IMPROVING THE ADOPTION AND AWARENESS OF EXPANDED POLYSTYRENE AS BUILDING MATERIAL IN THE CONSTRUCTION INDUSTRY

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ABSTRACT

Housing provision has become a global issue as the need for affordable housing kept increasing in Nigeria. This has emerged due to various economic, socio-cultural, and environmental factors which have increased pressure on conventional building materials, thereby leading to the invention of alternative building materials. This paper investigated the adoption of expanded polystyrene (EPS) for building construction. Expanded polystyrene is a thermoplastic material obtained from the polymerisation of styrene and used as packaging material. The methodology adopted elicited information through a structured questionnaire which assessed the socio-economic characteristics of the respondents, their level of awareness of EPS as a building material. Strategies in reducing the cost of construction of EPS buildings, advantages of using polystyrene, factors hindering its adoption for building and the remedies to factors impede the adoption of EPS for building construction were also elicited. Structured questionnaires were used for the data collection and subsequently analysed. The study revealed that EPS demonstrates fast construction time, flexibility, reduced heat transfer, high strength and stability and environmental friendliness. The outcome of this research shows that perceived high cost and lack of awareness were the key hindrances to the adoption of EPS for construction and if strategies such as cutting production costs, reducing supply expenses, lower financial expenditure etc. can be adopted the material will be highly suitable in construction.

Keywords: *Adoption, Building Construction, Expanded Polystyrene, Sustainability, Cost Reduction*

INTRODUCTION

The search for shelter has made man come across several materials ranging from tree branches, leaves, grasses, bamboo, clay/mud, metals, brick and block (Ibrahim, Bankole, Ma'aji, Ohize, & Abdul, 2013). They added that their use is very vital in all phases of life as no field of engineering is conceivable without them and there is always a new technology to replace outgoing technology due to mans' technological advancement. Expanded polystyrene (EPS) is a plastic material derived from crude oil used in a variety of applications, including thermal insulation in buildings, civil engineering applications and decorative mouldings and panels. Outside of the construction industry, EPS is used as protective packaging for consumer items and packaging for food and pharmaceuticals, among a wide variety of other industrial and consumer applications. Expanded polystyrene is available in a loose-fill form (beads) for cavity wall insulation, and as panels for internal and external insulation projects. EPS can be used to retrofit an existing home or building, or it can be used as part of a new build. Although made from crude oil, EPS accounts for less than 0.1% of crude oil's total usage. 83% of all crude oil is turned into another form of energy, while an additional 4% is used in the production of plastics that end up in our landfills.

EPS is a chemically stable compound (Ede & Abimbola, 2014) and possesses some characteristics that make it suitable as a construction material and for packaging of consumer products (Aminudin, Mohammed, Zurina, Zainura, & Kenzo, 2011). The material is not susceptible to decay due to its non-biodegradable nature when exposed to landfill (Ede & Abimbola, 2014). The eco-friendly quality of EPS has increased its versatility and use in commercial and residential construction (Aminudin, Mohammed, Zurina, Zainura, & Kenzo, 2011); (Ede & Abimbola, 2014) hence, it is expected that waste will occur. EPS can be recycled infinity times (Aminudin, Mohammed, Zurina, Zainura, & Kenzo, 2011). This paper seeks to promote the adoption of EPS because as reported by (British Plastics Federation, 2020), it is a cost-effective way to significantly alleviate the global warming effect of greenhouse gases (by reducing CO_2 emissions). Ede & Abimbola (2014) further emphasise that EPS uses greenhouse gas production materials, owing that characteristic to its chemically and environmentally non-aggressive nature. Furthermore, "Thermal Insulation is the primary tool to improve a building's energy behaviour

