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Flexural studies on Basalt Fiber Reinforced Composite sandwich panel with profile sheet as core

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HIGHLIGHTS

- Basalt fiber & profile sheet are used in sandwich panel, studied as flexural member.
- Constructed adopting both prefabrication and cast-in-situ construction process.
- The panel has ultimate flexural strength of 26 kN exhibiting ductile behaviour.
- Compositeness, failure mechanism & debonding phenomenon was studied experimentally.
- Partial compositeness of the panel has been validated using numerical approach.

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ABSTRACT

In this paper, the experimental behaviour of Basalt Fiber Reinforced Composite (BFRC) sandwich panel under flexural loading has been investigated. The BFRC sandwich panel investigated in this study comprises of top skin, bottom skin and core. Both top and bottom skin are composed of BFRC mix and flanges of profile sheet to act as composite in effectively resisting flexure where as the core is constituted by the web portion of profile sheet in resisting shear. The panel is constructed by adopting both prefabrication and cast-in-situ construction process exploiting the advantages of both the process. The panel has ultimate flexural strength of 26 kN, exhibiting ductile behaviour. The panel exhibited 200% ductility over the deflection at the ultimate load with 10% loss in the ultimate load making it an ideal for flooring units. Further, numerical study has been conducted to assess the integrity of the connection between skin and core and to find the effectiveness of connection on overall strength, stiffness of the panel. The results from the finite element analysis have been compared with the experimental results of BFRC sandwich panel and are found to be in good agreement. Finite element study also helped in concluding that with improved connection mechanism both strength and stiffness of panel can be enhanced.

1. Introduction

Sandwich panel is an often sought out area of research in the field of civil engineering for its open bounds in arriving at a panel which is competent in terms of strength, stiffness and weight using new construction materials [1]. The present civil engineering industry demands ease and fast track construction probing research towards prefabrication and light weight structural element, thereby making sandwich panel as one of the main area of research [2]. Sandwich panel generally consists of two skins bonded together by a core to act as single integral system. Theoretically in a homogenous sandwich panel, all the components should be constrained against relative movement in order to ensure proper composite action without any relative slip due to interfacial shear. But in case of composite sandwich panel it is unlikely to achieve full composite action due to differential curvature attributed by stiffness variation of the materials used [3].

The mid 1940's, marked the use sandwich panel and the basic idea was to develop it for structural application was initiated after 1970 [4]. Generally composite panels were constructed of honeycomb core with different types of facing material like plywood, high density and medium density hard board, cement, asbestos, aluminium, etc. The inner core was classified broadly into cellular,

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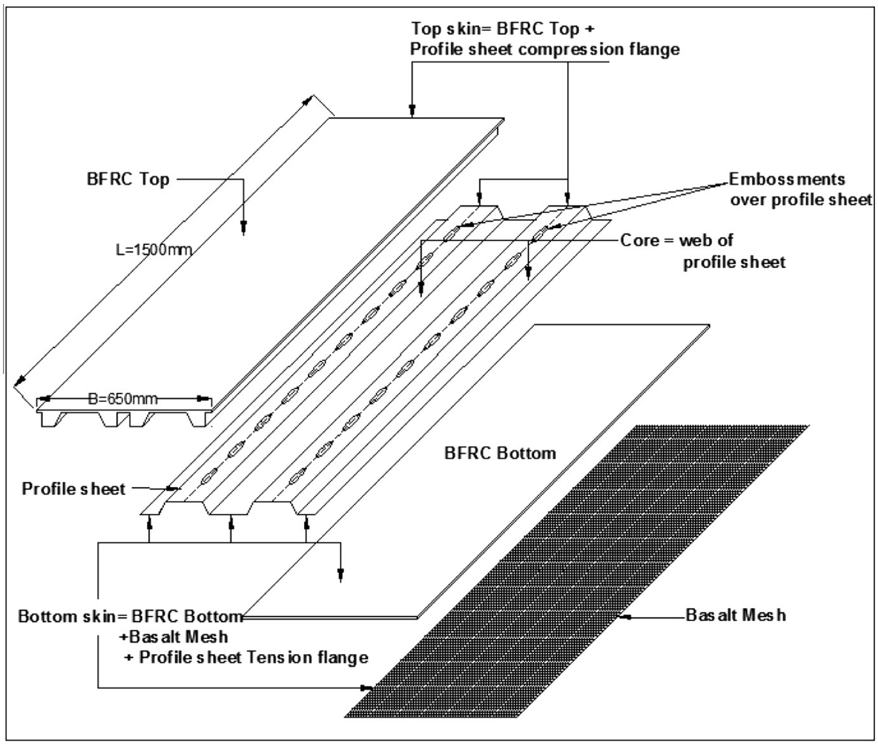

