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Study on Two way RC Slab using ANSYS with and without central opening

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Abstract— ***ANSYS is finite element software. In the present work, finite element analysis of RCC slab models have been carried out. The study is based on the fact that stress and displacement variation depends on boundary conditions of slab. Present study is aimed to know the variation of displacement, stresses, in slab with different boundary conditions. Non-Linear static analysis is carried out using ANSYS 10 Software. Load on slab is calculated as per IS 875 part I for dead load and part II for live load. Parameter considered is to study the effect of opening in slab on stress and displacement. The study shows that displacement is highest in slab having simple support on all sides and stresses are least in same slab along the edges. Also slab with fixed support on all sides shows least displacement and highest stresses along the edges of the slab.***

Keyword - Bridge pier, Reinforcement, Displacements, Stresses, ANSYS.

I. Introduction

Understanding the behaviour of reinforced concrete (RC) components in structures subjected to different loading conditions is very important in order to obtain comprehensive knowledge to design a safe and functional structure.

There are several methods to analyze the response of RC structural components. Experimental testing is one of the most reliable methods to understand the behaviour of structure. While this method yields a high degree of accuracy, it is time consuming and always entails a high cost. Use of finite element analysis (FEA) method has become popular in recent years; it is fast and saves time and money. Although the use of this method was time consuming because of low processing capability of computers before, it is much easier these days with existing of faster computers in terms of both software and hardware capabilities.

The results obtained from FE analysis must be scrutinized very carefully. To fully understand the result of a FE analysis program, one must closely check the result and compare them with other method of analysis such as reliable and reasonable hand calculation methods. The validity of FE models must be verified.

In this study of two way reinforced concrete slab with and without openings are modelled using commercial software package ANSYS to understand the behaviour of slab with different boundary conditions. The aim of this study is to determine the effect of opening on stresses and deflection in two way reinforced concrete slab.

II. Material and Methodology

The finite element method is a numerical analysis technique for obtaining approximate solutions to a wide variety of engineering problems. ANSYS is a general purpose finite element modeling package for numerically solving a wide variety of problems which include static/dynamic structural analysis (both linear and nonlinear), heat transfer and fluid problems, as well as acoustic and electro-magnetic problems. The Rectangular RC slabs with tensile reinforcement have been analyzed using a finite element (FE) model in ANSYS. Here, a non linear analysis is considered throughout the study by assuming that there is a perfect bonding between concrete and steel reinforcement.

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

The slab of size 2*3 m has been designed for service load of 12kN/m^2. This factored load has been applied in the form of load step and displacement and stresses at each load step has been noted down. All slabs were 120 mm thickness. Concrete cover 20 mm is used and reinforcement adopted is 8 mm diameter bar @ 250mm c/c on both sides.

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

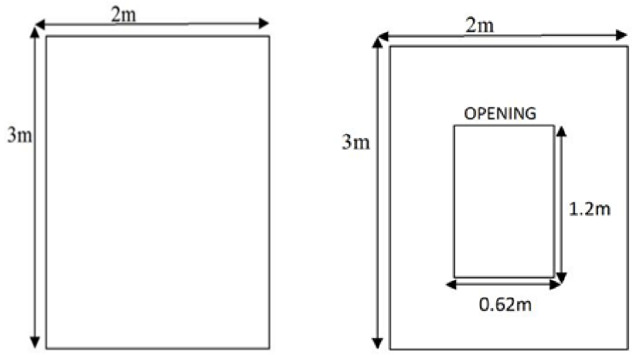
Case I: Slab with fixed support on all four edges.

Case II: Slab simply supported on two adjacent edges and fixe supported on two adjacent edges.

Case III: Slab simply supported on two opposite edges and fixe supported on two opposite edges.

Case IV: slab with simple support on all four edges.

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



(a) **(b)**

Figure 1 – dimensions of the slab (a) without opening, (b) with opening.

The following has been used for the materials idealization:

A. Concrete idealization:

The solid65 element models the nonlinear response of reinforced concrete. The behaviour of the concrete material is based on a constitutive model for the triaxial behaviour of concrete. Solid 65 is capable of plastic deformation, cracking in three orthogonal directions at each integration point. The cracking is modelled through an adjustment of the material properties that is done by changing the element stiffness matrices. If the concrete at an integration point fails in uniaxial, biaxial, or triaxial compression, the concrete is assumed crushed at that point. Crushing is defined as the complete deterioration of the structural integrity of the concrete.

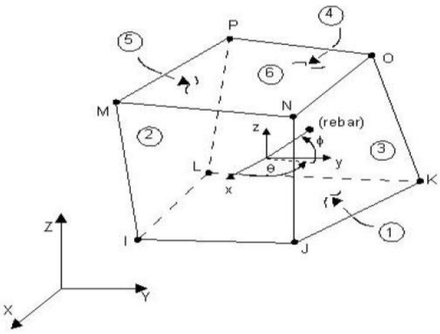


Figure 2 – solid 65 elements

Table-1 lists concrete properties within Solid65 element prior to initial yield surface.

The solid65 element is capable of cracking in tension and crushing in compression. The multi linear isotropic concrete model uses the von Mises failure to define the failure of concrete.

Table-1. Concrete properties prior to initial yield surface

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Material	Material model	Modulus of elasticity (MPa)	Poisons ratio
concrete	Linear elastic	27162	0.2

Table-2 Concrete parameters beyond initial yield surface.

