FLEXURAL RESPONSE AND CORROSION PERFORMENCE OF FERROCEMENT PANEL

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ABSTRACT

This research work was carried out to investigate the performance of ferrocement as infill wall panel in building structures. For this, five types of panel were casted and tested to find out the flexural strength, deformation and corrosion of ferrocement panel.Panels are constructed to find out the mechanical properties of ferrocement in size of 0.3m×0.3m having 30mm and 65mm thickness for single and double layer wire mesh respectively. Samples of 0.3m × 0.3m size with single and double mesh layer were also casted to found out the corrosion effect.To observe the effect of temperature on ferrocement panel, another series of specimens were casted as corrosion sample were kept in 105ºc in the oven for 12 hours. Then removed and stored other 12 hours in air and water of a cycle, total 45 such cycles was completed. The test results show that the flexural performance of single layer and double lyer mesh specimen under corrosion control reduce 20% and 10% respecively when compared with the specimen kept in controlled condition. Again test results of temperature effect test show, flexural strength of single layer mesh specimen in air cooling condition reduce 30% and specimen in water cooling condition reduce 14%, for double layer mesh specimen. Double layer mesh specimen exhibits greater flexural strength than single layer mesh specimen.

Keywords: *Ferrocement, Flexural Strength, Corrosion, Temperature Effect, Wire mesh.*

1. INTRODUCTION

The ferrocement is a type of reinforced concrete thin elements constituted by cement mortar and woven wire mesh with relatively small diameter. According to ACI “It is a type of thin wall reinforced concrete commonly constructed of hydraulic cement mortar reinforced with closely spaced layers of continuous and relatively small diameter wire mesh; the mesh may be made of metallic or other suitable materials” (ACI 549R, 1997; ACI-549 2R, 2004). As ferrocement is made of same cementitious materials used in reinforced concrete (RC), it can be widely used as strengthening material for rehabilitation works in any RC structure (Zamin, et al, 2010). According to some previous works the engineering properties of ferrocement structure are equivalent to normal concrete, though in some applications, it performs better. The closely-spaced and homogeneously-distributed reinforcement transform the brittle concrete material into an elastic composite and is regarded as highly flexible construction material possessing unique properties of strength and serviceability. The serviceability and the achievement of ferrocement as a structural material depend upon its durability (Mathews, et al, 1993). The durability of a ferrocement compound may be defined as its capability to resist cracking and any other process of destruction, weathering action, chemical attack, abrasion, (Ramesht, et al, 1993).

The tensile strength capacity of ferrocement panel is a function of the volume of reinforcement used in the panel. A ferrocement element subjected to tensile stress behaves something like linear elastic material until the first crack appears. After this, the ferrocement element will be faced multiple cracking and eventually continuing to a point where the mesh starts to experience yielding. In this stage, the number of cracks will continue to grow with the increase in the tensile force. The specific surface area of ferrocement element has been found to influence the first crack in tension, as well as the width of the cracks. The maximum stress at first crack for ferrocement element increases in proportion to the specific area of the element. The strength behavior of ferrocement panel under compression is depended on the properties of cement mortar. (Clear, April 1973)

Bangladesh is a tropical country where three distinct seasons are present, a hot, humid summer from March to June; a cool, rainy monsoon season from June to October; and a cool, dry winter from October to March. In general, maximum summer temperatures range between 30°C and 40°C. April is the warmest month in most parts of the country. January is the coldest month when the average temperature for most of the country is about 10°C. Concrete expands when heated and contracts when cooled, and ferrocement also behave as like the concrete. So this temperature variation causes thermal expansion and contraction of ferrocement and may cause for thermal cracking.

Corrosion of wire mesh in ferrocement is one of the major deterioration causes in the structure. The entrance of chloride ions and carbon dioxide to the steel surface is the most important causes of corrosion initiation of steel wire mesh in ferrocement panel. After initiation of the corrosion process, the corrosion products recognized as red-brown dust (hydrous ferric oxide Fe2O3. 3H2O) are usually deposited in the restricted space in the concrete around the mesh. Their formation within this restricted space sets up expansive stresses, (the corrosion products resulting from the corrosion of steel wire mesh occupy a volume equal to three to six times that of the original level) which may causes cracks, creates internal pressure and spall the concrete cover. According to R.Elavarasan (2016) this, in turn, results in enormous losses, direct and indirect, all over the world.

