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Analysis of G+12-Structure under Different Slab Conditions Using ETABS

Soha Khanam*, Swathi. V**
*(M. Tech Student, Department of Civil Engineering, VJIT, Hyderabad, India
** (Assistant Professor, Department of Civil Engineering, VJIT, Hyderabad, India

ABSTRACT
In every aspect of human civilization, we need building structures to live. But to build efficient structures so that they can fulfill the main purpose for what it is made. The analysis is the process of determining the behavior of the structure under specified load combinations. The demand for multistorey buildings is increasing day by day. The building may be residential or commercial. The principal purpose of this paper is to summarize a report on the analysis of different types of slab arrangements such as Conventional slab, Flat slab, Waffle slab, and Ribbed slab concepts by different researchers. The effect of seismic and wind forces on structures has been analyzed by ETABS software. The analysis is done as per IS-456-2000 code.M25 grade of concrete and Fe-500 steel is adopted. There are several concerns that affect the performance of structure from which story drift, base shear, and story displacement play a crucial role in finding the behavior of structure against wind and seismic loads. Results are conveyed in the form of tables and charts. Conventional slab, Flat slab with drop panels, Grid/ Waffle slab, and Ribbed slab. The effect of seismic and wind forces on buildings with different slab arrangements has been analyzed utilizing ETABS software. The review paper concluded that a Flat slab can be more effectively used for the multistorey building. The use of conventional slab increased stiffness, increased weight carrying ability, as well as being safe and cost-effective, and Economical. The use of Waffle or Grid and ribbed slab can be used for high-rise structures and is stable and economical because of the more resisting moment capacity of the slab.

Keywords - Flat slab, Conventional slab, Waffle slab, and Ribbed slab, Storey Drift, Storey Displacement, Base Shear, ETABS.

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I. INTRODUCTION

There has been an increasing demand for the construction of tall buildings due to ever-increasing urbanization and an increase in population. In urban areas due to the scarcity of space vertical construction has developed such as low-rise, medium –the rise and high-rise buildings. These types of buildings utilize frame structures such as Conventional RC frame structures and Flat slab frame structures. Different types of slabs as an excellent option for architects when a larger span in a building must be covered with the least possible number of columns. As such, Waffle, Ribbed, and Flat slab are evolving as a new trend and are becoming a big challenge for structural engineers. Before the construction of any high-rise buildings, the building should be analyzed under seismic loads and wind loads. When evaluating a building's stability against seismic load and wind load, base shear, storey displacement, storey drift, and lateral forces acting on the structure are crucial. The computer-based analysis is preferred in the case of complex types of structures over manual analysis to gain more accurate results

Types of Slabs

"**1. Flat Slab**", Flat slabs also known as beamless slabs are the type of slab in which the floor slab is supported directly on columns without the action of beams or girders. Building in-situ concrete frame buildings are best accomplished with thin flat slabs that range in thickness from 5 to 9 meters. These slabs are typically used on parking decks, commercial buildings, hotels, or places where beam projections are not desired. The flat slab is reinforced by re-bars, thus forming an RC slab with or without a drop, generally retained by columns and slab. The whole slab rests on these column heads and column strips and acts as a diaphragm. These structures are vulnerable to dynamic earthquake forces so analysis regarding the dynamic earthquake behavior of the structure must be done before designing these structures in earthquake-prone areas.

"**2. Conventional Slab**", The conventional slab is used for construction that accomplishes a system where a slab is resting on ordinary beams and columns. In conventional slabs, load transfers from slab to columns, Columns to beams, and beams to Foundation. This may be called the Beam –Slab Load Transfer method, a technique that is common practice all over the world.

"**3. Waffle Slab**", A waffle slab is made of reinforced concrete slab with concrete ribs running underside in two directions. Due to the grid arrangement generated by the R.C. ribs is named as waffle. It is also known as a two-way joist slab. The slab has two parts. Part one is on the top side which is a flat surface and the second part at the bottom consists of joists creating a grid-like structure. The grid appears when molds are removed from it. It is also used when heavy loads are acting on the structure. Under the effect of rigidity, this type of Slab is used when buildings require minimal vibration, such as used for laboratory, and manufacturing facilities. Grid slabs are often used for industrial and commercial buildings. It is used where column spacing is more and can be constructed quickly when compared to a conventional slab. The height of a flat slab is less when compared with a grid slab.

