Cyclic Behavior Of LGS Ferrocement Composite Under Compression And Flexure

Yash Wanjari, Amrut A. Joshi

Abstract: The main objective of this investigation is to study the axial and flexural behavior of Ferrocement-LGS composite section when subjected to half cyclic uniaxial compression and half cyclic 4 point bending. The connection between the ferrocement LGS composite was done by self-tapping gypsum screw. 3 different specimen of length 450mm and 900mm are connected with 150mm screw spacing and epoxy are tested under axial loading and 2 specimen of length 900mm with different screw spacing of 150mm are tested under flexural loading. The parameters studied here are load carrying capacity, maximum deflection/deformation, damping, stiffness degradation, load vs deflection curve, bending moment capacity, modulus of elasticity and failure pattern. Comparison of results with different specimen are done. This research will further provide guidance for study on ferroocement LGS composite system for construction

Index Terms: Damping behavior, Ferrocement, Half cyclic loading, Light Gauge Steel, Self-tapping screw, Stiffness degradation, Uniaxial compression, 4 point bending.

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1 Introduction

The world is shifting from conventional construction material/technique to rapid construction techniques. Steel is most commonly used for rapid construction. With the ongoing population growth there is increased demand of construction. To cope up with this demand new techniques and technology are to be invented. Ferrocement is a composite material consisting of a matrix made of cement mortar and a number of layers of continuous steel mesh reinforcement distributed throughout the matrix. It is a technical word that should not be confused with normal reinforced concrete. The primary distinction between ferrocement and reinforced concrete is a thin composite made of cement matrix strengthened with closely spaced wire meshes of small diameter instead of larger diameter bars and large size aggregate. Light gauge steel building is in theory very comparable to wood framed construction-thin steel segments replace the wooden framing components. Cold formed steel is shaped by guiding thin sheets of steel through a series of rollers, with each roller changing the shape very slightly, resulting in the transformation of a flat sheet of steel into a C or S-shaped section. To safeguard it from corrosion, the steel used here is covered with zinc or a combination of zinc and aluminium (known as galvanized). The thickness of this coating can differ depending on a variety of environments. Marine environments typically involve most protection, while the least protection is required for dry, arid regions.

The most significant and frequently found composite of buildin g materials is that of steel and concrete, with applications in co mmercial multi-storey structures as well as bridges. These materials can be used in composite structural systems, such as concrete cores encircled by steel pipes, as well as in c omposite structures where steel and concrete composite mate rial components function together. These substantially distinct materials are fully compliant and complementary to each other; they have nearly the same thermal expansion; they have an ideal balance of strength with compression-efficient concrete and tension-efficient steel; concrete also provides steel with corrosion protection and thermal insulation at high temperatures and, in addition, thin steel sections can be restrained from buckling locally or laterally.

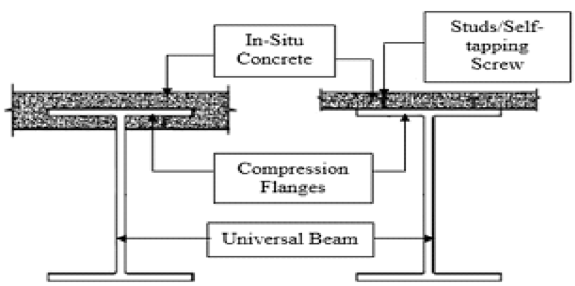

Figure 1 *General used composite section*

2 Objectives

The main goal of this study is to investigate behavior and the properties of an innovative precast proposed Ferrocement-LGS composite beam and column structural system under cyclic loading. The work focuses on studying:

1. Stiffness degradation
2. Equivalent damping

When subjected to axial and flexural cyclic loading. These two parameters are of prime importance in Direct Displacement Based Design of structure.

3 Methodology

Experimental work includes casting of ferrocement panel and casting of cubes according to mortar mix proportion, preparation of specimen and applying axial and flexural cyclic loading. IS code 801-1975 and IS 800:2007 is used for light gauge steel bending moment capacity. Macaulay's method is used for finding out bending moment, deflection at the centre of the span, modulus of elasticity of composite section. Priestley's method of Direct Displacement Based Design is used to find out equivalent viscous damping.

