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Production of Plastic Waste Sand Blocks to Conform to Conventional Geometry

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Abstract:- Plastic has become a material that has gained acceptance for application in so many aspects of human activities and it is therefore widely used around the world. Its desirability for use is due to its versatility, compactness, light weight, ease of production and molding to fit an incredible wide range of needs. Part of the appeal of plastic comes from the fact that it can be reused. Common use of plastic materials include food and drugs packaging, production of bottles and all kinds of containers, household and work place items, electronics; the list is endless. In spite of the huge benefits of using plastic, it also generates huge amount of waste that is toxic to plants, animals and humans if not properly disposed. Plastic disposal is difficult due to its long decomposition period which may take up to 500 years and this has led to a huge environmental pollution crisis. This research presents results of experimental work on Plastic Waste Sand Blocks (PWSB) made from shredded Polyethylene Terephthalates (PET), High Density Polyethylene (HDPE) and sand. This is an attempt to further proffer solutions to plastic waste disposal. The research also tries to address concerns of accepting new sustainable strategies and technologies, therefore the test specimens were prepared using fabricated moulds to conform to conventional geometry for block moulds. A 1:3 and 1:4 plastic to sand mix ratio and batching by weight was adopted.

Results obtained shows that the compressive strength of PWSB at 1:3 was 8.58N/mm² and 9.01N/mm for 450×225×225 and 450×150×225 geometries respectively. For 1:4 mix, 9.20 and 12N/mm² was recorded, with best results exceeding four times that of normal block (3.5N/mm²). It was also observed that the maximum density of PWSB at 1945.90Kg/m³ was less than that of the control sample at 2110.95Kg/m³.

The water absorption of PWSB was found to be very minimal. It was therefore recommended that PWSB due to its high strength in conventional geometry can be used for construction purposes. It can also be used at foundation levels without DPC due to its negligible water absorption.

I. INTRODUCTION

Plastic is an incredibly versatile human innovation that is synthesised mainly from petroleum hydrocarbons, however it is not a naturally occurring material. It has become so important to modern societies to the point that its use is almost indispensable for daily human activities as well as for use as raw material in many industries such as in the medical, food, pharmaceutical and packaging industries. Jassim, (2017) observed that plastic materials and their various composites have very wide applications which are ever growing particularly because they have a low production cost, easier production process compared to other products for similar purpose and they generally have appealing and attractive qualities. Some of the desirable qualities of plastic that makes it attractive were captured by Jassim to include water resistant, lightweight, water retaining, expandability, strength, durability and low cost; He opined that these qualities has created a huge dependence on plastic leading to the over consumption of products that are plastic-based. Beaumont et. Al (2019) noted that plastic is a material that people do not consume correctly as there is lack of information on the environmental damage its use entails. Per capita plastic consumption continues to rise and remains high in high-income countries, despite its obvious contributions to the global issue of plastic pollution (Barnes, 2019). The chemical structure of plastic shows that it is a polymer which is difficult to decompose. This makes plastic non-biodegradable and creates a huge environmental crisis when not properly disposed. The incredible amount of plastic used also easily becomes generated waste which dose not decompose for decades and centuries when placed in landfills, earth or rivers and seas. Plastic waste therefore pollute land air and water after their use and this is a huge dilemma; while on one hand plastic is a very important, versatile and useful material, it is an environmental pollution crisis on the other hand. Furthermore, plastic releases toxic gases and chemicals, over time, which has deleterious effect on human health such as high blood pressure, asthma, cancer, etc. and also on animals. About 300 million tons of plastic are produced globally each year of which only about 25% is recycled and the rest is landfilled (Kamaruddin et. Al, 2017). Therefore, the ways to properly dispose plastic waste has become a global issue that requires input from different professional fields.

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II. LITERATURE REVIEW

A. Plastic

The use of plastic and plastic composites products has now dominated, displaced or replaced the use of many other products such as glass, wood and metal. A very vital area in which plastic use has gained prominence is in the food and packaging industry and this means that plastic has become indispensable for many people due to the need to buy and package food severally on a daily basis. Plastic production requires a few basic steps to be completed such as sourcing out raw materials (usually from petroleum, natural gas or plants), refining raw material to obtain propane and ethane, synthesizing propylene and ethylene into polymers, extrusion, moulding, cooling and cutting. Global plastics production was estimated at 390.7 million metric tons in 2021, an annual increase of four percent. Plastics production has soared since 1950s (Statista Research Department, 2023). Some reports indicate that up to 50% of that is for single-use purposes – utilized for just a few moments, but on the planet for at least several hundred years. It's estimated that more than 10 million tons of plastic is dumped into our oceans every year. Plastic is a valuable resource in many ways, but plastic pollution is an unnecessary and unsustainable waste of that resource (Plastic Oceans, n. d).

