# Yield Line Analysis of Three-Side Supported Two-Way Reinforced Concrete Slab by Various Location of Concentrated loading

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**Abstract -** In this work, plastic analysis is performed using ANSYS on a variety of concrete reinforced slabs, with an emphasis on the distribution of stress, maximum moment, and deformation in each scenario. The main conclusions of this study provide insight into how these slabs behave under various loading scenarios.

This study focuses on how various concrete slabs react differently to outside pressures. This performance disparity highlights how important it is to properly design and strengthen structures in order to reduce deformations and improve structural integrity.

Additionally, by evaluating the results under every loading scenario, it is possible to determine which scenario is best for withstanding stress. The significance of structural factors in the design and upkeep of concrete reinforced slabs is emphasized by this result.

The study also notes that ANSYS software's accuracy in identifying fracture routes is limited. However, it highlights that a finer mesh leads to more accurate analysis and more realistic results, allowing yield line patterns in concrete slabs to be approximated closely. By providing insightful information to the field of structural engineering, this research helps to build strong and durable concrete structures.

***Key Words***: Yield Line Analysis, ANSYS, Reinforced concrete slab, plastic analysis

## 1.INTRODUCTION

Ingerslev introduced the yield line method of analysis [1]. The work of Ingerslev was expanded upon by Johansen [2, 3], who created the yield line method of analysis as a workable technique based on the notion of plasticity. To complement Johansen's work [2, 3], Nielson [4] performed yield line analysis for orthogonally reinforced slabs. The hypothesis gained popularity in the 1960s, 1970s, and 1980s, and Johansen's original research [2, 3] was expanded upon and verified. Yield line analysis became less used as computer-based elastic methods gained popularity since it could not be adapted to computer-based programs.

Slabs are by definition structures that distribute the load perpendicular to their plane. Slabs of reinforced concrete are widely utilized as flooring, not just in homes and both as decking in bridges and as industrial buildings. Two-way slabs are a unique type of construction that strengthened concrete is one of the main structural contents. It is a commonly utilized, cost-effective, and efficient structural framework. All four sides of it are supported, and the Less than double the width is the length [5]. The divergence of the two-way slab can be found in two different ways. All supports receive the loads.

Using the polar coordinate system, Gong et al. [6] computed the ultimate concentrated load-carrying capacity of a reinforced concrete slab for orthotropic reinforcing circumstances analytically. His method was mathematical, though, and the only things he discussed were the simply supported slab borders on all sides and the point load being maintained at the center of the slab geometry. In an effort to automate the yield line pattern creation process, Smith and Gilbert [7] and Gilbert et al. [8] employed the discontinuity layout optimization (DLO) technique, which is frequently utilized in truss topology optimization. Gilbert et al. [9] used the DLO projected yield line pattern for a variety of slab designs with complicated boundary conditions and even orthotropic reinforcement circumstances.

Finite element analysis, made possible by the advancement of computers, suited a standard device to investigate and design complex structures. The finite element method agrees with multifaceted investigation of the nonlinear response of reinforced concrete structures to be sanctioned out in indulgent its performance under the loading state. Finite element analysis offers an instrument able to simulate in addition to estimate the structural performance of reinforced concrete structures. While this technique requires a high degree of correctness, it is relentlessly very costly and time wasting.

Recent studies have concentrated on enhancing the predefined yield-line pattern. It follows that a wider application of optimization techniques is necessary. [10] described a method that begins with a plate construction that is regularly triangulated, from which the active yield-lines are identified. A direct search process finds the final yield-line pattern.

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On the other hand, [11,12] optimized a rather coarse triangular mesh using a gradient approach that was specially tailored. The analysis of both optimization processes will take place within the framework of the yield-line pattern detection approach that is being presented.

## 2. METHODOLOGY

### 2.1 Specimen Details

A reinforced concrete (RC) slab with particular dimensions of 2 m X 2.4 m and a thickness of 15 centimeters was analyzed. This slab was built using M25 grade concrete and reinforced with Fe415 steel. It was subjected to a concentrated load, which is a common occurrence in structural engineering applications. The material properties of the slab were considered to be isotropic in this research, suggesting that its mechanical properties are consistent in all directions.

Three of the slab's borders were designed with fixed supports to match real-world situations, essentially barring any movement or displacement along those limits. This boundary condition is frequently chosen to simulate circumstances in which a slab is connected to adjacent structures or foundations. the remaining edge was left free, allowing it to deform and respond to the applied stress with greater flexibility. the analysis was carried out with the help of ANSYS software, a robust structural simulation tool.

