Strength characteristics of light weight concrete blocks using mineral admixtures

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Abstract. This paper presents an experimental study to investigate the characteristics of light weight concrete blocks. Cement was partially replaced with mineral admixtures like Fly ash (FA), limestone powder waste (LPW), Rice husk ash (RHA), sugarcane fiber waste (SCW) and Chrysopogonzizanioides (CZ). The maximum replacement level achieved was 25% by weight of cement and sand. Total of 56 cubes (150 mm x 150 mm x150 mm) and 18 cylinders (100mmϕ and 50mm depth) were cast. The specimens being (FA, RHA, SCW, LPW, CZ, (FA-RHA), (FA-LPW), (FA-CZ), (LPW-CZ), (FA-SCW), (RHA-SCW)).Among the different combination, FA,FA-SCW,CZ,FA-CZ showed enhanced strength and durability, apart from achieving less density.

Keywords: Mineral admixtures, light weight concrete, wet density, dry density, compressive strength, water absorption

1. Introduction

In order to reduce environmental effects, pollution caused in manufacturing of cement and also to achieve light weight building blocks, different admixture were used as partial replacement of cement. Earlier researchers suggested replacing various mineral admixtures to design a structural lightweight high strength concrete (SLWHSC). They also found that silica fume produce good compressive strength and light weight concrete. It was found that structural lightweight concrete can reduce the dead weight and increase the strength of the structural components [1].The strength and durability of lightweight concrete was concentrated elaborately [2]. Strength characteristics were concentrated for different replacement level of light weight cinder aggregate based cement concrete [3].Development of high strength was concentrated on scoria aggregate based light weight concrete [4].

The strength of light weight was least sensitive to lack of initial curing [5]. Partial replacement of cement with various mineral admixtures for producing a lightweight concrete block as a building material was investigated. The maximum replacement level achieved was 25% of weight of cement [6]. Sludge ash aggregates could be used to develop lightweight concrete. It was found to have less thermal conductivity and good fire resistance [7].The ductility of pumice lightweight aggregate concrete replaced with steel and various fibers was studied [8]. It was found that apart from reduction in dead load, ductility was improved in all modes of loading.Flexural behaviour of lightweight concrete panel with GFRP barswas concentrated [9]. It was confirmed that light weight concrete performed well under flexural loading.

1.1*Research significance*
The objective is the partial replacement of cement with Fly ash (FA), lime stone powder waste (LPW), Rice husk ash (RHA), sugarcane fibre waste (SCW) and Chrysopogonzizanioides (CZ) to achieve light weight building blocks. The replacement would result in reduction of the dead load of the building. Parametric analysis of strength and durability characteristics of light weight concrete blocks, with that of normal concrete blocks was carried out.

2. Materials and methods
2.1 Materials used
The following materials were used to study the strength characteristics of the light weight concrete. Cement used for the research work was ordinary Portland cement of 53 grade confirming [10]. Granular river sand passing through 4.75mm sieve (grading zone III) with specific gravity 2.6 was used as fine aggregate confirming [11]. Class F fly ash with specific gravity 2.3 was obtained from thermal power plant. Rice husk ash burned in suspension at a temperature 700ºC with specific gravity 2.3 and bulk density 98 kg/m^3 was used.The sugarcane waste fibers were dried and soaked in a 10% NaOH (Sodium Hydroxide) solution for about 2 to 6 hours with a temperature of about 60-70̊C and are made to dry. Treated fibers were cut into pieces of 3cm length. Similar treatment was followed for Chrysopogonzizanioides. Lime stone powder waste with specific gravity of 2.61 and density of 2.45(g/cm^3) was used. The mix proportion and the specimen details were shown in table1 and table 2.

