

Structural Behaviour of Laterally Loaded Plain and Fibre Reinforced Precast Foamed Concrete Sandwich Panels

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ABSTRACT: Foamed concrete is an aerated lightweight concrete. Foamed concrete does not contain coarse aggregate. Foamed concrete can be designed to have any density of range 400-1850 kg/m³. Experimental studies were carried out to investigate the structural behaviour of precast foamed concrete sandwich panels under lateral load. Mechanical properties of both plain and coir fibre reinforced foamed concrete were obtained, which are needed for the design of sandwich panel. It is found that the fibre reinforcement largely enhances the mechanical behaviour of foamed concrete.

KEYWORDS: Foamed concrete, Light weight concrete, Compressive strength, coir fibre, Ultimate load carrying capacity.

I. INTRODUCTION

Precast building system is a system where parts, members and elements of structures are produced either on-site or at the factory, and transported to the site of construction. Using concrete material, the precast component may be cast in a formwork in a position other than the actual one. After the concrete has matured, the forms are removed and the component are installed and fixed in the actual position. The benefits of precast concrete as compared to conventional system include its better quality control and, fast delivery and installation. In most cases, precast panels are cast with high quality concrete and therefore results in smooth surface appearance. Structures made of precast sandwich panels can be remarkably strong and lighter in weight. Sandwich panel has a load carrying capacity 1.5 times greater than that of reinforced concrete panel [10]. The trend for “stronger-lighter” product is becoming increasingly important in the construction industry. Affordable quality housing is vital in developing countries to meet its growing population. Development of a new cost effective system is crucial to fulfil these demands. In view of this, a study is carried out to develop Lightweight Foamed Concrete Sandwich Panel as a new affordable building system. The panel consists of two foamed concrete wythes and a corrugated steel sheet in between the wythes. The wythes are reinforced with coir fibres. The use of fibres also alter the behaviour of the fibre matrix composite after it has cracked, thereby improving its toughness [9]. Foam concrete is mainly composed of cement, water and air pores without any coarse aggregates. The air pores are formed by agitating air with a foaming agent. Foamed concrete is defined as a light cellular concrete which can be classified as lightweight concrete with random air-voids created from the mixture of foaming agent in mortar [13]. Foam concrete is characterized by have low density and low cost when compared with normal concrete. The density of foam concrete is around 400 – 1850 kg/m³. Therefore, the low density enhances low dead load and has extensive applications when low loadings are required. Foam concrete is also self compacting.

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II. RELATED WORK

E.A. Flores Johnson, Q.M Li “Structural behaviour of composite sandwich panels with plain and fibre-reinforced foamed concrete cores and corrugated steel faces” (2012) studied the four-point bending response and failure mechanisms of sandwich panels with corrugated steel faces and either plain or fibre-reinforced foamed concrete core. Mechanical properties of both plain and polyvinyl alcohol fibre-reinforced foamed concrete were obtained, which are needed for the design of sandwich panel and numerical modelling. It was found that the fibre-reinforcement largely enhances the mechanical behaviour of foamed concrete and composite sandwich panels. Vinoth Kumar, Kavitha, “Experimental Study on Composite Sandwich Panels with Concrete and Corrugated Steel Faces” (2016) conducted experimental investigation on composite sandwich panel. Sandwich composite panel consists of three layers of two different materials (Concrete and steel). Concrete was sandwiched between steel layers (i.e a 1 mm thick plain cold-rolled sheet on top and corrugated sheet underneath concrete layer). Panel dimension is of 650mm wide, 100mm high and 1250mm long (One Way Distribution). Six numbers of panels were casted of which three from each Reinforced concrete panel and Composite Sandwich panel. Embossment of seven numbers was provided in corrugation and 10mm diameter eight number of shear stud required to connect plain Cold Rolled sheet and corrugation layer. Behaviour of sandwich panel as well as RC Panel was tested under Four-point loading setup. Test results and failure pattern of both panels were compared with one another. M.A. Othuman Mydin, N.A. Rozlan, S. Ganesan, “Experimental Study on the Mechanical Properties of Coconut Fibre Reinforced Lightweight Foamed Concrete” (2015), conducted experimental studies on the use of coir fibre for the enhancement of mechanical properties of foamed concrete which focuses on 3 parameters which are compressive strength, flexural strength and splitt tensile strength with different percentages of coconut fibre (0%, 0.2% and 0.4%). The addition of coconut fibre significantly improved all the properties investigated. The results of the test showed that the compressive strength, flexural strength and splitting tensile strength of the foamed concrete increase as the fibre volume percentage of the coconut coir fibre increased in the concrete mix.

