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Simplified Mathematical Model to Predict Response of Ferrocement-Lgs Composite Wall to In-Plane Loading

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Abstract**:** ***Ferrocement-LGS (Light Gauge Steel) composite construction is recently proposed novel form of construction as a substitute to traditional RCC framed construction. In this construction form, walls of the building behave more or less like a shear wall in resisting in-plane lateral loads. The present paper attempts to propose a simplified mathematical model for obtaining response of composite wall under in plane lateral loading. As first part of present work, in-plane force deformation behavior of Ferrocement-LGS composite wall panel is predicted through FEM analysis (ANSYS). This force deformation curve was employed to estimate equivalent spring parameters of simplified mathematical model (ETABS) of composite walls. The simplified mathematical model saves significant computational efforts in predicting the in-plane response compared to the traditional FEM model without compromising the accuracy.***

Keywords: Ferrocement and LGS Composite, Ferro composite section, Composite Structures, Mathematical Model, In-plane loading

I. INTRODUCTION

Modern construction techniques are the require of rapidly growing construction industry. For better performance, cost effectiveness and rapid construction solutions various researches are being carried out in all parts of the world. Ferrocement is one such area which is gaining importance due to its promising results from studies all across the world. Ferrocement is a form of thin reinforced mortar members in which a cement-sand mortar mix is reinforced with closely spaced layers of thin iron wire grid or small diameter bars, uniformly distributed throughout the matrix of the composite member. Ferrocement has marked a significant place among the different material in construction, due to its properties such as strength and durability, primarily, its small thickness, which turns it to be material suitable for constructing many lightweight structures. Ferrocement finds to be an economic alternative material for walls & roofs of the building.

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In steel, there are primarily two main families of structural members. One is the popular group of hot-rolled sections of steel built out of plates. The other, less popular but of growing importance is composed of sections cold formed from steel (LGS) strips, plates, sheets, or flat bars formed in roll-forming. machines or by press brake or bending brake operations. These are cold-formed light gauge steel (LGS) structural members.Ferrocement-LGS composite structures is newly introduced construction technique in which ferrocement wall panels with
(LGS) strips, plates, sheets, or flat bars formed in roll-forming. LGS sections can be used as alternative to the traditional RC structures with Infilled masonry walls. In this recent form of structure, walls of the building behave more or less like shear walls. Therefore, its response to the in-plane loading need to be predicted. To predict this, analytical modeling of the composites finds out be a good approach. Finite element modelling of such materials involves complicated details and marathon work. Therefore, the idea of developing a simplified model makes it easy, cost effective and time saving way to predict the behavior of such complicated geometry.
A. Madan, et. al. (1997) proposed a macro-model for masonry infills based on an equivalent diagonal strut. Francisco J. Crisafulli et. al. (2007) proposed a macro-model in order to represent the effect of masonry infill panels. The model implemented as a 4-node panel element which connected to the frame at the beam-column joints. This assembly allowed adequate consideration of the lateral stiffness of the panel and of the strength of masonry panel. Alireza Mohayeddin et. al. (2013) – proposed a three-dimensional finite element model of a reinforced-concrete frame with an infill panel. It was concluded that a dynamic strut model would be a more appropriate replacement for the infill panel than a single strut. Nima Usefi, et. al. (2019) reviewed various methods of modelling cold formed steel-framed walls. Based on their review of number research studies concluded that analysis of well-developed macro-models can give the fairly accurate results as that of micro models.
The preset paper aims to propose a simplified mathematical model to predict response of ferrocement-LGS composites to in-plane loading. In this, the ferrocement panels, are arranged as cladding on both sides of LGS sections due to its flexure and tension carrying capacity. This construction form involves mainly two elements, as follows:
a) Ferrocement panels (600 mm X 900 mm X18 mm)
b) Light Gauge Steel (LGS)

In practice, these constituents can be connected using polymer-based binder and self-tapping screws at regular spacing as shown in fig. 1c

II. SCOPE & OBJECTIVES

Initially, a finite element model using ANSYS was developed to analyze behavior of the Ferrocement-LGS sandwich panel. The results of this model were used to develop a simplified model. The objective of developing a simplified macro-model was to capture initial tangent modulus and the ultimate displacement under in-plane shear.

