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# AN EXPERIMENTAL STUDY ON FIBER REINFORCED AERATED BLOCKS USING CERAMIC WASTE

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**Abstract -** *This experimental study deals with the effect of ceramic waste powder on Aerated cement block by using polypropylene fiber as an additive. Ceramic waste is used as a partial replacement for fly ash in varying percentage in order to utilize waste and create eco-friendly environment. In this study the compressive strength has been tested for the aerated blocks by curing these blocks by different methods like autoclaving, water curing and applying curing compound. This compressive strength is compared with each other and with the standard value. The usage of the aerated block is cost effective and reduces up to 20% of dead load of wall on beams and makes the structure lighter. Aerated blocks have many benefits on structures like sound and heat insulation, fire resistance, faster and easy construction. In this study the highest compressive strength is obtained for 20% replacement of ceramic waste to fly ash in all types of curing. And it was concluded that autoclave curing gives early and better strength than the other types of curing.*

***Key Words*: Autoclaved aerated block, Polypropylene fibre, Ceramic waste, Aluminium Powder, Compressive strength.**

## 1. INTRODUCTION

### 1.1 General

The manufacturing of ceramic tile and sanitary ware has an high environmental issue and causes emission of harmful green house gases and leads to production of solid waste. About 100 million tones of ceramic waste is generated per year in India and requires large area for disposal which causes dumping problem and pollution to environment. In order to overcome this problem and to create eco-friendly environment the ceramic waste is used as an raw material in the manufacture of aerated block. As the ceramic waste is hard, durable, high resistant to physical, chemical and biological degradation forces and also offers cost reduction and energy saving.

The aerated block has many advantages regarding mechanical properties, but due to its brittle behavior it has many disadvantages. In order to overcome these problems and to increase the flexible property polypropylene fibers are used to manufacture aerated block. The usage of polypropylene fibers increases the tensile capacity, load carrying capacity and crack arresting capacity of the aerated block. They also reduce shrinkage crack area due to their flexibility and avoid flow of water through aerated block.

Aerated concrete is a lightweight, noncombustible cement based material, manufactured from a mixture of Portland cement, fly ash, quick lime, gypsum, water and aluminum powder. Along with these materials we are using ceramic waste as a partial replacement for fly ash in order to minimize the disposal problem and to create ecofriendly environment. Polypropylene fibers are used to reduce the shrinkage cracks which may occur when the concrete surface is allowed to dry. Their ability to reduce bleed and segregation helps to maintain original water/cement ratio of mortar. This leads to improvement in surface layer so resistance to abrasion can be increased. It helps to distribute stress effectively and ability to resist the frost action can be increased.

### 1.2 Aim and Objective

The aim of the work is to study the usage of polypropylene fiber as additive and the effects on properties of aerated block due to the use of ceramic waste along with fly ash and comparing strength for different method of curing.

- In order to achieve light weight block with low density.
- In order to get high degree of thermal insulation and use of waste materials like ceramic waste to create eco-friendly environment.
- To compare the compressive strength of blocks by different curing methods
- To get good strength and resistance to cracking by using polypropylene fibers.

By using the materials like Fly ash and waste Ceramics can save the dumping space and disposal problem and keep the environment clean

## 2. MATERIALS

**a) Cement:** Ordinary Portland cement of 53 grade is used. The physical properties of cement as obtained from various tests.

**Table -1:** Properties of Cement

| SL NO | Properties | Values |
|---|---|---|
| 1 | Standard consistency | 30% |
| 2 | Initial setting time | 45 Min |
| 3 | Final setting time | 290 Min |
| 4 | Specific gravity | 3.16 |

**b) Ground Granulated Blast Furnace Slag (GGBS):** A cementitious material obtained by Quenching iron slag from blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into fine powder.

**Table -2:** Properties of GGBS

| SL NO | Properties | Values |
|---|---|---|
| 1 | Specific gravity | 2.85 |

**c) Lime:** The lime obtained from calcinations process of lime stone is used. It is also known as burnt lime or quick lime.