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4 EXPERIMENTAL PROGRAM

4.1 Constituents of Ferrocement Panel and LGS

Ferroement panel of size 600mm x 900mm x 18mm are casted using 43 grade of Ordinary Portland Cement (OPC). The fine aggregate consist of artificial crushed sand and free from organic or other deleterious matter. Density of fine aggregate is 1900kg/m^3. 40% of aggregate passing through the 2.36mm sieve and 60% of aggregate passing through 4.75mm sieve and retaining on 2.36mm sieve were used. Water cement ratio is 0.34. Admixture used is SPRMC APC 1000H provided by RAZON. The admixture is used to increase the workability and rate of strength gain. The dosage of admixture taken is 1.2% of cement by weight. Square welded mesh of size 560mm x 860mm with 20mm c/c opening and 1mm mesh diameter are used. The spacer bar of 4mm diameter are also used in the form of welded fabric. Spacer chair are also provided between the mesh to maintain the spacing. Extra bar are provided at the corner to improve the shear strength while demoulding. LGS channel section with lip is used. The self-weight of LGS channel is 2.55N/m and cross section area of 159mm^2 Elastic modulus of steel is E=200 x 10^3 N/mm^2 and grade of steel F_y is 500. Nails of 2mm diameter were driven into the mould at predetermined spacing according to the specimen. After the mortar is placed and spread on the mould the nails were removed after initial setting time (30min). The ferroement panel are cut in the size of 200mm x 900mm x 18mm and 200mm x 450mm x 18mm to meet the specimen requirement. The ferrocement panel were connected to LGS channel with self-tapping gypsum screw and epoxy as per the requirement of specimen.

Table 1 Specimen for half cyclic 4 point bending test

Specimen name	Length (mm)	Screw spacing (mm)
C-150	900	150
C-250	900	250

Table 2 Specimen for half cyclic uniaxial compression test

Specimen name	Length (mm)	Screw Spacing (mm)	Epoxy/Non-Epoxy
C-450-E	450	150	Epoxy
C-900-E	900	150	Epoxy
C-900-NE	900	150	Non-Epoxy

Figure 2 shows the cross section of composite section and its connection and figure 3 shows arrangement of screw spacing between panel and LGS section. All the specimen are tested and loading capacity and deflection is observed.

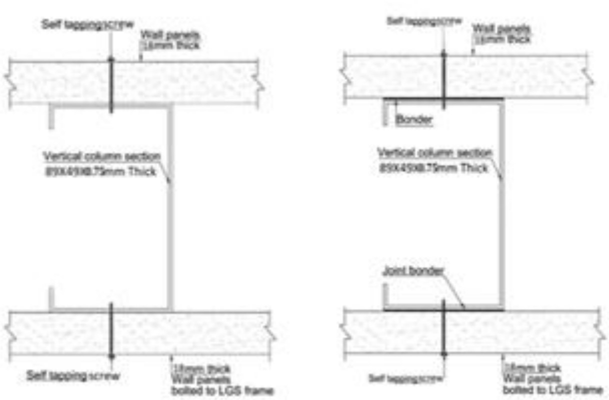

***Figure 2** Connection of ferrocement LGS composite*

4.2 Test setup

The testing of ferron-LGS composite is done in the Universal Testing Machine (UTM). The capacity of UTM is 100tons. The dial gauge is used to measure deformation. Dial gauge is capable of measuring deformation upto 0.01mm. Two types of loading test are performed on UTM

1) Half cyclic 4 point bending
2) Half cyclic uniaxial compression test.

Sensor responses that are measured

1) Load applied
2) Deformation at middle
3) Compressive deformation
4) Contraction.

5 RESULTS AND DISCUSSION

Load carrying capacity and deflection of each specimen were tested under half cyclic uniaxial compression and half cyclic 4 point bending. Behavior of each specimen was noted and its failure pattern was also noted.

