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Effect of admixtures on the physical properties of non-autoclaved light weight blocks using pond ash*

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ABSTRACT

In the present study effect of activator calcium chloride and superplasticizer on the compressive strength and demoulding time of light weight non-autoclaved blocks has been studied. De-moulding time has been reduced from 48 hrs. to 8-10 hrs. With 1% activator and superplasticizer further reduction in de moulding time by 2 hrs. and increase in compressive strength has been observed. Petrography study of inner surface of block has shown distribution of air entrainment. Overall thermal transmission (U) value of the blocks of different densities has also been determined. It is noticed that U value is increasing with enhancement of densities and vice – versa.

Keywords : Cement, pond ash, compressive strength, activator, super plasticizer, thermal transmission

INTRODUCTION

Cellular light weight concrete is one of the recent emerging technology in making concrete. It has many advantages when compared to the normal conventional concrete. A cellular concrete is a lightweight product consisting of Portland cement, cement-silica, cement-pozzolan, lime-pozzolan, lime-silica pastes or pastes containing blends of these gradients and having homogeneous void or cell structure, attained with air entraining agents or gas-forming chemicals of foaming agents.

Fly ash is considered as one of the waste industrial product that cannot be easily disposed. It solves the problem of disposal of flyash and at the same time it reduces the cost of the construction. Therefore, flyash based light weight concrete is considered as environment friendly sustainable material produced with least energy demand. Density ranges from 650 Kg/m^3 to 1850 Kg/m^3 as compared to 1800Kg/m^3 to 2400 Kg/m^3 for conventional brick and concrete respectively. Despite millions of tiny air filled cells, it is strong and durable. The medium density range 800-1000 kg/m^3 is utilized for making pre- cast blocks for non-load-bearing walling masonry in framed structures.

Advantages of light weight concrete are well known across the globe due to better thermal properties. Lesser dead load weight makes this component acceptable in high rise buildings. It has a long life and does not produce toxic gases after it has been put in place. It also offers a substantial material savings as little cement and no gravel is used being a volumetric phenomenon.

Worldwide, more than 65% of fly ash produced from coal power stations is disposed of in landfills & ash ponds. The cost of pond ash after transportation charges are less than 50% of fly ash.

In the present study use of pond ash collected from 1 km. from the discharge point has been used in the development of CLC blocks using non-autoclaving technique and use of various additives to reduce the de-moulding time to workable schedule.

Experimental Details:

Cement: Ordinary portland cement of 43 grade conforming to BIS 8112(2005) has been used. The physical and chemical properties of the OPC are given in table no. 1

Pond Ash: Pond ash was collected from 1 km from active point from Badarpur thermal power station, New Delhi. The physical and chemical properties are given in table no. 2.

Sand: Quarry sand of fineness modulus is 2.6 was used in the present study.

Activator: Calcium chloride has been used as an activator.

AEA: Aluminium powder is used as air entraining agent.

Superplasticizer: SNF based superplasticizer has been used in the present study

Particle Size Distribution

The particle size distribution of pond ash was determined using HORIBA 950SA particle size analyzer and is shown in fig. no. 1.

Chemical analysis of pond ash

Properties of pond ash were analyzed using S8 TIGER wavelength dispersive X – ray Fluorescence Spectrometer and is shown in table no.2.

Surface Area: Surface area of pond ash was determined using PC controlled automatic Blaine apparatus (Testing) and is 3050 cm^2/gm. LOI of pond ash has been found to be 3%.

Petrography Studies:

For petrography studies a thin section of the block was cut and petrography study of this inner section of sample was carried out using AXIO microscopic under high resolution. The photograph of the section is shown in figure no. 2

Mix proportions:

Light weight blocks containing various percentages of ordinary Portland cement, pond ash and sand were blended in certain proportions and different percentages of additives was added in a high speed laboratory mixer to prepare a thin homogeneous slurry. Cubes of 800 kg/m^3 were cast under ambient conditions. Various mix proportions used in the present study is given in table no 3.

