International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 8 Issue 4, Jul-Aug 2024 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Performance Evaluation of Ribbed Slab and Waffle Slab Systems Under Lateral Loading using ETABS

Payal Hanwat, Prof. Afzal Khan

Department of Civil Engineering, Millennium Institute of Technology and Science, Bhopal, Madhya Pradesh, India

1. INTRODUCTION

GENERAL

Floor and roof systems are essential in construction, primarily supporting gravity loads and transferring them to columns and walls. They also play a crucial role in distributing wind and seismic forces to vertical elements of the lateral load-resisting system. Typically, slabs are not considered in structural analysis for lateral load resistance due to their complex behavior. However, during seismic events, slabs can significantly enhance lateral load resistance due to their in-plane stiffness.

This study investigates the impact of slab stiffness in reinforced concrete structures during seismic events. It compares the performance of ribbed and waffle slabs in a G+10 building under Zone-II seismic conditions using ETABS software. The analysis focuses on frame forces, nodal displacements, and support reactions to determine the most effective and economical design.

Role of Slabs

Slabs are critical components that handle dead and live loads in buildings and structures. They can be classified into one-way and two-way systems:

- One-way Slabs: Supported by beams in one direction, suitable for small spans (up to 6 meters).
- Two-way Slabs: Supported by beams in both directions or without beams, ideal for larger spans, high loads, and areas with long spans like parking floors.

How to cite this paper: Payal Hanwat | Prof. Afzal Khan "Performance Evaluation of Ribbed Slab and Waffle Slab Systems Under Lateral Loading using ETABS" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-8 | Issue-4, August 2024, pp.452-460, URL: www.ijtsrd.com/papers/ijtsrd67174.pdf

IJTSRD67174

Types of Slabs

1. Ribbed Slabs: Comprise parallel reinforced concrete T-beams (ribs) and are used in residential and commercial buildings. They are efficient for small live loads and long spans. The ribs reduce the amount of concrete needed, making the slab lighter and providing space for utilities.
2. Waffle Slabs: Feature a grid of ribs forming a waffle-like pattern, used for large spans (e.g., assembly halls). They use less concrete and steel compared to solid slabs, offering lower floor deflections and better vibration control. Ideal for areas where fewer columns are preferred.

Seismic Analysis

In multi-storeyed buildings, earthquake damage typically occurs at areas with structural weaknesses in the lateral load-resisting frames. Effective seismic design aims to evenly distribute mass, stiffness, and strength both horizontally and vertically. Discontinuities in stiffness or mass can lead to increased damage.

Seismic analysis is crucial as it helps design structures to withstand earthquakes, reducing potential damage. Proper design and construction can mitigate the effects of earthquakes and ensure buildings perform adequately with minimal damage.

2. OBJECTIVES

OBJECTIVES OF THE STUDY

The main aims of this study are as follows:

- Evaluate the performance of waffle and ribbed slabs under various design loading conditions with different boundary conditions.
- Assess the performance of waffle and ribbed slabs within a multistory building system subjected to seismic loading.

- Compare the behavior of waffle and ribbed slab systems under lateral loads and review their performance.
- Investigate the advantages and disadvantages of waffle and ribbed slabs in terms of cost, stability, and strength.

3. METHODOLOGY

GENERAL

In this research work our motive is to evaluate seismic assessment ribed 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-10: Check complete modelling and boundary conditions of the structure and