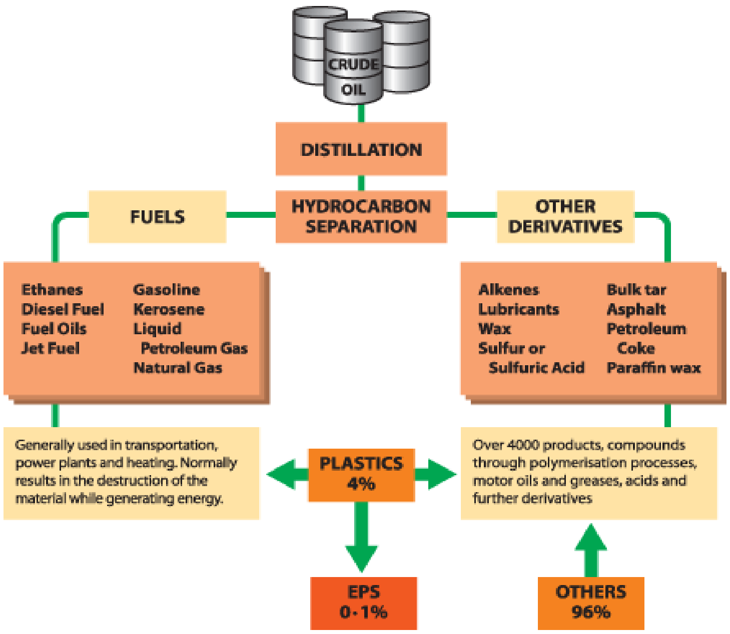
(Papadopoulos, Karamanos, & Avgelis, 2002) and EPS is reported to have a thermal conductivity value of 0.037w/mk (Ibrahim, Bankole, Ma'aji, Ohize, & Abdul, 2013); (Raj, Nayak, Akbari, & Saha, 2014).
The choice of building materials is influenced by several factors which include status, cost, aesthetics, structural stability, ease of maintenance. Others include durability, continued availability, environmental friendliness, and suitability to the prevailing climate which EPS possesses (Ibrahim, Bankole, Ma'aji, Ohize, & Abdul 2013). They further bolstered the latter position by showing that the product possesses all properties to function as a material for the construction of houses. EPS can be used in constructing load-bearing walls, non-load bearing walls, slabs, culverts, stairways and other building elements since it passed all the tests it was subjected to. In terms of life span, (British Plastics Federation, 2020), explains that EPS panels achieve optimum levels of energy efficiency and provide continuous insulation over their 50-year lifespan.

EXPANDED POLYSTYRENE

Expanded Polystyrene is a thermoplastic material obtained by the polymerization of styrene, which produces spherical beads about the size of sugar granules and is used in packaging electronics, food items and building houses (Olasehinde, 2009). The polymer, polystyrene, used in the manufacture of expandable polystyrene has been in existence for more than 60 years, and it is used for a wide range of plastics and plastic products. Expanded polystyrene is made from expandable polystyrene, which is a rigid cellular plastic containing an expansion agent.
EPS is an inert material that does not rot and provides no nutritional benefits to vermin; therefore, does not attract pests such as rats or termites. Its strength, durability and lightweight nature make it a versatile and popular building product. EPS is widely used in many everyday building and construction situations where its lightweight, strength and thermal insulation characteristics provide cost-effective and high-performance solutions. EPS can be recycled and can be used as an additive to make lightweight concrete blocks for construction purposes (James, 2008).

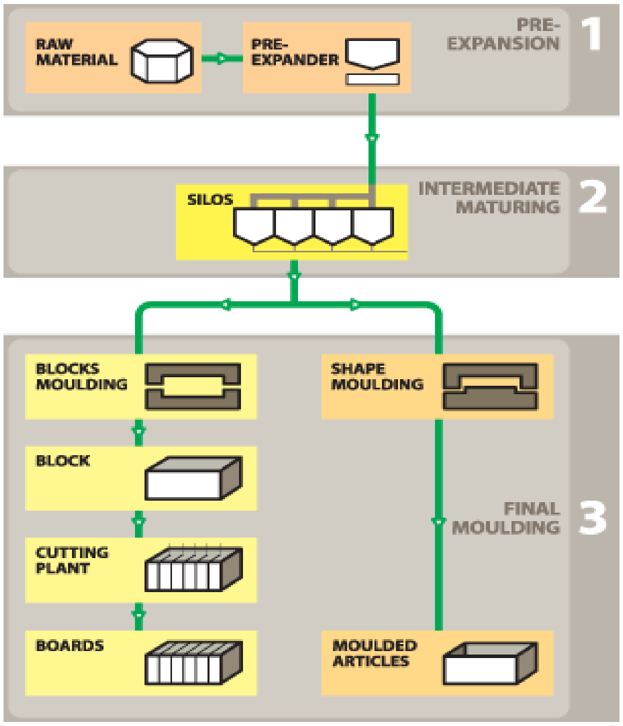
MANUFACTURING PROCESS OF EXPANDED POLYSTYRENE

EPS is made from styrene, a by-product of crude oil. For every 1000 liters of oil extracted, only a small amount of EPS is obtained. No oil is extracted solely for EPS production. The following diagram demonstrates the source of materials used to produce EPS.



