PERFORMANCE EVALUATION OF AERATED CONCRETEPRODUCED FROM INDUSTRIAL BY-PRODUCTS

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Abstract – *Excessive* waste generated from industries is one of the main challenges we face in our day today practices, if we can convert these industrial waste into an energy efficient aerated concrete blocks which helps in reducing the environmental impact due to global warming and if it provide better waste management then it is a key step for energy efficient construction practices. In the recent years aerated concrete is gaining importance due to their advantages such as heat insulation, Light weight, Sound insulation, Easy usability, Thermal conductivity, Easy transport, Fire resistance, Durability compared to conventional concrete.

Current study is aiming at developing and optimizing an eco-friendly low density, moderate strength concrete mix design using various combinations of industrial wastes like fly ash, GGBS and silica fumes. Experimental studies will be further extended to evaluate engineering properties, mechanical properties and durability.

Key Words: :- Aerated concrete, eco-friendly , industrial by product , durability, mineral admixture, PVC granules.

1. INTRODUCTION

Aerated concrete is one of the well-known forms of a cellular concrete. It can be dividedinto two main types based on the method of production. One is foamed concrete (non-autoclaved aerated concrete (NAAC)) and other is autoclaved aerated concrete (AAC). According to production methods ,the types of light weight concrete are (a) Light weight aggregate concrete, which can be produced by using light weight aggregate of low specific gravity in place of the normal weight aggregates, (b) Aerated, cellular, foamed or gas concrete which can be produced by inducing bubble voids within the concrete or mortar mass by suitable air entraining agents, and gives more homogeneity and distribution of the voids within the concrete,(c) No fines concrete, which can be produced by eliminating the fine aggregates from the mix and this gives no segregation between the ingredients. Lightweight concrete is normally categorized to 3 grades: low density concrete with a density lower than 800 kg/m^3, moderate strength concrete with a density between 800kg/m^3 and 1400 kg/m^3 and structural concrete with a density between 1400 kg/m^3 and 2000 kg/m^3.

1.1 Aerated concrete

This type of Concrete has the lowest density, thermal conductivity and strength, Like timber it can be sawn, screwed and nailed, but they are non-combustible.The precast products are usually made by the addition of about 0.2 percent aluminium powder to themix which reacts with alkaline substances in the binder forming hydrogen bubbles. The reactions between the composition of cement and water are as follows:

$$\rightarrow \quad 2(3CaO.SiO_2)+ 6H_2O \qquad 3CaO .2SiO_2.3H_2O+3Ca(OH)_2$$

When the aluminum powder is filled into the cement paste, the following reaction is generated:

$$\rightarrow \quad 2\,Al + 3Ca(OH)_2 + 6\,H_2O \quad \uparrow \quad 3\,CaO.Al_2O_3.6H_2O + 3\,H_2$$

Aerated concrete is a lightweight, cellular material consisting of cement and/or lime andsand or other siliceous material. Manufacture of this aerated concrete is made by either aphysical or a chemical process during which either air or gas is introduced into a slurry, which generally contains no coarse material. Aerated concrete is generaly cured by high-pressure steam to increase its strength.

1.2 OBJECTIVE

The main objective of this study is to

- Develop eco-friendly low density, moderate strength concrete using industrialwastes
- Optimise mix design of aerated concrete using industrial by products.
- Performance evaluation of mix proportion for various engineering and mechanical properties
- Study on durability

2. SCOPE

- Mix design will be carried out for no coarse aggregate concrete only
- Curing period is considered for 7 & 28 days

- Industrial wastes considered are
   i. Fly ash
   ii. *GGBS*
   iii. Silica fumes
- External agent used for aeration
   i. Aluminium oxide powder is used
   ii. Bentonite powder
   iii. zeolite

3. AERATED CONCRETE MIX DESIGN

Mix are designed based on trial and error method by casting cubes for various ratios of cement, fine aggregates and water and an optimum mix is selected based on stiffness of the mix and strength. The optimum mix founded out to be 1: 2 by volume

Typical calculation work for aerated concrete with Al constant (0.5) and w/c = 0.45.Cement = 800g

Sand = 1600 g

Aluminium powder = $\frac{0.5 \times 800}{100} = 4g$

4. SPECIMENS USED

As in keeping with IS: 5161959 ,70.7mm x 70.7mm x 70.7mm and moulds had been used to solid mortar 150mm x 150mm x150mm cubes to decide the compressive energy of concrete and cylinder of base 150mm dia and peak 300mm.The checks to be conducted consist of compressive power and cut up tensile test at 7 and 28 of curing.

