"BEHAVIOR OF SKELETAL STEEL REINFORCE LIGHT WEIGHT FERROCEMENT BEAMS UNDER MONOTONIC AND REPEATED FLEXURAL LOADING"

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ABSTRACT

Light weight ferrocement is a composite material consisting of cement-sand mortar (matrix) along with light weight fine aggregate (In this research blast furnace slag is employed as light weight fine aggregate) as a replacement of sand in some quantity reinforced with layers of small diameter wire meshes and closely spaced small-diameter steel rods. The present work is concentrated on two major aspects, (i) Effect of blast furnace slag on ultimate strength and (ii) Behavior of light weight ferrocement element under flexural loading. The first part of the present study has been focused on the effect of blast furnace slag(BFS) on ultimate strength with replacement of slag by 0%,10%,20%&30% and second part of the work focusing the behavior of light weight ferrocement beam under monotonic & repeated loads with increased load. The results obtained from this work is expected to be useful in determining the first crack strength and ultimate strength of light weight ferrocement beams subjected to similar types of forces and thus will help toward designing ferrocement elements to withstand monotonic and repeated flexural loading.

Key words: Light weight ferrocement, Blast furnace slag, wire mesh, skeletal steel bar & repeated loading.

INTRODUCTION

Light weight ferrocement is a composite material consisting of cement-sand mortar (matrix) reinforced with layers of small diameter wire meshes and BFS. It consists of closely spaced, multiple layers of mesh & fine rods completely embedded in cement mortar. Usually steel bars are used in addition, to form a steel skeleton, which helps in retaining the required shape of the ferrocement components until the cement mortar hardens. It differs from conventional reinforced concrete primarily by the manner in which the reinforcement is arranged within the brittle matrix. Since its behavior is quite different from that of conventional reinforced concrete in performance, strength and potential applications, it is classed as a separate material.

Light weight ferrocement has high resistance against cracking; also many of its engineering properties such as toughness, fatigue against resistance, and impermeability etc. are improved when compared to reinforced concrete

It has been regarded as a highly versatile construction material having unique properties of strength and serviceability. Its advantageous properties such as strength, toughness, water tightness, lightness, durability, fire resistance and environmental stability cannot be matched by any other thin construction material. Ferrocement is a promising composite material for prefabrication and industrialization of the building industry.

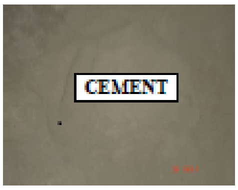
EARLIER WORKS

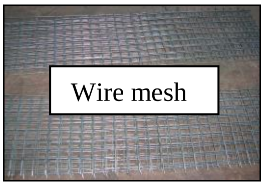
Investigations related to batching mixing and job control of Lightweight concrete (ACI COMMITTEE,1982), concrete mechanical properties of ferrocement elements under monotonically with increased loading (Desayi P *et. al*, 1984 and PRAKHYA,G.K.V *et. al*, 1988) and fatigues have been reported (Balaguru P. *et. al*., 1977) and some design procedure has been suggested based on the results of such studies. Both first crack and ultimate moment increases with increasing matrix grade (SURYAKUMAR, G.V *et. al*, 1976) (decreasing w/c ratio) (Walkus B.R,1986) and increasing volume fraction of reinforcement have been reported(Suresh G.S *et. al*, 2007), No information has been available on the response of light weight ferrocement structure subjected to monotonic and repeated loading. In this work matrix grade increase and volume fraction is increasing by taken as 6 layer wire mesh and study the behaviour of light weight ferrocement beam.

EXPERIMENTAL WORK

The materials used in the casting of flexure specimens are used in strength studies. Hence the properties of cement, sand, lightweight aggregate are Testing in Laboratory are same as given below. Water cement ratio used was 0.45 by weight. The replacements of sand by BFS considered in this study are 0.0%, 10%, 20% and 30 % which are adopted for the preparation of flexure specimens.

