International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 10 | Oct - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

Comparative Study of Yield Line Analysis of Different Slab (Rectangular and Circular Slab)

Meenakshi Rai*[1], Anjali Rai*[2]

*[1]M.Tech Student, Institute Of Engineering And Technology, Lucknow, UP, India.

*[2]Assistant Professor, Institute Of Engineering And Technology, Lucknow, UP, India.

Abstract:

One significant structural element that requires a lot of concrete is a slab. The thickness of the slab will increase if there is a heavy load on it or if the spacing between columns is not shortened. Overall, thicker slabs require more concrete and steel, which raises the slab's self-weight.

This paper presents the Finite Element Method (FEM) for analysing the failure pattern of rectangular slab , circular slab and triangular slab with same loading condition . Non-Linear static analysis is carried out using ANSYS Software. It has been done to bring the maximum central deflection in Triangular and Rectangular plates closer to the mesh's increased fineness. Yield line theory and FEM (ANSYS software) findings have been compared traditional outcomes. Engineers were obliged to rely on empirical calculations because it was difficult to determine displacements and stresses in reinforced concrete analytically. Concrete is composed of a number of materials, including creep, and shrinking affected its deformations. During their service life loadings, the concrete slab and other delicate materials show growing bending as a result of mechanical and environmental conditions. For this project, Ansys software is used to study various slab shapes.

Key Points: Reactangular slab , Circular slab ANSYS Workbench, yield line , deformations , stresses, finite element analysis

1. Introduction:

A method for analyzing ultimate loads is the yield line theory. The yield line theory is utilized based on the bending moment of the structural element in its collapsed condition. In 1923, Ingerslev introduced the concept of yield analysis. An analysis of slabs showcases the theory's increased importance.
Yield line analysis is a powerful method for predicting the collapse load of reinforced concrete slabs. In 1921, Ingerslev first coined the phrase "yield line." Following that, Johansen conducted a systematic examination of the concept that featured a geometrical explanation. In the field of structural engineering, Johansen, Nielsen, and Jones and Wood were the main pioneers of introducing yield line analysis for reinforced concrete slabs. Nowadays, yield line analysis is utilized for various purposes, such as calculating the collapse load of reinforced concrete slabs and steel connections, walls, steel base plates, and doors. The two primary methods employed to solve for the unknown dimensions defining the actual yield pattern.The yield line analysis supposedly starts with the yield collapse pattern. A yield line is a line on the slab where the reinforcement bars have failed, causing severe deformation and plastic rotations under continuous ultimate moment until failure occurs. Yield lines are created as a result of this flexibility, leading to small areas with limited yielding. The method of yield-line can be used to forecast collapse loads of slabs and plates. Both steel plates and underreinforced concrete with uniform reinforcement distribution are able to utilize it. The yield line method is a technique used for limit analysis of reinforced concrete slab systems. It is based on

assumptions that failure occurs due to complete yielding of reinforcing steel along the yield lines on the tension face of the slab. Analysis can be done using the principle of virtual work or equilibrium equations.. Objective of this paper is providing an alternative technique for finding failure pattern by FEM (ANSYS software). Some of the work already commenced on yield line theory are by Famiyesin et al. (2001), Kumar and Prakash (2001) on ultimate load of two way rectangular Reinforced concrete (RC) slabs. Phuvoravan and Sotelino (2005) have proposed a new finite element for the non linear analysis of reinforced concrete RC slabs, Zhang and Zhu (2010) developed a simple shear flexible rectangular layered Fibre reinforced polymer reinforced concrete slab element, Ibrahim et al. (2011) performed numerical simulations using ANSYS to study the response of waffle slabs with and without openings.

The following are the characteristics of yield lines formed in reinforced concrete slabs under ultimate loads:

- The yield line are straight
- Yield lines terminate at the slab's supporting edges.
- Yield lines cross the points where the adjacent slab elements' axes of rotation intersect.
- The axis of rotation crosses columns and runs parallel to the lines of support.

.

