

Studying the Response of Flat Slabs & Grid Slabs Systems in Conventional RCC Buildings

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Abstract: 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 paper 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.

Keywords: Flat Slabs, Grid Slabs, Grid Floors, Slab Design, Earthquake, Wind load

I. INTRODUCTION

There has been an increasing demand for construction of tall buildings due to an ever increasing urbanization and flexuous population. Earthquake is the bane of such tall structures. As the earthquake forces are haphazard in nature & unpredictable, we need to acuminated engineering tools for analyzing structures under the action of these forces. Thus a careful modeling of such earthquake loads needs to be done, so as to evaluate the behavior of the structure with a clear perspective of the damage that is expected. To analyze the structure for various earthquake intensities and then perform checks for various criteria at each level has become an essential practice for the last couple of decades. (Romy M and PrabhaC, 2011).

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 variations in seismic behavior of multistoried RC framed building for different seismic intensities in terms of various responses such as lateral displacements, story drift 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. (Duggal S K, 2010).

The principle objective of this project is to analyze flat slabs and grid slabs and compare them with normal slab using STAADpro, to get the optimum design. The design involves load calculations and analyzing the whole structure by STAADpro. The design methods used in STAADpro analysis are Limit State Design conforming to Indian Standard Code of Practice. STAADpro 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, STAADpro is the professional's choice. STAADpro 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.

A. Objectives of the Study:

1. To perform dynamic analysis for seismic and wind loading of multistoried RCC buildings with Flat slab & Grid slab (10, 20, 30Storey) having Square, Hexagonal Orthogonal geometry, using Response Spectrum Analysis, considering different earthquake Zones as per the Indian Standard code of practice IS 1893-2002 part-I: Criteria for Earthquake resistant structure (Zone II, III, IV, V).
2. To compare seismic behavior of multistoried RCC building with Flat slab & Grid slab for different earthquake intensities in terms of various responses such as, base shear, Story displacements, Story Drift, Axial Force, Time Period.
3. To find the relationship between earthquake intensities and responses.

II. METHODS OF ANALYSIS

The analysis can be performed on the basis of external action, the behavior 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-

A. 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. (Duggal S K, 2010).

B. 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 behavior 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.

C. 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. The maximum response is plotted against the undamped natural period and for various damping values, and can be expressed in terms of maximum relative velocity or maximum relative displacement. (Duggal S K, 2010).

D. 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. (Wilkinson S and Hiley R, 2006).

III. FLAT SLAB FLOOR SYSTEM

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

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 constructmembers and many other concrete frame contractors can undertake this work.
- Flat slabs are particularly appropriate for areas where tops of partitions need to be sealed to the slab soffit for acoustic or fire reasons. Flat slabs are considered to be faster and more economic than other forms of construction, as partition heads do not need to be cut around downstand beams or ribs.
- Flat slabs can be designed with a good surface finish to the soffit, allowing exposed soffits to be used. This allows exploitation of the building's thermal mass in the design of heating, ventilation and cooling requirements, increasing energy efficiency.
- Flat slabs provide the most flexible arrangements for services distribution as services do not have to divert around structural elements

IV. GRID SLAB FLOOR SYSTEM

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.

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. 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. They offer the following benefits:

- All elements of the space grid contribute to the load carrying capacity.
- Loads are distributed more evenly to the supports.
- This can reduce the cost of the supporting structures especially when heavy moving loads may be applied to the space grid (e.g. overhead cranes).
- Deflections are reduced compared to plane structures of equivalent span, depth and applied loading, assuming that the structural elements are of similar size.
- The open nature of the structure between the two plane grids allows easy installation of mechanical and electrical services and air-handling ducts within the structural depth.

