

Analysis of ribbed & Waffle Slabs with Design Loading Condition under Different Boundary Conditions

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ABSTRACT

When a large space within a building needs to be covered without hindrance and supports, architects often deploy waffle slabs to construct floors and ceilings. Structural designers analyse such slabs, assuming the grid work as simply supported system (all four edges) and deriving solutions based on displacement compatibility of beams or plates to arrive at an approximate solution or performing a detailed finite element analysis (FEM) of the slab beam system using any of the generalized finite element software available in the market. This is so because no analytical solution or quick computational tool exists, except for the case of slabs with all edges simply supported. In this study we are performing comparative analysis of ribbed and waffle slab to determine the most stable and distributive one in comparison. To validate the results, selected cases are compared with finite element analysis and results are compared in terms of forces, moment, displacement and drift in both direction.

Keywords: Bending moment, Deflection, boundary condition, Plate equations, Shape functions, Shear force, Waffle slab, Ribbed slab, Plate theory based on Timoshenko method.

I. INTRODUCTION

The primary function of floor and roof systems is to support gravity loads and to transfer these loads to other structural members such as columns and walls. Furthermore, they play a central role in the distribution of wind and seismic forces to the vertical elements of the lateral load resisting system. The effect of the slab panels is not considered in reinforced concrete structural analysis because designers neglect their contribution in lateral load resistance. Their contribution is neglected in the structural analysis because they show large complexity in structural behavior. Mostly, the construction carried out is reinforced concrete with slabs providing the useable floor area. During an earthquake, these slabs will increase the lateral earthquake load resistance significantly. As they form a large part of structural

system, therefore designers should get benefit from their large in plane stiffness. So in this study the response of two essentially same structures, with and without consideration of stiffness of slabs were evaluated and compared on the basis of different structural parameters. Reinforced concrete slabs are widely used in the concrete constructions. In structural analysis, the torsional stiffness of slab is ignored in common. When this stiffness is taken into account, the exact theory of bending of elastic plates shows that the twisting moment relieve the bending moments about 25 percent and this decreases the reinforcement requirement of the structure.

Slabs are the auxiliary components that convey the extra dead and live loads in various structures. They are utilized in buildings, ways and extensions. For the most part, they can be ordered to one way and two

different ways frameworks. One path slabs with beams in a single heading are usually utilized for little ranges up to six meters. Two-path slabs with beams and without beams are utilized for bigger ranges. Two-way slab frameworks are for the most part used to oppose high loads or they are utilized when there are enormous ranges to limit the slab thickness and to diminish the inner powers in the slab and to restrict the slab diversion. It isn't unexpected to have two-route slabs in stopping floors as the ranges are long and they may reach around nine meters or more.



Fig 1 : Structure with slab

WAFFLE SLAB: A waffle slab is a kind of slab with gaps underneath, giving an appearance of waffles. It is typically utilized where enormous ranges are required (e.g assembly room) to maintain a strategic distance from numerous sections meddling with space. Thus thick slabs traversing between wide beams (to keep away from the beams jutting underneath for stylish reasons) are required. Since the rigidity of cement is mostly fulfilled by the steel bar fortification, just the "ribs" containing the support are kept where the staying 'unused' solid bit underneath the unbiased hub is evacuated, to diminish oneself load of the slab. This is accomplished by putting mud pots or different shapes on the formwork before throwing of the solid.

RIBBED SLAB: Ribbed or waffle slab is a slab framework which comprises of arrangement of parallel fortified solid T beams encircling into strengthened solid braces. The slab is the spine of the

beam and the all-encompassing part is the web. The all-inclusive part is known as ribs. The separating between the ribs ought to be by and large 20-30 inch. The ribs are decreased in cross-area in its lower part.

In multi-storeyed surrounded building, harms from earthquake for the most part starts at areas of auxiliary shortcomings present in the horizontal burden opposing edges. This conduct of multi-story confined buildings during solid earthquake movements relies upon the conveyance of mass, solidness, quality in both the level and vertical planes of buildings. In not many cases, these shortcomings might be made by discontinuities in solidness, quality or mass along the stomach. Such discontinuities between stomachs are frequently connected with unexpected varieties in the edge geometry along the length of the building. Auxiliary specialists have created trust in the plan of buildings in which the dispersions of mass, solidness and quality are pretty much uniform. There is a less certainty about the plan of structures having unpredictable geometrical arrangements.