MATERIALS USED AND ITS PROPERTIES





Cement

Ordinary Portland cement of grade 43 conforming to IS: 8112-1989, which is stored in a cool and dry place before it's used. Compressive strength of Cement used and other physical properties as show in table.1.

Table-1 Physical Properties of Cement

Physical property	Results obtained	IS specifications
Standard consistency (%)	30	Not specification
Initial setting time	45 mins	Not less than 30 mins
Final setting time	434 mins	Less than 600 mins
Fineness of cement	1.95%	Not more than 10%
Specific gravity	3.14	3.15
Compressive strength 3-days	23.6 N/mm2	23.0 N/mm2
Compressive strength 7-days	33.19 N/mm2	33.0 N/mm2
Compressive strength 28-days	44.10 N/mm2	43.0 N/mm2

Sand

Table-2 physical Properties of Sand

Fineness modulus	2.85
Density (kN/m^3)	1.53
Water content (%)	0.5
Specific gravity	2.61

The river sand is totally free from all impurity and organic matters. Experiment physical properties are obtained is shown in table.2.

Blast Furnace Slag (BFS)

The blast furnace slag used to replace sand was obtained from Visvesvaraya Iron and Steel Plant, Bhadravathi. The chemical composition of this BFS given by the supplier and the physical properties are as shown in tables 3 and 4 .

Table-3Physical Properties of BFS

Fineness modulus	3.58
Density (kN/m^3)	1.12
Water content (%)	0.05
Specific gravity	2.41
Grading zone	I

Table-4 Chemical Properties of BFS

Constituents	Compositions (%)
SiO_2	30-33
Al_2O_3	20-22
CaO	33-35
MgO	9-10
S	Traces
Others	3-5

Water

Ordinary potable water was used for mixing. The mixing water should be fresh, clean, and potable

Wire mesh

wire meshes have square openings 4x22 gauge (0.55 mm average dia at 4.17 mm c/c) are used. Meshes with square openings are available in woven form. Woven-wire mesh is made out of straight wires in both the longitudinal and transverse directions. The tensile strength of steel wire, in a mesh is 430 N/mm^2

Skeletal Steel

Mild steel bars of 4 mm diameter have been used as skeletal steel. The yield strength is assumed equal to 90% of ultimate strength. The ultimate tensile stress of steel bar is 860 N/mm^2

CASTING & TESTING OF SPECIMEN

Casting of specimens

Parameters considered in this study are, the percentage of sand replacement and mesh wires. Four percentages of replacing sand by lightweight aggregate (L.W.A.) viz., 0%, 10%, 20% and 30% by weight and mesh wires in terms of number of mesh layers per specimen viz., 0,2 and 4 layers is designations as show in table.5. A total of 84 ferrocement specimens have been cast on name as groups A. 6 specimens were cast at a time of dimension as shown in fig 2 & 3, using of teak wood moulds as shown in Fig 1. The layer of mesh was held in position at required spacing in the moulds by means of suitable aluminum spacers, which were removed while casting. In each casting about 3 mortar cubes 70.6 of mm side were also cast as control specimens. A plate vibrator was used for compacting the specimens. Moulds were dismantled 24 hours after casting and cured under water up to age of 28 days. After curing the specimens were removed from water and kept in a cool and dry place till they were tested. All the specimens were white washed before applying the load to notice the cracks clearly. Three cubes were tested for their composition strength after testing each set of specimens in each group.