"**4. Ribbed Slab**",The slab system consists of a series of parallel reinforced concrete which in turn are supported by a set of beams, the extended part is known as the ribs. The spacing between the ribs should be in general 20-30 inches. The lowest part of ribs are tapered in cross-section. The advantage of a ribbed slab is reducing the weight achieved by removing part of the concrete below the neutral axis. Ribbed slabs are integrally cast slabs with a number of closely spaced joists that are supported by a set of beams.

Etabs Overview

The ultimate comprehensive software programme for the structural analysis and design of buildings is the innovative ETABS. This most recent version of ETABS, which draws on 40 years of ongoing research and development, provides unparalleled 3D object-based modelling and visualization tools, lightning-fast linear and nonlinear analytical power, sophisticated and thorough design capabilities for a variety of materials, and perceptive graphic displays, reports, and schematic drawings that help users quickly and clearly understand analysis and design results.

II. OBJECTIVE OF WORK

The following are the main goals of this project:

Analysis of a structure by Response spectrum method by using ETABS.

To analyze a G+12 structure for Zone-III and comparison for commercial buildings.

To study the behavior of the commercial structure under different types of slab conditions.

To compare the different parametric results such as storey displacement, base shear, storey drift, and quantity of concrete.

III. METHODOLOGY

The Analysis of Regular commercial G+12 storey structures with different types of slab systems flat slab, conventional slab, waffle slab, and ribbed slab are considered. For this analysis, the dimensions of the building are taken as 36m in length and the width of the building is 36m considered. The height of the building is considered 35.5m. Fixed types of support conditions are considered. ETABS software is used to model and analyse the building. Seismic analysis is also performed to determine whether the structure is safe. To determine the values of storey drift, base shear, and storey displacement, by using response spectrum method.

IV. MODELLING AND ANALYSIS

A G+12 structure was modeled in ETABS. All 4 structures are separately modeled and analyzed by the Response Spectrum Method. The models created in ETABS software by assigning proper

Material properties and columns are assigned and fixed support at the base. The plan is designed and is used for all models i.e., flat slab structure with a drop cap, conventional slab structure, waffle slab structure, and ribbed slab structure. The plan and

3-Dimensional view of the building is shown in bellow figures.The entire 4types of structural characteristics are shown in the below tables. All the structures are checked for various load combinations as per IS codes for analysis.

Types of Models for Analysing the Structure
Where,
Model – 1: Flat Slab with drops
Model – 2: Conventional Slab
Model – 3: Waffle Slab
Model – 4: Ribbed Slab

Table:1 Common Building Parameters

PARAMETER	ASSUMED DATA
Number of storeys	G + 12
Utility of Building	Commercial
Structure Type	Rigid frame
Spacing along the X-direction	6m
Spacing along the Y-direction	6m
Height of the building	35.5m
Individual storey height	3m
Total span of building	36m

Table:2 Material Properties

PARAMETER	VALUES
Material	Concrete
Grade of concrete	M30
Grade of steel	HYSD500

Table:3 Seismic data for G + 12 building

PARAMETER	VALUES
Seismic zone	Zone III
Seismic zone factor, Z	0.16
Importance Factor, I	1.0
Response reduction factor, R	3
Site type	Medium stiff (II)

