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Aerocon Wall Panel: A Promising Innovative Precast Walling Solution For Environmental Sustainability In Construction

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Abstract: Sustainability is a global challenge. The construction industry, a major resource user and polluter, must prioritize sustainability. While traditionally slow to adopt new practices, the sector is now embracing sustainable solutions. Unsustainable resource use leads to environmental damage and climate change. Traditional on-site construction has limitations in time, productivity, weather, resources, pollution, and safety. Sustainable materials offer a solution. Precast construction, manufacturing components off-site, enhances sustainability. This study explores alternative precast walling solutions and gives a promising approach for improving environmental performance in the construction industry.

Index Terms **–** Aerocon wall panel, Precast Walling Solution, Sustainability, Environmental Sustainability, Construction.

I. INTRODUCTION

The construction industry, a major contributor to environmental issues, must prioritize sustainable practices. While traditionally slow to adopt new approaches, the sector is now embracing sustainable solutions, recognizing the need for environmentally responsible design.

Our current consumption patterns are unsustainable, leading to climate change. Traditional on-site construction methods have limitations in terms of time, productivity, weather dependence, resource waste, pollution, and safety. Sustainable materials offer a solution.

Precast construction, involving manufacturing components off-site and assembling them on-site, enhances sustainability. This study explores alternative precast walling solutions, which focusing on a promising approach for improving environmental performance in the construction industry.

II. RELEVANCE OF STUDY

- **Social sustainability (SOS) -** Focuses on meeting the needs of all, ensuring satisfaction and morale for both consumers and employees. Environmental sustainability
- **Environmental sustainability (ENS) - E**mphasizes protecting the environment and ecosystems through responsible building practices, using resources wisely, incorporating recycled or sustainably sourced materials, and managing waste and water efficiently.
- **Economic sustainability (ECS)** - Aims for higher productivity and profitability, steady profit growth, and cost-effective projects with predictable costs, benefiting workers, suppliers, and customers.

2.1 How 3P's Intertwined

Here are some examples:

- **Environment and Social:** Pollution from factories can harm people's health (social impact). Investing in renewable energy sources (environmental solution) can create new jobs (social benefit).
- **Social and Ecological:** Unequal access to education can lead to unsustainable resource use (ecological impact). Investing in education for rural communities (social solution) can empower them to manage their natural resources sustainably (ecological benefit).
- **Environment and Ecological:** Deforestation (environmental issue) reduces biodiversity (ecological impact) and can also lead to soil erosion (environmental impact). Planting trees (environmental solution) helps restore biodiversity (ecological benefit) and improve soil health (environmental benefit).

Therefore In this Research Paper-Comparing sustainable walling material by Simulation of innovative precast wall material with Environmental considerations that is **Environmental pillar** of sustainability (ENS) which directly connected to Social Pillar of sustainability and Ecological pillar of sustainability.

2.2 Planet: Preserving our Precious Environment (ENS)

It implies to preserving natural resources and lessening the effects of human activity on the environment. Protecting our natural environments, preserving our already finite resources, creating eco-friendly goods, making sure that everyone has access to clean water and air, and cutting down on waste and pollution are all priorities for this pillar.

Some key principles of environmental sustainability in construction:

- Conservation and Impact Reduction
- Material and Resource Efficiency
- Reducing Environmental Impact
- Sustainable Practices

By adopting these principles, the construction industry can significantly contribute to a sustainable future.

III. Features of Aerocon Panel

Aerocon panels consist of a lightweight concrete core made from Portland cement, binders, and silicaceous and micaceous aggregates, sandwiched between two fiber-reinforced cement sheets. They are factory-cured and feature a unique tongue-and-groove jointing system for easy assembly. These panels are made with either Flexo Board (FOB) or Fiber Cement Board (NT).These panels are shown in Figs. Incorporate fly ash, reducing the need for virgin materials and diverting waste from landfills. Serve as an alternative to wood, helping conserve forests. Lightweight core and good thermal insulation reduce energy consumption for heating and cooling. Prefabrication reduces construction time and energy use. Less onsite work means less construction waste. Resistant to fire, water, termites, and weather, leading to longer building lifespan and fewer replacements. Can be disassembled and reused, reducing environmental impact. Lightweight nature reduces transportation impact.

