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Behaviour of Ternary Blended Ferrocement Two-Way Slab Panels

Battina Swathi[1] , Tannimki Chandrasekhar Rao[2]

[1] Research Scholar, Department of Civil Engineering, Acharya Nagarjuna University, Guntur, AP ,522508
[2] Professor, Department of Civil Engineering, Bapatla Engineering College, Bapatla ,AP,522102.

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ABSTRACT

Experimental investigation is carried on six two-way simply supported ternary blended ferro cement slab panels of size 500 x 500 x 25mm subjected to patch loading to evaluate the punching shear resistance and the improvement in the behavior of the slabs when the ferromesh is added from 2 layers to 6 layers. A duplicate specimen is casted for all the specimens. Rich cement mortar blended with GGBS, SF and SNF based super plasticizer is added to improve the strength and fresh characteristics of the mortar. Test results obtained revealed that increase in volume fraction of reinforcement increases the punching strength of the panels. It is also observed that the failure mode shifted from punching failure to flexural failure when the reinforcement layers increased from 3 to 4 layers and more.

INTRODUCTION

The use of conventional building materials like steel and concrete is increasing drastically making the raw sources depleted and increase in Co2 emissions. Ferro cement like conventional structures do not demand much materials and is light in weight, the arrangement of reinforcement in the form of mesh makes the elements homogeneous in all the directions [1-4]. Use of supplementary cementitious materials to ordinary Portland cement not only reduce Co2 emissions but also improves the fresh and hardened properties of the mortar to a great extent [5].

The plenty of research available also has not gained the use of ferrocement elements in real time practice, many of the engineers and builders in the construction industry are not yet utilizing the advantage of light weight elements in ferrocement and the ductility performance of the ferrocement of the ferrocement elements. The major advantage of ferrocement elements is, it can be made of small thickness with high stiffness, resilience, durability and good strength. The mesh in reinforcement tends to fold instead of crumble (or) break like pottery (or) stone [6].

Many researchers have studied the behavior of ferrocement in flexure, shear, axial and punching strength. [7] Studied the effect of bamboos as reinforcement in ferrocement slabs under flexural loading by testing slab panels of size 470 x 940mm. The study concluded that the experimental failure load have been found almost same for both type of slabs. [8]

Studied the behavior of 32 one way ferrocmenet panels using GI & polypropylene meshes under line loading with 450 x 1000mm as each panel size. The study concluded that GI mesh panels out classes pp mesh panels both in flexure and compression but pp panels exhibited better ductility than GI panels. [9-11] studied the flexural performance of ferrocement slabs and observed that the slabs have high stiffness and lowest deflection among all tested slabs.

[12-15] tested ferrocement square panels under patch loading for observing the punching shear behavior of the slabs and reported that the behavior of square panels under patch loading is improved with the increase in slab thickness and reinforcement ratios.

This study aims to investigate the shear behavior of 12 two-way slab panels of size 500 x 500mm with 25mm thick using ternary blended mortar reinforced with ferro meshes varying from 2 layers to 6 layers under patch loading. The obtained results will be helpful for further development of ferrocement panels.

2. MATERIALS

Cement

KCP 53 grade cement was used. They conformed to IS: 8112 with specific gravity 3.13 and standard consistency of 33%

Fine Aggregate

Locally available river sand confirming to IS: 650 with a Fineness modulus of 2.4 and a specific gravity of 2.67 as used and it is conforming to Zone - III.

Water

Potable water was used for mixing and curing purpose

Silica fume

The mineral admixture was obtained from a local Ferro Alloys Industry and had a specific gravity of 1.2.

GGBS

Ground – granulated blast- furnace slag is obtained by molten iron slag from a blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into a fine powder and had a specific gravity of 2.84.

Super plasticizer

Sulphonated Naphthalene Formaldehyde condensate (SNF) was used for the present study. Its specific gravity was 1.18 at 25°C and had good compatibility, with Portland cement. Different dosages of Super plasticizer were used for obtaining the flow values of the mixes.

3. EXPERIMENTAL TEST SETUP

Tests were conducted on loading frame of 100T capacity using a constant displacement rate of 0.2mm/min. A central patch of 100 x 100mm is marked from center where both the diagonals of the slab panel meets. The constant load is applied through the patch on to the slab panel and a dial gauge is placed at the center to record the deflection during the loading. Circular steel plates of 100mm diameter is used to transfer the load to the slab from the machine. The cracks are marked after testing the specimen to failure and crack patterns are clearly examined for punching shear failure (or) yielding of reinforcement.