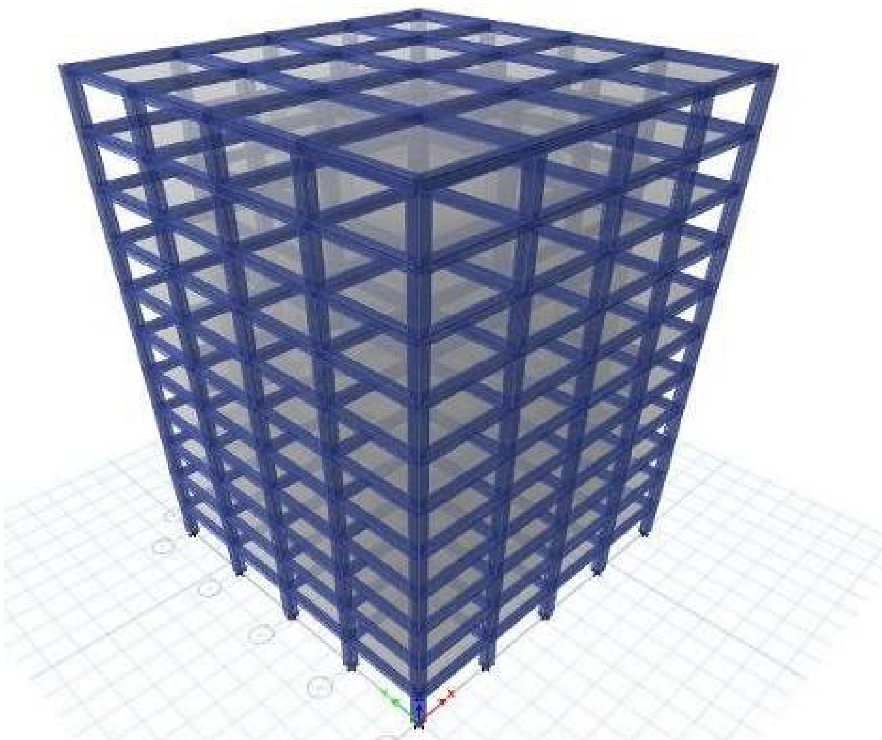
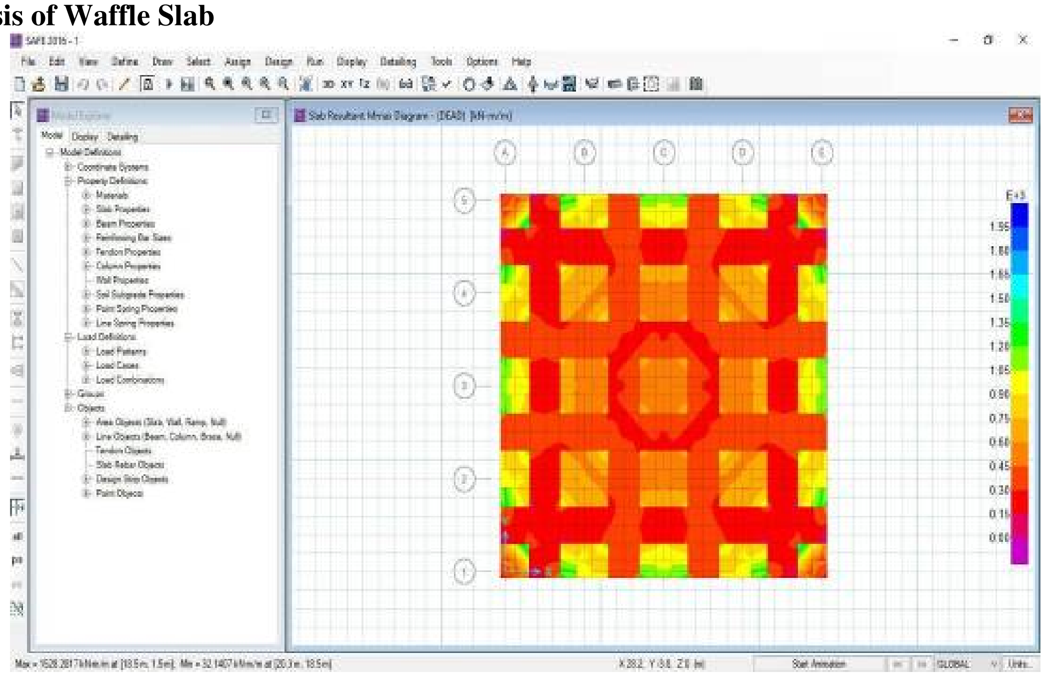


Figure 3-d modelling of the structure

Step-12: Analysis considering boundary conditions and cases:

A. Analysis of Waffle Slab



B. Analysis of Ribbed Slab

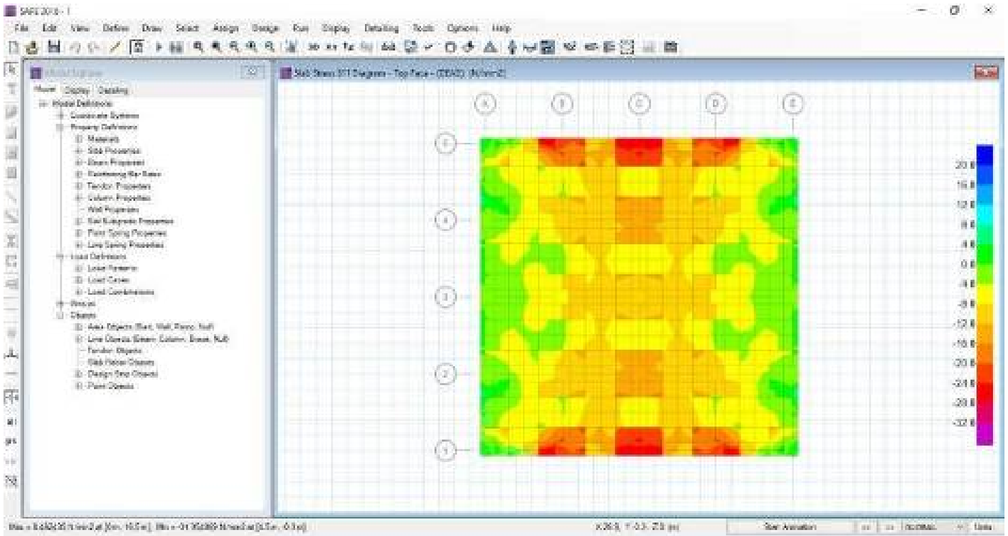


Figure 4.11 Analysis of both Cases

Flow Chart of the study

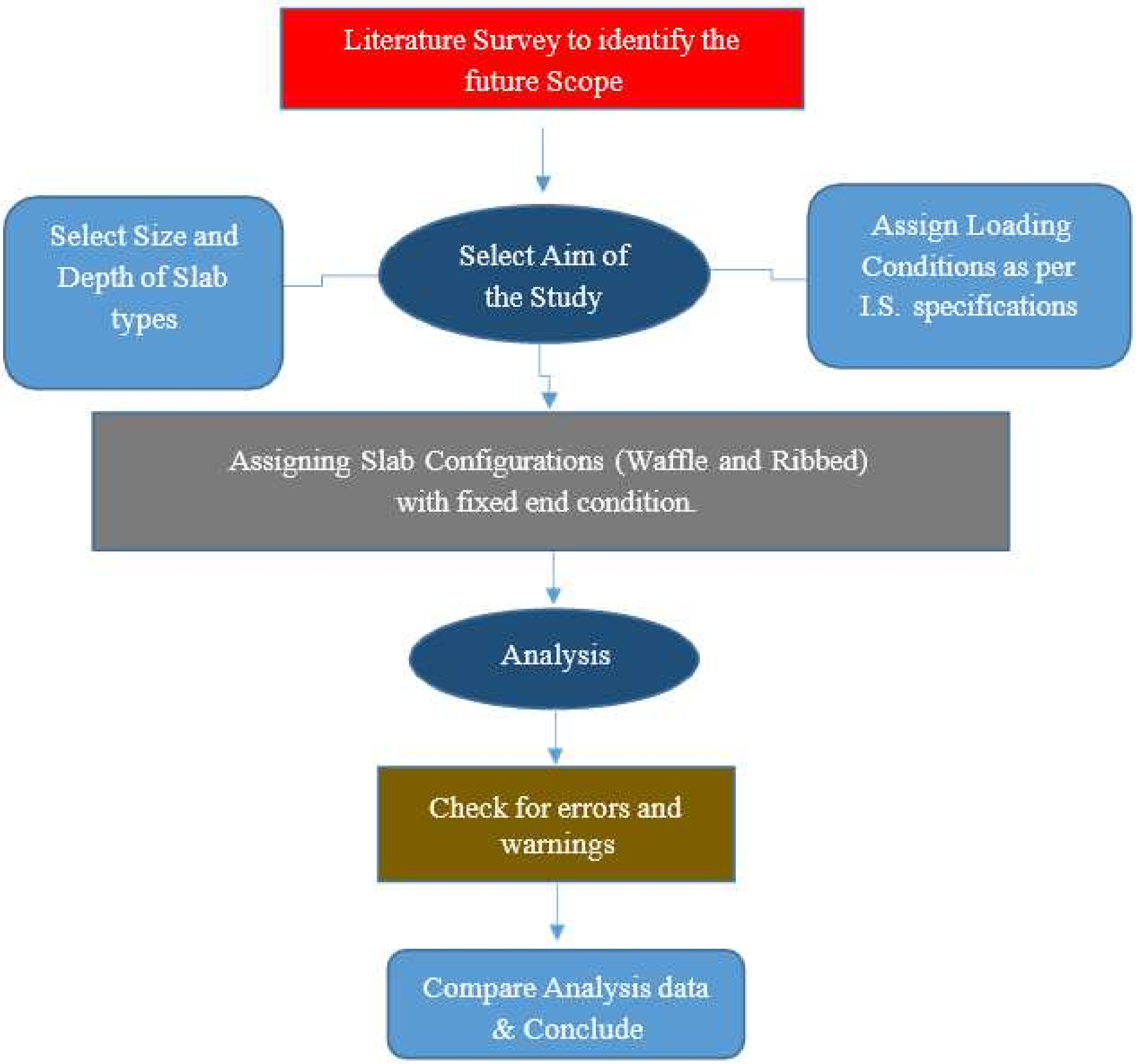


Figure Flow chart of the study

LOAD CALCULATIONS AND GEOMETRICAL FORMULATIONS
GENERAL

This chapter deals with loading calculation of the critical load placing over the considered building applying seismic loading.

In this research work, we have used ETABS and SAFE software which are based on the application of Finite Element Method. These software's is a widely used in the field of structural design and analysis. Now a day this software is very much friendly for the analysis of different type of structures and to calculate the result at every node & element wise.

Geometrical details considered in this study are as follows:

Table 5.1 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

In this study two cases are considered for comparative analysis with same loading, geometrical and sections conditions are as follows:

Case-I: Structure with Waffle Slab

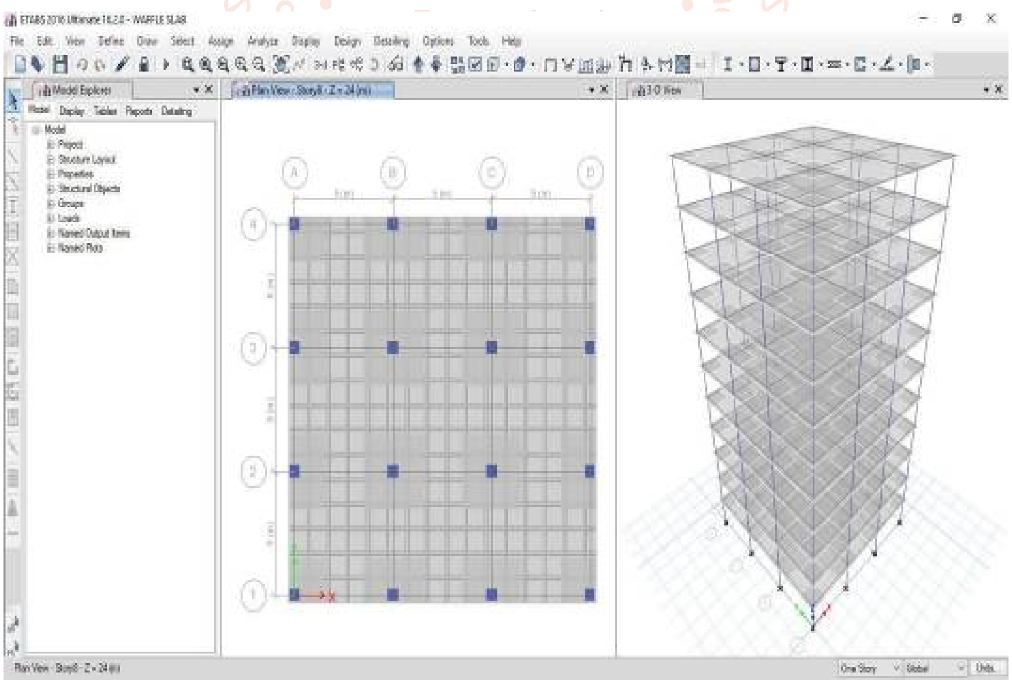


Figure 5.1 Waffle Slab Case-II: Ribbed Slab Structure

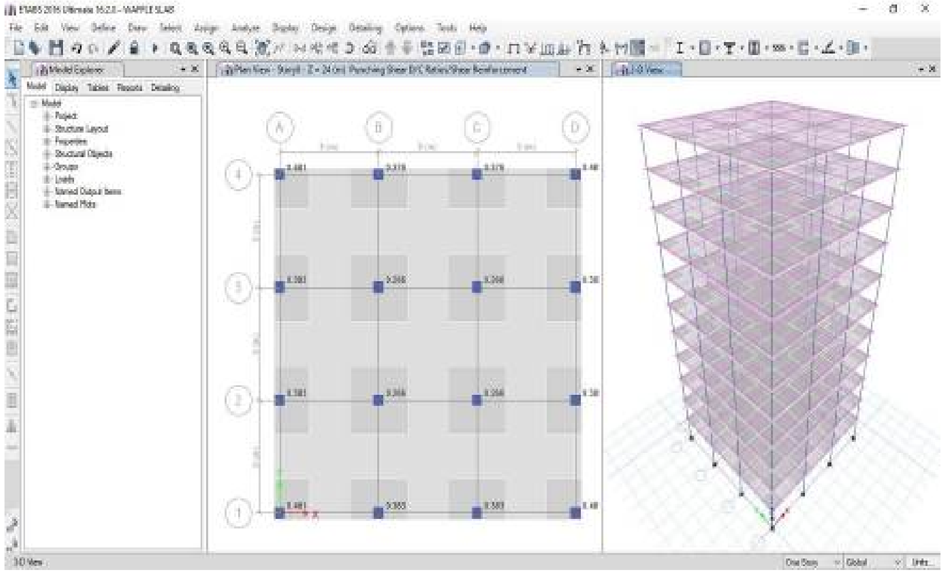


Figure 5.2 Ribbed Slab Structure

COMPARATIVE RESULTS

Maximum Storey Displacement (mm)

Table 6.1 Storey Displacement

Storey Displacement mm		
Storey	Waffle	Ribbed
Story11	7.846	7.711
Story10	7.531	7.403
Story9	7.057	6.939
Story8	6.449	6.342
Story7	5.736	5.641
Story6	4.946	4.864
Story5	4.103	4.034
Story4	3.228	3.174
Story3	2.341	2.3
Story2	1.458	1.431
Story1	0.607	0.594