Table 5 - Designation of the specimens

No. of mesh layers	Percentage replacement of B.F.S. of 1:2 cement mortar			
	0	10	20	30
0	LMNC 1 – 0% LMNC 2 – 0% LMNC 3 – 0%	LMNC 1 – 10% LMNC 2 – 10% LMNC 3 – 10%	LMNC 1 – 20% LMNC 2 – 20% LMNC 3 – 20%	LMNC 1 – 30% LMNC 2 – 30% LMNC 3 – 30%
2	LMNA 21 – 0% LMNA 22 – 0% LMNA 23 – 0%	LMNA 21 – 10% LMNA 22 – 10% LMNA 23 – 10%	LMNA 21 – 20% LMNA 22 – 20% LMNA 23 – 20%	LMNA 21 – 30% LMNA 22 – 30% LMNA 23 – 30%
4	LMNA 41 – 0% LMNA 42 – 0% LMNA 43 – 0%	LMNA 41 – 10% LMNA 42 – 10% LMNA 43 – 10%	LMNA 41 – 20% LMNA 42 – 20% LMNA 43 – 20%	LMNA 41 – 30% LMNA 42 – 30% LMNA 43 – 30%
6	LMNA 61 – 0% LMNA 62 – 0% LMNA 63 – 0%	LMNA 61 – 10% LMNA 62 – 10% LMNA 63 – 10%	LMNA 61 – 20% LMNA 62 – 20% LMNA 63 – 20%	LMNA 61 – 30% LMNA 62 – 30% LMNA 63 – 30%
2	LRPA 21 – 0% LRPA 22 – 0% LRPA 23 – 0%	LRPA 21 – 10% LRPA 22 – 10% LRPA 23 – 10%	LRPA 21 – 20% LRPA 22 – 20% LRPA 23 – 20%	LRPA 21 – 30% LRPA 22 – 30% LRPA 23 – 30%
4	LRPA 41 – 0% LRPA 42 – 0% LRPA 43 – 0%	LRPA 41 – 10% LRPA 42 – 10% LRPA 43 – 10%	LRPA 41 – 20% LRPA 42 – 20% LRPA 43 – 20%	LRPA 41 – 30% LRPA 42 – 30% LRPA 43 – 30%
6	LRPA 61 – 0% LRPA 62 – 0% LRPA 63 – 0%	LRPA 61 – 10% LRPA 62 – 10% LRPA 63 – 10%	LRPA 61 – 20% LRPA 62 – 20% LRPA 63 – 20%	LRPA 61 – 30% LRPA 62 – 30% LRPA 63 – 30%

