MODELLING AND ANALYSIS OF COLD-FORM BASED COMPOSITE PANEL

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ABSTRACT

Composites are ideal materials for the manufacture of prefabricated, portable and modular buildings. The work deals with the modelling and analysis of a cold form based composite panel using finite element analysis. Cold-formed steel is the common term for steel products made by rolling or pressing thin gauges of sheet steel into goods. The proposed panel was modelled and analysed using ANSYS and the simulated results were tabulated. A concrete panel was also modelled and analysed in the same manner. The scope of the proposed panel in construction industry was checked by comparison with the modelled concrete panel.

Keywords: Composite panel, Finite element analysis, Mezzanine, Prefabricated, Pre-Engineered Buildings.

I. INTRODUCTION

Composites are ideal materials for the manufacture of prefabricated, portable and modular buildings. They are made from two or more constituent materials with significantly different physical or chemical properties. The composite materials produced by the combination of such constituent materials possess characteristics different from its individual components. The individual components remain separate and distinct within the finished structure. The composite structure considered here consists of two external facings bonded to a light weight and weaker core [1][2]. Such a panel will be light weight with high strength to weight ratio that are desirable qualities to be used in a pre-engineered building as an alternative for mezzanine floor slabs, partition walls, roofing purposes etc. In Pre-Engineered Buildings (PEBs), a significant portion except mezzanine floors and partitions are prefabricated. These works are outsourced to local agencies which may lead to poor quality work and delay in completion of the work [3]. This work deals with an alternative solution to this limitation in PEBs. Applications of pre-engineered buildings include factories, commercial showrooms, supermarkets, office building, warehouse, convention halls, workshops, labour camps, restaurants, aircraft hangars, schools, almost any one, two or three storeyed building. The key restricting factors in the application of composites are initial costs due to raw materials and also inefficient conventional moulding processes. Industry & design experts are of the view that with the adoption of advanced technologies and some extent of standardization, these problems could be easily taken care of.

1.1. Cold-Form Slab Section

Cold form sections are thin sections that are formed in the cold state (i.e. without application of heat) from steel sheets of uniform thickness. These sections are made to various structural section like C, Z, tube and various other shapes. Composite structures combine two or more materials in a unit structure to provide tangible benefits and a versatile solution to suit different applications. A composite system helps to develop sections that are less in weight, without sacrificing the required capacity. The composite sections for precast applications are rapidly on an increase with the development of better construction techniques [4][5].

II. MATERIALS

A cold-form section (CFS) based composite panel which would help in using lighter sections is studied with the help of analysis software. The proposed composite panel consists of bottom layer of single skin steel sheet and top layer of 10 mm cement boards both connected using cold-form corrugated rib Fig 1. The total thickness of the panel was being 100 mm and the corrugated rib [6] is expected to contribute to the required flexural capacity for the prefabricated panel. The gaps in the corrugated rib between top and bottom layers are filled using glasswool insulation. This ensures adequate fire and sound insulation. The panel had a dimension 1000x700x100mm. To compare the results of the proposed panel, a concrete panel of the same dimension was also modelled.

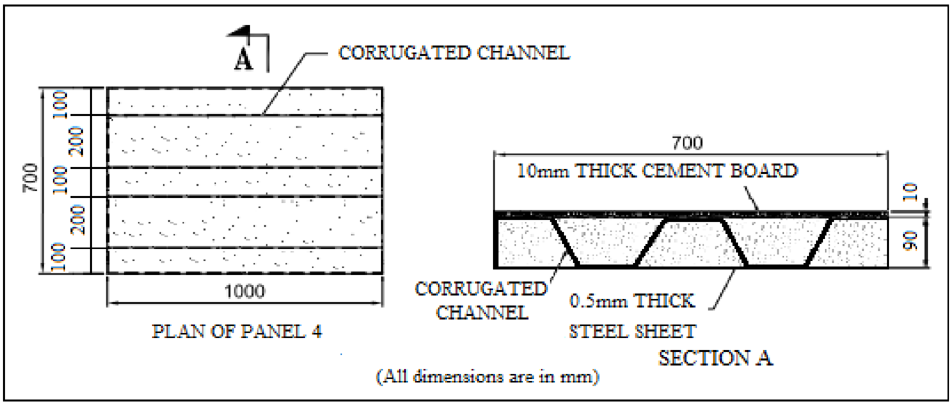

Fig. 1 Typical Layout Of The Proposed Panel

The work undertaken here was aimed to investigate the potential application of cold form sections for designing prefabricated slabs and walls. The preliminary experimental investigation was carried out to evaluate the capability of prefabricated slabs. It was anticipated that this would help to assess the load carrying capacity of the designed panel. The deflection analysis of the panel was undertaken using finite element analysis of the panel.

