ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 11, Iss 10, Oct 2022

Experimental Performance of Effects of Opening on Reinforced Concrete (RC) Flat Plate Slabs

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ABSTRACT

The reinforced concrete (RC) flat plate provides a good solution for the roofing system. This method of flat plate construction generally employed at commercial projects. The structural behavior of reinforced concrete flat plate is different from conventional RC slabs as these flat plates are directly supported on columns. The flat plates are more susceptible to reduce load carrying capacity due to openings and also reducing the capacity of punching shear failure. The openings are required in existing slabs due to post installment of cables, sanitary pipes, lift, escalators. This present study involves analyzing the effect of flat plate with and without opening. The parameter studied was load carrying capacity.

1. INTRODUCTION

The different roofing systems are available as per the requirement which includes economy, aesthetics and other parameters. Apart from all the relevant considerations structural stability plays a crucial role in the design system. One of the conventional roofing adopted systems adopted is the inclusion of beams between columns to support the slab which provides the required structural stability .The another system adopted for roofing is the flat plate or flat slab. The flat plate or flat slab is the slab without beams which directly rests on the columns. As the beams are excluded there is a concentration of shear stresses and reduction in load carrying capacity surrounding the column. To enhance the shear resistance capacity surrounding these regions additional components in the form of drop or capital is provided or higher concrete grade can be attempted.

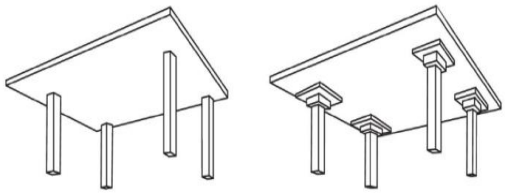

Fig 1 : Flat Plate & Flat Slab[11]

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2. LITERATURE REVIEW:

Taehun Ha *et al.* [1]: studied, openings in RC flat-plate slabs are one of the critical factors that influence the punching shear strength of the slab and determine its thickness in the vicinity of the slab-column joint. This study experimentally investigates the effects of openings on the punching shear strength of flat-plate slabs without shear reinforcement. Tests were performed on eight flat-plate slab specimens considering the layout and number of openings as test variables. The measured punching shear strengths of the test specimens are compared with the predictions of several concrete design codes, including the American Concrete Institute (ACI).

Valery Filatov *et al.* [2]: carried out experimental study on the test specimens of the stress-strain condition of flat reinforced concrete slabs of a girder less framework at punching by columns of square and rectangular section are presented. The research of influence of a form of a column cross section on the stress-strain condition of a reinforced concrete slab in a punching zone is conducted. The results of the research of cracking in a zone of punching of reinforced concrete slabs are presented here.

Ozgur anil [3] investigated flexural behavior of one way RC slab with opening and applying strengthening to them by using CFRP strips. Size and location of opening on the slab are the main parameters that are investigated in this experimental research. Three different square opening with 300 mm, 400 mm and 500 mm side are tested. These openings are situated in two different places, bending and shear zone. Two series of test are done during experimental program. First set of experiments are done without strengthening and second set of test are done after strengthening with CFRP strips. Totally, thirteen test specimens are tested, including one reference specimen, six specimens without strengthening and six specimens with strengthening. CFRP strips are located around the openings along the specimen. Finally some evaluations of test results are done for determining the performance of strengthening techniques. Strength, stiffness, ductility and energy dissipation capacities of specimens are calculated and compared.

Chee Khoon Ng [4], studied on simply-supported and fixed-end, square slabs with opening at ultimate limit state using the yield line method was carried out and the results are presented herein. For simply-supported slabs, the analytical study on the ultimate load capacity of the slab shows that the ultimate total load decreases with the size of the opening. However, when the ultimate total load is converted to ultimate area load, the results show otherwise. In the study of fixed-end slabs, the results show that the opening has insignificant effect on the ultimate area load capacity for a small opening size of up to 0.3 times the slab dimension.

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Ahmed Aziz Abdulhussein [5], the six square reinforced concrete flat plates with dimensions of (1500×1500×100) mm were tested under a concentrated load applied on a column located at the center of the slabs. One of these slabs was the control specimen, whereas, in the others, steel angles (steel collars) were used, fixed at the connection region between the slab and the column to investigate the effect of the presence of these collars on punching shear strength.

Priya M P &Santhi A S [6], the paper presents an experimental study on the behavior of the flat slab against punching shear under different support conditions. Nowadays flat slabs are widely using for different concrete structures because of its several advantages. In order to conduct the study, six slab-column specimens of the flat slab were casted and subjected to test with four, three and two sides rigidlysupported. The tests were conducted to study the punching shear capacity and the crack pattern of the slab-column connection of the flat slab.

S.C. Floruț [11], the paper presents the results of experimental investigations and numerical analyses performed on reinforced concrete flat slabs. Two tests were carried out on two flat slab specimens designed without specific shear reinforcement. The present paper deals only with the experimental behavior and numerical modeling of such slabs.

3 EXPERIMENTAL PROGRAM:

The flat plate is casted in the laboratory using the formwork. The scaled flat plate is of size 750 mm x 750 mm as shown in the figure below. The total six flat plate panels were prepared. The compressive strength found after the casting of the concrete cube was M20. The reinforcement of 6 mm diameter used, of grade Fe 500.The flat plate considered for the analysis was with and without opening. The details of which are enumerated below. The experiment is performed in universal testing machine

Flat Plate	Dimension mm	Thickness mm	Opening Size mm
FL1	750*750	75	Without opening
FL2	750*750	75	60
FL3	750*750	75	75
FL4	750*750	75	90

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Fig 1: Flat Plate Specimen with & without opening

Results & Discussion:

The observations were made for the ultimate loads and first crack load. The deflections were measured. The ultimate load described the flexural failure of the RC flat plate.

The loads are listed in the table 1 below.

Flat Plate	Dimension mm	Thickness mm	First Crack load kN
FL1	750*750	75	28.5
FL2	750*750	75	27.7
FL3	750*750	75	26.9
FL4	750*750	75	24.3

Flat Plate	Thickness mm	Ultimate load kN	Deflection mm
FL1	75	39	7.45
FL2	75	33	7.15
FL3	75	31	7.32
FL4	75	30	7.70

The loads at first crack and ultimate loads were observed and corresponding deflections were noted for flexural performance of RC flat plates.

4 CONCLUSION:

The following conclusions can be drawn from the experimental work.

The percentage decrease in load carrying capacity was observed

1. The load carrying capacity flat plate with circular opening of 60 mm was found to 15.4% less as compared with flat plate without opening.
2. The deflection of the slab values at different opening sizes was indicated.
3. The load carrying capacity flat plate with circular opening of 75 mm was found to 20 % less as compared with flat plate without opening.
4. The load carrying capacity flat plate with circular opening of 90 mm was found to 23% less as compared with flat plate without opening.

It was observed that the load carrying capacity reduced as the sizes of opening is increased.

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