Ferrocement: Cost effective method of retrofitting

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Abstract

RCC structures, as they age, get structurally and aesthetically corroded. They start showing signs of weaknesses in the form of cracks, breaking of plaster, among others. These failures occur due to the structure being constantly under the exposure of loading, environmental conditions, and sometimes even overloading. There is thus a need of a new scientific methodology to be adopted to strengthen existing structures. Retrofitting is such a method. Retrofitting can be defined as modifying existing equipment or structures with additional or new components or members. Among many retrofitting techniques such as CFRP, GFRP and steel jacketing, "Ferrocement" has been proved as an effective and efficient method for retrofitting as it provides similar level of strength in a more economic manner. In this paper, the effect of wire mesh and cement mortar i.e. ferrocement on RCC beams is discussed. The economic advantage of ferrocement structures is that they are stronger and more durable than some traditional building methods. Ferrocement is used here to strengthen the beam in case of bending and shear. Beams are casted of rectangular cross-section using M20 (1:1.5:3) normal mix and HYSD bars are used as longitudinal and shear reinforcement. The test result shows the effects of ferrocement on RCC beams.

Keywords: *Beam, Concrete, Ferrocement, Retrofitting, Reinforcement, strengthening*

1. Introduction

Concrete structures are designed with an expected period, throughout which they are supposed to withstand exerted loads and environmental factors in a safe and satisfactory manner. However, in recent times, due to poor adherence to standard norms, environmental conditions and improper loading considerations, these structures are at risk of failing during their operational life. Such carelessness poses a serious threat to human life, economy, and integrity of the system. Through the process of retrofitting, the strength and the overall life of the structure can be enhanced. The strengthening technique that enhances the performance of deficient structural elements in a structure or the structure as a whole, is referred to as retrofitting.

Retrofitting can be efficiently achieved by the method of plate bonding. Plate bonding furthermore can be accomplished by various methods at disposal which include the use of Carbon Fiber Reinforced Polymer (CFRP), Glass Fiber Reinforced Polymer (GFRP), Steel Jacketing, etc. Out of these techniques Ferrocement has proven to be superior to the other methods in discussion in terms of cost-efficiency, ductility, and over all application process. The flexural strength and ductility of the beams repaired with Ferrocement was reported to be greater than the corresponding original beams and the beams repaired by the conventional methods. Beams rehabilitated with Ferrocement jackets show better performance in terms of ultimate strength, first crack load, crack width, ductility, and rigidity of the section.

2. Ferrocement

Ferrocement is a composite material consisting of rich cement mortar matrix uniformly reinforced with one or more layers of very thin wire mesh with or without supporting skeletal steel.

American Concrete Institute Committee 549, 1988, [1] has defined Ferrocement in broader sense 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".

There are some major differences between RCC elements and Ferrocement members. They are specified as follows:

- The thickness of Ferrocement structural elements is relatively lesser than traditional concrete members which are around 25mm as compared to 100mm of standard RCC structures.
- The cement matrix used in Ferrocement is Ordinary Portland Cement (OPC) whereas in conventional concrete structures, coarse aggregates are present.
- Small diameter wire meshes are used in Ferrocement to ser ve as the reinforcement instead of long reinforcing bars used in RCC.

Ferrocement exhibits a very high tensile strength and superior performance against cracking. Formwork is very rarely needed for fabrications while on the other hand they are considerably used in RCC structures.

3. Experimental Procedure

3.1 Material Used

- Cement: Ordinary Portland Cement Grade 43 was used in concrete mix.
- Fine and Coarse Aggregate: Sand was used as fine Aggregate. Coarse Aggregate of size 20mm, 10 mm are used in present work.
- Steel bars: High Yield strength deformed (HYSD) Steel Strength (Fe415) of nominal diameter 10mm and 12mm are used as tension and compression reinforcement respectively.
- Stirrups: 8mm diameter, two-legged shear reinforcement are used. The bars were bent at angles of 180°.
- Wire Mesh: Mild Steel welded wire mesh of 0.8mm diameter with square grid pattern and rectangular size of 600x700mm was used as Ferrocement jacket in required beams.

3.2 Mixed Proportions

M20 Mix Design was used. Ratio for (Cement: Fine Aggregate: Coarse Aggregate = 1:1.5:3) Water to cement ratio used was 0.5.