Fig.1 Teak wood mould

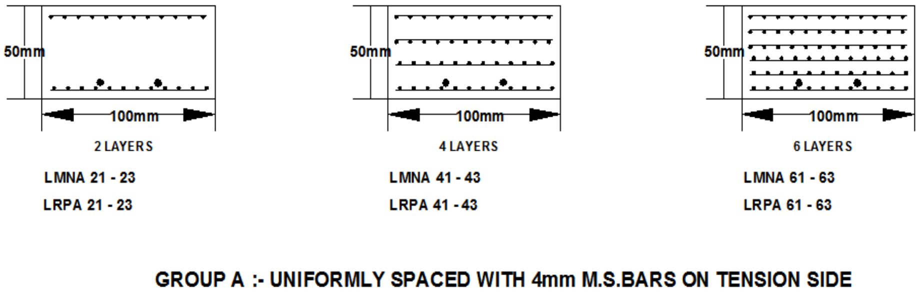


Fig 2 Details of Reinforcement in Specimen

Testing of Specimens

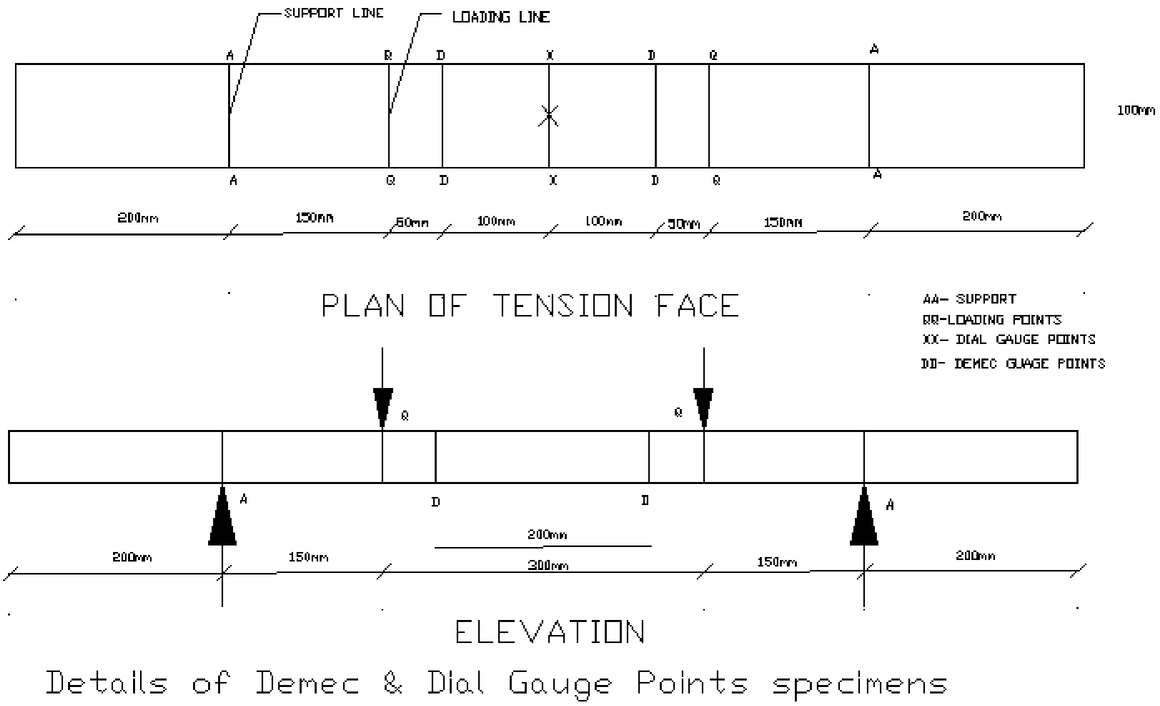


Fig 3 Details of Demec & Dial Gauge points specimens

In each set six specimens were cast, out of which three specimens were tested under monotonic loading and other three under repeated loading. A reaction frame was fabricated for testing specimens under monotonic and repeated load as shown in figure 3.The specimen was seated in between two supports spaced 600mm apart center to center in reaction frame. Loading was applied from top upwards such that the tension face of specimen is on bottom as shown in fig 4. This was done to facilitate marking of cracks in the flexure zone. Rubber padding was used both that supports and at load points, to ensure that the load was applied uniformly across width of the specimen. Loads were applied at one fourth span points, ie at 150mm from supports using a mechanical screw jack of 250kN capacity through a distribution steel high beam shown fig 3.Applied load was measured using a proving ring of 50KN capacity.

Failure of Specimens

Fig4 – ***Failure of 2L Specimen in 0% Replacement of B.F.S under Monotonic Loading***

RESULTS & DISCUSSION

Behavior of average of three specimens for each percentage of slag replacement under monotonic load, represented by the load-deflection curves show in fig 5

