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"Analysis of a Multistorey Building with Grid slab in Different Seismic Zones by using ETABS"

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Abstract - *Grid slab/Waffle slab/Ribbed slab is the floor slab which consists of the beams spaced at regular intervals in perpendicular directions which are monolithically built with the slab. Generally these slabs are used for architectural purposes for the larger span requirements such as auditoriums, public assembly halls, showrooms, function halls, theatre halls which covers a larger column free space area. Grid slab provides more stiffness so that the rectangular voided pattern grid slab is analysed in the present project. In the present project G+8 building having 3m storey height is considered which is analysed for both gravity and seismic loading conditions as per the IS code books such as IS 456:2000 and 1893:2000 by considering the medium soil condition. Analysis with respect to the seismic activity is performed by adopting the Response Spectrum method. Here the seismic analysis is conducted for the different seismic zones such as zone II, zone III, zone IV and zone V by considering the different seismic zone factors as per IS 1893:2000. From the tables and graphs of this Grid slab structure's displacement, story shear, auto lateral loads and maximum story drift result values we can conclude the status of different story responses.*

Key Words: Grid Slab, Waffle slab, Zones, Ribs, Drop, Response Spectrum, Story responses, Seismic zone factors

1. INTRODUCTION

Today the world is handling some of the major complications induced by the nature. Earthquake is one of those major complication effecting the nature. Hence the seismic analysis is one of the important factor to consider for the structural analysis and design to safe the structure against collapse causing due to earthquake which may occur during the structure's life.

Generally the construction of frames includes slabs, beams and columns. But a frame structure can be construct only with slabs resting on columns without the beams. The slabs using here are the flat slabs in which the load from the flat slab transferred directly to the columns then to the foundation.

Similarly Grid slabs which are having internal ribs with or without drop panels also directly rests on the columns to get the free column space area.

1.1 Grid Slab

Grid slabs or Waffle Slabs are the slabs which are having the internal ribs connecting at the regular interval spacing in the perpendicular directions, directly resting on the columns with or without having the drop panels to get the large column free space area.

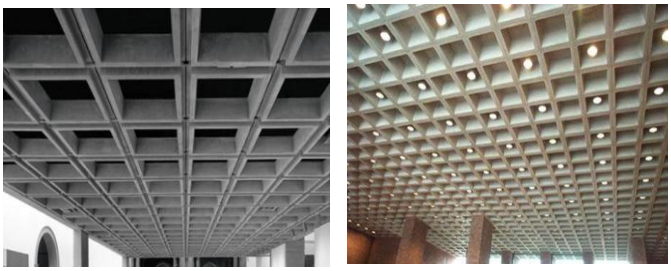

Fig-1: Grid Slab

They are mainly adopted for the architectural purposes such that where the large room space area mainly requires such as in theatre halls, in auditoriums, lobbies, large showrooms etc., The voids present are generally square or rectangle shapes in the ceiling are utilize to adopt the various architectural lightings and other purposes.

Types of Grid slab generally used are

1. Rectangular grid 2. Skewed Grids 3. Curved surface Grids

1.2 Features of Grid Slab

- All the elements of the waffle slab system contributes for the load collecting capacity.
- Here the loads from the slab distributed uniformly into the below supports.
- Grid slab reduces the cost of supporting elements especially when the application of heavy moving loads to the Grid (Ex: Overhead moving cranes).
- Here the deflection of slab is very less or reduced as compared to the conventional slab structure.
- The voids or openings which are present between the internal ribs in the grid slab helps to utilizing for the easy insertion of the Electrical and Mechanical systems.
- Grids provide good vibration control capacity.
- Grids gives attractive experience when exposed.
- Shrinkage of Grid slab is low compared to other slabs.

1.3 Uses of Grid Slab

- These are adopted for the ceiling and also for the floors.
- Adopted in the special projects like large empty rooms or space requirement areas, where there is a need of very low deflections in the floor, need to reduce the vibration frequencies.
- They are also used in airports, industrial, commercial buildings, residences, parking garages and many more constructions where the extra stability is required.
- Waffle slab provides good capability resistance for the sag and cracking. It also bears more amount of load as compared to the conventional slabs.

