"EXPERIMENTAL STUDIES ON AXIAL BEHAVIOUR OF STEEL-CONCRETE COMPOSITE-WALL PANEL USING BASALT FIBRE"

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Abstract – Composite walling is a novel building system comprising of two outer skins of profiled steel sheeting infilled with concrete. This paper deals with an experimental investigation to understand the Axial behaviour of a Composite Wall Panel (CWP) which are casted and tested without reinforcing bars using Basalt Fibre reinforced concrete (BFRC). Its development has come about as an extension of the well-known composite system used worldwide. Steel components are relatively thin and prone to buckling, whereas the infill concrete provides restraint against buckling and thermal insulation at high temperatures. Composite wall panels have many advantages, when used in conjunction with composite floor panels and can be used as core walls in steel frame building structure, although they have the potential to be used in load bearing construction. Thus, these panels can serve as an alternative to load carrying brick walls and therefore, low rise buildings can be constructed by using these light weight wall panels.

Key Words: **Composite wall panel (CWP), Basalt Fibre Reinforced Concrete (BFRC), Basalt Fibre (BF), Axial Behaviour.**

1.INTRODUCTION

In the day-by-day emergence of recent trends in construction industry, composite construction method has gained it popularity for its economical usage of materials and providing excellent sustainability than conventional construction system.

The composite construction method is a widely used diaphragm strengthening method where two different materials perform a composite wall depends upon shear action between the corrugated steel sheeting on the hardened concrete. Structures made of two or more distinct materials are referred to as composite constructions. Typically, the materials used in structural engineering include concrete-steel, plastic-steel and concrete-timber etc. By effectively connecting the two components, composite construction includes the structural characteristics of both materials to create more rigid, stronger and lighter members. In order for the two materials to function as a single unit, their shear-bond connection is crucial. In the Fig.1 elements of the composite wall are shown.

In the present study, the composite wall panel structures, the steel sheeting will act to stabilize the building frame when it is fixed and it provides permanent formwork for the infill concrete. Once the concrete has hardened axial, lateral and in-plane loads will be carried out for both the steel and concrete. Finally, the study is to determine the fundamental behaviour of load bearing composite wall panels made of cold formed steel sheet and concrete under the axial load condition.

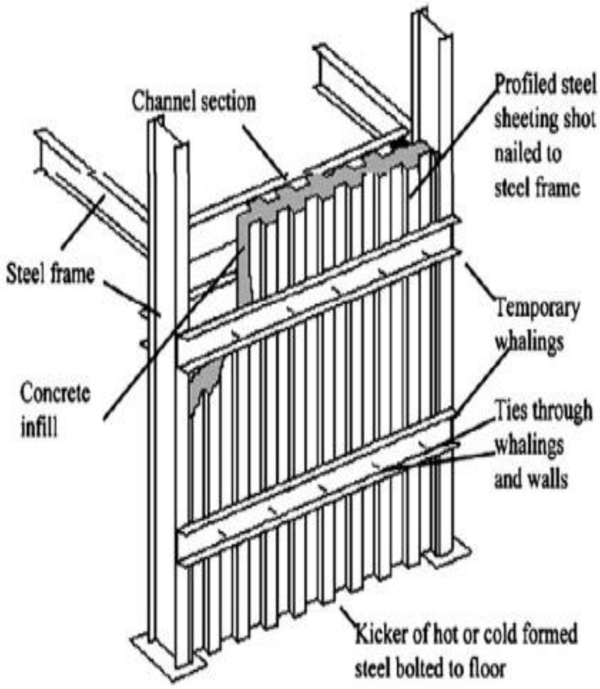

Fig. 1: Elements of Composite Wall

2. DESIGN AND DETAILING OF COMPOSITE WALL PANEL

In this project, wall panels are designed and cast, which are experimentally tested. These walls are designed as per Recommendations of EN 1994-1-1 2004. Wall panels are tested under axial loads.

A Cold formed steel wall was identified to carry out experimental program on composite wall panels. The test specimens having the length 880 mm and width 880 mm and the thickness of the profile sheet is 1 mm. Fig 2 shows the geometrical properties of profiled steel wall.

