EPH - International Journal of Science And Engineering
ISSN (Online): 2454-2016
Volume 04 Issue 04 December 2018

DOI: https://doi.org/10.53555/eijse.v4i4.141

STUDY ON THE BEHAVIOR OF POLYMERIC MESH MODIFIED FERROCEMENT UNDER IMPACT LOADING

Rubaiyet Hafiza[1*], Akhter Hossain Sarkar[2], Shafinaz Sameen[3]
*[*1]Research Fellow, Housing and Building Research Institute*
[2]Senior Research Officer, Housing and Building Research Institute
[3]Former Research Fellow, Housing and Building Research Institute

Corresponding Author:-

Abstract:-
This study concentrates on determining the impact strength of polymeric fiber mesh reinforced ferrocement, under low velocity impact load. The Low-velocity impact study has been conducted on 250 mm square ferrocement slabs. The concept of using polymeric wire mesh is to reduce the corrosion of iron wire mesh, which is one of the major reasons for deterioration of ferrocement. The test procedure has been conducted on fifty four specimens including four different types of iron wire mesh and two types of polymeric mesh, with varying mesh layers from one to three. Results emphasized that the impact energy absorption increases with the raise in the number of polymeric mesh layers and the crack widths are least in amount and size compared to the specimens incorporated with iron wire mesh.

Keywords:- *Ferrocement, low –velocities, impact test, crack width etc.*

1. INTRODUCTION

The success of ferrocement is recognized due to the ready availability of its component materials, low level technology needed for its construction and relatively low cost of final product. The exceptionality lays in its thin wall construction technology and light weight characteristics. Many researches have been carried out on ferrocement properties with particular reference to marine application and building construction where FC has been used as roofing material. When FC is to be used in buildings as external walls (building envelope), the impact of harsh weather on FC walls may affect its durability as well as indoor living quality. Hence there is a need to study their feasibility as a material of building envelope. Ferrocement, in spite of all of its good properties like toughness, impact and crack resistance has some apprehensions about its long-term performance and raises some questions about steel rusting, especially when it comes in touch with salt water. (P. B. Sakthivel, 2012) Corrosion of reinforcement is one of the major reasons for deterioration of FC. Research on corrosion with various types of meshes is very important for the full development of ferrocement. Replacement of iron with waste polymer may result in corrosion free and more economic material. This can also enhance the use of recycled waste materials and protection of the environment as well as preparation of polymer mesh will provide work scope for women. Again, Polymer material is high thermal and sound insulator. Use of polymer fiber in FC may increase its resistance to heat and sound transmission and thus ensure a standard indoor living.

2. Experimental Investigation

2.1. Materials

According to BNBC, the ranges of mix proportions for common ferrocement applications shall be sand cement ratio by weight, 1.5 to 2.5, and water cement ratio by weight, 0.35 to 0.5. In this study mortar was prepared with cement-sand ratio of 1:2 and water cement ratio of 0.40. The ferrocement test specimens were prepared using Portland cement of type CEM 2, sand and iron wire mesh and polymer fibers. All the materials were collected from local market. The Portland cement used in this study is characterized in the laboratory with the following physical properties.

Test performed	Result
1. Fineness test	0.068%
2. Setting time	
Initial	2 hours
Final	3 hours
3. Compressive strength	
7 day	15 MPa
28 day	19 MPa

Table 1: Physical properties of cement

The locally available sand was collected from the localities Sylhet, Bangladesh, and characterized in the laboratory. Table 2 shows the sieve analysis of sand. Sands that passed through 1.18 mm sieve were used (according to BNBC) in the preparation of specimens in this study.