2. LITERATURE REVIEW

Abhishek Arya, Lovish Pamecha investigates and contrasts how multi-storey buildings with slabs with beams, flat slabs with and without drops, and grid slabs behave when subjected to seismic loading, and observes the influence on metrics such as lateral displacement and storey drift. Three examples of multi storey buildings 10, 15, and 20 stories are taken into consideration for this purpose. All three cases are taken into consideration to have a conventional frame, a flat slab with and without drops, and a grid slab system. The Staad-pro software is also used to analyse each case for zone III, IV and V. According to observation, flat slab systems are more flexible for seismic loadings than other slab systems. According to the analysis's outcome parameters, the building's lateral displacement and storey drift increase from lower to higher zones since the intensity's magnitude will be greater in higher zones.

Umamaheswara Rao Tallapalem, Gopi Pagidimarry, Nurulla Shaik entitled as , "Analysis of Multi-storey Building in Different Seismic Zones of India" studies that The building's base shear is higher in seismic zone V than in seismic zones II, III, and IV according to an analysis of the structure in several seismic zones across India. Zone-V Floor Displacements are higher than Zone-II, Zone-III, and Zone-IV Displacements. Based on the zone factor, base shear, displacements, support reactions, and steel quantity are more prevalent in zone-v.

3. OBJECTIVES

1. Creation of 3D Multi-story Grid slab structure model for the idealization to analyse the seismic method using ETABS.
2. To study the seismic evaluation method for the Grid slab structure by adopting the Response Spectrum method as per IS: 1893-2000.
3. Performing the seismic analysis of this multi-storied building (G+8) to evaluate the story drift, displacements, story shear and auto lateral loads parameters in different seismic zones 2,3,4 and 5 using this RS method.
4. To conclude the status of different story responses at different zones from the final comparison graphs.

4. METHODOLOGY

The structure's behaviour, structural components, external action, and the model type chosen can all be taken into consideration when analyzing it. Analysis with respect to the seismic activity is performed by adopting the Response Spectrum method. The peak responses of a building structure model are plotted directly from the earthquake reactions in this linear dynamic analysis method. With this technique, the maximum response which can be defined as the maximum relative displacement or maximum relative velocity is displayed versus the undamped natural time and for different damping values.
Grid slab provides more stiffness so that the rectangular voided pattern grid slab is analysed in the present project. In the present project G+8 building having 3m storey height is considered which is analysed for both gravity and seismic loading conditions as per the IS code books such as IS 456:2000 and 1893:2000. Here the Grid slab structure is analysed using the ETABS which is a FEM based structural software by considering the medium soil condition. Steps includes,
1. Modeling 2. Analysis Phase (RS method) 3. Design Phase

