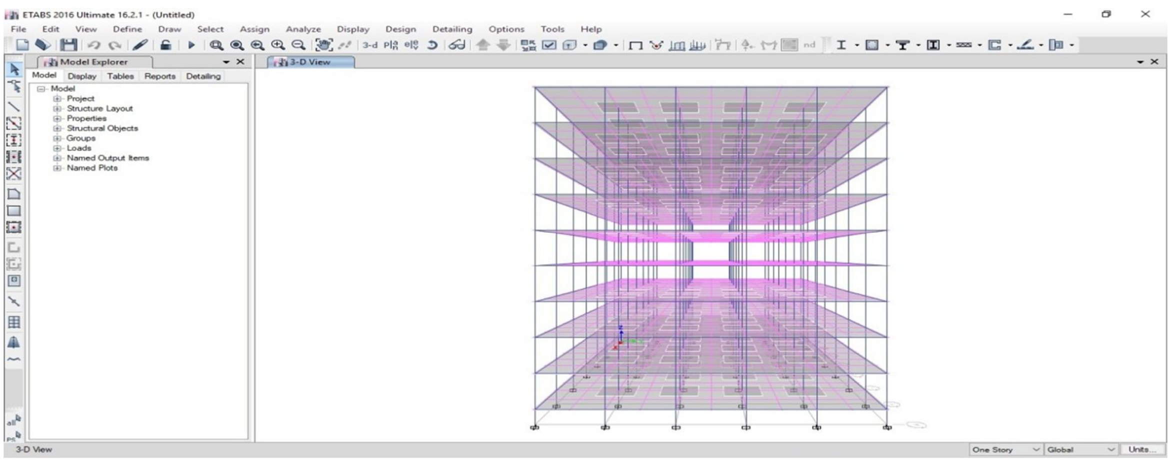

Fig. 3 – 3D (Elevation) View of flat slab with perimeter beams.

B. Material and Geometrical Properties

Following material properties has been considered in modelling:

Density of RCC: 25 kN/m^3

Density of Masonry: 20 kN/m^3

Poisson ratio: 0.20

The foundation depth is considered at 1.5 m below ground level and the typical story height is 3.5m.

C. Loading Conditions

Following loading is adopted for analysis:-

1) Dead Loads (IS 875 part -1):

Self-wt. of slab considering 150 mm tk. Slab = 0.15 × 25 = 3.75 kN/m^2

Masonry Full Wall Load = 0.20 × 3.50 × 20 = 14.0 kN/m

Masonry roof wall load = 0.20 × 1 × 20 = 4.0 kN/m.

2) Live Loads (IS 875 part -2):

Live Load on typical floors = 2 kN/m^2

Live Load on Roof = 1 kN/m^2.

3) Earth Quake Loads(IS 1893 part -1: 2002/05):

All the building frames are analysed for 3 seismic zones i.e, Zone III, IV and V. The earth quake loads are derived for following seismic parameters as per IS: 1893(2002)

Earth Quake Zone: III, IV and V.

Response Reduction Factor: 5
Importance Factor 1
Damping 5%
Medium type Soil

D: Structural Analysis

Structural analysis of high rise structure is carried out by using ETABS software. All the columns are restraints in all possible directions (i.e. fixed) at the ground. Analysis of building frames is carried out in 5 analysis combination including seismic weight of the structure, which is shown in table:

S. No.	Define Combination	Notation	Combination
1	Dead Load	DL	1.5 DL
2	Live Load	LL	1.5 LL
3	Earthquake Load (Eqx)	Eqx (+/-)	1.5 DL + 1.5/1.2 Eqx(+/-)
4	Earthquake Load (Eqz)	Eqz (+/-)	1.5 DL + 1.5/1.2 Eqz(+/-)
5	Seismic Weight	Joint Weight	1DL + 0.25 LL

IV- RESULT AND DISCUSSION

From above literature, many researchers gave his results on the seismic analysis of high rise structures. Researchers done their work on the flat slab structure as well and analyse it using seismic and wind loads. Some conclusions are seen while reviewing such papers related to my work is:

Linear static method is used for the analysis of flat slab and conventional slab structure and it shows lesser deformations in case of flat slab as compared to conventional slab.

