CHARACTERIZATION OF FERROCEMENT PANELS REINFORCED WITH POLYPROPYLENE MESH

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ABSTRACT::*Shelter for human beings has become one of the most pressing challenges, especially in developing countries. Owning a house has become a dream for low and middle income families. Adoption of cost effective, environment friendly, durable and innovative techniques is the need of the modern era to make housing affordable. One of such solutions is to use ferrocement panels in place of brick and mortar. This research is focused on gauging the possibility of using polypropylene wire mesh ferrocement panels in the construction of a single storey house. Panels with three different thicknesses including 20mm, 30mm and 40mm were tested with 2, 3 and 4 mesh layers in each size. Initial crack loads, ultimate loads and cracking patterns were observed and energy absorption was computed for all the specimens tested in flexure and compression. This initial testing shows that polypropylene ferrocement panels have potential to be used in construction, however, the design needs improvement and further testing is also required.*

Keywords: Ferrocement, Polypropylene, Low Cost Housing

INTRODUCTION

Ever since mankind came into existence, shelters have been constructed of different natural materials like trees and stones etc. with the growth of world's population, need of housing kept on increasing. This growing need compelled human being to develop novel materials and efficient construction techniques to match the pace of the population growth. Ferrocement is one of such materials which were developed to be used in various housing and non-housing applications. Conventional ferrocement is a mixture of cement, sand, water and layers of steel wire mesh. It can be used to make wall panels, bins and shell roofs etc. It has been widely used in pre-engineered buildings because of its good strength and ductility. It has very high tensile strength to weight ratio and superior cracking behavior as compared to conventional concrete (ACI 549R_97) [1].

Pakistan is a country where natural calamities like earthquakes are common. Earthquakes may have major impact on the integrity of structures. The response of structure to the earthquake is a function of the weight of the structure. Researchers always emphasize on reducing the structural weight which is possible by using light weight and high strength materials with sufficient ductility. Steel structures provide more resistance to earthquakes due to less weight but due to high cost, less availability and high thermal conductivity etc, steel structures are not generally the first choice. Reinforced concrete structures are preferred due to local availability of raw materials. Ferrocement, being light-weight and ductile may be a good choice for earthquake prone regions.

Conventional ferrocement panels are prepared using galvanized iron (G.I.) wire mesh with or without skeletal steel. These panels are susceptible to corrosion because the moisture may reach to the mesh. The galvanization layer vanishes with time and when moisture and air penetrate through a cracked region, corrosion becomes inevitable (Figure 1.). This research work is focused on gauging the possibility of using poly propylene wire mesh in place of galvanized iron mesh to develop a corrosion-free solution. Polypropylene ferrocement has a potential to provide a more sustainable solution as compared to the conventional G.I. reinforced panels.

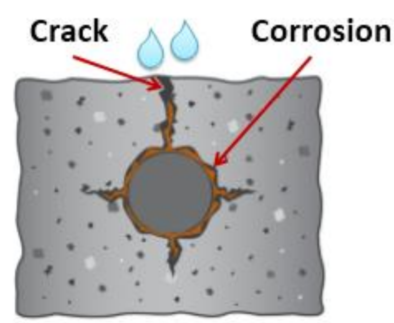

Fig 1: Widening of cracks due to corrosion

The major objective of this research was to investigate the flexural and axial behavior of ferrocement panel reinforced with polypropylene wire mesh. A secondary objective was to compare cost of ferrocement construction with conventional brick and mortar construction.

LITERATURE REVIEW

Several attempts have been conducted to study the behavior of ferrocement. Following are some of the researchers and their research conclusions.

Darshan et al in 2014 [2] concluded that the flexural loads and first crack depends on the number of mesh layers, Increasing the number of mesh layers increases the ductility and capacity to absorb energy, Increasing the thickness of ferrocement panel increases the strength, ductility and capacity to absorb energy. Mahmood et al in 2008 [3] also concluded that increasing the number of layers of wire mesh from 1 to 3 significantly increases the ductility and capability to absorb energy of both types of the panel. Kaushik studied the effect of orientation of the wire mesh on flexural behavior and concluded that a square type of wire mesh provided more ductility and strength. Saleem and Ashraf in 2008 [4] proposed a conceptual design of a low cost earthquake resistant ferrocement house and calculated the material cost as Rs. 260/- per sft. Sakthivel and Jagannathan [5] concluded that flexural strength of slabs with PVC-coated weld mesh was 90% than that of specimens reinforced with G. I. mesh.

