Comparative Analysis of Modified Aerated Concrete Blocks and Conventional Fired Clay Bricks

Varun Kumra[1], Dr. Hemant Sood[2]

[1]M. tech student, National Institute of Technical Teachers Training & Research, Chandigarh
[2]Professor, Department of Civil Engineering, NITTTR Chandigarh

---***---

Abstract - *Today's most popular building material, concrete, is also the subject of most civil engineering studies. It has applications not just in building construction but also in all the structures created to support loads in some form. Even after years of study on this material, many researchers believe that our understanding of concrete is incomplete, and there are still many associated challenges; thus, the research should continue. One such issue is its weight, which prevents it from being used as a masonry unit when produced conventionally. This study is a small step towards the larger objective of creating a form of concrete that may effectively replace bricks as a masonry unit whose production results in significant carbon emissions during their burning stage.*

Key Words: **Aerated Concrete, Modified Aerated Concrete, Embodied Energy, Aerating Agent, Autoclaving, Compressive Strength, Lightweight Concrete**

1. INTRODUCTION

Numerous attempts have been made to make the concrete lighter. A few methods found to do so are:

i) By replacing conventional aggregates with by cellular, porous, or light weight aggregates.
ii) By omitting sand fraction from aggregates to make 'no fines concrete'.
iii) <u>By introducing air bubbles in mortar to make **'aerated concrete'.**</u>

The techniques mentioned above can produce lightweight concrete with a density of 300 and 1,850 kg/m^3; however, the drawback of this type of concrete is that its strength is much less than that of concrete manufactured using the typical technique. This study involves the testing of '**modified aerated concrete'** to make concrete lighter without significantly reducing its strength.

Normally, aerated concrete is made by introducing air bubbles into a slurry composed of cement and sand mixed in water by adding an air entraining agent. The concrete produced is autoclaved to enhance its dimensional stability and make the strength-gaining process quick, thus giving it another name - autoclaved aerated concrete (AAC).

For this study, coarse aggregates were added to aerated concrete replacing 5% of the sand in the, which is then cured conventionally for 28 days. Autoclaving is not performed, as is common with aerated concrete, thus referring to it as modified aerated concrete.

The following materials were used in the study:

- Two different aerating agents: Aluminum Oxide (Al_2O_3) and Zinc Oxide (ZnO) added 0.4%, 0.5%, 0.6% and 0.7% by weight of binding materials.
- Coarse aggregates of following two sizes replacing 5% sand by weight:
  - 10 mm graded aggregates
  - 12.5 mm graded aggregates
- Grade 53 cement of two different brands:
  - Cement A
  - Cement B

2. OBJECTIVE

The research was conducted to determine the optimal mix of cement, sand, coarse aggregates, and aerating agent to produce masonry blocks comparable or superior to first-class bricks in terms of density, compressive strength, and water absorption.

3. METHODOLOGY

The stepwise procedure followed to meet the objective is as written below:

i) **Reference Design:** From the studies conducted on autoclaved aerated concrete so far, 1 part of cement, 0.11 parts of lime, 1.11 parts of sand and water to binder ratio 0.5 with aerating agent dosage of 0.5% by wight of binder was found to be its most optimal design. *[5]*

ii) **Mould Formation:** For casting, 23 cm x 11.4 cm x 7.6 cm wooden molds were made.

iii) **Reference Cubes:** 24 reference cubes were cast using the reference design mentioned in step 1 with different cement types and aerating agents listed in the Table 1 below.

iv) **Test Cubes:** 5% of sand was replaced with coarse aggregates in the reference design. A total of 192 cubes, 6 each of 32 distinct combinations of various components and proportions, as mentioned in Table 2 below were cast.

Table -1: Combinations of air entraining agents and cement types used in the reference cubes.

Sr. No.	Air Entraining Agent	Cement Type	Count of Cubes
1	Aluminium Oxide	Cement A	6
2	Aluminium Oxide	Cement B	6
3	Zinc Oxide	Cement A	6
4	Zinc Oxide	Cement B	6

Table -2: Combinations of air entraining agents, cement types and aggregate types used in the test (main) cubes.