V. MODELLING

STAAD.pro 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, STAAD.pro is the professional's choice for steel, concrete, timber, aluminium and cold-formed steel design of low and high-rise buildings, culverts, petrochemical plants, tunnels,

bridges, piles and much more. STAAD.pro consists of the following:

- The STAAD.pro Graphical User Interface: It is used to generate the model, which can then be analyzed using the STAAD engine. After analysis and design is completed, the GUI can also be used to view the results graphically.
- The STAAD analysis and design engine: It is a general-purpose calculation engine for structural analysis and integrated Steel, Concrete, Timber and Aluminium design.

To start with we have solved some sample problems using STAAD pro 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 behavior 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.

A. Problem Statement

10, 20&30 storied buildings are modeled using conventional slabs, flat slabs & grid slabs respectively. These buildings were given square, hexagon and octagon geometries each. 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.

SN	Specifications	Type of Building Geometry		
		Square	Hexagonal	Octagonal
1	Plan dimensions	25m x 25m (X x Z)	15 m (side length)	11.28 m (side length)
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 above the foundation level	2 m above the foundation level	2 m above the foundation level
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	300 x 300 mm	300 x 300 mm	300 x 300 mm
SN	Specifications	Type of Building Geometry		
		Square	Hexagonal	Octagonal
10	Slab Thickness for flat slab	200 mm	200 mm	200 mm
11	Beam	300 x 500 mm	300 x 500 mm	300 x 500 mm
12	Grade of concrete	M 25	M 25	M 25
13	Grade of Steel	Fe 415	Fe 415	Fe 415
14	Column = 10 story Structure	0.6 x 0.6 m	0.6 x 0.6 m	0.6 x 0.6 m
	= 20 story Structure	0.8 x 0.8 m	0.8 x 0.8 m	0.8 x 0.8 m
	= 30 story Structure	1.0 x 1.0 m	1.0 x 1.0 m	1.0 x 1.0 m