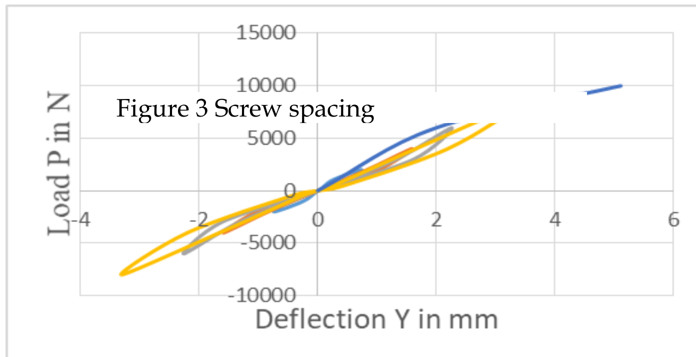

***Figure 4** Load vs Deflection of C-150*

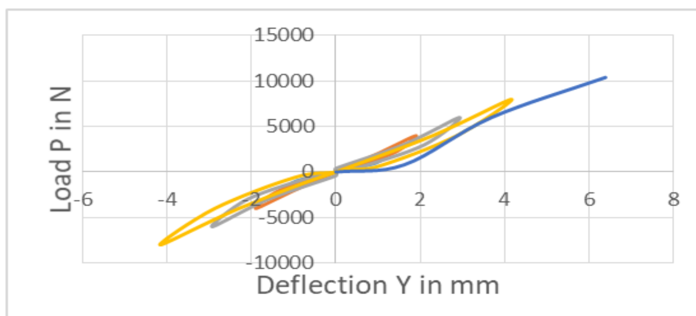

***Figure 5** Load vs Deflection of C-250*

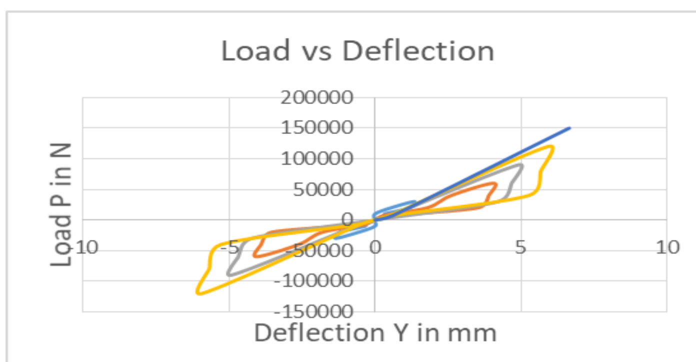

***Figure 6** Load vs Deflection of C-450-E*

From the experimental results it is observed that load carrying capacity increases with increase in spacing for bendin and the specimen failed due to local buckling of LGS channel. In compression, the load carrying capacity increases with increase in length. Addition of epoxy for connection increases load carrying capacity and specimen failure occurred due to crushing of ferrocement panel and web buckling of LGS channel.

Table 3 *Parameters obtained from experimental data for bending*

Parameters	C-150	C-250
Maximum Load (N)	10000	10400
Maximum Deflection (mm)	5.1	6.39
Average E (MPa)	432.37	270.3

From table 3, modulus of elasticity decreases with increase in screw spacing. Maximum deflection occurred in C-250 specimen. From table 4, modulus of elasticity increases with length of specimen. It increases further if connected with epoxy and screw both. Although the failure stress of C-900-NE is less but its modulus of elasticity is more.

Table 4 *Parameters obtained from experimental data for compression*

Parameters	C-450-E	C-900-E	C-900-NE
Failure Stress (MPa)	20.38	26.16	19.17
Ultimate Strain	0.015	0.0046	0.0019
Modulus of Elasticity (MPa)	1223.1	5830	11792

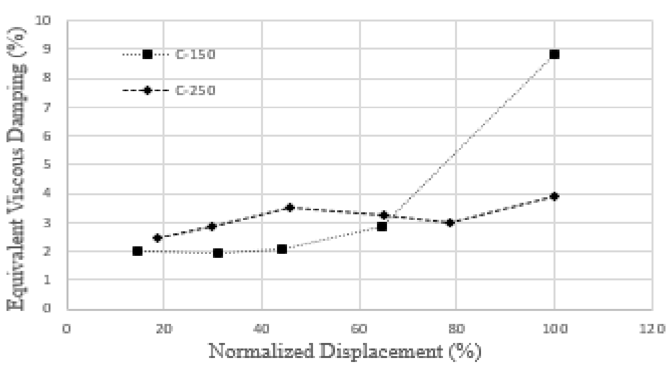

Figure 9 *Damping bahaviour of flexure specimen*

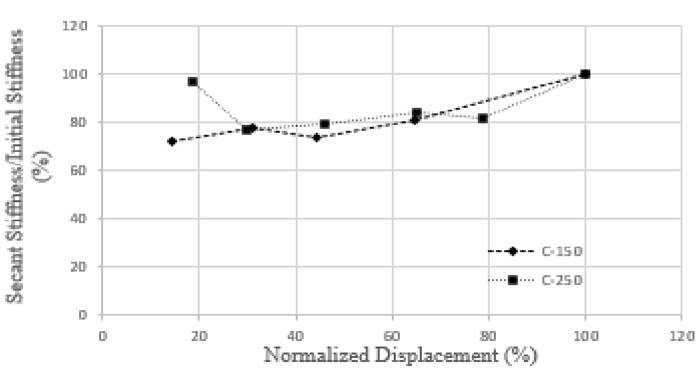

Figure 10 *Stiffness degradation of flexure specimen*

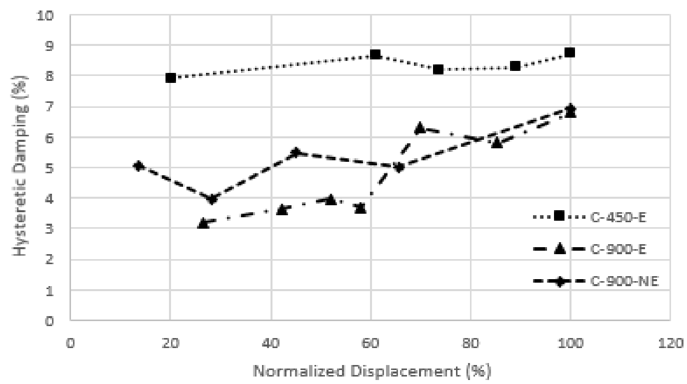

Figure 11 *Damping behaviour of compression specimen*

6 Conclusion

From the experimental results it is seen that damping decreases with increase in length and spacing of specimen. Load carrying capacity increases as screw spacing increases.

- Load carrying capacity of C-250 specimen is more than C-150 by 4%.
- Load carrying capacity of C-900-E specimen is more than C-450-E by 28% and C-900-NE by 33%.

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