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A STUDY ON MECHANICAL BEHAVIOUR OF DIFFERENTLY REINFORCED RECTANGULAR FERROCEMENT ROOF PANEL

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Abstract - *Ferrocement is commonly used building material of mortar mix of cement which was reinforced with wire meshes and steel bars. It can be molded into any shapes and sizes such as tanks, silos, swimming pools, pre fabricated houses and panels of thickness ranges between 25mm to 30mm. We can give different shapes to roof panel for aesthetic appearances. By considering the structures such as prefabricated houses, tanks, partition walls etc, the behaviour of rectangle panels are studied. The study involves find the optimum percentage of polypropylene fibre with cement mortar mix. Based on that, a comparative study was conducted. A comparative study on the flexural behaviour of rectangular ferrocement panels which was reinforced with wire mesh, skeletal steel and wire mesh and also incorporating polypropylene fibre. The parameters considered in the study are the effect of polypropylene fibre on cement mortar, cracking load, ultimate load, load strain characteristics, load-deflection characteristics and specimen weight of each panel.*

Key Words: **Wire mesh, Ferrocement, Polypropylene fibre, skeletal steel, cement mortar.**

1. INTRODUCTION

Ferrocement is commonly used construction material consists of cement mortar which was reinforced with mesh or metal fibres and steel rods(thin). The applications of ferrocement have been increased in parks, housing due to its advantages such as superior cracking behaviour, strength, light weight, low cost and can be molded into any shape. It is considered as an attractive, good material due to the utilization of locally available materials, semi-skilled labours and low cost of maintenance and repair and considered as a good material of construction.

It can be used for the manufacture of boats, tanks, silos, prefabricated housing, partition walls. American Concrete Institute Committee 549 defined ferrocement as "a type of thin wall reinforced concrete commonly constructed of hydraulic cement mortar, reinforced with closely spaced layers of continuous and relatively small diameter mesh. The mesh may be made of metallic or other suitable materials".

Thickness of ferrocement panels varies from 10mm to 60mm and wire mesh had a role on structural strength. Due to their thinness, it can be used as roofing / flooring elements to cover large spans.

Ferrocement shells can be cast in various shapes and can be used for the construction of folded plates, cylindrical shells, circular domes, funicular shells for roofing. Several studies were conducted on the mechanical behaviour of ferrocement under various loads.

2. OBJECTIVE

The main objectives are:
1. To fix the mix according to ferrocement code provision – A.C.I committee 549-R-97.
2. To find the optimum percentage of polypropylene fibre on mix.
3. Compare the properties like first crack load, ultimate load, load versus deflection, load strain characteristics and specimen weight on rectangle panel with different reinforcement such as hexagonal mesh, skeletal steel and hexagonal mesh, skeletal steel, hexagonal mesh and polypropylene fibre.

3. MATERIAL CHARACTERISTICS

The materials used in this study are Ultra Tech cement, M Sand as fine aggregate passing through 4.75mm IS sieve and potable water. Fibre namely polypropylene fibre has been selected. The detailed properties and specifications are tabulated in Table 1 and Table 2.

Table – 1: Material specification

Materials	Specifications
Steel bars	6mm diameter
Wire mesh	Hexagonal wire mesh with 12mm opening
Polypropylene fibre	Fibrillated mesh fibre of length 12mm and aspect ratio 48

Table – 2: Test results on constituent materials

Materials	Test for	Observed value
Cement (PPC 53 Grade)	Specific Gravity	3.125
	Initial setting time	45minutes
	Final setting time	6hours
	Fineness	9%
	7day compressive strength	29.08N/mm^2
Fine aggregate	Specific Gravity	2.67
	Sieve analysis	Zone I

4. REINFORCEMENT AND SPECIMEN DETAILS

The geometry of rectangular ferrocement panels are 1000mm x 400mmx 30mm.Specimen details are tabulated in Table 3 is used. Rectangular panels with different reinforcement such as hexagonal mesh, hexagonal mesh and skeletal steel, hexagonal mesh, skeletal steel and fibres with 1000mm x 400mm x 30m are constructed.

The reinforcement used was skeletal steel and hexagonal wire mesh. 6mm diameter steel bars is used as it was used in sites for the construction of ferrocement homes. Reinforcement was placed inside the moulds by providing proper cover blocks.

