EPH - International Journal of Science And Engineering
ISSN (Online): 2454 2016
Volume 07 Issue 02 June 2021

DOI: https://doi.org/10.53555/eijse.v2i4.20

A STUDY ON STYRENE - BUTADIENE RUBBER (SBR) LATEX MODIFIED FERROCEMENT

Balamuralikrishnan R[1]* and Aravind N[2]
*[*1,2]Department of Built & Natural Environment, Caledonian College of Engineering, Muscat, Oman*

Corresponding Author:-
Email: bmk.gaya@gmail.com

Abstract:-
Ferrocement is a composite construction material which consists of high performance mortar and meshes. Ferrocement is a good technique in the field of strengthening of existing structural members. However, there is a chance for corrosion of steel meshes used for ferrocement, since the cover thickness is very less. In the present study, SBR latex modified ferrocement technique was introduced for the laminate preparation and the results were compared with normal ferrocement. In this work, Styrene - Butadiene Rubber (SBR) polymer was added to the mortar to increase the strengthening performance and to avoid the corrosion. Six numbers of ferrocement laminate were cast and tested in the laboratory, out of which three ferrocement laminates with SBR latex and remaining three are ferro-cement laminate without SBR latex (normal ferrocement laminate). The sizes of laminates are 550 mm length, 150 mm width and 20 mm thickness. All the laminates were tested under a two point loading system. The ferro-cement laminate with SBR latex shows better strength and improved flexural capacity compared to the normal ferrocement. The experimental results proved that the development of strength, deformability and fracture properties of laminate with SBR latex were more when compared to conventional ferro-cement.

Keywords: - *Ferro-cement, two point loading, Styrene - Butadiene Rubber (SBR) latex, Flexural capacity*

1. INTRODUCTION

The world of engineering is a set of new adventures and creations. The major points considered by the researchers are to design something which is strong, cost effective and durable. Concrete is extensively used for construction purpose all over the world which is a heterogeneous material. Reinforced concrete is a composite material in which concrete and steel are used. Concrete is weak in tension where the tensile stresses in flexural member is resisted by the steel reinforcement. Steel is far greater than concrete in compression, reinforcing steel can also addition strength to concrete in compression. Ferro-cement is considered to be one of the first inventions of reinforced concrete and it is a highly versatile form of reinforced concrete made up of wire mesh, sand, water, and cement, which possesses unique qualities of strength and serviceability. Ferro-cement over the years have gained respect in terms of its superior performance and versatility and now is being used not only in housing industry but its potentials are being continuously explored for its use in retrofitting and strengthening of damaged structural members.

Also, it can be prepared with a minimum of skilled labour and utilizes readily available materials. There are several applications of ferrocement which include building industry, irrigation sector, and water supply and sanitation areas. Studies indicate that it appears to be an excellent composite in the case of seismic resistant structures. Ferro-cement is a building material composed of a relatively thin layer of concrete, covering such reinforcing material as steel wire mesh. The building techniques are simple enough to be done by unskilled labour, ferrocement is an attractive construction method in areas where labour costs are low to construct something from ferrocement, and someone starts by creating a frame of wire mesh. Chicken wire mesh is a common choice, but any sort of metallic mesh will work. The mesh is often layered, creating a matrix. A mixture of cement, sand, and water is spread over the frame, typically very thinly, and then the ferrocement structure is allowed to cure. The curing time varies, but can exceed a month in some climates and situations. At the end of the curing period, the resulting structure is quite strong and very solid, despite the fact that the walls are very thin. The thickness of ferrocement generally ranges from 25 - 50 *mm*.

The main problem of using ferrocement was the poor impact resistance and less durability. Hence, in the present research work, Styrene - Butadiene Rubber (SBR) latex was added to the mortar which resists steel mesh corrosion.