B. Types of Plastic

While many types of plastic are made and are possible, the vast majority of industrial plastic production falls into six main types: polyethylene (PE), polypropylene (PP), polyvinyl chloride (PVC), polyurethane (PUR), polyethylene terephthalate (PET), and polystyrene (PS) (Restco, n.d). These are briefly discussed below.

- **Polyethylene:** This is one of the major plastic polymers that is globally produced. It can be either of the High Density or Low Density Polyethylene type (HDPE or LDPE). The temperature of melting point range from 80^0C-180^0C, specific gravity range from 0.93 g/cm³ to 0.97 g/cm³ and this means both HDPE and LDPE can float in fresh and seawater causing unsightly view if improperly disposed. They are used for plastic bags and wrap production.
- **Polypropylene:** this is also known as polypropene and it ranks second on the list of globally produced polymers. Its melting point ranges from 130^0C-171^0C and has specific gravity ranging from 0.895 g/cm³–0.92g/cm³. It floats in fresh and seawater and it is basically used for plastic rope making.
- **Polyvinyl Chloride (PVC):** This is third in number of polymers used worldwide. It has a specific gravity of 1.1 to 1.45 g/cm³ and typically will not float in freshwater or seawater. It is used for plumbing materials and toy manufacturing.
- **Polyethylene Terephtalate (PET):** This is the fourth highest plastic polymer worldwide having a specific gravity of 1.38 g/cm³, meaning it should sink in freshwater and seawater. However, due to entrapped air in bottles made from PET, they float on water surfaces they are dumped in. PET melts at 260^0C. They are often used in the production of plastic drink bottles.
- **Polystyrene (PS, Styrofoam):** Ranking fifth in highest production plastic polymer worldwide, it has a specific gravity of 0.96 to 1.04 g/cm³. The melting point of PS is 170^0C to 280^0C or and it is used as disposable cups and plates, take–out packs, snacks packaging, expandable boards etc.
- **Polyurethane (PUR, PU):** This polymer is typically not used for single-use purposes. Densities vary from one product to the other due to high air entrainment. Most polyurethanes do not melt because they are mostly thermosetting polymers. They are used to produce foams.

C. Plastic Decomposition

The different types of plastics polymers take a long period to decompose, usually anytime between 20 to 500 years, and this is dependant on the way the structure of the polymers bond. The decomposition time also depends on the amount of sunlight incident on the plastic waste. This is because plastic polymer absorb ultraviolet radiation which aids to break down the chemical structure or molecules of plastic and thus enhance decomposition. The process is known photodegradation, and it is the reason why landfills managers expose plastic waste to the sunlight so as to accelerate the breakdown process. Plastic carbon bonds are not the same as the chemical bonds found in nature, making it harder and more energy-intensive to break them down. Moreover, as plastic degrades, it can leak toxins into the soil around it, leading to a whole host of other issues researchers must tackle (Chariot Energy, 2021).

D. Managing Plastic Waste

Many methods for managing plastic waste, such as recycling, has been proffered. Recycling is one of the most important actions that provides a solution on environmental and ecological threats by reducing oil usage, carbon dioxide emissions and the quantities of waste generated for disposal. Binci et. al., (2012) was of the opinion that recovery and recycling plastic waste remains grossly inadequate which results in millions of tons of plastic waste dumped each year in landfills and oceans. Despite plastic recycling being the best means of minimizing plastic waste, its quality is influenced by polymer cross-contamination, additives, non-polymer impurities and degradation. Different plastic recycling strategies have been proposed around the world; mechanically (classification, crushing and cleaning), chemically(pyrolysis, hydrolysis and glycolysis) and energy (plastic waste is used as fuel to produce electricity, steam or heat).

Newer modern innovative ways of managing plastics, as highlighted by Chariot Energy, (2012), include the production of biodegradable plastics, or bioplastics. This type of plastic have polymers that are fairly easy to degrade. Work done by some scientists have shown that plant-based plastics using corn or sugarcane as a base material can be synthesised while others have been able to engineer the chemical bonds of polymers that are petroleum-based in order to naturally accelerate the break down of plastic molecules and hence making its decomposition faster. Another approach at management of plastic waste is the recent discovery of plastic eating bacteria species at a dumpsite; This bacteria can both digest plastic as food as well as tolerate and survive the toxic

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chemicals released from the breakdown process. In spite of new innovation in plastic production, conventional production has not slowed down and it is projected to increase. Therefore sustainable measures, practices and policies are now being promoted by governments and concerned organisations.