Flat slab produces more stress in structural elements that conventional, Flat slab was found to be cheaper.

In this work, we have made approximations on the geometrical plan of structures, which are going to be drawn on the Etab interface. These structures are being analysed further on the basis of Seismic loads as per the provisions given in IS: 1893: 2002/05. Seismic analysis results will be evaluated on the basis of following sub-heads, i.e. Base shear, Support reaction, Joint displacement and Elapsed time.

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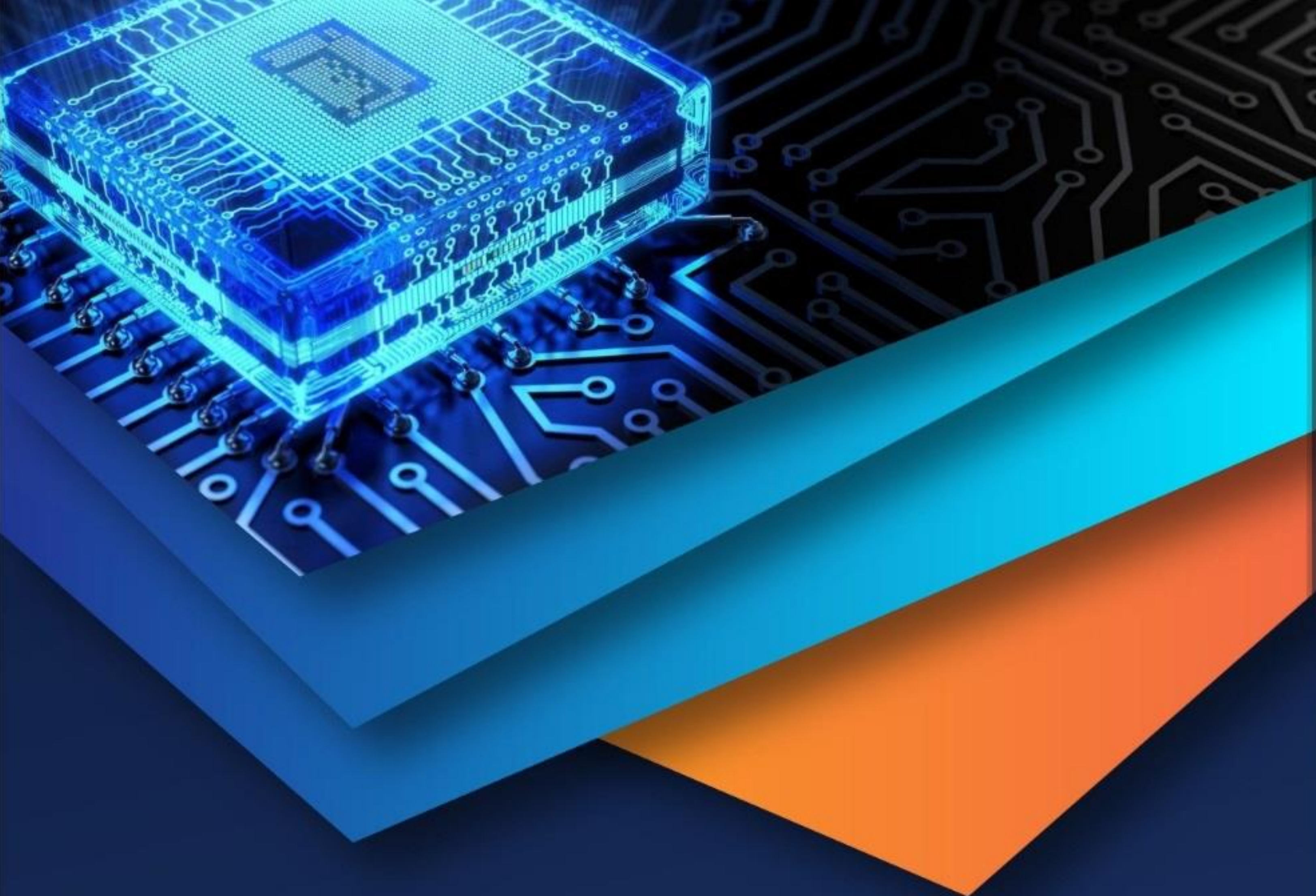

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