Objectives of the study:

The main aim of this study are as follows:

1. To evaluate performance of waffle & Ribbed slab under the design loading condition with different boundary condition .
2. To check performance of waffle & Ribbed slab with multistory building system with seismic loading performance .
3. To compare the behavior Waffle and Ribbed slab system under lateral load and review the performance.
4. To study advantages/disadvantages of waffle & ribbed slab in the form of cost stability & strength.

II. LITERATURE REVIEW

Atif et. al. (2019) ^[4] this research paper presented assessment on two different slabs namely Grid slab and Ribbed Slab constituting of ribs to evaluate seismic response as they were highly suitable and economical for construction of long span structures. The considered models in this examination were OMRF outline with sheer walls along with the selection of 4,6,8 number of the story by utilizing ETABS programming for investigating and structure, the pursued examination techniques were Equivalent static strategy, reaction range, and time history. The criteria for the analytical comparison were story float, base shear, time-period, story shear and axial force in the columns.

Vinit and Patel (2019) ^[17] the research paper valued the behavior of reinforced concrete waffle slab attributable to rhythmic activities of human beings and resonance. The specimen Waffle slab was modelled with the use Element Meshing Method using analytical programming “ETAB’s” with various aspect ratios. The analysis included two different dynamic procedures namely, Free Vibration analysis so as to attain natural frequencies and Mode Shapes and force Vibration was use to attain Maximum Displacement.

Abdulhameed et. al. (2017) ^[5] This research paper introduces the consequences of finite element investigation for two test apparatus (considered from other research works). This examination was based on the utilization of the Finite Element Method (FEM) by utilizing ANSYS (v.15) programming to investigate the rationality of experiments to confirm the legitimacy of FEM by correlation with exploratory outcomes. Besides, some parametric investigations on these works were done to cover the impact of some significant factors on ultimate load capacity and deflection which were not shrouded in the test work. The analytical reports of ANSYS programming for defined models presented great

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concurrency with the test results. Load-diversion curve for ANSYS models was found higher than the experimental curves. The normal estimation of the relationship factor was (98.85%) for the primary model and (73.7%) for the subsequent one. Results have demonstrated that the level of increment in firmness increments with an increase in the thickness of the slab, however, this expansion was administered by the separating between ribs.

Mohammed et. al. (2017) ^[12] this research paper was subjected to investigation of various stresses non-linear analysis of a one way ribbed reinforced slab of a ten storey structure when addressed to seismic loads The structures are generally designed so as to resist any form of lateral loads (seismic loading) with the use of elastic investigation considering all the about all experience significant inelastic distortions when exposed to intense earthquake tremors. The results led to the conclusion that one way ribbed slab reduces the stress and maximum displacement in comparison to traditional solid slabs and such reduction decreases simultaneously with increase in number of stories on the structure. Besides, even the value of stress in ribbed slab was less than that of stresses in traditional solid slabs.

Outcome of the Study:

The researchers have tried to find the variation in forces which occurs due to waffle and ribbed slab, following are the outcomes of literature review:

- 1 Determine that frames with different slab types shows variations as per structural geometry.
- 2 That structure considering diaphragm is more stable and symmetric.
- 3 Difference in frame without slab, flat slab and other diaphragm types.

III. METHODOLOGY

In this research work our motive is to evaluate seismic assessment ribbed slab and waffle slab over a symmetrical building considering dynamic loading to evaluate its strength.

In this study our main motive is to determine the capability or the design life of an RC building frame with two different slab for same geometrical data under dynamic loading using analysis tool ETABS.

Step-1: To configure Indian Provisions and unit data in ETABS.

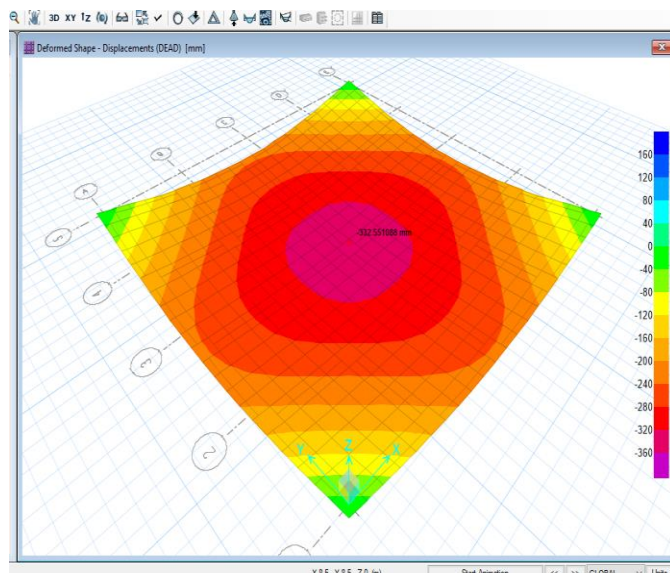
Step-2: To Assign Grid data using analysis tool ETABS.