Nowadays this is an emerging issue to find out the effect of corrosion and temperature along with the mechanical properties of ferrocement panel. Wire mesh was used as reinforcement in one and two layers embedded with thin cement composite panels. Some samples were subjected to a corrosive environment under controlled condition and other were kept under thermal effect. After 60 days under controlled condition

2. METHODOLOGY

2.1 Material Properties

The properties of used materials, such as specific gravity, absorption, fineness modulus and unit weight were done according to ASTM C128, ASTM C128, ASTM C136, ASTM C29 testing standards respectively in the material lab of the Department of Civil Engineering of KUET, Bangladesh. River bed sand was used as fine aggregate and properties of this are shown in Table 1. Wire mesh available in the local market was used to prepare the sample. The diameter of mesh wire is 1mm and consisted of a square opening of 10.0 mm x 10.0 mm. Portland Composite Cement was used as binding materials to prepare the specimens.

Table 1: Properties of Fine Aggregate

Unit Weight (Kg/m^3)	Voids (%)	Moisture content (%)	specific gravity	Absorption	F.M value
1487.98	23.14%	1.17%	2.04	4.17%	3.9

2.2 Specimen Preparation

Two types of 20 numbers and 24 numbers specimens were prepared for corrosion test and temperature effect measurement respectively. The specimens are designated as type A and type B for corrosion and temperature effect respectively. Size of the specimen was 0.3m × 0.3m and the thickness was 30mm and 65mm for single and double layers of wire mesh.

For the preparation of specimen, sufficient numbers of the wooden frame were prepared. Steel cutting scissor was used to cut and prepare the mesh according to the size and flat on the wooden platform by hammering. A typical view of the frame, wire mesh, and electric wire assembling and finished sample are shown in Figure 1 and 2.

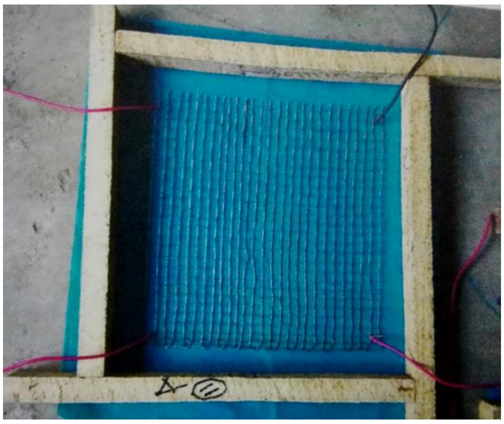


Figure 1: Spcimen ready for casting

Figure 2: Specimen after casting

All corners of the wire mesh were attached with electric wire for the specimens which were kept under corrosion test. After completing all necessary arrangements, the mortar was well mixed, placed and well compacted to ensure a homogeneous body shown in figure 1 and 2. The mixing proportion of cement sand is used 1:2 and water were used 40% of the cement weight. After 24 hours of specimen preparation, the frame was removed and the specimen was transferred to water chamber for curing up to 28 days.general information of samples with identity shown in Table 2.

Table 2; Sample Description

Sample No	Length(mm)	Width(mm)	Thickness(mm)	Mesh layer
A	300	300	30	Single
B	300	300	65	Double

2.3 Corrosion Setup

For this experiment, a water tub was prepared temporarily with bricks and thick polythene paper. Total 20 numbers of the sample are placed in the water tub at a time. The samples were tied by a thin jute rope so that the sample can rest in the position easily. Then the water tub was filled with water. A copper plate was placed in water and electrically connected to the wire mesh through adapter As shown in figure 4 and 5.