III. METHODOLOGY

The structure was analysed using Finite Element Method (FEM). The whole analysis was carried out in ANSYS 12.1. The structures were modelled first. Each model was then assigned its elemental properties and meshed. The meshed model was loaded and boundary conditions were applied. Then analysis was carried out and the desired solutions were obtained.

3.1. Modelling Of The Panels

For modelling the composite panel, three element types were used. For the top concrete panel, SOLID65 element type was chosen. For the corrugated rib and the steel sheet at the bottom, SOLID185 was chosen and for the intermediate glass wool insulation layered SOLID186 was chosen. Elastic constant [7] [8] and poisson's ratio were the material properties entered for each element type. The model was then meshed. In ANSYS the accuracy of the result is improved by the increased number of elements generated i.e., the finer the mesh, better is the result. As the fineness of the mesh is increased, the time to produce the solution too increases. Hence a medium meshing was adopted. The meshed model of the proposed panel is shown in Fig. 2.

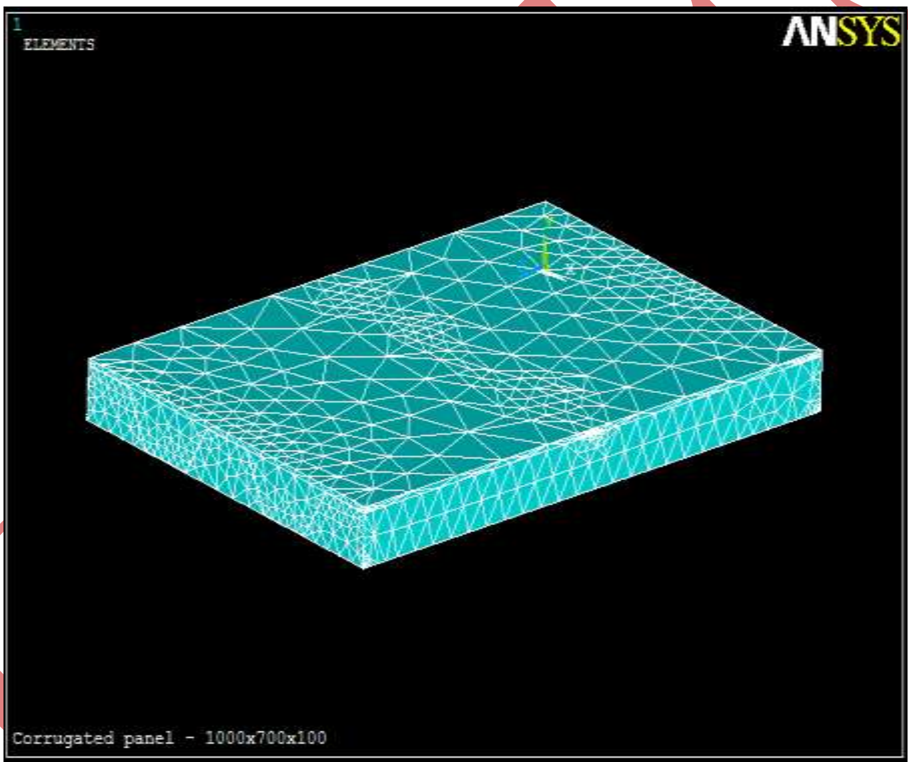

Fig. 2 Meshed Model Of Proposed Panel

3.2. Loads And Boundary Conditions

The panel was supported to produce a span of 800 mm at the centre i.e., it was provided with two supports at 100mm from each end. Each panel was subjected to load uniformly transferred to the mid-section of the panel. The loads were provided till the limiting deflection was obtained. The deflection under each load was recorded.

IV. RESULTS AND DISCUSSION

The typical result obtained from the deflection test on the proposed panel specimen is given in Fig. 3. The maximum deflection obtained under 2kN load is 0.37mm which is represented in the blue coloured region in the mid span.

