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# Assessment Of The Strength Properties Of Polystyrene Material Used In Building Construction In Mbora District Of Abuja,Nigeria

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**Abstract: -** This study was designed to assess the strength potentials of polystyrene material used in building construction in Mbora district, Abuja. Two research questions were formulated to guide the study. An experimental research design was employed for the study. The study was carried out in the building technology laboratory, Federal University of Technology, Minna Niger state and the construction site of Citec International estates Mbora District, Abuja. The findings of the study revealed among others that polystyrene material has good strength potentials in building construction. Based on the findings, it was also recommended that there should be a proper orientation on the use of Expanded Polystyrene (EPS) material for building construction since it posses the required quality for building material, the government and the people of Nigeria should make use of EPS material in the construction of houses since it is a strong and safe building material.

## I. INTRODUCTION

In life, the wealth of man is measured by his ability to acquire his basic needs of survival which are food, shelter, and clothing. Reference [1] stated that, after man has eaten, the struggle for survival continues as he must protect himself from the various climatic conditions (such as cold/rain, heat/sun), wild animals and criminals and provide comfort which may be an aesthetic/luxury need. From the very time of creation, man had always had a place to call home not minding what it looks like; starting with the Garden of Eden. This search for shelter has made man come across several materials ranging from tree branches, leaves, grasses, bamboo, clay/mud, metals, brick, block and even polystyrene. All these materials he calls building materials. Over the years, a lot of materials have being used in building construction ranging from stones, mud, timber, bamboo, glass, block, brick, grass, metal, cement, concrete and polystyrene among others. According to [2] building materials are those materials that are used in building construction. He added that their use is very vital in all phases of life as no field of engineering is conceivable without their use as there is always a new technology to replace an outgoing technology due to mans' technological advancement. The use of building materials have changed from one material to another over the period of time due to technological advancement. This technological advancement has lead to the production and use of polystyrene blocks in building construction.

Polystyrene is a thermoplastic material obtained by the polymerisation of styrene and is used in packaging electronics, food items and building houses ([3]). Polystyrene which is a light synthetic material cannot be used in building houses unless being polymerised to form a block. The polymerisation of styrene to form a block is called Expanded Polystyrene (EPS). Reference [4] observed that, Expanded Polystyrenes is formed by a union of so many beads of polystyrene produced during a modelling process with a supply of heat which comes in form of steam until the following characteristics are obtained: - Normal density of 15kg/m³, Thermal conductivity of 0.037w/mk, Steam resistance of 0.15mmHgm² dia/gcm and Compressive stress at 10% of strain is 50kpa.

Polystyrene used for building construction are of various types and sizes with the common ones for wall panels and panels for slab. But these panels cannot be erected without the use of some meshes. While Reference [5] stated that the EPS blocks usually with a height of 3000mm, breadth of 1200mm and a thickness of 100mm are used as wall panels which also have a thin layer of metal/ steel serving as a form of reinforcement. According to him, the panels being used for slabs are usually with a height of 6000mm, a breadth of 400mm and a thickness of 300mm. It is alongside with reinforcements of Ø8mm, Ø10mm, Ø12mm, Ø16mm, Ø20mm which are used according to the bar bending schedule for the slab. Literature has shown that the mechanical property of expanded polystyrene depends on two primary factors: the density of the materials and the fusion, or integral bonding of the expanded polystyrene beads. Although density plays a key role in defining the mechanical properties as density alone does not adequately define the important characteristics and should not be the sole criteria used to specify the product. Reference [1] also stated that, the strength of an expanded

polystyrene structure is determines to a large extent how well it is able to keep its monolithic nature which makes it an outstanding building material.

