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Comparative Study on Structural Behaviour of Ferro Cement Two Way Slab Panels with TMT Bars and Slotted Angles

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ABSTRACT: The construction industry has grown up towards great heights due the growth in the construction and building materials. Since Construction Industry reached great heights the cost of construction keeps on increasing due to the increase in self weight, this can be reduced with the help of ferrocement panels. A wide research is going on in the area of ferrocement, this paper deals with the partial replacement of cement with marble powder will give better results or not. The failure pattern observed from the studies the propagation of crack starts from the mid span. This can be minimized with the help of introduction of the thin walled steel sections which can be placed as main reinforcement. The strength parameters have also discussed in this paper.

KEYWORDS: ferrocement, Two-point loading, Industrial Wastes

I. INTRODUCTION

Structural Light weight construction is growing towards a height due to the development of research in ferrocement. Ferrocement is a composite material that can be manufactured with the help of cement mortar along with the structural light weight reinforcement which are also known as wire mesh. The ferrocement slab can be manufactured with the help of three methodologies that can be prescribed by (M.S.Shetty, 2014)^[1]. The ferrocement slabs panels can be used as roof sheets for the temporary structures, Structural light weight single storeyed building. The Ferro cement slab panels manufactured with multiple layers of closely packed thin walled structural light weight meshes. The Purpose of the wire mesh is to carry the very small amount of tensile loads that can come from the different kinds of loading condition. The strength and serviceability of the ferro cement is almost like that of reinforced concrete.

The flexural strength of the reinforced concrete beams can be increased with the help of the slotted angles with the reduction in the structural weight of the structures as reported by $(N.Gayathri, 2017)^{[2]}$. And one more study analytically proved that the structural load deflection behavior can be increased with the help of the slotted angles that has been collected from the colleges with the thickness less than 2.4 mm as reported by $(N.Gayathri, 2017)^{[3]}$.

The main objective of this paper is to identify the effective utilization of the glass fiber in Ferrocement slabs for achieving better flexural properties and also utilize the industrial wastes such as marble powder for the replacement of cement. The post cracking behavior that can be increased with the help of the introduction of slotted angle sections in the failure zone



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II. EXPERIMENTAL SETUP

The Nominal Mix ratio of M20 grade concrete has been taken up for the study. The nominal Mix of 1:1.5:3 has been used for the study. The glass fibers are used from 0.5% with the increment of 0.25% up to 5%. The mix designation as shown in Table 1

Table 1 Mix designation				
S.No	Mix	% of Fiber		
1.	S1	0.25		
2.	S2	0.5		
3.	\$3	0.75		
4.	S4	1.0		
5.	\$5	1.25	Å	
6.	\$6	1.5		
7.	S7	1.75		
8.	S 8	2		
9.	S9	2.25		
10.	S10	2.5		
11.	S11	2.75		
12	S12	3		
13	S13	3.25		
14.	S15	3.5		
15	S16	3.75		
16	S17	4		
17	S18	4.25		
18	S19	4.5		
19	S20	4.75		
20	S21	5		
21	СМ	0		
L				

From the observed results of the split tensile strength from the table 1 the optimum fiber has been found to be 3.25. the testing of the cylinder as shown in figure 1.



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Figure 1 Split tensile testing of Cylinders

From the results the ratio of 3.25 % to the weight of cement has been taken for the further study. The Marble powder content has been increased with a percentage of 2.5% from 0 up to 15%. The slab cast for this study is of 450 mm x 300 mm x 75 mm. the aspect ratio of the glass fiber has been maintained as 150 with a ultimate tensile stress of 650 N/mm^2 . The Mix designation is shown in Table 2.

S.No	Mix	% of Marble
1.	CS	0
2.	M1	2.5
3.	M2	5
4.	M3	7.5
5.	M4	10
6.	M5	12.5
7.	M6	15

Table 2 Mix Designation with marble powder



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casting details of the specimen as shown in Figure 2.



Figure 2 Casting of Ferrocement slab panels



Figure 3 Experimental setup

The experimental setup has shown in figure 3.



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III. RESULTS AND DISCUSSION

The split tensile test results area shown in figure 4.





From the results as shown in figure 4 it is concluded that the split tensile of the specimen was increased due to the presence of the fiber the split tensile strength has increased up to 3.25% to the weight of cement and the strength of the specimen keeps on decreasing when the fiber added more than 3.25%. This is mainly due to the bond between the fiber and the concrete specimens. The bond between the fiber will decrease when more amount of fiber has been added to the weight of the cement. It is clearly shown that the bond between the cement mortar matrix is very low with the glass fiber. From this it is concluded that the bonding between the glass fiber is not up to the level. The C-S-H gel formed during initial stage has been gives better strength. The 7 days split tensile strength and 28 days split tensile strength are mostly similar in this case the 7 days split tensile strength and 28 days split tensile strength as shown in figure 5.