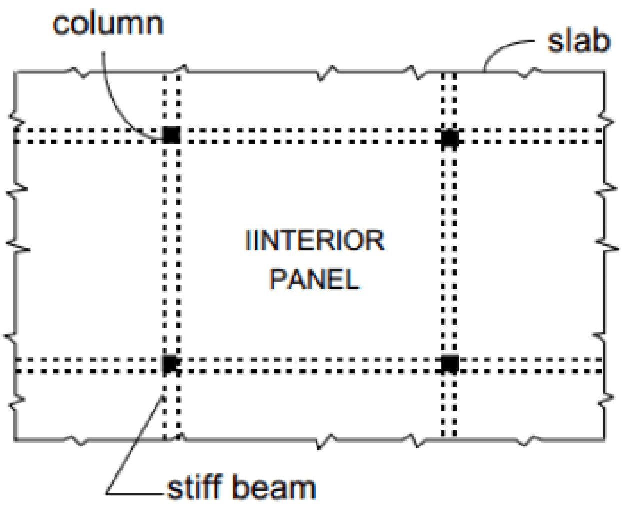


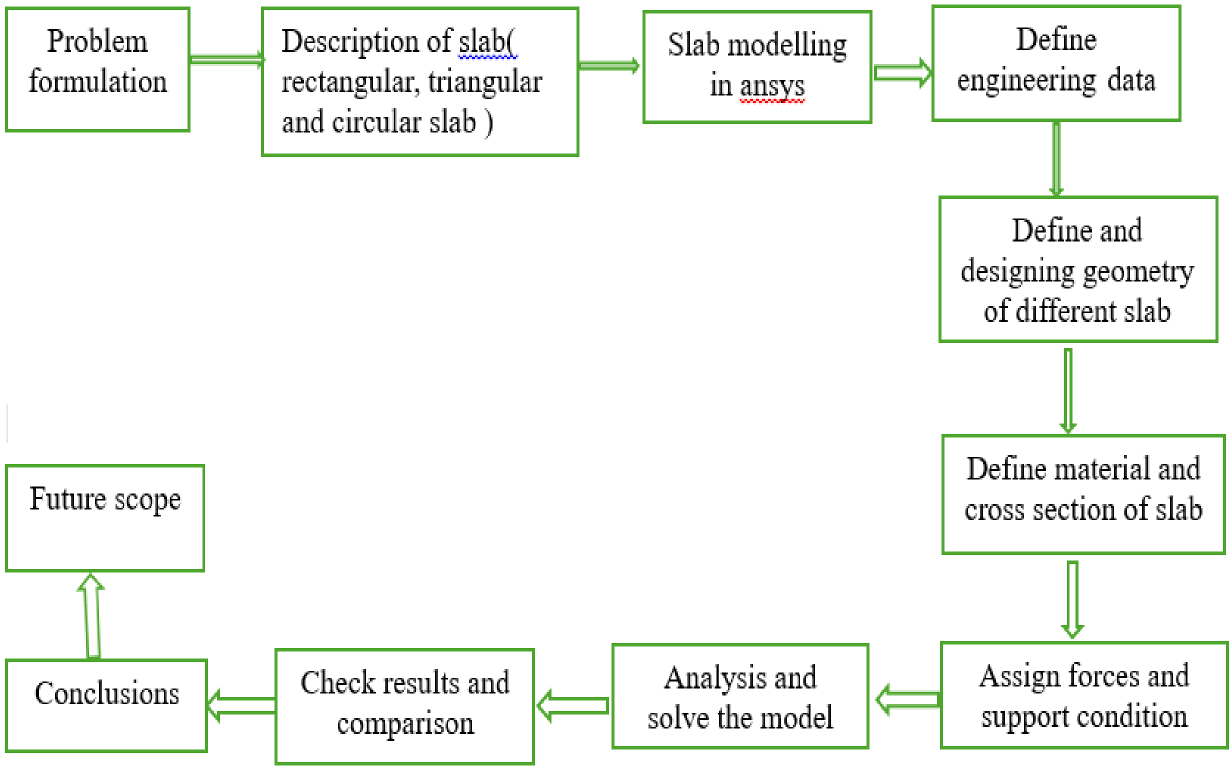
Figure: 1 Typical interior panel in two way slab

The yield line analysis of reinforced concrete slab is based on the following assumptions :

- The bending and twisting moments are evenly distributed throughout the yield lines and have the maximum values given by the ultimate moment capacities.
- The reinforcing steel yields completely along the yield lines. At failure, the slab undergoes plastic deformation, and the yield lines divide it into segments. These separate slab portions exhibit elastic behaviour.
- The elastic deformations are minimal in comparison to the plastic deformations.
- The individual slab segments are therefore plane segments at collapse since the full deformation occurs solely along the yield lines.

In a one-way simply supported slab, the yield line will form at the centre of slab at the bottom. In a one-way continuous slab, the yield lines will occur at the supports in addition to those near the mid-span. The yield line due to sagging BM will be referred to as positive yield line, whereas due to hogging BM will be called as negative yield line.

2. Methodology



III. Description of slab and material properties

3.1 Description of slab

S.NO	Parameters	Value
1.	Length	4400mm
2.	Width	4000mm
3.	Aspect Ratio	1.1
4.	Thickness of bar	160mm
5.	Diameter of bar	12mm

Rectangular slab

S.NO	Parameters	Value
1.	Diameter of Cirle	4200mm
2.	Diameter of bar	12mm
3.	Thickness of Slab	160mm

Circular model

3.2 Material Properties

S.No	Parameters	Dimensions
1.	Structural Steel	Fe250
2.	Density	7850Kg/m^3
3.	Young Modulus of Elasticity E	2.1x10^5 N/mm^2
4.	Poisson's Ratio	0.3
5.	Concrete	M25

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 10 | Oct - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