In the studies of Abdel et al, (2020) emphasis was placed on how sustainability has gained top priority in project management and in the construction industry worldwide in recent times. Researchers have been able to introduce various types of waste materials and industrial by-products to serve as raw material for construction purposes. Some examples include the use of ceramic, glass, recycled concrete aggregate, fly ash and slag to produce concrete for traditional construction. Some of these unconventional raw materials partially replace natural aggregates (sand and gravels) and Portland cement in concrete or masonry units. The results of such studies was able to demonstrate that the properties of these unconventional materials compare favourably with conventional materials and are therefore suitable for production of new concrete up to certain replacement limits. In their work, Maunahan and Adeba, (2021) also stated that extensive studies was carried out in the past few decades to identify different waste from industrial processes as a replacement binding agent, fine aggregate and coarse aggregate and the results show that there is potential to adopt these alternative materials in concrete production due to the ability of these substitute materials to improve mechanical and durability properties. These studies are leading the construction industry into sustainable practices in concrete development.

The use of plastic as a sustainable alternative to conventional building material is gaining recognition by various professionals. The consideration that Concrete bricks and blocks are one of the most common material used in construction and the possibility of using plastic waste, which is a well known environmental pollution menace, as a binding agent has captured the interest of several researcher. Also, the increased search and use of low cost, eco-friendly and lightweight construction materials has contributed to the interest in the investigation on how plastic waste can be sustainably used to address proper disposal issues by developing bricks and building blocks which maintain the material requirements and standards for masonry units, as well as lower construction cost in comparison to conventional materials. In the study of Binici et al., (2012), production of mortars without the use of cement was achieved by using disposable polyethylene bottles which were crushed, melted at the temperature range of 180–200^{0}C, mixed with different sand types and then tested for mechanical and physical properties of mortar. The findings showed that bending strength and toughness of mortars were improved, water absorption of mortar was negligible, and abrasion was nearly equal to zero. Another research work done by Agyeman et al, (2019), replaced cement with plastic to produce concrete pavement blocks with high Density Polyethylene (HDPE) and low density polyethylene (LDPE) with contents ratio of plastic: quarry dust: sand at 1:1:2 and 1:0.5:1 by weight, respectively. The results of the pavement blocks revealed a compressive strengths of 6.07 N/mm, 8.53 N/mm ^{2} and 7.31 N/mm^2 and water absorptions of 4.9%, 0.5% and 2.7%, for the control, 1:1:2 and 1:0.5:1 ratio respectively. A recommendation was made by the authors to use these pavement blocks made from the recycled plastic waste in non-traffic areas such as walkways, footpaths, pedestrian plazas, landscapes, monument premises and in waterlogged areas due to their low water absorption property. Abubakar (2020) discovered that LDPE-sand composite brick after six days of production tends to have high compressive strength, density and specific gravity with ratio 1:2 (LDPE to 3.35mm sand particles), while porosity and water absorptivity decline significantly after day 6 with 1:6 of the blend. It is the representation of high compressive strength, durability and good quality of bricks.

E. Use of Conventional Sandcrete Block Geometries to Manage Plastic Waste

Although the advantage of sustainability practices with regards to use of plastic waste as a building material is great, the challenges of accepting new sustainable technologies by end users or clients is also great. A need to develop seamless transition between conventional and sustainable building materials can not be ignored. Ayarkwa et al, (2022) opined that Sustainability concept suggests a positioning between merging future and present needs and assisting with the different issues that radiate from long term and short-term management of structures, organisations and resource. Understanding the sustainable building processes in the construction industry is at its infant stage of research which requires further exploration and study (SBCI, 2009). Lack of sustainable product information concerning sustainable materials and sustainable construction process which needs to be understood in sustainable buildings constitute a challenge for project management teams (Schoggl et al., 2017; Häkkinen and Belloni, 2011 and Ayarkwa et al, 2022). Therefore, more research is required not only to develop new sustainable building materials but also to develop strategies, methods, specifications and standards that make it readily acceptable for implementation.

For this research, HDPE and PET waste collected shall be adopted as a binder with sand to produce Plastic Waste Sand Blocks (PWSB) according to conventional geometry within the Nigerian construction industry. The emphasis on conventional geometry aims at seamlessly incorporating PWSB as a building material that can replace or be used along side conventional sandcrete/concrete blocks. The PWSB, in conventional geometry, will be subjected to test to assess the compressive strength, bulk density, efflorescence and water absorption. These parameters will be compared with conventional geometries for sandcrete/concrete blocks.