2. Literature review

Ferro-cement is a type of thin wall reinforced concrete, commonly constructed of hydraulic cement mortar reinforced with closely spaced layers of continuous and relatively small size wire mesh. The mesh may be made of metallic or other suitable materials [1]. Recent trends have "ferrocement" being referred to as ferro concrete or reinforced concrete to better describe the end product instead of its components. By understanding that aggregates mixed with Portland cement form concrete, but many things can be called cement, it is hoped this may avoid the confusion of many compounds or techniques that are not Ferro concrete [2]. Like other applications of cement, about 28 days is necessary for the material to fully cure and reach its final strength, unless chemical accelerators or steam curing are used. As the cement hydrates, it becomes increasingly strong. Depending on the span of the building element or structure, and the load to be applied, it may be possible to put it into service prior to full curing [3]. Chopped glass or poly fibre can be added to reduce crack development in the outer skin. Chopped fibre could inhibit good penetration of the grout to steel mesh constructions. This should be taken into consideration and mitigated, or limited to use on outer subsequent layers. Chopped fibres may also alter or limit some wet sculpting techniques [4]. Behaviour of beam elements retrofitted with high performance ferro-cement laminates with various volume fraction of mesh were studied and found that the performance of ferro-cement laminate performs well [5]. Flexural strengthening of reinforced concrete beams retrofitted with corrugated glass fiber reinforced polymer (GFRP) laminates performs well when compared with GFRP plain sheets [6]. Many researchers have done research in the field of ferro-cement. In the present study, Styrene - Butadiene Rubber (SBR) polymer was added to the mortar to increase the strengthening and durability properties.

3. EXPERIMENTAL METHODOLOGY

3.1 Materials used in ferro-cement construction

There are many materials used in ferro-cement construction include Rod reinforcement, Mesh reinforcement, Staples and lacing wire, Welding rods, Cement, Sand, Styrene - Butadiene Rubber (SBR) polymer and Water.

3.2 Mesh reinforcement

The ideal mesh is a 13 *mm* × 13 *mm* × 19 gauge (1 *mm*) welded mesh according to British Standards [7]. Although meshes of 18-22 gauge can be used, 19 gauge will prove to be the best from a practical point of view. In colder, less humid climates, it may be used un-galvanised; in semi-tropical/tropical it will need to be galvanised. A specification for welded mesh is, initially rod used in the manufacture of welded wire mesh is a low carbon content (0.15% max by weight) rimming steel with the carbon concentrated in the centre. The rod used in the manufacture of the wire mesh is hard-drawn from 'X' size down to 19 gauge (1 *mm*), hot rolled (perhaps copper washed) passed through stearate soap and then welded. It is then passed through the galvanising process. The rod has a very low silicon value. Other mesh types which may be used are hexagonal mesh and, to a lesser extent, woven square mesh. Classification societies may need evidence of how the alternate meshes are used, in what direction they lay, and the combination of meshes that can or may be used. Using expanded mesh in certain forms of construction may also be acceptable but is rarely employed other than in a construction using moulds. Different types of mesh are shown below in figure 1. In the present study, square welded mesh was used for ferro-cement preparation work as shown in figure 2.