Table:4 Structural Properties of All Models

MODEL-1: FLAT SLAB WITH DROPS		
S.No	**PARAMETER**	**VALUES**
1	Slab Thickness	125mm
2	Beam Size	No beams
3	Thickness of Drops	300mm
4	Drop Size	2mX2m
5	Number of Columns on One Floor	49
MODEL-2: CONVENTIONAL SLAB		
1	Slab thickness	125mm
2	Beam Size	300mmX450mm
3	Column Size	600mmX450mm
4	Number of Columns on One Floor	49
MODEL-3: WAFFEL/GRID SLAB		
1	Slab Thickness	70mm
2	Beam Size	300mmX450mm
3	Column Size	600mmX450mm
4	Stem width at Top	120mm
5	Stem width at Bottom	100mm
6	Spacing of stem along the X-direction	600mm
7	Spacing of stem along the Y-direction	600mm
8	Number of Columns on One Floor	49
MODEL-4: RIBBED SLAB		
1	Slab Thickness	70mm
2	Beam Size	300mmX450mm
3	Column Size	600mmX450mm
4	Stem width at Top	120mm
5	Stem width at Bottom	100mm
6	Spacing of stem along the X-direction	600mm
7	Spacing of stem along the Y-direction	600mm
8	Number of Columns on One Floor	49

Types of Models for Analysing the Structure:

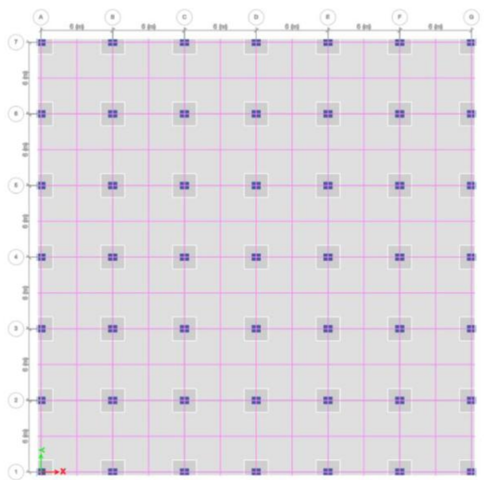


Fig:1Flat Slab -Plan view

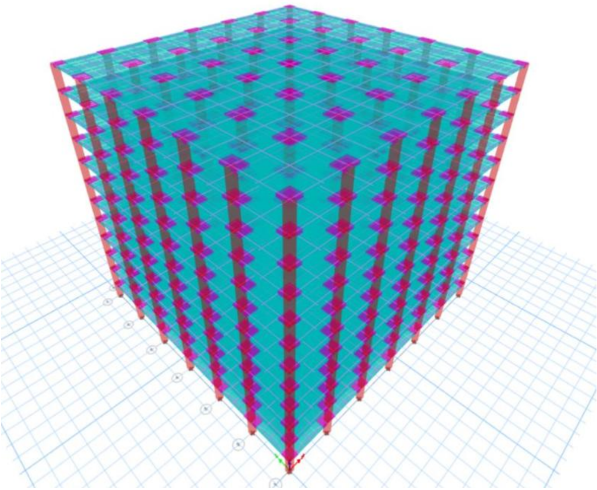


Fig:2Flat Slab – 3D view

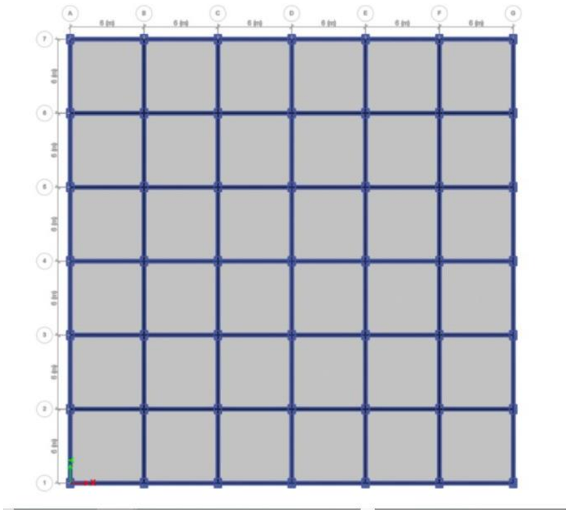


Fig:3Conventional Slab -3D view

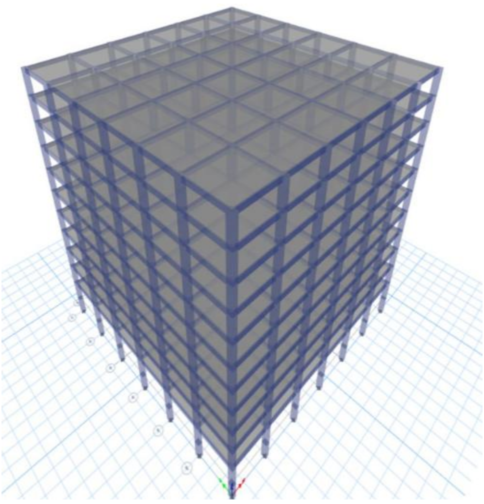


Fig:4Conventional Slab -3D view

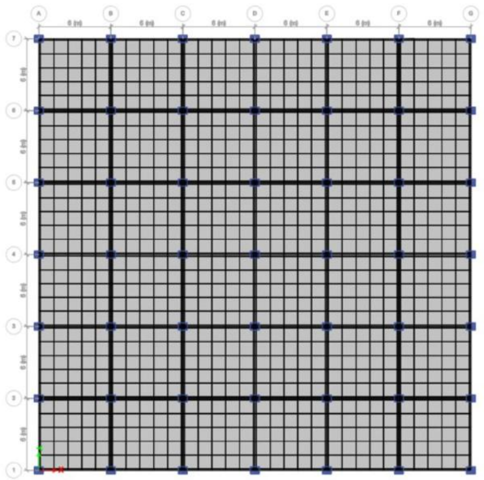


fig:5Waffle Slab - Plan view

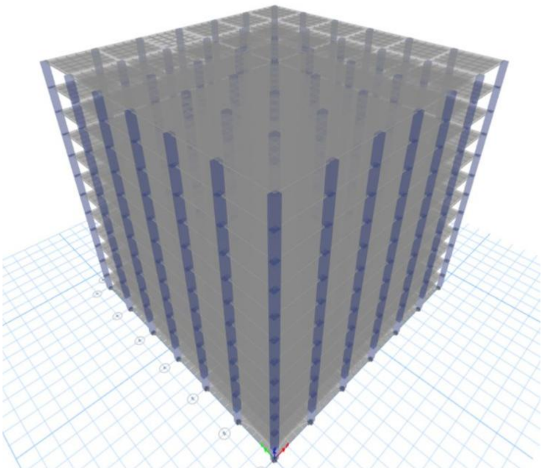


Fig:6Waffle Slab -3D view

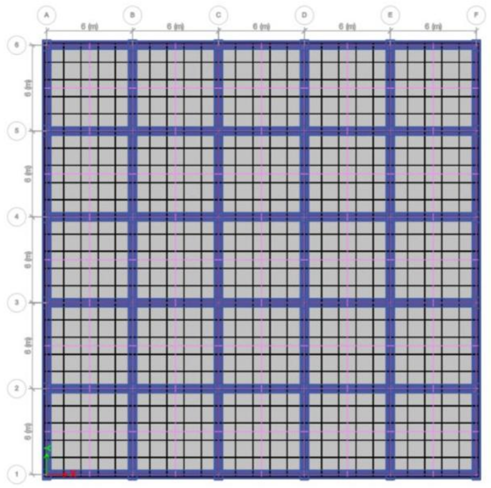


Fig:7Ribbed Slab -Plan view

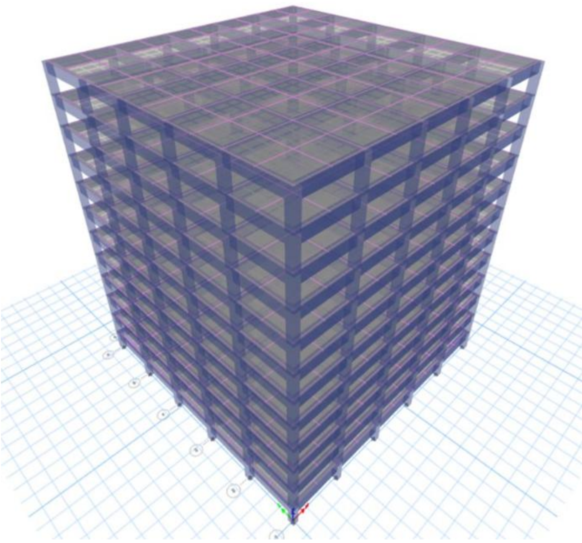


Fig:8Ribbed Slab -3D view

V. RESULTS

The summary of project after analyzing the G+12 structure under different slab conditions using various load combinations following conclusion have been made.