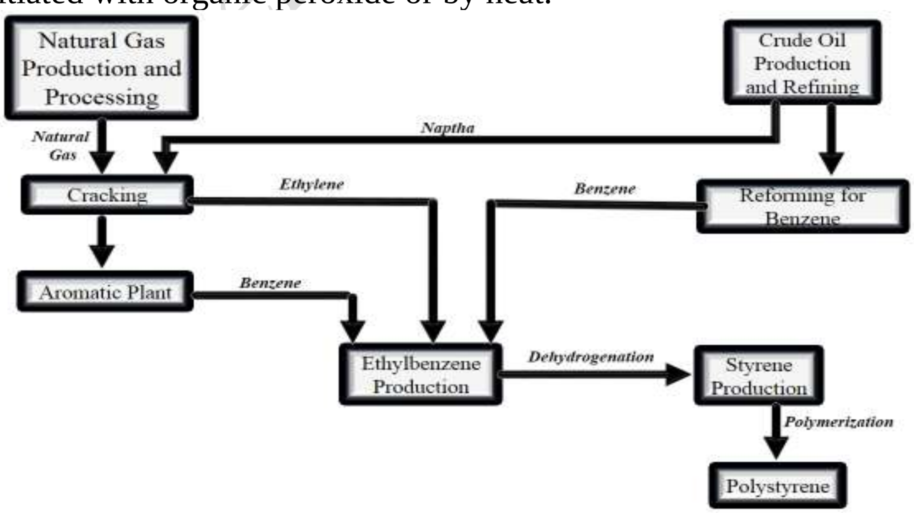
Source: Expanded Polystyrene (EPS) and the Environment

Expanded polystyrene foam is made from expandable polystyrene, which is a rigid cellular plastic foam containing an expansion agent. EPS is obtained from oil as can be seen from the diagram. The manufacturing process of EPS products from the raw material (expandable polystyrene) uses natural gas to produce steam. The manufacturing process also uses some electricity to run the molding machines and ancillary equipment. Cooling water used to cool the moulds after the EPS has formed. The desired product is collected and reused in the cooling process. Steam that condenses during the molding process is also collected and reused to conserve water. The expanding force in the foam is produced from the pentane, which is contained within the expandable polystyrene. The pentane is released during the molding process. Styrene is the building block (monomer) of polystyrene and is obtained from crude oil (British Plastics Federation, 2020); (Olasehinde, 2009). The effect of this discovery does not affect the initial discovery process but it creates an easier option for production of the monomer before the polymer.



Source: Expanded Polystyrene (EPS) and the Environment

A range of processes starting with distillation, steam cracking and dehydrogenation are required to transform the crude oil into styrene. In practice, the production route from crude oil refining produces naphtha, which contains a mixture of low molecular weight, saturated hydrocarbons of various compositions. This is converted into a smaller group of unsaturated hydrocarbons by cracking (a process in which the naphtha is heated to a high temperature in the absence of air). The resulting mixture is then separated into its constituent's components by distillation producing principally ethylene, propylene and a number of other products, which find uses elsewhere in the petrochemical plant as either feedstock or fuels. Natural gas is also converted into ethylene and other products by cracking. Ethylene and benzene are reacted to form ethyl benzene, which is dehydrogenated into styrene. At the end, polystyrene is produced by polymerizing styrene. This exothermic reaction can be initiated with organic peroxide or by heat.



Source: Expanded Polystyrene (EPS) and the Environment

EXPANDED POLYSTYRENE IN CONSTRUCTION

EPS consist of lightweight foam blocks made of EPS which are cut into panels (single or double depending on design requirements). It is prefabricated in a factory and are stacked together to make up the desired wall shapes which are then coated with cement and stone dust mix or filled with concrete. Expanded Polystyrene (EPS) is a material used to build single-level and multilevel walls, slabs, retaining walls and underfloor insulation panels for heating, cooling and sound insulation.

EPS has experienced a wide range of applications owing to its lightweight, rigidity, thermal and acoustic insulating properties. Initially, EPS was mainly used for insulation foam for closed cavity walls, roofs and floor insulation. Ultimately, the application has extended vastly in the building and construction industry such that EPS is now used in road construction, bridges, floatation and drainages. EPS used for building construction are of various types and sizes with the most common ones being for wall panels and floor slab. Steel meshes are punctured unto them to serve as reinforcement. The EPS 3D reinforced wall system usually transfers shear and compression forces along the wall plane. The wall system is completed by applying concrete layers of acceptable thickness on both sides to perform the dual functions of protecting the reinforcements against corrosion and for the transference of compressive forces (Ede & Abimbola, 2014). With the proven strengths of plastic materials used in commercial and residential construction in the past 30 years, the adoption of plastic in civil constructions is dramatically on the increase due to improved material performance, efficient use of technologies in new applications, and the need for lightweight, durable materials and insulation purposes (Papadopoulos, Karamanos, & Avgelis, 2002).

