A Comparative Study on Two Way Slab with and without Opening with Different Boundary Conditions using Ansys

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Abstract— Analytical determination of displacements and stresses in reinforced concrete material was a difficult task and engineers had to rely on empirical formulas because concrete consists of heterogeneous material and creep and shrinkage influenced deformations in it. The slab is made of brittle materials like concrete, show increasing deflection during their service life due to mechanical and environmental loadings. In this project, a parametric study on a slab to study stress and deflection was carried out. The study consisted of various specimens of slabs with different span ratio which was modeled and analyzed. The study revealed that the modeled slabs with opening showed greater deflection when compared to the deflection slabs without opening under different boundary conditions and found that all the results were subjected to within the permissible limits as per Indian Standard.

Keywords: Two Way Slab, Boundary Conditions, Stress, Deflection, FEM

I. INTRODUCTION

In this era of urbanization, materials used for construction simply cannot be wasted by creating different structural members and testing them in laboratories. As we already know that river sand is being replaced by M-sand, To overcome this FEA software's are available. ANSYS is one of the FEA software which provides the results which are nearly equal to the theoretical results. The accuracy of this software is more because the structure is divided into finite elements during analysis. Understanding the behavior of reinforced concrete (RC) components in structures subjected to different loading conditions is very important to obtain comprehensive knowledge to design a safe and functional structure. There are different methods to analyze RC members. Ansys is one of the modern tools which helps to understand the behavior of RC members under different loading conditions.

In this study of two way reinforced concrete slab with and without openings are modeled using commercial software package ANSYS to understand the behavior of slab with different boundary conditions. This study aims to determine the effect of opening on stresses and deflection in two way reinforced concrete slab using ANSYS 16.0.

II. LITERATURE SURVEY

Koh Heng Boon.et.al (2009) [9] carried out to determine the structural performance of one way reinforced concrete slabs with a rectangular opening. Five types of RC slab which consists of two panels for each type were tested by four points bending test. These include one control slab without opening and other four with the rectangular opening at the center. Based on the experiment result it was found that the reduction of 15% area due to the rectangular opening located at the center of RC slabs reduces 36.6% of flexural strength. The crack pattern obtained for slabs with opening and without additional reinforcement around was found to be same as that of slabs with opening and additional reinforcement of either rectangular bars or diagonal bars around the opening. The provision of additional reinforcements surrounding the opening increases the flexural capacity of the RC slab. Also, the cracking pattern found in the opening slab shows high concentration stress occurred at the corner of the opening when the vertical load applied.

Sheetal Gawas and Dr. S.V.Itti (2013)[8] presented finite element analysis of RCC slab models to study the variation of displacement and stresses, in the slab with different boundary conditions. Non-Linear static analysis was carried out using ANSYS 10 Software and a rectangular RC slabs with tensile reinforcement was analyzed. Comparing the slabs with different boundary conditions both with and without opening, the slab simply supported on all the edges shows the highest displacement and slab fixed all the edges shows the least displacement. The slab having fixed support on all the edges with and without opening shows highest stresses, whereas slab simply supported on all edges shows least stresses among all other slabs.

Chee Khoon Ng et.al (2008)[3] carried out, a study on simply-supported and fixed-end, square slabs with an opening at ultimate limit state using the yield line method. A study on the effect of opening on the load-carrying capacity of simply supported and fixed-end slabs was presented. After their analysis they came to a conclusion that, since most of the slabs have small opening of size up to 0.3 times the slab dimension, a simply supported slab would have a reduction in ultimate area load of up to 11% and a reduction of ultimate total load of up to 19% and a fixed-end slab would experience less significant reduction in both ultimate area load and ultimate total load capacities of 4% and 7%, respectively. They also presented charts in normalized load capacity and opening size which could be e used as guidelines for predicting the load capacity of simply- supported and fixed end slabs with openings.

Mr.Yadav Jaideep Purushottam (2016) [10] performed experimental study and testing on solid flat slab and voided slab using ANSYS Workbench. The deformation of both slab systems under same loading conditions was calculated using Finite Element Analysis.the deformation due to live load and long-term deformation of the solid flat slab and voided slab was in the range of permissible limits as per provisions made in ACI 318-11. He concluded that according to the structural efficiency point of view the voided slab shows good agreement.

Samal M. Rashied: [1] This paper deals with the aims compilation of the state of review on the evaluation of the predicted punching shear strength. A total of 79 tested slabs without shear reinforcement were selected from literature to study the treatments by these methods. The comparisons from their failure loads compared to their

reference specimens without opening show that the punching shear resistance is inversely proportional to the opening size, location, and distance to the face of the related columns.