Sr. No.	Air entraining agent (% by wt. of binding material)	Cement Type	Size of Coarse aggregates (mm)
1	Aluminium Oxide (04)	Cement A	12.5
2	Aluminium Oxide (0.5)	Cement A	12.5
3	Aluminium Oxide (0.6)	Cement A	12.5
4	Aluminium Oxide (0.7)	Cement A	12.5
5	Aluminium Oxide (0.4)	Cement A	10
6	Aluminium Oxide (0.5)	Cement A	10
7	Aluminium Oxide (0.6)	Cement A	10
8	Aluminium Oxide (0.7)	Cement A	10
9	Zinc Oxide (0.4)	Cement A	12.5
10	Zinc Oxide (0.5)	Cement A	12.5
11	Zinc Oxide (0.6)	Cement A	12.5
12	Zinc Oxide (0.7)	Cement A	12.5
13	Zinc Oxide (0.4)	Cement A	10
14	Zinc Oxide (0.5)	Cement A	10
15	Zinc Oxide (0.6)	Cement A	10
16	Zinc Oxide (0.7)	Cement A	10
17	Aluminium Oxide (0.4)	Cement B	12.5
18	Aluminium Oxide (0.5)	Cement B	12.5
19	Aluminium Oxide (0.6)	Cement B	12.5
20	Aluminium Oxide (0.7)	Cement B	12.5
21	Aluminium Oxide (0.4)	Cement B	10
22	Aluminium Oxide (0.5)	Cement B	10
23	Aluminium Oxide (0.6)	Cement B	10
24	Aluminium Oxide (0.7)	Cement B	10
25	Zinc Oxide (0.4)	Cement B	12.5
26	Zinc Oxide (0.5)	Cement B	12.5
27	Zinc Oxide (0.6)	Cement B	12.5
28	Zinc Oxide (0.7)	Cement B	12.5
29	Zinc Oxide (0.4)	Cement B	10
30	Zinc Oxide (0.5)	Cement B	10
31	Zinc Oxide (0.6)	Cement B	10
32	Zinc Oxide (0.7)	Cement B	10

Six cubes of each set of materials and composition were cast, two each for compressive strength on the seventh day, compressive strength on the twenty-eighth day, and water absorption & density.

4. RESULT AND ANALYSIS

Following tests were performed on the cubes cast:

i) Water Absorption Test

ii) Compressive Strength Test on 7^{th} and 28^{th} Day

The Inferences from the results obtained are as follows:

i) Much less bulging (aeration) was found than is claimed in most of the research works done so far, which may be because of the following reasons:

a. No autoclaving done:

In almost all the works, the major bulging (aeration) occurred during the autoclaving, suggesting that a significant portion of the reaction between cement and the aerating agent occurred in autoclaves.

b. Inclusion of coarse aggregates:

Only fine aggregates were used in all the works carried out thus far on aerated concrete to keep its weight light. However, in this work, 5% of fine aggregates were replaced with coarse aggregates, making the aeration process difficult.

Also, since lesser aeration took place, more material was required to fill the blocks, increasing the weight.

ii) The best results were obtained at the aerating agent dosage of 0.5% by weight of the binder. [**Error! Reference source not found.**, **Error! Reference**

source not found., **Error! Reference source not found.** & **Error! Reference source not found.**]

iii) Better results were obtained in samples where Al_2O_3 was used as an aerating agent rather than ZnO. [Evident from **Error! Reference source not found.** & **Error! Reference source not found.**]

