Comparative Analysis and Design of Flat Slab & Grid Slab In Multi-storey Building Under Seismic Condition

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ABSTRACT

The flat slab construction is one in which the beam is used in the conventional methods of construction. The slab directly rests on column and the load from the slabs is directly transferred to the columns and then to the foundation. Drops panel or columns are generally provided with column heads or capitals. Grid Slab systems consisting of beams spaced at regular intervals in perpendicular directions, monolithic with slab. They are generally designed for large rooms such as vestibules, auditoriums, theatre halls, show rooms of shops where column free space is often the main requirement. The aim of the project is to determine the seismic analysis between the flat slab and grid slab. The proposed construction site is Sri Nirmal madhav apartment 4 manis nagar behind shardha square, Nagpur. The total length of slab is 36m and width is 30 m. total area of slab is 1080 sqm. It is designed by using Fe500 steel and M40 Grade concrete and Fe415 steel. Analysis of the grid slab and flat slab has been done by software according IS 456-2000. Flat slab and Grid slab has been analyzed by ETABs software. Rates have been taken according to N.M.C. C.S.R...

Keywords: **Grid Slab, slab flat slab, spacing of grids beams, Etabs, thickness of slab flat slab, Etabs**

I. INTRODUCTION

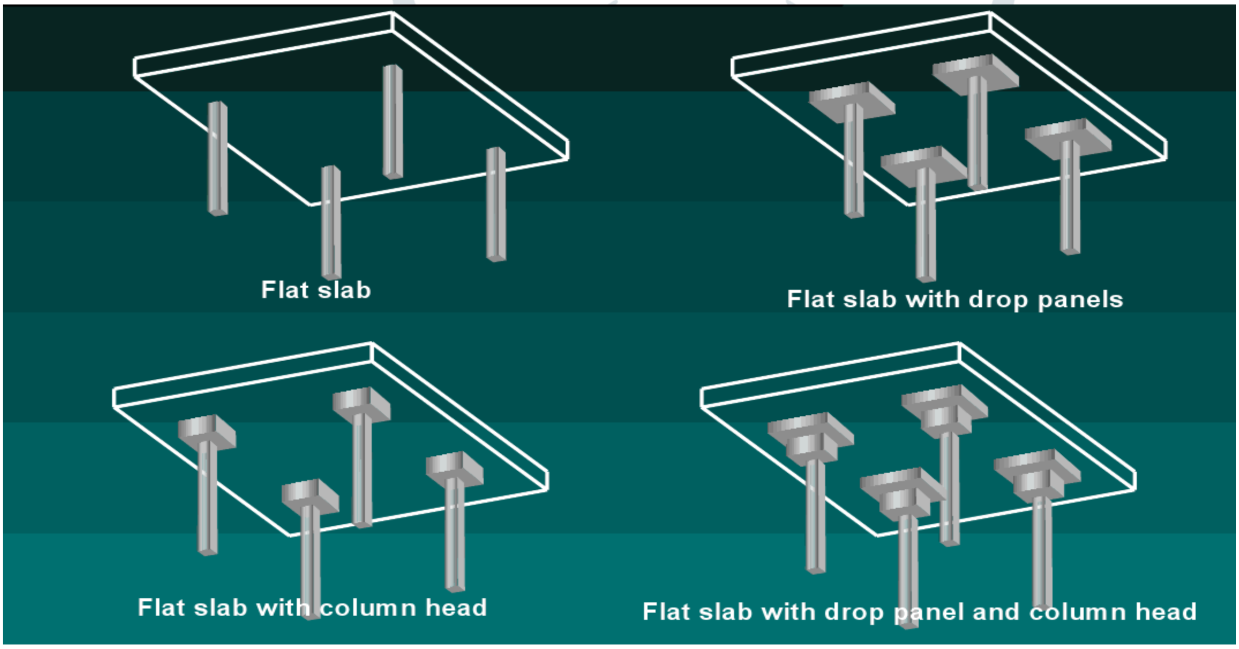
This project presents the "comparative study of flat and grid type of slab for for multi storied building under seismic condition ".This work includes the analysis of flat slab and grid slab. The purpose of this study is to understand the characteristics, the method of analysis, and the design of flat slab and grid slab; and to find out which slab system with certain parameters is superior to other. A slab is a flat two dimensional planar structural element having thickness small compared to its other two dimensions. It provides a working flat surface or a covering shelter in buildings. It primarily transfers the load by bending in one or two directions. Reinforced concrete slabs are used in floors, roofs and walls of buildings and as the decks of bridges. The floor system of a structure can take many forms such as in situ solid slab, ribbed slab or pre-cast units. Slabs may be supported on monolithic concrete beam, steel beams, walls or directly over the columns. Concrete slab behave primarily as flexural members and the design is similar to that of beams.