4. Analysis of rectangular slab with center loading

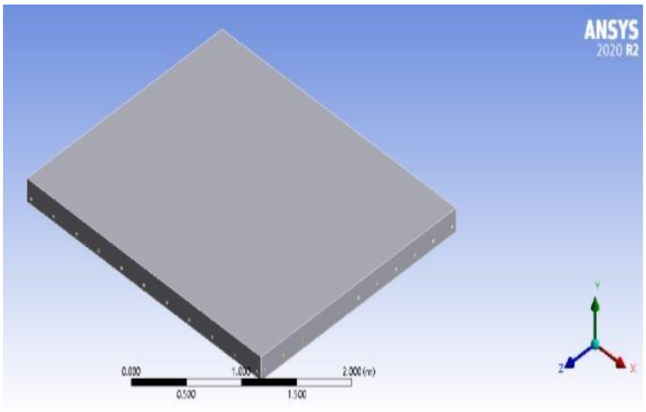


Figure 4.1 3-D model of rectangular slab

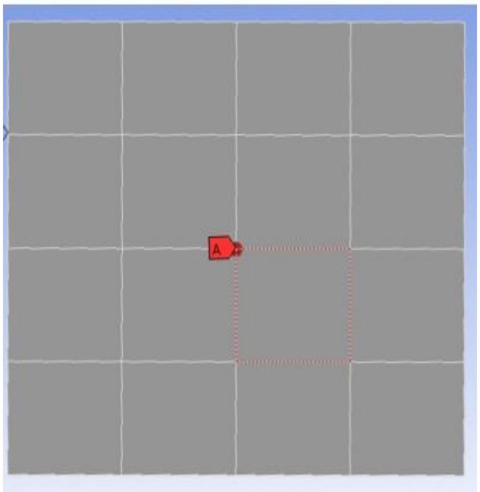


Figure 4.2 Loading condition of rectangular slab

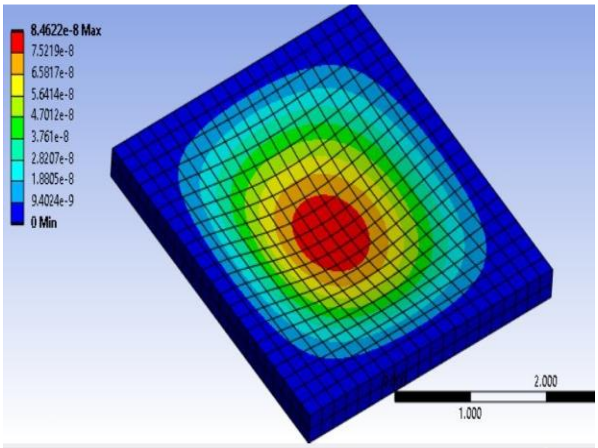


Figure 4.3 Deflection in slab

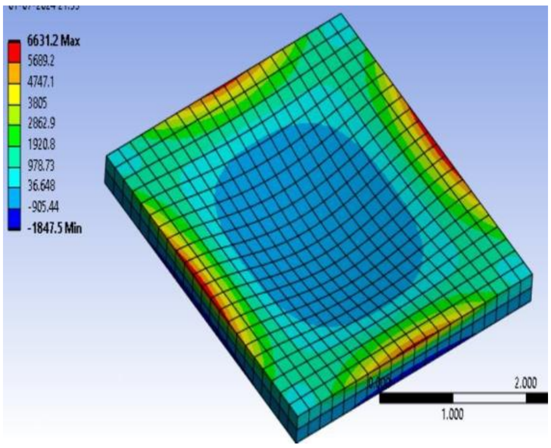


Figure 4.4 Max principle stress

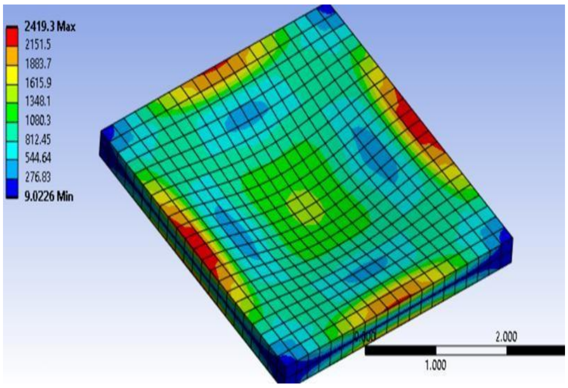


Figure 4.5 Max Shear Stress

Volume: 08 Issue: 10 | Oct - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

