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# Biochar Aerated Calamus Rotang Block (BAC Block)

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**Abstract -** This study investigates the incorporation of biochar as a cement replacement along with calamus rotang into Autoclaved Aerated Concrete (AAC) blocks. Through a comparative analysis with traditional red bricks and AAC blocks, the project highlights the environmental benefits of BAC (Biochar Aerated Calamus Rotang) blocks, particularly their potential to reduce carbon emissions in the construction industry. A series of experimental studies evaluated the compressive strength, water absorption, density and dry shrinkage test. The results revealed that 1.5% replacement of cement by biochar along with addition of extra 1% calamus rotang shows at most similar properties and value of an AAC block. Thus the findings underscore the importance of exploring alternative materials like BAC blocks to address environmental challenges and promote greener building solutions. Overall, the study advocates for the adoption of BAC blocks as a viable and sustainable option for construction projects, aligning with global efforts toward sustainable development and environmental conservation in the built environment.

**Key Words:** BAC, AAC, Biochar, Calamus rotang, Aluminium powder, Fly ash.

## 1. INTRODUCTION

In the dynamic landscape of construction, sustainability has emerged as a critical consideration, driven by the urgent need to address environmental challenges and mitigate climate change. Our project embarks on a journey to revolutionize traditional building materials by exploring the integration of biochar and calamus rotang powder into Autoclaved Aerated Concrete (AAC) blocks. This innovative approach aims to enhance the sustainability and resilience of construction materials, marking a significant step towards a greener and more environmentally conscious future.

Autoclaved Aerated Concrete (AAC) blocks have gained popularity in construction due to their lightweight nature, thermal insulation properties, and ease of installation. However, concerns persist regarding their environmental impact, particularly in terms of carbon emissions and resource depletion. As advocates for sustainable development, we recognize the imperative to address these challenges and strive to pioneer solutions that align with the principles of environmental stewardship.

Biochar, a carbon-rich material derived from the pyrolysis of biomass, presents a promising avenue for mitigating carbon emissions and enhancing soil fertility. Its incorporation into AAC blocks not only sequesters carbon but also offers the potential to improve the thermal properties and structural integrity of the blocks. Additionally, calamus rotang powder, extracted from the rattan palm, possesses reinforcing properties that can further enhance the strength and durability of construction materials.

Our project sets out to investigate the feasibility and benefits of integrating biochar and calamus rotang powder into AAC block production. Through a combination of literature review, laboratory experimentation, and simulation studies, we aim to assess the impact of these additives on the mechanical properties of BAC (Biochar Aerated Calamus rotang) blocks. By systematically evaluating the potential of biochar-enhanced AAC blocks, or BAC blocks, we seek to pave the way for their widespread adoption in sustainable construction practices.

## 2. EXPERIMENTAL PROGRAM

### *2.1 Materials*

The study includes incorporating sustainable materials like Biochar, calamus rotang along with cement, quick lime, fly ash, aluminium powder in the preparation of AAC block. Biochar is a carbon rich material produced through the pyrolysis of biomass in the absence of oxygen (Typically between $300^0$ C and $800^0$ C). Calmus rotang is a species of climbing palm native to tropical regions of Asia, Africa, and Australia. Calamus rotang powder has emerged as a potential additive in the block preparation offering unique properties that enhance the performance and sustainability. The Ordinary Portland Cement with 53 grade was used. The specific gravity of cement was determined by using Le-Chatelier bottle and the value obtained is 2.6. Quick lime serves as a crucial ingredient that reacts with other material during the process of autoclaving, this reaction forms Calcium Silicate Hydrates, reinforcing the block structure and improving the thermal and mechanical property and it makes the AAC block light weight and durable. Fly Ash is a very good substitute of soil and the presence of the required percentage of silica, aluminium iron oxide etc. is very suitable for the physical and chemical properties of AAC block. Aluminium powder is applied in the block production as a foaming agent, contributing to the creation of light weight and insulating aerated concrete blocks.