The advantage of grid over other types of floors is that the flat roof or floor is obtained. By using ordinary reinforced concrete construction and by increasing number of beams, the depth of beam can be shortened. Thus, greater clearance can be obtained. The structure is monolithic in nature and these types of floors have more stiffness. The maintenance cost of these floors is also negligible than that of steel-girders and prestressed concrete.

II. ECONOMICAL ASPECTS OF LONG SPAN SLABS BETWEEN FLAT SLAB AND GRID SLAB

2.1 FLAT SLAB

A reinforced concrete flat slab, also called as beamless slab, is a slab supported directly by columns without beams. A part of the slab bounded on each of the four sides by centre line of column is called panel. The flat slab is often thickened closed to supporting columns to provide adequate strength in shear and to reduce the amount of negative reinforcement in the support regions. The thickened portioni. the projection below the slab is called drop or drop panel. In some cases, the section of column at top, as it meets.



2.3 ADVANTAGES OF FLAT SLABS

It is recognized that Flat Slabs without drop panels can be built at a very fast pace as the framework of structure is simplified and diminished. Also, speedy turn-around can be achieved using an arrangement using early striking and flying systems. Flat slab construction can deeply reduce floor-to –floor height especially in the absence of false ceiling as flat slab construction does act as limiting factor on the placement of horizontal services and partitions. This can prove gainful in case of lower building height, decreased cladding expense and pre-fabricated services. In case the client plans changes in the interior and wants to use the accommodation to suit the need, flat slab construction is the perfect choice as it offers that flexibility to the owner. This flexibility is possible due to the use of square lattice and absence of beam that makes channelling of services and allocation of partitions difficult.

2.3 DESIGN OF FLAT SLAB

Multitudes of process and methods are involved in designing flat slabs and evaluating these slabs in flexures. Some of these methods are as following:

i. The empirical method
ii. The sub-frame method
iii. The yield line method
iv. Finite –element analysis

For smaller frames, empirical methods are used but sub-frame method is used in case of more irregular frames. The designs are conceptualized by employing appropriate software but the fact is using sub-frame methods for very complicated design can be very expensive. The most cost effective and homogenous installation of reinforcements can be achieved by applying the yield line method. A thorough visualization in terms of complete examination of separate cracking and deflection is required since this procedure utilises only collapse mechanism. Structures having floors with irregular supports, large openings or bears heavy loads, application of finite- element analysis is supposed to be very advantageous. Great thought is put into choosing material properties or installing loads on the structures. Deflections and cracked width can also be calculated using Finite- element analysis.

3.4 GRID SLAB

Grid slab or waffle slabs have two major types, I.e, waffle slabs with hidden beams or waffle slabs with solid sections around columns. The first waffle slab type, with beams, behave like solid slab(slab with beams between columns) and the analysis method could also be similar to that of solid slab. And in most codes coefficients are provided for slabs with beam. This coefficients could be used to analyse grid slabs with beams. The second type, with solid section around columns, behave somewhat similar to flat slabs. And you can analyse it using direct design or equivalent frame methods. Please note that , codes specifiy limitations on the grid slab sections in order to show that analyzing the slabs as solid or flat slab is possible

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III. STRUCTURAL MODELING

13 storied buildings are modeled using flat slabs & grid slabs respectively. These buildings were given rectangular geometry. These are then analyzed using response spectrum method for earthquake zone II of India. The details of the modeled building are listed below. Modal damping of 5% is considered with SMRF and Importance Factor (I) =1. The The building has been modeled as 3D Space frame model with

six degree of freedom at each node using etabs software for stimulation of behavior under gravity and seismic loading. The isometric 3D view and elevation of the building model is shown as below.