Open shear transfer coefficient, β*t*	0.3
Closed shear transfer coefficient, β*c*	0.9
Uniaxial cracking stress	3.5 Mpa
Uniaxial crushing stress f'c	33.4 Mpa

The compressive uniaxial stress-strain relationship for the concrete model was obtained using the following equations to compute the multilinear isotropic stress-strain curve for the concrete.

$$f = \frac{E_c \varepsilon}{1 + \left(\frac{\varepsilon}{\varepsilon_o}\right)^2} \quad 1$$

$$E_c = \frac{f}{\varepsilon} \quad 2$$

$$\varepsilon_o = \frac{2 f'_c}{E_c} \quad 3$$

Where

f = stress at any strain

ε = strain at stress *f*

ε_o = strain at ultimate compressive strength

Ec = concrete modulus of Elasticity

B. Steel Reinforcement:

LINK8 is a spar which may be used in a variety of engineering applications. This element can be used to model trusses, sagging cables, links, springs, etc. The 3-D spar element is a uniaxial tension-compression element with three degrees of freedom at each node: translations in the nodal x, y, and z directions. As in a pin-jointed structure, no bending of the element is considered. Plasticity, creep, swelling, stress stiffening and large deflection capabilities are included.

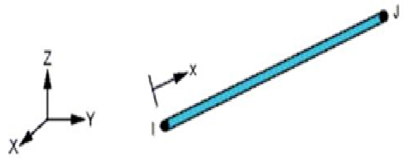

Figure3 - LINK8 Geometry

III. Results and Tables

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

DISPLACEMENTS IN SLABS:

Table 3 - Result of comparison of variation in displacement in mm in slab with different boundary conditions without opening.

Load (kN/m²)	**Case I**	**Case II**	**Case III**	**Case IV**
2.4	0.318	0.371	0.374	0.377
3.6	0.477	0.557	0.562	0.565
4.8	0.636	0.743	0.749	0.753
6	0.794	0.928	0.936	0.942
7.2	0.953	1.114	1.123	1.130
8.4	1.112	1.300	1.310	1.318
9.6	1.271	1.485	1.497	1.507
10.8	1.430	1.671	1.685	1.695
12	1.589	1.857	1.872	1.883

Table 4 - Result of comparison of variations of displacement in mm in slab with different boundary conditions with opening.

Load (kN/m²)	**Case I**	**Case II**	**Case III**	**Case IV**
2.4	0.365	0.452	0.459	0.459
3.6	0.548	0.677	0.688	0.689
4.8	0.731	0.903	0.917	0.919
6	0.913	1.129	1.187	1.149
7.2	1.096	1.355	1.376	1.378
8.4	1.279	1.580	1.605	1.608
9.6	1.462	1.806	1.835	1.838
10.8	1.644	2.032	2.064	2.068
12	1.827	2.258	2.293	2.297

From tables 3and 4 it is observed that case IV shows highest displacement whereas case I shows least displacement. Case II and III show little variation in displacement compared to case IV.

STRESSES IN SLABS

Table 5 - Result of comparison of variation in stresses in kN/m^2 in the slab with different boundary conditions without opening.

Load (kN/m^2)	Case I	Case II	Case III	Case IV
2.4	.245823	.23742	.195457	.154885
3.6	.368734	.356141	.293186	.232327
4.8	.491646	.474855	.390915	.309769
6	.614557	.593569	.488643	.387712
7.2	.737469	.712283	.586372	.464654
8.4	.86038	.830997	.684101	.542096
9.6	.983292	.94971	.781829	.619539
10.8	1.106	1.0680	.879558	.697081
12	1.229	1.1870	.977287	.774423

Table 6 - Result of comparison of variation in stresses in kN/m^2 in the slab with different boundary conditions with opening for loading 12kN/m^2.

Load (kN/m^2)	Case I	Case II	Case III	Case IV
2.4	.294927	.273561	0.209727	.187095
3.6	.44245	.410342	0.31459	.280643
4.8	.589934	.547122	.419453	.374191
6	.737417	.683903	.524316	.467739
7.2	.884901	.820683	.62918	.561286
8.4	1.032	.957464	.734043	.654834
9.6	1.18	1.09400	.838906	.748382
10.8	1.327	1.23100	.94377	.841929
12	1.475	1.36800	1.049	.935477

From tables 5 and 6, it is observed that case IV shows least stresses whereas case I shows highest stresses. Case II and III show little variation in displacement compared to case I.

IV. Conclusion

1. The displacement in slab fixed on all the edges with opening is 13% higher than the slab without opening with same boundary condition.
2. The displacement in slab having fix support on adjacent edges and other adjacent edges simply supported with opening is 17.75% higher than the slab without opening with same boundary condition.
3. The displacement in slab having fix support on opposite edges and other opposite edges simply supported with opening is 18.36% higher than the slab without opening with same boundary condition.
4. The displacement in slab simply supported on all the edges with opening is 18.02% higher than the slab without opening with 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 highest displacement and slab fixed all the edges shows least displacement. A slab with other boundary conditions shows little variation in displacement.
6. 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. 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 slab with fixed support.

Acknowledgement

Foremost, I would like to thank my God for His graciousness, unlimited kindness and with the blessings of whom the good deeds are fulfilled.
Finally I would like to dedicate this work to my family and all my beloveds.

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