Table 1. Mix proportion of light weight concrete

Specimen	OPC	GRS	FA	LPW	RHA	SCW	CZ
Control	50	50	0	0	0	0	0
FA	25	50	25	0	0	0	0
LPW	25	50	0	25	0	0	0
CZ	46.5	50	0	0	0	0	3.5
RHA	25	50	0	0	25	0	0
SCW	46.5	50	0	0	0	3.5	0
FA-RHA	16.7	50	16.7	0	16.7	0	0
FA-SCW	29.8	25	16.7	0	0	3.5	0
RHA-SCW	29.8	50	0	0	16.7	3.5	0
FA-LPW	25	25	25	25	0	0	0
FA- CZ	29.8	50	16.7	0	0	0	3.5
LPW-CZ	29.8	50	0	16.7	0	0	3.5

Table 2.Specimen details

Specimen details (mm)	Density	Water absorption	Sorptivity	Compressive strength
Cube 150x150x150	12	12	0	12
Cylinder 100ϕ x 50 H	0	0	18	0

2.2 Methods
The consistency and setting time tests were carried out for Ordinary Portland cement according to [12].The consistency value was 33% and initial setting time was 33min. Fresh density as per [13] and dry density as per [14] were calculated for each combinations. Water absorption test was conducted to find the amount of water absorped. After 24 hours of curing, the cubes were heated in oven, cooled, weighted and kept for water absorption. Compressive strength test was conducted as per [15].From the figure 1(a) and figure 1(b) shows the cubes subjected to curing and testing. Sorptivity measures the rate of ingress of water through capillary action. Specimens for sorptivity were prepared in accordance with [16] (figure 2).

Figure 1. Specimens under sorptivity test

Figure 2. Specimens for water absorption

Figure 3. Specimen under compression

3. Results and discussion
3.1 Bulk density
Replacement of cement and sand with 25% of mineral admixtures showed the value of wet and dry weight of cast specimens as shown in the table 3. Compared to control specimens, reduction in fresh density achieved was 17.89, 20.75%, 24.61%, 24.10%, 19.03%, 22.9%, 24.10%, 30.05%, 14.28%, 23.07% and 30.62% respectively. Corresponding reduction in dry density was 8.76%, 15.53%, 9.94%, 27.63%, 10.76%, 22.11%, 25.62%, 31.90%, 4.32%, 11.64%and 18.43%respectively. Similar results were reported [6]. Bulk densities for the specimens are compared in figure3.

Table 3. Wet weight and dry weight of cube specimen

S.No.	Specimen	Area (mm²)	Wet weight(kg)	Dry weight (kg)
1	Control	150 x 150	8.960	7.960
2	FA	150 x 150	7.60	7.320
3	LPW	150 x 150	7.420	6.890
4	CZ	150 x 150	7.190	7.240
5	RHA	150 x 150	6.800	5.790
6	SCW	150 x 150	8.240	7.006
7	FA-RHA	150 x 150	6.900	6.200
8	FA-SCW	150 x 150	6.840	5.920
9	RHA - SCW	150 x 150	6.240	5.420
10	FA -LPW	150 x 150	7.840	7.630
11	FA - CZ	150 x 150	7.280	7.130
12	LPW - CZ	150 x 150	6.86	6.721

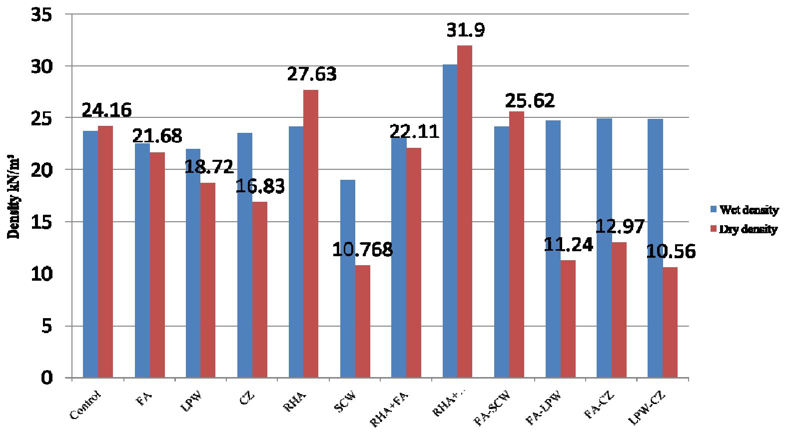

Figure 4. Wet and dry density of specimens

3.2 Water absorption

Percentage of water absorption are shown in figure 4.As compared to control specimen, RHA, (FA-RHA), (FA-SCW), (RHA-SCW) achieved the highest percentage of water absorption. As compared to control specimens, FA, LPW, CZ, SCW, (FA-LPW), (FA-CZ), (LPW-CZ) showed decrease in percentage of water absorption. It has been compared from the earlier studies, percentage increase in water absorption was gradual by using various admixtures [6].