Obinna, (2014) reported that popular sandcrete block sizes include 450mm x 225mm x 225mm and 450mm x 150mm x 225mm which may either be hollow or rectangular in geometry. According to The Nigerian Industrial Standards (NIS 87: 2007) block can either be Type A load bearing blocks or Type B non-load bearing blocks. After hardening sandcrete blocks should have a minimum strength requirement of 2.5 N/mm^2 for 150 mm and 3.45 N/mm^2 for 225 mm, according to NIS 87:2007.

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III. MATERIALS AND METHODS

A. Study Area

This research was conducted at the University of Jos, Plateau State, Nigeria, The city of Jos is located at latitude 9.967245N and longitude 8.879478E. The current metro area population of Jos in 2023 is 970,000 (Macrotrends, n. d). It covers 8600 km² and is bounded by 300–600 m escarpments around much of its boundary. With an average altitude of 1,280 m, it is the largest area over 1,000 m in Nigeria, the altitude ranges from around 1,200 metres (3,900 ft) to a peak of 1,829 metres (6,001 ft) above sea level in the Shere Hills range near Jos (Wikipedia). A large percentage of buildings within this geographical area are constructed from hollow Sandcrete blocks. Aside from contributing to general knowledge, This research has the potential of benefitting the immediate community who are low income earners and may be opened to innovative, cost effective emerging sustainable technologies.

B. Plastic

Many waste dumps, schools, occasion venues etc are a source for obtaining PET and HDPE Plastic waste as raw materials. The plastic materials for this study were obtained from different sources such as homes, schools, hospitals. Plastics which includes food containers and plastic bottles will come under the PET and HDPE types of plastic. After collecting the waste plastics, they were cleaned, washed and then shredded into small pieces to enable faster melting.

C. Sand

The fine aggregate was river bed coarse grained sand; locally referred to as 'sharp sand', which is a naturally occurring clean sand obtained from Magama-Gumua, in Toro, of Bauchi State. Sieve analysis was conducted on the aggregates in accordance to BS 812: (1975). Aggregate less than 4.75mm are known as fine aggregates. The fine aggregate used was river-bed sand passing 4.75*mm* sieve and falls within zone 2. It is free from particles and substances such as clay, loam, dirt and any organic or chemical matter.

The methods employed for this study were made to conform to high standards. No cement was used for the PWSB experiment; melted plastic was used as a 100% replacement for cement. A control test specimen of 1:6 cement and fine aggregate mix was however produced. Three specimens of PWSB were produced for each experiment and geometrical classification, making a total of 24 specimens for the study.

D. Preparation of Moulds

Moulds fabricated from metal were made to conform to conventional geometries of 450mm×225mm×225mm and 450mm×225mm×225mm. The mould were calculated and designed to provide for interlocking between PWSB units and reinforcement holes were also provided on each block unit.

E. Mix Proportion and Batching

Two experimental sand to plastic ratios were adopted for this study to produce Plastic Waste Sand Blocks PWSB. In the first experiment, designated as **PWSB 1**, building blocks were made using 1:3 plastics to sand ratio and the second experiment, designated **PWSB 2,** had a 1:4 plastic to sand ratio. Chauhan et al 2019, opined that the reason behind taking different proportions of plastic and sand is to find the optimum proportion which gives the desired results. The bricks made of these ratios will further be investigated for various desired properties.Batching was done by weight to have 25%:75% plastic to sand weights for the 1:3 mix and 20%:80% for the 1:4 mix.

F. PWSB Production

Plastic was heated to completely melt at a temperature of about 160^0C–260^0C, this was consistent with the experimental observations of S. S. Chauhan et al, (2019). After melting, the fine aggregate was gradually added and mixed. Mixing by hand was done continuously to mix the plastic and sand until a homogeneous mixture was obtained. The hot molten plastic-sand paste was then placed into oiled moulds and tampered with a tampering rod to remove bubbles until the mould was filled and then it was allowed to set. Demoulding was done after 24 hours and there was little need for further curing due the already impervious nature of the block units. However the masonry units were allowed to cure for 7 days.