Source: Fieldwork 2019

On the economic side, the EPS material technology appears to be very enticing for the key players in the construction industry. Most often, the clients, designers, contractors and end-users are always at loggerheads over terms of establishing acceptable equilibrium on

the major building industry concerns of cost, quality and time. Every client would want to construct a facility of the highest quality while minimising cost and time. End-users are attracted to good quality houses at an affordable cost. The most suitable way to achieve this is through proper and careful choice of building materials. Expanded Polystyrene is one product that can contribute towards achieving good quality and record time completion of building product at all stages of its life cycle, from manufacture to application, recycling or disposal, EPS has shown excellent performance. The use of expanded polystyrene offers considerable cost and environment advantages since it contributes positively towards a better environment and at the minimal cost.
The benefits of expanded polystyrene (EPS) in the building industry worldwide can be summed up as lifetime durability, moisture resistance, proven acoustic and excellent thermal insulation. Also, it has design versatility, easy installation leading to record time completion, flexible mechanical properties, functional strength and structural stability (Ede & Abimbola, 2014)). Specifically, on the cost of production and time of construction, EPS material has the edge over conventional building materials because it is prefabricated. Nevertheless, despite all the merits and advantages of the EPS building system, the application by developers in the Nigerian building industry is very limited. This is due to relatively scarce knowledge of this innovative method of construction and poor access to the material. Low level of usage and awareness to the building professionals and the general public as well as its non-availability is because in Nigeria, very few manufacturers of the EPS building material system exist. The EPS blocks or panels used for building processes are scarce and this leads to the high cost of production, which is transferred from client/contractors to end-users. Based on these scenarios and the proven properties and applications of EPS, this research is aimed at evaluating better adoption of EPS as a building material. A building estate where EPS is predominantly used in Abuja will be the case study.

EPS AND ITS ENVIRONMENT

The impact on the environment of everyday materials is increasingly essential if we are to reduce our carbon footprint and protect our natural heritage for future generations. EPS (expanded polystyrene) is an excellent material for packaging and construction as it is a light yet rigid foam with excellent thermal insulation and high impact resistance. Using EPS insulation actively contributes to a better environment during the entire working life cycle of the building. EPS offers substantial environmental advantages through energy-saving and greenhouse gas emission reduction and is therefore ideally suited to the creation of environment-friendly new building projects. It is easy to handle, safe, non-hazardous and has proven constant mechanical and insulation properties for the lifetime of the building in which it is used. EPS doesn't contain or use any ozone-depleting chemicals at any stage of its life cycle. At every stage of its life cycle, from manufacture to application, to recycling and final disposal of EPS, it offers exceptional eco-credentials. All manufacturing processes comply with current environmental regulation.

EPS AND SUSTAINABILITY

EPS offers substantial environmental advantages through energy-saving and greenhouse gas emission reduction and is therefore ideally suited to the creation of environment-friendly new building projects. EPS does not contain or use any ozone-depleting chemicals at any stage of its life cycle. Its products are available for nearly all building insulation applications: floor, wall and roof insulation in new and renovated buildings. The proven durability of EPS makes it a material of choice for sustainable buildings, with continuous insulation and mechanical properties over time, unaffected by moisture and typical in-use mechanical stresses (XCO2 Conisbee Ltd Consulting Engineers, 2002). Well-insulated buildings not only help preserve the environment for subsequent generations, but they also allow for more comfortable living for the people using them and have a significant economic benefit to the individual and the community (Plastics Make it Possible, 2016).EPS as a building material benefits the three pillars of Sustainability.

Also, EPS is already one of the most widely recycled plastics. Unlike the primary competitive insulation materials, it is easily recycled and recycling results in real environmental and financial gain. Not only do EPS manufacturers recycle factory waste into insulation boards, but post-consumer packaging waste is collected and included to optimise costs and the need for virgin EPS material. EPS used as insulation has a long lifetime in buildings. So at the moment, there is still little need to recycle EPS insulation material since EPS does not degrade or deteriorate; at the end of its useful life, it can be reused in several ways. EPS is recyclable as it will become polystyrene plastic when recycled. With the highest recycling rates for any plastic and accounting for a non-substantial portion of municipal waste, expanded polystyrene is an environmentally friendly polymer. EPS can be recycled in many different ways such as thermal densification and compression. It can be re-used in non-foam applications, lightweight concrete, building products and remoulded back into EPS foam.