**Table -1:** Detail of modals

| Type | Corresponding location of loading |
|---|---|
| Case 1 | Concentrated load at centre |
| Case 2 | concentrated load at center of (a) left half (b) right half |
| Case 3 | concentrated load on center of (a) upper half (b) lower half |

### 2.2 Design Inputs

**Table -2:** Geometrical Properties of Slab

| S No. | Parameters | Dimensions |
|---|---|---|
| 1. | Length (Lx) | 2.4 m |
| 2. | Width (Ly) | 2.0 m |
| 3. | Thickness | 150 mm |
| 4. | Dia of bar | 10 mm |
| 5. | Aspect Ratio | 1.2 |

**Table -3:** Material Properties (I.S. 456:2000)

| S No. | Parameters | Dimensions |
|---|---|---|
| 1. | Structural steel | Fe415 |
| 2. | Young's modulus 'E' | $2.1x10^5 N/mm^2$ |
| 3. | Poisson's ratio | 0.3 |
| 4. | Density | 7850 kg/m3 |
| 5. | Concrete | M25 |

### 2.3 Boundary Condition

For this analysis, the support conditions are meticulously defined. Specifically, three sides of the slab are firmly fixed in place, ensuring that they do not undergo any displacement. In contrast, the fourth side of the slab is left unconstrained, allowing for flexibility and deformation in response to external loads.

Furthermore, to assess the structural behavior under different scenarios, a 1-kilogram (1KN) concentrated load is applied. This loading is strategically positioned in various ways: it is initially centered on the slab, then shifted along the central axis along the length of the slab, and finally shifted along the central axis in a direction transverse to the length. These carefully planned load applications serve to comprehensively investigate the slab's response and behavior, enabling a thorough analysis of its structural performance.

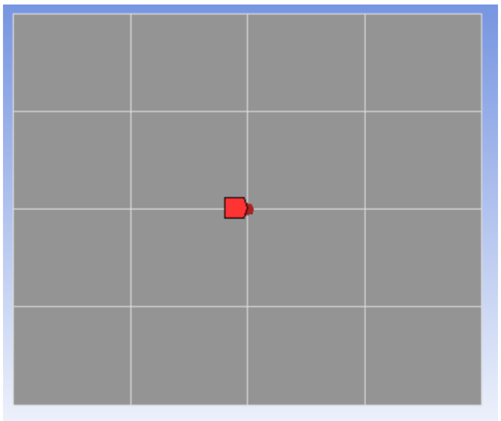

**Fig -1:** Case 1 loading at centre

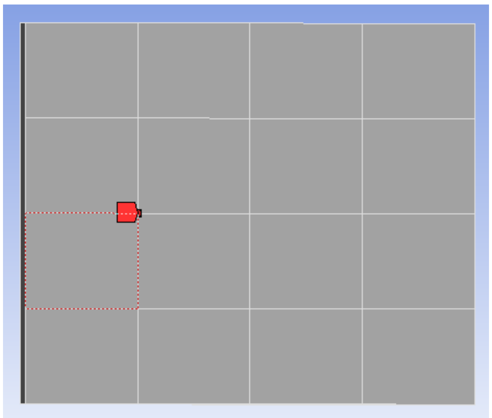

**Fig -2:** Case 2(a) concentrated load at center of left half

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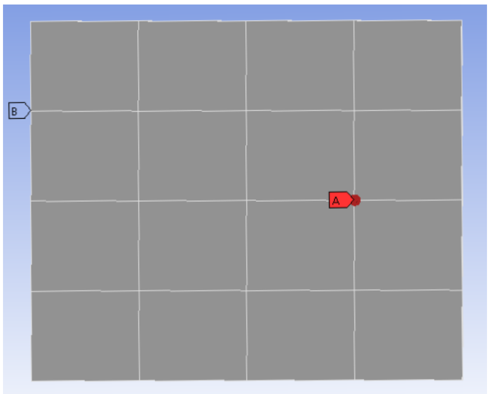