4.1 Building Description

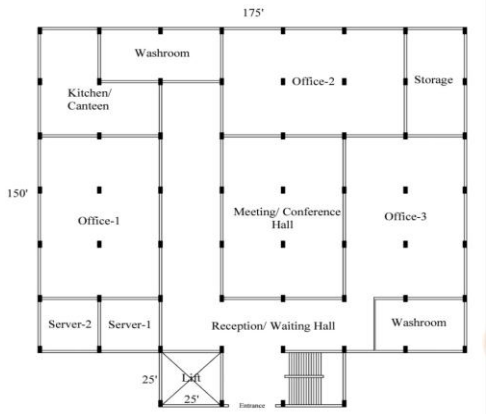

Fig-2:2D Plan Layout

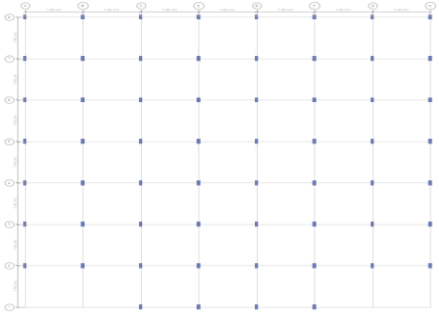

Fig-3: Column Layout

4.2 Data Taken for the Analysis

RCC Structure:
Plan Dimension : 53.34m X 53.34m
Number of stories : G+8
Each Story height : 3m
Grade of concrete : M40
Grade of steel : Fe550
Span Length in Both Direction of slab : 7.62m
Column (Story 2 to 9) : 450×900 mm
Column (Story 1) : 600×1200 mm
Grid Slab:
Overall Depth : 400mm
Slab Thickness : 150mm
Depth of Rib : 250mm
Width of Rib at top : 200mm
Width of Rib at bottom : 200mm
Ribs spacing in both directions : 750mm
Drop Panel:
Total Slab Thickness at drop : 400mm
Drop at Interior : 2500x3000mm
Drop at Edges : 1500x3000mm
Drop at corners : 1250x1750mm
Others:
Shear wall for the Lift : 300mm
Staircase (One Way Load Distr) : 150mm
Load Patterns
Live load : 1.5 kN/m³
Dead load : 1 kN/m³
Code Details for RCC: (IS: 1893:2002 Part II)
Seismic Zones : II, III, IV and V
Seismic zone factors : 0.10, 0.16, 0.24, 0.36
Importance factor : 1.5(Refer table 6)
Response Reduction Factor : 3.0(Refer table 7)
Soil condition type : Medium
Structure type : RC Frame structure

5. MODELING AND ANALYSIS

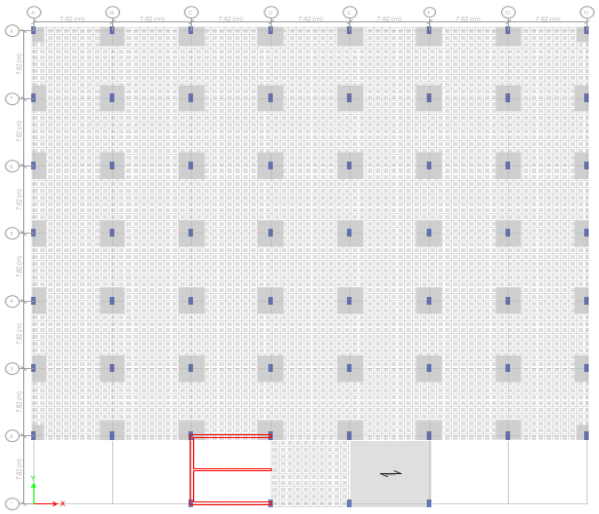

Fig-4: 2D frame layout

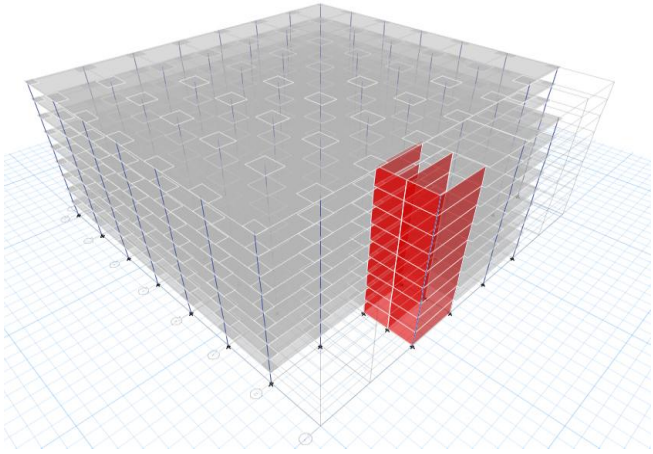

Fig-5: 3D Model

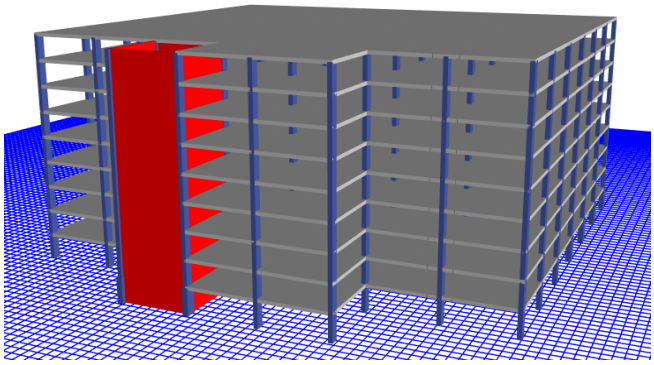

Fig-6: Rendered Model

5.1 Analysis Results Comparison

MODEL	X-in mm	Y-in mm
ZONE 2	15.042	11.99
ZONE 3	24.068	19.184
ZONE 4	36.102	28.776
ZONE 5	54.153	43.164

