Utilization of Ecosand and Flyash in Aerated Concrete for a Richest Mix Design

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ABSTRACT

Aerated concrete is made by introducing air or gas into slurry composed of portland cement and finely crushed siliceous filler, so that when the mix sets and hardens uniformly cellular structure is formed. Thus it is a mixture of water, cement and finely crushed sand. By using finely powdered metal aluminium powder with the slurry and made to react with the calcium hydroxide liberated during the hydration process to give out large quantity of hydrogen gas. This hydrogen gas when contained in the slurry mix gives the cellular structure. This study involves the use of fly ash eco-sand, a byproduct of cement as filler material, aluminium powder as metal powder, hydrogen peroxide as foaming agent and OPC 43 grade cement as binder. This product emphasizes its economic feasibility when compared with the commonly produced AAC.

1. INTRODUCTION

Historically concrete has been used to construct various structures, especially in defense structure such as retaining wall, shelter, barrier, nuclear reactor containment, offshore structures, and etc. It is not only applied for normal loads such as weight but is also subjected to impact load due to explosion, against ballistic effect or earthquakes. Currently, bunkers and command center in military application are developed as weapon systems. It is consequently the penetrability of concrete in relation to projectile and resistance concrete against ballistic and explosion [1].

In USA, approximately 950 million metric tonnes of coal is consumed annualy for electrical and industrial use, in which 110 million tonnes of ash consisting of bottom ash, boiler slag and 64 million tonnes of fly ash [2]. Currently, 40% of the fly ash is reused. The rest is landfilled or surface impounded. These landfilled flyash causes huge financial burden for industries, such as the foundry industry, and makes them responsible for potential environmental effects far into the future. Scientists have therefore been looking for a way to reuse or recycle this waste into a productive, environmentally friendly alternative. Alkali activation or geopolymerisation is a field developed for the purpose of turning this solid waste into cost-effective solutions [3].Good source materials include by-product materials such as fly ash, blast furnace slags and silica fume [4]. Alkali-activated fly ash is now thought to have a better effect. Geopolymers also gain strength very quickly as well, obtaining 70% strength within the first three to four hours of production.

Autoclaved aerated concrete (ACC) was developed in Erope in 1923. AAC is the only viable, single component structural insulation system available. Besides insulating capability, one of AAC's advantages is its quick and easy installation since the material can be routed, sanded and cut to size on site using standard carbon steel band saws and drills. AAC is well known as environmentally friendly construction material. The production process emits no pollutants and creates no toxic waste products. All waste products produced during manufacturing is reused. Production of AAC requires relatively little energy for the volume of material produced.

Disposal of waste products such as fly ash has been difficult because it must be stored in such a way that it does not seep into ground water and must have structural stability with respect to adverse environmental conditions. Alkali activation became the most cost-effective solution to this problem and can be utilised in precast structures and concrete products that are resistant to heat and environmental decay. It can give a variety of characteristics, depending on the mix design, including high compressive strength, light weight and resistance to acid decay. It also has a significantly reduced energy requirement for manufacture of materials involving geopolymers [5].

Recently, the application of many structures gets substituted from normal concrete to lightweight concrete because of its advantage and eco-friendly nature. For many years lightweight concrete has been used successfully for structural purposes. Structural applications are related with foundation size and construction cost. The density of lightweight concrete is often more important than the strength. Lightweight concrete with the same strength level may reduce the self-weight consequence of a decreased density [6]. Lightweight concrete can easily produced utilizing natural lightweight aggregate as well waste material [7]. Lightweight concrete has its obvious advantage of high strength/weight ratio, good tensile strength, low coefficient of thermal expansion, waste utilizing, heat preservation, noise insulation characteristic, and energy saving, as well as good absorbability of impacting energy due to air void in lightweight aggregate [8]. Impact resistance of lightweight concrete is affected by strength, density, the lower modulus elasticity and tensile strain capacity.

Aerated concrete is made by introducing air or gas into slurry composed of Portland cement and finely crushed siliceous filler. So that when the mix sets and hardens uniformly cellular structure is formed.The ingredients of AAC are mixed to form slurry that is poured into large metal moulds. The reaction between the expansion agent and other components used in AAC causes the slurry to expand (rise) in the mould and form a "cake." After several hours, the mould is stripped away and the "cake" is wire-cut into aerated concrete elements of high dimensional accuracy. These elements are then put into an autoclave (a vessel in which they are steam cured under pressure) After autoclaving, AAC can be shipped and used immediately.