Sieve Nos.	Sieve openings (in mm)	Quantity retained (in gm.)	Percentage retained (%)	Cumulative percentage Retained (%)	Fineness modulus (F.M)
30	600μm	219.9	43.98	43.98	
50	300μm	169.8	33.96	77.94	2.17
100	150μm	86.5	17.3	95.24	

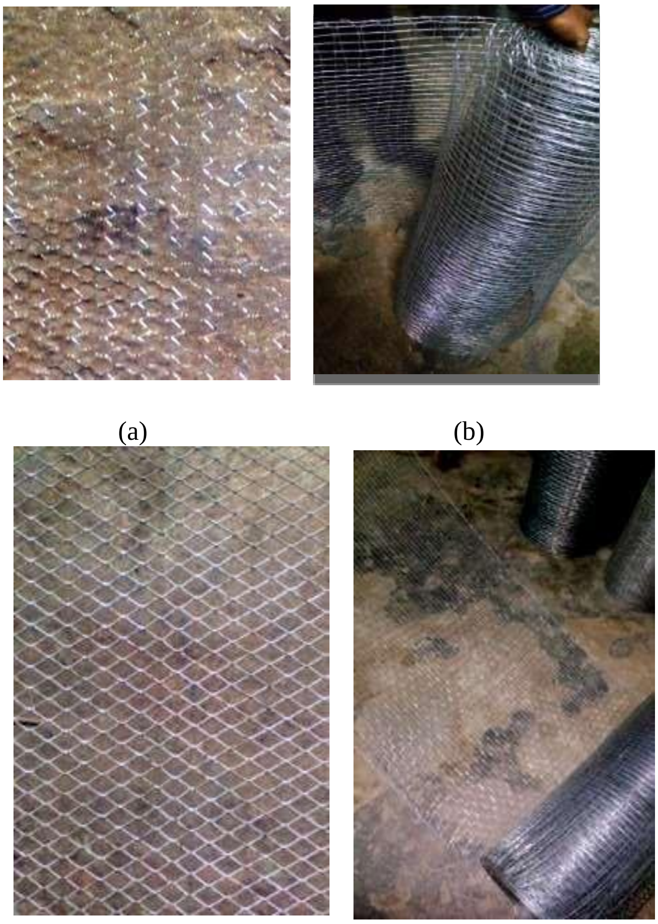
Table 2: Fineness Modulus of Sylhet Sand

2.2. Categories of Wire Meshes

Expanded metal mesh, Woven wire mesh of 18 gauges and 20 gauges and hexagonal mesh for iron reinforcement have been used in this study. Polypropylene (PP) and Nylon 66 were used as polymer fiber reinforcement. These materials were selected because of their availability in the local market.

Figure 2: Preparation of polypropylene mesh and Nylon Mesh

Two kinds of meshes had been prepared by manual weaving (PP and Nylon Polymer Mesh).



(a) (b)

(c) (d)

Figure 1: (a) Hexagonal iron mesh, (b) Woven 20, (c) Expanded Metal Mesh (d) Woven 18

2.3. Specimen preparation

Fifty four specimens have been prepared. Nine Specimens for each six different meshes have been prepared. Among the nine specimens each three specimens were incorporated with one, two and three layers of mesh respectively. During the preparation of a specimen, a layer of mortar of 6.25 mm thick was cast at first, following the placement of one layer mesh above it and the second and final layer of mortar was then placed above the mesh. Considerable care has been taken to maintain minimum cover of 3 mm (1/8 in.). After 24 hours of molding, the specimens were kept under curing for 28 days.

3. Impact Test procedure

This study followed the impact test procedure from the studies of P. B. Sakthivel and A. Jagannathan (authors of the paper entitled "Corrosion-free cementitious composites for sustainability") (P. B. Sakthivel, 2012). This study has chosen a simple but widely used lowvelocity free-fall drop weight test method, which involves continuous application of load to the slab and transfer of external energy to the specimen till it rupture or fails completely. In their study, the ferrocement slabs were placed on a rigid steel frame, with simply supported arrangement on all edges over a span of 250 mm. One kg (9.81 N) mass was continuously dropped on to the slab from a height of 600 mm, through a pulley arrangement attached to a steel frame till it reached failure. During impact on top of the slab, the energy is dissipated from the top to bottom and cracks are formed at the bottom of the specimen. After testing, the slab specimens were removed from the test set up and both top and bottom sides were examined to investigate the sustained damage and cracking pattern at the bottom face. The number of blows that are required to cause a prescribed level of distress and formation of initial cracks and also the final cracks (at specimen failure stage) in the test specimen gives the qualitative estimate of the energy absorbed by the slabs. The impact energy is calculated using the following equation

$$\textbf{Impact Energy Absorption (in Jules)} = n \times W \times h \times 9.81$$