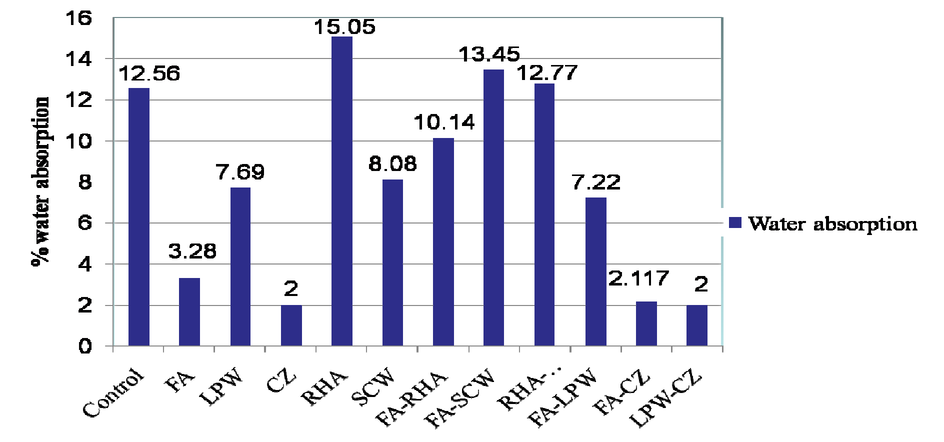

Figure 5. Percentage of water absorption for specimens

3.3 Sorptivity

The sorptivity in specimens were carried out in accordance with [16]. Behaviour of FA, CZ, (FA-CZ), (FA-SCW) was similar to control specimen. As compared to control specimen, light weight concrete specimens RHA, SCW, (FA-RHA), (RHA-SCW) showed higher value of sorptivity. Similar behaviour was noticed in light weight concrete specimens [17].

Table 4. Sorptivity for the specimens

√t	C	FA	FA-CZ	CZ	RHA	SCW	RHA-FA	RHA-SCW	FA-SCW
0	0	0	0	0	0	0	0	0	0
3.166	0.032	0.032	0.030	0.098	0.415	0.42	0.6358	0.382	0.254
5.472	0.017	0.017	0.018	0.01	0.411	0.45	0.7643	0.382	0.382
7.745	0.012	0.012	0.013	0.012	0.309	0.25	1.0191	0.509	0.382
13.41	0.007	0.007	0.007	0.007	0.508	0.65	1.1464	0.636	0.382
15.49	0.006	0.006	0.006	0.006	1.006	0.94	1.273	0.764	0.509
17.32	0.005	0.005	0.103	0.005	1.106	1.28	1.5286	0.891	0.509
18.97	0.005	0.005	0.103	0.005	1.205	1.20	1.5286	1.019	0.509