Table - 3: Details of specimen

Sl no	Specimen notation	Specimen Type	Size (mm)
1	RP-01	Rectangular panel with hexagonal mesh	1000x400 x 30
2	RP-02	Rectangular panel with hexagonal mesh and steel bars	1000x400 x 30
3	RP-03	Rectangular panel with hexagonal mesh, steel bars and fibre	1000x400 x 30

5. FIXING OF MIX

In order to determine the characteristic strength of mix, cement mortar cubes of 70.6mm x 70.6mm x 70.6mm were prepared. Select various mixes (1:1, 1:2 and 1:3) with different water cement ratios and determine the characteristic strength of mortar mixes. From the mixes, 1:2 with water cement ratio 0.45 according to ACI 549-R-97 was selected since it gives maximum compressive strength i.e., 29.08MPa. It is mentioned in the code that, sand to cement ratio by weight should be between 1.4 to 2.5.

Fig – 1: Casting of cube specimens.

Table – 4: Compressive strength of cube specimen

Cement : sand ratio	Water cement ratio	Compressive strength after 7days (N/mm^2)
1:1	0.41	34.29
1:2	0.41	24.49
	0.43	28.57
	0.45	29.08
1:3	0.45	36.73

Fig - 2: Testing of mortar cubes in compression testing machine.

6. FIND THE OPTIMUM PERCENTAGE OF POLYPROPYLENE FIBRE

Mortar cubes were prepared by varying the percentage of polypropylene fibre..The percentage variations chosen are 0%, 0.05%, 0.1%, 0.15%, 0.2%, 0.25%, 0.3%, 0.35%,0.4% and 0.45%.

The Chart-1 shows the compressive strength of polypropylene fibre with different water cement ratios. It can be seen that maximum strength is obtained for 0.25% addition of polypropylene fibre by weight of cement and this is taken for casting of ferrocement roof panel.

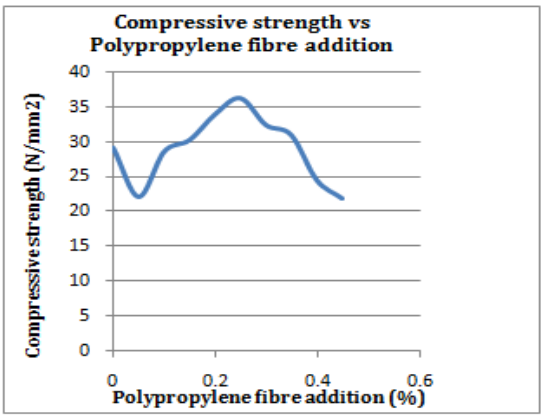

Chart – 1: Compressive strength versus addition of polypropylene fibre.

7. CASTING AND CURING OF RECTANGULAR PANELS

The panels of size 1000mm x 400mm x 30mm were made using a plywood mould to the required geometry. The panels were casted using ferrocement materials comprise of cement mortar and reinforcement. The mould is arranged properly and placed on a flat surface. The sides of the moulds were greased properly for easy removal of the specimen. For the construction of panels with wire mesh reinforcement, were placed at mid depth of panel with a cover of 8 mm.

After 24 hours from casting, the samples are remolded from the mould and cured in water for 28 days. After 28 days, it was dried in air and painted with white cement for tracing cracks.

Fig – 3: Fabrication of mould

Fig – 4: Casting of rectangular panel.

8. TESTING OF SPECIMEN

A total of 3 panels each of size 1000mm x 400mm x 30mm were casted with 1:2 mixes with water cement ratio 0.45. The loading conditions are concentrated line load with simply supported at the two ends.

The panels were loaded till failure occurs. Under loading, the behaviour of panels was observed. For each loading, the dial gauge readings at the centre were observed.

Fig – 5: Test setup

9. RESULTS AND DISCUSSIONS

Rectangular panels of size 1000mm x 400mm x 30mm of three different reinforcement were constructed and studied the following characteristics. The parameters like first crack load, ultimate load, load versus deflection curve, load-strain characteristics and crack pattern of rectangular panels with different reinforcement are studied and individually compared.

9.1 Load-deflection characteristics

The load versus central deflection curve was plotted by taking deflection (in mm) along X axis and load (in kN) along Y axis. The curve was compared with rectangular panels with different reinforcement.

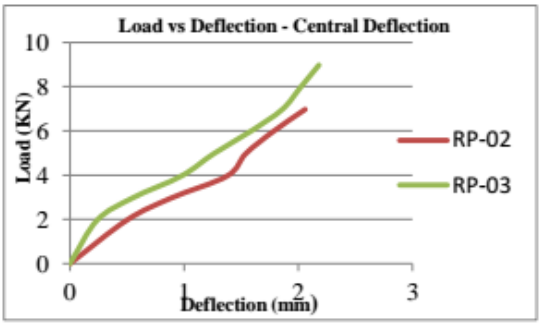

Chart – 2: Load versus deflection curve

Load- deflection curve of RP-01 is not given since it fails under single load. Fibre reinforced rectangular panel shows a smooth curve compared to RP-02 i.e., load is proportionate to deflection. At same load, RP-03 had less deflection compared to RP-02.