Structure Data

Site Properties:

- Details of building:: G+12
- Dimension:: 30m x 36m
- Length in X- direction:: 30m
- Length in Z- direction:: 36m
- Total height of Building:: 43.4m
- Soil Type:: Hard
- Spacing:: 6m
- Base storey height:: 5m
- Floor height ::3.2 m

Seismic Properties

- Seismic zone:: II
- Zone factor:: 0.16
- Importance factor:: 1
- Response Reduction factor R:: 5

Material Properties

- Grade of concrete :: M40
- Grade of Steel :: Fe500

Loading on structure

- Dead load :: self-weight of structure +1kN/m2
- Live load:: 4kN/m2

- Wind load :: Not considered
- Seismic load:: Seismic Zone II

Optimized Sizes of members

Flat slab Design parameters

- Column:: 700mm x 700mm
- Flat Slab thickness:: 250mm
- Drop:: 1.5m
- Drop thickness:: 350mm

Grid slab Design parameters

- Column:: 700mm x 700mm
- Beam:: 400mm x 500mm
- Slab thickness:: 250mm
- Grid Size :: 1m

Models to be considered for study are:

- Model 1- Flat Slab with Drop by the effect of Diaphragm for zone II.
- Model 2- Grid Slab by the effect of Diaphragm II.

Above types of slab are analyzed for seismic zone by response Spectrum Method.

Load combinations as per IS 1893:2016 (part 1)

- For the analysis following load combinations specified by the IS 1893 : 2016 are used. The basic load combinations given by the code as per clause 6.3.4.1 are as follows
- 1.5 (D.L. + L.L.)
- 2(D.L. + L.L. ± EQ x)
- 1.2 (D.L. + L.L. ± EQ y)
- 1.5 (D.L. ± EQ x)
- 1.5 (D.L. ± EQ y)
- 0.9 (D.L.) ± 1.5 (EQ x)
- 0.9 (D.L.) ± 1.5 (EQ y)

- 1 (D.L. + L.L. ± EQ x)
- 1 (D.L. + L.L. ± EQ y)
- 1 (D.L. ± EQ x)
- 1 (D.L. ± EQ y)

IS 1893 2002 Auto Seismic Load Calculation

This calculation presents the automatically generated lateral seismic loads for load pattern EQX according to IS1893 2002, as calculated by ETABS.

Direction and Eccentricity

Direction = Multiple

Eccentricity Ratio = 5% for all diaphragms

Structural Period

Period Calculation Method = Program Calculated

Factors and Coefficients

Seismic Zone Factor, Z [IS Table 2]	$Z = 0.16$
Response Reduction Factor, R [IS Table 7]	$R = 5$
Importance Factor, I [IS Table 6]	$I = 1$

Site Type [IS Table 1] = II

Seismic Response

Spectral Acceleration Coefficient, Sa /g [IS 6.4.5]	$\frac{S_a}{g} = 0.34$	$\frac{S_a}{g} = 0.34$

