

Sustainable Construction: Assessment of Expanded Polystyrene and Conventional Sandcrete Block in Green Building Material

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ABSTRACT

Expansion of housing facilities due to rapid population growth in Nigeria has led to various environmental issues caused by the use of non-sustainable building materials, processes, and greater costs. This has made the quest for better and less expensive alternatives a critical priority in the provision of housing in Nigeria in recent years. This study assessed the strength, cost of installation, and environmental benefit of expanded polystyrene and conventional sandcrete blocks as construction materials in Nigeria. The research, which was carried out at the Federal University of Technology Minna, shows that even though expanded polystyrene has its limitations, it has good strength, reduced cost of installation, high reusability, reduced weight, and high fire resistance compared to conventional sandcrete blocks used in the country. It was also recommended that property developers should be encouraged to adopt expanded polystyrene in building construction over conventional sandcrete blocks through orientation as it is safe, cheap, and encourages green building.

Keywords: Expanded polystyrene, Conventional sandcrete blocks, green building, Building materials, Sustainable construction.

I. INTRODUCTION

In today's world, a person's wealth is determined by his capacity to meet his fundamental survival needs, which include food, shelter, and clothes. Because of technological improvement, the usage of construction materials has shifted from one to another over time (Goodier, 2012). Man has discovered a variety of materials in his hunt for shelter, including tree leaves, bamboo, clay, steel, brick, block, and even polystyrene. Hence, the rate at which these scarce resources are being drained as

a result of human exploitation is worrying. Earth's energy supplies are rapidly depleting, posing a severe threat to mankind's present and future. The construction industry is a major contributor to this depletion in energy, using about 50% of it. Because of the environmental threat posed by the building industry, there has been a call for a better way of carrying out construction activities, necessitating a paradigm shift from the conventional system of building construction to best practices to reduce the negative environmental impacts (Carpenter 2009). Therefore, the idea of sustainable development has been brought to the forefront to address this (Prucnal-Ogunsote et al., 2010). For a material to contribute to sustainable development, it must make use of low energy during production, transportation, and operation (Ortiz, Castells, Sonnemann, 2009).

The housing shortage situation in Nigeria has been exacerbated in recent decades as a result of fast population growth, with estimates indicating a deficit of at least 17.0 million. The housing shortfall has steadily increased, from 7.0 million in 1991 to 14 million in 2010. According to a World Bank report in 2018, Nigeria requires around 700,000 housing units each year over 20 years to handle the growing population. With current indicators and Nigeria's slow housing sector growth, there is an urgent need to address the issue of the housing deficit in the country. To close the housing gap, more efficient and cost-effective construction technologies are necessary.

The objective of this research work is to compare the use of expanded polystyrene (EPS) and conventional sandcrete block (SCB), which is the traditional construction material in the country in terms of strength, cost of installation, thermal

conductivity, durability, energy consumption and environmental benefit in the construction industry.

II. LITERATURE REVIEW

A. Expanded Polystyrene (EPS)

In 1839, polystyrene was discovered from storax in Berlin by an apothecary, who named it styrol. The chain reaction of styrol led to what is called polystyrene today. In 1954, a chemist in the USA accidentally invented foamed polystyrene, which was 30 times lighter than regular polystyrene while developing flexible electrical insulation material. Due to its moisture-resistant and thermal properties, expanded polystyrene has been manufactured into a wide range of shapes and sizes for use in walls, floors, and roofs in buildings. They're also employed in civil engineering projects as void-forming fill and as lightweight fill in road and railway construction.

Polystyrene used in construction comes in a variety of types and sizes, with wall panels and slab panels being the most prevalent. According to Olasehinde in 2009, EPS can be generally classified into two types: single and double. A single panel is composed of a polystyrene sheet sandwiched between welded wire mesh on both sides, whereas a double panel is composed of two single panels united by an intervening cavity. The mesh is coated with a layer of shotcrete applied under pressure using a pneumatic device to construct the walls. A building can go up to four floors with a single panel and fifteen floors with a double panel. These panels can't be built without the help of reinforcing materials like metal mesh (Olasehinde 2009). He also stated that EPS blocks with a height of 3000mm, a width of 1200mm, and a thickness of 100mm are commonly utilised as wall panels, with a thin coating of metal/steel acting as reinforcement. Panels with 600mm length, 400mm width and 300mm thick alongside reinforcement of 12mm, 16mm, and 20mm diameter for slab construction as shown in Figure 2.1.



Figure 2.1: Wall and Slab constructed of EPS panels

B. Sandcrete Blocks (SCB)

Sandcrete blocks as shown in Figure 2.2 are primarily a mixture of sharp sand, cement and water, with cement and sharp sand in a ratio of one to six (1:6). The qualities of SCB are determined by the material ingredients, their mix, the presence of admixtures, and the production method. SCB has played an important part in the construction sector across the world including in Nigeria. It is used in the construction of almost 90% of Nigeria's physical infrastructure (Baiden and Tuuli, 2004). As a result, sandcrete blocks are an important building material in the nation, which can either be in loadbearing or non-load bearing walls as specified by NIS and shown in Table 2.1

SCB has high compressive stress that ranges from 2.5N/mm^2 to 3.45N/mm^2 in its cured form, and this strength increases with density (NIS 87:2007). However, there is inconsistency in the quality of SCB and not meeting the minimum standard required by NIS due to the production method, and material employed by the various producer (Abdullahi 2005).