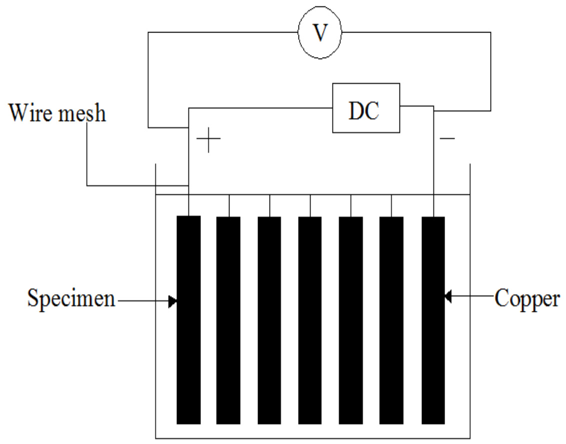


Figure 4: Curreent Application Diagram

Figure 5: Specimens in Corrosion Cell

The current was applied from an external AC source to the cell through the adapter. Initially, 3 volts was supplied, however, the measured output voltage at the initial time was 2.56 volt and it was varied from 2.35 to 2.65 until 4 weeks. The adapter had one end connected to the copper plate in the water and another end is connected to the wire mesh in the specimen via an electric wire. Samples were ready for testing after 60 days in the corrosion chamber.

2.4 Temperature Effect

To find out the temperature effect 24 numbers of the sample were prepared for single layer and other 24 nos for double layer wire mesh. Samples were tested under different condition shown in Table 3

Table 3: Specimen designation for testing under different condition

Normal condition		Temperature effect			
Single layer mesh (A)	Double layer mesh (B)	Single layer mesh (A)		Double layer mesh (B)	
		Specimen cooled in air	Specimen cooled in water	Specimen cooled in air	Specimen cooled in water
A-9	B-9	A-1	A-3	B-1	B-3
A-10	B-10	A-2	A-4	B-2	B-4
A-11	B-11	A-5	A-7	B-5	B-7
A-12	B-12	A-6	A-8	B-6	B-8

Two number of samples were tested under each group and provide the average result in this work for single and double layer mesh. To observe temperature effect 32 samples were kept in 105ºC in the oven for 12 hours. After removing from oven 16 samples were kept in room air and rest samples were quenching for 10 minutes and then stored in room air for another 12 hours. Heating in the oven was conducted at night and other works at day time, confirm a cycle. 45 such cycles were performed to find out the temperature performance of ferrocement panel. In each cycle 20 pictures were taken just after removed from the oven, quenching and before placed in the oven again.

2.5 The Flexure Test Procedure

For testing, the specimens 3-point flexure test was performed. The force in applied by means of loading pins. The ferrocement wall panels were loaded under three-point bending with a shear span of 8 inches. A load was applied at mid of the shear span by UTM (Universal testing machine). A deformation gauge was attached to the mid of the specimen.

Deformation was measured at the interval of 0.5 KN increased of the load. The configuration provides a uniform loading of the specimen and prevents the frictions between the specimen and the supporting point.

3. RESULT AND DISCUSSION

The results of the tested specimens in flexure is given below.

3.1 Flexure Test Results for Sample Under Corrosion Control

Figure-6 shows that flexural strength of specimen A is 26 percent reduced due to the effect of corrosion. However, for specimen B the flexural strength reduced by an amount of 12 percent due to the corrosion shown in Figure 7. The specimen B is better than A in both under normal and corrosion condition. These results exhibit that the flexural strength of specimen in normal condition is more than the specimen kept under corrosive environment and specimen with double layer mesh gives more flexural strength than the specimen with single layer mesh.

