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## Polystyrene: A Sustainable Material for Building Construction

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**Abstract** The paper highlighted the significance of Expanded Polystyrene (EPS) material as an alternative to conventional building materials. The paper also looked at the conventional materials possessing number of challenges which caused ineffectiveness in building performance. The paper concluded that since polystyrene material can be used in the construction of residential, commercial and industrial buildings, owing to its excellent properties of reducing heat significantly within the building and also mitigating impact of CO<sub>2</sub> emission as it is recyclable instead of burning, the material will be highly suitable in the construction of sustainable buildings over the conventional materials.

**Keywords** Expanded Polystyrene, Sustainable, Conventional, Building Material

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### Introduction

After man has eaten, the next line of struggle is shelter against various climatic conditions (sun/rain, wind/heat). The quest for shelter has made man seek for number of materials varying from clay/mud, grass, stones, metals, plastics, blocks/bricks even polystyrene. According to John [1], building materials are those materials that are used in construction of building. He further explained that the use of materials are vital aspect in which no field of engineering survive without their use as there is always need for replacement for the outgoing technology due to man's advancement in technology. Over the time, the use of building materials have shifted ground from the conventional one to modern ones due to the advancement in the technology which has turn out to the production and use of expanded polystyrene blocks in construction of building.

Polystyrene material is a thermoplastic material obtained from the polymerization of styrene suitable for use in packaging electronics, food items and in construction of building as a replacement for other materials (fig 1.). The polymerization of the styrene formed a unit block termed expanded polystyrene (EPS) [2]. He added that the polystyrene block thickness varies from 4cm to 25cm based on the architectural design requirement (fig. 4). Once the polystyrene is formed or produced, meeting the following properties: Normal density of 15kg/m<sup>3</sup>, Thermal conductivity of 0.037w/mk, Steam resistance of 0.15mmHgm<sup>2</sup>dia/gcm and Compressive stress at 10% of strain is 50kpa, reinforcement (mesh) are placed at the both sides joined by electro-welded steel connectors (fig. 7).



Figure 1: Styrene Material



Figure 2: Polymerized styrene



Figure 3: Wall Insulated with EPS [4]



According to Saint-Goban [4] Polystyrene has five platforms of productions which include: pre-expansion, intermediary conditioning and stabilization, moulding, shaping and post-production procedures. In the pre-expansion stage, the EPS beads (fig. 1) are heated to about  $80^{\circ}$  and  $100^{\circ}$  with a steam boiler. Pentane re-agent is added to enlarge the beads containing series of non-interconnected closed cells. Air is induced to the beads as it cools thereby reducing the bulk density from  $630\text{kg/m}^3$  to  $10$  and  $35\text{kgm}^3$ . The intermediary conditioning and stabilization stage allows the cooling of the EPS prior conveyed to aerated storage silo for development. In the silo, the EPS cool and air is gradually diffused into the gap/pores replacing the other components until the beads enclose over 90% of air. At this stage, the beads then attain higher mechanical elasticity and expansion capacity is also regain.

The third stage of EPS production is moulding. The pre-expanded beads are moulded to form boards, blocks or special designs of the product. The steam caused fusion of each beads to its neighbor in the process of moulding, thus forming the uniform product. The fourth stage of the process is the shaping. After the moulding block has been removed from the moulding machine, it is allowed to cool. The hot wire or appropriate techniques is then used to cut or shape the block. The last procedure is the post-production where the finished material (EPS) is laminated with foils, plastics, roofing felt, and wall cladding materials.

Works related has shown that the two principal factors of mechanical properties of expanded polystyrene (EPS) are: the integral bonding of the EPS beads and the density of the material. Even though, density play a dynamic role in describing the mechanical characteristic, it does not adequately define its significant properties and should therefore not be the criteria used to identify the product. Goodier [5] indicated that EPS is sustainable material as the excellent acoustic, fire resistance, excellent thermal resistance and structural strength of it are considerably resilient due to the monolithic nature that amount it an exceptional building material. Despite the uniqueness, merit and significant of EPS material, the use in building construction in Nigeria building industry is still precisely low. According to Ede, Alegiuno and Awoyera [6] asserted that, this is due to the relatively rare information of this advancement of material and also lowly accessibility to the material. They continued that very little manufacturers of the EPS material are readily available resulting to rare awareness to the building industry, professionals and entire public, which has also, paves way for the high cost of the product to the end users.

To this effect, the performance of EPS as a building material needs to be reviewed to ascertain its sustainability to replace other building materials.