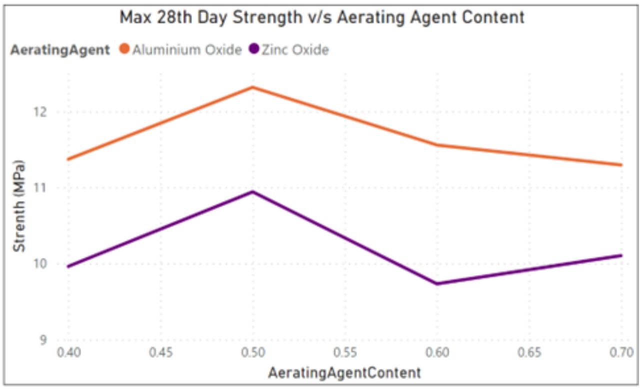

Chart -1: Maximum 28 Day Strength v/s Aerating Agent Content

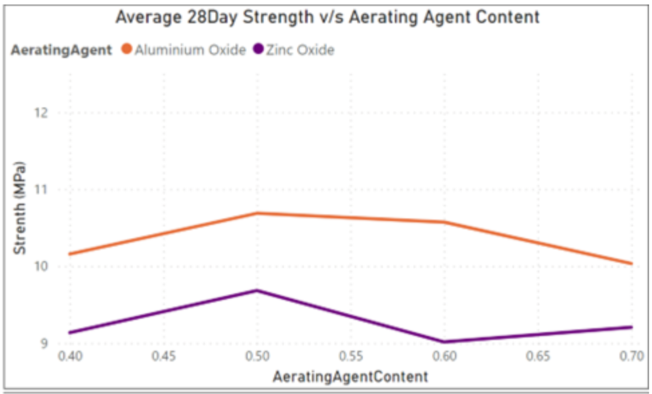

Chart -2: Maximum 28 Day Strength v/s Aerating Agent Content

iv) 12.5 mm aggregates gave a better result in terms of strength, as evident from **Error! Reference source not found.** and **Error! Reference source not found.**.

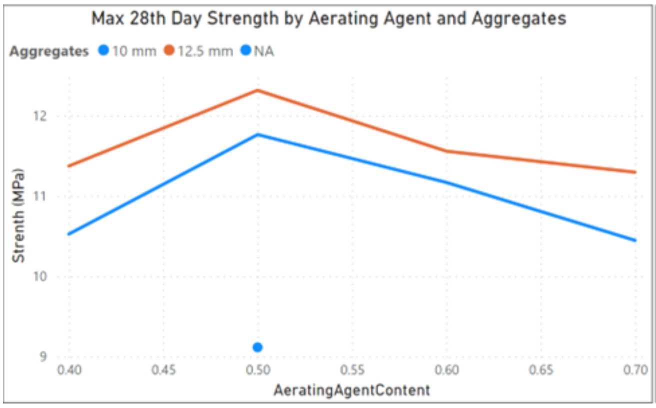

Chart -3: Maximum 28 Day Strength v/s Aggregate Size

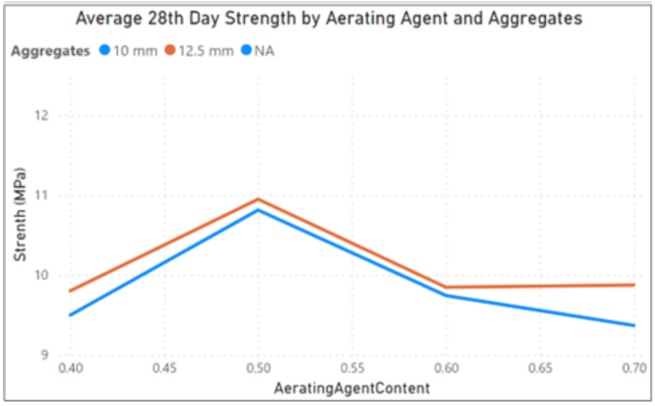

Chart -4: Average 28 Day Strength v/s Aggregate Size

v) Overall, Cement 2 was a better performer in terms of strength, as seen in **Error! Reference source not found.** and **Error! Reference source not found.**. However, slightly higher unit weights are obtained in the samples prepared by it [**Error! Reference source not found.** and **Error! Reference source not found.**].

vi) Mass Decreases with the increased dosage of the aerating agent. However, the least water absorption was found at the dosage of 0.5% by mass of binder, suggesting the best workability and least connected pores [Figure 7, Figure 8, Figure 9 and Figure 10].