9.2 First crack load and Ultimate load

Ultimate load is the load at which the specimen fails and it was noted. Failure of RP-01 occurs suddenly because hexagonal wire mesh is located at mid depth of the panel while in other two steel bars are provided. First crack load and ultimate load of RP-02 increased tremendously compared between RP-02 and RP-03 and there is a high gain in ultimate strength in RP-03.

Table – 5: Experimental results

Specimen type	First crack load (KN)	Ultimate load (KN)
RP-01	1.97	1.97
RP-02	4.97	6.97
RP-03	5.97	8.97

9.3 Load strain characteristics

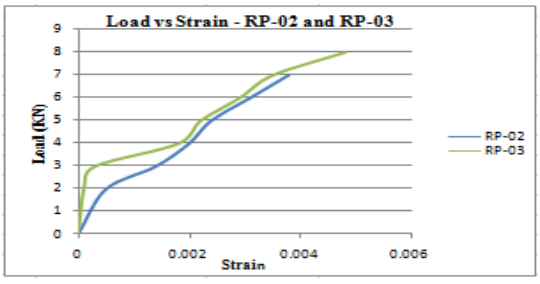

Chart – 3: Load versus Strain

It was found that strain is proportionate to deflection at the initial stage which shows panel is in elastic stage. The plastic stage has reached after certain loads, since the strain increased suddenly.

9.4 Specimen Weight analysis

Weight of all the three panels were taken and compared with that of Rectangular Panel with hexagonal mesh (RP-01).The specimen weight was calculated by taking weight of each panel.

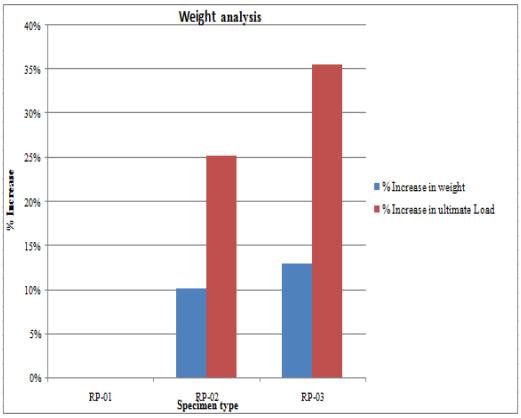

Chart – 4: Weight analysis with ultimate load of Rectangular Panel

Table – 6: Weight comparison of RP-01, RP-02 and RP-03

Specimen type	Total weight (Kg)	% Increase in weight	Ultimate Load (KN)	% Increase in Ultimate load
RP-01	27.6	-	1.97	-
RP-02	30.4	10.14	6.97	25.30
RP-03	31.2	13.01	8.97	35.53

On comparing specimen weight and ultimate load of RP-02 and RP-03 with RP-01, there is a high percentage increase in ultimate load with less increase in weight

9.5 Cracking behavior

Fig. – 6: Crack pattern of RP-01

Fig – 7: Crack pattern of RP-02

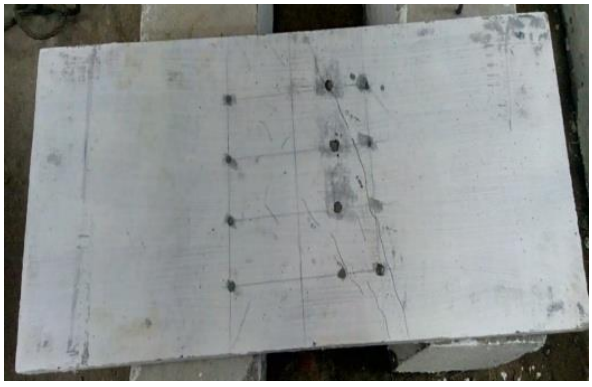

Fig – 8: Crack pattern of RP-03

It can be seen that cracks at the failure load at the bottom extends to the top face of the panels. From the above figures, it was found that crack pattern is similar. The panels incorporating fibre shows minimum cracks compared to other panels.

10. CONCLUSIONS

From the experimental study the following conclusions were drawn.

- Optimum percentage of polypropylene fibre was found to be 0.25% by weight of cement
- Fibre incorporated rectangular panel have significant improvement in terms of deflection, ultimate strength, strain and cracking behaviour.
- Rectangular panel with hexagonal mesh fails under single small load due to the yielding of wire mesh reinforcement.
- All the properties were increased tremendously in rectangular panels reinforced with hexagonal mesh and steel bars where as fibre reinforced rectangular panels shows some more improvement in properties.
- The crack patterns were similar for all the three panels.

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