III. COMPOSITION OF FOAMED CONCRETE

Foam concrete is an aerated concrete which is produced by introducing air voids in to cement based slurry. The cement slurry consists of cement, sand and water. The introduction of air voids is achieved by adding pre-formed foam in to the mixture. A foaming agent is diluted with water and aerated to foam the foam. Foamed concrete is prepared with the help of a foam generator. In this study, natural coir fibre is used. The fibres with length 30 to 40 mm length were used for the study. A ratio of 1:1.5 of cement: sand was used in this study to fabricate a foamed concrete of density 1800kg/m^3 . The water cement ratio is about 0.46 to achieve reasonable workability. The foaming agent was diluted in water with a ratio of 1:33 by water volume.

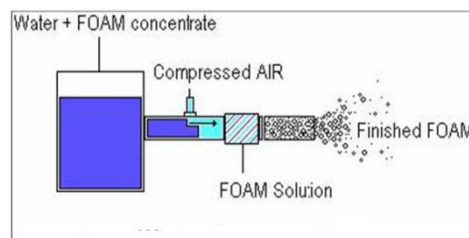


Fig 1: Production of the foam

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IV. COMPRESSIVE STRENGTH OF FOAMED CONCRETE

The compressive strength of foam concrete with different percentages of coir fibre (0%, 0.2%, 0.4%, 0.6%, 0.8%) was determined at the age of 28 days using 150 mm x 150 mm x 150 mm concrete cubes in accordance with IS 516-1959. Plain and coir fibre reinforced foamed concrete mix were prepared by foam generator. Then the concrete is filled in the mould. After 24hrs of moist air curing, specimens were placed in water tank for water curing of 28 days. Specimens of 150 mm x 150 mm x 150 mm foam concrete cubes were tested in a Compression Testing Machine (CTM) of capacity 2000 kN. The bearing surfaces of testing machine was wiped clean and any loose sand or other material was removed from the surface of the specimen which are to be in contact with the compression platens. The load was applied without shock and increased continuously at a rate of approximately 140 kg/cm²/min until the resistance of the specimen to the increasing load breaks down and no greater load can be sustained. The maximum load applied to the specimen was then recorded. The compressive strength of the specimen was calculated by dividing the maximum load applied to the specimen during the test by the cross-sectional area.