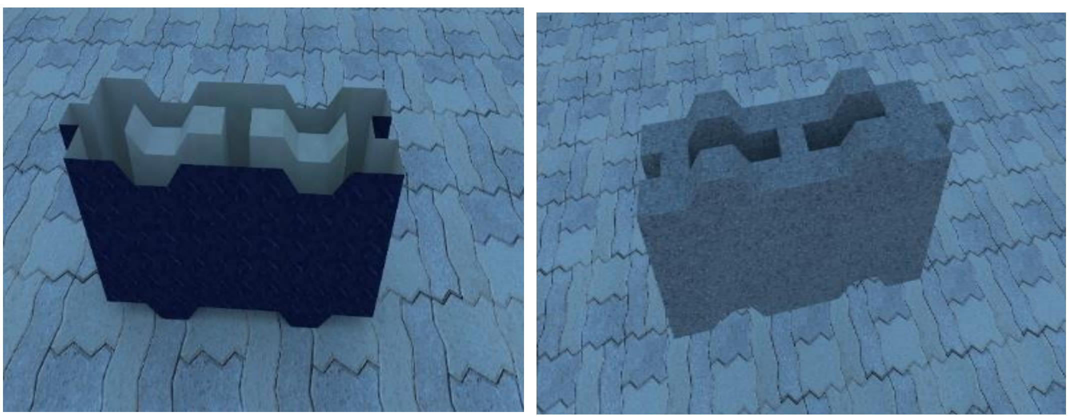

Fig. 1: Design and diagram of Hollow PWSB Mould and Block

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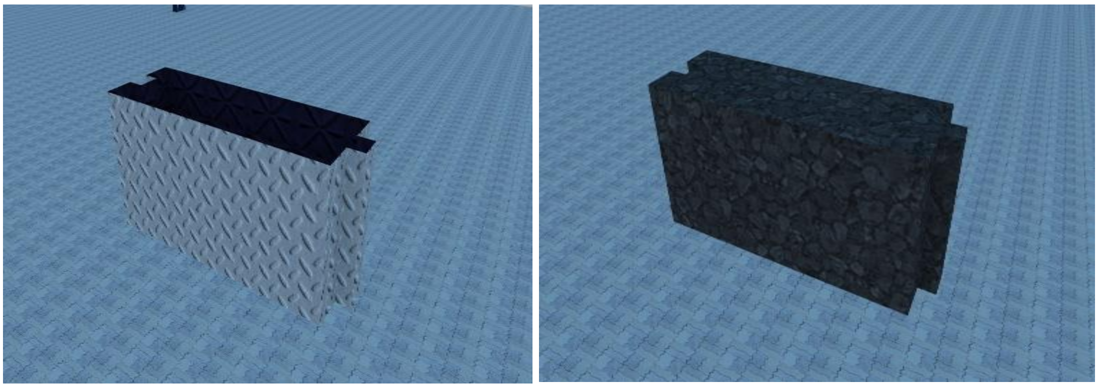

Fig. 2: Design and diagram of Solid PWSB Mould and Block

Fig. 3: PET and HDPE Plastic Gathered

Fig. 4: Crushing of PSWB for Compressive Strength

Table 1: Sieve analysis teat Results

Sieve size	Weight of soil retained (g)	Cumulative weight of soil retained (g)	% retained	Cumulative % retained	% passing
4.75mm	0.00	0.00	0.00	0.00	100
2.00mm	12.00	12.00	6.00	6.00	94.00
1.18mm	19.00	31.00	9.50	15.50	84.50
600µm	46.00	77.00	23.00	38.50	61.50
300µm	36.00	133.00	18.00	66.50	43.50
150µm	73.00	186.00	36.50	93.00	7.00
75µm	9.00	195.00	4.50	97.50	2.50
Pan	0.00	195.00	0.00	97.50	2.50
TOTAL	195			414.50	

Fineness modulus=414.50/100 =4.145

Table 2: The Mix Ratio and Quantities Used to Produce Conventional and PSWB Samples

S/N	Sample Ratio	Percentage of Plastic	Percentage of Sand	Percentage of Cement
Control	1:6	0.00	85.71	14.29
PSWB 1	1:3	25.00	75.00	0.00
PSWB 2	1:4	20.00	80.00	0.00

Table 3: Mass, Bulk Densities and Strengths of Test Samples

Specimens		Mass in (Kg)	Bulk Density	Compressive Strength (N/mm²)	Percentage of Standard 3.45N/mm² Compressive Strength (%)
Control (1:6)	450×225×225	21.30	2110.95	5.89	171
	450×150×225	17.50	2020.35	3.00	87
PSWB 1 (1:3)	450×225×225	15.50	1895.90	9.79	284
	450×150×225	10.50	1855.80	4.57	133
	Solid 450×150×225	14.50	1880.30	9.12	264
PSWB 2 (1:4)	450×225×225	16.90	1945.90	12.23	355
	450×150×225	11.50	1940.10	6.09	177
	Solid 450×150×225	16.70	1930.20	12.03	349