**Table -3:** Properties of Lime

| SL NO | Properties | Values |
|---|---|---|
| 1 | Specific gravity | 2.71 |
| 2 | Lime slaking test | Temp in 10min 30-40ºc |
| 3 | Sieve test through 106µ | Min 80% |

**d) Gypsum:** Gypsum is a rock mineral usually found in earth's crust. It acts as a hardening retarder in Portland cement.

**Table -4:** Properties of Gypsum

| SL NO | Properties | Values |
|---|---|---|
| 1 | Specific gravity | 2.25 |
| 2 | Sieve test through 106µ | Min 80% |

**e) Fly ash:** Ash produced from combustion of coal. It is also known as pulverized fuel ash, composed of particulates that are driven out of coal-fired boiler together with fuel gases.

**Table -5:** Properties of Fly ash

| SL NO | Properties | Values |
|---|---|---|
| 1 | Specific gravity | 2.5 |

**f) Aluminum Powder:** It is a finely divided aluminum. It is used as a foaming agent, added to create hydrogen bubbles in the mix which increases the volume of the block.

**f) Ceramic Waste Powder:** Ceramic waste is a crushed tiles powder obtained by crushing the waste ceramic tiles in order to reduce the disposal problems and to create eco-friendly environment.

**Table -6:** Properties of Ceramic Waste Powder

| SL NO | Properties | Values |
|---|---|---|
| 1 | Specific gravity | 2.3 |

**Table -7:** Chemical Composition Ceramic Waste Powder

| SL NO | Oxides | Wt. (%) |
|---|---|---|
| 1 | $SiO_2$ | 67.35 |
| 2 | $Al_2O_3$ | 19.79 |
| 3 | $Fe_2O_3$ | 2.52 |
| 4 | $Na_2O$ | 0.15 |
| 5 | $K_2O$ | 4.13 |
| 6 | $TiO_2$ | 0.92 |
| 7 | MgO | 2.0 |
| 8 | CaO | 2.32 |

**g) Polypropylene Fibers:** Synthetic material used as secondary reinforcement used to reduce the shrinkage cracks which may occur when the concrete surface is allowed to dry rapidly.

**h) Mapecure ASW:** It is a liquid substance that is added as a surface coating on freshly installed blocks. It is used to reduce the loss of water or heat in order to create ideal condition.

## 3. METHODOLOGY

### 3.1 Flow Chart of Manufacturing Process

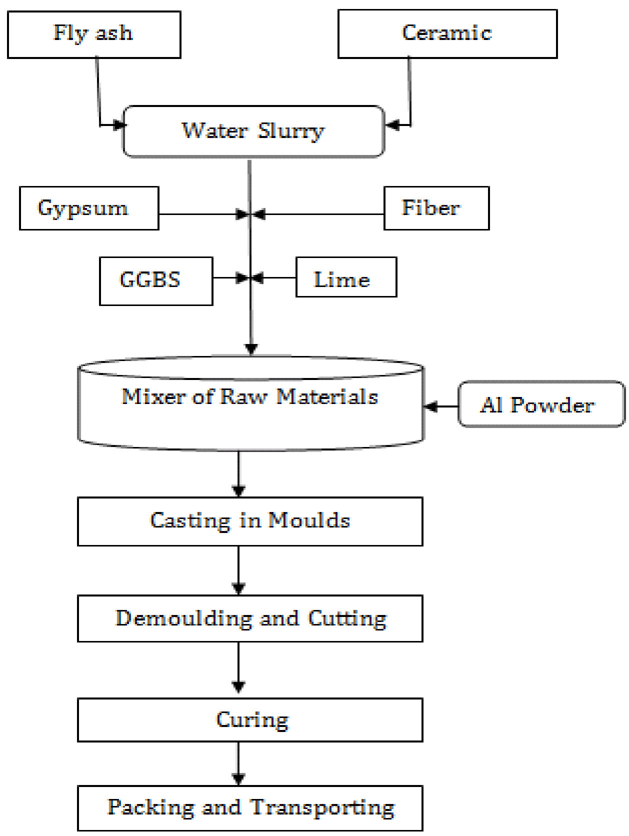


**Fig -1**: Flow Chart

### 3.2 Manufacturing Process

- **Mixing of raw materials**

  - Fly ash and ceramic waste slurry is prepared by maintaining a liter by weight of 1.550kg/liter.