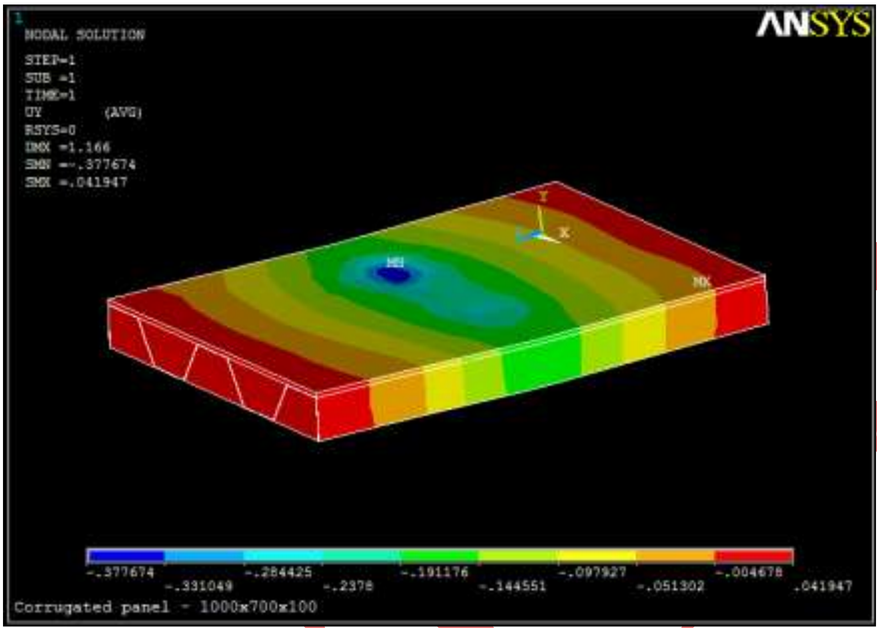

Fig. 3 Deflection Of Proposed Panel Under 2kn Load

The deflection of proposed panel and the concrete panel under different loads were compared to understand the performance of the proposed panel and whether it can be used as an alternative to the concrete panel. Table 1 shows the comparison of deflection of the panels. It may be noted that the deflection of concrete panel is less than the deflection of proposed panel by 0.2mm under 2kN load, which means the deflection of the proposed panel is close to that of concrete panel.

Table 1 Comparison Of Deflection

Loads (kN)	Deflection (in mm)	
	Proposed panel	Concrete panel
2	0.37	0.35
4	0.75	0.70
6	1.13	1.05
8	1.51	1.40
10	1.82	1.75
12	2.23	2.10
14	2.60	2.45
16	2.97	2.80
18	3.34	3.15

For the light weight prefab panel, serviceability criteria would be dominant than the flexural failure condition [9]. Deflection limit of span/240 as per AISC 05 (Allowable Stress Design) is considered and load corresponding at which deflection of span/240 occurs was noted which will be considered as the maximum load carrying capacity of the panel [10]. The load corresponding to the allowable mid-span deflection, 3.2mm for the proposed panel was obtained as 16kN while that of the concrete panel was 18kN. The load – deflection curve of both models have shown identical behavior. Fig. 4 shows the load deflection graphs for proposed corrugated panel and the concrete panel. It can be seen that the deflection values of both panels are close and hence the proposed panel may be used as an alternative to concrete panels.

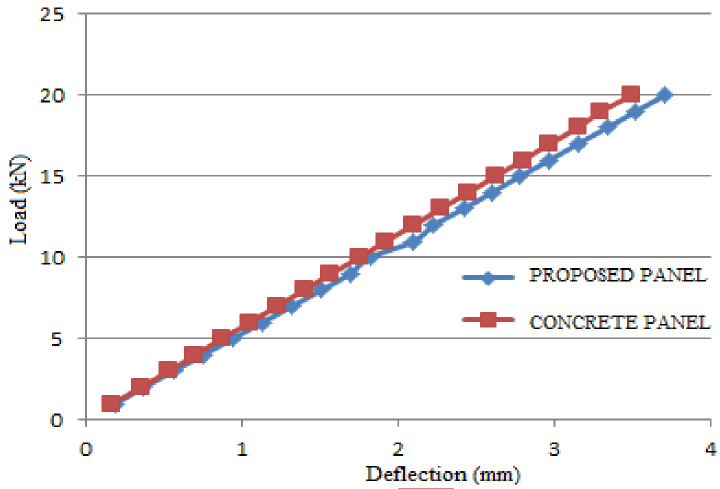

Figure 5.10 Load Vs Deflection Comparison Graph For The Panels

V. CONCLUSION

Composites hold a huge promise for the development of sustainable building practices. The work presented here was related to the application of the cold form steel sections for the development of pre- fabricated floor panel. In case of the proposed panel the limiting deflection occurred at 16kN when the same for concrete panel occurred at 18kN. From IS 875(Part 2)-1987, it can be found that this panel could be used in residential buildings and office buildings and some areas of storage, industrial and mercantile buildings. The comparison of the proposed corrugated panel and the presently used concrete panel showed close deflection values. The feasibility of using such configurations for various construction practices has thus been confirmed. Apart from structural application, it could find applications in a variety of other fields. Some of these applications are ships and submarines, aircraft and spacecraft, trucks, rail vehicles, automobiles [11]. As further development, the panel could be tested experimentally. New modifications can be imparted in this panel to improve its performance.

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