III. ANSYS MODEL

Two ferrocement panels, each 600X900X18mm.with 1mm wire mesh spaced 20mm center to center at top and bottom were modelled. The geometric representation of the panel is shown in (fig.1a). The LGS channel sections of size 89xb49x14x0.75mm (aXbXcXt) (fig. 1b) were arranged horizontally at top and vertically on the edges and were sandwiched between these ferrocement panel. (fig. 2). Program controlled bonded connections were used for connection of the elements of the model. ANSYS auto meshing tool was used for the FE meshing.

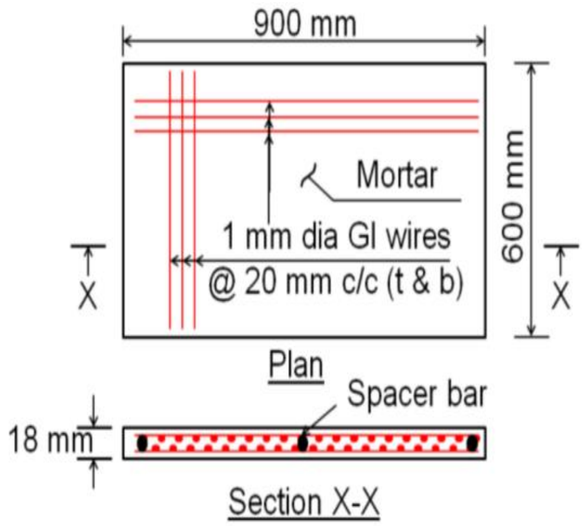

Fig. 1a. Reinforcement Details of Ferrocement Panel

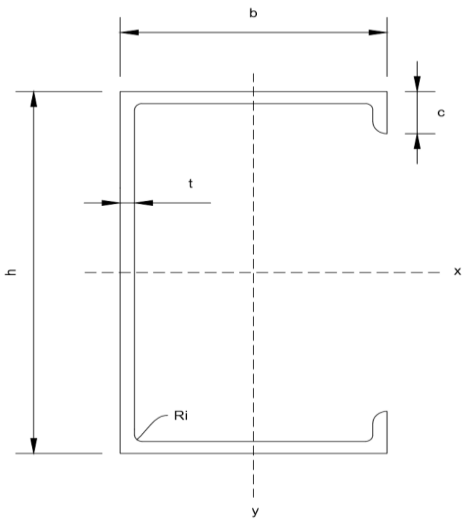

Fig. 1b. Reinforcement Details of Ferrocement Panel

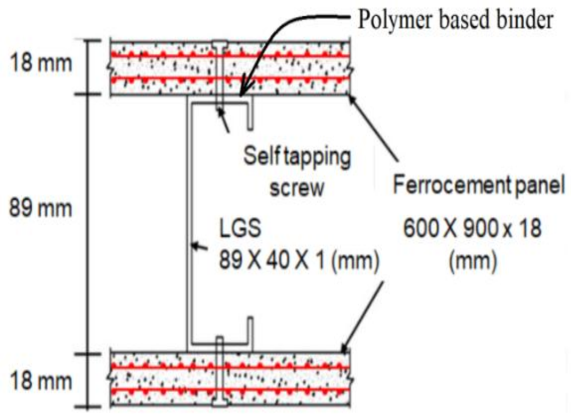

Fig. 1c. Connections Between Ferrocement Panel & LGS Section

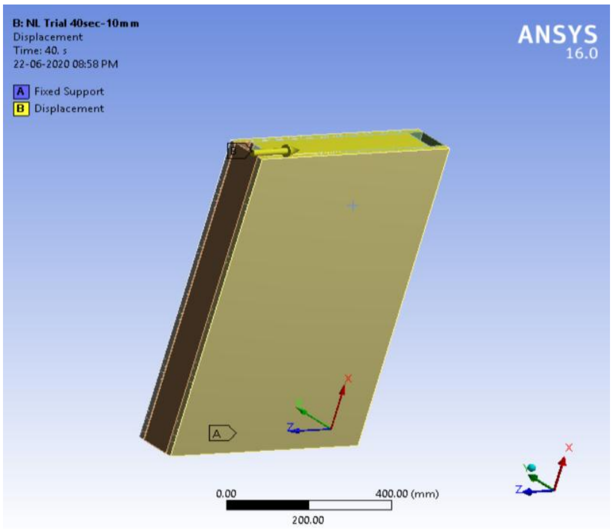

Fig. 2. ANSYS Model

The physical properties for the respective materials were assigned. The stress strain curves of the material for the elements are shown in fig 3a, fig 3b & 3c where steel properties were applied as bilinear isotropic hardening and mortar properties as multilinear isotropic hardening. The assembly was fixed at bottom and a displacement of 10mm was applied at top. The directional force was measured and these results were used to evaluate the force vs deformation curve shown in fig. 6