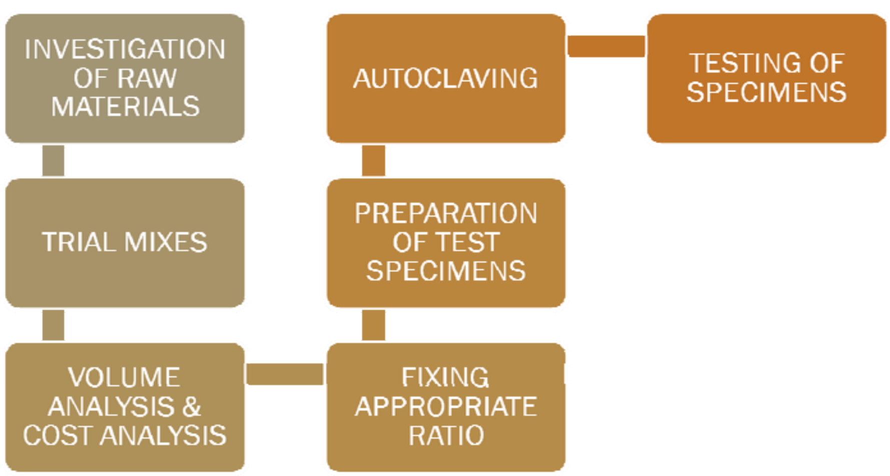
1.1 Research significance

Ecosand are very fine particles, a bi-product from cement manufacture which can be used to increases efficiency in concrete. Ecosand is finely powdered crystalline silica which can replace up to 50% of conventional sand usage in concrete and mortars. Its micro-filling effect reduces pores in concretes and provides better moisture resistivity and thus durability. It has more consistent grading than many extracted aggregates. Effective use for waste material and thus cost effective and performs as well as naturally occurring sand. The use of ecosand rather than extracted or dredged natural sand will help designers and contractors address issues of sustainability. The present study are checking the compressive strength of concrete block using flyash, ecosand, cement and hydrogen peroxide.

The ecosand has various advantages such as energy efficient, fire resistant, reduction of dead load, environmentally friendly, durable, light weight, low maintenance, low construction cost.

2. Methodology:

Figure 1. Schematic diagram of entire work



2.1 Materials used

Ordinary Portland Cement (OPC) 43 grade conforming to IS 8112-1989 (Table 1) is processed by product of cement plant. – Ecosand (chemical composition SiO_2 : 58 – 60%, Al_2O_3 : 2 – 3 %, Iron : 1 – 3 % , MgO : 0.4 – 1 % and CaO: 20 – 25%) and fly-ash are (Table 2) used as fine aggregate. Aluminium powder is used as metal powder. The foaming agent is replaced by industrial grade hydrogen peroxide (50%). Hydrogen peroxide (H_2O_2) is a colorless transparent liquid, slightly more viscous than water. It is a weakbase, has strong oxidizing properties, and is a powerful bleaching agent. A gas cell produced by hydrogen peroxide improves the homogeneity of the void structure and minimises drastic strength variations (Table 3).

Table 1. Physical Properties of OPC 43 Grade Cement

PROPERTIES	**REQUIREMENTS AS PER IS 8112-1989**
SPECIFIC GRAVITY	3.0 – 3.15
FINENESS (sqm/kg)	225(min)
SOUNDNESS (mm)	
Lechatlier method	10mm (max)
Autoclave (%)	0.8 (max)
SETTING TIME	
Initial (min)	30 minutes
Final (max)	600 minutes
COMPRESSIVE STRENGTH (MPa)	
3 days (min)	23
7 days (min)	33
28days (min)	43

Table 2. Chemical Properties of Fly-ash

CHEMICAL PROPERTIES	**FLY ASH MTPP**	**As per IS:3812-1981**
SiO2+Al2O3+Fe2O3,min% by mass	70.0	90.5
SiO2, min% by mass	35.0	58
CaO max % by mass	5.0	3.6
SO3, max % by mass	2.75	1.8
Na2O, max % by mass	1.5	2
L.O.I, max 5 by mass	12.0	2
MgO, max %by mass	5.0	1.91

Table 3. Properties of hydrogen peroxide

Acidity (m/m % H2SO4)	**0.040**
Volatile matter (m/m %)	0.080
Stability(%)	9
Freezing point	-52°C (-62°F)
Boiling point/boiling range	115 °C (239 °F)
Relative density / Density	1.2

2.2 Test on ecosand:

Tests were conducted to obtain specific gravity and particle size distribution of ecosand used in this study as per IS: 2386-1983 and the resultsin table 4

Table 4. Properties of Ecosand

Test particulars	Result obtained
Specific gravity	2.63
Particle size	Passing through < 15 μ sieve

2.3 Trial mix ratio

There is no specific method of mix design for aerated concrete. Trial and error method was adopted to determine the quantities of various ingredients (Table 5).Various mix ratios were obtained with fixed percentage of filler, binder, foaming agent and metal powder such as M1, M2,M3,M4,M5 and M6. From all those M4 was found to be the richest mix design.