Table no.1 Physical & Chemical Properties of Cement

Compressive strength	Observed	BIS 8112 - 2005
3 day	260 kg cm^2	≮ 230
7 day	370 Kg/cm^2	≮ 330
28Day	480 kg/cm^2	≮ 430
Fineness	334m^2 /kg	≮300m^2/kg
Setting Time (mins.)		
Initial	185	≮ 30 mins
Final	230	≯600 mins
Insoluble Residue	1.2	
Magnesia	3.2	Max. 5%
Alkalies	0.40	
SO_3	2.5	
Silica Content	20.5	
CaO	60.5	

Table No. 2. Properties of pond ash (%)

Cao	SiO_2	Fe_2O_3	Al_2O_3	MgO	TiO_2	P_2O_5	MnO	ZnO
2.11	54.35	10.64	23.66	0.57	2.54	1.71	0.11	0.03

Table No. 3 Mix proportion of ingredients for CLC Blocks

Cement	Flyash	Sand
100%	-	-
80%	10%	10%
70%	20%	10%
60%	30%	10%
40%	50%	10%
100%	-	-
80%	10%	10%
70%	20%	10%
60%	30%	10%
40%	50%	10%

Table no. 4 Compressive Strength (MPa) of CLC blocks without Additives

flyash	7d	28d	56d	90d
10%	1.13	1.9	2.58	2.71
20%	0.82	1.76	2.22	2.66
30%	0.76	1.5	1.96	2.62
50%	0.66	1.1	1.65	2.48

Table no. 5. Compressive Strength (MPa) of CLC blocks with activator

Flyash	Activator	De molding time (hrs)	56days	90 days
10%	½ %	8-10	2.65	2.96
	1%	6-8	2.76	3.07
20%	½%	8-10	2.35	2.78
	1%	6-8	2.42	2.89
30%	½%	10-12	2.12	2.65
	1%	8-10	2.26	2.73
50%	½%	10-12	2.01	2.52
	1%	8-10	2.23	2.58

Table no. 6 Mix proportion of ingredients for CLC Blocks

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with different %ages of additives

Cement	flyash	Sand	Activator	Super plasticizer
100%	-	-	½ %	-
80%	10%	10%	½ %	-
70%	20%	10%	½ %	-
60%	30%	10%	½ %	-
40%	50%	10%	½ %	-
100%	-	-	1%	1%
80%	10%	10%	1%	1%
70%	20%	10%	1%	1%
60%	30%	10%	1%	1%
40%	50%	10%	1%	1%

Table no 7. Water reduction (%) and de-molding time (hrs)

Flyash	Act.	SP	Water reduction %	C.S 56d	90d	De-molding time (hrs)
10%	1%	1%	22	3.10	3.56	4-6
20%	1%	1%	19	2.55	2.92	4-6
30%	1%	1%	16	2.40	2.75	6-8
50%	1%	1%	14	2.35	2.65	6-8

Table no. 8.Thermo–physical properties of light weight blocks

Density kg/m^3	Thermal Conductivity W/mK	Sp. Heat kcal/ kgh °C	U value W/m^2 K	λ value decreement factor	Phase lag Φ
770	0.183	0.21	2.32	0.714	2.96
790	0.192	0.21	2.41	0.722	2.91
820	0.214	0.21	2.56	0.736	2.84

Fig. no. 1 Particle Size distribution of pond ash

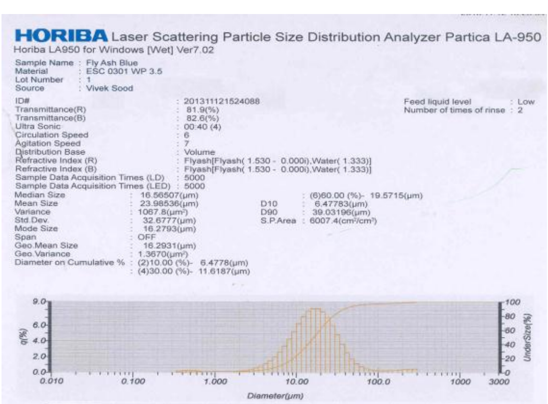
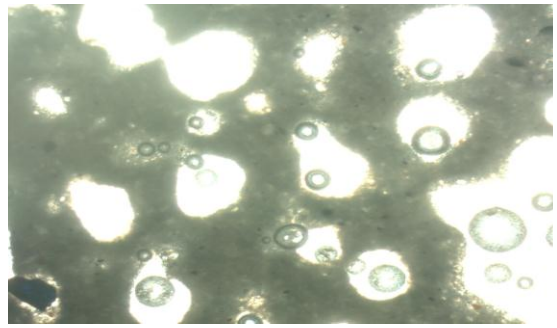