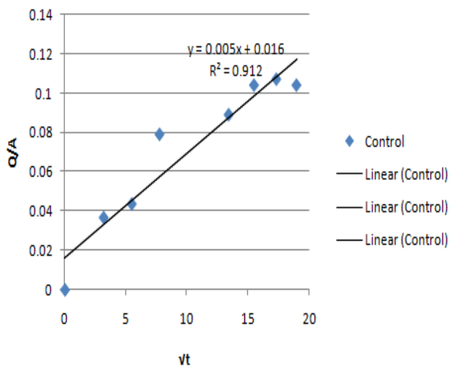

Figure 6 (a) Control

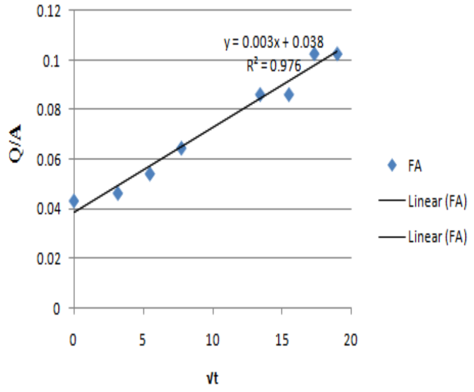

Figure 6 (b) Fly ash

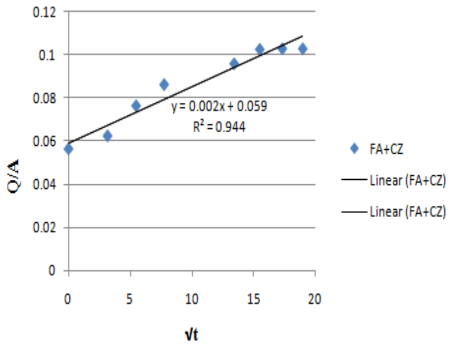

Figure 6 (c)FA-CZ

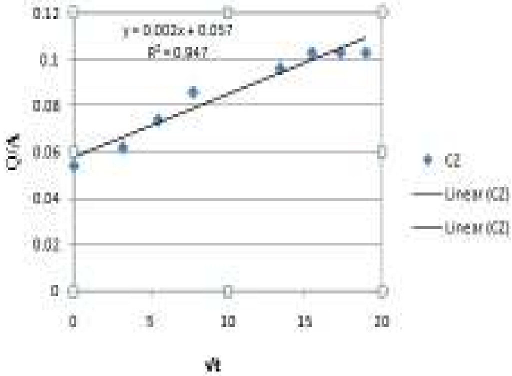

Figure 6 (d)CZ

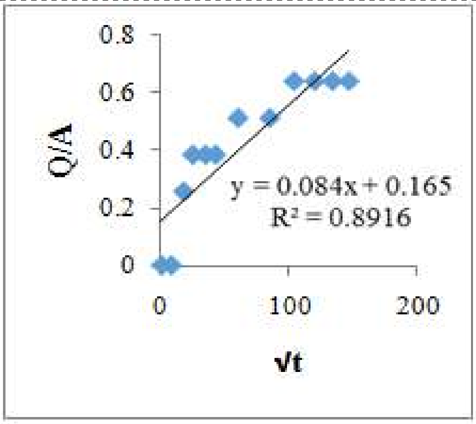

Figure 6 (e)RHA

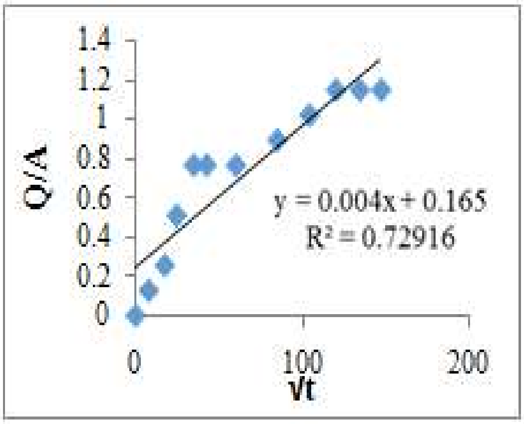

Figure 6 (f)SCW

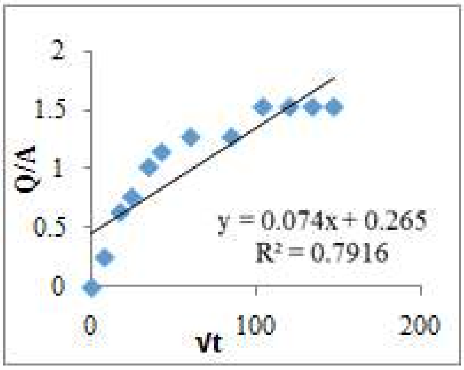

Figure 6 (g)FA-RHA

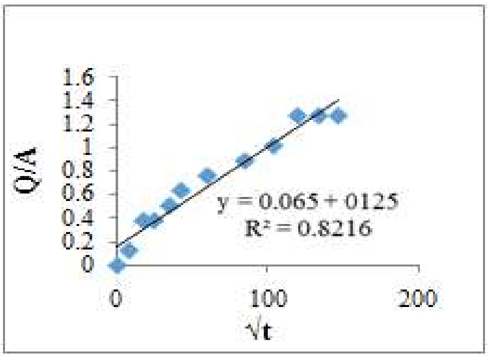

Figure 6 (h)HA-SCW

Figure 6. Sorptivity index for specimens

3.4 Compressive strength

Compressive test was achieved in CTM of loading capacity 3000 kN. After 28days of moisture curing the specimens were surface dried and tested to failure. Comparison of compressive strength are listed in the table 6, percentage of difference in strength are shown in the figure7.