## Literature Review

### Overview of Sustainable Building Materials

The choice of environmentally friendly materials and techniques is very relevant. To ensure a better quality life and guaranteeing the health and safety of the building occupants and users, Carpenter [7] stated that the construction materials and process must preserve unique ecosystem and local landscapes. It was also stated that series of researchers have recognized the major environmental afflictions related with building materials and techniques comprises of embodied energy of building materials and greenhouses gases emissions. Barbra [8] viewed sustainable building material as material with overall superior performance in terms of specified criteria. The criteria's are as follows: Locally produced and sourced materials, Transport cost and environmental impact, Thermal efficiency, Occupant needs and health considerations, Financial viability, Recyclability of building material, Waste and pollution generated in the manufacturing process, Energy required in the manufacturing process, Use of renewable resources, Toxic emission generated by the product, and Maintenance cost. Ortiz, Castells and Sonnemann [9] asserted that for materials to be sustainable, it must ensure low energy consumption for their production, transportation (embodied energy) and for their operations in use.

The types of material selected at the design stage of a building have fundamental effect on its long-term sustainability, consequence on improving energy saving and comfort-ability of the occupiers. Building material that meets the safety standards and the comfort of inmates' needs must also be thermally insulating, light weight and inexpensive [10]. Nigeria as a developing nation, with rapid growing population needs affordable and sustainable housing systems. EPS being one of the results of the innovative researches that gave birth to drastic reduction of cost of building, affordable houses in the advanced nations, this could be of good option open to



Nigeria for tackling housing problems. Also, the world is becoming more concerned about the environment, and measures are being taken in every nation to reduce the impact of activities on environment [11].

They continued that, construction materials have evolved over the years till the real breakthroughs in the construction industry in the 21<sup>st</sup> century through the development of versatile, easy to construct and economically viable materials, it is becoming easier worldwide to build sustainable houses. For the building and construction industry worldwide, these concerns are being addressed by the careful choice of building materials, and in particular, the selection of insulation [12]. This paper therefore, highlights benefits to which Polystyrene material is made possible to be used as a sustainable building material over the conventional materials.

### Utilization of Polystyrene Material in the Construction of Building

Technology advancement in all stages of life have really assisted in making life easy for man, but not all can be accepted as their after effect may be too hazardous. Though over 30 years, EPS has been used as a building material [13]. He continues that, the use of EPS technology is routed from Italy and to most countries in the world such as Mexico, Spain, Egypt, Eritrea, Nigeria, Mozambique, Libya, and Saudi Arabia, among others.

The use of the EPS material in building and other civil structures ranges from erection of panels, slab, kerbs, culverts, stairways, floor panels, retaining walls, road embankments, pavement insulation such as airport, basement construction for car parks among others. Polystyrene used in construction varies by type and sizes with the common ones for wall panels and slabs panel. These panels cannot be constructed without the in-cooperation of reinforcement elements like metal mesh [2]. According to Olasehinde [2], EPS blocks usually have 3000mm height, 1200mm breadth and 100mm thick used as wall panels that is also accompanied with a thin layer of metal/steel serving as reinforcement (fig. 7). He further said that panels used for slabs usually have 6000mm length, 400mm width and 300mm thick. This alongside too is reinforced with 10mm, 12mm, 16mm and 20mm diameter based on the bar bending schedule for the slab construction. Kelvin [13] briefly remarked that stair panels consist of polystyrene block shaped in line with the design requirements coated alongside with two steel wire mesh coupled with electro-welded wire and finished *in-situ*.

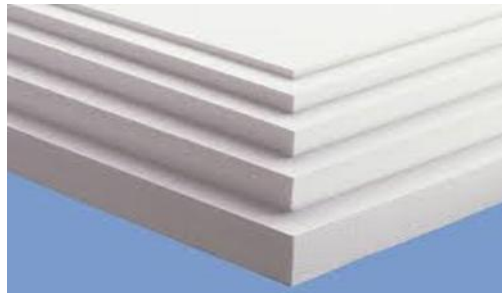


Figure 4: EPS blocks in sizes [3]

Polystyrene blocks (fig.4.) are used in construction as permanent insulation in buildings (fig. 3) and as well act as thermal insulation. The blocks are energy efficient and ensure optimal insulation not only for walls of buildings, but also for the roofs and even floors (fig. 6), electrical wiring and plumbing pipes can also be inserted in the polystyrene material. Building with EPS blocks is simple like building with the toy blocks. Once in place, the blocks forms structure (Fig.7) and as soon as the concrete is cast in the blocks (EPS), stability is gained.