5. Analysis of Circular slab with center loading

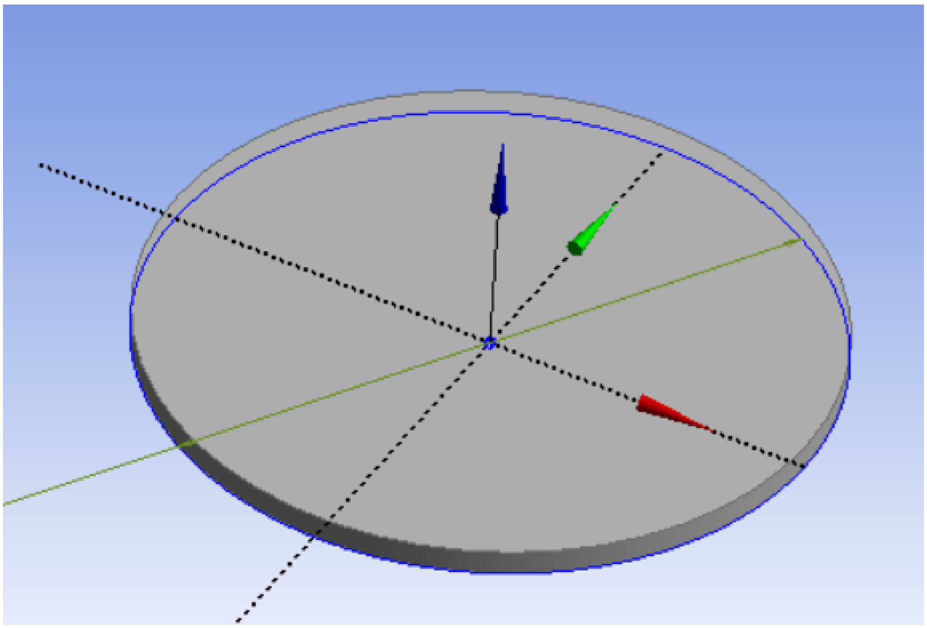


Figure 5.1 3-D View of circular slab

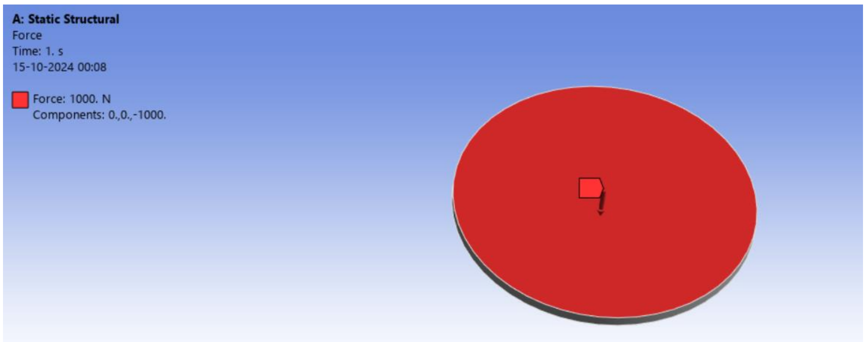