Table 5. Comparison of compressive strength

S.No	Specimen	Area (mm^2)	Compressive load (kN)	Compressive stress (N/mm^2)
1	Control	150 x 150	562	24.99
2	FA	150 x 150	597	26.53
3	LPW	150 x 150	405	18.01
4	CZ	150 x 150	545	24.20
5	RHA	150 x 150	578	25.68
6	SCW	150 x 150	552	24.53
7	RHA-FA	150 x 150	375	16.66
8	RHA-SCW	150 x 150	397	17.64
9	FA-SCW	150 x 150	425	18.88
10	FA-LPW	150 x 150	582	25.86
11	FA-CZ	150 x 150	573	25.46
12	LPW-CZ	150 x 150	520	23.11

The influence of various mineral admixtures on compressive strength of concrete specimens was concentrated [1].Light density for concrete have achieved without compromising the compressive strength.

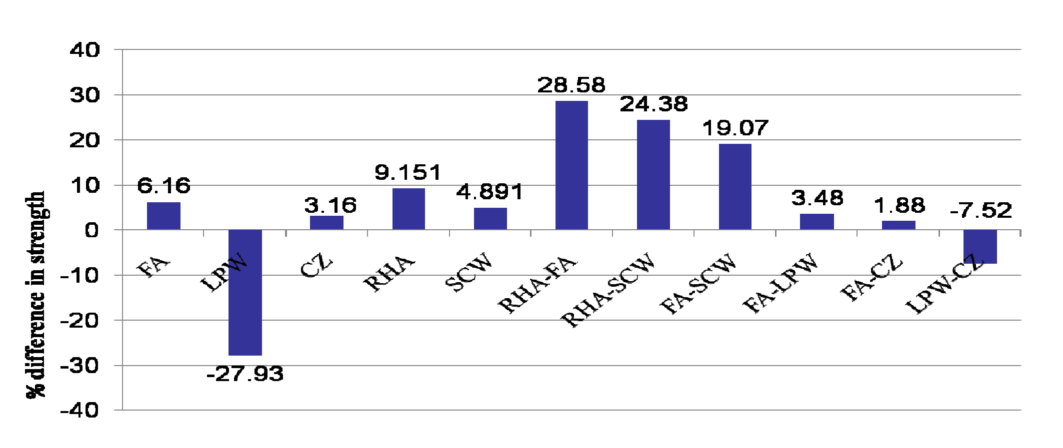

Figure 7. Percentage difference in compressive strength

From the comparison it was inferred that LPW and LPW-CZ showed decrease in compressive strength. Compared to control specimen, the other combinations FA, CZ, RHA, SCW, RHA-FA, RHA-SCW, FA-SCW, FA-LPW and FA- CZ showed enhanced results for compressive strength.

4. Conclusion

Mineral admixtures were used as partial replacement for cement to achieve light weight concrete blocks and conclusion were arrived

- FA showed less reduction in bulk density without considerable reduction in compressive strength.
- Replacement with LPW showed better reduction in density but failed to achieve the strength.
- FA and (FA-SCW) showed less reduction in the density without substantial reduction in the compressive strength.
- The results observed that (FA-LPW) specimens had higher compressive strength compared to the control specimen.
- Replacement with CZ resulted in better reduction in water absorption and density of the sample. Sample achieved good strength.
- By the addition of RHA, water absorption and bulk density of the samples considerably increased.
- Combination of (FA-CZ) sample gave reduction in density and water absorption. The samples achieve good strength.
- Combination of (LPW-CZ) sample gave reduction in density and water absorption. The samples achieved good strength.
- Sorptivity of CZ gradually decreased the sorptivity value as compared to control specimens.
- Sorptivity of FA, FA-CZ sample achieved lowest value of sorptivity as compared to control specimens.
- Study for strength and durability showed that cement replaced with FA and (FA-SCW) were effective compared to other combinations. As compared to all other specimens (FA-CZ) and (LPW-CZ) achieved light weight concrete blocks. These blocks showed good compressive strength and also performed better under durability conditions.

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