Fig. no. 2. Microscopic view (matrix of the block) under high resolution



Results and Discussion:

From table no. 4 it is found that when no additive was used the compressive strength of the blocks decreases as the percentage of fly ash increases up to 56 days of curing. However, at 90 days compressive strength of blocks with 20% -50% fly ash replacement is comparable to 10% replacement. When activator is used, compressive strength of CLC blocks as shown in table no.5 increases at 56 and 90 days at all replacement levels when compared to without activator. Further, it is also found that by increasing the activator dose to 1% there is no appreciable increase in strength, suggesting thereby that ½% activator dose is sufficient. Reduction in de-moulding time with different fly ash replacement levels varies between 6-12 hrs. Maximum gain in strength (35%) has been observed in case of 50% fly ash at 56 days. At 90 days except 10% fly ash all other replacement shows comparable strength indicating that at higher levels of replacement silica from fly ash is reacting with CH liberated from cement to form C-S-H gel to give strength to the matrix.

From table no. 7 it has been found that when superplasticizer was added along with activator it has been found that reduction in de-moulding time varies between 4-8 hrs. compared to 6-12 hrs. when only activator was used. Further, increase in compressive strength especially in 30 and 50% fly ash replacement at 56 days has been found to be 20 and 40% compare to control. At 90 days except 10% which shows gain of 35% increase in strength there is 5-10% gain in strength. Since main objective of adding superplasticizer was to reduce the water content of the mix while maintaining the fluidity so that the mix can be easily poured into the moulds similar to the fluidity of the control mix. This same fluidity with reduced water content gives additional strength and reduces the de-moulding time. Basically superplasticizer are adsorbed onto the cement particles and disperses them which has been observed in the mixes. As the cement is replaced by fly ash, dispersion of cement particles will be less as fly ash percentage increases and as such maximum strength has been observed in case of 10% replacement of cement by fly ash compare to higher replacement levels. In fact, this is one of the objectives of the studies to reduce the de-moulding time so that non-autoclaving can be feasible at site of construction.

Thermal behaviour

The petrography of the section of the block in Fig No.2 clearly shows the wide spread distribution of air entrapment, responsible for the light weight blocks and better thermal properties. Air is known to be the best insulation material available. Air voids, if smaller than 2 mm each, consequently increase thermal insulation substantially. Normal aggregate concrete has a specific thermal conductivity of 1.78 W/mK, compared to 0.192 W/mK only for 790 kg/m^3 light weight concrete.

Overall thermal transmittance (U), decrement factor(λ) and time phase lag (Φ) (U)has been determined by the using following equation:

$U = (1/h_i+1/h_o+\Sigma(L/K))^{-1}$, $\lambda = Exp(-\pi.R.C/24)$
where $R=L/K$, $C = L\rho c$, and $\Phi = 1/15\ Cos^{-1}(\lambda)$

It is also well known that as density of the fabric material decreases, its thermal behavior improves. It is found from the above Table No.8 that as the density of light weight blocks increase, its thermal conductivity, overall transmittance (U) and decrement factor increases whereas, the phase angle decreases with the decrease of density. Thermal properties of light weight component are improving as its density decreases because the entrapment of air is more in blocks of lesser densities.

Conclusion:

From the present study it has been found that cellular light weight concrete blocks of medium density using pond ash (upto50%) can be developed using admixtures of required strength and thermal properties.

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