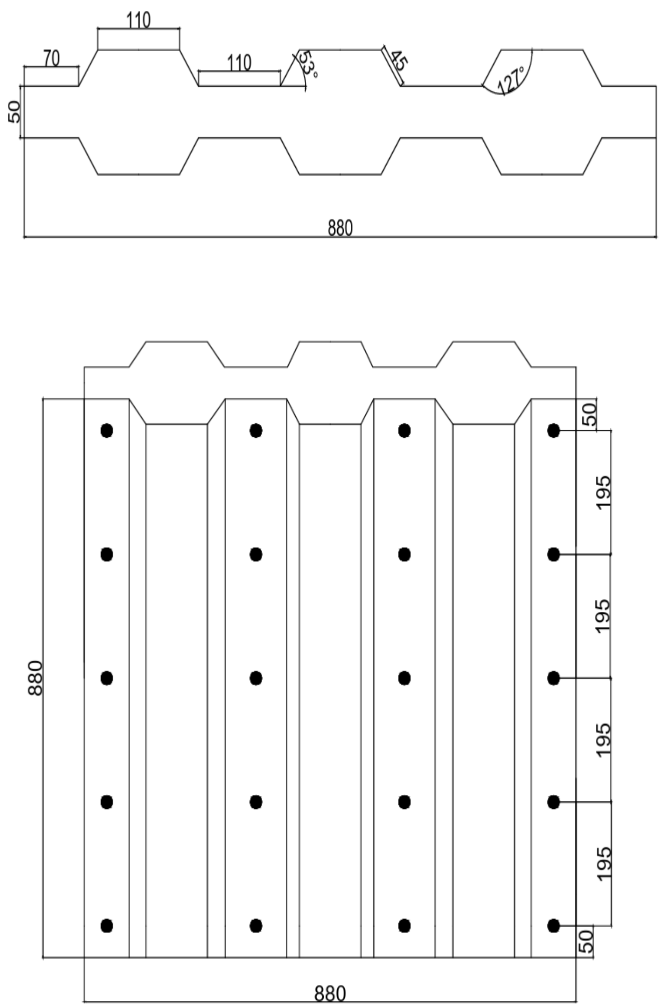

Fig. 2: Geometrical Properties of profiled Steel Wall

3. MATERIAL PROPERTIES

A. Basalt Fibre Reinforced Concrete

In the casting of test specimen of composite walls, Basalt Fibre Reinforced Concrete (BFRC) has been developed to get the characteristic strength of M-25 grade concrete. For developing Basalt fibre reinforced concrete, ordinary Portland cement (OPC) is used, Fly ash 30% is used to reduce cement content, M-sand used as Fine Aggregate and 20mm and 12mm down sized Coarse Aggregate are used. For getting desired workability 0.6% Chryso optima KR77 super plasticizer (SP) is used and 1 % Basalt Fibre is used as additive to improve the mechanical properties of the concrete.

4. CONSTRUCTION AND TEST DETAILS

A. Specimen Design and Construction

The dimension of the test specimens are 880 mm length, 880 mm wide and configuration of panels are shown in Fig. 2. The compressive strength achieved was 35.26Mpa.

The profile steel sheet was connected with a shear connector of 8 mm thickness and 80 mm height with rubber washers to get a high grip between the nut and bolt. Totally 20 studs were required for one sheet. It helps to get a good shear bond between steel and concrete. In these specimens reinforcing bars were eliminated to know the structural behavior of panels under axial loads.

The composite Wall panels with BFRC concrete were casted and cured and also these were tested at the 28th day after casting.

B. Test Set-up

The Experimental test set-up is shown in Fig. 3 and the procedure is as follows.

- The centre line both horizontally and vertically, a line from one third from the top and at the top are marked on the wall panel as shown in the figure.
- Dial gauges of 3 no's are placed at the front face of the wall panel. One at the Top, second dial gauge at one third distance from the Top and third at the Midspan of the Composite wall panel to obtain the axial compression of the specimen. Fig 4 shows the Dial gauge and LVDT.
- The Axial load is applied at the top as the uniformly distributed load and the axial compression is observed.

Fig. 3: The Experimental test set-up

Fig. 4: Dial gauge

C. General Observation on Test Specimen

The general observation on the test specimens are discussed here. It is clearly observed that the axial strength of wall panel is influenced by the degree of confinement provided by the studs and the steel sheet.

At the beginning of the loading, specimen showed linear-elastic compression with respect to load. The lateral pressure exerted by concrete caused the sheet to bulge out, but provision of large number of studs prevented the outward bulging. Under Axial loading the concrete experienced sudden brittle fracture mode of failure. As seen in Fig 5 and Fig 6 the specimen which has stud connections in the trough portion and without the stopping edges, the failure mode is followed by the formation of edge shear cracks in the exposed concrete portion followed by local buckling of steel.

Fig. 5: Bulging of Sheet in between the Studs

Fig. 6: Crippling of sheet and Diagonal Compression Shear Failure

Fig. 7: Compression of Sheet

5. RESULT AND DISCUSSION

With the use of basalt fibre in the M25 grade concrete, the Mechanical properties of Concrete are listed in Table.1 and it shows the improvisation in mechanical strength using basalt fibres compared to conventional concrete mix.

Table 1. Results of Mechanical Properties of BFRC and CC.

No. of Days	Average compressive strength of cubes (N/mm²)		Average split tensile strength of cylinder (N/mm²)		Average flexural strength of prism(N/mm²)	
	BFRC	CC	BFRC	CC	BFRC	CC
7	20.05	19.3	2.67	2.35	2.67	2.26
14	22.83	20.65	2.85	2.45	3.52	3.25
21	29.4	23.75	2.98	2.74	4.83	4.36
28	35.26	32.46	3.45	3.05	5.12	4.62

The Composite Wall Specimen undergoes brittle failure as it is evident from the test results. From the load Vs Axial Compression curve, it is observed that, at the beginning stage load is linearly related to compression and as the load increases the compression also increased. For CWP-I the load is 940kN with 9.68 mm compression and load 940kN with 6.02mm compression for the CWP-II. Fig. 5 shows the bulging of sheet in between the studs. Fig. 6 shows crippling of sheet and diagonal compression shear failure. Compressions of the specimens under axial behaviour are shown in Fig. 7.