EXPERIMENTAL WORK

A total of 16 ferrocement slabs were tested. Size of each panel was 900mm x 450mm with varying thicknesses of 20mm, 30mm and 40mm having different meshes as presented in Table 1. Ordinary Portland cement was used along with the sand of Lawrencepur and Chenab, passing through 2.36 mm sieve and in a ratio of 50% each. Cement to sand ratio was 1:2, water cement ratio used was 0.45. Average cross sectional area of polypropylene mesh was 2.71mm^2 and opening size was 13.8mm (see Fig. 2).

The first step of experimental work was cutting of wire mesh according to the size of specimen and binding the wire mesh with skeletal steel with the help of binding wire. Before placing the mesh into the mould, the mould was properly oiled and initial layer of mortar was placed as a cover of 3mm. First layer of mesh was then placed, followed by the mortar and external vibration for compaction. This process continued till all the layers were placed. Mould was opened after 2 to three days and the specimens were cured by covering with jute bags. After 28 days of curing, the slabs were whitewashed, labelled and tested both in flexure and axial (see Fig. 2).

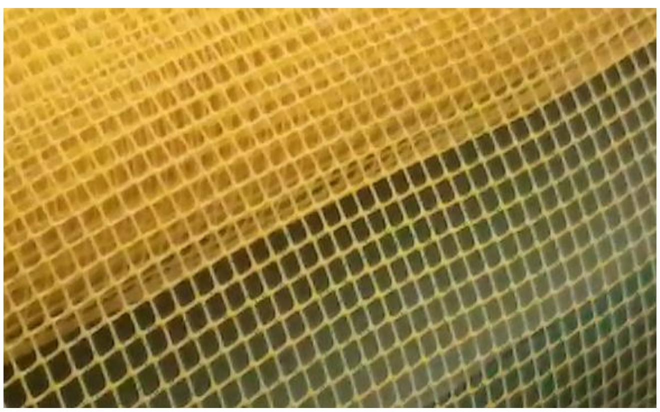

Fig 2: Polypropylene wire mesh

Fig 3: Method of casting ferrocement slabs

Table 1: Ferrocement panel properties

#	Flexural Test	Axial Test	Thickness (mm)	Mesh Layers
1	20P-2	20P-2	20	2
2	20P-3	20P-3	20	3
3	30P-2	30P-2	30	2
4	30P-3	30P-3	30	3
5	30P-4	30P-4	30	4
6	40P-2	40P-2	40	2
7	40P-3	40P-3	40	3
8	40P-4	40P-4	40	4

RESULTS AND DISCUSSION

Flexural Testing

Four point flexure test was performed on the ferrocement slabs reinforced with polypropylene wire mesh and the type of cracks observed were flexural cracks. In case of axial testing buckling failure was observed. Rate of loading kept was 2mm/min and a load cell along with two LVDT's were used to measure the deflection of the ferrocement panel. Average value of both the LVDT's were computer and reported. Figure 4 shows actual flexural testing of polypropylene ferrocement panels. All the samples were subjected to four point flexure load and the cracking pattern, first crack loads and ultimate loads were noted. Figure 5 shows load deflection curve of 20mm polypropylene panel with 2 and 3 layers. 2 layers sample has shown greater strength then 3 layers samples which can be due to lesser space available to accommodate three layers in 20mm thickness. In figure 6 we can see the strength of 30mm sample reinforced with 3 layers of polypropylene is greater than the sample of same thickness but 2 and 4 layers. Sample with 4 number of layers has shown greatest ductility same trend is followed in 40mm samples as shown in figure 7. First crack load and ultimate load has also not shown any increasing trend by increasing the number of mesh layers as shown in figure 8 and 9. Hence one can say that the strength in ferrocement panel reinforced with polypropylene wire mesh is independent of number of layers but a minimum of 40mm sample thickness if preferred.