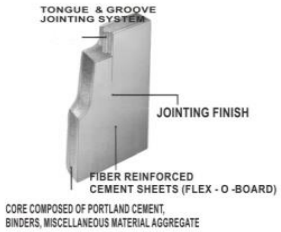

Fig.01-Aerocon panel

Fig.02-Tongue and Groove

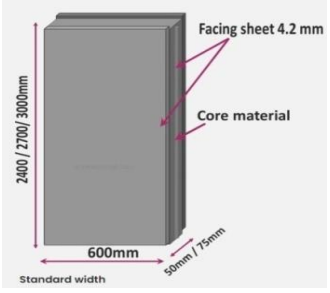

Fig.03- Dimensions

3.1 Aerocon Panel: Panel range and Sizes

Sr.No.	Size (mm)	Thickness (mm)
1	600x2400	50,75&100
2	600x2700	50,75&100
3	600x3000	50,75&100

Table No.01-Rance & Sizes of Aerocon Panel

3.2 AEROCON PANEL:TYPES

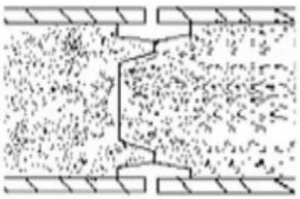

Fig.04-Square Edge Panels

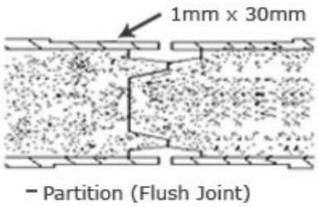

Fig.05-Recess Edge Panels

Aerocon Panels include tongue and groove joints for interconnecting..Square edge panels are utilized for a number of purposes, including mezzanine, roofing, and partitioning..Recess edge panels are utilized in prefabricated structures and for a variety of other purposes, including partitioning..

3.3 INSTALLATION PROCEDURE

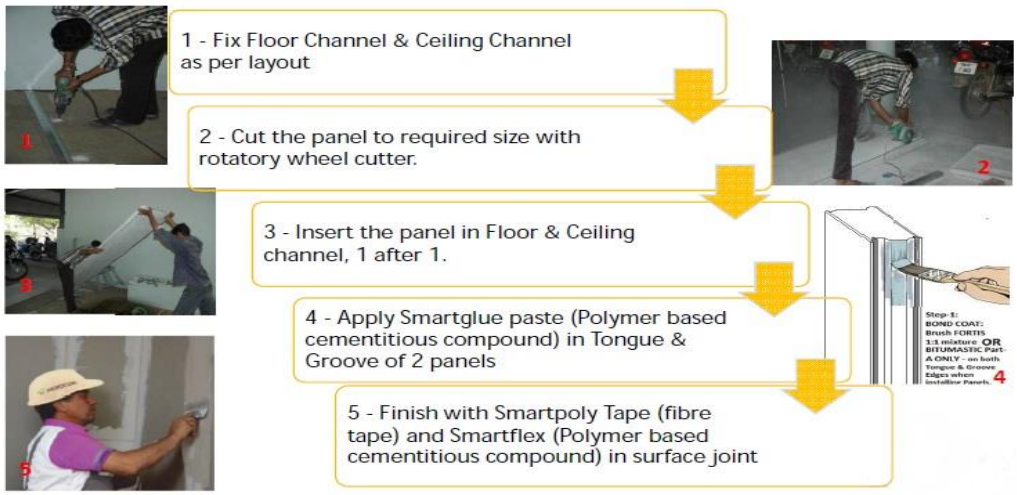

Fig.06-Installation Procedure of Aerocon Panels

3.4 MATERIAL LIMITATIONS

The maximum floor spans that may be achieved with movable forms are 5.60 meters And Aerocon wall panels are available in heights of 2.4 m, 2.7 m, and 3.0 m

- **Structural Limitations:**
  - Load-bearing capacity: While they can handle moderate loads, Aerocon panels might not be suitable for very heavy structures or those requiring high load-bearing capacities without additional reinforcement.
- **Seismic resistance:** While they are generally resistant to seismic activity, their performance in high-seismic zones might require additional engineering considerations or reinforcement.
- **Installation and Maintenance:**
  - Skill requirement: Proper installation of Aerocon panels requires specific skills and knowledge, which might not be readily available in all regions.
  - Maintenance: While they are relatively low-maintenance, issues like cracks or damage might require specialized repairs.
- **Cost Considerations:**
  - **Initial cost:** While the long-term benefits can offset the initial cost, Aerocon panels might be more expensive than traditional materials in some regions.
  - **Transportation:** The transportation costs for large Aerocon panels can be significant, especially for remote locations.

