Structural Behavior of Ferrocement Beam under Gradual Loading

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Abstract: ***The use ferrocement in construction industry to look for a dependable and cheaper strengthening component for reinforced cement concrete structure, proves to be best solution. This paper gives detailed account on word of beam strengthened with ferrocement laminate and compared to a control beam for analysis of the desirable usage of ferrocement. Beam casted with the usage of ferrocement proves to have a higher cracking load, ultimate load & lower deflection as compared with normal beam.***

Keywords: about four key words separated by commas

1. Introduction

Ferrocement is made up of thin layer of cement mortar reinforced with layers of continuous uniformly distributed wire mesh. The mix consists of cement and sand mortar while steel wire mesh has openings large enough for adequate bonding of the mixture. The steel wire mesh gives greater tensile strength and flexibility which can't get in ordinary RCC structure. The ACI Committee 549 [1] 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 wire mesh". As ferrocement is made up of same as cementations material, it can be used as alternative strengthening component.

The most used construction material would be concrete and steel to make RCC. The greatest benefit of ferrocement is economical. The use of ferrocement is to construct tanks, roofs, silos and mostly boats. This paper explains flexural behavior of the beam use of ferrocement. The result of testing of ferrocement strengthened beam will be compared with control beam. The cracking behavior and ultimate load carrying capacity will also be studied in this paper.

2. Experimental Programme

2.1 Test specimen

Two concrete beams of Grade 30 were casted for laboratory evaluation. One beam, on its soffit strengthened with ferrocement and while other beam is without ferrocement which can be called as control beam. Both beams were casted using the same reinforcement, 2 bars of 10 mm diameter for top and bottom steel reinforcement. The shear reinforcements were of 6 mm diameter bars spaced at 150 mm C-C. In ferrocement laminate, square wire mesh with 1 mm diameter and spacing 14 mm was used. [2]

2.2 Material Properties

Normal weight concrete designed to achieve compressive strength of 30 N/mm^2 after 28-days was used. Ordinary Portland cement, sand and coarse aggregate of maximum size 20mm were mixed in the proportion 1:1:2.5 by weight with a water to cement ratio of 0.45. Slumps of 63 mm were recorded. Steel reinforcements which were selected for tension and compression reinforcement was 10mm diameter bars with characteristic strength of 415 N/mm^2. For shear reinforcement, steel bars of 6 mm diameters with characteristic strength of 250 N/mm^2 were used. For the beam strengthened with ferrocement, 5 L-shaped bars of 6-mm diameter were used as shear connector.

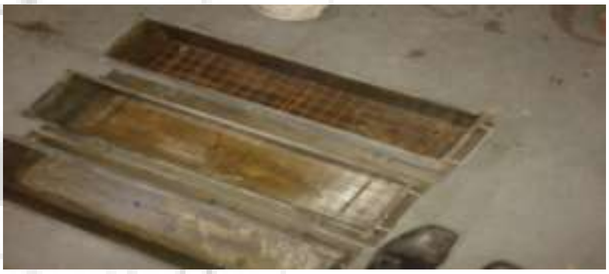

Figure 1: Mould with wire mesh

2.3 Strengthening of Beam

To form the ferrocement beam, 3 layers of square wire mesh of 14-mm opening were attached to the soffit of the beam. Five L-shaped shear connector were used to secure the wire mesh from peeling off during testing. Mortar is placed through hand plastering whereby mortar is forced through the mesh. Surfaces are finished to about 30mm to assure proper cover to the last layer of wire mesh and leave to dry for about 1 week before it undergo flexural testing. All the beams were based under 2 point loading over a span of 1400 mm.

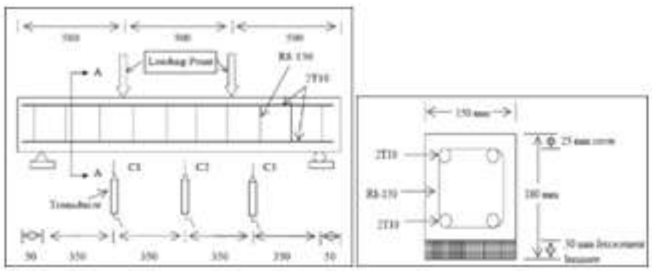

Figure 2: Experimental setup

3. Results & Conclusion

The results of the tests are tabulated below in Table 1 and Table 2 respectively. It can be observed that ferrocement strengthened beam has lesser value of deflection as compared to control beam.