Equivalent Lateral Forces

Seismic Coefficient, Ah [IS 6.4.2] $A_h = \frac{ZI\frac{S_a}{g}}{2R}$

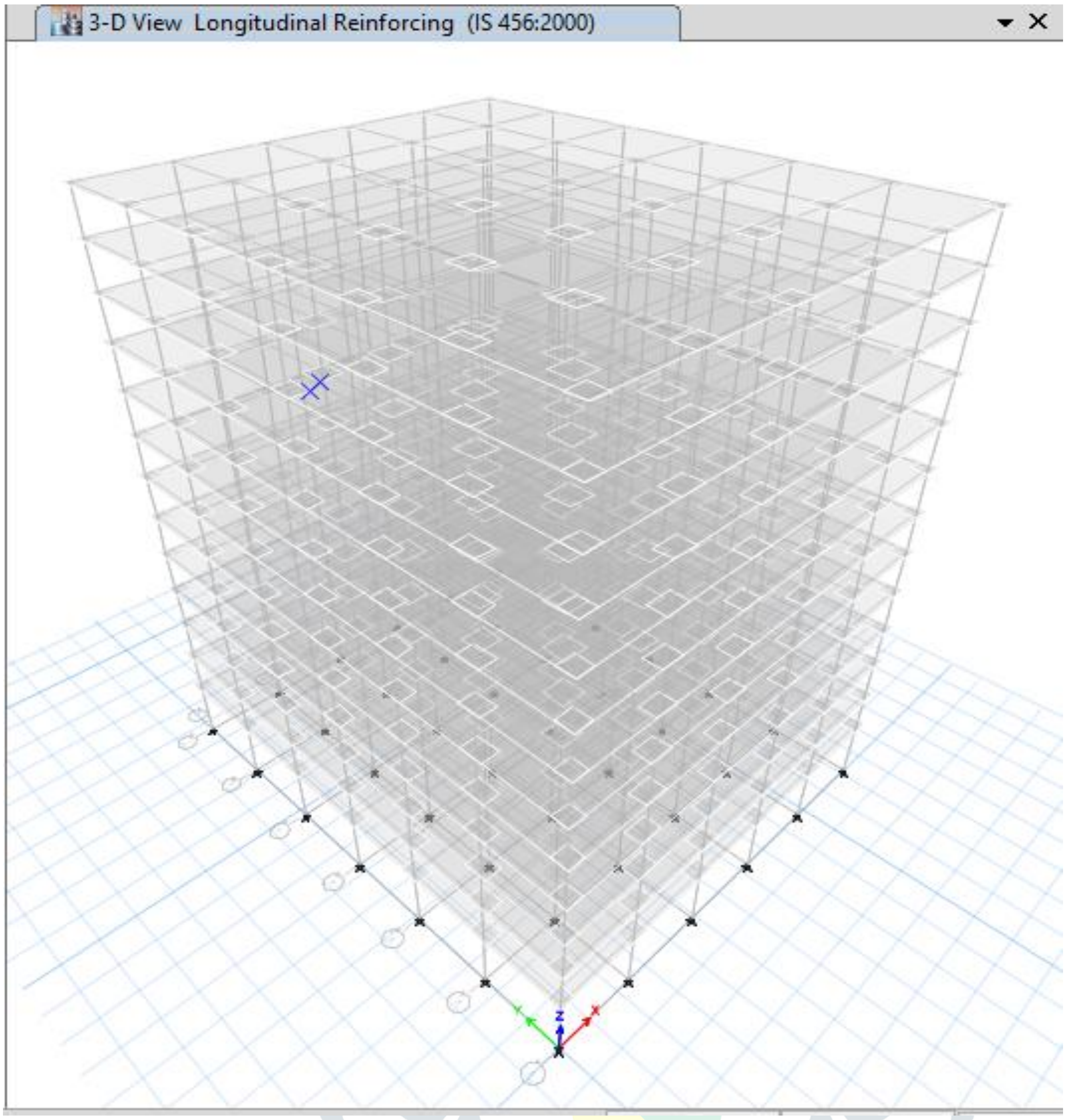

Figure 3.1 : 3D view of Model 1

(Flat Slab With Drop panel for G+12 building)