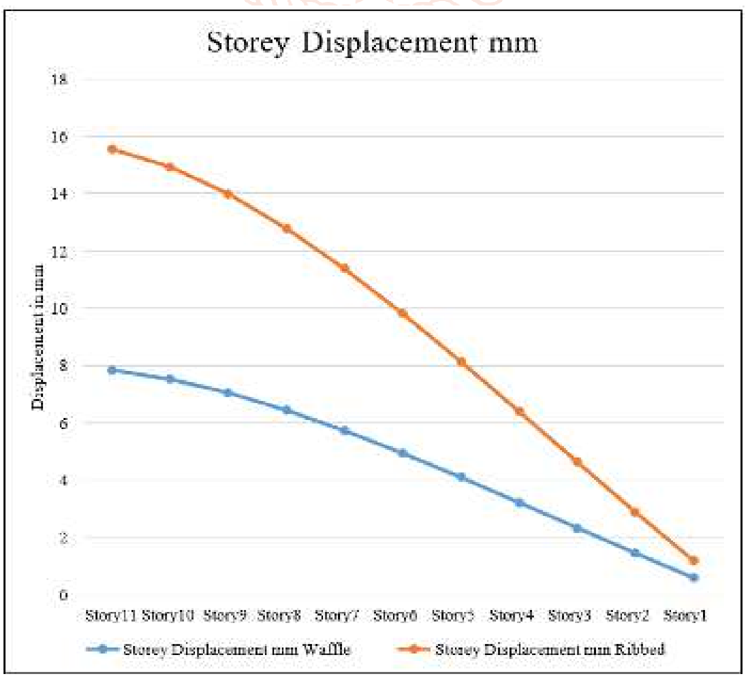


Figure 6.1 Storey Displacement

Discussion:

As observed in fig 5.1, it can be said that displacement in waffle slab is comparatively more in comparison. Ribbed slab is in permissible limit as per I.S. 1893-I:2016.

Storey Drift

Table 6.2 Storey Drift

Storey Drift mm		
Storey	**Waffle**	**Ribbed**
Story11	0.379	0.371
Story10	0.57	0.559
Story9	0.732	0.726
Story8	0.858	0.844
Story7	0.952	0.936
Story6	1.015	0.999
Story5	1.053	1.037
Story4	1.069	1.053
Story3	1.024	1.048
Story2	0.729	1.008
Story1	0.82	0.713