Table -1: various mix used

SL	Mix	components
1	Mix 1	Control mix- cement , fine aggregate water
2	Mix 2	Aerated concrete 0.5%al- Cement, fine aggregates , water , aluminum oxide 0.5%
3	Mix 3	Aerated concrete 1%al- Cement, fine aggregates , water , aluminum oxide 0.5%
4	Mix 4	Aerated concrete 1.5%al- Cement, fine aggregates , water , aluminum oxide 0.5%
5	Mix 5	No fine aerated concrete 0.5%al- Cement, water , aluminum oxide 0.5%
6	Mix 6	No fine aerated concrete 1.0%al- Cement, water , aluminum oxide 1.0%
7	Mix7	No fine aerated concrete 1.5%al- Cement, water , aluminum oxide 1.5%
8	Mix8	Mineral admixture aerated concrete- cement, fine aggregates , betonites , water
9	Mix9	Mineral admixture aerated concrete- cement, fine aggregates , zeolite , water
10	Mix10	No fines aerated concrete with PVC granules- Cement , water PVC granules

Water = 0.45 x 800 + 0.04 x 1600 = 304 ml (4% water absorbtion for dried M sand.dried sand is used throughout)

5. RESULT AND DISCUSSION

The first part of the study deals with optimization of water-cement ratio and aluminium content in aerated concrete of grade 1:2. The w-c ratio is optimized and aluminum 0.5% using density and compressive strength.

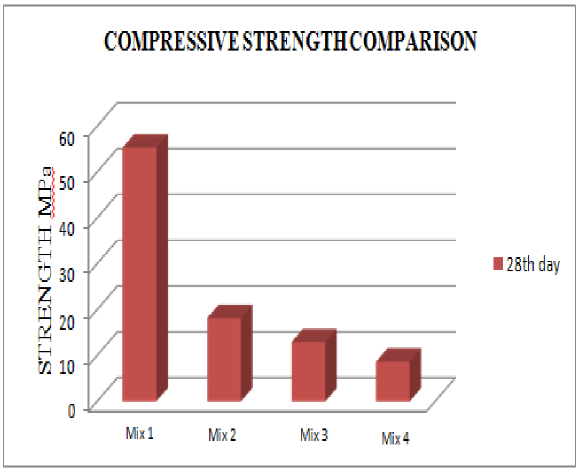

Chart 1 comparison of control specimen vs aerated concrete

From above mix 1 shows the value of conventional concrete and mix2, mix 3, mix 4shows the value of aerated concrete It is evident that on addition of aluminium oxide the strength decreases and this is due to formation of the voids formed during aeration, by addition of more aluminium content more voids arecreated.

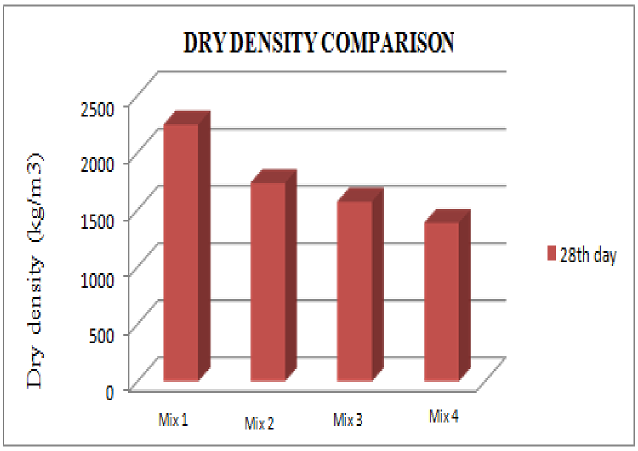

Chart 2 dry density recorded for concrete and aerated concrete

From the above chart it is evident that on increase in aluminumoxide content it accelerates aeration hence the voids increses and reduces density and make concrete lightweight

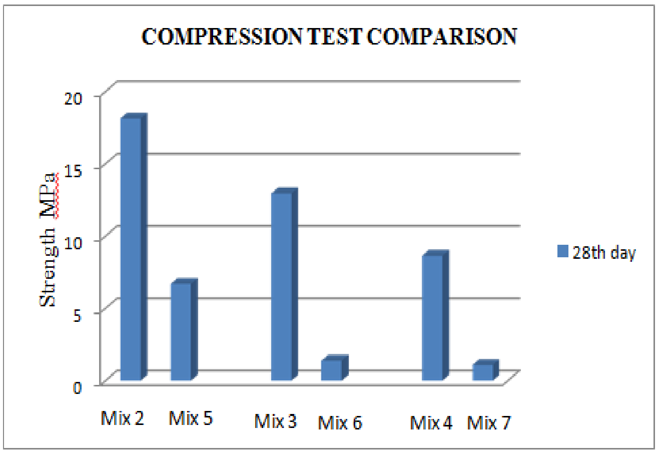

Chart 3 compression test on aerated and no fine aerated concrete

From the above chart 3, Shows the value of aerated concrete and corresponding no fine aerated concrete value for aluminum oxide content of .5%(mix 2) , 1% (mix 3)and 1.5% (mix 4). we can see in binder paste aeration happens much more compared to the aeration happening in the sand mortar and hence reduction in strength is more in binder paste.