Fig.1 Casting of slab

Fig.2 Test Setup

4. RESULTS AND DISCUSSION

The load deflection behavior of all the specimens tested are shown in figure 5 and are tabulated in table 1. The first specimen is casted without any wire mesh and is used as reference slab to observe the improvement in performance of the ferro meshed slabs where reinforced layers are added from two to six layers. The load-deflection behavior of any specimen subjected to failure can be categorized into three phases. Phase - I a linear curve showing a straight line indicates the pre-cracking stage. Phase - II post-cracking stage which covers the major portion of the load-deflection response where the applied load is affectively restricted by the ferro mesh provided and phase - III is the post-peak portion [8].

Table 1: Failure load and ultimate deflections of one-way slab panels

S.NO.	No. of Layers	Failure Load, KN	Ultimate Deflection, mm
1	Solid	0.6	1.2
2	Two	5.6	16
3	Three	11	20
4	Four	14.2	24
5	Five	15.8	28.3
6	Six	18.1	29.2

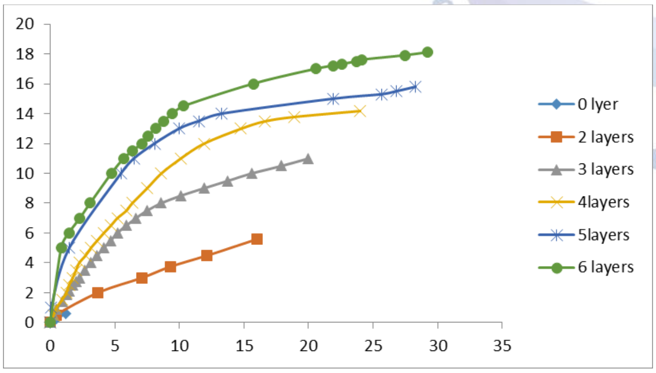

Fig 5. Load Vs Deflection curves of slab panels

From the figure 5 it is clearly evident that the reference specimen without any mesh, failed suddenly without any sign and can be referred to be failed in phase – I of the load-deflection curve as discussed earlier. The load at failure is considered as the reference load and the improvement in load carrying capacity of all other specimens is calculated. The specimen with two layers of mesh arrangement has shown a great improvement in load carrying capacity by 9.33 times of the reference specimen, the specimen failed after entering post-peak portion. The specimen with three layers of mesh has an increase in load carrying capacity by 17.33 times of the reference specimen, this specimen also failed just at the initial state of post-peak portion. The specimens with four, five and six layers have obtained a flat curve after peak load before failure which is an indication of increase in ductility. The deflection in the members are decreased with increase in the layers of mesh, which is in correlation with the findings of the earlier research [7-10].

Crack pattern

All the samples after testing carefully removed from the test setup and the crack propagations are marked up as shown in figure 6 (a) - (f). The type of failure can be classified in two different ways, it depends on the load-deflection curve. The failure is said to be in flexure if the load-deflection curve flattens after the peak load and it can be classified as shear failure (punching) if there is a sudden fall in load (a vertical drop) in the load-deflection curve. On the other hand failure type can be named depending on the crack pattern of the loaded specimen. If the crack is initiated in the central patch area and extended diagonally towards the support it can be named as flexural failure and if the crack occurs tangential to the patch area and extends diagonally, it can be named as punching shear failure.

The reference slab specimen failed in pure punching failure as shown figure 6(a). The slab specimen with two layers of ferromesh also failed in punching shear, the first crack initiated along the patch in the center and multiple cracks originated from the cracked patch area. In the slab specimens with three and four layers of ferromesh, both tangential cracks and radial cracks appeared parallel, this can be considered as flexural-shear failure. The slab panels with five and six layers of ferromesh have major cracks in radial direction and minor cracks in the patch area, the final failure is observed by widening of the radial cracks with no change in the width and depth of cracks in patch area. It can be clearly stated from the observed data that the increase in number of layers of ferromesh can change the failure mode from punching shear to flexural. An attempt can also be made in increasing the depth of the slab and decreasing the volume fraction of reinforcement to exactly identify the change in failure mode from punching shear to flexural failure.

Fig 6. Crack patterns of slab panels

5. CONCLUSIONS

From the tabulated results and crack patterns observed, the following are the conclusions

1. No sign of bonding failure is observed when the wire mesh is increased from two layers to six layers.
2. Clear sign of punching shear failure is observed with low volume fraction of wire mesh.
3. A change in failure mode from punching shear to flexural shear is identified in three and four layers of ferrocement wire mesh.
4. A clear change in failure mode from shear to flexure is observed when wire mesh is increased to five and six layers.

Conflict of interest statement

Authors declare that they do not have any conflict of interest

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