Figure 5: EPS under steel roof as insulation [3]



Figure 6: Slab lay of EPS blocks [3]





Figure 7: Wall constructed of EPS blocks [3]

### Conventional/Traditional Building Materials Challenges

Most forms of buildings are traditionally based on locally produced materials. Partly due to the high cost of transportation of heavy building materials from long distance and some as a result of climatic differences in the World. Most traditional building materials are of low durability and therefore, frequent replacement on comparing to the modern building materials [14]. He added that stone is not traditionally popular material for the construction due to obvious reason that it is difficult to obtain in certain areas and in those areas where it is obtainable, it is hard to shape into required sizes suitable to handle. Furthermore, despite the merit associated with timber as material such as easy to handle by non-regular worker, cheap, flexible to form and easy to repair, although, the demerits of timber used in the construction as a wall unit in Africa is the high cost of eradicating termites and also highly inflammable, therefore, unsuitable where buildings are near one another.

Obande [14], wrote in his book that for building to meet its functional requirement the materials in use must provide adequate internal comfort for the inhabitants such as a healthy temperature and dry environment; the material should be strong enough and durable to protect human inhabitants and equipment from the effect of weather either by rain, sunshine and wind. He however highlighted some of the properties of the conventional building material on which emphasis is on sandcrete block work which undergoes dimensional changes with change in temperature, especially if accompanied by drying and wetting. It is also accompanied with poor sound absorption and transmission due to its wide texture. He further added that, best materials are those capable of excluding heat from the building whereas sandcrete block does not serve the purpose [14].

### Significance of Polystyrene Material in the Construction of Building

Owing to the unique properties of the polystyrene blocks benefits, the material can be used in the construction of residential, commercial and industrial buildings in a very fast and cheap rate than conventional brick/blocks and mortar buildings. Ede *et al.*, [6] summed up the benefit of expanded polystyrene EPS material as lifespan lastingness, moisture resistance, proven acoustic and excellent thermal insulation, rapid assembling, termite resistance, light weight and resistance to damage by burglars and energy saving /green building.

### Rapid Assembling

The light weight property of EPS makes it easy to handle and assembled (fig 7). Less skilled labour are required since there would not be any casting at every stage but only where long span of lintel exist and this does not have any effect to the entire structure. Ibukunoluwa and Adedeji [15] stated that another merit of EPS is the absence of formwork for installation which results in speedy erection of the component. The construction of formwork which is inevitable in the construction of concrete fascia is totally avoided during installation of EPS material.

### Termite Resistance and Resistance to Damage by Burglars

Beside plastering and shortcreting, termite cannot pass through polystyrene block as it does not give any nutritional benefits. In the same vein, in block structure, burglars break through the walls to access the house but in the case of EPS structure, even as the shortcreting and plastering are removed, the reinforcements (wire mesh) will be difficult to cut, talk of destroying the EPS panel. British Plastic Federation BPF, [16] affirmed that on



durability issues, strength tests performed on EPS which was first placed in the ground almost 30 years ago show that it is still strong today (fig. 7).

### **Energy Saving/Green Building**

The EPS is capable of been recycled and reused. The production of EPS generates no waste compliment with the struggle the entire World is fighting against the damage caused to ozone layer every day. EPS as a suitable substitute to the conventional building material would assist a long way in reducing the damage on the ozone layer since it can be reused and recycled rather than burning. Ibukunoluwa and Adedeji [15] identified another vital benefit in the use of EPS has energy efficiency potential and also environmental-friendly in both its production and application.

### **Excellent Acoustic**

Similar to the property of energy saving, EPS does not allow sound transmission (in and out) of the building. EPS block serves a very good sound proof material which resist echoing or pollution caused by noise in the environment.

### **Resistance to Fire**

The spreading of fire outbreak is improved by the material. EPS material structure has the property strength to contain fire for about 120minute prior exhausted by fire which is enough periods to be saved. Based on the monolithic structure and method of assembling, EPS is unique in nature.

### **Affordability of EPS Material**

Cost and time savings are two of the most important considerations in the building industry. When building with polystyrene block system it is possible to save on labour, time taken to complete the project and the overall construction costs. The study of Ibukunoluwa and Adedeji [15] deduced that the cost of installation of expanded polystyrene (EPS) fascia and the cost of installation of concrete fascia 81m length of a residential bungalow under the same construction condition. The cost of the installation of EPS fascia is found to be cheaper than the cost of concrete fascia under the same construction condition which indicates 52.35% percentage difference

### **Conclusion**

This paper has presented EPS as a sustainable material for building construction. It summaries the benefit and use of the material as sustainable over the conventional materials, it has also coherently X-rayed the need for pattern shift from the conventional materials characterized by poor sound and heat transmission, low durability, high cost of transportation due to heavy weight of material to a waste free, recyclable, easy handling and assembly, excellent acoustic, affordable and termite resistance material as substitute for building construction. The paper therefore concludes that owing to the unique nature and properties of EPS, the material should be used in the construction of residential, commercial and industrial buildings in Nigeria.

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