Table-1: Displacement Results

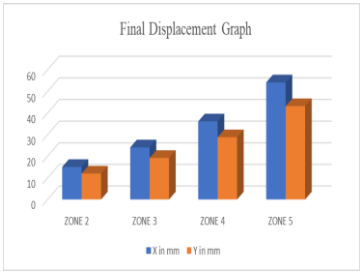

Fig-7: Displacement Graph

MODEL	X-in kN	Y-in kN
ZONE 2	4252.1163	7133.6507
ZONE 3	6803.3861	11413.841
ZONE 4	10205.079	17120.762
ZONE 5	15307.619	25681.142

Table-2: Story Shear Results

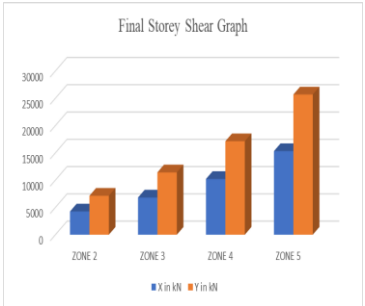

Fig-8: Story Shear Graph

MODEL	X-in kN	Y-in kN
ZONE 2	1336.197	2734.63
ZONE 3	2137.916	4375.41
ZONE 4	3206.873	6563.1
ZONE 5	4810.31	9844.67

Tab-3: Auto lateral Load Results

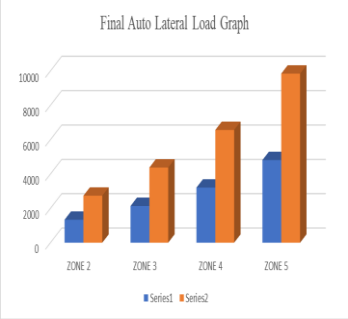

Fig-9: Auto lateral Load Graph

MODEL	X	Y
ZONE 2	0.00101	0.00071
ZONE 3	0.00162	0.00113
ZONE 4	0.00242	0.0017
ZONE 5	0.00364	0.00255

Table-4: Story Drift Results

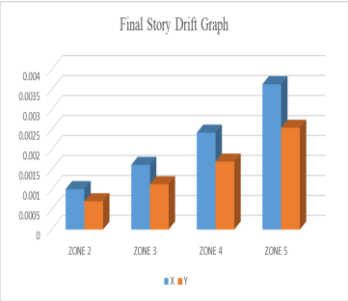

Fig-10: Story Drift Graph

5.2 Response Spectrum values

The Response Spectrum method of Analysis of this Multi story Grid slab structure from the history it always varies as per the structure and its elements but here we can clearly say that the scale factor remain constant for all the different seismic zones indicating the Base Reaction passes the 84% minimum criteria and also according to Response Reduction factor, Modal Participating Mass Ratio is greater than 90%.

6. CONCLUSIONS

1. From this study of final comparison of analysis of a multi-story building with Grid slab at different seismic zones we can clearly conclude that for the Displacement, Story Shear, Auto Lateral Loads, Maximum Story Drift parameters increases as the zone values increases i.e., from the Zone-2 to Zone-5. Here Zone-5 have higher of these parameter values compared to other zones. These parameter values are increased by about more than 72% from Zone-2 to Zone-5.

2. This linear increase in these all parameter values of a Grid slab building structure with respect to the zones implies that this structure with inner core can withstand in all the zones we considered.

3. Also from bar graph/charts for the Displacement, Story Shear, Auto Lateral Loads, Maximum Story Drift parameter values of the Grid slab structure we can clearly see that the graph linearly increases as per the zone values. Hence we can see the stability of the Grid slab structure without any variation the values are constantly varying.

4. The Response Spectrum method of Analysis of this Multi-story Grid slab structure from the history it always varies as per the structure and its elements but here we can clearly say that the scale factor remain constant for all the different seismic zones indicating the Base Reaction passes the 84% minimum criteria and also according to Response Reduction factor, Modal Participating Mass Ratio is greater than 90%.

5. So from the above all parameters we can finally conclude that the Multi-story Building with Grid slab structure is more safe at zone 2 as compared to that of all other Zones. Because, the magnitude of intensity is more for the upper zones.

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