DRIVERS TO REDUCE EPS PRODUCTION COST

Companies of all sizes have an incentive for cost reduction to remain competitive and to increase profits. For companies that offer goods for sale, production costs are a major factor in pricing and overall performance. Approaching the initial reduction of production costs in a structured way and putting in place a system that continuously watches for additional savings are effective ways of achieving reductions and keeping costs down. Scuderi (2012) identifies the drivers of high production costs and develops strategies to deal with them as follows:

Component Costs

One of the main costs of production is the cost of the components that make up the finished product. Reducing these costs even slightly on a percentage basis can have a substantial impact on the cost of production. Sometimes companies can reduce component costs by buying in bulk or substituting less expensive components that satisfy the requirements. Sometimes a design will allow for fewer fasteners or less material without affecting quality. A review of such possibilities often results in a decrease in production costs.

Change Suppliers

If the supplier of components is not willing to consider price reductions and can't offer less expensive alternatives, a company can explore sourcing from different suppliers. It can send the component requirements to various possible suppliers and select those that offer the best value in terms of meeting the specifications and low pricing. Sourcing from two or three suppliers keeps prices low due to competition.

Change Design

An effective strategy for reducing production costs is to redesign the product. Companies have to identify the critical characteristics of the product that are responsible for its success in the marketplace. Other features may be costly but add little value to customers. Companies can change the design of the product to reduce costs by eliminating unimportant features while retaining the characteristics that customer's value.

Employee Training

A company evaluating its production costs may find that employees are not working efficiently or lack the awareness of costs that would allow them to help with reductions. Training employees to understand how the production cycle works and their role in cost reduction makes them part of the solution. When a company trains its employees to be aware of how to reduce costs and informs them of progress, production workers become partners in cost reduction.

Optimise with Technology

Technology allows cost reduction in two ways. It enables automation of certain production processes, resulting in greater consistency and reduced costs, and companies can use it to analyse their production workflow. Many companies already use a high degree of automation but have considerable scope for work-flow optimisation. Software analyses the production processes and identifies waiting times and their causes. It shows where material and components are not available when needed and allows companies to streamline production, increasing efficiency and reducing costs.

METHODOLOGY

The research adopted the quantitative method of investigation with its inherent characteristic of small samples. The paper focused on Abuja being one of the few states that use EPS for construction. The target population were Consultants, Contractors and End users. The Sampling frame consisted of data obtained from one manufacturing (CUBIC CONTRACTORS) and two installation companies (CITEC, STAG).

The sampling technique used was purposive sampling. Criteria for selection was informed by the need to obtain reliable answers to the research questions from professionals in the value chain of EPS within the Nigerian construction industry: Manufacturers and installers on an organisational basis, and the end-users with their lived-in experience.

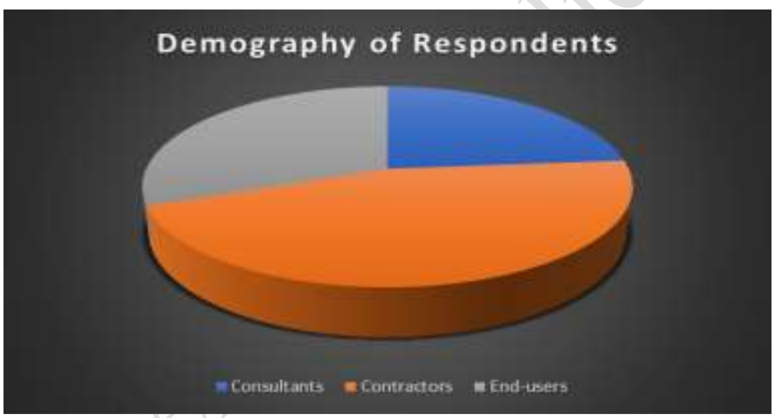
A semi-structured questionnaire was utilized to obtain primary data to capture the objectives of the study. The questionnaire designed for this research was such that the first section dwelt on the background information of the respondents while other sections focused on matters relating to the research study. The data collected will be presented in tables and analysed through simple percentages, frequency tables and mean score. The Mean Item score was gotten using the formula

$$MIS = \frac{5F_5 + 4F_4 + 3F_3 + 2F_2 + F_1}{F_5 + F_4 + F_3 + F_2 + F_1}$$

Where F = the frequency of each of the rankings

Upon calculating the mean, it was used to rank the responses from highest to the lowest.