Table 4: Compressive Strength Results for Conventional and PSWB Geometries

Specimens		Applied Load (KN)	Contact Area (mm²)	Compressive Strength (N/mm²)	Average Compressive Strength (N/mm²)
Control (1:6)	450×225×225	593.50 595.10 601.10	101250	5.86 5.88 5.94	5.89
	450×150×225	201.90 202.60 202.50	67500	2.99 3.00 3.00	3.00
PSWB 1 (1:3)	450×225×225	981.50 985.20 980.40	101250	9.69 9.73 9.68	9.70
	450×150×225	309.20 305.60 310.10	67500	4.58 4.53 4.59	4.57
	Solid 450×150×225	620.30 615.50 610.50	67500	9.19 9.12 9.04	9.12
PSWB 2 (1:4)	450×225×225	1240.00 1236.50 1238.50	101250	12.25 12.21 12.23	12.23
	450×150×225	410.00 412.50 410.50	67500	6.07 6.11 6.08	6.09
	Solid 450×150×225	830.50 815.30 790.30	67500	12.30 12.08 11.72	12.03

Table 5: Water Absorption Results of Test Specimens

Sample Type	Sample Ratio	Number of Block Sample	Water Absorption (%)
Control	1:6	3	8.10
PSWB 1	1:3	3	0.02
PSWB 2	1:4	3	0.05

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Table 6: Efflorescence of Test Samples.

SAMPLE	NIL (0%)	SLIGHT (Up to 10%)	MODERATE (10%-50%)	HEAVY (more than 50% without powdered flakes)	SERIOUS (more than 50% with powdered flakes)
Control		✓			
PWSB 1	✓				
PWSB 2	✓				

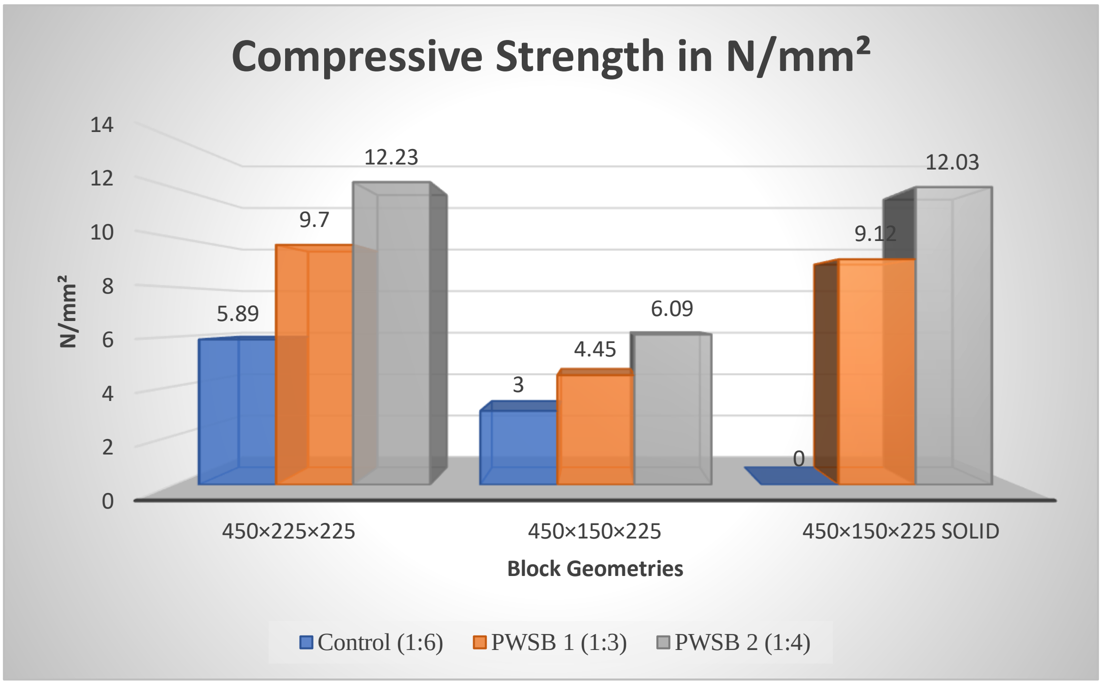

Fig. 5: Compressive Strength Results for Different Conventional and PSWB Geometrie