IV. COMPARISON OF SELECTED INNOVATIVE MATERIAL WITH ECS, ENS &TECHNICAL AND PHYSICAL SPECIFICATIONS.

Ecological (ECS)			
Sr. No	**Parameters**	**AAC Block**	**Aerocon Panels**
1	Cost effective	Minimum as compare to panels	Reduced dead weight leads to savings in steel and concrete.
2	Availability of skilled labor	Available	Available
3	Transport of material	Easy	
4	Effective training	Not Required	Required
5	Material handling on site	Easy	Easy, as it is lightweight
6	Transport of material	Easy	Easy
7	Need of special engineering consultancy	No	The supervisor from manufacturing company is present on site during erecting of the work.
8	Period of construction	More as compare to panels.	Less as compare to AAC blocks
9	Need of plastering	Yes	Yes/No
10	Need of painting	Yes	Yes/No
11	Ease of addition and alteration	Easy	Easy
12	Alternate use of material other than walls	No	Yes, as it used for mezzanine floor in industrial construction.
13	Ease of concealed plumbing	Good	Good
14	Ease of concealed Electrification	Good	Good
15	Maintenance	More, due to early cracks and leakages in construction method.	Less
16	Cost saving benefit factor	Average dead load reduced	More dead load reduced as compare to AAC block-its due to its lightweight property.

Table No.02-Parameters comparison of ECS

Technical and physical Specifications			
Sr. No	**Technical & physical Specifications**	**AAC Block**	**Aerocon Panels**
1	Compressive Strength	3 to 4 N/mm²	2-5 N/ mm²
2	Time required for installation	20 days	4 Days
3	Density of material	6.4kn/m3	falls within the range of 600 kg/m³ to 850 kg/m³ (37.4 lb/ft³ to 53.0 lb/ft³). This is significantly denser than EPS panels used for insulation.
4	Durability	20 yrs construction method which causes failure in cracks, leakages in wall	20 yrs
5	Fire Ratings	2 hours up to 6 hours	2 hrs
6	Fire Resistance	≥3hour(BlockWallThickness:100mm	≥ 4 hour(Panel Wall Thickness:100mm)
7	Dry Density	450 kg/m³ to 1000 kg/m³	550-700 kg/m3
8	Water absorption capacity	5% To 20% by volume	5% TO 20% by volume
9	Weight	6 kg to 25 kg per block	600 kg/m³ - 1200 kg/m³
10	Sound transmission	35 dB to 50 dB.	35 dB to 50 dB.

	class(STC)		
11	Thermal Conductivity	0.070-0.120 W/mK at a temperature of 10°C	0.070 - 0.120 W/mK at a temperature of 10°C.
12	Surface spread of flame	Class I (ASTM E84)	Class I (ASTM E84)

Table No.03- Comparison of Technical & Physical Specification

From the above comparison between CCT (AAC block) and ACT or Innovative material(Aerocon Panels) regarding different sustainable parameters, It is clear that Prefabricated Fiber Reinforced Sandwich Panels (Aerocon Panels) are most efficient and Versatile Precast walling material that can be adopted for Sustainable walling solution in multi story residential building construction.

V. INTRODUCTION U-VALUE CALCULATION THROUGH SIMULATION

In wall material efficiency analysis and simulation, the U-value (also known as thermal transmittance) is a measure of how well a building element, such as a wall, roof, or window, can transfer heat. It is expressed in watts per square meter per degree Celsius ($W/m^2 \cdot °C$). The U-value quantifies the rate at which heat passes through a material or assembly of materials. Key points about U-value:

- Lower U-value: Indicates better insulating properties. Lower U-values mean that the material is better at reducing heat loss, leading to higher energy efficiency.
- Higher U-value: Indicates poorer insulating properties. Higher U-values mean more heat passes through the material, resulting in greater energy loss.

In simulations, the U-value is crucial for evaluating the thermal performance of different wall materials. It helps in determining how well the materials will maintain indoor temperatures, which directly impacts energy consumption for heating and cooling, overall comfort, and sustainability.