DATA ANALYSIS, PRESENTATION AND FINDINGS



Sampling frame consists of 16 consultants, 25 contractors and 17 end-users. Total population being 58

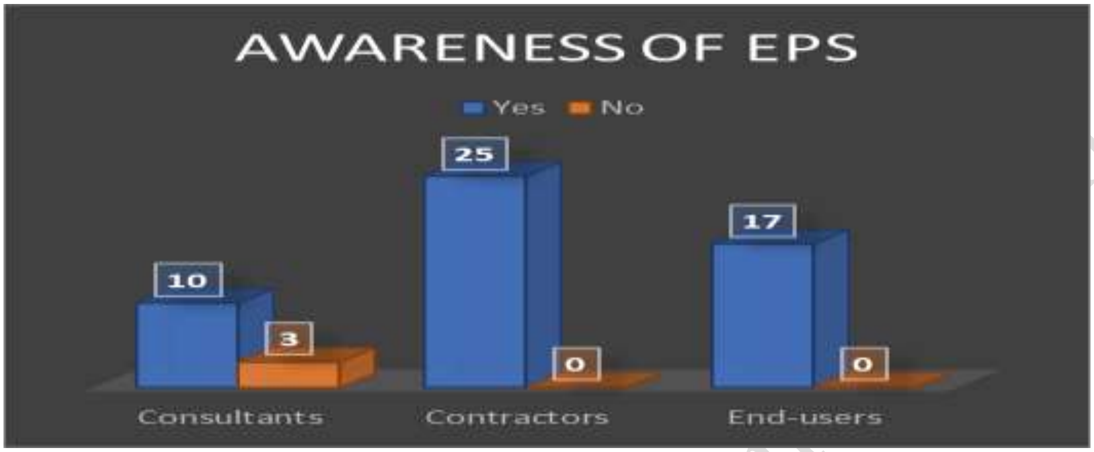
Source: Field Survey 2019

Awareness of EPS as a building material in the building industry by all respondents

Respondents	F	Yes	No	% that are aware	% not aware
Consultants	16	13	3	76.00	24.00
Contractors	25	25	0	100.00	0.0
End users	17	17	0	100.00	0.0

Total	58	55	3	95.00	5.00

Source: Field Survey 2019

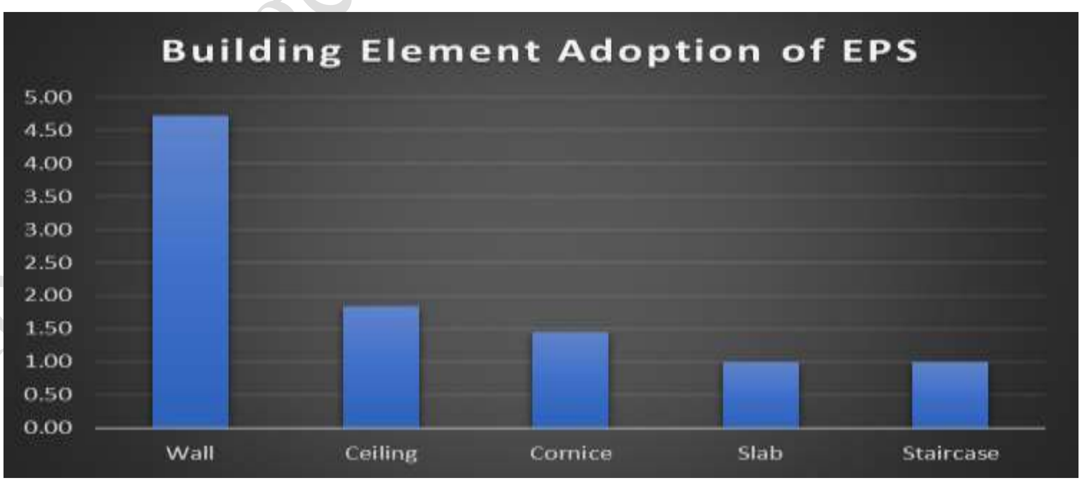


95% of the respondent are aware of EPS as a building material, while 5% of the respondent are not aware**.**

Frequency of adoption of elements of building utilizing EPS

S/N	ELEMENT	5	4	3	2	1	N	∑FX	Mean
1	Wall	40	15	0	0	0	55	260	4.73
2	Ceiling	9	2	0	10	36	55	101	1.84
3	Cornice	4	3	0	0	48	55	80	1.45
4	Slab	0	0	0	0	55	55	55	1.00
5	Staircase	0	0	0	0	55	55	55	1.00

Source: Field Survey 2019



Walls are the most often element of building adopting polystyrene followed by ceiling and least utilised are staircases and slabs.