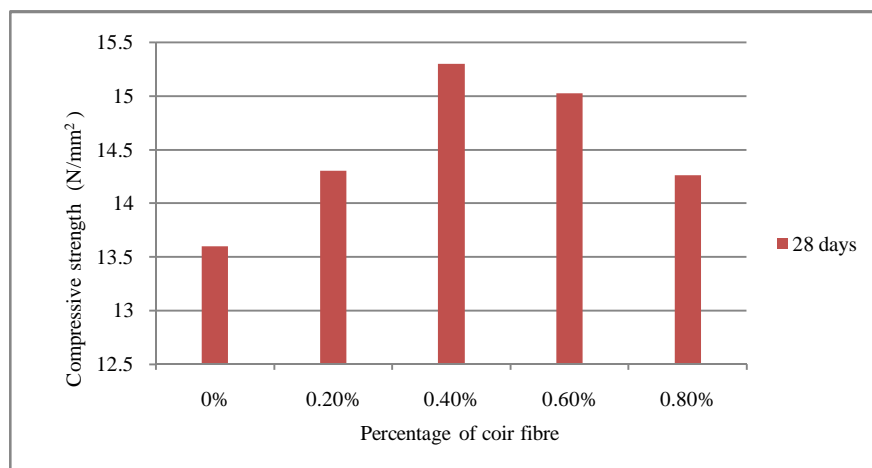


Fig 2: Compressive strength with Percentage of coir fibre

From the test results it can be seen that when the coir fibres added to the foam concrete mix the compressive strength increases slightly. The optimum value obtained is 15.3 N/mm² by addition of 0.4% of coir fibres by weight of the cement content. Beyond 0.4% the strength value is found to be decreasing. Increase in compressive strength is due to the crack arresting properties of the fibres.

V. BENDING TEST OF PANELS

The flexural behaviour of the plain, coir fibre reinforced and normal concrete panels were analysed. The clear span is 1400mm. The load is applied at the midspan of the panel.

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Fig 3: Bending test of the Panel

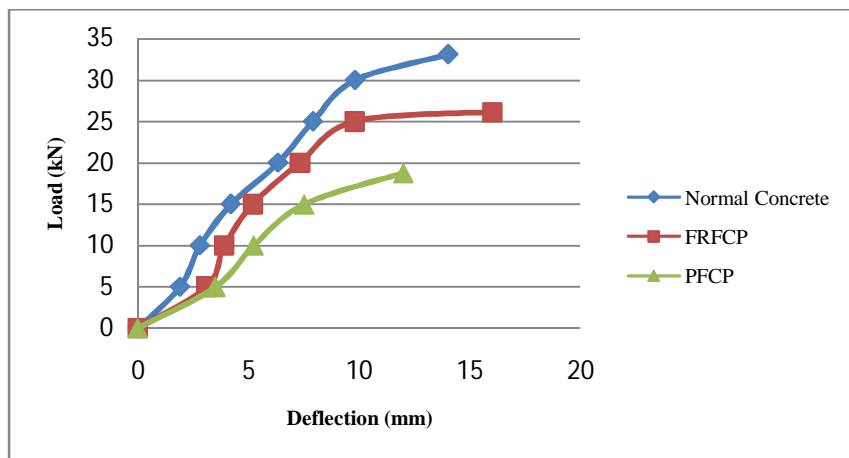


Fig 4: Corrugated steel sheet with holes

The sandwich panels were manufactured in using 0.7 mm thick corrugated steel sheets with holes as core and foam concrete as faces. Foamed concrete was prepared and cast into the mould .The panels of normal concrete (M 20), plane foam concrete and fibre reinforced foam concrete (0.4%) were cast. The support provided at both the ends and the load is applied at the mid span. Two dial gauges were fitted at both the sides and from the values obtained load deflection graph is plotted. The panels of 1600mm length, 720mm width and 110mm thickness were used for the experiment.

VI. RESULTS AND DISCUSSIONS

Fig.5 shows the load deflection graph of plain foam concrete, fibre reinforced foam concrete and of normal concrete panel. All the panels are of size 1600mm length ,720 mm width and 110mm thickness.



From the load deflection graphs of the panels, it is seen that for plane foam concrete panel (PFCP) the ultimate load obtained is 18.78 kN, for fibre reinforced foam concrete (FRFCP) the ultimate load obtained is 26.25 kN and for

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normal concrete the ultimate load obtained is 33.12 kN. There is a significant increase in the flexural strength when the foam concrete is reinforced with coir fibre. There is a 30% increase in the flexural strength of the foam concrete panel when it is reinforced with coir fibre. Even if the flexural strength of fibre reinforced foam concrete panel (FRFCP) is lesser than the concrete panel, when considering the lightweight nature and reduced cost, FRFCP is a better option.

VII. CONCLUSION

The findings of experimental investigations on the potential of coir fibre in lightweight foamed concrete for the flexural strength improvement are reported in this study. The addition of coir fibre improved the strength of the foamed concrete significantly. Since the use of coir fibres has given an excellent result, there is still possibility of the invention of new products containing coir fibres with improved results.

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