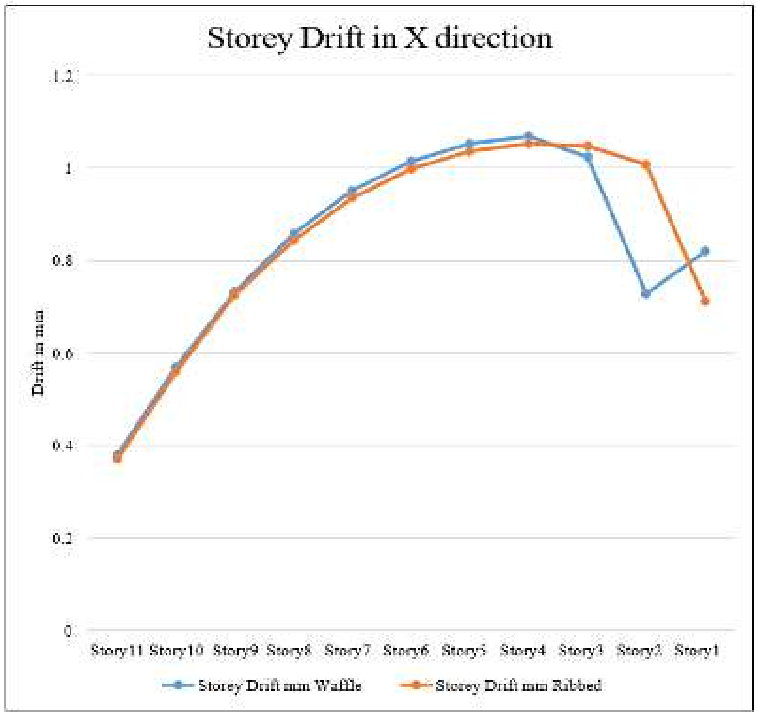


Figure 6.2 Storey drift in X direction

Table 6.3 Storey Drift in Y direction

Storey Drift in Y direcction mm		
Storey	**Waffle**	**Ribbed**
Story11	0.455	0.476
Story10	0.684	0.726
Story9	0.879	0.944
Story8	1.03	1.115
Story7	1.142	1.243
Story6	1.218	1.332
Story5	1.264	1.387
Story4	1.282	1.412
Story3	1.229	1.408
Story2	0.874	1.342
Story1	0.82	0.882

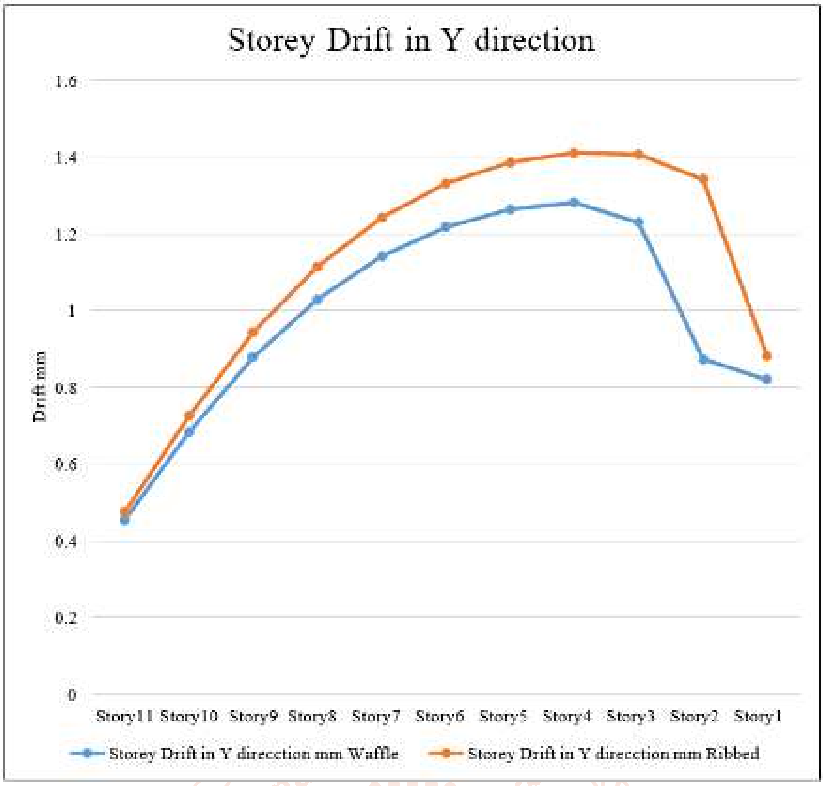


Figure 5.3 Drift in Y direction

Discussion:

Drift can be define as a relative consecutive displacement of two storey, in this study it can be said that upto 6 storey waffle slab has less drift increament but after 6th storey ribbed slab is observed as more stable.

