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Non Autoclaved Aerated Concrete (NAAC) Blocks: An Alternative Building Construction Material

Anshul Shrivastava[1], Prof. Archana Tiwari[2]
[1,2]*Civil Engineering Department, Madhav Institute Of Technology & Science, Gwalior, M.P*

Abstract: ***NAAC is the concrete which is light in weight that is used as an alternative construction material in modern world. The purpose of this investigation is to construct NAAC blocks to replace clay bricks in masonry. NAAC is a lighter concrete in weight which is formed by using fly ash, cement, lime, gypsum, aluminum powder and water. Fly ash is a waste material that collects from the coal used thermal power industries that can be utilized in NAAC. Different dosages of aluminium powder (0%,0.04%,0.08%,0.12% and 0.16%) taken by using weight of dry material to design aerated concrete blocks of 70.6mm×70.6mm×70.6mm. Based on in advance investigations and understanding, water to dry substances ratio is taken as 0.65. The dry density, water inclusion and compressive strength of blocks are acquired at various fractions of aluminum powder. Mixing of aluminium powder lessen the weight, density and the compressive force of the blocks. From this research it is determined that, the blocks made with aerated concrete are higher than the conventional clay bricks used in brick masonry as they are lighter in weight and saves natural clay.***

Keywords: Aluminium powder, NAAC, Density, Water absorption, Compressive Strength.

I. INTRODUCTION

Now-a-days aerated concrete is an innovative construction material employ in a construction industry 60% to 80% of its volume contains pore space. The properties like strength, durability, toughness, heat transfer and wetness convey are get affected by the pore dimension and micro structure [3,9]. This porous material will provide high acoustic insulation and thermal insulation functions [5]. However, due to increased pores the compressive strength of cubes reduces. It is low weight than the conventional clay bricks with a dry density ranging between 600 kg/m^3 to 1600 kg/m^3. On the basis of method of curing, aerated concrete can be of two types which are autoclaved aerated concrete (AAC) and non autoclaved aerated concrete (NAAC). In this research, focus has been through on non autoclaved concrete (NAAC) in which water curing of blocks has been done. Non autoclaved aerated concrete can be created either by using foaming agent or by with air entraining mediator. In this research, aluminium powder has been used as an air entraining agent. Aerated concrete is obtained by a chemical reaction that takes place in a fresh mortar. The effect of aluminum powder with the hydroxide of calcium and alkali from cement and lime releases hydrogen, which causes bubbles in the mixture. The bubbles enlarge the mixture and concrete augments. The hardened concrete contains voids left by the reaction. Several investigators have studied the compressive strength and density of Autoclaved Aerated Concrete but there is fewer investigations are done on Non Autoclaved Aerated concrete. S O Rathi, Khandve P. V., have examined the density and compressive strength of aerated concrete blocks. From the experimental results, they have found that the density of AAC blocks ranges from 250 kg/m^3 to 1800 kg/m^3 as compared to 2500 kg/m^3 for conventional concrete and the compressive strength of 2.86 MPa has been achieved on 650 kg/m^3 density. Radhika Shukla, have compared the burnt clay bricks with aerated concrete blocks. The results shows that compressive strength of aerated blocks is 3-4 MPa, dry density of blocks ranging between 600 kg/m^3 to 800 kg/m^3, and fire resistance for blocks are 7 hours ,which are better than burnt clay bricks. Desani Parth, Soni Mansi Et al., have examined the mechanical functions of aerated autoclaved concrete cubes and they have concluded that compressive strength of Aerated Autoclaved Concrete is between 3-4 MPa and dry density ranges between 600 kg/m^3 to 800 kg/m^3. Begum Razia, Habib Ehsaan Et al., studied the effect of rice husk on Non Autoclaved Aerated concrete. At 30% RHA and 70% OPC, the compressive strength is found 3.87 MPa at 21 days, density is about 570kg/m^3 and water absorption is 39 %.

II. NEED

Now-a-days, the demand for construction material is continuously increasing with the increase in buildings for housing and commercial purposes in both urban and rural areas. The resources used to manufacture large amount of construction materials have the adverse effect on environment and human health by depleting the natural resources, using energy and creating pollution. These NAAC blocks developed by using fly ash will helps in reducing the problem of disposing fly ash.

Further, these light weight aerated concrete blocks helps in easy transport and faster construction and reduction in dead load. NAAC is a green building material, possess excellent thermal insulating properties, good sound absorber and can also be used as a decorative material [6].

III. MATERIALS USED

The following raw materials are used in the manufacturing of NAAC blocks-

A. Cement

Cement is used as a binding material in NAAC blocks. Ordinary Portland Cement (Ultratech) of 43 grade is used in the production process. Cement of this grade is available in local market.