Technological advancements in all phases of life have really helped life making it easy for man, but not all technological advancement can be accepted as their after effect may be too dangerous. Polystyrene as a building material has been used for over 30years ([6]). According to [6], the use of polystyrene is a technology with Italian origin that boasts more than 52 manufacturing lines installed all over the world in most countries such as Mexico, Guatemala, Costa Rica, Venezuela, Ecuador, Santo Domingo, Panama, Argentina, Russia, Italy, Ireland, Spain, Bosnia, Egypt, Eritrea, Nigeria, Mozambique, Libya, Saudi Arabia, Kurdistan (Iraq), Turkey, Reunion Islands, Malaysia, Republican Dominicana, Philippines, Qatar and USA. To this effect, the effectiveness of polystyrene as a building material needs to be assessed to know if its use can be encouraged or not and if it can serve as a good replacement to other building materials.

Assessment is the process by which the value of a building material's performance and quality is obtained. Reference [7] viewed assessment as the process of examining carefully, thoroughly and objectively as possible an individual, group of people, product or programme in order to ascertain its strength and weakness. From the foregoing therefore, assessment can be seen as the systematic process of judging the worth, desirability, effectiveness or adequacy of something according to a given criteria. Also, according to [7], without a valid assessment, there would be an unreliable data which will cause an adverse effect on the occupants of a house built of expanded polystyrene material. Experience has shown that so many building materials have not been properly assessed before use as they really have caused a lot of damage on the part of building owners and loss of lives and properties on the part of occupants. The question therefore is; can polystyrene be a better replacement for other building materials?; Can it stand the test of time, quality, cost, availability, safety, variety of design, structural strength, ease of construction and maintenance among others? For a material to be effective, it means it is producing an intended result. Then, the question is: what are the intended results that come to mind; such results include: safety, strength, durability, affordability, availability and variety among others. Hence, this study is designed to assess the effectiveness of polystyrene material as a building construction material in Mbora district of Abuja, Nigeria.

**Statement of the Problem**

After man has met his basic need of survival (food, shelter and clothing) he begins to boast it, showing some luxury and aesthetic value to it. But lay man has failed to know how well this materials used for aesthetic value would serve it. And to this effect, so many houses have collapsed wasting a lot of lives and properties. Experience have shown that, lack of effective assessment of building materials has caused and imposed a lot of risk on so many lives and properties ([6]). This error has occurred in the past and should not be allowed to continue especially as polystyrene is being used as a building material in Mbora district in Abuja, Nigeria. Based on the foregoing therefore, this study is designed to assess the effectiveness of polystyrene material for building construction in Mbora district of Abuja, Nigeria.

**Purpose of the Study**

The study was designed to assess the effectiveness of polystyrene material for building construction in Mbora district of Abuja, Nigeria. Specifically, the study was carried out to determine:

- The strength properties of expanded polystyrene material used for building construction at Mbora district of Abuja through axial loading.
- The compressive strength of expanded polystyrene material used for building construction at Mbora district of Abuja through crushing

**Research Questions**

The following research questions guided the study:-

- What is the compressive strength of Expanded Polystyrene through axial loading?
- What is the compressive strength of Expanded Polystyrene block through crushing?

## II. METHODOLOGY

The research design for this study is an experimental research design this is because of the nature of the information needed for the study. The study was carried out at Citec Mbora Mount Pleasant Estates Mbora district of Abuja, the building workshop of Industrial and Technology Education (ITE) and the building Laboratory of the Building department both of the Federal University of Technology Minna- Niger state, Nigeria. The materials used for the study are:

i. Plaster sand: these consist of natural sand particles passing through a 3/8 inch (9.5mm) sieve. The plaster sand used for this work was gotten from Maikunkele in Niger state of Nigeria.
ii. Stone dust: The stone dust used for this work was obtained from a quarry in F-layout Bosso local

government area of Niger state.

iii. Cement: this is a fine, soft, powdery – type substance that is made from a mixture of elements such as limestone, clay, sand and /or shale found in natural materials. It is also made of calcium, silicon, aluminium and iron. It basically serves as a binding material. The cement used for this work is Dangote Obajana Portland cement.

iv. Expanded Polystyrene (EPS) this is the major material used for this work. As discussed earlier in page 12 of chapter II, it is a polymer of styrene used in building construction in several parts of the world but seems to be a new material here in Nigeria. The sample used for this test was gotten from Citec Int'l Estates, Mbora district, Jabi- airport road Abuja Nigeria.