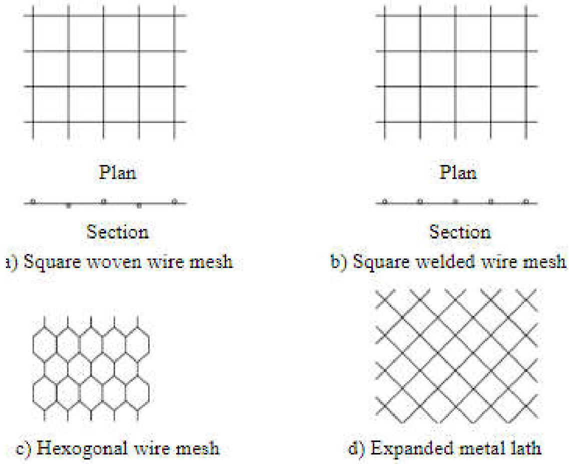


Figure 1 Types of mesh

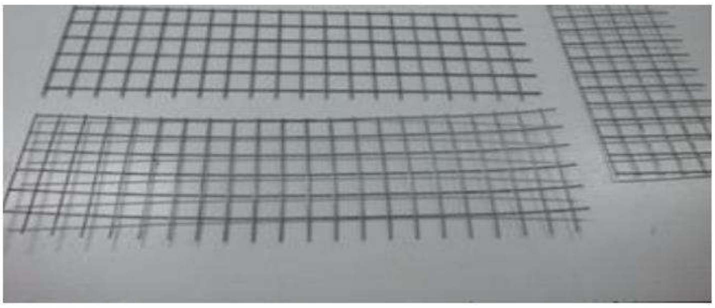


Figure 2 Square welded mesh

3.3 Cement: Sand

For ferro-cement preparation, cement sand ratio should be about 1: 3 by volume and not higher. Also cement water ratio should be maintained 1: 0.4. Ordinary Portland Cement (OPC) is used for ferrocement preparation. Clean and well graded sand was used as aggregate.

3.4 Styrene - Butadiene Rubber (SBR) Latex

Admixture named Styrene - Butadiene Rubber (SBR) Latex (Admix 225MB) was also used for the experimental work for increasing durability. Specifications of SBR supplied by the SODAMCO Company are shown in Table 1. The purpose for adding SBR latex is, it fills the voids of the cement mortar and arrest the water intrusion which is the major reason for corrosion. Corrosion of reinforcement affects the durability of structural member.

Figure 3 Styrene - Butadiene Rubber (SBR) Latex

Table 1 Properties of Styrene - Butadiene Rubber (SBR) Latex

Property	SBR Latex
Compressive Strength at 7 days	28 MPa
Flexural Strength at 7 days	14.3 MPa
Tensile Strength at 7 days	3.3 MPa
Appearance	White liquid
Unit weight	1 kg/L
Solids content by weight	48%
pH value	10 to 11
Shelf life	1 year

3.5 Specimen Preparation

Six samples were cast and the dimensions of the specimen which is specify as the base size of UTM machines are shown in table 2.

Table 2 Description of Test Specimen

Specimen type	Length (*mm*)	Width (*mm*)	Thickness (*mm*)
Specimen without SBR	550	150	20
Specimen with SBR	550	150	20

The quantities of materials used for ferro-cement preparation are given in Table 3.

Table 3 Description of Test Specimen

Materials	Quantity
Cement	1.5 *kg*
Sand	3 *kg*
Water	360 *ml*
SBR	170 *ml*

In this experimental works three ferrocement laminate without SBR latex and three ferrocement laminate with SBR latex were cast. Laminates were cast in the construction materials laboratory. Three meshes were kept over the cover blocks as shown in figure 4 and the prepared cement mortar was applied at top and bottoms the mesh as shown in figure 5. Cast specimens were allowed to air dry for 24 hours as shown in figure 6.

Figure 4 Arrangement of meshes

Figure 5 Applying cement mortar

Figure 6 Specimen Exposed to air Dry

After casting, all the laminate specimens were kept in water for curing. Curing is required for the laminates to develop the desired properties in terms of strength & durability.

3.6 Testing of Laminates

After curing, the specimens were tested under two point loading system as shown in figure 7. Two point loading system gives pure bending and pure shear force. Flexural test was conducted on all the prepared specimens. Experimental test results proved that all the ferrocement laminates showed a ductile behaviour and the failure pattern is shown in figure 8.