Table 1. Properties of cement

|S. No.	Physical property	Results
1.	Specific gravity	3.11
2.	Initial setting time	90 minutes
3.	Final setting time	150 minutes
4.	Fineness	2 %

B. Fly Ash

Fly ash used in this experiment is taken from the Parichha thermal power plant, Jhansi, U.P.

Table 2. Properties of Fly ash

S. No.	Physical property	Results
1.	Specific gravity	2.34
2.	Bulk density	1.12 gm/cc

C. Quicklim

Quick lime are obtained by calcining limestone at temperatures above 900°C.Quicklime taken for this research is taken from INDUS MINERAL PRODUCTS OF INDIA, KATNI, M.P.

D. Gypsum

Gypsum ($CaSO_4.2H_2O$) is easily available in market and used in powder form.

Table 3. Properties of Gypsum

S No.	Physical property	Results
1.	Specific Gravity	2.32

E. Aluminium Powder

A fine grey colour, uniform, smooth metallic powder available in market is used in this experimental process, having a molecular weight 26.98.

F. Water

Water is an important constituent that helps in chemical reaction. Potable water is used in this process.

IV. METHODOLOGY

A. Quantities of Materials

Following mixing materials are taken which are listed in table below.

Table 4. Quantities of materials in percentage

Sample Designation	Cement	Fly Ash	Quicklime	Gypsum	Al. powder	Water/dry material
SC	40	50	7	3	0	65
S1	40	50	7	3	0.04	65
S2	40	50	7	3	0.08	65
S3	40	50	7	3	0.12	65
S4	40	50	7	3	0.16	65

B. Mixing

All materials are weighed properly as per the requirement of mix design. Water is heated upto 70^0c to make the end temperature of mixing upto 40^0c for the chemical reaction of aluminium powder with other materials. Quantity of water is taken as 0.65 times of weight of dry material. First, The slurry is formed by mixing fly ash with water for 3-4 minutes in a container. On the other hand , remaining dry materials i.e Cement, Lime, Gypsum and Aluminium powder is properly mixed in dry form. Dry material is then mixed with slurry and keeps on stirring for 2-3 minutes.

C. Moulding

Oil is applied in 70.6mm*70.6mm*70.6mm cube moulds and the mixture is poured in the moulds. Mould is filled upto two third of the total height. It was observed that the concrete expanded and filled the completely.

D. Curing

Cubes are demoulded after 24 hours. Cubes are kept in air for two hours at room temperature for drying. Curing was done by immersing the cubes in water at room temperature for 7 days, 14 days and 21 days.

V. RESULTS

After completing the curing , the density, Water absorption and Compressive Strength of cubes are obtained at different stages of curing.

A. Water Absorption Analysis

The cubes are placed in water for 24 hours. After that, Remove the cube from water and wipe out the traces of water with cloth and weigh the cube. Then, dry the cube in oven for 24 hours and weigh it. Max. Permissible Water absorption is 40%. .Water absorption test of NAAC blocks are shown in following table 5.

Table 5. Water absorption test

Samples	Water Absorption (%)	Result
SC	6.12	Satisfied
S1	30.64	Satisfied
S2	36.84	Satisfied
S3	43.13	Unsatisfied
S4	44.68	Unsatisfied

B. Expansion in volume

Expansion in volume of cubes with respect to SC sample.

Table 6. Expansion in volume

Sample	Volume increase
S1	36.80 %
S2	41.82 %
S3	48.00 %
S4	52.04 %

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C. Variation of Density

The density of the NAAC blocks varied with aluminium powder content. It decreased significantly from 1392.45 kg/m3 at 0% to 667.81 kg/m3 at 0.16% and these results are shown in Fig1. With increasing aluminium powder content, the density of the non autoclaved aerated concrete gradually decreases due to increase in pores formed.