Table 1: Results for control beam

Load (bar)	Load (kN)	Deflection		
		C1	C2	C3
0.00	0.00	0.00	0.00	0.00
10.00	3.15	0.06	0.10	0.08
15.00	4.75	0.21	0.38	0.27
20.00	6.30	0.54	0.78	0.70
25.00	7.80	0.88	1.30	0.99
30.00	9.40	1.19	1.85	1.52
35.00	10.95	1.80	2.63	2.05
40.00	12.55	2.25	4.45	2.55
45.00	14.05	4.65	7.45	5.12
50.00	15.60	7.50	11.15	7.64

Table 2: Results for ferrocement beam

Load (bar)	Load (kN)	s		
		C1	C2	C3
0.00	0.00	0.00	0.00	0.00
10.00	3.15	0.03	0.07	0.02
15.00	4.75	0.06	0.15	0.05
20.00	6.30	0.12	0.23	0.17
25.00	7.80	0.30	0.45	0.32
30.00	9.40	0.65	0.75	0.55
35.00	10.95	0.75	1.19	0.70
40.00	12.55	0.90	1.86	0.90
45.00	14.05	1.55	2.62	1.80
50.00	15.60	2.15	3.49	2.55
55.00	17.06	2.95	4.50	3.70
60.00	18.65	4.90	9.01	6.90

From Table 1 & Table 2, it can be seen that both beams behaved in the same pattern. Once the cracking point has been reached, the gradient decreases until it almost become flat when it reaches the ultimate load. Since both the beams are made of the same cementitious materials, this behavior is expected with the only difference being the beam strengthened with ferrocement which shows a higher cracking point as well as higher ultimate loading point.

When the beams were loaded, the concrete layer at the tension zone is able to resist the tensile forces exerted before the concrete tensile strength at the bottom of the beam has exceeded. This also means the deflection of the beam would increase steeply after cracking at the beam has occurred. Thus, the rate of increase in deflection of the beam can be used to detect the starting point of cracking in the concrete beam. For comparison, the rate of increase of deflection for every 10 bar is computed in Table 3 and Table 4.

Table 3: Increase of deflection for every 10 bar (3.15kN) loadings (beam without ferrocement)

Load		Beam without ferrocement (mm)		
Bar	kN	C1	C2	C3
0 – 10	0.0 – 3.15	0.06	0.10	0.08
10 – 20	3.15 – 6.3	0.48	0.68	0.62
20 – 30	6.3 – 9.4	0.65	1.07	0.82
30 – 40	9.4 – 12.55	1.06	2.6	1.03
40 – 50	12.55 – 15.6	5.25	6.7	5.09

Table 4: Increase of deflection for every 10 bar (3.15kN) loadings (beam with ferrocement)

Load		Beam with ferrocement (mm)		
Bar	kN	C1	C2	C3
0 – 10	0.0 – 3.15	0.03	0.07	0.02
10 – 20	3.15 – 6.3	0.09	0.16	0.15
20 – 30	6.3 – 9.4	0.53	0.52	0.38
30 – 40	9.4 – 12.55	0.15	1.11	0.35
40 – 50	12.55 – 15.6	1.21	1.62	1.62

It can be seen from Table 3 and Table 4 that when cracking occurs, an abrupt rate of deflection value is observed. For example, for beam strengthened with ferrocement, the initial increase in deflection are about 0.30 mm per 10 bar of load applied. But once the loading reached about 40 bars, an abrupt increase of about 1.10mm is observed. Thus, it can be conclude that cracking occurred at this point of loading. Comparing the cracking point of both the beams whereby the ferrocement beam first develop cracks at a loading of 12.40 kN while the control beam starts to crack at a load around 6.20 kN, it shows that ferrocement laminate increases the cracking load of the beam by about 50%. From the load-deflection curve in Figure 6, it can be predicted also that ferrocement beam increases the ultimate load of the beam by approximately 17%.

4. Conclusion

Based on the results from the experiment carried out, it can be concluded that ferrocement can increase and thus strengthen the beam in terms of its cracking load as well as deflection. It reduces the beam's mid-span deflection and increases its strength as compared in the experiment carried out. The experiment indicates the following:

- The ferrocement beam shows the same load versus deflection pattern as found in the control beam.
- The ferrocement beam increases the first cracking load of the beam by about 50%.
- Deflection measured in the beam strengthened with ferrocement is roughly 70% less than the deflection found in control beam within the elastic limit.
- Ferrocement laminate increases the ultimate load of the beam by about 17%.

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