Figure 5.2 force on circular slab

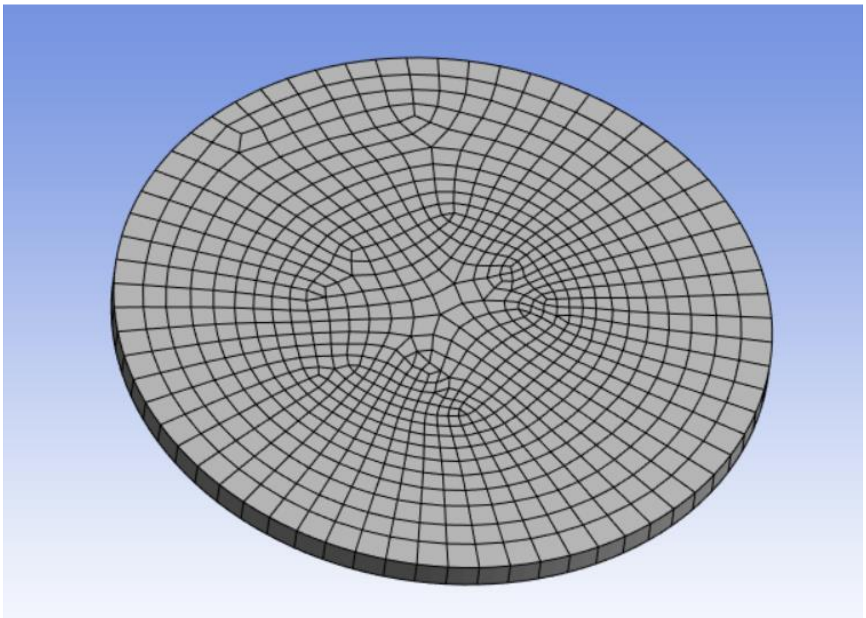


Figure 5.3 Meshing on circular slab

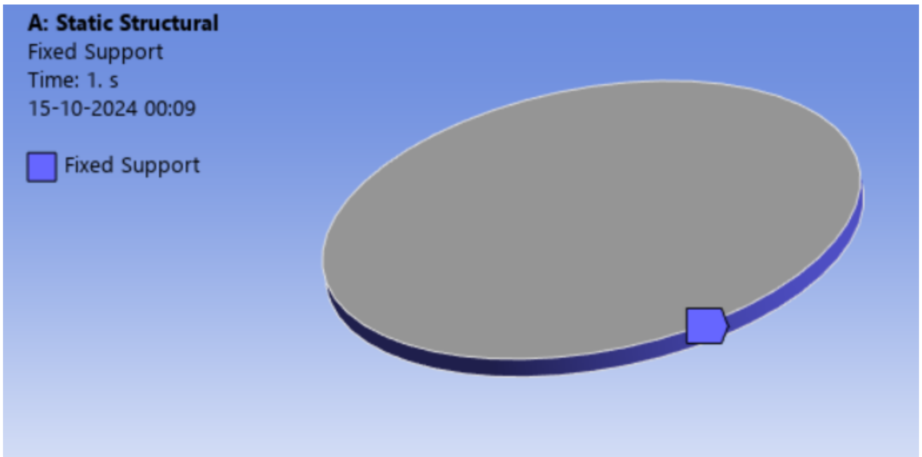


Figure 5.4 Fixed support