**Fig -3:** Case 2(b) concentrated load at center of right half

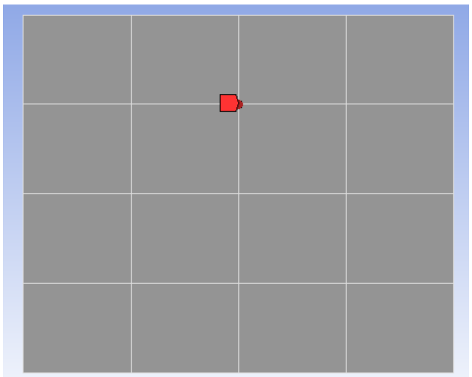

**Fig -4:** Case 3(a) concentrated load on center of upper half

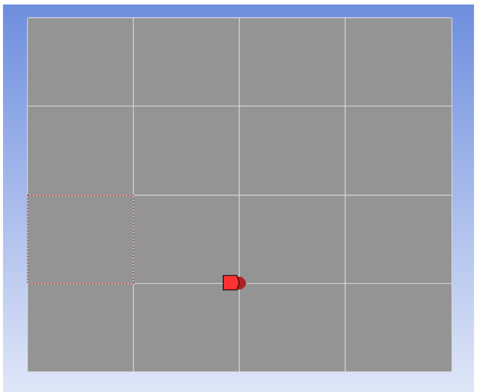

**Fig -5:** Case 3(b) concentrated load on center of lower half

## 3. RESULTS AND DISCUSSION

As a result of comparison between the slab with diffrent loading condition, following inferences has been made

### 3.1 Deflection

Five different slabs were analyzed in which Case 3(a) had the highest deflection and case 3(b) had the least deflection.

The graph you sent 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.

The graph shows five different curves, one for each of five different cases

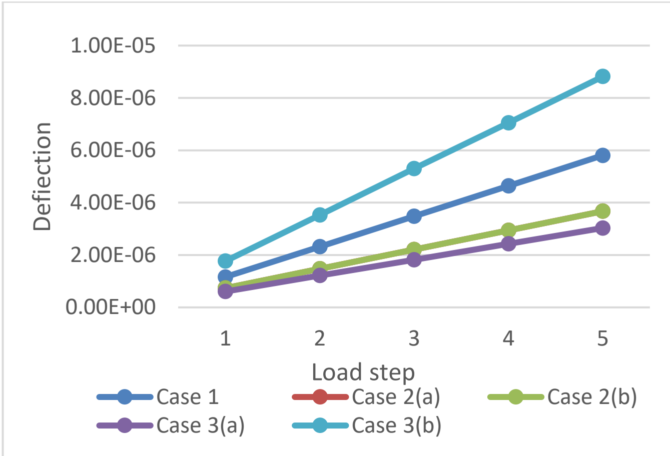


**Fig -6:** Load Deflection curve of slabs

### 3.2 Max moment

This line graph shows the maximum moment (Nm) of different cases of slabs at different loading. the x-axis of the graph is the load step, which is a measure of the applied load on the slab. The y-axis of the graph is the maximum moment, which is the bending moment at the most critical point of the slab.

The graph shows that the maximum moment increases with the loading for all cases. However, the rate of increase varies depending on the case. For example, Case 3(b) has the highest rate of increase, while Case 1 has the lowest rate of increase. The graph also shows that Case 3(b) has the highest maximum moment at all load steps. This means that Case 3(b) is the most critical case, and it requires the most reinforcement.

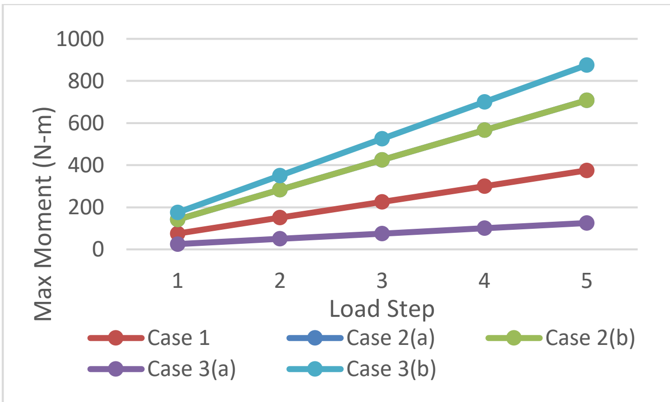


**Fig -7:** max moment for slabs

## 3. CONCLUSIONS

In this study, the distribution of stress and deformation were determined for each example using ANSYS to perform plastic analysis on a few concrete reinforced slabs. Additionally, each case's yield line design was displayed.

From this study we can conclude this

1. Minimum deformation is generated in case 3(a) and maximum deformation is generated in case 3(b).
2. Case 3(b) has the highest rate of increase, while Case 1 has the lowest rate of increase.
3. The graph also shows that Case 3(b) has the highest maximum moment at all load steps. This means that Case 3(b) is the most critical case, and it requires the most reinforcement
4. Based on a comparison of all loading conditions, we conclude that case 3(a) is the most appropriate condition. Case 3(b) is the most critical situation.

ANSYS software cannot pinpoint the precise fracture path; however, by examining the stress distribution in slabs, one can approximate the yield line pattern. When the mesh is smaller, the analysis is more precise and the result is more realistic.

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