With reference to the normal RCC Wall, the Composite Wall structures are novel construction system where it is more economical and speedy construction for medium to high rise buildings.

A. Load Deformation Response

The axial compression of the composite wall panels, compression at the top, one third distance from the top of the wall panel and mid-point are shown in the Fig. 7, Fig. 8 and Fig. 9 for CWP-I and CWP-II respectively and the comparison of Axial Compression of CWP-I and CWP-II are listed in Table. 2.

Table 2. Results of Axial Test

Sl.No	LOADS (kN)	Comparison of Axial Compression of CWP-I and CWP-II (mm)		
		At TOP	At one third from Top	At Midspan
1	940	9.68	6.6	3.84
2	940	6.02	4.44	2.56

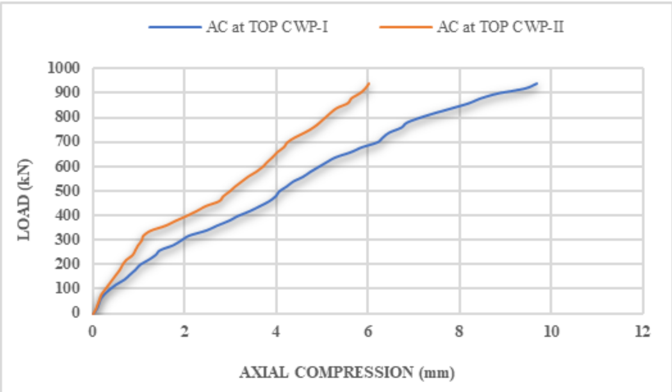

Fig.7: Load v/s Axial Compression Curve for CWP-I and CWP-II at Top.

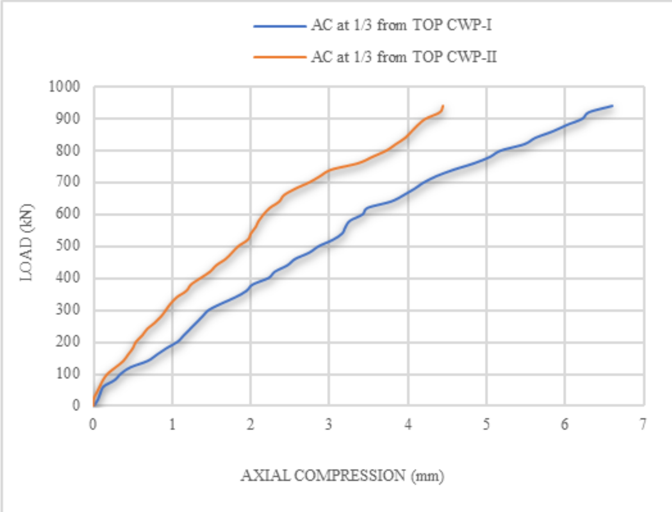

Fig.8: Load v/s Axial Compression Curve for CWP-I and CWP-II at one third from the Top.

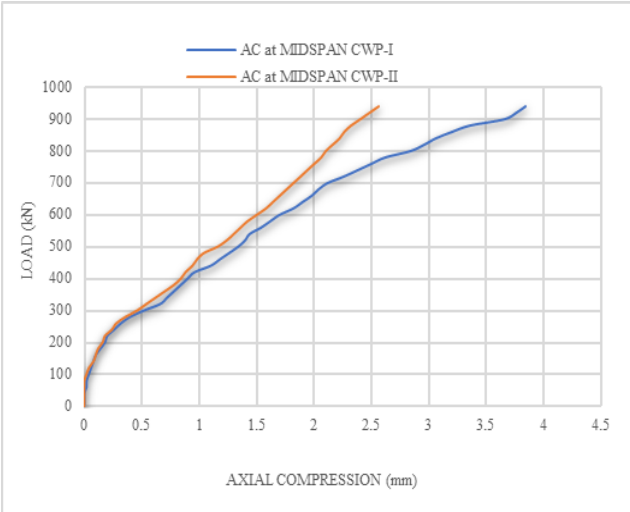

Fig. 9: Load v/s Axial Compression Curve for CWP-I and CWP-II at Midspan.

6. CONCLUSION

From the above experiments, it is concluded that the mechanical properties of concrete can be improved with the use of Basalt fibres and also it can improve the strength of structural elements like Composite wall panels. Conclusion of the above experimental work are listed below-

- The use of 1 % Basalt fibre as additive material in concrete improves 4 to 8 percent more strength compared to Conventional concrete (CC).
- Using Basalt Reinforced Concrete, the ultimate load carrying capacity of the composite wall panel-1 is 940 kN and composite wall panel-2 is 940 kN.

- The load carrying capacity and shear bond capacity between cold formed sheet and concrete are adequate with the above-mentioned shear studs or shear connectors (no slip observed).
- From the result analysis, these kind of composite wall panels can be used in the middle high-rise buildings and commercial buildings using cold formed steel with shear connectors.

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