Where n=no. of blows, W= weight in kg (1 kg), h=drop height in meters (0.6 m)

Also, the Impact Residual Strength (IRS) ratio can be calculated as follows

$$\textbf{IRS} = \frac{\textbf{Energy Absorbed up to failure of specimen}}{\textbf{Energy Absorbed at initiation of first crack}}$$

4. Result and Discussion

4.1. Impact Energy Absorption Characteristics

In order to evaluate the toughness (ability of the material to absorb energy) and relative performance of ferrocement specimens cast, impact test will be conducted on the ferrocement slabs. Impact resistance (Impact energy) is calculated by the capacity of the render to provide safety in use and to guarantee its performance after impact (Yousry B.I. Shaheen, 2013)

Fig 3: Test Set Up

The results shown in table 3 shows the average results of three samples of each mesh for three different layers.

Types of mesh	Symbol	Layers of mesh	No. of Blows at First Crack	Energy Absorption of Slabs at First Crack (in Joules)	No. of Blows at Ultimate Specimen Failure	Energy Absorption of Slabs at Ultimate Specimen Failure (in Joules)	IRS Ratio
Hexagonal	IH 1	1	2	11.77	17	100.06	8.50
	IH2	2	3	17.69	35	206.01	11.65
	IH3	3	3	17.69	40	235.44	13.31
Woven 18	IW4	1	15	88.29	50	294.30	3.33
	IW5	2	15	88.29	52	306.07	3.47
	IW6	3	20	117.72	57	335.50	2.85
Nylon	IN7	1	20	117.72	65	382.59	3.25
	IN8	2	26	153.036	69	406.13	2.65
	IN9	3	35	206.01	78	459.10	2.23
Polypropylene	IP10	1	35	211.89	69	406.13	1.91
	IP11	2	48	282.53	75	441.45	1.56
	IP12	3	55	323.73	89	523.85	1.62
Expanded Metal	IE13	1	32	188.35	60	353.16	1.88
	IE14	2	40	235.44	71	417.91	1.78
	IE15	3	52	306.07	78	459.11	1.50
Woven 20	IW16	1	28	164.81	51	300.19	1.82
	IW17	2	37	217.78	60	353.16	1.62
	IW18	3	42	247.21	69	406.13	1.64

Table3: Energy Absorption and IRS Ratio of FC

4.2. Crack Pattern Study

From Table 3 and Fig 4, it is observed that the energy absorption at first crack of ferrocement slabs incorporated with iron wire meshes are less than that of ferrocement slabs incorporated with polymer meshes.