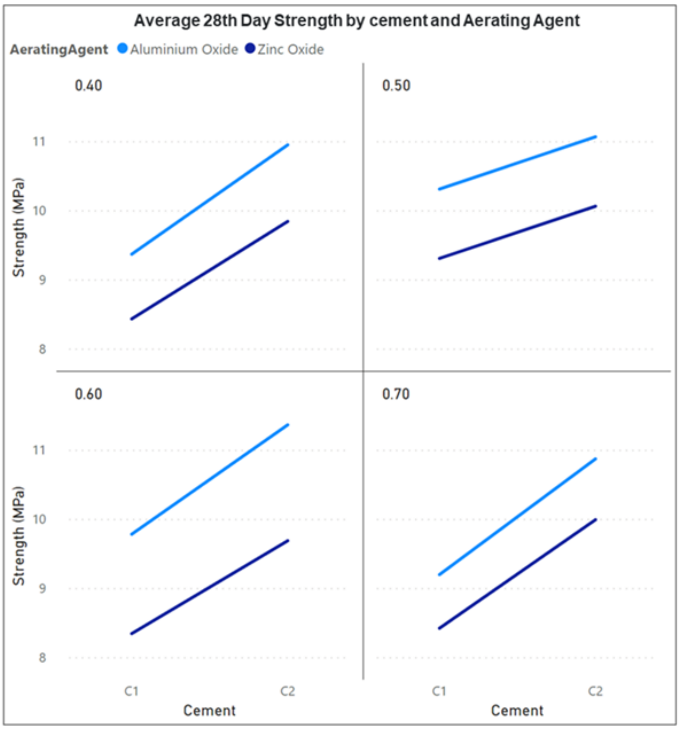

Chart -5: Average 28th Day Strength v/s Aerating Agent Content and Cement Type.

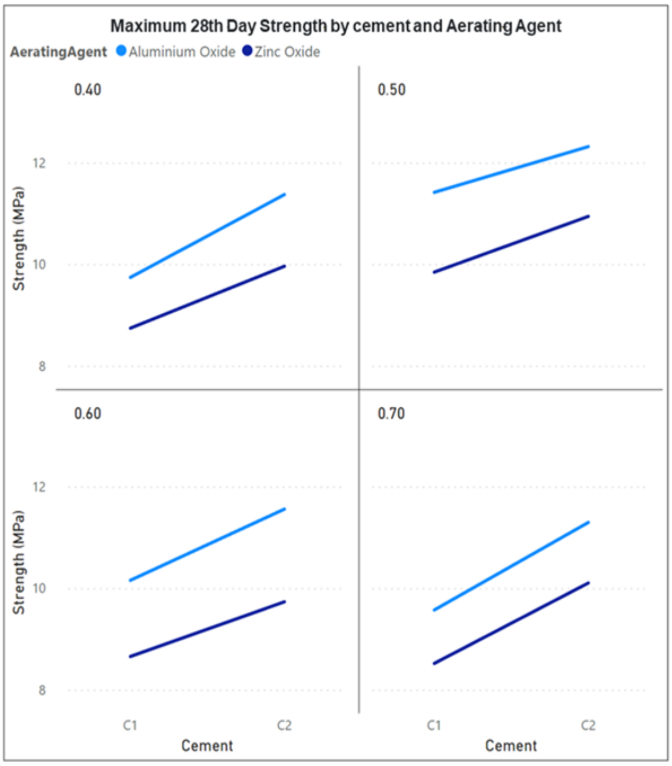

Chart -6: Maximum 28th Day Strength v/s Aerating Agent Content and Cement Type.

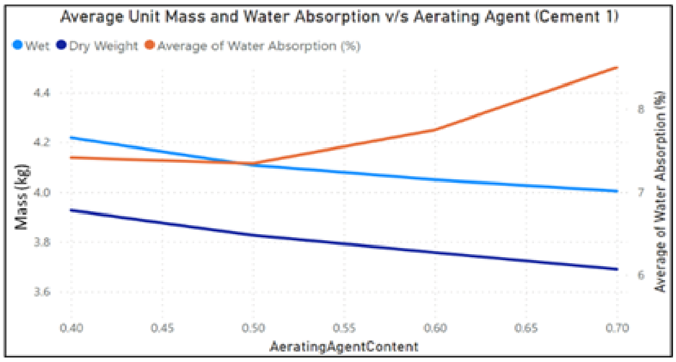

Chart -7: Average Mass and Water Absorption v/s Aerating Agent for Cement A.

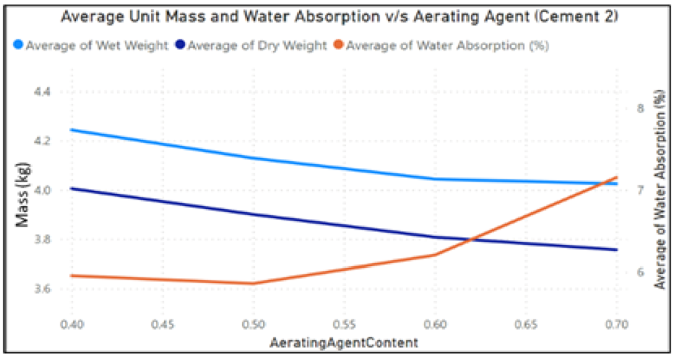

Chart -8: Average Mass and Water Absorption v/s Aerating Agent for Cement B.

