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Development of sandwich panels combining aluminium powder-cement composites lightweight concrete

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ABSTRACT

The heavy dead weights of concrete structures are posing a headache for the structural engineers to design the various members much complicated to take its own weight. The present investigations are carried out to develop a simple, lightweight and cost-effective technology for replacing the existing wall systems. In this paper, we have used the materials Portland pozzolana cement (PPC) is matrix materials and the reinforcing materials is aluminum powder, bamboo natural fiber. The methodology of this paper is a sand casting process used to produces the composite plate or bars. The composition of reinforced samples is Lightweight Concrete (LC) mixes were prepared with 0%, 0.25%, 0.5%, 0.75%, 1%, 1.25%, 1.5%, 1.75%, 2%, of foaming agent by weight of cement In this paper we are tested in deflection behavior, tensile test and compressive test.

Keywords— *Portland Pozzolana Cement (PPC), Aluminium powder, Bamboo natural fiber, Lightweight Concrete (LC), Deflection behavior, Tensile test, Compressive test*

1. INTRODUCTION

Aerated concrete is a light weight concrete in which aeration can be done with the help of air entraining agents like aluminum powder in which air is entrapped in the mortar matrix. Lightweight concrete is an important and versatile material in modern construction. The worldwide cement production results in approximately 5% of global manmade carbon dioxide emissions. From a life-cycle perspective, however, the energy consumption and the resulting CO2 emission from the operation of buildings are much larger than the energy consumed during the production of the building materials. This indicates that developing efficient construction products can be a cost-effective way to reduce our overall energy consumption. Aerated concrete is a class of construction materials which can serve the purpose of manufacturing and construction efficiency and thermally attractive products. The air-pores in aerated concrete are usually in the range of 0.1–1 mm in diameter and typically formed by the addition of aluminum powder (or paste) at 0.2– 0.5% (by weight of cement).The chemical reaction of calcium hydroxide and aluminum generates hydrogen gas shown in Eq. (1) is associated with large volume changes, resulting in the expansion of the fresh mixture to about twice of its original volume [3]. A novel class of aerated concrete is Fiber-Reinforced Aerated Concrete (FRAC) or Flex Crete which includes internal reinforcement with short polymeric fibers such as polypropylene steel fibers etc. In order to avoid potential damage to the polymeric fibers, autoclaving is eliminated from the production of FRAC and curing is performed at room temperature. Elimination of the auto claving process may create lower strength values and higher in homogeneity when compared with autoclaved aerated concrete. The structures of FRAC and AAC are therefore of different natures. Short fibers, however, have a positive effect in bridging the cracks formed during the plastic stage or later on due to the mechanical forces, drying shrinkage, or heating-cooling cycles. It has been reported by Perez-Pena and Mobasher that the addition of short polypropylene fibers to lightweight cementitious panels can largely improve the mechanical properties. In their study, modulus of rupture increased from 3.2 to 4.0 MPa and toughness increasedfrom0.6to1.2Nmwhenfibercontentwasraised from 0.4%to1.4%. Additionally, adding short fibers reduces the shrinkage cracking in the plastic phase or later in the elastic phase while drying. Aerated concrete products can exhibit a considerable amount of residual compressive strength after reaching the peak strength. With the increase in population, residential requirements are increasing day by day. Thus, there arises a need for high-speed, superior quality and cost-effective construction. The housing need can be satisfied by the development of precast concrete structural elements. Since walls are one of the major parts of houses, the demand for precast concrete structural wall panels is gaining more and more important in the field of construction in the present scenario of housing for all. Wall panels are two-dimensional structural elements subjected to in-plane loads having negligible thickness compared to their length and breadth. The use of mild steel, steel fibers or steel fabric meshes as reinforcement in concrete wall panels will make them good enough to take in-plane loads. Bamboo is a strong, fast growing and very sustainable material, having been used structurally for thousands of years in many parts of the world. In modern times, it has the potential to be an aesthetically pleasing and low-cost alternative to more conventional materials, such as timber, as demonstrated by some visually impressive recent structures. Portland Pozzolana Cement (PPC) is a variation of OPC which includes a mixture of a pozzolanic material which is known to increase the strength of concrete and reduce the amount of OPC used. Nowadays it is being used as a replacement to OPC as it is known to fulfill green building criteria and hence helps in sustainable development.