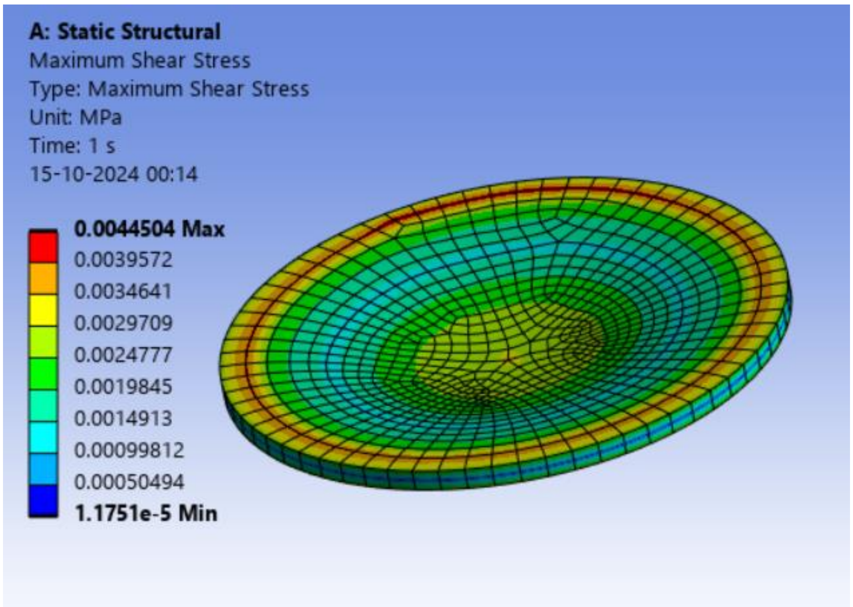


Figure 5.5 Max shear stress

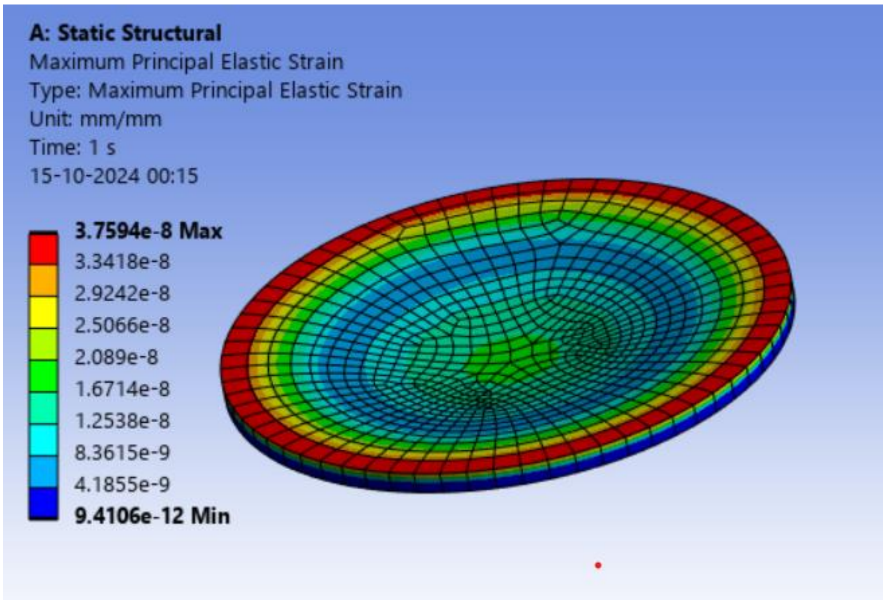


Figure 5.6 Max prinicipal strain

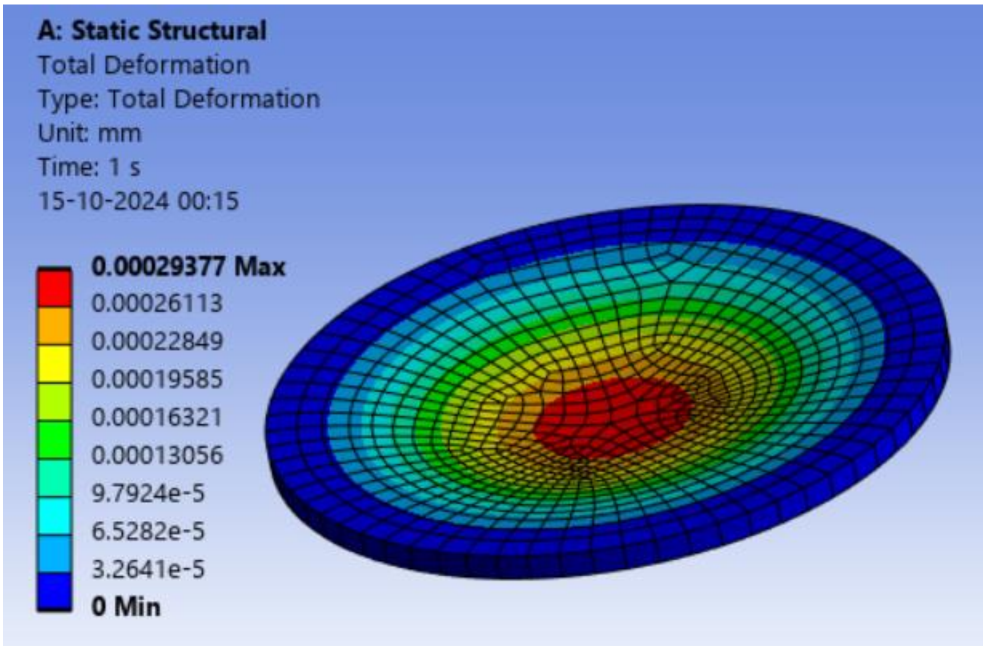