Fig 4: Setup for flexural testing of ferrocement panels

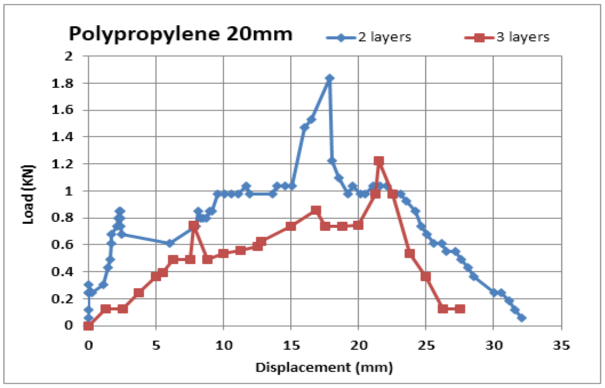

Fig 5: 20mm Polypropylene panel with 2 and 3 layers

Axial Testing

Axial testing assembly is shown in figure 10. All samples were loaded axially and the failure load was noted. Buckling failure was observed in all samples. Load deflection curves were plotted and compared with other curves. The load deflection curve of 20mm polypropylene sample as shown in figure 11 indicates that sample with 3 layers has more strength then 2 layers but that was opposite in case of flexure. 30mm ferrocement panel reinforced with 4 mesh layers of polypropylene was accidently broken that's why the curve of 30mm polypropylene sample in figure 12 has shown lesser strength whereas in figure 13 we can see that 40mm sample reinforced with 4 layers shows the maximum strength as compared to the sample with same thickness but with 3 and 2 layers. Hence minimum recommended sample thickness for ferrocement panels is 40mm.