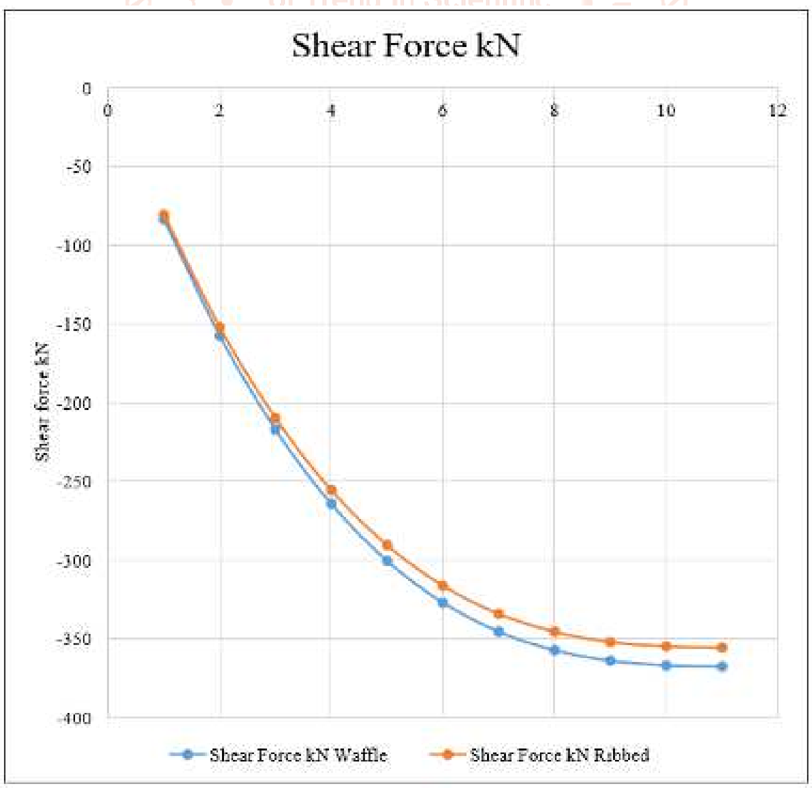


Figure 6.5 Shear force

Discussion:

As observed in above fig 5.5, it can be said that unbalance forces generating in both the cases are in negative i.e. opposite direction due to geometry of slab, here values observed in ribbed slab is comparatively less than waffle slab.

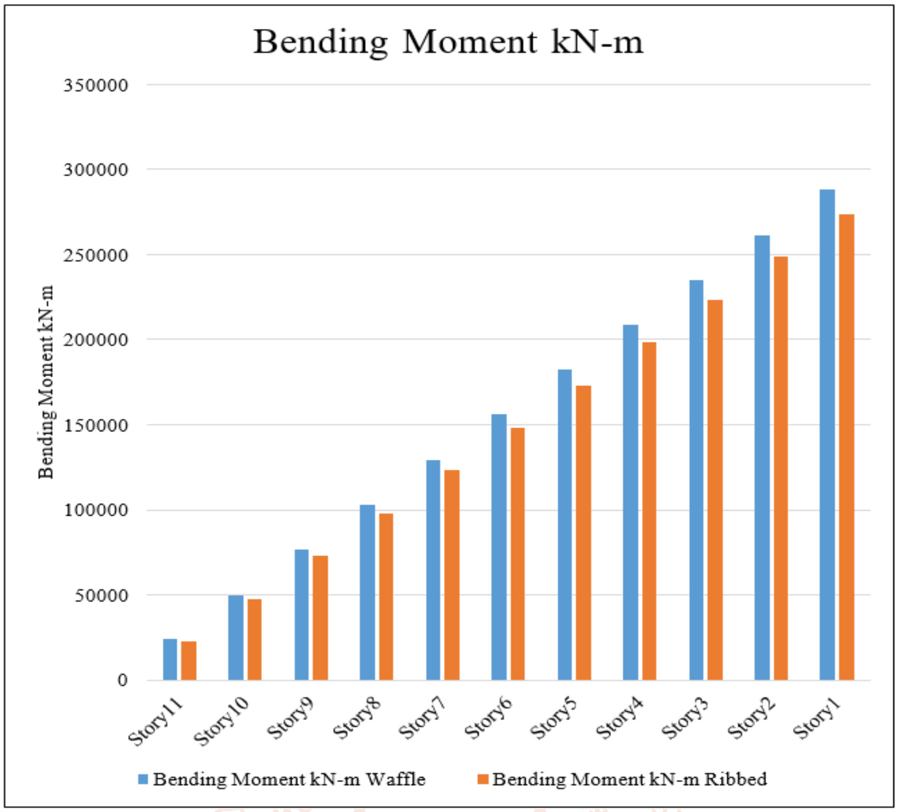


Figure 6.7 Bending Moment kN-m

Discussion:
As shown in fig 5.7 it can be said that bending moment is observed more in waffle slab case ths it can be stated that ribbed slab case is comparatively more stable and cost effective.