Figure 5.7 Deflection of circular slab

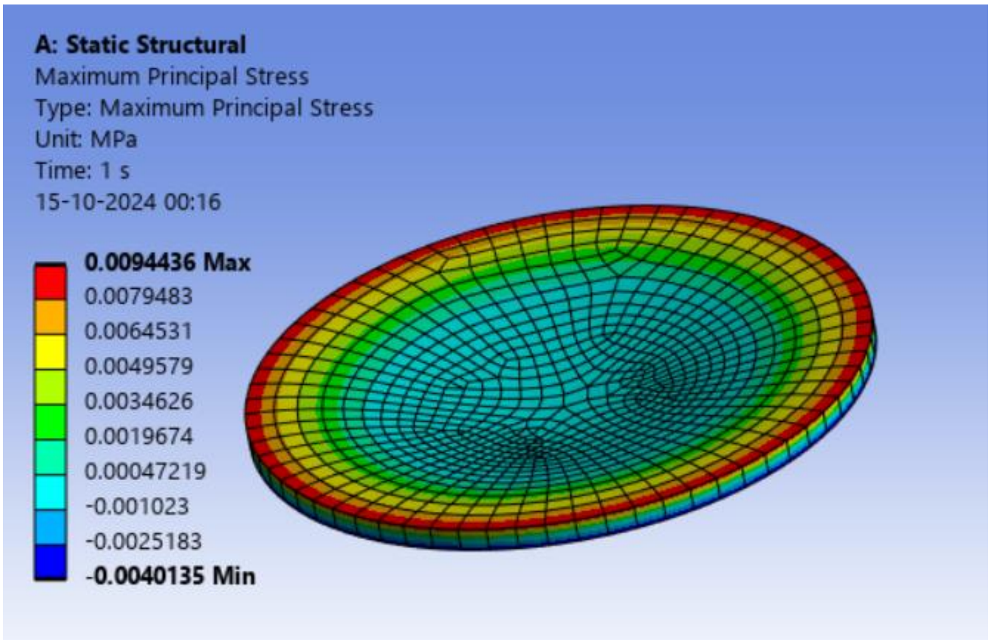


Figure 5.8 Max prinicipal stress

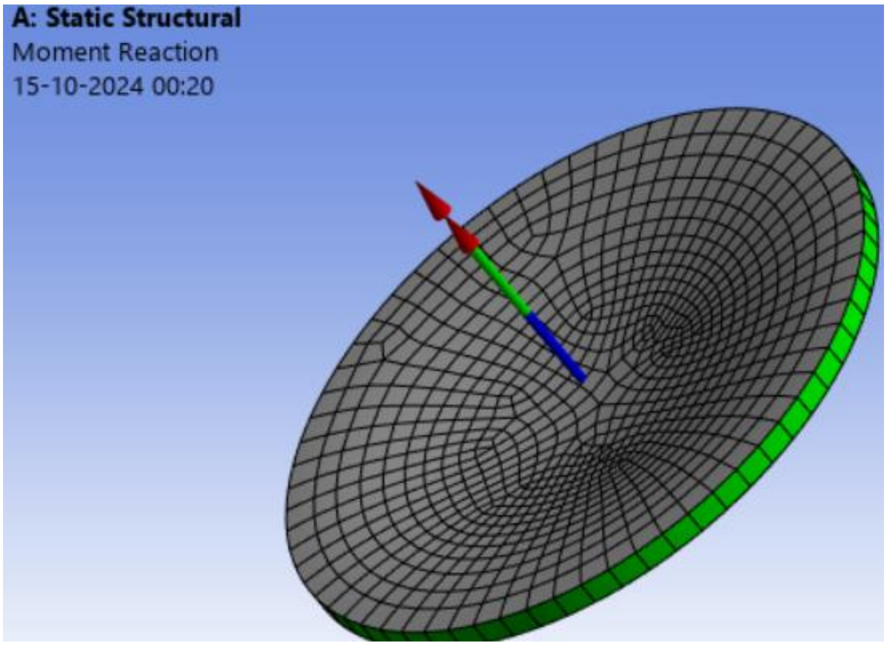
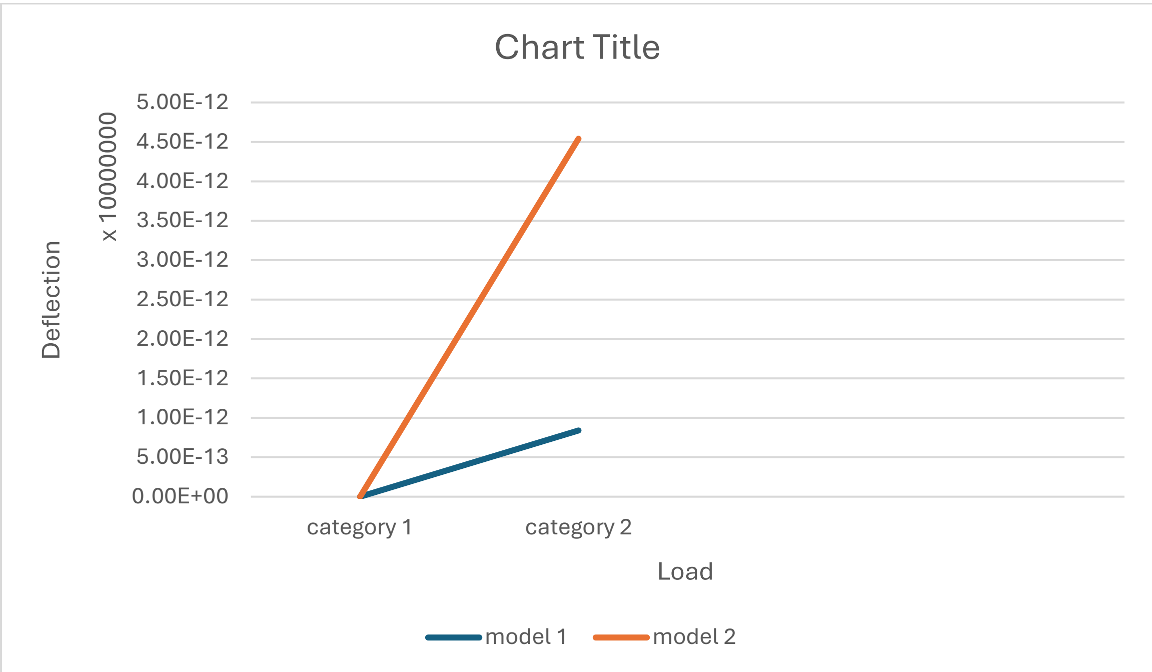