Fig. 1. Detailed view of BFRC sandwich panel.

Table 1
Mix proportion of BFRC mix.

Materials	Units	Detail	Qty
Cement	kg/m^3	OPC, 53 grade	520
Flyash	kg/m^3	Class F	175
Silica fume	kg/m^3	–	70
Sand	kg/m^3	Ennore sand grade III	500
Quartz powder	kg/m^3	–	300
Superplasticiser		Polycarboxylate	0.3
Water	kg/m^3	Tap water	280
Water/binder ratio			0.36
Basalt fiber	%	16 μm dia, 23 mm long	0.5

Table 2
Basalt fiber properties.

Property	Unit	Value	Tolerance
Technical data for basalt chopped fiber			
Density	kg/m^3	2630	±5%
Moisture content	%	0.1	±0.05
Melting Point	°C	1350	±100
Diameter	μm	16	
Sizing type	Silane		
Moisture Content	%	0.0642	±5%
Tensile Strength	MPa	>2000 MPa	
Elastic Modulus	GPa	70–85	±5%
Elong. at break	%	3.1	±5%

Table 3
Basalt mesh properties.

Property	Unit	Value	Tolerance
Mesh size	mm	10 × 10	±5%
Specific weight	g/m^2	350	±5%
Thickness	mm	0.70–0.80	
Width	mm	1000	
Type of fiber	Silane		
Geo-grid coat	PVC		
Coating content	g/m^2	60 g/m^2	
Moisture	%	<0.3	
LOI, sizing	%	0.5–0.7	
Combustibility	No	Pass	
Maximum load	N/5 cm	7000 (warp) 7000 (weft)	±5%

foam, polymer, honey comb and corrugated [5–8]. Thereafter down the line, the panels were constructed using light weight material [9] to be used as non load bearing component, but present scenario has once again encouraged the use of sandwich panel as load bearing component.

For the present study, sandwich panel of dimension 1500 × 650 × 70 mm is constructed using Basalt Fiber Reinforced Composite (BFRC) mix and profile sheet and studied as a flexural member. The BFRC sandwich panel will have top skin as a composite of BFRC and compression flange of profile sheet, the bottom skin as composite of BFRC, basalt mesh and tension flange of profile sheet and the core comprising of web of the profile sheet. Ease and fast track construction is achieved by attaching prefabricated bottom skin to the core using self tapping screws wherein the integrity of connection is obtained by dowel action. Economy is achieved by cast in situ concreting of top panel using profile sheet as construction platform; the integrity of connection is obtained by means of adhesion and shear interaction.

More recently though, advanced composite fibers and resins are being used to create skin material. The basalt fiber can also be thought of as a possible material for the sandwich panel due to the following economical and durability advantages such as low price, light weight, good adhesion and excellent corrosion resistance properties. From the literature review, basalt fiber is found to have good mechanical and chemical properties such as high elastic modulus, high elastic strength, and stability at high temperature, etc which will make it a viable construction material [10]. The bonding capability of basalt has been exploited by using