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Comparative Study on Crack Pattern of RCC and Brick Composite Slabs

Arun Singh Chahar[1] Mr. R.D. Patel[2]
[1]PG Scholar [2]Associate Professor
[1,2]Department of Civil Engineering
[1,2]M.M.M.U.T. Gorakhpur, India

Abstract— In this paper present a study carried out on Crack Pattern and Failure modes of RCC and Brick Composite slabs. The main objective of this thesis is to study replacement of concrete by bricks. The concrete of tension zone has been replaced by Brick in order to reduce weight and cost of the reinforced concrete beams An experimental program is conducted on six simply supported concrete slabs. All six slabs casted in two different groups and every group having three slabs. The first group of slabs are of reinforced concrete slabs and second group of slabs are composite slabs. The Crack Pattern of both groups of slabs compare with each other. The comparative study has been carried out on the Crack Pattern, cracks has been seen by applying four point loading on the both types of slabs and the deflection is also measure by using dial gauge. In this study three Rcc slabs and three Brick composites slabs have been casted of concrete grade M25, and behaviour under four point loading conditions is checked in Structure & Concrete Laboratory of Madan Mohan Malviya Engineering College Gorakhpur. This will include the variation in load displacement graph, the crack patterns, propagation of the cracks, the crack width and the effect of the nonlinear behaviour of concrete and steel on the response of control Slab and the deformed slab.

Key words: RCC, Brick, Flexural strength, Crack Pattern, Deflection, Four Point Load

I. INTRODUCTION

Brick and RCC composite slabs an attempt is being made to reduce cost of reinforced concrete slabs, replacing concrete by brick near the neutral axis as well in tension zone. The behaviour of brick and RCC composite slabs is same to that of reinforced concrete slabs.

We know that concrete is fairly strong in compression but very weak in tension. So concrete of tension zone has been replacing by brick. Steel is very strong in tension. The steel bars are placed near the bottom with the cover of 20 mm of slabs where they are most effective in resisting the tensile bending stresses. Thus, the tensile weakness of bricks overcomes by the provision of steel bars in the tension zone. The bond between brick and concrete layers at the brick concrete interface should be good. It should be ensure that no slip occur between concrete and brick.

In this study partially utilized concrete of RCC slab have been replaced by bricks in order to reduce the weight of slabs and also achieve economy, and by reducing concrete we have to save cement and by saving cement reduced the greenhouse gasses emissions. So it will be environment friendly.

II. EXPERIMENTAL STUDY

Total six numbers of simply supported slabs were casted for the experimental study. All the six slabs were cast in two different group of three beam in each group. The first group of slabs is the control group in which three reinforced concrete slabs were casted. The second group of slabs is the composite slabs in which three brick and reinforced concrete composite slabs were casted. The Crack Pattern and failure modes of both groups of slab compare with each other.

Fig. 1: Arrangement of Bricks with Reinforcement Cage

III. MTERIALS USED

A. *Cement:*

Ordinary Portland cement 43 grade is used throughout the study conforming to IS 8112–1989. Cement is a material that has cohesive and adhesive properties shown in the presence of water. We tested the cement in laboratory and it has following properties:

S.No.	Physical Properties	Test Results
1.	Specific Gravity	3.152
2.	Fineness (%)	8
3.	Initial Setting Time (min)	70
4.	Final Setting Time (min)	320
5.	Compressive Strength (MPa)	44

Table 1 Physical Properties of Cement:

B. *Coarse Aggregate:*

Crushed aggregate of 4.75-20 mm sizes are used for control concrete for comparison. Coarse aggregate of size 20 mm and 10 mm both are used in this project. It's conforming the IS 383:1970. Their properties greatly influence the behaviour of concrete since they occupy about 50 % of the total volume of concrete. For sieve analysis of coarse aggregate, the large tray shaker is most commonly used.