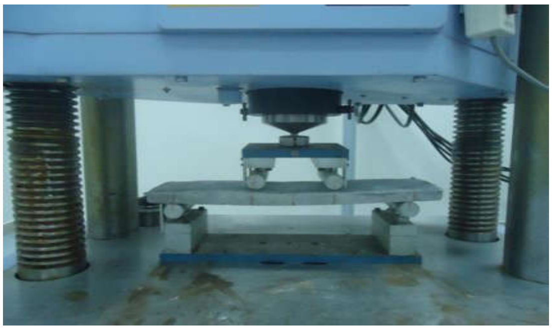


Figure 7 Ferro-cement Laminate under Flexure Test

Figure 8 Closer View of Tested Laminate

4 RESULTS AND DISCUSSIONS

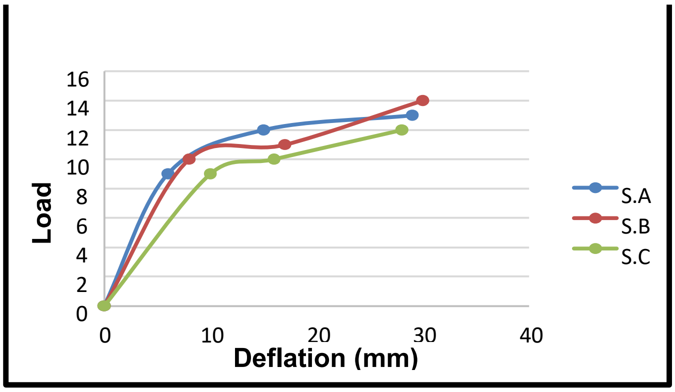
4.1 Load Deflection curve

Load and deflections were taken from the experimental tests. Table 4 states the results obtained from the load tests for ferrocement laminate with and without SBR latex. The maximum load and deflection of ferrocement laminate with SBR latex was (30 *KN* -14 *mm*) and for ferrocement laminate without latex was a bout (25 *KN* -10 *mm*).

Table 4 Experimental results

Type of specimen	Specimen description	Maximum Load (*KN*)	Deflection corresponding to maximum load (*mm*)
Laminate without SBR	1	23	10
	2	24	9
	3	25	10
Laminate with SBR	A	29	13
	B	30	14
	C	28	12

The set of load and mid span deflection curve for all the laminates specimens were shown in figures 9 and 10. The load increases at start while the deflection increases as well to a certain load, yield load and straight after the mid span point deflection varies and till it gets to the maximum value. Ahead of the ultimate load point, the deflection starts increasing noticeably with the decrease in load. From the load and deflection curves it is obvious that the ultimate load carrying capacity of ferrocement laminate with latex is comparatively higher than those ferrocement laminate without latex.



F

Figure 9 Load and Deflection curve for ferrocement Laminate with SBR

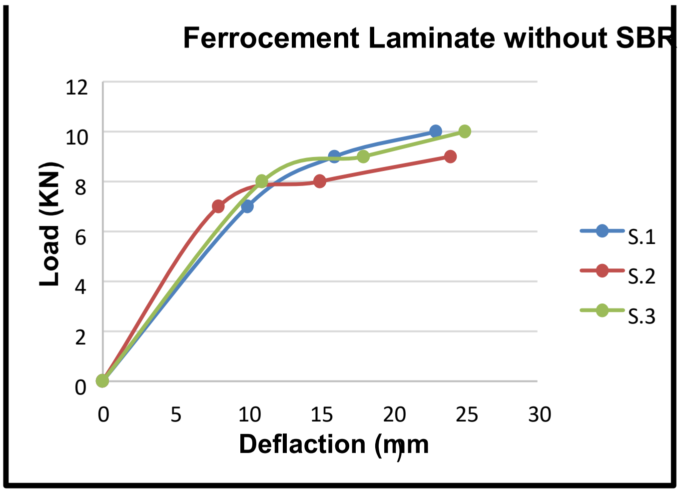


Figure 10 Load and Deflection curve for ferrocement Laminate without SBR

4.2 Theoretical analysis

Theoretical analysis was carried out to determine the flexural strength of ferro-cement laminate with and without SBR latex. Flexural strength is a material's ability to resist deformation under load. The flexural strength represents the highest stress experienced within the material at its moment of rupture. It is measured in terms of stress and the symbol is σ. Equation 1 was developed based on the theory of simple bending. Figure 11 shows the schematic diagram of a two point loading system.