2. EXPERIMENTAL WORK

2.1. Material

Portland pozzolana cement (PPC) conforming to IS: 1489 (Part 1): 1991, M-S and conforming to grading zone II of IS: 383-1970 (Reaffirmed 2002), 12-mm coarse aggregate conforming to Table 2 of IS: 383-1970 (Reaffirmed 2002) and potable water were used to obtain M20 grade concrete. M20 mix was designed as per Indian Standard Concrete Mix Proportion Guidelines of IS: 10262-2009. The aluminum powder used forthestudyhasanatomicweightof26.98andparticlesize 200mesh. The steel fiber reinforcement offers a solution to the problem of cracking by making concrete tougher and more ductile.Splints of Bambusa bambos were used as reinforcement in concrete.

3. EXPERIMENTAL SETUP

The ratio of cement to fine aggregate was 1:2and the water-cement ratio was taken as 0.45.The first stage deals with the determination of the optimum percentage of the foaming agent by weight to be added to a mortar with cement sand ratio of 1:2. Lightweight concrete (LC) mixes were preparedwith0%,0.25%,0.5%,0.75%,1%,1.25%,1.5%, 1.75%, 2%, of foaming agent by weight of cement. The optimum percentage of aluminum powder is determined with the density and compressive strength of LC with different percentages of foaming agent. These condstage deals with the effect of adding bamboo natural fibers with different percentages to 1.5%, 2%, 2.5% of bamboo fibers by volume of the concrete specimen and optimized and finally Fiber reinforced Lightweight Concrete wall panels (FLP) were prepared.

3.1. Casting of wall panel

The 600mm x 600 mm x 100mm mould was prepared and water was sprinkled on the base in or
der to reduce the water absorption.

(a) (b) (c)

(d) (e)

Fig. 1: (a) Setting of panel mould, (b) Placing reinforcement, (c) Top surface after filling the concrete (d) After leveling top surface (e) Demoulded wall panel

For casting of wall panels three different reinforcement cases are studied, with a single layer of reinforcement, single layer mesh, and two-layer mesh reinforcement. The first two panels are cast as shown in the figure 1, the first layer of mortar was placed up to half the thickness required. Then the reinforcement was placed over the first layer. The last layer of mortar was placed over the reinforcement so that the reinforcement was sandwiched in between the mortar layers. In two-layer mesh reinforced panels wire meshes are provided at one third and two third of its height.

4. RESULTS AND DISCUSSION

4.1. The density of aerated concrete with various percentages of aluminium powder

The wet and dry densities of Lightweight Concrete (LC) with different percentages of aluminium powder is calculated at 7 and28days.The aluminium powder percentages taken were 0%, 0.25%, 0.5%, 0.75%, 1%, 1.25%,1.5%,1.75%,2%by weight of cement which is weighed using vessel.

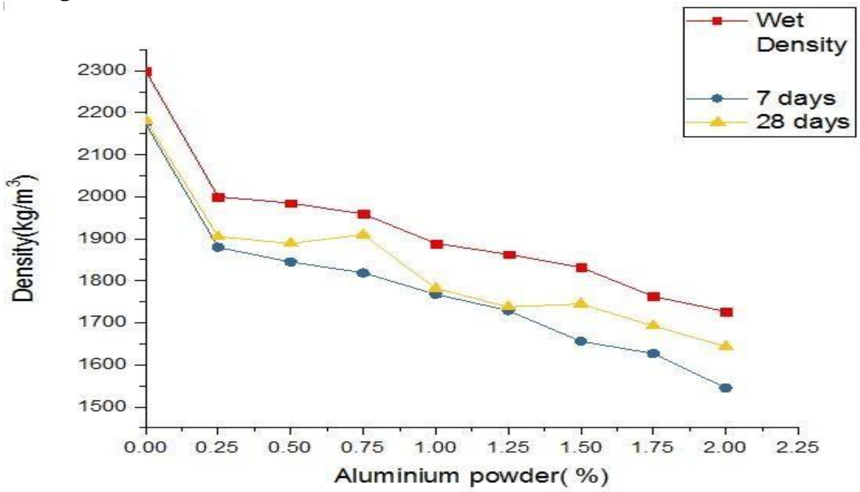

Fig. 2: The density of aerated concrete with various percentages of aluminium powder

4.2. Compressive strength with various percentages of aluminium powder

The compressive strength of specimens with cement sand proportion 1:2 with different proportion of aluminum powder was calculated at 7, and 28 days of curing and the results are graphically represented. Lower sand cement ratio results in aerated concrete of higher compressive strength and from the experimental study comparing the values of density and compressive strength the mix proportion was fixed as 1:2 and the aluminum dosage was fixed as 1%.