- The remaining materials cement, Lime, GGBS, Gypsum and Polypropylene fibers are added to the slurry and mixed until uniform consistency is obtained.

- The consistency is obtained by maintaining 20cm Diameter in flow test apparatus.

- **Addition of expansion of agent**

Aluminum powder is added which reacts with the silica, resulting in the formation of millions of microscopic hydrogen bubbles. The hydrogen bubbles cause the mix to expand than its original volume.

- **Pre-curing and cutting**

Pre-curing process starts after mix is poured into metal moulds to reach its shape and after this cutting will be done using wire cutter.

- **Curing Process**

The curing is done by three methods

**1. Autoclaving:** Autoclave is done in strong pressurized and steam heated vessel maintaining temperature of 190◦C and essential pressure of 10 to12 atm and this process should be continued up to 12hrs to provide proper condition for hydration.

**2. Water Curing:** The blocks are cured by submerging in water for 28days.

**3. Curing Compound:** After demoulding the coat of curing compound is applied on blocks and kept until 28days.

## 4. MIX PROPORTION AND TESTS

### 4.1 Mix Proportion

The mix is composed of OPC, Fly ash, Lime, Gypsum, GGBS and Water. The fly ash is partially replaced by ceramic waste powder at various percentages of 10, 15, 20 and 25%. The polypropylene fibers are added at 0.3% by weight of cementitious materials (cement and GGBS). Aluminum powder is also added to the mix. The mix proportion is as shown in the Table-8. Firstly the fly ash and ceramic waste slurry is prepared by maintaining liter by weight of 1.550kg/liter and the remaining dry materials are mixed with the slurry for 3-4 minutes. Then the aluminum powder is added to the mix and mixed for about 20 seconds. Then the mix is poured into mould of size 150x150x150mm and mould is kept for hardening at room temperature for 4hrs before Autoclaving and for about 24hrs before water curing and application of curing compound.

**Table -8:** The Mix Proportions for a cube size of 150x150x150mm

| SL NO | Materials | Quantity in gms |
|---|---|---|
| 1 | Fly ash Slurry | 2570 |
| 2 | Cement | 325 |
| 3 | GGBS | 49.7 |
| 4 | Lime | 77 |
| 5 | Gypsum | 13.7 |
| 6 | Polypropylene Fibers | 0.3%(Cement+GGBS) |
| 7 | Aluminum Powder | 1.16 |

### 4.2 Curing of Specimens

The demoulded specimens were cured by three different methods. They are, Autoclaving for 12hrs. Water Curing and by applying Curing Compound for 28days.

### 4.3 Testing of Specimens

Compressive strength is tested for specimen which is a cube of size 150x150x150mm and tested at the period of 3,7,14 and 28days.

#### 4.3.1 Compressive Strength Test

The specimens of size 150x150x150mm was tested in 500KN capacity compression testing machine and the compressive strength is calculated by using the formula,

**Compressive Strength=P/A**

Where Compressive Strength is in C

P = Maximum Load in KN

A = Cross sectional area in $mm^2$

The graphs i.e chart1, chart2 and chart3 are plotted with Ceramic Waste % along X-axis and Compressive Strength in $N/mm^2$ along Y-axis.