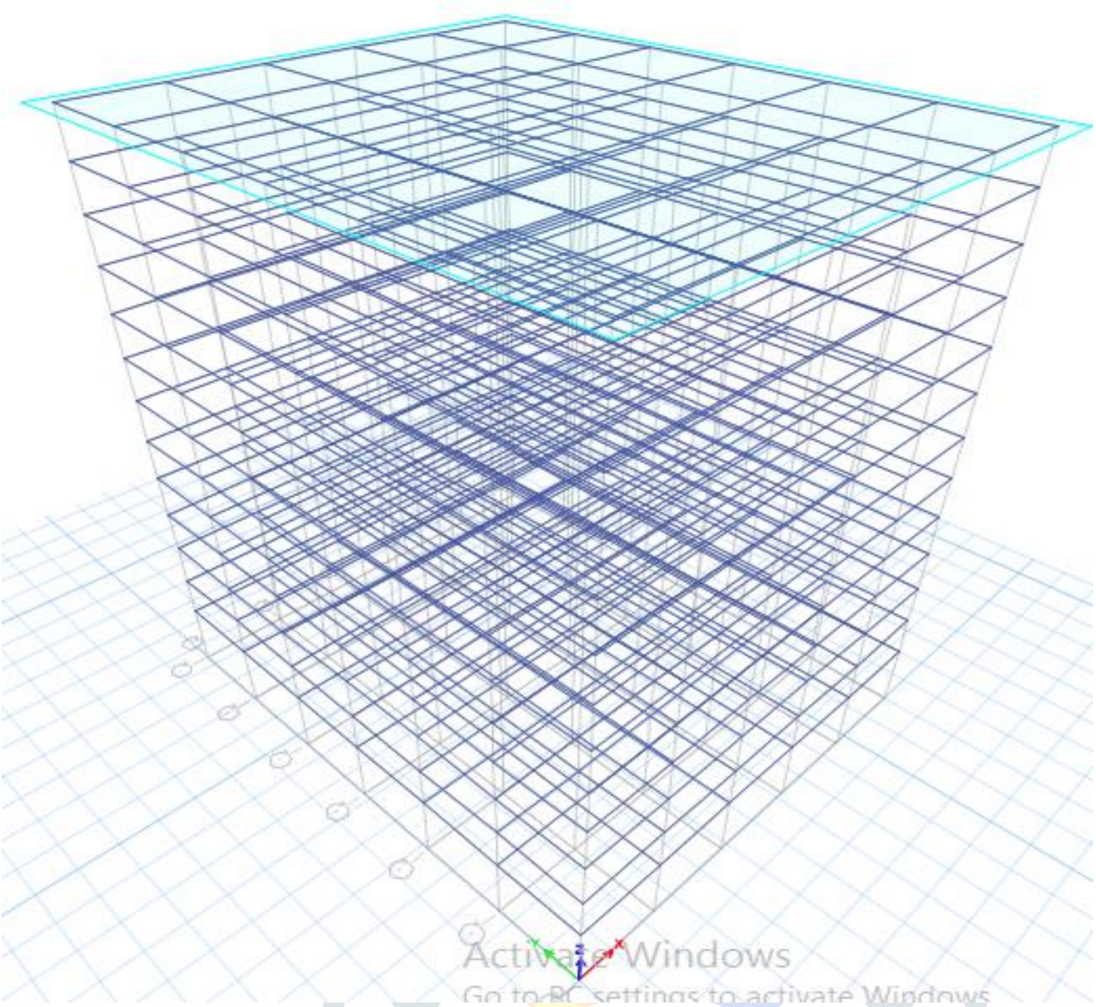

Figure 3.2: 3D view of Model 2

(Grid Slab with G+12 building)

IV. OBJECTIVES OF THE PROJECT

Aims and objectives present an outstanding agenda for the container for support in a research allowance application. The objectives of this project can be shortening as follows.

1. Study of earthquake design methods for flat slab and grid slab as per Indian standard (1893-2002) building codes.
2. To study base shear, axial force and moments of the structure along different direction by using response spectrum method
3. Flat slab will be designed using direct design method, by considering a dimension Panel.
4. Grid slab for same panel dimension will be designed using approximate method.
5. To compare the Etabs result for a grid and flat slab.

To study the variations in parameters such as Shear Force, Bending moment, Displacement, Storey Drift in different seismic zones.

V. OUTLINE OF PROJECT

The project work is divided into seven stages with following contents.

Stage 1 deal with the introduction on the different slab and specific objective of the project are presented in it.

Stage 2 studies of different research papers and journals on modeling and analysis of different types of slab and different forces acting on structure.

Stage 3 structural analysis is carried out to predict its behaviors by using Mathematical modeling.

Stage 4 analysis of building by using response spectrum method is analyzed using ETABS software.

Stage 5 gives the comparison between different parameters of flat slab and grid slab

Stage 6 conclusion made from the whole analytical study and future scope of the project

IV. ANALYSIS OF RESULTS

General:-

A 13 storied RCC building in zone II is modeled using Etabs software and the results are computed. The configurations of all the models are discussed in previous chapter. Thirty six models were prepared based on different configuration, for Flat Slab and Grid Slab.