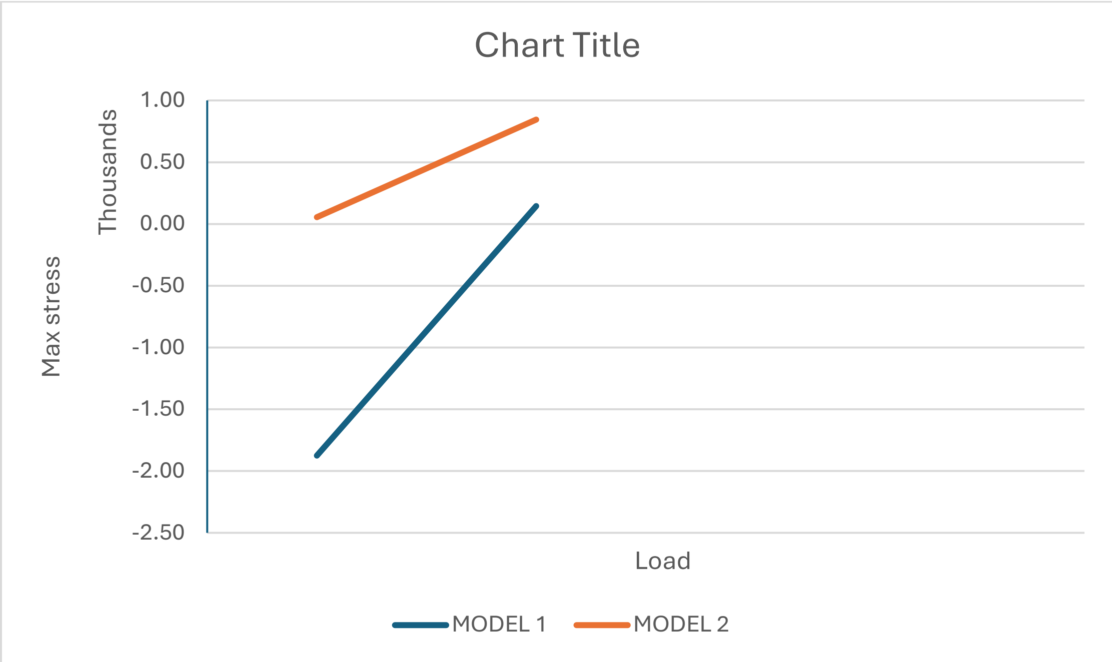
Figure 5.9 Moment Diagram

6. Results and discussion



The graph is a load-deflection curve of slabs. It shows the relationship between the load applied to a slab and the deflection of the slab at the center of the span. The x-axis of the graph is the load, and the y-axis is the deflection.

Three different shape of slab analysed (Rectangular and circular) it show that Rectangualr slab has minimum deformation whereas circular slab have highest deformation so rectangular slab has more efficient than triangular and circular slab.



The graph is a load-stress curve of slabs. It shows the relationship between the load applied to a slab and the stress of the slab at the center of the span. The x-axis of the graph is the load, and the y-axis is the stress.

Three different shape of slab analysed (Rectangular and circular) it show that Rectangualr slab has minimum stress generated whereas circular slab have highest stress generated so rectangular slab has more efficient than triangular and circular slab.

7.Conclusion

In this work find stress and deflection of three different type of slab (rectangular,triangular and circular) slab

Rectangular slab has minimum stress than circular so rectangular slab has more efficient.

Rectangular slab has minimum deflection than circular so rectangular slab have less deformation.

In this work rectangular slab have less deflection than triangular and circular slab we would prefer rectangular and triangular both but as the analysis is done we say use rectangular slab.

8. Future scope

8.1 Multi-Layer and Composite Slab Systems

- **Yield Lines in Composite Slabs**: Composite slabs (e.g., steel-concrete) are widely used in construction, and analyzing yield lines in these structures could enhance load-sharing between materials. New models could address the interactions between different layers and improve overall performance.

- **Fiber Reinforced and High-Strength Concrete Slabs**: The inclusion of fiber reinforcement or advanced materials affects the yield line patterns. Yield line analysis can be adapted for these advanced materials to provide design insights and improve structural reliability.

8.2 Optimization in Design and Sustainability

- **Resource Optimization**: Yield line analysis can guide optimized slab thickness and reinforcement layout, reducing material use and waste in construction. Future work could develop design standards or optimization algorithms that use yield line theory for sustainable slab designs.
- **Modular Slab Design**: Prefabrication and modular construction are growing fields, and yield line analysis can help optimize modular slab units for strength, material usage, and load-sharing, aiding in faster, more efficient building assembly.

8.3 Dynamic Loading and Impact Analysis

- **Yield Line Analysis for Dynamic Loads**: Future developments can apply yield line theory to scenarios like seismic loading, blast impacts, and other dynamic events, where the behavior of slabs differs significantly from static conditions.
- **Performance under Long-Term Loads**: For situations with sustained loading (e.g., in parking structures), incorporating yield line theory can help predict slab fatigue and long-term degradation patterns, improving maintenance and retrofit planning.

References:

[1] Edwin koźniewski, marcin orłowski (2022) "pre-determination of prediction of yield-line pattern of slabs using voronoi diagrams."

[2] S. Gupta, H.Singh (2021) "O hotropic coefficients and continuity factors of reinforced concrete slabs suppo ed on 3-sides."

[3] Anusuri uma maheswari, shaik khasim peera (2020) "evaluation of ultimate capacity of a rectangular solid slab using yield line analysis."

[4] Sushant gupta, sanjeev naval,(2020) "analysis of O hotropic RC rectangular slabs suppo ed on two adjacent edges - A simplistic approach"

[5] Mr. Duvvi. Varaha, mr. K. Appala naidu(2020) "development of design cha s of A parallelogram shaped slab by using yield line methodology"

[6] Sushant gupta, harvinder singh (2019) "analysis of reinforced concrete rectangular slabs with three-sides suppo ed under uniformly distributed load."

[7] J.G. Dickens along with others (1988) " A general computer program for edge-supported slab yield-line solution Computer Structure".

[8] Johnson, D. (1995) "Analyzing yield lines with sequential linear programming International Journal of Solids Structure".

[9] IS 456 Method of RCC design of Concrete, Bureau of Indian Standards (BIS) New Delhi.

[10] IS 800 " General construction in steel, code of practice" Bureau of Indian Standards (BIS) New Delhi.

[12] et al., (2008) J.W.Methodical forecasting of yield-line arrangements for any polygonal plate Engineering Structure.