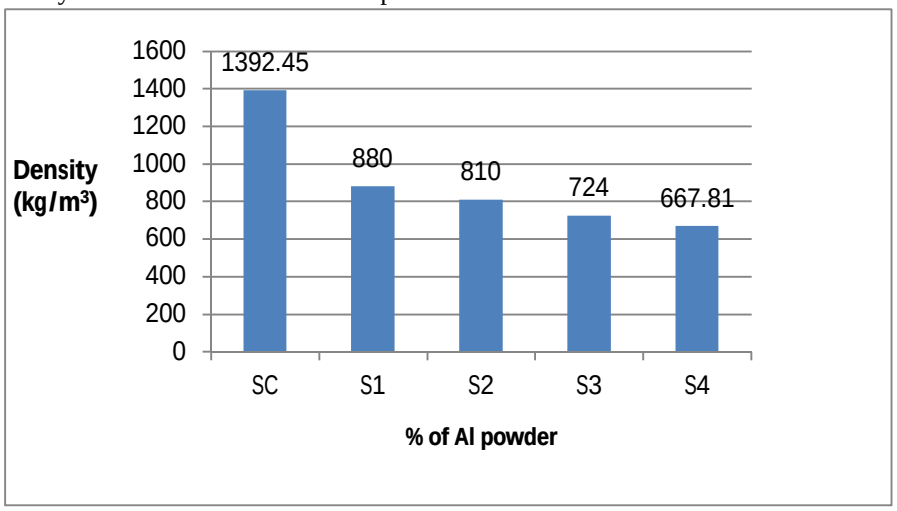

Figure 1. Density variation of blocks

D. Compressive Strength Test

This test is performed by compressive testing machine. The compressive strength of NAAC blocks was obtained at the age of 7 days, 14 days and 21 days. The results of the tests are shown below:

Table 7. Compressive strength

Sample	Compressive strength in N/mm²		
	7 days	14 days	21 days
SC	4.00	6.70	10.32
S1	1.84	2.97	4.48
S2	1.63	2.38	3.75
S3	1.10	1.86	2.90
S4	0.80	1.3	2.08

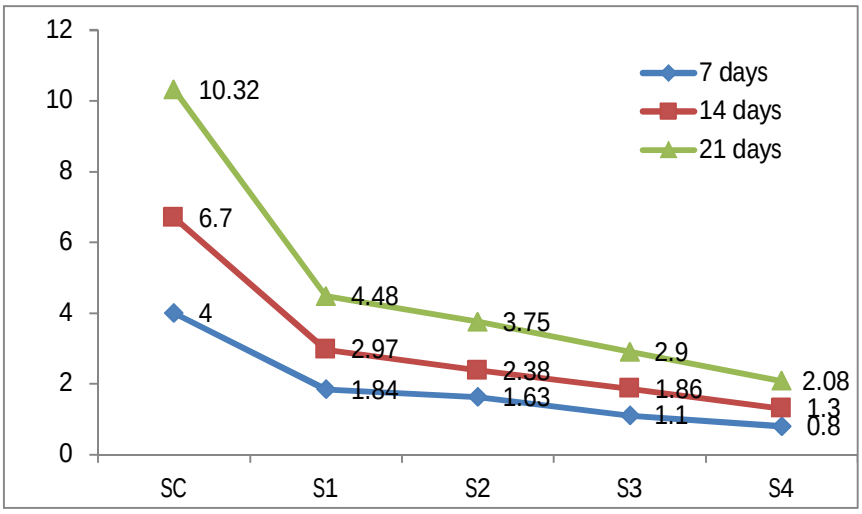

Figure 2. Compressive strength of NAAC blocks

E. Cost Analysis

Cost analysis is done by considering the cost of materials only. NAAC blocks gives equal and better results than conventional clay bricks**.** The cost of NAAC blocks are shown in following table:

Table 8. Cost analysis

S. No.	Material	Rate (Rs)	SC	S1	S2	S3	S4
1.	Cement	300/50 Kg	2340	1478.88	1361.4	1216.8	1121
2.	Fly ash	0.4 /Kg	194	123.2	113.3	101.29	93.38
3.	Lime	1.5/Kg	102	65	59.3	53.04	48.81
4.	Gypsum	1.1/Kg	32.175	20.306	18.7	16.73	15.55
5.	Aluminum Powder	200/Kg	0	49.29	90	121.4	149.4
6.	Water	0	0	0	0	0	0
Total (Rs)			2668.175	1736.67	1642.7	1509.26	1428.14
Per Brick Cost (Rs)			4.72	3.07	2.90	2.67	2.53

VI. CONCLUSIONS

The following conclusions are drawn from this experimental work

A. Water absorption of NAAC blocks increases with the increase in aluminium powder from 0.04% to 0.16% respectively.
B. Samples S1 and S2 gives water absorption less than 40%, which is acceptable for light weight concrete.
C. NAAC blocks are lighter than conventional clay bricks.
D. The density of material decreases with increase in quantity of aluminium powder. Density decreases between the range of 512 Kg/m^3 to 725 Kg/m^3 from sample S1 to S4.
E. S1 and S2 samples of NAAC blocks have a compressive strength 4.48 N/mm^2 and 3.75 N/mm^2 respectively, which is more than the strength of third class bricks.

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