Step-3: To Create materials as per Indian standards.

Step-4: To Define sectional data

Step-5: To Create building design

Step-6: Assigning slab type i.e. waffle and ribbed.



a. Ribbed Slab

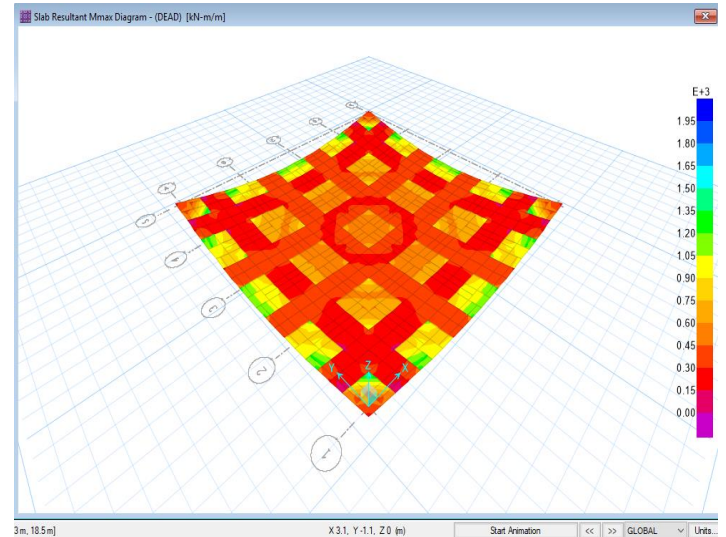


Fig 2 : Slab Configuration

b. Waffle Slab

Step-7: Assigning fixed end conditions.

Step-8: Define Loading Conditions

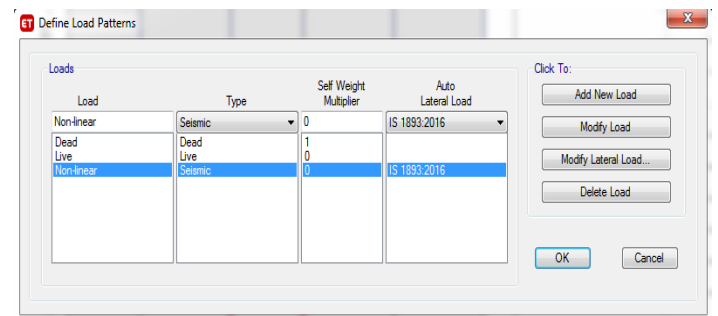


Fig 3 : Loading Conditions

Step-9: Assigning Load combination:

Step-10: Check complete modelling and boundary conditions of the structure and analyze the programme

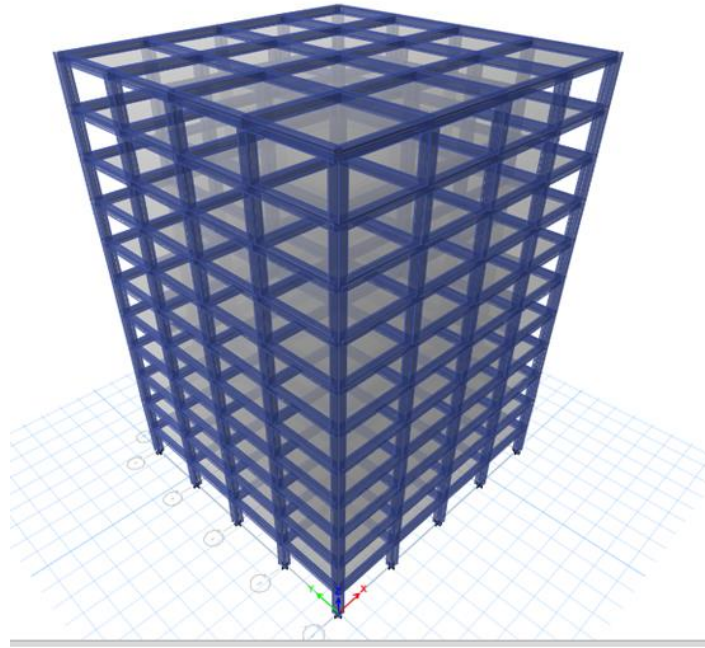


Fig 4 : 3d modelling of the structure

Step-12: Analysis considering boundary conditions and cases:

a. Analysis of Waffle Slab

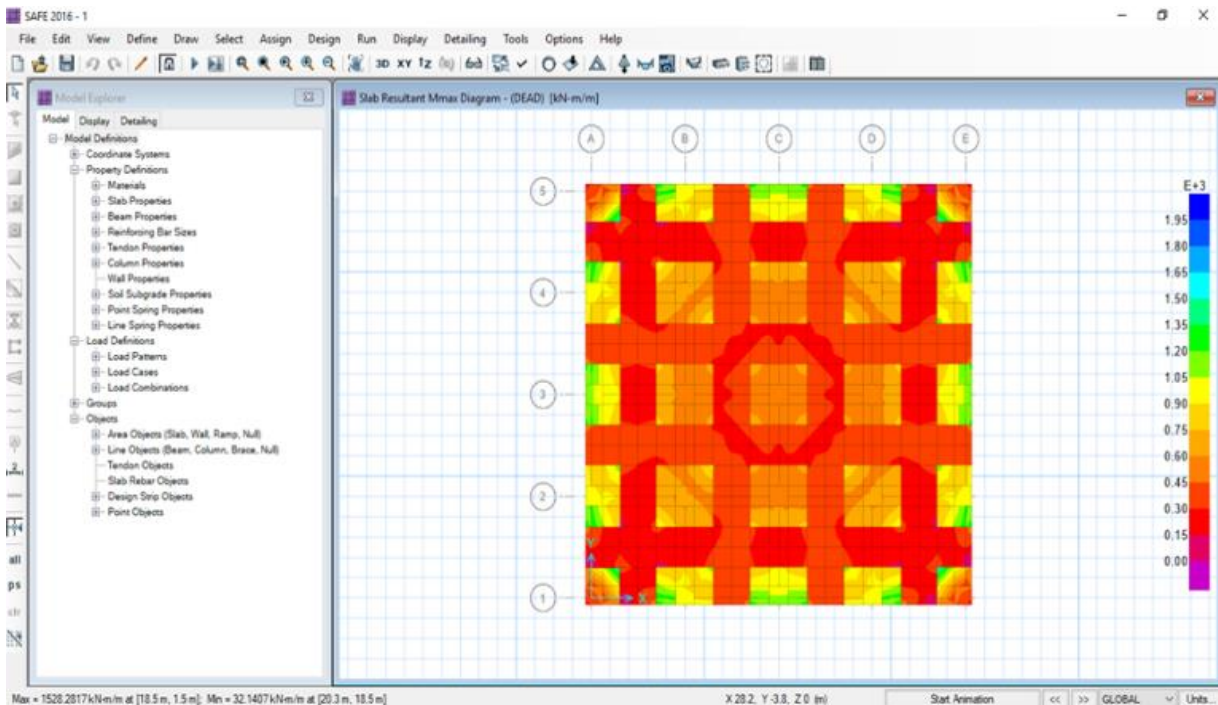


Fig 5. Analysis

b. Analysis of Ribbed Slab

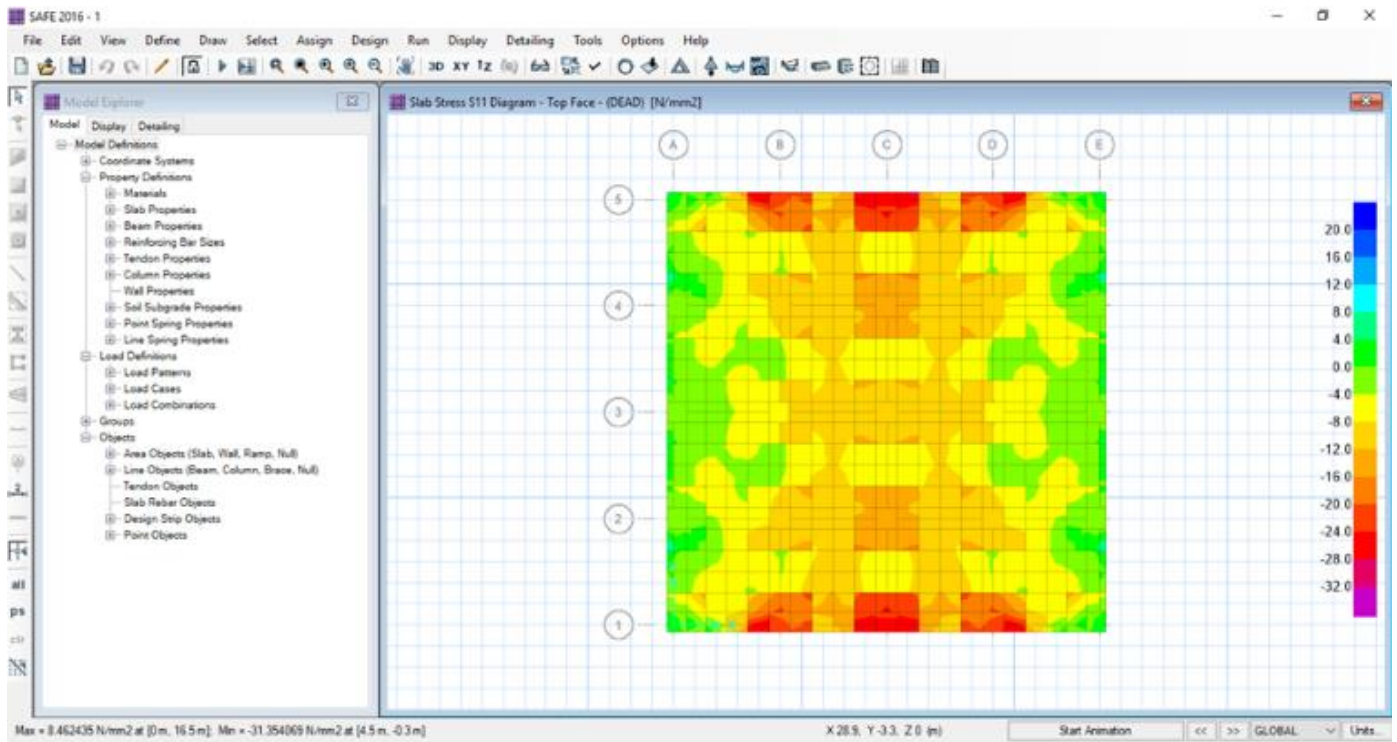


Fig 6 : Analysis of both Cases

Table 1: Geometrical details

SR .NO.	PARAMETER	SIZES
1.	SURFACE AREA OF SLAB	400 m ²
2.	FLOOR HEIGHT	3 m
3.	LIVE LOAD	3 Kn / m ²
4.	FLOOR FINISH	1 Kn / m ²
5.	SIZE OF COLUMN	500x500 mm
6.	SIZE OF BEAM	150x500 mm
7.	DEAPTH OF SLAB	150 mm
8.	DROP THICKNESS	500 mm
10.	ZONE	II
11.	IMPORTANCE FACTOR	1.2
12.	SOIL PROPERTY	MEDIUM SOIL

Analysis Result:

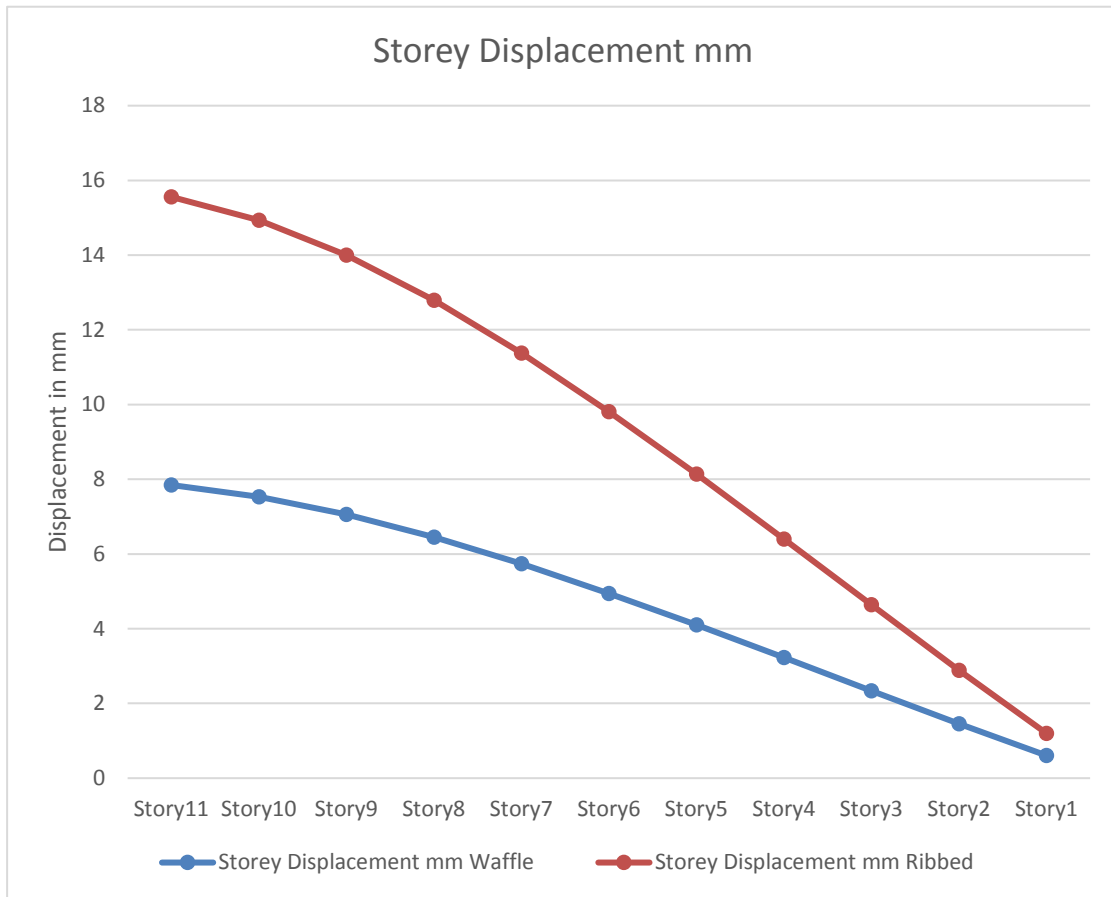


Fig 7 : Displacement in mm

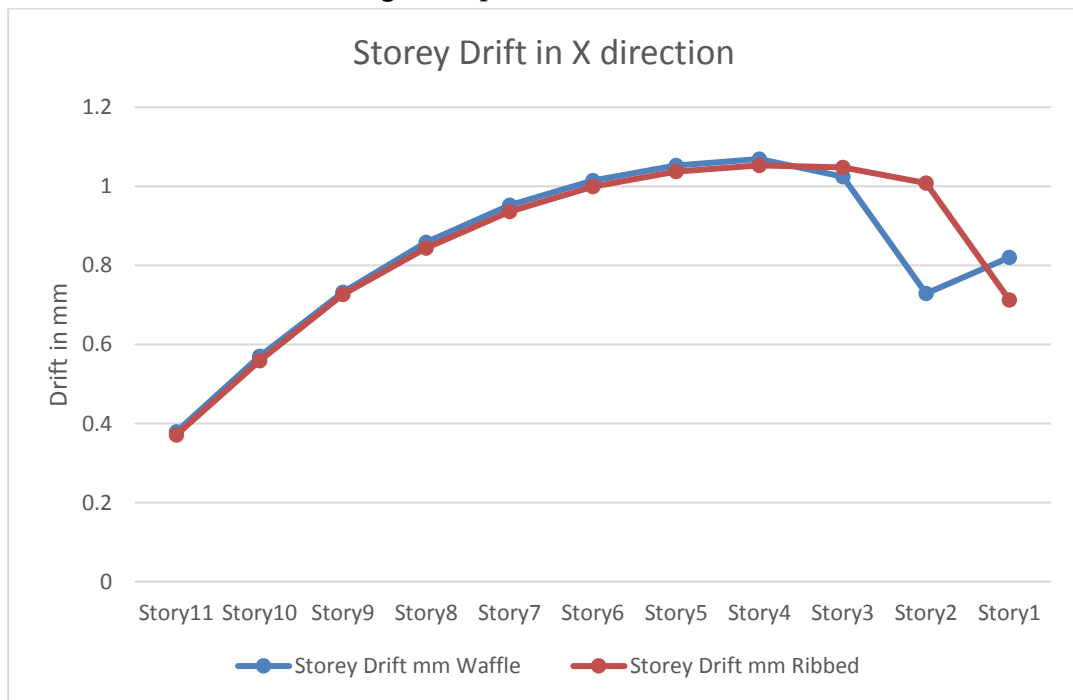


Fig 8 : Storey drift in X direction

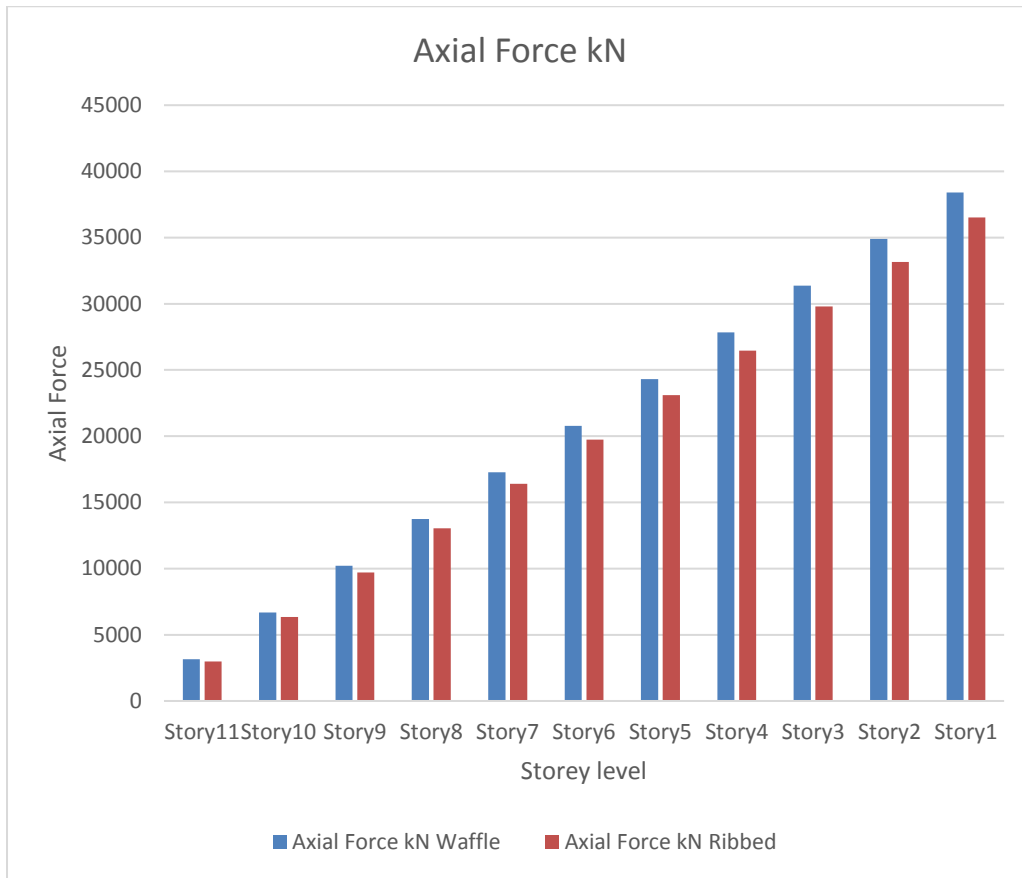


Fig 9 : Axial Force

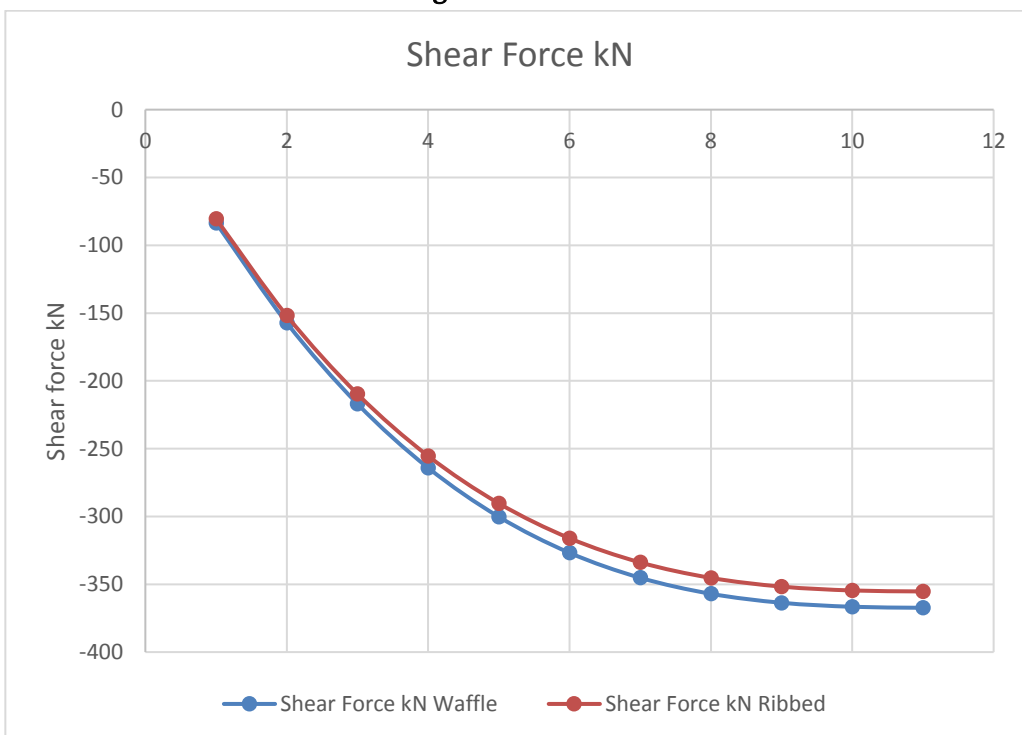


Fig 10 : Shear force

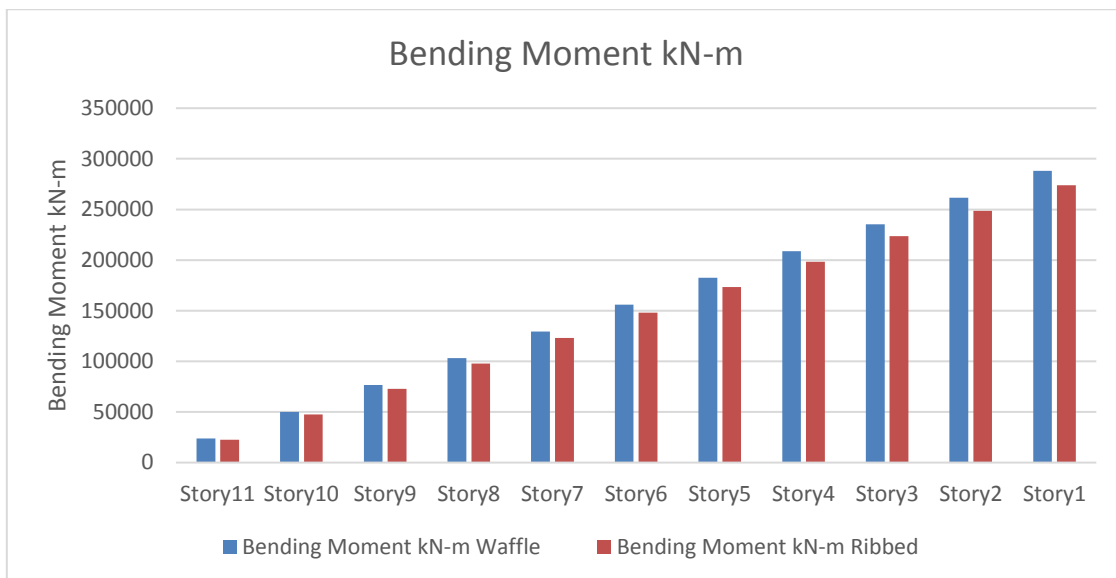


Fig 11 : Bending Moment kN-m

IV. CONCLUSION

Storey Displacement:

In terms of Storey Displacement it can be conclude that ribbed slab is more stable in resisting lateral deformation of the structure due to seismic forces. As observed in analysis waffle slab shows 7.8 mm displacement whereas ribbed slab shows 7.711 mm displacement.

Drift:

Drift can be defined as the relative displacement of two consecutive floors. It is observed that upto 6th storey waffle slab is working more stable but as floors are increasing ribbed slab become more resisting and stable. Maximum drift observed in waffle slab is 1.069 mm whereas in ribbed 1.053 mm is observed.

Bending Moment:

In terms of bending moment it can be said that ribbed slab is more effective as it is retraining moment by 6% which can be said as more economical and cost effective than waffle slab. As less moment results in less area of steel required. Waffle slab is showing 23740.96 KN-m whereas ribbed slab observed 22440.08 KN-m.

Axial Force:

In terms of Axial forces it is observed that the distribution of load become uniform and linear it case of ribbed slab whereas in waffle slab it is comparatively unstable. In terms waffle slab shows 3165.461 KN and ribbed slab shows 2992.011 KN.

Shear Force`:

In terms of shear force ribbed slab shows 83.47 KN whereas waffle slab shows 80.45 KN of unbalance forces over horizontal members i.e. beam. Thus it can be said that waffle slab is observing 4.6 % less unbalanced forces.

V. FUTURE SCOPE

- i) In the proposed work ribbed and waffle slab is considered whereas in future other types of slab can be consider for comparison.
- ii) In this study seismic analysis is considered whereas in future study wind load can be consider.
- iii) In this study analysis is done using etabs and Safe whereas in future SAP2000 can be prefer for P-delta analysis to determine the displacement force graph.

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