5.1 U-VALUE CALCULATION FOR AAC BLOCK WALLING CONSTRUCTION WITH RESULTS

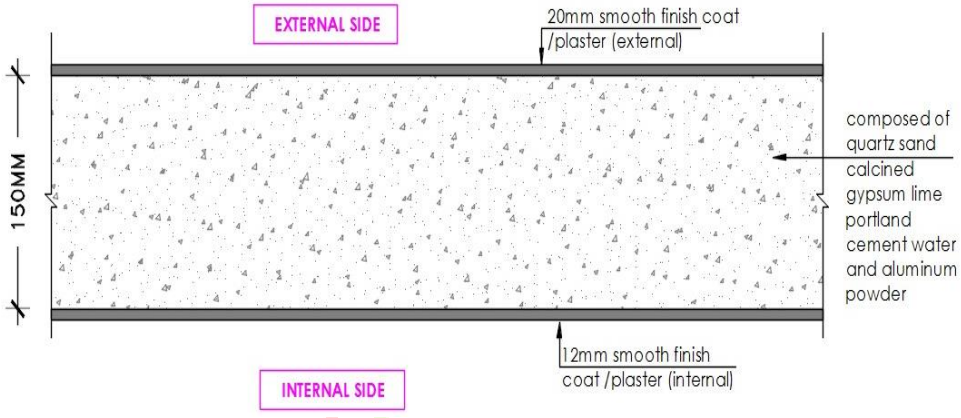

Fig.07–Detailed wall Section for AAC Block (150mm thk.)

Material Details –

- Thickness- 150 mm thk panel
- Material Component & Insulation -Composed of quartz sand calcined gypsum lime portland cement water and aluminum powder (acting as a rising agent)
- Plastering - External and Internal compulsory required .External coat-20mm thk Internal coat-12mm thk

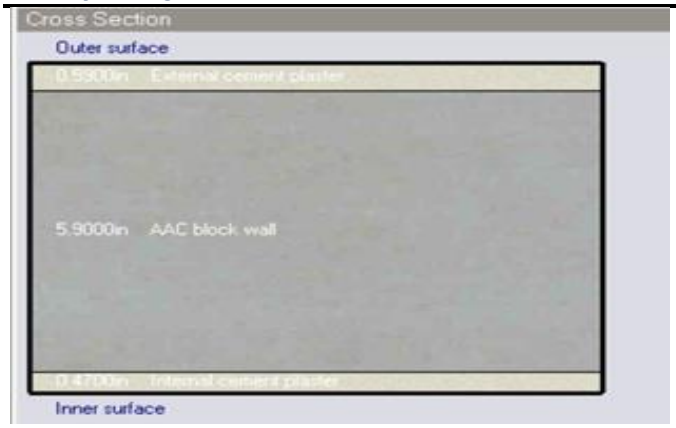

Fig.08 –Calculated Walling Layers (AAC Block) (Source: Snapshot Design Builder software)

Result-

With Bridging (BS EN ISO 6946)	
Thickness (in)	1.650
Km - Internal heat capacity (-)	0.0000
Upper resistance limit (ft2-F-hr/Btu)	0.251
Lower resistance limit (ft2-F-hr/Btu)	0.251
U-Value surface to surface (Btu/h-ft2-°F)	3.987
R-Value (ft2-F-hr/Btu)	0.251
U-Value (Btu/h-ft2-°F)	**3.987**

Fig.09 –Calculated U-Value for Wall Material (AAC Block)(Source: Snapshot Design Builder software)

Better thermal insulation is signified by a lower U-value, which means that less heat is lost (or gained) by means of the element. Here are some general guidelines for U-values in walls:

- Good insulation: $U \leq 0.3$ W/m²K (Watts per square meter-Kelvin)
- Medium insulation: $0.3 < U \leq 0.5$ W/m²K
- Poor insulation: $U > 0.5$ W/m²K

As per Design Builder Software the U value of AAC Block wall Construction It shows 3.987 W/m²K which is Medium insulation: $0.3 < U \leq 0.5$ W/m²K

5.2 U-VALUE CALCULATION FOR AEROCON PANEL WALLING CONSTRUCTION WITH RESULTS

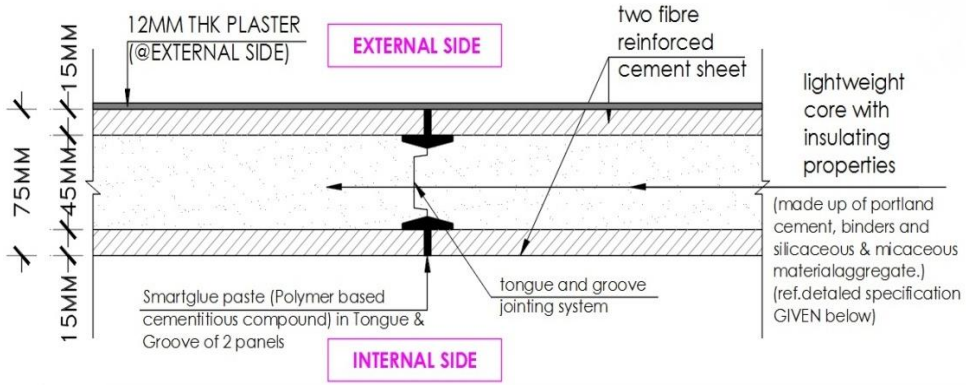

Fig.10 –Detailed wall Section for Aerocon Panel (75mm thk.)