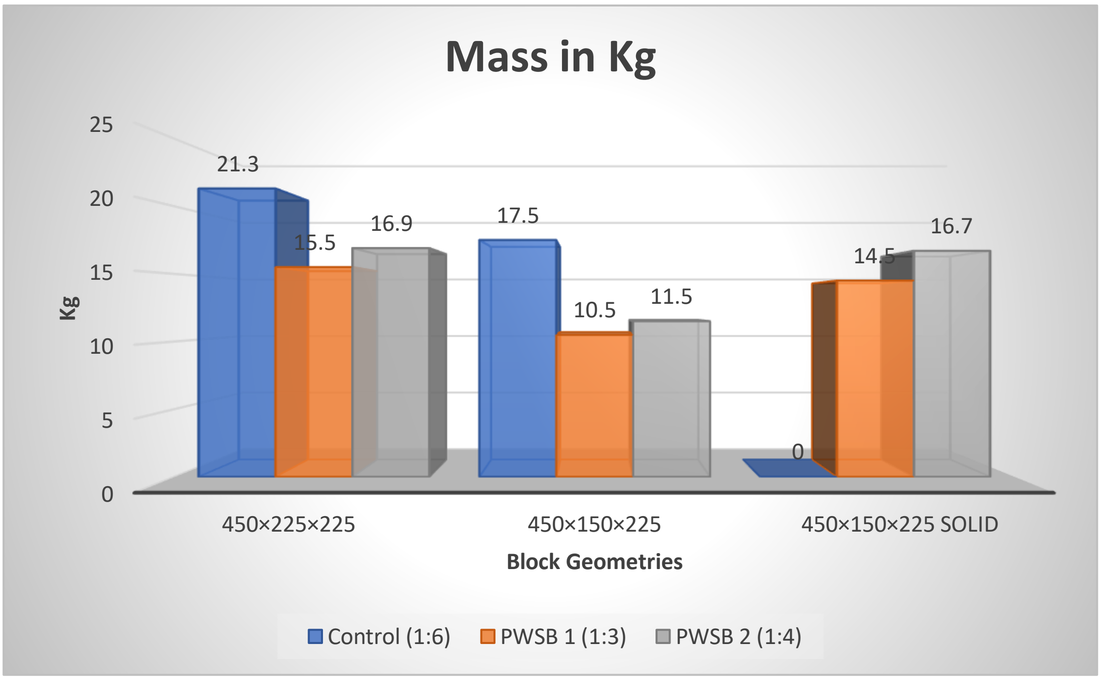

Fig. 6: Mass Results for Different Conventional and PSWB Geometries

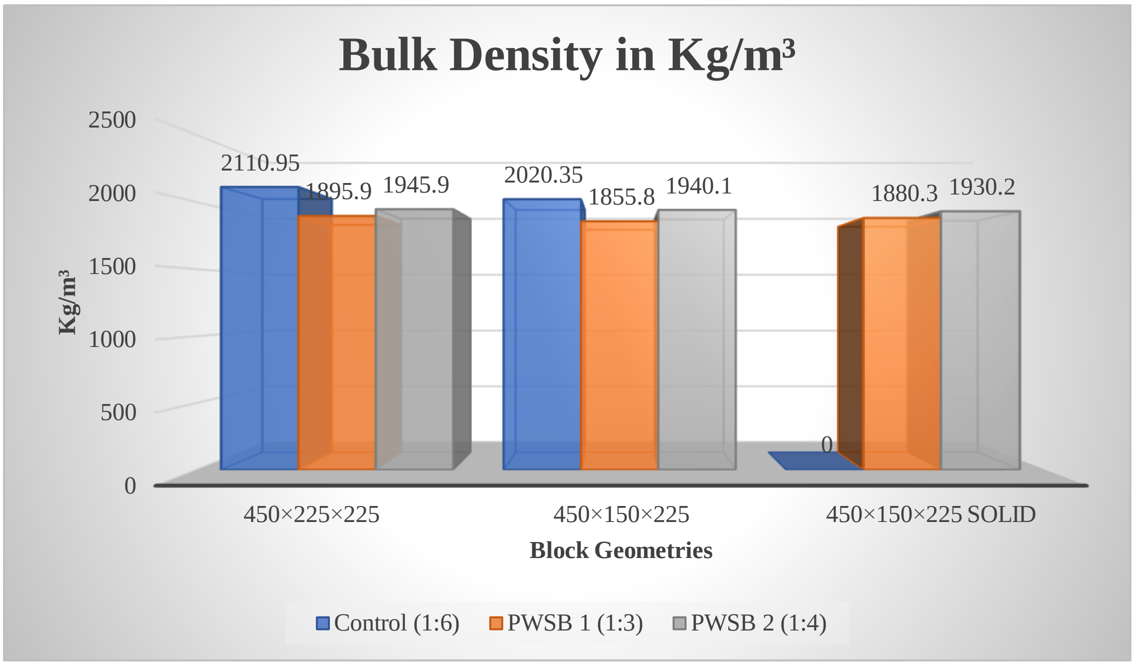

Fig. 7: Bulk Density for Conventional and PSWB Geometries

IV. RESULTS AND DISCUSSION

A. *Sieve Analysis*

The sieve analysis includes the determination of fine aggregate passing through a series of sieves. The sieve analysis was carried out according to BS 812-1985. The result of the sieve analysis of the sand used for the plastic sand block production showed that the sand satisfies the standard requirements. Table 1 shows the sieve grading of the fine aggregates.

B. *Mix Proportion*

The Mix Proportion of this study was identical to works done by Bien Maunahan (2021). The proposed optimal mix ratio for plastic to sand, as confirmed by this research, should be 1:3 or 1:4. This gives a corresponding 75% to 80% of sand and 20% to 25% of plastic.

C. *Compressive Strength*

The compressive strength of PWSB made to conform to conventional geometry was measured in (N/mm^2) as shown in Table 4 and figure 5. Table 3 also shows the comparison, in percentage, of Compressive Strength of samples to the minimum stipulated strength of 3.45N/mm². Analysis and Results show that there was an increase in compressive strength of PWSB 1 and PWSB 2 samples over conventional hollow Sandcrete blocks. According to the approved stipulations of the Nigerian Industrial Standards (NIS 87:2007), the minimum compressive strength for 450mm×150mm×225mm and 450mm×225mm×225mm, also known locally as 6 inches and 9 inches blocks, are 2.5N/mm² and 3.45N/mm² respectively. However, PWSB 1 (1:3 plastic to sand ratio) samples at 4.45N/mm² for Hollow 450mm×150mm×225mm, 9.12N/mm² for Solid 450mm×150mm×225mm Specimens and 9.70N/mm² for Hollow 450mm×225mm×225mm already exceeded the compressive strength of the prepared 1:6 cement to sand control samples (using a 0.5 W/C). The PWSB 2 (1:4 plastic to sand ratio) samples yielded an even better result of 6.09N/mm², 12.23N/mm² and 12.03N/mm² for hollow 450mm×150mm×225mm, Hollow 450mm×225mm×225mm and Solid 450mm×150mm×225mm respectively. These findings resemble that of Kameshwar et al (2022) where the average compressive strength of 1:3 plastic to sand mix was observed to be 9.72N/mm² and 12.28N/mm² for 1:4 sand to plastic