Table 1. Mixed Design of RCC Beam

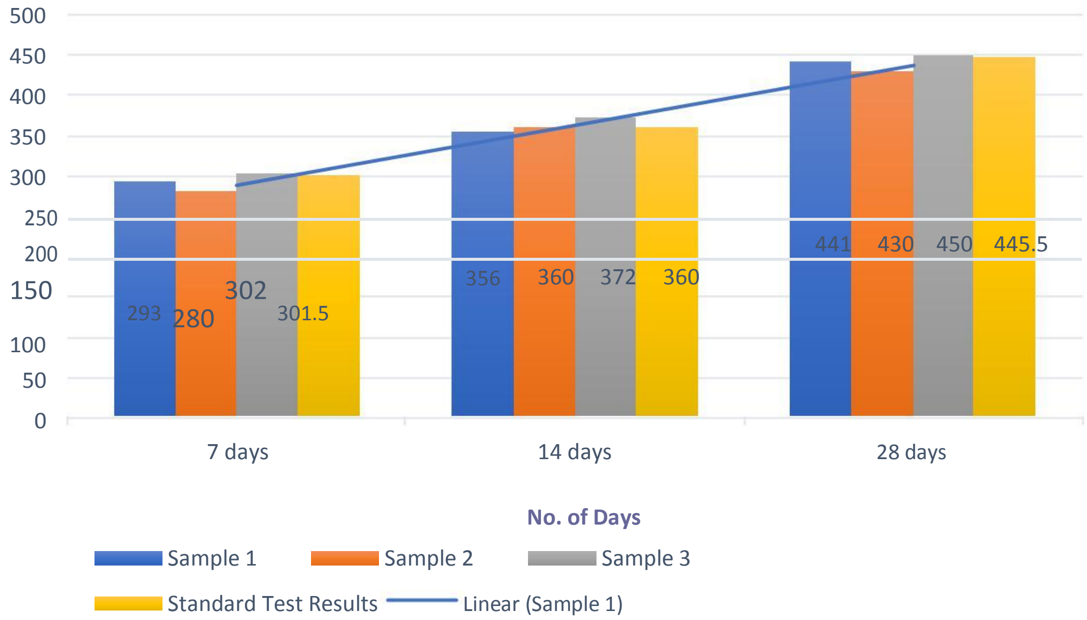
S. No.	Material	Quantity (Kg/m3)
1.	Water	200.0
2.	Cement	403.2
3.	Fine Aggregate (Sand)	672.0
4.	Coarse Aggregate (20mm)	663.0
5.	Coarse Aggregate (10mm)	663.0

The entire experimental process consists of two parts, the preliminary concrete mix compression testing using standard cube molds and casting and testing of beams.

3.2.1 Concrete mix Preliminary Testing under compression

Preliminary testing consists of casting of nine cubes of dimensions 15x15x15 mm of mixed design ratio M20. Each of the three cubes were cured for 7 Days, 14 Days and 28 Days respectively and the tested for compression on the Universal Testing Machine.

Figure 1. Cube Testing results under compression with Universal Testing Machine (UTM)



3.2.2 Design and Casting of Beams

A total of six beams have been casted, two of each of the following:

- Reinforced Cement Concrete (RCC).
- Plain Cement Concrete (PCC) retrofitted with Ferrocement jacket.
- Reinforced Cement Concrete (RCC) retrofitted with Ferrocement jacket.

The beams are of 150x150x700 mm in dimension, with M20 Concrete Mix and Fe415 Reinforcement bars. Stirrups of 8mm diameter were provided as stipulated in figure 2.

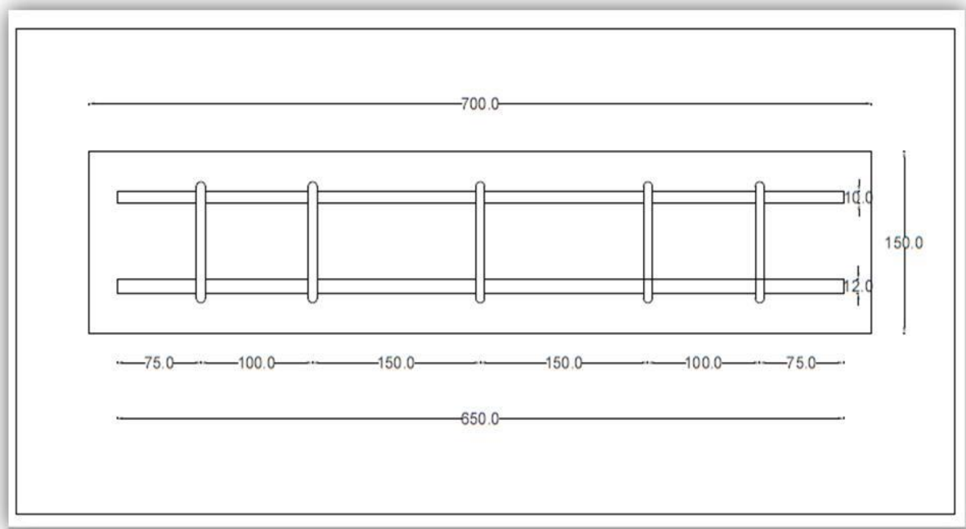


Figure 2. Reinforcement Detail

- After seven days of curing, the desired beams are to be encapsulated with Ferrocement jacket with 15mm thick cement mortar.
- Cement Mortar having the ratio of 1:3 by weight and water ratio cement ratio is to be kept at 0.5.
- The beams are then to be left to cure for the entire duration of 28 days.
- After 28 days of curing, flexure and shear tests are to be performed on the beams, with the use of Universal Testing Machine (UTM) of 600 KN capacity with two-point loading pattern.
- The deflection at dial gauge of least count 0.01 mm will be recorded.
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Figure 3. Beam Casting

Figure 4. Reinforcement Detail

Figure 5. Casted Beam being cured

Figure 6. Casted Beam

4. Expected Conclusion

- The strength of RCC Beam retrofitted with Ferrocement is expected to be greater than other two cases.
- The PCC beam should fail suddenly in shear due to lack of shear reinforcement.
- Due to retrofitting of the beams, the deflection should ideally be decreased.
- These series of experimentations will work towards establishing, that use of Ferrocement mesh as retrofitting will have serious impact on cracking patterns of RCC Beam by delaying the crack appearance and the crack width associated with it.

5. References

5.1. IS Codes

[1] IS Code Handbook 456:2000 – General Guidelines.

5.2. Journal Article

[1] ACI Committee 549, "Guide for The Design, Construction and Repair of Ferrocement", ACI Structural Journal, May – June **1988**.

[2] D.S. Vijayan and Dr. J. Revathy, “Study on Retrofitted RCC Beams” in International Journal of Engineering Science and Computing, Volume 6, Issue No. 5, May **2016**, pp 5664-5667.