❖ **Material Details –**

- Thickness-75 mm thk panel
- Material Component & Insulation –

two fiber reinforced cement sheets (ercs): these form the outer laye rs of the panel,
core: this lightweight core is the key to the panels insulating properties.lt's made of:
binders: portland cement for strength and structure. reinforcing agents: cellulose fibers and synthetic binders to reinforce the core.
fillers: pulverized fy ash and lightweight aggregates for reduced weight and cost.

foaming agents: these create air pockets within the core, enhancing insulation.
Reinforcing Agents: Cellulose fibers and synthetic binders to reinforce the core.
Fillers: Pulverized fy ash and lightweight aggregates for reduced weight and cost.
Foaming Agents: These create air pockets Within the core, enhancing insulation.**fly ash is used which is waste product of thermal power plants**

- Plastering - External and internal not required technically but for my project i gave it externally only of 12 mm thk. plaster is provided.

Fig.11–Calculated U-Value for Wall Material (Aerocon Panel)(Source: Snapshot Design Builder software)

Result-

With Bridging (BS EN ISO 6946)	
Thickness (in)	4.600
Km - Internal heat capacity (-)	0.0000
Upper resistance limit (ft2-F-hr/Btu)	1.798
Lower resistance limit (ft2-F-hr/Btu)	1.798
U-Value surface to surface (Btu/h-ft2-°F)	1.203
R-Value (ft2-F-hr/Btu)	1.798
U-Value (Btu/h-ft2-°F)	**0.557**

Fig.12 –Calculated U-Value for Wall Material (Aerocon Panel)(Source: Snapshot Design Builder software)

Better thermal insulation is signified by a lower U-value, which means that less heat is lost (or gained) by means of the element. Here are some general guidelines for U-values in walls:

- Good insulation: $U \leq 0.3$ W/m²K (Watts per square meter-Kelvin)
- Medium insulation: $0.3 < U \leq 0.5$ W/m²K
- Poor insulation: $U > 0.5$ W/m²K

As per Design Builder Software the U value of Aerocon Panel wall Construction It shows 0.557 W/m²K which Medium insulation: $0.3 < U \leq 0.5$ W/m²K (Watts per square meter-Kelvin)

3.5 AEROCON PANEL: PANEL RANGE AND SIZES COMPARISION & RESULT FOR ENS:BY CALCULATING A U-VALUE FOR SELECTED WALLING MATERIALS.

Sr.No.	Wall Material	Standard U-Value	Simulated U-Value
1	AAC Block	➢ Good insulation: $U \leq 0.3$ W/m²K ➢ Medium insulation: $0.3 < U \leq 0.5$ W/m²K ➢ Poor insulation: $U > 0.5$ W/m²K	3.987 W/m²K(Refer Fig.09)
2	Aerocon Panel		0.557 W/m²K (Refer Fig.12)

Table No.05- Comparison of Technical & Physical Specification

Result -

The U-value of a material is a measure of its thermal transmittance, indicating how well it insulates. A lower U-value signifies better insulation properties. **Aerocon panels have a U-value of 0.557 W/m²K**, indicating medium insulation, which is closer to the lower end (0.3 W/m²K), which means they have **a medium** U-value (0.557 W/m²K). But AAC blocks have a higher U-value (3.987 W/m²K), which means they have poorer insulation properties compared to Aerocon panels.

VI. CONCLUSION

In this paper, the conclusion is based on "sustainability," which encourages the use of alternative precast walling in construction. Moreover, the root or base of sustainability is the 3 P's,, which include environmental, social, and ecological sustainability, which are interconnected. Therefore ENS is analyzed and which directly connected to SOS and ECS**.**

According to results of U-value calculation through simulation, **Aerocon panels** have a U-value of 0.557 W/m2, indicating medium and minimum insulation, which is closer to the lower end (0.3 W/m2), which means they have better insulating properties than the other walling material which is AAC blocks.

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