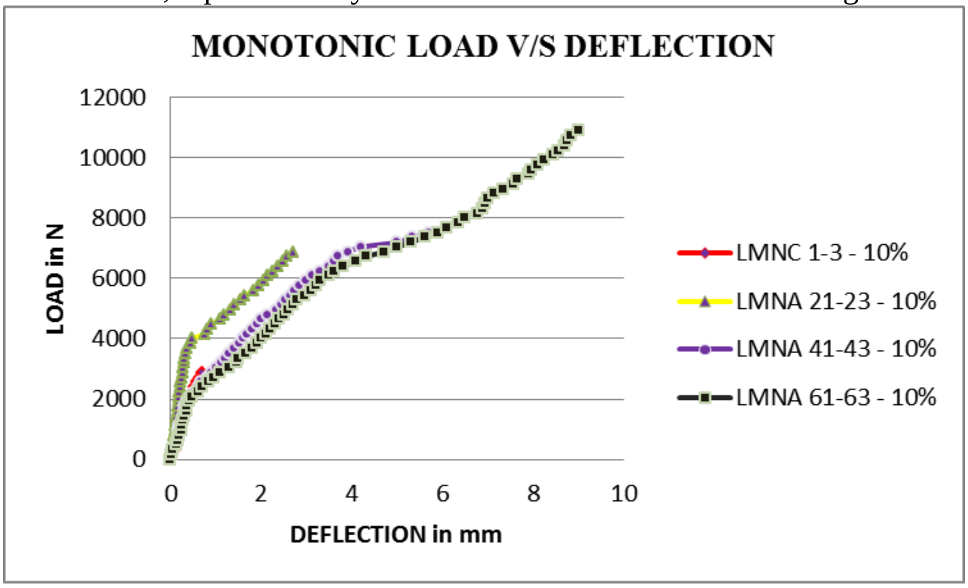


Fig 5: Load Vs Deflection under Monotonic Loading

Behavior of average of three specimens for each percentage of slag replacement under repeated load, represented in the load-deflection curves show in fig 6

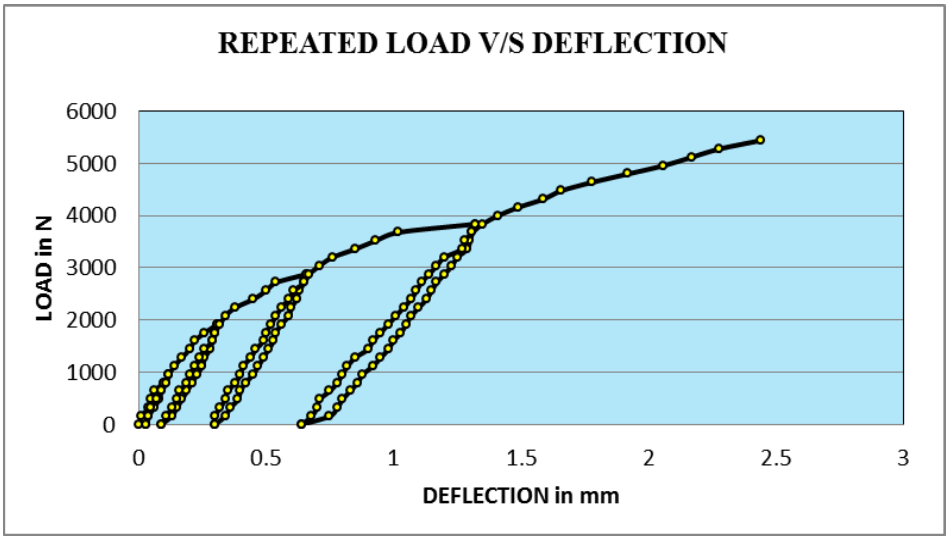


Fig 6: ***Repeated load V/s Deflection Diagram for 2 Layers of Mesh and 10% Replacement of BFS Slag***