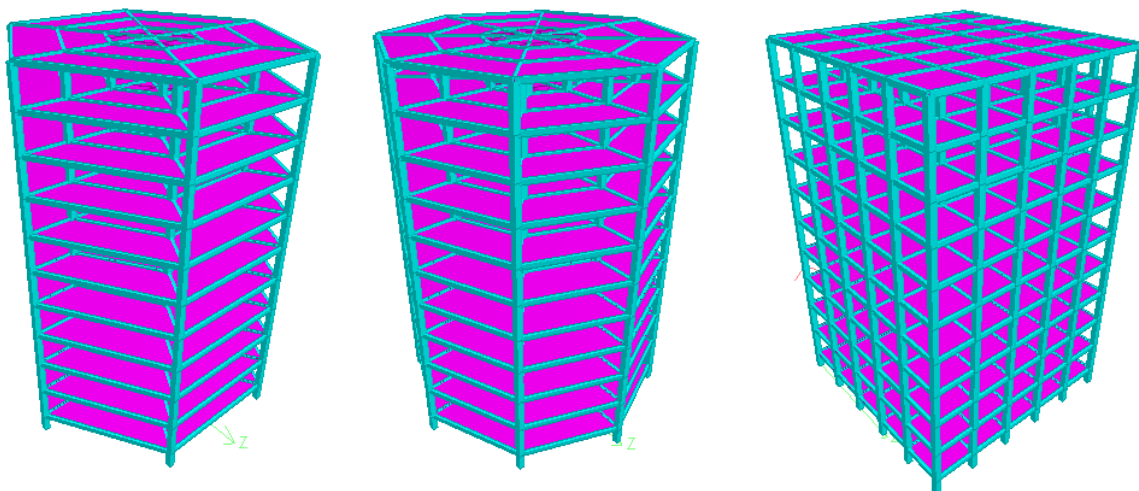


Figure 3: Conventional Slab

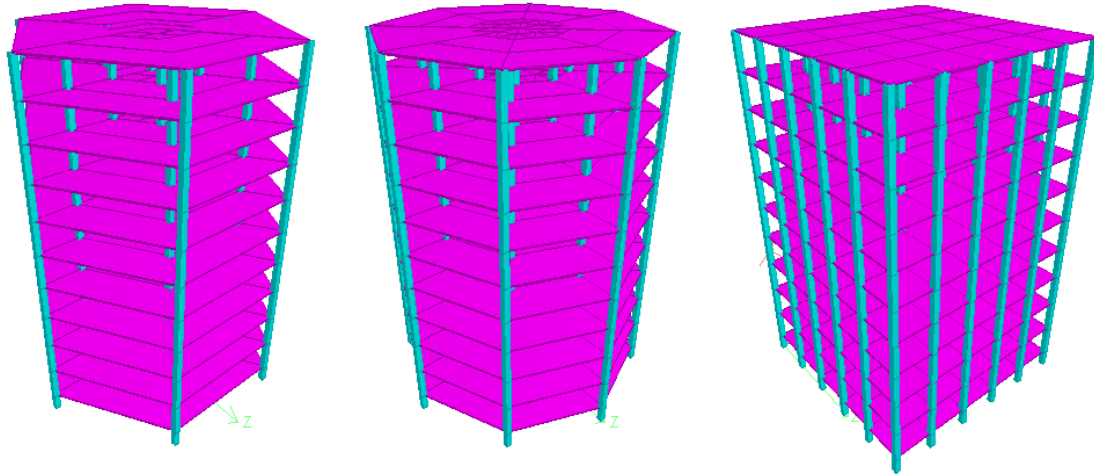


Figure 4: Flat Slab System

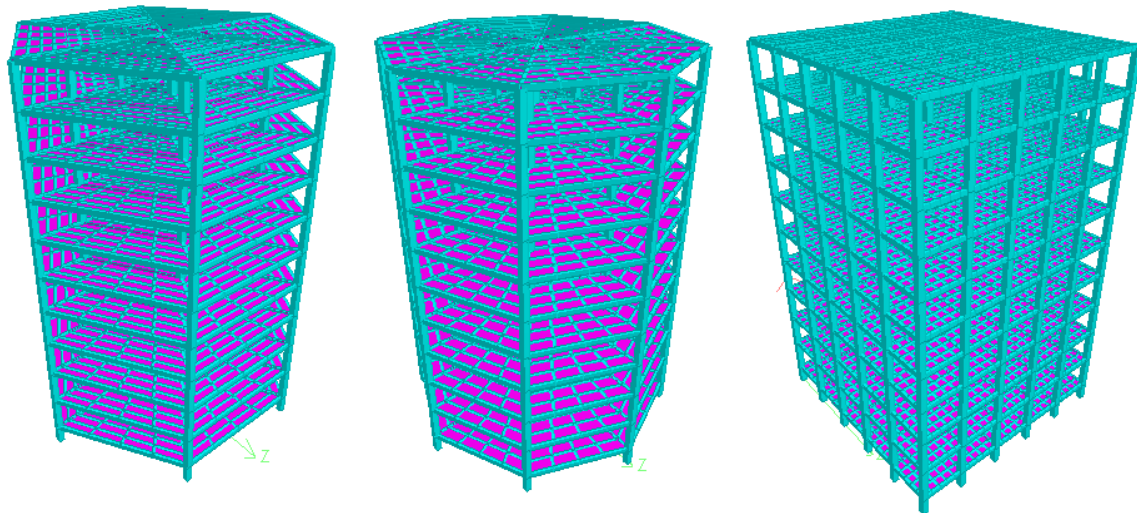


Figure 5: Grid Slab System

VI. SUGGESTED APPROACH

It is evident that the performance and structural characteristics of Flat Slabs & Grid Floors are superior to conventional slabs. It is observed not only in terms of deflection but also in terms of its material cost. Therefore, different tests need to be carried out to evaluate the performance of these 3 slab systems and give us an idea about the performance. To do so, we are going to model 3 various structures, each having a different slab system and geometry and compare them to get the best slab system available. The points considered to prepare a comparative study are Concrete used, Steel used, Bending in Y direction, Bending in Z direction, Slab Stresses and Overall Displacement.

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