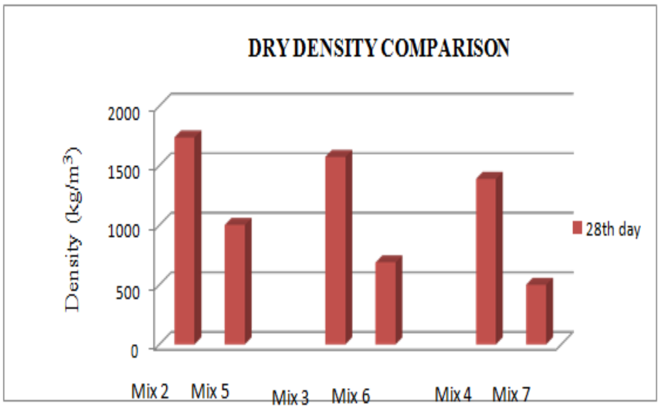

Chart 4 density variation for aerated concrete

From the above chart the density is found to be very low in nofine aerated concretethan in aerated concrete, indicating that in aerated concrete sand act as a buffer to reduce aeration

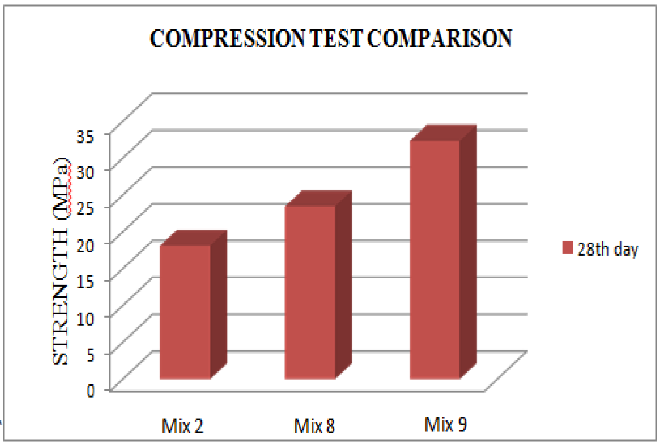

Chart 5 compressiom test result on aerated concrete

In the above chart aerated concrete of (0.5% aluminum content) is compared with mineral admixture (bentonite and zeolite) and the results are compared. From above graph it is evident that mineral admixture give better strength capacity compared to chemical admixture

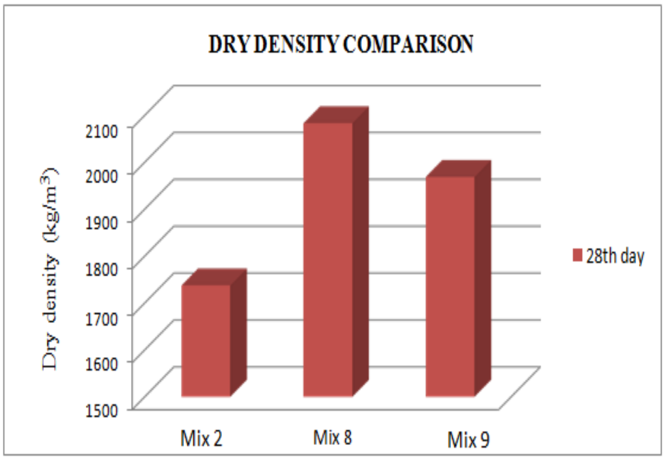

Chart 6 dry density recorded on aerated concrete

in the above chart aerated sand mortar of (0.5% aluminum content) is compared with mineral admixture (bentonite and zeolite) and the results are compared. Fromabove graph it is evident that mineral admixture have higher density indicating lesser aeration compared to that of the chemical admixture.