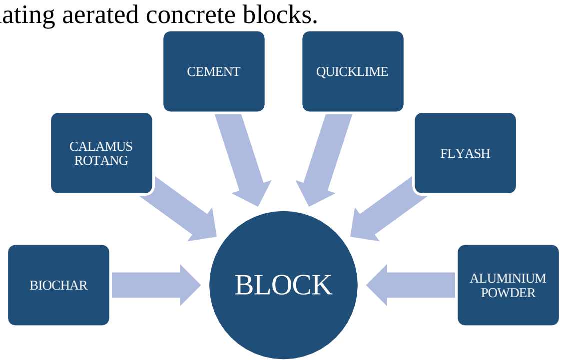



**Fig -1**: Materials

**Fig -2**: Compaction testing machine

*2.2 Methodology*

The methodology worked out to achieve the objectives are discussed below:

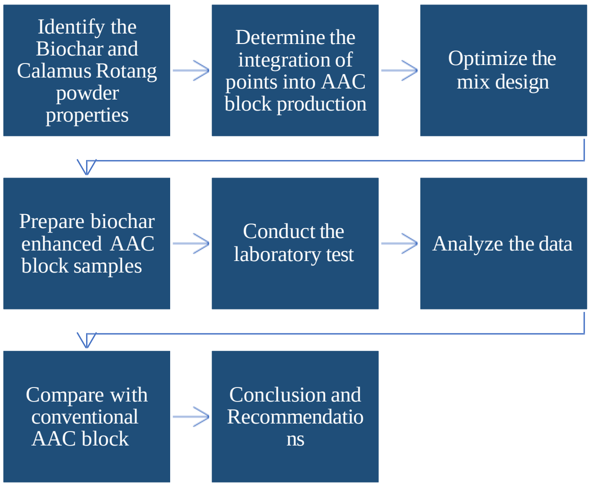



**Fig -3**: Flow Chart of Methodology

- Fly ash quantity 1333 gm and Charcoal quantity 27 gm taken in a bowl and mixed with 1 Liter of water and mixed well.
- Cement quantity 395 gm, Lime quantity 120 gm, and Gypsum quantity 15 gm all are taken and mixed in the first bowl, which is already in the same bowl.
- Add 50 ml water and 1.5 gm aluminum, mix and pour into the same bowl, and after 30 seconds of mixing, immediately pour the material into the mould box (15cm X 15cm X 15cm).
- After 3 to 4 hours later, we remove the mould box and put the cake in the autoclave for curing purposes.

## 3. RESULT AND DISCUSSIONS

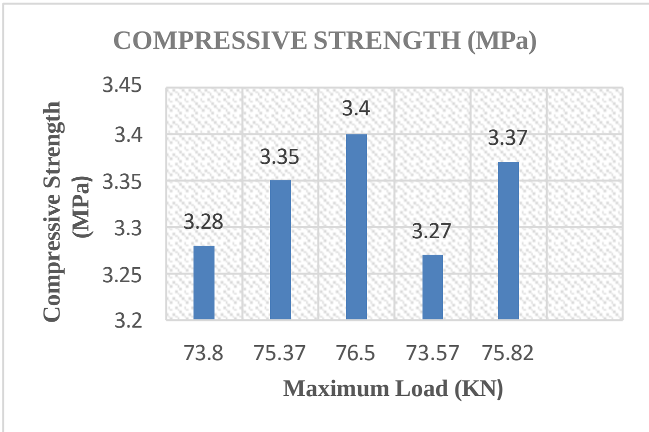
### *3.1 Compressive Strength*

The compressive strength of Biochar aerated calamus rotang block was tested. It is noted that when cement is replaced with 1.5% Biochar and adding extra 1% calamus rotang powder gives significantly good compressive strength after 3 days (sun dried) up to 3.35Mpa and when cement is replaced with 1% Biochar and extra 1% calamus rotang gives additional compressive strength than conventional AAC block up to 3.23 MPa.

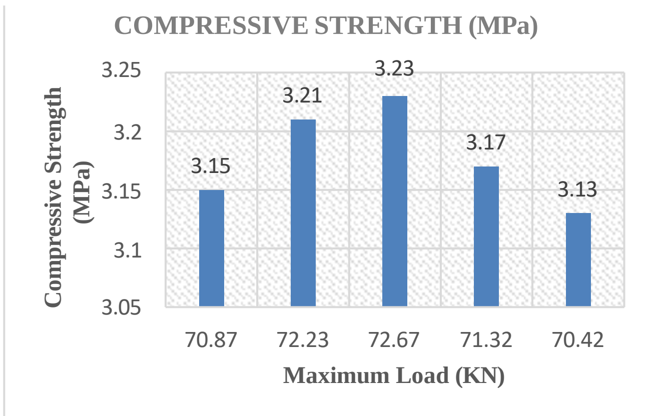
$$\text{CompressiveStrength} = \frac{\text{Load}}{\text{CrossSectionalArea}}$$

a) Replacement of cement with 2% biochar and adding an extra 1% calamus rotang powder to the total volume. Results: - not suitable for test.