**Test carried out for study:**

The following tests were carried out; Compressive strength test via axial loading; Compressive strength test via crushing; Specific gravity of cement; Specific gravity of plaster sand; Specific gravity of stone dust and Water absorption/ resistance of EPS.

**Apparatus and materials used for the study includes**

10 EPS blocks cut into a size of 450mm×225mm×150mm, sprayed and plastered; Trowel; Shovel and Wooden float

## III. RESULT AND DISCUSSION

**Research Question 1**

What is the compressive strength of expanded polystyrene through axial loading?

To determine the compressive strength of expanded polystyrene through axial loading, the axial loading test was carried out on the expanded polystyrene (EPS) slab in order to determine the strength and the sag.

**The result for this test is presented below.**

The expanded polystyrene slab was loaded with 50bags of 50kg Dangote Portland cement each to give a load of 2500kg. It was observed that there was no sag on the slab, this load was later increased to 100 bags that is 5000kg, and there was no sag. It was then agreed that the compressive strength of an expanded polystyrene slab via axial load is good and high enough to carry the dead and live load of a building since the total load including dead weight of the slab amounts to more than 1400kg/m² which at least twice the load in a usual residential building.

**Research question 2**

What is the compressive strength of an expanded polystyrene block through crushing?

In determining the compressive strength of an expanded polystyrene block through crushing, nine (9) expanded polystyrene blocks were cut into a dimension of (450×225×10)mm were shortcreted and plastered while it was left for 24 hours to set properly in the building laboratory of the Department of Industrial and Technology Education, Federal University of Technology Minna, Niger state .The expanded polystyrene blocks were cured with water for 7days, 14days and 28 days respectively and were crushed (3 EPS blocks each) on the 7$^{th}$, 14$^{th}$ and 28$^{th}$ day respectively at the building laboratory, School of Environmental Technology (SET), Federal University of Technology Minna, Niger state, Nigeria.

Table 4.1 below shows the data obtained from the crushing of the expanded polystyrene blocks at 7days, 14 days and 28 days respectively.

**Table 4.1, Data obtained from the crushing of EPS blocks at 7, 14 and 28 days respectively.**

| S/N | Curing days | Mass of EPS block (kg) | Volume of the EPS block (mm³) | Density of the EPS block | Load applied on the EPS block (N) | Compressive strength of the EPS block(N/mm) | C.S in psi |
|---|---|---|---|---|---|---|---|
| 1. | 7days | 14.38 | 450×225×10 | | 10.0 | 0.10 | 145.14 |
| 2. | 7days | 12.39 | " | | 24.0 | 0.24 | 348.33 |
| 3. | 7days | 12.98 | " | | 21.0 | 0.22 | 319.30 |
| 4. | 14days | 12.93 | " | | 15.0 | 0.15 | 217.71 |
| 5. | 14days | 14.53 | " | | 30.2 | 0.30 | 435.41 |
| 6. | 14days | 10.62 | " | | 17.0 | 0.17 | 246.73 |
| 7. | 28days | 12.78 | " | | 32.6 | 0.32 | 464.44 |
| 8. | 28days | 14.73 | " | | 44.3 | 0.44 | 638.61 |
| 9. | 28days | 12.27 | " | | 19.8 | 0.20 | 290.28 |

**Table 4.2 Standard Deviation for the Compressive Strength**

| S/N | Compressive strength (x) | Deviation from mean $(x - \bar{x})$ | Square of deviation $(x-\bar{x})^2$ |
|---|---|---|---|
| 1. | 0.10 | -0.138 | 0.019044 |
| 2. | 0.24 | 0.002 | 0.000004 |
| 3. | 0.22 | -0.018 | 0.000324 |
| 4. | 0.15 | -0.088 | 0.007744 |
| 5. | 0.30 | 0.062 | 0.003844 |
| 6. | 0.17 | 0.068 | 0.004624 |
| 7. | 0.32 | 0.082 | 0.006724 |
| 8. | 0.44 | 0.202 | 0.040804 |
| 9. | 0.20 | 0.038 | 0.001444 |