- Model 1- Frame Structure with Flat Slab.
- Model 2- Frame Structure with Grid Slab.

Above types of Slab are analyzed for zone II by conventional fixed base, Limit State Design Method. So total thirty six models are prepared for analysis.

These models are analyzed and designed as per the specifications of Indian Standard codes IS 1893:2016 IS and IS 456: 2000. The response spectrum method had been used to find the design lateral forces along the storey in X and Z direction of the building.

Comparison of Different Parameters

1. Maximum Story shear (kN)

Maximum Story shear (kN)		
Direction	X	Y
Flat Slab	10046.493	10046.431
Grid Slab	6769.2991	6769.2831

Table 5.6.1 Comparison of Maximum Storey Shear of Flat Slab and Grid Slab

2. Maximum shear Force & Bending Moment

Maximum shear Force & Bending Moment			
Maximum shear Force	FX	FY	FZ
Flat Slab	31942.821	31942.821	221385.9
Grid Slab	31942.821	31942.821	31942.82
Maximum Moment	MX	MY	MZ
Flat Slab	2340715	90626.793	5804329
Grid Slab	910980.91	91098.091	2340715

Table 5.6.2 Comparison of Maximum Shear Force & Bending Moment of Flat Slab and Grid Slab

3.Maximum & Minimum Displacement (mm)

Maximum displacement			
Direction	X	Y	Z
Flat Slab	15	18	43.4
Grid Slab	15	18	43.4
minimum displacement			

Direction	X	Y	Z
Flat Slab	15	18	5
Grid Slab	15	18	5

Table 5.6.3 Comparison of Maximum &Minimum Displacement of Flat Slab and Grid Slab

4.Maximum & Minimum Storey Drift (mm)

Storey Drift		
Min &Max Drift	Min	Max
Flat slab	2951.111111	606066183
Grid slab	2951.116635	606066183

Table 5.6.3 Comparison of Maximum &Minimum Storey Drift of Flat Slab and Grid Slab

VII CONCLUSION

A 13 storied RCC building in zone II is modeled using Etabs software and the results are computed. The configurations of all the models are discussed in previous chapter.

- Model 1- Frame Structure with Flat Slab.
- Model 2- Frame Structure with Grid Slab.

Above types of Slab are analyzed for zone II by conventional fixed base, Limit State Design Method. These models are analyzed and designed as per the specifications of Indian Standard codes IS 1893:2016 IS and IS 456: 2000. The response spectrum method had been used to find the design lateral forces, drift, base shear, base reaction along the storey in X and Z direction of the building.

1. **Storey shear** – It is the lateral force acting on a storey, due to the forces such as seismic force. It is calculated for each storey, changes from minimum at the top to maximum at the bottom of the building. As per analysis Storey shear is maximum for flat slab and minimum for grid slab.

2. **Shear Force**: As per the observation, shear force value is same for grid slab and flat slab in the direction X & Y. But for direction Z Shear Force value is Maximum for grid slab and minimum for flat slab. So basically shear force value is maximum for Grid slab. Shear force value is minimum for flat slab.

3. **Bending Moments** –: As per the observation, bending moment value is greater for flat slab in the direction X. For direction Y bending Moment value is maximum for grid slab as well for direction Z bending Moment value is Maximum for flat slab. So overall bending Moment value is maximum for flat slab and bending Moment value is minimum for grid slab.

4. **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 displacement is same for all direction.

5. **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 drift is same for flat slab and grid slab.

VIII. FUTURE SCOPE

- Present study is limited to response spectrum analysis for Grid Slab and flat slab commercial building for seismic zone II. This can be further continued for analysis through flat slab with column head and drop panel and conventional Slab & Grid Slab with Shear effect in different zones even with time history analysis.
- Even Grid / Waffle slab can be continued for further analysis through different zones with different method.
- The study can be further extended to analysis of irregular building.
- The structure can be analysed with effect of Shear Wall
- Analysis can be done by using software SAP 2000, ETAB etc.
- Analysis can be carried out using time history method.
- Comparison of Time history method and response spectrum method can be done.
- Analysis can be done with different seismic zone.

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