Benefits of using polystyrene

S/N	Benefits	5	4	3	2	1	N	ΣFX	Mean	Rank
1	Reduced heat transfer	22	26	7	0	0	55	235	4.28	1st
2	High strength and stability	0	42	9	4	0	55	203	3.69	2nd
3	Prevention of termite	0	33	22	0	0	55	198	3.60	3rd
4	Sound insulation	0	13	22	20	0	55	158	2.87	4th
5	Low cost of maintenance	0	0	26	29	0	55	136	2.47	5th
6	High resistance	0	0	2	46	7	55	105	1.91	6th

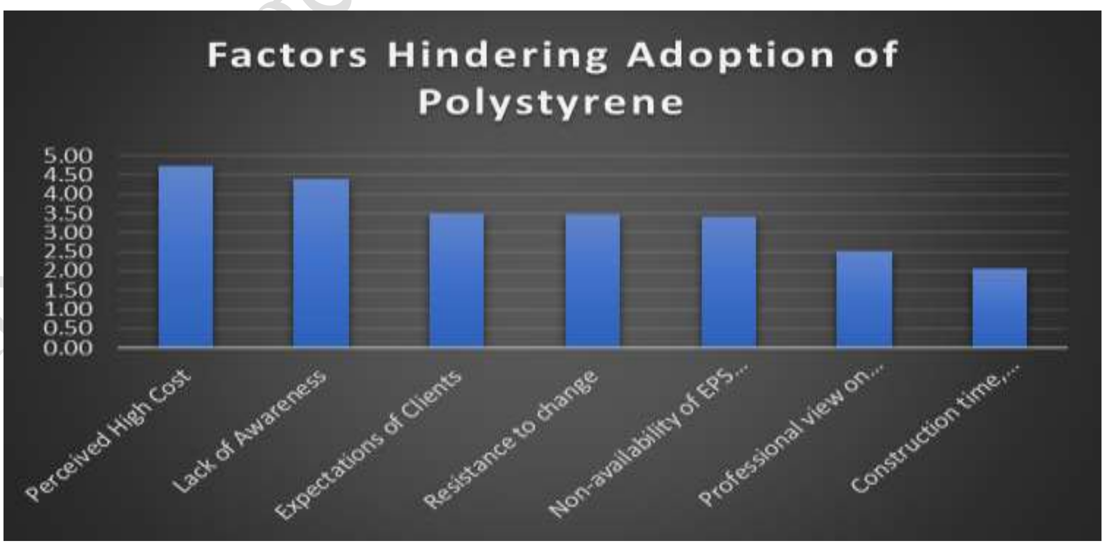
Source: Field Survey 2019

Reduction in heat transfer is the highest advantage of EPS as perceived by the respondents with a mean score of 4.28, high strength and stability is second with 3.69 mean score while high resistance is ranked the least among the advantages with a mean score of 1.91

Factors hindering the adoption of expanded polystyrene

S/N	Hindrances	5	4	3	2	1	N	ΣFX	Mean	Rank
1	Perceived high cost	43	9	3	0	0	55	260	4.73	1st
2	Lack of Awareness	32	15	6	2	0	55	242	4.40	2nd
3	Expectations of clients	0	32	18	5	0	55	192	3.49	3rd
4	Resistance to change	5	18	30	2	0	55	191	3.47	4th
5	Availability of EPS raw material	5	20	23	7	0	55	188	3.42	5th
6	Professional view on quality of EPS	0	2	24	29	0	55	138	2.51	6th
7	Construction time, method or quality	0	0	6	47	2	55	114	2.07	7th

Source: Field Survey 2019



The high cost of EPS is the most prominent hindrance with a mean of 4.73, lack of awareness was ranked second with a mean of 4.40, Expectations of clients was ranked third with a mean of 3.49, while construction time, method or quality ranked least with a mean item score of 2.07.