Storey Displacement: Storey displacement is also called lateral displacement or sway of the building. It is defined as displacement taken in the lateral direction of the building due to wind load and seismic load that acts in the lateral direction on the building.

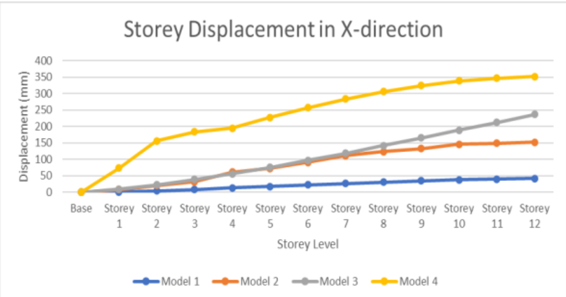
Storey displacement is tabulated below for all models and given a graphical representation of both the X-Direction and the Y-Direction

Table:5 Storey displacement in X Direction

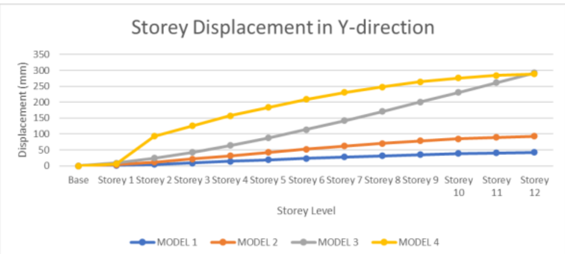
STOREY Number	MODEL 1 (mm)	MODEL 2 (mm)	MODEL 3 (mm)	MODEL 4 (mm)
Base	0	0	0	0
Storey 1	1.036	7.959	9.113	73.163
Storey 2	4.135	20.835	22.525	156.255
Storey 3	8.289	31.393	38.321	183.523
Storey 4	12.917	61.206	56.167	194.861
Storey 5	17.683	72.458	75.733	227.493
Storey 6	22.367	91.214	96.701	257.744
Storey 7	26.805	110.929	118.764	283.865
Storey 8	30.864	123.85	141.638	306.055
Storey 9	34.425	132.869	165.067	324.534
Storey 10	37.401	145.715	188.833	338.951
Storey 11	39.752	148.625	212.764	347.342
Storey 12	41.556	152.07	236.749	352.586

STOREY Number	MODEL 1 (mm)	MODEL 2 (mm)	MODEL 3 (mm)	MODEL 4 (mm)
Base	0	0	0	0
Storey 1	1.181	3.094	9.146	5.734
Storey 2	4.588	11.275	23.867	93.285
Storey 3	8.992	21.101	42.193	125.294
Storey 4	13.778	31.558	63.618	156.964
Storey 5	18.629	42.091	87.647	183.679
Storey 6	23.35	52.326	113.794	208.794
Storey 7	27.797	61.968	141.599	230.619
Storey 8	31.844	70.752	170.63	248.333
Storey 9	35.371	78.435	200.5	264.408
Storey 10	38.276	84.809	230.88	275.756
Storey 11	40.503	89.774	261.511	283.892
Storey 12	42.11	93.472	292.224	288.799

Table:6 Storey displacement in Y Direction



Graphical representation of Storey displacement in X Direction



Graphical representation of Storey displacement in Y Direction

From the grapgh ,Storey displacement is least in Flat slab and maximum in Ribbed slab. In waffle slab we can see slightly increasing the value of storey displacement.

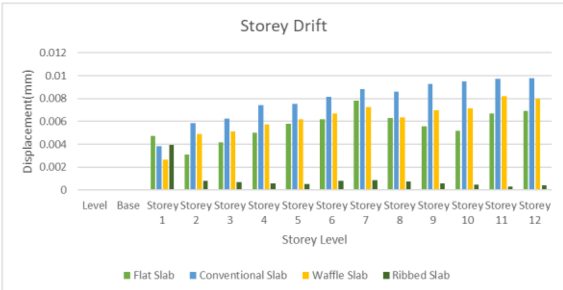
Storey Drift: Storey drift is the relative displacement taken between two consecutive floors to the height of the building. It is also defined as the lateral displacement of a single-story that occurs in a multistorey building.