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Figure 5 comparative Analysis of 7 and 28 days strength

From the figure 5 it is clearly noted that there is very small amount of increase in the strength of the 28 days strength compared with 7 days strength. The 28 days split tensile strength is comparatively low with the 7 days strength of the specimens with fibers. From this it is clearly noted that the tensile capacity of the cylinder specimens increased with the introduction of the glass fiber. In order to finalize the optimum fiber percentage as 3.25% the axial compression test has been carried out to determine the modulus of elasticity of the cylinder specimen under compressive loading. The stress strain curve is shown in figure 6.





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From Figure 6 also it is concluded that the stress strain curve for the cylinder with a percentage of 3.25% has undergone very less amount of deformation compared with the other two specimens. This result also reveals that the bonding between the fiber and the cement will decrease when the percentage of fiber goes on increasing.

The slabs were tested as shown in the experimental setup figure 3. And the cracked pattern is shown in the figure 7.



Figure 7 crack pattern of Ferrocement slabs

From the crack pattern it is clearly understood that the failure happened under the point at which the load that has been applied. The ultimate load taken for the different slab specimens as shown in figure 8.



Figure 8 Load carrying capacity of the specimens

From the results as shown in figure 10 it is clearly noted that the ultimate load carrying capacity of the specimens increased when marble powder partiallyreplaced at a percentage of 10% to the weight of the cement. From the particle size distribution curve obtained for the marble powder as well as the cement was found to be similar. But marble powder was found to be more finer than cement. The increase in strength due to the micro filling ability of the



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marble powder. When marble powder percentage increased more than 10 % the calcium required to formulate the C-S-H gel decreased this is the main reason to decrease the strength. From the failure pattern obtained from the figure 7. Tensile reinforcement has been introduced in the form of slotted angle sections. The position of the slotted angle section has been shown in figure 9.



Figure 9Position of slotted angles

Figure 9 shown the introduction of tensile reinforcement in the form of slotted angles the Initial cracking load and the ultimate load carried by the specimens with and without the slotted angles as shown in figure 10.



Figure 10 Load carrying capacity of the different specimens



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From the figure it is concluded that the initial cracking load and the ultimate failure load has increased compared with the specimens without reinforcement. In order to evaluate the ultimate capacity of the specimens the TMT bars also placed at the same position where the slotted angles has been placed.



Figure 11 Ultimate Load comparison

The same results have been evaluated by creating an analytical model with the both TMT and CFS thin walled slotted angles. The results obtained form the finite element analysis, The slabs reinforced with slotted angles has undergone a large deformation before failure with increase in ultimate flexural strength of the slabs reinforced with TMT bars. The figure given below Figure 12 shows the stress distribution of the analytical model that has been created using a finite element software with same loading set up as that of the experimental results. The loading rate also has been maintained same for the two types of loadings.



Figure 12 Stress Distribution of Ferro cement Slab model



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Figure 13 Path created for the load deflection curve

Figure 13 shows the path created manually by for the obtainment of the load deformation graph. From the obtained results form both software and Experiment have been compared and the following observations has been made and the load deformation graph has been shown in Figure 14.



Figure 14 Load Deformation comparison

From the figure 11 it is noted that the ultimate load carrying capacity has been increased with the introduction of steel in tensile fiber zone. The load carrying capacity of the Slabs with slotted angles is much higher than the slabs with TMT bars. This is mainly due to the holes present in the slotted angles gave higher bond due to the interlocking property of the slotted angles. The interlocking behavior is high compared with TMT bars as results reported by (N.Gayathri, 2017)^[3]. The Slotted angles gave better post cracking behavior due to the interlocking property as stated above but the TMT bars fails to do the same property. The percentage of variation between the Cracking load and ultimate load is in the range of 60-65% whereas in the case of TMT bars the range lies between 20-25%. The bonding between the TMT bars and the concrete is somewhat lower when compared with slotted angles. From figure114 the



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load deformation characteristics it is concluded that the introduction of reinforcement gives more ductile behavior compared with the slabs without reinforcement. But the load deflection characteristics up to the ultimate load carried by the TMT bars are similar. From this result it is revealed that the post cracking behavior only changes due the interlocking property of the slotted angles. The structural behavior of the slabs with TMT bars and the slotted angles are same up to the Initial crack propagation.

IV. CONCLUSION

- From the Experimental results of the split tensile strength the 28 days split tensile strength increases to a percentage in the range of 225% compared with the specimens without glass fibers.
- From the experimental results carried out using SEM Analysis the reduction in strength with the increase in fiber is mainly due to the reduction in bond between the glass fiber and cement.
- From the experimental results of the slabs, the ultimate load carrying capacity increased 25% when cement was partially replaced with marble powder at a ratio of 10% to the weight of cement.
- The introduction of Slotted angles as reinforcement to the ferrocement in addition to the wire mesh it gave better load carrying capacity.
- The structural behavior of the Slabs with slotted angles gave better load carrying capacity compared with TMT bars due to the interlocking property of the slotted angles

RECOMMMENDATIONS FOR FUTURE WORK

- The same study can be repeated with different industrial wastes such as granite powder and quarry dust for the partial replacement of ingredients.
- The same material properties can be repeated with the different industrial wastes such as Bagasse ash, Rice Husk Ash, Pond Ash, Coconut shell Ash, etc... for the partial replacement of ingredients.

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