Where $\bar{x}$ = mean $= \frac{\sum x}{n} = \frac{2.14}{9} = 0.238$

$\sum(x - \bar{x}) = -0.02$

Variance $= \frac{\sum(x-\bar{x})}{n} = \frac{0.084556}{9} = 0.009395$

$$standard\ deviation = \frac{\sqrt{(\sum(x - (x)))}}{n}$$

$$S.D = \frac{\sqrt{0.009395}}{9} = 0.0969 \approx 0.1$$

The expanded polystyrene block was also cut and crushed separately without being shortcreted. The analysis of the data presented in table 4.1 revealed that the compressive strength of expanded polystyrene is high. This signifies that the expanded polystyrene material has the required strength to withstand the load of a building.

**Findings**

Based on the test carried out, the following findings were made according to the research question posed for the study:

a. The findings of the study on the compressive strength of expanded polystyrene via axial loading revealed that the strength of an expanded polystyrene slab is good and can carry both the dead and live load of a building which is basically what every building should strive for.
b. The findings of the study on the compressive strength of expanded polystyrene via crushing shows that the compressive strength of expanded polystyrene panels is high and good as the compressive strength of expanded polystyrene is measure in pound per square meter (psi)
c. The findings on the study on the specific gravity of cement shows that the test carried out is in relation to what is being conducted as the specific gravity of cement.
d. The findings on the specific gravity of plaster sand shows that the test carried out is in relation to what is being conducted as the specific gravity of Plaster sand.
e. The findings on the specific gravity of stone dust shows that the test carried out is in relation to what is being conducted as the specific gravity of stone dust.

**Discussion of Findings**

The major findings of the study were discussed in the order of the research questions.

a. Research question one dealt with the compressive strength of expanded polystyrene through axial loading. The findings as indicated from the test carried out revealed that the compressive strength of expanded polystyrene through axial loading is high and is able to carry the dead and live load of a building which makes it a good material since that is one of the major requirement of a slab. This finding was in line with the views of reference [4] who stated that, the strength of an expanded polystyrene structure is determines to a large extent how well it is able to keep its monolithic nature which makes it an outstanding building material.

Research question two dealt with the compressive strength of expanded polystyrene blocks through crushing. The findings as indicated from the test result carried out revealed that the compressive strength of expanded polystyrene is high. This is in line with view of reference [8] which stated that the compressive strength of expanded polystyrene (EPs) should not be less than 65 pound per square meter (psi) of which the least compressive strength from the result in table 4.1 is 145.14 pound per square meter (psi). Review from the literature shows that what actually gives the expanded polystyrene block most of its strength is the mortar used in shortcreting and plastering as [2] in his work says expanded polystyrene is a lightweight material.

The findings also indicated that the compressive strength of expanded polystyrene block either through axial loading or crushing was high and good which means that it is a good material to be encouraged in the construction industry since it meets the basic requirements of building material.

The findings also revealed that the test results for the specific gravity of the materials used was in line with the Building Standard (BS) Regulation for cement, plaster sand and stone which means that, the results given have no negative or imposing strengths given the compressive strength of the expanded polystyrene material.

It is glaring from the study to note that expanded polystyrene (EPs) has all it takes to be used as a building material in Mbora district, Abuja for the construction of houses either as load bearing walls, non-load bearing walls, slabs, culverts, stairways and other uses since it passed all the tests subjected to.

**Recommendations**

Based on the findings of the study, the following recommendations were drawn:

1. There should be a proper orientation on the use of EPS material for building construction since it posses the required quality for a building material.
2. The government should make use of EPS material in the construction of mass housing since it is cheaper, has a faster erecting time and safe.
3. Areas liable to flooding and river over flowing should make use of EPS in the construction of their buildings as it leaves the building standing not minding flow of the river or water due to its box like nature.

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