b) Replacement of cement with 1.5% biochar and adding an extra 1% calamus rotang powder to the total volume. The result is as follows:




c) Replacement of cement with 1% biochar and adding an extra 1% calamus rotang powder to the total volume. The result is as follows:




### *3.2 Water Absorption*

The procedure for water absorption test is as follows:

- The weight of the block is taken.
- Immerse the block in water for about 24 hours.
- After soaking for 24 hours, surface dry them using a cloth.
- Weigh the block again after surface drying.
- Calculate the water absorption.

$$\text{Water Absorption}(\%) = \frac{(\text{Wet Weight} - \text{Dry Weight})}{\text{Dry Weight}} \times 100$$

Replacement of cement by 2% biochar and adding extra 1% calamus rotang powder to the total volume.

Results: - not suitable for test.

- Replacement of cement by 1.5% biochar and adding extra 1% calamus rotang powder to the total volume. Results are as follows.

**Table -1:** Water absorption test after 1.5% replacement of cement by biochar and adding an extra 1% of calamus rotang.

| Sl. No | Dry Weight (kg) | Wet Weight (kg) | Water Absorption (%) |
|---|---|---|---|
| 1 | 6.8 | 7.487 | 10.18 |
| 2 | 6.95 | 7.657 | 10.24 |
| 3 | 7.03 | 7.743 | 10.13 |

- Replacement of cement with 1% biochar and adding an extra 1% calamus rotang powder to the total volume.

**Table -2:** Water absorption test after 1% replacement of cement by biochar and adding an extra 1% of calamus rotang.

| SI. No | Dry Weight (kg) | Wet Weight (kg) | Water Absorption (%) |
|---|---|---|---|
| 1 | 7.8 | 8.68 | 11.4 |
| 2 | 7.4 | 8.25 | 11.1 |
| 3 | 6.95 | 7.749 | 11.6 |

*3.3 Density test*

The procedure for dry density test is

- Measure the dimension of the block.
- Calculate the volume of the block.
- Weigh the block in a calibrated balance. Record the value.
- Calculate the density of each block.

$$\text{Density} = \frac{\text{mass}}{\text{volume}}$$

Replacement of cement by 2% biochar and adding extra 1% calamus rotang powder to the total volume. Results: - not suitable for test.

Replacement of cement by 1.5% biochar and adding extra 1% calamus rotang powder to the total volume. Results are as follows:

**Table -3:** Water absorption test after 1.5% replacement of cement by biochar and adding an extra 1% of calamus rotang.

| Sl. No | Mass (kg) | Volume ($m^3$) | Density ($kg/m_3$) |
|---|---|---|---|
| 1 | 1.937 | 0.15 x 0.15 x 0.15 | 574.17 |
| 2 | 1.971 | 0.15 x 0.15 x 0.15 | 584.17 |
| 3 | 1.949 | 0.15 x 0.15 x 0.15 | 577.5 |

Replacement of cement by 1% biochar and adding extra 1% calamus rotang powder to the total volume. Results are as follows:

**Table -4:** Water absorption test after 1% replacement of cement by biochar and adding an extra 1% of calamus rotang.

| Sl. No | Mass (kg) | Volume ($m^3$) | Density ($kg/m_3$) |
|---|---|---|---|
| 1 | 2.095 | 0.15 x 0.15 x 0.15 | 620.83 |
| 2 | 2.053 | 0.15 x 0.15 x 0.15 | 608.33 |
| 3 | 1.960 | 0.15 x 0.15 x 0.15 | 580.83 |

*3.4 Dry Shrinkage*

The procedure for dry shrinkage test is as follows:

- Each test block should have a length of 150 mm.
- Cement two steel balls at the centre of each sample.
- Immerse the samples in water for 4 days at 27°C.
- Measure the initial length.
- Dry the samples in an oven for 44 hrs at a specified temperature and humidity.
- Cool the samples in a desiccator for 4 hrs.
- Measure the final length.
- Calculate the dry shrinkage

$$\text{Dry Shrinkage} = \frac{\text{initial length} - \text{final length}}{\text{initial length}} \times 100$$

Replacement of cement by 2% biochar and adding extra 1% calamus rotang powder to the total volume. Results: - not suitable for test.