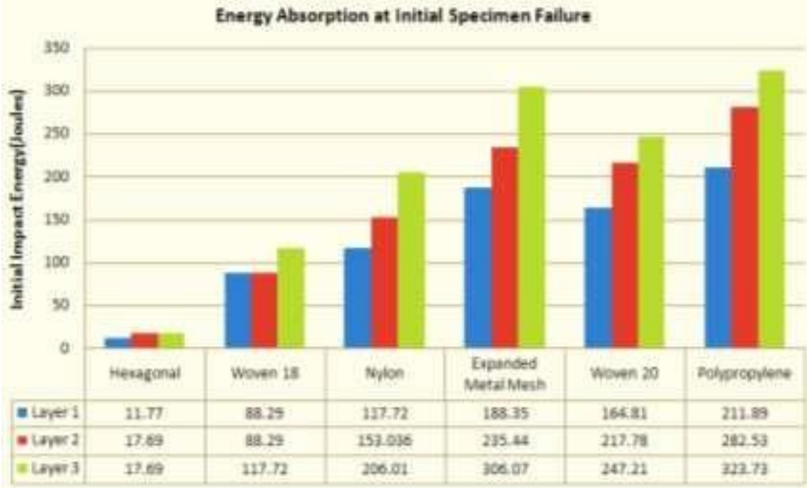


Fig 4: Graph Showing Initial Specimen Failure

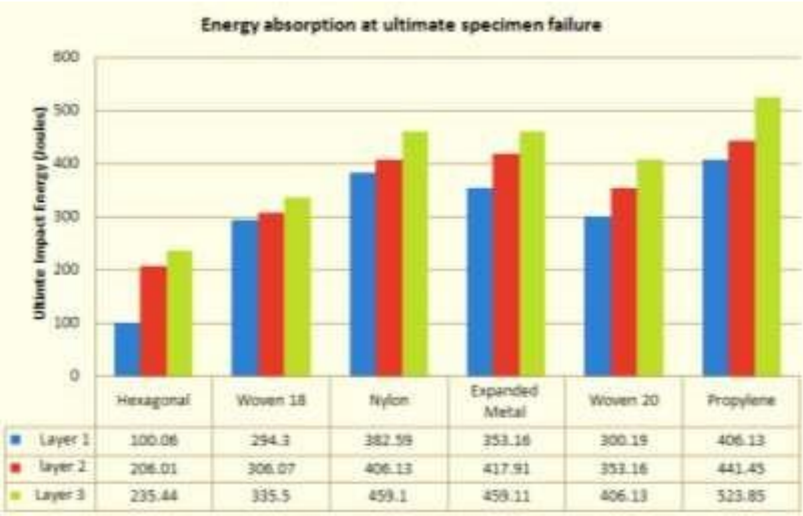


Fig 5: Graph Showing Final Specimen Failure

From Fig 5, it can be inferred that for increase in volume fraction of reinforcement (increased number of layers), there is an increase in energy absorption.

- The energy dissipated from the top to the bottom and cracks were formed at the bottom of the specimens.

FIG 6: CRACK PATTERN

- It can be concluded that the nylon meshes are capable of increasing the energy absorption capacity of cementitious slabs than that of other types of mesh modified cementitious slabs.
- Also with the varying layers of meshes (1 to 3), the crack width of slabs decreased substantially on subjecting the slabs to impact loading.

5. Advantages of using polymer mesh instead of iron wire mesh

The incorporation of polymer mesh with ferrocement technology exerted some advantages which can be used in modern construction technology for more sustainable, resilient and costeffectiveness. The followings are some considerable facts-

- Corrosion free.
- Can be used in the salinity prone areas.
- Can be a great employment solution to the rural women by weaving meshes with nylon and polymer ropes to be used in ferrocement instead of iron wire mesh.

Acknowledgement

This study was done as a part of regular research program of Housing and Building Research Institute. The authors would like to acknowledge the kind co-operation provided by the staff of HBRI.

Conclusion

This paper presents the use of polymer meshes alternative to iron wire mesh in ferrocement based on the research and development work carried out at Housing and Building Research institute. The research shows that the use of polypropylene mesh and nylon mesh shows better crack arresting property than that of iron wire mesh. This approach of doing free falling impact load test on ferrocement samples is the first known attempt by any institution in Bangladesh. This would be a great achievement. These have demonstrated that both quality and economy can be achieved by using alternative modern construction techniques.

References

[1]. P.B. Sakthivel, A. J. (2012). CORROSION-FREE CEMENTITIOUS COMPOSITES FOR SUSTAINABILITY. 37th Conference on Our World in Concrete & Structures. Singapore: CIPremier PTE LTD.

[2]. Eltehawy, E. (2009). Effect of Using Ferro-Cement on the Mechanical Properties of Reinforced Concrete Slabs Subjected to Dynamic Loads. 13th International Conference on AEROSPACE SCIENCES & AVIATION TECHNOLOGY. Egypt: ASAT-13-MS-24.

[3]. P.B. Sakthivel, D. A. (2014). Innovative Applications of Steel Mesh Reinforced Cementitious Composite. International Journal of Emerging Technology and Advanced Engineering, 429-434.

[4]. P.B. Sakthivel, A. J. (2012). Fibrous Ferrocement Composite with PVC-coated Weld Mesh and Bar-chip Polyolefin Fibers. Int. J. of GEOMATE, 382-388.

[5]. Sakthivel, P. (2012). Thin Cementitious Slabs reinforced with Stainless Steel Fibers. IOSR Journal of Mechanical and Civil Engineering, 39-45.

[6]. Yousry B.I. Shaheen, N. M. (2013). Influence of Reinforced Ferrocement Concrete Plates under Impact Load. International Journal of Current Engineering and Technology, 1528-1540.