III. Materials and Methodology

ANSYS (version 10) has been chosen to analyze RC slabs with and without openings in this study due to its flexibility in geometry and materials modeling.

In the present study following slabs are analyzed with four different boundary conditions as follows.

1) Case I: Slab with a fixed support on all four edges.
2) Case II: slab with simple support on all four edges
3) Case III: Slab simply supported on two adjacent edges and fixed supported on two adjacent edges.
4) Case IV: Slab simply supported on two opposite edges and fixe supported on two opposite edges.

The analysis of slab has also been carried out with openings using the same boundary conditions mentioned above.

Three Specimens were analyzed in Ansys. In each case the opening is 50% of Slab dimensions, the load applied is 12 KN/m^2.

A. *Specimen A*

Size of the specimen = 6m X 6m
Reinforcement = 8mm @ 180 mm c/c both side
$L_Y / L_X = 1.0$
Location of Opening = Centre

B. *Specimen B*

Size of the specimen = 4m X 5m
Reinforcement = 8mm @ 195 mm c/c both side
$L_Y / L_X = 1.25$
Location of Opening = Centre

C. *Specimen C*

Size of the specimen = 3m X 5m
Reinforcement = 8mm @ 180 mm c/c both side
$L_Y / L_X = 1.67$
Location of Opening = Centre

IV. Results and Tables

In the present work the results for slabs with four different types of boundary conditions are being analysed and studied. The effect of opening in slabs, on displacements and stresses has been obtained from the analysis.

A. *Specimen A*

Support conditions	Without Opening	With opening
CASE I	40.344	45.467
CASE II	50.815	59.453
CASE III	48.206	56.883
CASE IV	46.02	54.469

Table 1: Result of comparison of variation in displacement in mm in the slab with different boundary conditions.

Support conditions	Without Opening	With opening
CASE I	12.907	14.574
CASE II	21.592	25.263
CASE III	21.318	25.155
CASE IV	17.437	20.638

Table 2: Result of comparison of variation in stresses in MPa in the slab with different boundary conditions

B. *Specimen B*

Support conditions	Without Opening	With opening
CASE I	26.087	29.452
CASE II	32.109	37.857
CASE III	29.272	34.539
CASE IV	26.007	30.792

Table 3: Result of comparison of variation in displacement in mm in the slab with different boundary conditions

Support conditions	Without Opening	With opening
CASE I	13.324	17.147
CASE II	17.704	21.057
CASE III	15.516	18.65
CASE IV	13.394	15.888

Table 4: Result of comparison of variation in stresses in MPa in the slab with different boundary conditions

C. *Specimen C*

Support conditions	Without Opening	With opening
CASE I	20.059	23.3
CASE II	25.512	30.104
CASE III	24.085	28.42
CASE IV	22.825	27.019

Table 5: Result of comparison of variation in displacement in mm in the slab with different boundary conditions

Support conditions	Without Opening	With opening
CASE I	40.344	45.467
CASE II	50.815	59.453
CASE III	48.206	56.883
CASE IV	46.02	54.469

Table 6: Result of comparison of variation in stresses in MPa in the slab with different boundary conditions

V. Conclusion

From the limited study carried out, to study the behavior of two way RC slab with and without openings with different boundary conditions, the following conclusions have arrived.

1) The displacement in slab fixed on all the edges with an opening is 13.03% higher than the slab without opening with the same boundary condition.
2) The displacement in slab having fixed support on adjacent edges and other adjacent edges simply supported with an opening is 17.99% higher than the slab without opening with same boundary condition.
3) The displacement in slab having fixed support on opposite edges and other opposite edges simply supported with an opening is 18.38% higher than the slab without opening with the same boundary condition.
4) The displacement in slab simply supported on all the edges with an opening is 17.63% higher than the slab without opening with the same boundary condition.
5) Comparing the slabs with different boundary conditions both with and without opening, the slab simply supported on all the edges shows the highest displacement and slab fixed all the edges shows the least displacement. A slab with other boundary conditions shows little variation in displacement.

The slab having fixed support on all the edges with and without opening shows higher stresses, whereas slab simply supported on all edges shows least stresses among all other slabs. Slab with other boundary conditions such as slab simply supported on opposite edges and slab simply supported on adjacent edges shows very less variation as compared to the slab with fixed support.

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