S.No.	Physical Properties	Test Results
1.	Maximum Size (mm)	20
2.	Specific Gravity	2.71
3.	Fineness Modulus	7.65
4.	Water Absorption (%)	0.2
5.	Crushing Value (%)	17.0
6.	Impact Value (%)	9.0

Table 2 Physical Properties of Coarse Aggregate:

C. *Fine Aggregate:*

Red gravel sand is used throughout the study as the fine aggregate conforming to grading zone II as per IS 383:1970. The sand was air-dried and sieved to eliminate any heavy particles before mixing. The fine aggregate also helps the cement paste to hold the coarse particles. The most important function of the fine aggregate is to provide workability and uniformity in the mixture. Fine aggregate has the following properties:

S.No.	Physical Properties	Test Results
1.	Specific Gravity	2.64
2.	Fineness Modulus	2.78
3.	Silt Content (%)	2.52
4.	Water Absorption (%)	0.4
5.	Bulking (%)	31.6

Table 3 Physical Properties of Fine Aggregate:

D. Bricks:

In this study we used the clay bricks to casting the composite slabs. Bricks are prepared by moulding clay into required shapes and then by subsequent drying and burning operations.

S.No.	Properties	Test Results
1.	Water absorption (%)	11.5
2.	Compressive strength (N/mm^2)	10
3.	Efflorescence	Slight
4.	Shape and Size	Rectangular and Standard
5.	Soundness	
6.	Hardness	No impression left made on brick surface by finger nail.

Table 4 Test Results of Brick:

E. Steel Bars:

In this study we have been used the high strength deformed bars of grade Fe500. In this 500 is the characteristics strength of steel in N/mm^2. These bars conforming the IS: 1786.

S.No.	Properties	Minimum	Test Results
1.	Yield Strength (N/mm^2)	500	545
2.	Ultimate Tensile Strength (N/mm^2)	545	661
3.	Elongation (%)	12	17.5
4.	Weight (kg/m)	0.398	0.400

Table 5 Properties of Steel Bars:

F. Water:

Potable tap water as per IS: 456 (2000) has been used for concrete mixing and curing of test Specimens. The water used for both mixing and curing was free from injurious amount of oils, acids, salts, organic materials or other substances that may be harmful to concrete or reinforcing steel.

IV. CASTING OF SPECIMEN

For conducting experiment , six reinforced concrete slab specimen of sizes as shown in the figure effective span, l_{eff} = 2.076m , breadth of slab b = 1 m, Overall depth of slab d = 0.1 m, Effective depth d_{eff} =.076m. The mix proportion used is for water, cement, fine aggregate and course aggregate is taken. The mixing is done by manual mixing. The slabs cured for 28 days. For each slab 2 cubes and 1 prism were casted to determine the compressive strength and flexural strength respectively for 28 days.

Fig. 2: Casting of Slab

V. EXPERIMENTAL SET UP

The slabs were tested at the loading frame in "Structural Engineering "Laboratory of Madan Mohan Malaviya University of Technology, Gorakhpur". The testing procedure for the entire specimen was same. First the slabs were cured for a period of 28 days then its surface is cleaned with the help of sand paper for cleared visibility of cracks. The four point loading arrangement was used for testing of slabs. It has the advantage of substantial region of uniform bending, the four point loading system is provided and it is being showed in figure. The load is transfer through load cell on to the spreader I beam. The spreader I beam is installed on rollers seated on desired point of slab loading was done by hydraulic jack of capacity 100KN.