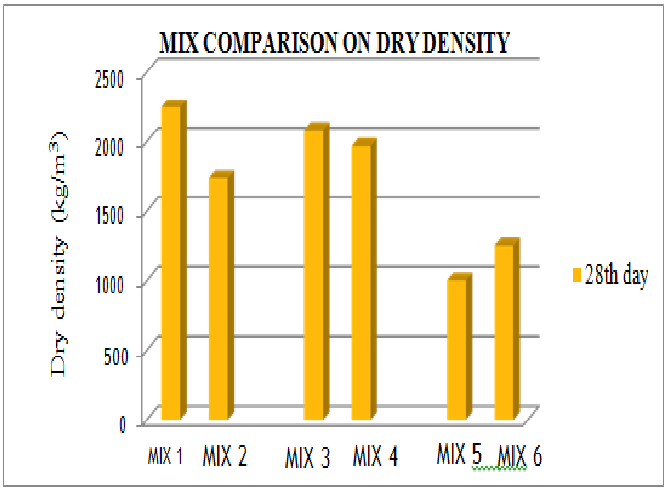

Chart 7 dry density recorded for various mix

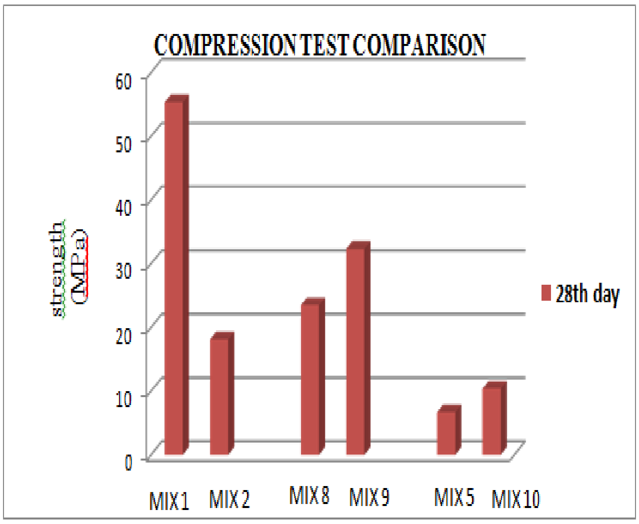

Chart 8 shows different mix details for its compressive strength

6 Durability test

In this study a short durability test of chloride and sulphate test is done on aerated concrete blocks as per ASTM 1012 and ASTM 1202 and the result are tabulated below 4.17 and 4.18

6.1 CHLORIDE TEST

Concrete does not change its weight in normal water curing. However, when it was exposed to 5% NaCl there was notable change in weight in all mixes. The highest weight loss have been noted in bentonite aerated concrete1.1% and least effect on aerated concrete with 0.5% aluminum content.

Table 2 Dry weight comparison after chloride test

Specimen	Dry weight kg/m³ (Before chloride test)	Dry weight kg/m³ (After chloride test)	Weight reduction (%)
Concrete block	2247.68	2238.46	0.41
Aerated block 0.5% al	1737.15	1731.42	0.33
Aerated block 1% al	1573.76	1567.51	0.36
Bentonite block	1980.12	1958.22	1.1

6.2 SULPHATE TEST

Table 3 Dry weight comparison after sulphate test

Specimen	Dry weight kg/m³ (Before sulphate test)	Dry weight kg/m³ (After sulphate test)	Weight reduction (%)
Concrete block	2247.68	2215.09	1.45
Aerated block 0.5% al	1737.15	1722.04	0.87
Aerated block 1% al	1573.76	1554.88	1.2
Bentonite block	1980.12	1964.16	0.2

Concrete does not change its weight in normal water curing. However, when it was exposed to 5% magnesium sulphate there was notable change in weight in all mixes. The highest weight loss have been noted in concrete block about 1.45% and least effect on bentonite aerated concrete with 0.2% reduction in weight.

7. CONCLUSIONS

i. On increasing the aluminium content above 1% (by weight of cement) the density and strength decreases rapidly.

ii. For aluminium content 0.5% the optimum water content lies in the region 0.45-0.5 asstrength and density tends to be constant at this region and above 0.5 w/c ratio and the formed bubbles collapse

iii. For no fines concrete shows increased rate of reaction, more aeration and more porosity is observed 45% reduction in density compared to aerated concrete.

iv. Cement is replaced by PVC granules 50% by weight of cement and shows more stability than no fines aerated concrete for the same w-c ratio and it shows twice strength compared to no fines concrete for small variation in density.

v. Different mixes are optimized and results shows that industrial waste can be effectively utilized to create aerated concrete however detailed study needed to be carried out to optimize the result.

vi. Chloride resistance test is carried out using sodium chloride and results shows us thataerated concrete is suitable to use in marine areas as reduction in weight is recorded to be 0.3% than bentonite aerated concrete 1.1% .

vii. Sulphate resistance test is carried out using magnesium sulphate and result shows us that bentonite aerated concrete is the best option as only 0.2% reduction in weight is recorded compared to aerated concrete 0.87% than conventional concrete 1.45%

8. SCOPE FOR FUTURE WORK

- Micro-structure analysis can be carried out to understand its pore structure
- Study can be extended to understand its Thermal performance
- Study can be extended to Autoclave curing method
- Study on chloride and sulphate test can be extended for longer duration
- Different durability test such as water permeability, alkali-silica reactions, sorptivitytest can be studied.

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