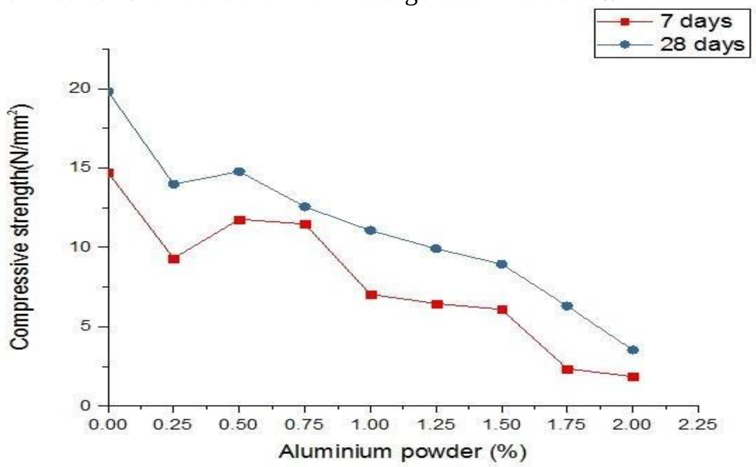

Fig. 3: Compressive strength with various percentages of aluminium powder

4.3. Load–deflection behaviour

Lateral deflections at the mid- and quarter points of wall panels were determined using linear variable differential transducer (LVDT) placed perpendicular to the wall panel. It may be noted from the figure that as AR increases, deflection of wall panels increases. The maximum deflections obtained at the mid- and quarter points of wall panels are given in Fig. It was observed that the deflections at quarter points were approximately half that obtained at the midpoint which confirms that the wall panels deflect under single curvature due to one-way in-plane action.

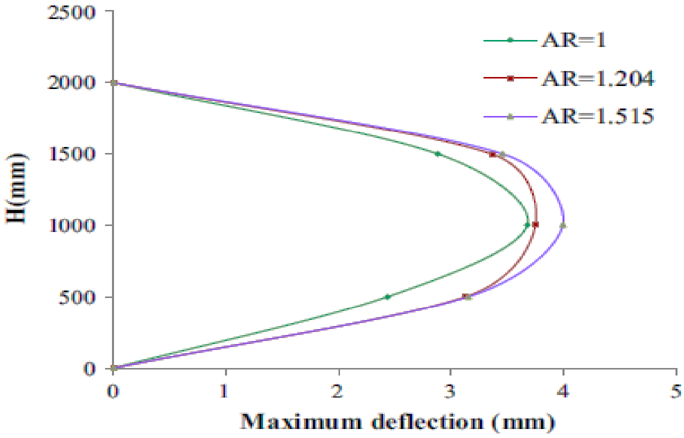

Fig. 4: Load–deflection behaviour

5. CONCLUSIONS

Based on the limited study made on lightweight concrete wall panels, the following conclusions are drawn:

- For all mixes a lower cement-sand ratio1:2 results in aerated concrete of lower density leading to a reduction in self-weight which made it lightweight.
- Density and compressive strength of aerated concrete decreased with the increase in aluminum content. The optimum dosage of aluminum powder to be added so as to produce foamed concrete with desirable strength is found to be 1%.
- Since the conventional foam concrete is brittle, the addition of steel fibers serves to mitigate the brittle nature of the material by imparting post-cracking strength and toughness to the composite and improves the strength of panels by about 30%.
- The wire mesh sufficiently confined the panel skins and effectively reduced the concretes palling out of outer skin layer.
- As per IS2185-1the minimum compressive strength for individual concrete masonry block of class A is 3.5 to 15N/mm^2 and as based on the results the strength obtained is in the range of 10N/mm^2.
- The ultimate compressive strength of RFLP panel and the 2MFLP panel is found about 11.33 N/mm^2 and 9.56N/mm^2, which is much comparable. The result confirms the suitability of fiber reinforced light weight concrete in filled panels for the load bearing and non-load bearing walls.
- The study indicates that BRC wall panels sustain loads as high as 700–850 kN, which
- Indicate that the bamboo reinforcement can replace the conventional steel reinforcement.
- This leads to sustainability.
- The ultimate load of wall panels was found to decrease with an increase in AR, whereas it increases with the increase in TR.
- A method for predicting the ultimate load of the BRC wall panel under one-way in-plane action is proposed, and it compares satisfactorily with the test results.

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