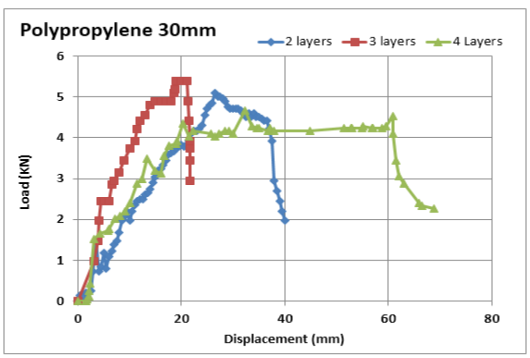

Fig 6: 30mm Polypropylene panel with 2, 3 and 4 layers

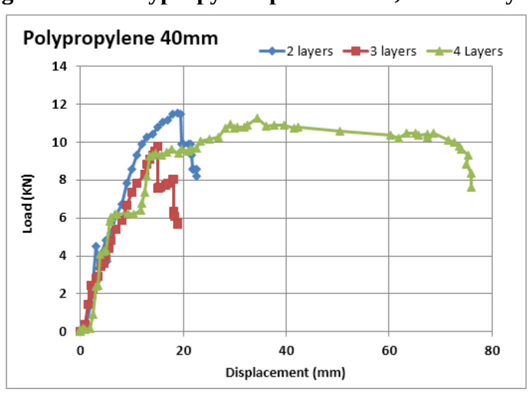

Fig 7: 40mm Polypropylene panel with 2, 3 and 4 layers

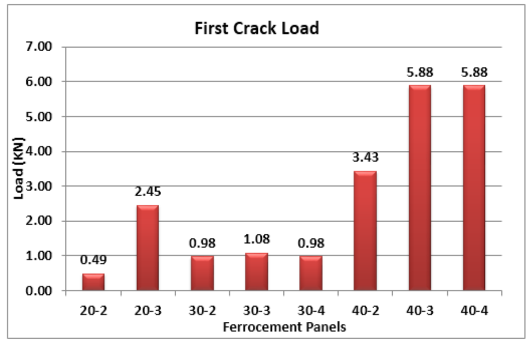

Fig 8: First crack loads of flexural ferrocement panels

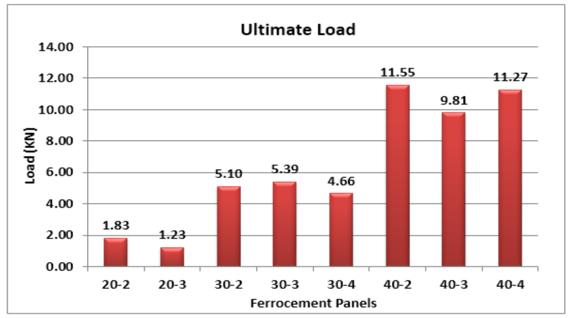

Fig 9: Ultimate loads of flexural ferrocement panels

Fig 10: Setup for axial testing of ferrocement panels

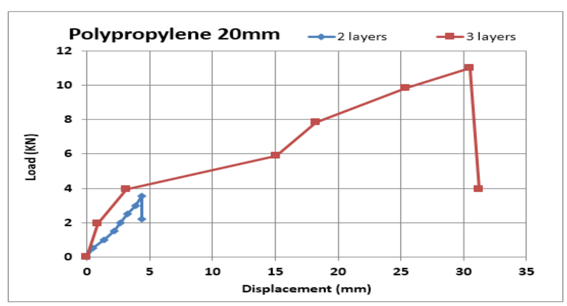

Fig 11: 20mm Polypropylene panel with 2and 3 layers

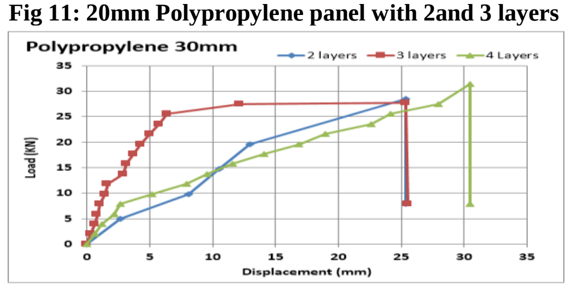

Fig 12: 30mm Polypropylene panel with 2, 3 & 4 layers

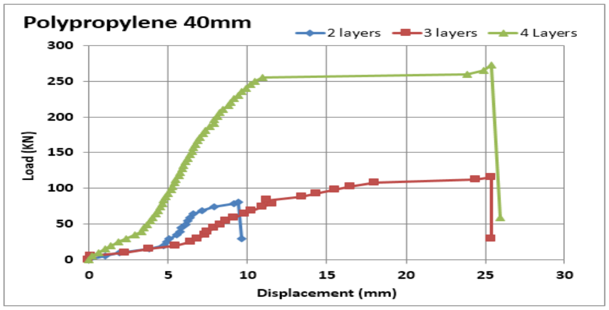

Fig 13: 40mm Polypropylene panel with 2, 3 & 4 layers

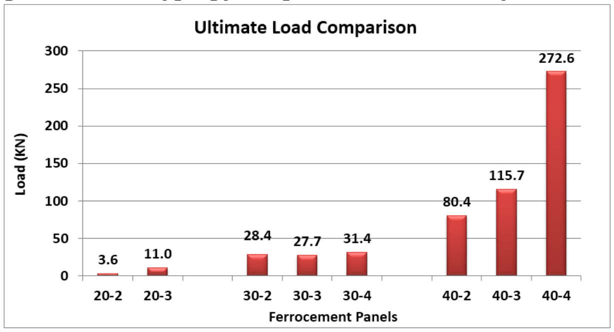

Fig 14: Ultimate loads for axial ferrocement specimens

CONCLUSIONS

Based on the experimental study conducted and the results presented herein, following conclusions can be drawn.

1. The first crack load and ultimate load does not seem to be sensitive to the number of layers of Polypropylene mesh for the same thickness of panel.
2. Stiffness of the flexural ferrocement panels increase with the increase in number of layers of meshes in the sample thickness of specimen.
3. Ultimate Loads in case of axial ferrocement panels have shown an increasing trend with the increase of number of mesh layers in the same thickness.
4. Polypropylene mesh has proved to be much ductile then galvanized iron specimen both in the case of flexural loading as well as in axial loading.

RECOMMENDATIONS

In order to increase the strength of the ferrocement panels reinforced with polypropylene mesh, one possible recommendation can be the addition of fibers in cement sand mortar and the use of hybrid construction can also be adopted in further researches.

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