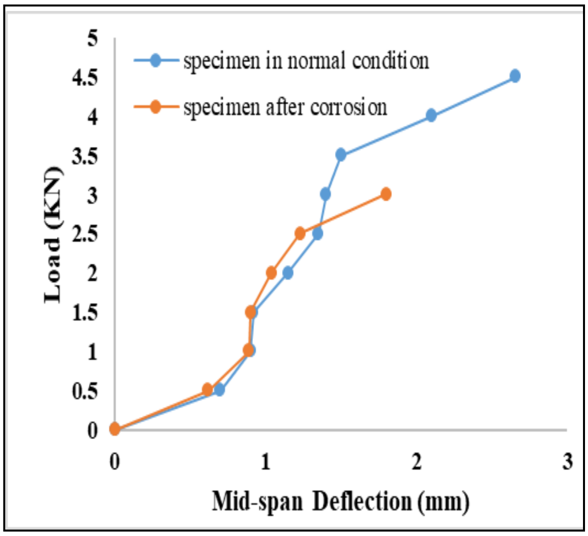


Figure 6: Load and deflection for specimen A

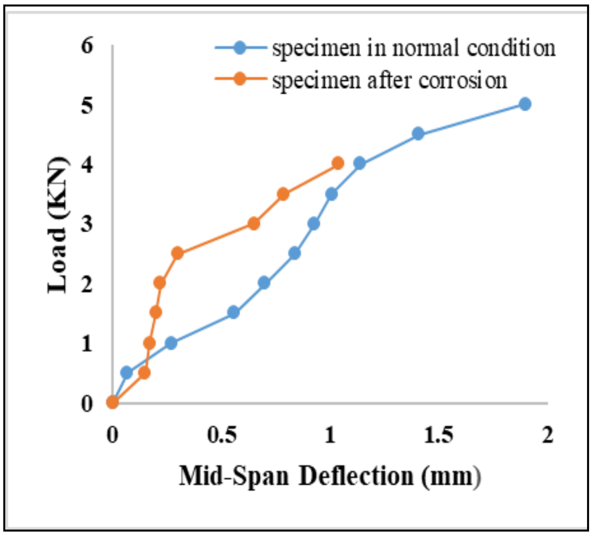
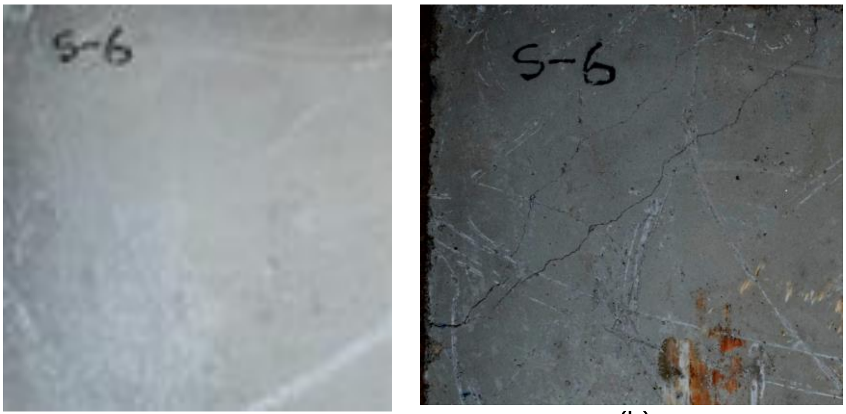


Figure 7: Load and deflection for specimen B

3.2 Cracking Behaviour of Samples Under Temperature Effect

Cracks were found in samples having single layer wire mesh (type A) after 45 cycles. However, no visible cracks were found up to 60 cycles for double layer mesh sample (type B) indicates double layer mesh element is more durable than single layer mesh element. Typical images of sample A under different type cooling conditions are shown in Figure 8.