Table 5. Percentage quantities of raw material

Trial No	MATERIALS (%)						W/C RATIO
	Cement	Filler	Sand	Flyash	H2O2 (% of cement)	Aluminium Powder (% of cement)	
M1	35	65	30	70	0.2	0.5	0.75
M2	35	65	30	70	0.2	0.45	0.68
M4	35	65	30	70	0.2	0.428	0.7

2.4 Volume analysis

Volume analysis was done by calculating the volume of the mix (table 6). The initial height of the mix in the mould was noted and the height of the expanded mix after a period of 15 minutes was noted. The initial and the final volume was calculated using the formula ΠD2h/4

Table 6. Volume increase data sheet

Trial No	W/C Ratio	Volume(cm3)		Increase in Vol (cm3)
		Initial	After 15mins	
M1	0.68	512	708.25	196.25
M2	0.75	512	786.75	274.75
M3	0.65	512	669.75	157.75
M4	0.7	512	800.9	288.9
M5	0.8	512	810.7	298.7
M6	0.85	512	792.55	280.55

2.5 Preparation of test specimen

All the Test specimens were cubes of size 700 x 700 x 700mm cast in steel moulds. The cubes were kept for a period of 15 minutes under conditions of normal room temperature and demoulded (Figure 1). They are subjected to steam curing and drying.

Figure 1. Cubes after Demoulding

2.6 Steam curing process

The autoclaving process can be done in a simple steam curing chamber as the temperature and pressure requirements are low in case of our mix ratio obtained. The temperature is set to 150°C and pressure to 14 bars. The temperature increases from an initial value of 40°C and as it increases, the required pressure value is attained. The cubes are kept for a period of 2hrs after which they are removed and kept for a period of 3 days for drying after which they are used for construction purposes.

3. RESULT AND DISCUSSION

Based upon the comparative study conducted the ratio M1, M2 and M4 were adopted for further testing processes as they are volume increase is substantial, mouldable, consistent, stable after cutting. The ratio M5 and M6 were found to be very soft after demoulding due to which arises difficulty in subjecting them for further test. The ratio M3 has less volume increase due to which it was not selected. There were three samples of M1, M2 and M4 each for testing and the results would be taken as the average of the three specimens of each mix. From the comparison of all the activity M4 was found to be the richest mix design.

Table 7. Density and Compressive Strength

MIX	Density (kg/m3)	Compressive Strength (Mpa)
M1	1074	5.98
M2	1100.9	6.34
M4	1141	6.78

The steam curing process adopted for our mix is energy efficient when compared to the conventional method because the pressure and temperature involved is comparatively less, the time period of steam curing is less and raw materials used are cheaper. Aluminium powder induces expansion and increased aluminium powder in the mix increases expansion but reduces the stability. Increase in W/c ratio induces heavy expansion upto a certain limit after which the expansion reduces due to the excessive slurry form of the mix. Temperature conditions during mixing plays a crucial role in determining the water content for the mix. Hydrogen peroxide brings about uniform cellular spaces in the concrete. Water demand in concrete increases with increase in ecosand. Steam curing increases the compressive strength of concrete.

4. CONCLUSION

Autoclaved concrete can be utilized as a normal concrete replacement structure shield. Aerated, concrete and autoclaved lightweight aggregate concrete also can be use as energy absorbent. The homogenized microstructure of aerated concrete component and air-void entrapment in cement is good energy absorption. Autoclaved aggregate concrete, it depends on the materials used, hence improve the strength to prevent local damage caused by ballistic loading also to absorb energy. Autoclaved concrete can develop to be high strength concrete and good absorbability of impact energy. It has a lower modulus of elasticity and higher tensile strain capacity further provides better impact resistance than normal weight concrete. In recommendation, more research is required if the capabilities of the material are to be exploited and utilization the reinforcement for enhance the tensile strain capacity of concrete.

5. REFERENCES

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