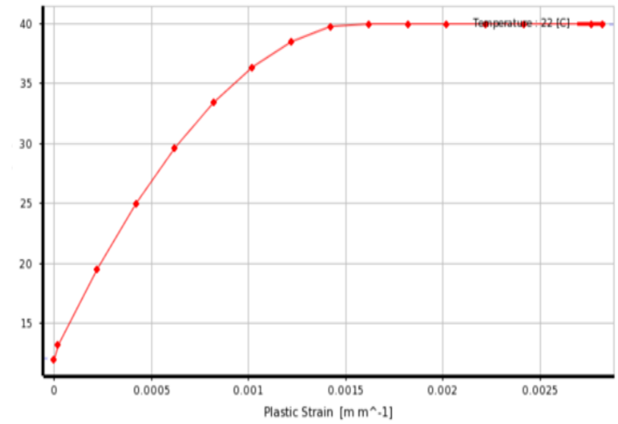

Fig. 3a. Stress vs Plastic Strain curve for Mortar

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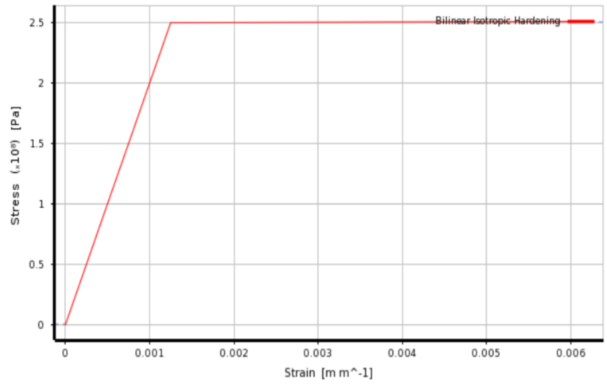

Fig. 3b. Stress vs Strain Curve for Wire-Mesh

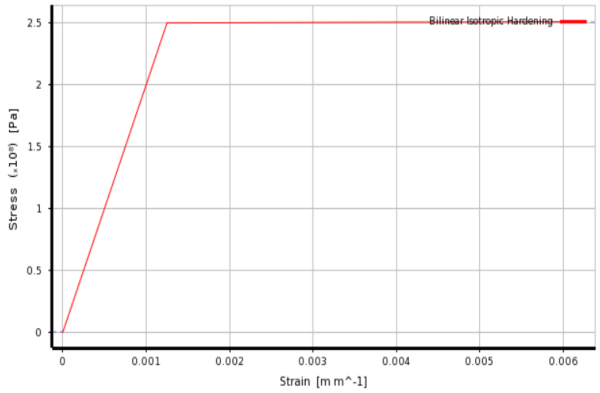

Fig. 3c. Stress vs Strain Curve for LGS Channel Section

IV. PROPOSED SIMPLIFIED MODEL

The simplified model was developed using ETABS. This included an I-section replicating the same elastic modulus of the LGS channel section with cental concrete column of size (100x36mm) which replicate partly, the properties of ferrocement panel. The dimensions of equivalent I-section in the model are listed in Fig 5. Various combinations of multilinear plastic links were tried with varying assumed effective width of the ferrocement panel and full lengths of the links. The most suitable combination was selected in which four links were arranged between two diagonally opposite corner nodes and four springs were arranged diagonally from four corners meeting centers of the horizontal steel members where the concrete column meets the horizontal members (fig 4). The particular combination was selected because it would return fairly same force vs deformation curve as that of the ANSYS model. Summary of few of the trials is shown in the fig. 6.