Replacement of cement by 1.5% biochar and adding extra 1% calamus rotang powder to the total volume. Results are as follows:

**Table -5:** Water absorption test after 1.5% replacement of cement by biochar and adding an extra 1% of calamus rotang.

| Sl. No | Initial length (mm) | Final length (mm) | Dry shrinkage % |
|---|---|---|---|
| 1 | 150 | 149.97 | 0.02 |
| 2 | 150 | 149.96 | 0.025 |
| 3 | 150 | 149.97 | 0.013 |

Replacement of cement by 1% biochar and adding extra 1% calamus rotang powder to the total volume. Results are as follows:

**Table -6:** Water absorption test after 1% replacement of cement by biochar and adding an extra 1% of calamus rotang.

| Sl. No | Initial length (mm) | Final length (mm) | Dry shrinkage % |
|---|---|---|---|
| 1 | 150 | 149..95 | 0.03 |
| 2 | 150 | 149.96 | 0.025 |
| 3 | 150 | 149.95 | 0.027 |

*3.5 Test on AAC Block and Red Bricks*

The test on AAC blocks and Red bricks and its results are as follows:

**Table -7:** Test on AAC Block and Red brick and its results

| Sl. No | Test | Avg. Test Results of AAC Blocks | Avg. Test Results of Red Bricks |
|---|---|---|---|
| 1 | Compressive test (MPa) | 3.5 | 3.2 |
| 2 | Water absorption (%) | 9 | 13 |
| 3 | Dry density (kg/m³) | 561 | 1950 |
| 4 | Dry shrinkage (%) | 0.01 | 0.15 |

## 4. EXPERIMENTAL ANALYSIS OF BAC BLOCK

The test result comparison of 1.5% and 1% replacement of cement by biochar and adding extra 1% of calamus rotang to the total volume.

**Table -8:** Result analysis of BAC block

| Sl.No | Test | 1.5% Replacement | 1% Replacement | Analysis |
|---|---|---|---|---|
| 1 | Compression test (MPa) | 3.334 | 3.13 | 1.5% replacement has better compressive strength value. |
| 2 | Water absorption test (%) | 10.18 | 11.37 | 1.5% replacement has lower water absorption value. |
| 3 | Density test (kg/m³) | 578.61 | 603.33 | 1.5% replacement has lower density value. |
| 4 | Dry shrinkage test (%) | 0.019 | 0.027 | 1.5% replacement has lower dry shrinkage value. |

## 5. COMPARATIVE ANALYSIS

The comparative analysis of red brick, AAC block and BAC block.

**Table -9:** Comparative analysis

| Sl.No | Specification | Red Brick | AAC Block | BAC Block |
|---|---|---|---|---|
| 1 | Dimensions | 190mm x 90mm x 90mm | 600 mm x 200mm x 100 mm | 600 mm x 200mm x 100mm |
| 2 | Raw materials | Locally available clay | Cement, flyash, quicklime, gypsum | Additional biochar & calamus rotang powder is used |
| 3 | Compressive strength (MPa) | 3.2 | 3.5 | 3.34 |
| 4 | Water absorption (%) | 13% | 9% | 10.18% |
| 5 | Dry density (kg/m³) | 1950 | 561 | 579 |
| 6 | Dry shrinkage (%) | 0.15 | 0.01 | 0.019 |
| 7 | Quantity of brick required | Large number of bricks are required | Very much less | Same as that of AAC block |
| 8 | Environment friendliness | Consumes topsoil. Damages the environment. | No topsoil consumption. Emits very low $CO_2$. | No topsoil consumption. Emits very much low $CO_2$ when compared to AAC block. |

## 6. CONCLUSIONS

- After comparing the values of red brick, AAC (Autoclaved Aerated Concrete) block, and BAC (Biochar Aerated Calamus rotang) block, it is evident that BAC blocks closely resemble AAC blocks in terms of their properties. Additionally, rotang blocks exhibit significantly lower carbon emissions compared to AAC blocks, indicating they are a more environmentally friendly choice for construction projects. This similarity in properties makes BAC blocks a promising alternative to AAC blocks in sustainable construction.
- Considering these comparable properties and the lower carbon emissions, it is recommended to use BAC blocks in construction projects where AAC blocks are typically utilized. Incorporating BAC blocks aligns with sustainability goals and initiatives, contributing to a reduced environmental impact and promoting eco-friendly construction practices.
- To further assess their suitability, it is crucial to conduct thorough performance evaluations of BAC blocks in real-world construction scenarios and compare their performance with AAC blocks.
- Raising awareness among stakeholders in the construction industry about the benefits of BAC blocks—particularly their environmental advantages—can drive their adoption and support sustainable development.
- Moreover, encouraging further research and development efforts to optimize the production processes and properties of BAC blocks will ensure continuous improvement and innovation in sustainable construction materials.

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