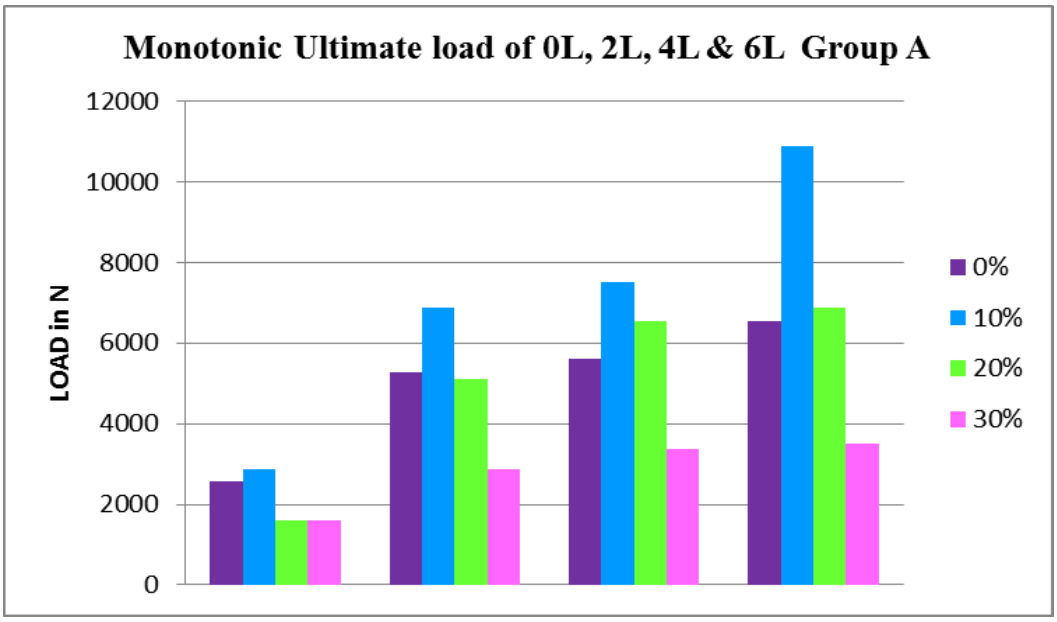


Fig 7: ***Monotonic Ultimate load Diagram for 0, 2, 4, 6 Layers of Mesh and 0%, 10%, 20% & 30% Replacement of BFS Slag Respectively***

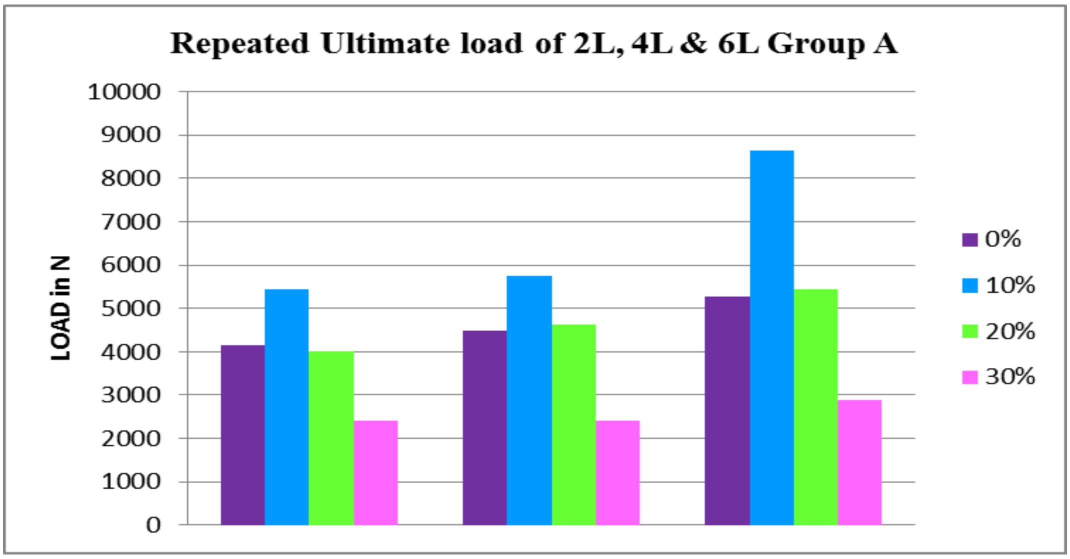


Fig 8: ***Repeated Ultimate load Diagram for 2, 4, 6 Layers of Mesh and 0%, 10%, 20% & 30% Replacement of BFS Slag Respectively .***

It can be seen that from the fig 7 and 8, the ultimate strength increases with the increase in number of mesh layers in the specimen and ultimate strength increased up to 10 % and then decrease with increase of percentage of sand replacement. And also the light weight ferrocement specimens having increased wire mesh could sustain greater number of repetitions, compared to the plain light weight ferrocement specimens.

CONCLUSIONS

From the above result the following conclusion can drawn,

1. Blast furnace slag is an industrial waste material, which can be used for construction purpose.
2. Magnitude of mid-span deflection at failure increases with increase in mesh reinforcement of specimens under monotonic and repeated loading.
3. It can be observed that, the ultimate strength increase up to 10% replacement of sand and decrease with the increased percentage of sand replacement.
4. The volume fractions of mesh wires are more effective in enhancing the ultimate flexural strength.
5. The light weight ferrocement specimens having increased wire mesh(Volume fraction)could sustain greater number of repetitions, for all replacement of blast furnace slag.

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