Fig. 3: 1st group RS on Testing Frame

Fig. 4 Crack in Tension Zone Propagates in Upward Direction

Fig. 5: Crack Pattern

Fig. 6: crack pattern on the bottom of group RS

Fig. 7: 2nd group CS on testing frame

Fig. 8: Crack in Tension Zone Propagates in Upward Direction

Fig. 9 Crack Pattern of 2nd group CS

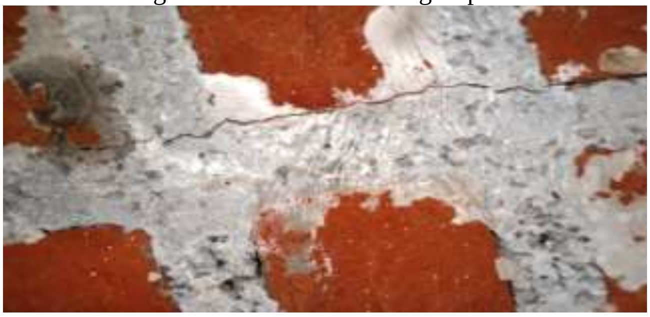

Fig. 10 crack pattern on bottom of group CS

VI. EXPERIMENTAL RESULT

The loading arrangement is same for all slabs. Here the deflection of each slab is analysed. Deflection of composite slab is compared with the deflection of control slab. Since the loading arrangement is same for all slabs so the crack pattern deflection behaviour and failure analysis is done by comparing the group slabs of CS.

Failure modes have been observed in the experiment of rectangular RCC slabs and brick composite slabs. Load was applied at the 300 mm here and there of centre of slab at each increment of the load, deflection is also measure where load was applied, with the help of dial gauges.

A. Study on Crack Pattern of group slab RS

As the slabs of group RS designed with the help of limit state designed philosophy and the designed load is for 16.75 kN. The control slab, flexure test starts as the test progress the crack pattern are found under the application of four points loading.

As the load and deflection curve is being curved out of first group slab. All the dial gauges reading is being marked out in this curve. Load is being applied on control slab the first hair line crack is being observed at the load of 27 kN. The cracks which are being observed in the middle as well as here and there of centre and crack pattern is also at the bottom of the slabs. At the middle of the slab the cracks are observed and are at 40^0-$50^{0.}$

B. Study on Crack Pattern of Group Slab CS

In group second CS as the load is being applied the first hair line crack is observed at 23 kN. The most of the cracks are being observed between four point loading. The cracks generate from bottom and then propagate towards the compression zone where load is being applied. Small cracks appear near the ends of the slab. In case of slab CS-2 cracks propagates in a zigzag manner and observed flexure area near applied loading. The cracks are propagated from bottom and joined around compression region. At the end of slabs the cracks are being observed and are at 200-300. A large crack appear where four point load is being applied.

C. First Hair Crack Load

It has been observed that RCC group slabs have more first hair crack strength as compared with composite group slabs.

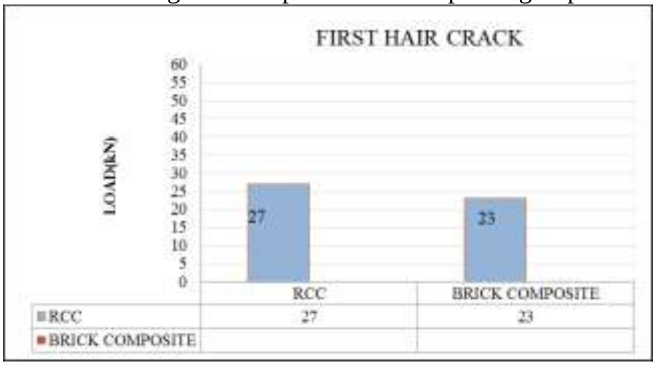

Fig. 11: Comparison Chart of First Hair Crack

VII. CONCLUSION

Brick Composite slabs may be required to maintain the weight of the structure. The study of RCC and Brick Composite slabs simply supported on two opposite rigid supports revealed the following fact:

- Four point loading shows the nonlinear load displacement curve after first crack is observed.
- No major difference in deflection of both types of slabs so we can say the performance of the both slabs near about same.
- In both slabs we observed first crack at load between 25 kN to 30 kN.
- In Brick Composite slabs required less quantity of concrete as compared to RCC slabs so, it is less costly slab.

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