1. The Compressive Strength of Autoclave curing for various proportions is given in Table 9

**Table -9**

| Mix Proportions | Compressive Strength in $N/mm^2$ | | | |
|---|---|---|---|---|
| | 3days | 7days | 14days | 28days |
| 10% | 3.2 | 3.2 | 3.2 | 3.3 |
| 15% | 3.5 | 3.5 | 3.5 | 3.6 |
| 20% | 4.1 | 4.1 | 4.1 | 4.2 |
| 25% | 3.8 | 3.8 | 3.9 | 3.9 |

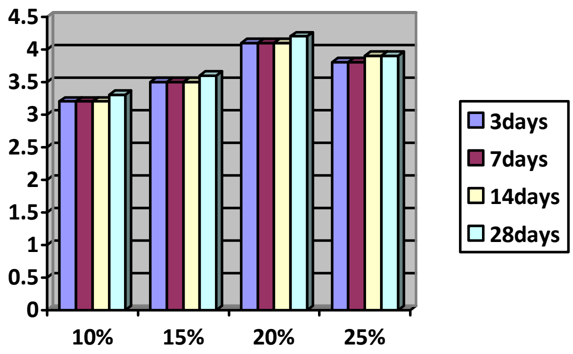


**Chart -1**: Graph of Autoclave

2. The Compressive Strength of Water Curing for various proportions is given is Table 10

**Table -10**

| Mix Proportions | Compressive Strength in N/mm² | | | |
|---|---|---|---|---|
| | 3days | 7days | 14days | 28days |
| 10% | 0.3 | 1.0 | 1.6 | 1.9 |
| 15% | 0.3 | 0.9 | 1.8 | 2.3 |
| 20% | 0.4 | 1.2 | 2.0 | 2.6 |
| 25% | 0.3 | 1.1 | 1.6 | 2.0 |

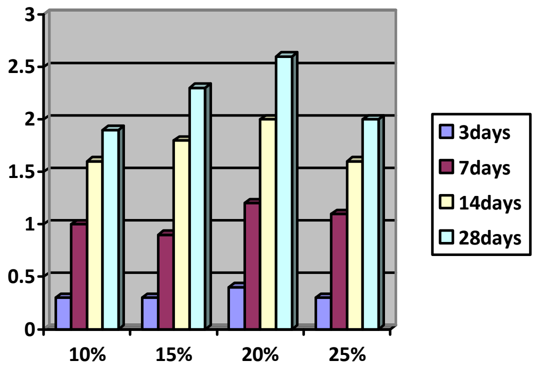


**Chart -2**: Graph of water Curing

3. The Compressive Strength of Curing Compound for various proportions is given is Table 11

**Table -11**

| Mix Proportions | Compressive Strength in N/mm² | | | |
|---|---|---|---|---|
| | 3days | 7days | 14days | 28days |
| 10% | 0.4 | 0.8 | 1.2 | 1.9 |
| 15% | 0.4 | 0.9 | 1.2 | 2.1 |
| 20% | 0.3 | 0.9 | 1.3 | 2.3 |
| 25% | 0.3 | 0.9 | 1.2 | 2.0 |

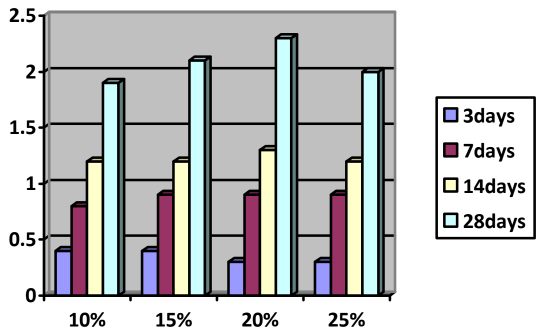


**Chart -3**: Graph of Curing Compound

## 5. CONCLUSIONS

- ✓ As per IS 2185 part 3 the compressive strength of autoclave block should be 3.5-4, We have got highest strength of 4.2Mpa for 20% replacement.
- ✓ Compressive strength of autoclave aerated block is much higher than that of aerated block cured by water and curing compound.
- ✓ Highest compressive strength is obtained for 20% replacement of ceramic waste for all types of curing.
- ✓ There is very slight variation in compressive strength of autoclave block for 3,7,14 and 28days.
- ✓ Expected strength is achieved for autoclave block within 3 days itself, where the other curing takes 28days to achieve full strength.
- ✓ Aerated blocks based on fly ash and ceramic waste has better thermal insulation than aerated block based on sand.
- ✓ Autoclave curing gives early and greater strength. Hence it can be preferred.

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