Drivers in reducing the cost of expanded polystyrene

S/N	Driver	5	4	3	2	1	N	∑FX	Mean	Rank
1	Cut production costs	28	23	4	0	0	55	159	4.42	1st
2	Reduce supply expenses	15	26	14	0	0	55	145	4.03	2nd
3	Lower financial expenditure	0	34	21	0	0	55	130	3.61	3rd
4	Narrow focus	6	12	35	2	0	55	123	3.42	4th
5	Raising alternative funding to cater for organizational and/ or manufacturing expenses	3	14	38	0	0	55	121	3.36	5th
6	Focus on quality	0	17	35	3	0	55	117	3.35	6th
7	Modernize marketing effort	0	12	43	0	0	55	116	3.22	7th
8	Harness virtual technology	3	4	48	0	0	55	115	3.19	8th
9	Allocating more money to project	0	12	41	2	0	55	115	3.19	9th
10	Use efficient time strategies	0	11	43	1	0	55	114	3.17	10th
11	Maximize employees' skills	0	14	35	6	0	55	113	3.14	11th
12	Make the most of space	0	4	51	0	0	55	111	3.08	12th

Source: Field Survey 2019

Cutting production cost is the most favourable strategy for reducing the cost of construction of EPS with a mean score of 4.42, followed by lowering the supply expenses, while to make the most of space is the least with a mean score of 3.08.

Remedies to other factors hindering adoption of polystyrene

S/N	Remedy	5	4	3	2	1	N	∑FX	Mean	Rank
1	Reducing cost through improving the supply of EPS beads	44	9	2	0	0	55	262	4.76	1st
2	Improving awareness of benefits	20	22	11	0	0	55	240	4.36	2nd
3	Increasing competitiveness by setting up more organization producing EPS panels	7	22	26	0	0	55	201	3.65	3rd
4	Raising more funds to cater for expenses	4	20	31	0	0	55	193	3.51	4th
5	Reducing resistance due to fear of changing traditional building materials	4	18	33	0	0	55	191	3.47	5th
6	Government enacting laws encouraging use of EPS	9	7	37	0	0	55	184	3.35	6th

Source: Field Survey 2019

Reducing cost through improving the supply of EPS raw material is the most prominent remedy with a mean of 4.76, Improving awareness of benefits was ranked second with a mean of 4.12, while Government enacting laws encouraging the use of EPS ranked least with a mean item score of 3.40.

DISCUSSION OF FINDINGS

Findings indicate that perceived high cost, lack of awareness, expectation of clients, are the main challenges as recognised by construction professionals to the adoption of EPS as a building material. Reduce heat transfer, high strength & stability and prevention of termite are seen by professionals as the prominent advantages EPS has as a building material. This study corroborated the work of Ogundiran and Adedeji (2012). EPS exhibits low thermal conductivity, lightweight, mechanical resistance, moisture and chemical resistance, ease of handling and installation and versatility, which makes it suitable for building construction. The factors that influence the use of EPS as a building material largely depends on its cost of production, lack of awareness and availability of the raw material. Strategies in reducing the cost of construction include cutting the cost of production, reducing supply expenses, lower financial expenditure, narrowing focus etc.

A good number of the respondents have substantial knowledge about both the manufacture and use of EPS in building construction. They are aware of a variety of applications to which EPS can be put into; in walls, ceiling or floor, beads for decorative purposes in buildings, they know the various materials that can be used in making Eps. This contradicts the research of Ogundiran & Adedeji (2012). They stated in their work that despite the eco-friendliness and other advantages of the EPS insulating material, it has been discovered that there is a low level of awareness on the part of the building professionals in Nigeria.

Lastly, the findings indicated that reducing cost through improving the supply of EPS, enhancing awareness of benefits, increasing competitiveness by setting up more organisation producing EPS panels. Others include raising more funds to cater for expenses, and government enacting laws encouraging the use of EPS are the remedies to factors hindering adoption of polystyrene as a building material in the construction industry.

CONCLUSIONS

This study attempted to assess the level of adoption of expanded polystyrene as a building material in the construction industry. It identified both organisations and individuals with great enthusiasm in the production and use of EPS for building construction, the level of adoption, the factors hindering the adoption of expanded polystyrene and strategies in reducing the cost of adopting it. The research concluded that despite the vast development in the level of awareness of polystyrene among construction professionals, its level of awareness among the general public is low. Major hindrances to its adoption are perceived high cost and lack of awareness

RECOMMENDATIONS

This study recommends:

- Reducing the manufacturing cost of EPS would go a long way in improving its adoption as a building material.

- Government, manufacturers and other stakeholders should embark on increasing awareness of EPS to the general public and encourage higher institution to include EPS study in their teaching and research curriculum,
- Increasing competitiveness by setting up more manufacturing companies will reduce cost, quicken the adoption rate and broaden its market share due to its advantage as a building material.
- Raising more funds from external sources to cater for expenses.

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