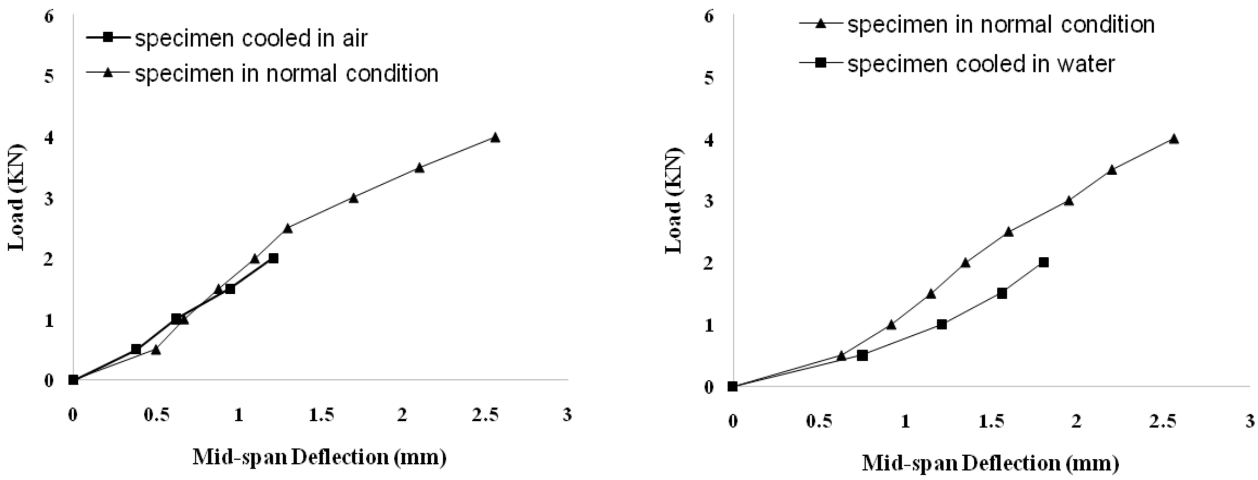


(a) (b)

Figure 8: Ferrocement Specimen Type A after 45 cycles (a) cooled in room (b) Quenched and cooled in room.

3.3 Flexure Test Results for Sample Under Temperature Effect

Flexural performance of single layer mesh specimen exhibits about 43% and 48% strength loss when cooled in normal room environment and quenched respectively due to temperature effect is shown in Figure 9. However, in case of double-layer wire mesh in ferrocement panel, the flexural capacity droops about 32% for both air and water cooling condition. It may be concluded here that the double layer wire mesh exhibits better performance when compared to single layer mesh element.



(a) (b)

Figure 9: Flexural performance of specimen "A" after temperature effect (a) cooled in air (b) Quenched and then cooled in air

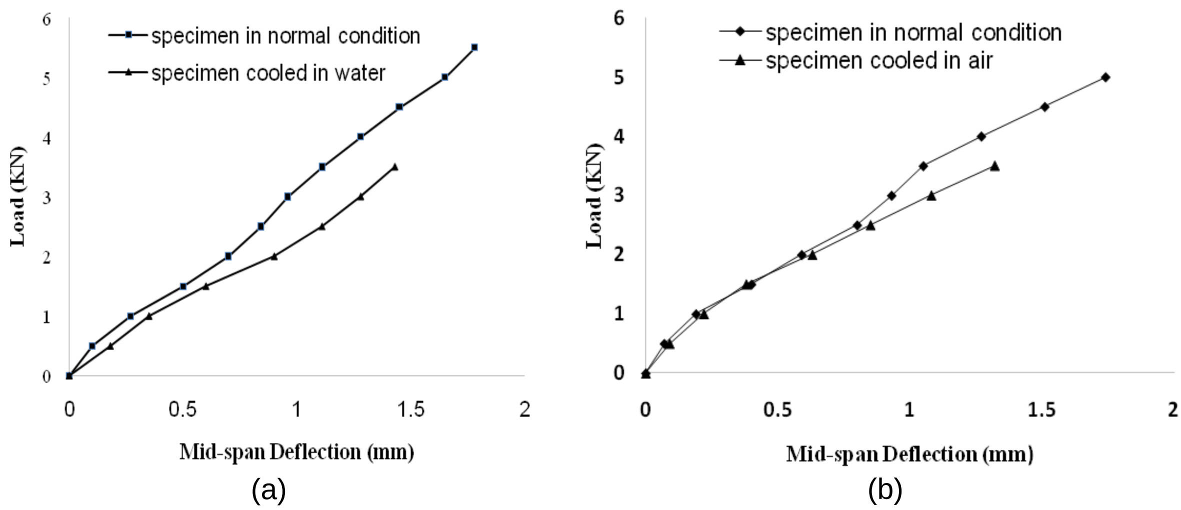


Figure 10: Flexural performance of specimen "B" after temperature effect (a) cooled in air (b) Quenched and then cooled in air

4. CONCLUSIONS

From this experiment, the following conclusion can be drawn on the performance of ferrocement panel under different condition.

Flexural strength of single and double layer wire mesh specimens are 26% and 12% lesser compared to the controlled specimen. These results conclude that the flexural strength of specimen in normal condition is more than the specimen kept under corrosive environment and specimen with double layer mesh gives better performance compared to the single layer.

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