4. CONCLUSION & FUTURE SCOPE

CONCLUSION

In conclusion of this study it can be said that on the basis of results observed in comparison in above chapter this can be said that Ribbed slab structure is capable of maintaining the structure stable and more resistible in earthquake load.

Following observations are made in above chapter are as follows:

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.

FUTURE SCOPE

1. In the proposed work ribbed and waffle slab is considered whereas in future othertypes of slab can be consider for comparison.
2. In this study seismic analysis is considered whereas in future study wind loadcan be consider.
3. In this study analysis is done using etabs whereas in future SAP2000 can be prefer for P-delta analysis to determine the displacement force graph.

REFERENCES:

[1] Mohammed jasim alrubaye, [study of nonlinear analysis one-way ribbed reinforced concrete slab of the tall building subjected to seismic load], international journal of scientific & engineering research volume 8, issue 11, november-2017.

[2] naziya ghanchi and chitra v, [waffle slab-analysis by different methods], international

journal of scientific & engineering research, volume 5, issue 12, december-2014.

[3] P. F. Schwetz, f. P. S. L. Gastal and l. C. P. Silva[numerical and experimental study of a real scale waffle slab], volume 2 number 4 (december, 2009), p, 380-403.

[4] Rana shabbarc, norizal noordin, eethar t. Dawood and mohd zailan sulieman, [comparison between ribbed slab structure using lightweight foam concrete and solid slab structure using normal concrete], concrete research letters, vol. 1 (1) – march 2010.

[5] Sarita r. Khot, vishwajit v. Jadhav, kumar t. Bharekar, himanshu v. Mahajan, purval d. Shiram and siddharth v. Tupe, [comparative study of waffle slabs with flat slabs and conventional rcc slabs], international journal of engineering research & technology (ijert), vol. 5 issue 04, april-2016.

[6] Vinit p.thakor and tushar n. Patel, [parametric study of dynamic behaviour of waffle slab], global research and development journal for engineering | emerging research and innovations in civil engineering, (erice - 2019) | february 2019

[7] Rahul Choat and Dr.Om Prakash (2017), "Application of post-tensioning in multi- storey buildings", "International journal scientific research and development", Vol 5, ISSN: 2277-9655.

[8] Rafal Szydlowski and Magdalena Szreniawa (2016), "About the Project and Study of Post-tensioned Transfer Beams Under the Five-storey Building in the Centre of Warsaw", "4th Annual International Conference on Architecture and Civil Engineering (ACE 2016)".

[9] Rafal Szydlowski and Barbara Labuzek (2017), "Post-Tensioned Concrete Long- Span Slabs in Projects of Modern Building Construction", "IOP Conf. Series: Materials Science and Engineering", Vol 3, ISSN 4562-2132, pp 245.

[10] Sujal P Jasani and Pradeep Pandey (2017) "Analysis of post tensioned transfer girder in g+11 story building using fem based software Etabs", "International Journal of engineering and researches", Volume 4, Issue 4.

[11] Sanjaya Kumar Patro, Sandeep jain (2013), Effect of diaphragm flexibility on seismic response of building structures, Proceedings of The Eight World Conference on Earthquake Engineering, pp. 735-742.

[12] Saeed Ahmad (2011), effects of economic reforms and openness on structureconduct and performance of agro-based industries in pakistan, American International Journal of Contemporary Research, Vol. 1 No. 2; September 2011

[13] Shanmathi Sridhar and A. Leema Rose (2019), "Performance Evaluation of Post- Tensioned Concrete Beams with Bonded System", "International Journal of Innovative Technology and Exploring Engineering (IJITEE)", ISSN: 2278-3075, Volume-8 Issue-7.

[14] V. Prakash, Keshav deskhmukh, ravi tridev and mahalaxmi (2017) The effects of the type of slab on structural system in the multi-storey reinforced concrete buildings, World Conference on Earthquake Engineering.

[15] Veerat Srilaxmi, K. Manju, M.Vijaya (2018) "a case study on pre-tensioning & post tensioning systems of a prestressed concrete", "International Journal of Science advances", Vol.5 Issue.2.