Figure 2.2: Sandcrete blocks

Table 2.1. Types of Sandcrete Blocks

Type	Work size (mm)		Web Thickness (mm)	Usage
	Length x Height	x Thickness		
Solid Blocks	450 x 225	x100	-	For non-load bearing and partition walls
Hollow	450 x 225	x 113	25	For non-load bearing and partition walls
Hollow	450 x 225	x 150	37.50	For load bearing walls
Hollow	450 x 225	x 225	50.00	For load bearing walls

Source: NIS 587: 2007

III. DISCUSSION OF FINDINGS

A. Lightweight

The unit weight of an EPS embedded structure can be up to 35% less than that of a conventional concrete structure. Its densities range between 10kg/m^3 and 35kg/m^3 making it easy to transport (Kageni, 2014). In low-energy structures when thicker insulation layers are necessary, EPS' outstanding lightweight to insulating ratio is a significant benefit. It's a great alternative to infill materials.

B. Strength and structural stability

Various studies have shown that a 2700mm single panel of EPS can withstand a load of 1530kN/m when subjected to axial load, which is sufficient to sustain double the dead and live load of a residential building when compared to SCB. Its stability does not deteriorate and absorbs moisture under usage as this is a major challenge to structure in the cold climate area. EPS mechanical properties can be easily adjusted to fit a specified purpose, making it usable for road construction, swimming pools, boundary walls and roof insulation (Kageni, 2014).

C. Fire performance

EPS has a thermal conductivity of 0.032 to 0.038 W/(mK), whereas SCB has a thermal conductivity of 0.4-0.7 W/(mK) (Rohit et al., 2017). Because of its self-extinguishing properties, EPS structures can contain the spread of a fire outbreak for approximately 120 minutes before being exhausted by fire, and can thus be used to regulate building temperature (Hannah et al., 2017). It is a maintenance-free, all-weather structure. Though the industry recommends that insulating material should be covered for improved fire performance and mechanical qualities, EPS should be covered with concrete through shotcrete as shown in Figure 3.1, bricks or gypsum.



Figure 3.1: Shotcreting of EPS panels

D. Handling and installation

As shown in Figure 3.2, EPS is easy to handle and assemble due to its lightweight, rigidity, and flexibility. Shape moulding enables the manufacture of complicated shapes in the factory to meet the most stringent architectural and design criteria compared to SCB, which mostly comes in fixed shapes and does not allow flexibility in architectural design. Flexible processing technology allows for the delivery of goods with the optimal density, insulation, and mechanical qualities, as well as size and form, reducing waste on the construction site. EPS may be handled and processed without causing skin irritation, dermatitis, or eye or lung problems. Its installation does not require formwork making it 52.35% cheaper when compared to SCB. (Ibukunoluwa and Adedeji 2014)



Figure 3.2: Handling and Installation of EPS panels

E. Environmental Benefit

EPS is eco-friendly, minimising the use of natural resources such as stone, cement, and water since they are made from small beads of polystyrene and pentane. It resists fire and earthquakes and saves a lot of energy due to its low thermal conductivity. There is no need for chemical treatment before installation (Ogundiran and Adedeji, 2012; EPG, 2013). EPS can be easily recycled compared to SCB. This does not only contribute to a green building; it's also a financial gain (Saint-Gobain, 2009). EPS has a long life in buildings and does not decay or corrode. Therefore, there is minimal need to recycle EPS insulation material. Recycled EPS can be used as insulation boards.

F. Summary

Table 3.1 summarises the research findings are discussed in section 2.0

Table 3.1: Research summary

Factor	SCB	EPS
Lightweight	High density (1800 – 2100 kg/m ³)	Low density 10kg/m ³ and 35kg/m ³
Strength and structural rigidity	Low strength and structural rigidity	Low strength and structural flexibility

stability		
Work Duration	Longer duration	Shorter duration; easy to assemble
Thermal Conductivity	0.032 to 0.038 W/(mK),	0.4-0.7 W/(mK)
Installation cost	High construction cost	52.3% cheaper than SCB
Formwork	Low reusability	High reusability
Environmental Benefit	Low earthquake and fire resistance	High earthquake and fire resistance
	Not waterproof	waterproof
Workers	Skilled Labour Required	Does not require skilled labour

IV. CONCLUSION AND RECOMMENDATION

A. Conclusion

When compared to SCB, this study shows that EPS leads to more sustainable building. It discussed the need to adopt EPS for building construction by highlighting its benefits over SCB in terms of strength, structural stability, resistance to fire and sound, environmental benefit, and installation cost since over 90% of property developers in the country still make use of SCB. EPS can be recycled, thereby reducing the rate of extraction of natural resources. It minimises global warming by conserving energy and benefits the global economy.

B. Recommendation

EPS technology has been invented over three decades with environmental and economic benefits. Its adoption rate is low in Nigeria. In Nigeria, there is a lack of awareness among construction experts and there are no quality guidelines to oversee the manufacturing. EPS material is not readily available in Nigeria; it is only produced in Abuja and Ondo State, making its adaptability very slow. More research on EPS technology should be funded by the federal government and the construction industry, and property developers should be educated on its benefits.

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