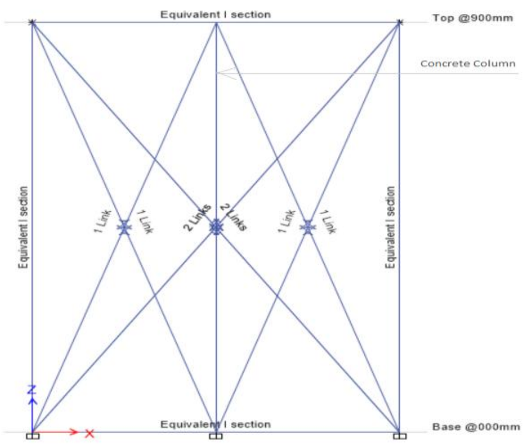

Fig. 4. Proposed Simplified Model

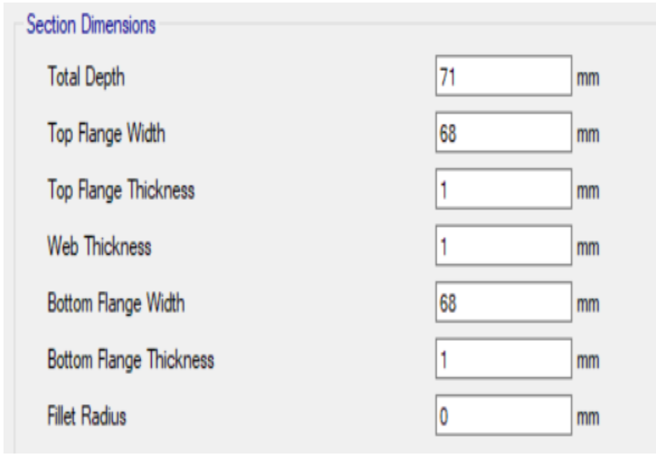

Fig. 5. Dimensions of equivalent I-Section

V. RESULTS & CONCLUSION

The Force vs Deformation values obtained for varied width of assumed width of ferrocement panels and compared with the ANSYS results. Few of the observations are plotted in the following graph.

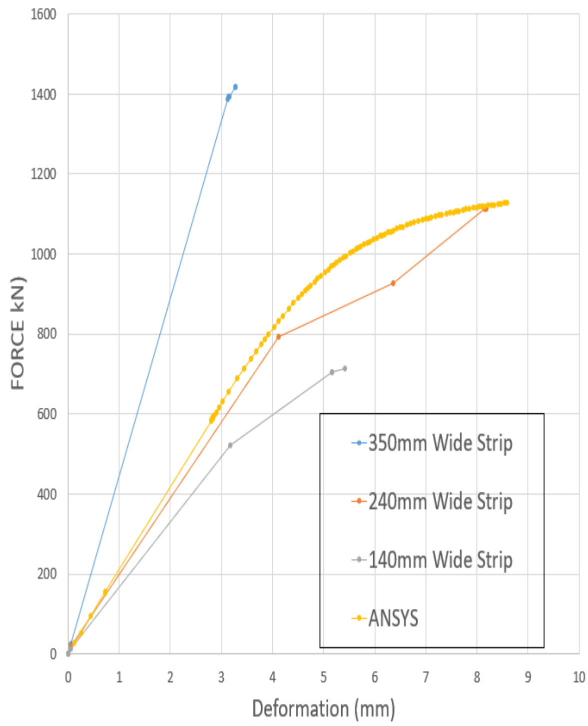

Fig. 6. Force vs Deformation Plot for Varying Width of Ferrocement Panel

It was observed that for an effective width of 240mm returned fairly satisfying results.

From the observation, it can be concluded that,

1. The simplified model correctly predicts the initial stiffness of ferrocement panel.
2. The model also predicts the point of breach of linearity.
3. Also, the ultimate strain is in close conformity with FEM model.
4. Therefore, this simplified model can be used to predict response of Ferrocement-LGS wall loaded in its plane till failure.

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