The result obtained from the analysis has been

STOREY Number	MODEL 1 (mm)	MODEL 2 (mm)	MODEL 3 (mm)	MODEL 4 (mm)
Base	0	0	0	0
Storey 1	0.00471	0.00385	0.002659	0.00393
Storey 2	0.00311	0.005848	0.004907	0.0008151
Storey 3	0.00417	0.006253	0.005109	0.0007131
Storey 4	0.00501	0.007432	0.005719	0.0006121
Storey 5	0.005801	0.00755	0.006209	0.0005118
Storey 6	0.00617	0.008149	0.006716	0.000794
Storey 7	0.00781	0.008813	0.007268	0.000871
Storey 8	0.00631	0.008595	0.006377	0.000744
Storey 9	0.00559	0.009282	0.006957	0.000603
Storey 10	0.00519	0.009502	0.007127	0.000461
Storey 11	0.0067	0.009731	0.00821	0.000315
Storey 12	0.0069	0.009798	0.007981	0.0004357

shown in a tabular form below.

Table:7 Maximum Storey Drift

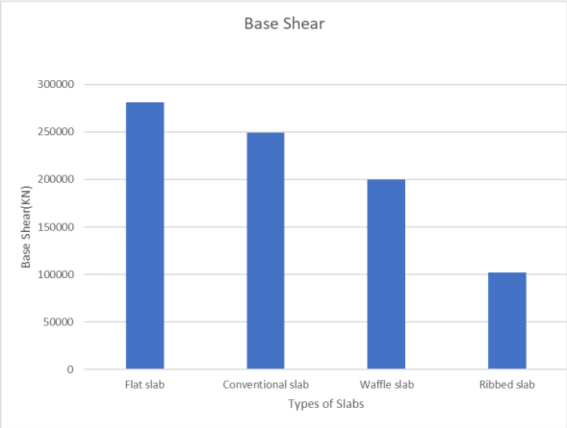


Graphical representation of Maximum Storey Drift

From the above graph we have concluded that storey drift has highest values for Conventional slab and lowest value is obtained for Ribbed slab. Minimum values are obtained for Waffle slab. Storey drift is Increasing with the height of the structure increases or number of storeys.

Base Shear: The maximum shear force at the base of the structure is termed as Base Shear. It depends on the lateral forces and dead weight of the structure. Based on the analysis results are shown in below table.

Table:8 Maximum Base Shear



Model	Max Base Shear
MODEL 1: Flat SLAB	281495.146
MODEL 2: Conventional Slab	249356.352
MODEL 3: Waffle SLAB	200090.902
MODEL 4: Ribbed Slab	102226.856

Graphical representation of Maximum Base Shear
Base Shear is Maximum for Flat Slab, Minimum for Conventional Slab and Waffle Slab and Least value we got for Ribbed Slab.
From the above data we can conclude that Building is more safe having Flat Slab.

VI. CONCLUSION

a. Storey Displacement is increasing with the height of the Structure. displacement is least in a Flat slab and maximum in Ribbed slab. In waffle slab, we can see slightly increasing the value of storey displacement.
b. Storey drift has the highest value for the Conventional slab and the lowest value is obtained for the Ribbed slab. Minimum values are obtained for Waffle slab. Storey drift is Increasing with the height of the structure increases or the number of storeys.
c. Base Shear is Maximum for Flat Slab, Minimum for Conventional Slab and Waffle Slab and Least value we got for Ribbed Slab.
d. Based on the Analysis buildings having Flat Structure have more stability, in Zone III.
e. For High Rise Structures, a Flat slab is more suitable when compared to Waffle and Ribbed Slab.
f. The building having flat slabs with drops is a more economical structure among all models which we have considered.
g. Waffle slabs have more load-carrying capacity than the other types of slabs when we have long spans.
h. The ribbed slab is also used for larger spans with light and moderate loads.

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