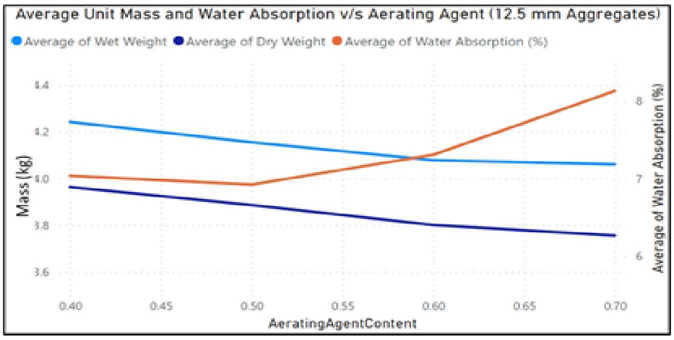

Chart -9: Average Unit Mass and Water Absorption v/s Aerating Agent for 12.5 mm Aggregates.

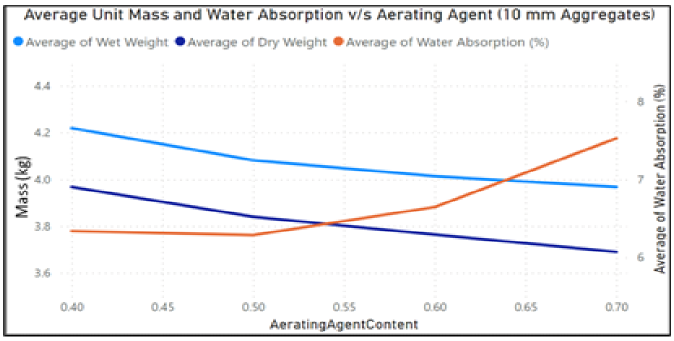

Chart -10: Average Unit Mass and Water Absorption v/s Aerating Agent for 10 mm Aggregates.

5. CONCLUSION

The results discussed and analyzed above suggest that the best strength was found with the combination when aluminium oxide was used at a dosage of 0.5% by weight of the binder, cement-2 with 12.5 mm aggregates replacing 5% of sand.

Although the blocks were found to be effective in terms of strength but were slightly on the heavier side compared to the first-class bricks, which weigh only 3.2 kg, in contrast to the block with the best compressive strength of 12.32 kN, which weighs 4.04 kg. This increased mass is because of two significant reasons mentioned below:

i) Coarse aggregates are added to the concrete.

ii) Normal curing is done in place of autoclaving, leading to the aerating agent's slower and lesser activity, thus decreasing the amount of air entrained in the concrete.

Due to higher unit weight than the bricks, these blocks are currently not fit to be used in load bearing, replacing the bricks as masonry units. However, the potential that these blocks have shown is highly encouraging and thus the study to find improvements in their design should continue.

REFERENCES

[1] Begum, Razia & Habib, Ahsan & Mostafa, Shah. (2014). Effects of Rice Husk Ash on the Non Autoclaved Aerated Concrete. IJEIR. 3. 2277-5668.

[2] Fudge, C., Fouad, F., &Klingner, R. (2019). Autoclaved aerated concrete. Developments In The Formulation And Reinforcement Of Concrete, 345-363. doi: 10.1016/b978-0-08-102616-8.00015-0

[3] Habib, Ahsan & Begum, Ara &Hafiza, Eng. (2015). Study on production of Aerated concrete block in Bangladesh.

[4] He, T., Xu, R., Da, Y., Yang, R., Chen, C., & Liu, Y. (2019). Experimental study of high-performance autoclaved aerated concrete produced with recycled wood fibre and rubber powder. Journal Of Cleaner Production, 234, 559-567. doi: 10.1016/j.jclepro.2019.06.276

[5] Kunchariyakun, K., Asavapisit, S., &Sombatsompop, K. (2015). Properties of autoclaved aerated concrete incorporating rice husk ash as partial replacement for fine aggregate. Cement And Concrete Composites, 55, 11-16. doi: 10.1016/j.cemconcomp.2014.07.021