$$\sigma = \frac{3F(L-S)}{2\,b\,d^2} \qquad Eqn. 1$$

Where,

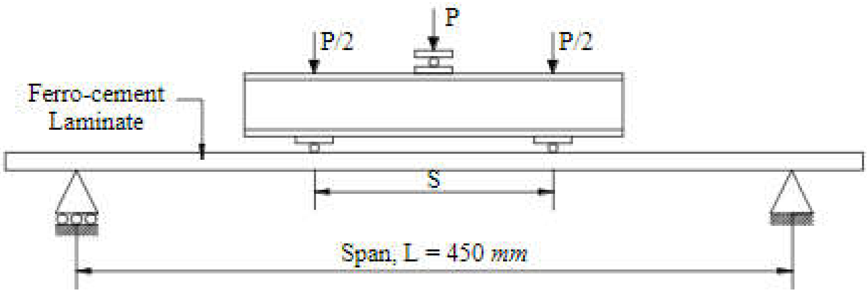
F – Applied load in *N*

L – Length of the laminate in *mm* = 450 *mm*

S – Spacing between two point loads in *mm*

b – Width of laminate in *mm*

d –Thickness of laminate in *mm*



Longitudinal section

Figure 11 Laminate Under Two Point Loading

Using equation 1, flexural strengths of laminates with and without SBR latex were determined. Average flexural strength of laminates with and without SBR latex were 225 *MPa* and 187.5 *MPa* respectively. Theoretical analysis results revealed that the flexural strength of ferro-cement laminate with SBR latex is higher than the flexural strength of ferro-cement laminate without SBR latex.

5 conclusions

The following conclusions were made based on the experimental and theoretical analysis.

1. Experimental results proved that the load carrying capacity of laminate with SBR latex gives more strength when compared with the conventional ferrocement.
2. Theoretical analysis results revealed that the flexural strength of ferro-cement laminate with SBR latex is higher than the flexural strength of ferro-cement laminate without SBR latex.
3. The amount of materials used for ferrocement laminate preparation and labour work required is much less than the conventional technique hence more cost effective and time effective.
4. Experimental test results proved that all the ferrocement laminates showed a ductile behaviour.
5. The load increases at start while the deflection increases as well to a certain load, yield load and straight after the mid span point deflection varies and till it gets to the maximum value. Ahead of the ultimate load point, the deflection starts increasing noticeably with the decrease in load.
6. From the load and deflection curves it is obvious that the ultimate load carrying capacity of ferrocement laminate with latex is comparatively higher than those ferrocement laminate without latex.

6 REFERENCES

[1]. Nagesh M. Kulkarni, D.G.Gaidhankar (2013), Analysis and Design of Ferrocement Panels an Experimental Study, Volume-1, Issue-5, pg. 2319–9598.

[2]. Ferrocement: Introduction, (2014). Civil Engineering: Ferrocement: Introduction, Property & Application. Available at: http://surfcivil.blogspot.com/2012/10/ferrocement.html [Accessed 7 Sept. 2014].

[3]. Fao.org,(2014).Materials Used In Ferrocement Construction.[online]Availableat: http://www.fao.org/docrep/003/v9468e/v9468e07.htm [Accessed 7 Jan. 2014].

[4]. En.wikibooks.org, (2014). Self-Reliance Handbook/Ferrocement Construction - Wikibooks, open books for an open world. [online] Available at: http://en.wikibooks.org/wiki/SelfReliance_Handbook/Ferrocement_Construction [Accessed 7 Oct. 2014].

[5]. Palani, B., and Balamuralikrishnan, R. (2015), Behaviour of Structural Elements Retrofitted with Ferrocement Laminates, Caledonian Journal of Engineering, Sultanate of Oman, Volume 11, No.1, pp. 07 -14. (ISSN: 1999-9496).

[6]. Aravind N, Amiya K. Samanta, D. K. Singha Roy and Joseph V. Thanikal., (2015), “Flexural strengthening of Reinforced Concrete (RC) Beams Retrofitted with Corrugated Glass Fiber Reinforced Polymer (GFRP) Laminates”, *Curved and Layered Structures* (ISSN: 2353-7396), Vol. 2 (1), pp.244-253. DOI: 10.1515/cls-2015-0012.
[7]. BS 4482 (2005), Steel wire for the reinforcement of concrete products – Specification.