ratio. The percentage increase in strength with reference to accepted standards were 87% and 171% for 150mm and 225mm control samples respectively, PWSB 1 exhibited a 183%, 284% and 264% compressive strength increase for Hollow 450mm×150mm×225mm, Hollow 450mm×225mm×225mm and Solid 450mm×150mm×225mm geometries respectively. Furthermore, PWSB 2 samples showed a 177% increase for Hollow 150mm geometry, 355% increase in strength for 225mm geometry and 349% increase in strength for 150mm solid geometry. The compressive strength of both PWSB 1 and PWSB 2 150mm geometries exceeded the minimum strength requirement for 225mm conventional geometries. These remarkable results suggests that aside from the appeal of recycling plastic waste, compressive strength values for plastic sand hollow block geometries are impressive and can greatly contribute to the desirability of PWSB as a construction material.

D. *Water absorption*

This test was carried out according to ASTM D570 and BS EN 772-11:2011 standard. This test checks the amount of water absorbed under certain specified conditions. Some of the factors considered are type of plastic, additives used, temperature and length of exposure. The data gives insight on how a material will perform in humid environment. The test Procedure include drying the test specimens in an oven at a particular temperature and time, then placed in a desiccator to cool. Upon cooling the specimens are weighed. The specimens is then emerged in water, usually at 23°C for 24 hours or until equilibrium is reached and then the Specimen are removed, dried and weighed. The test results as presented in Table 5 where consistent with the results obtained by Kameshwar et al 2020, which indicates that PWSB performs excellently. The NIS states 12% to be the maximum acceptable water absorption in Nigeria as observed by Ubani, 2022.

E. Efflorescence test

The standard used for the test is ISS 1077-1970. This test is carried out for the detection of alkalis in Masonry units. White or grey patches is an indication of alkalis on the surface of the blocks. The procedure include pouring sufficient quantities of distilled water into a flat bottom container and then immersing the brick or block to a depth of 25mm in the distilled water for a period of 24hours. To stop substantial evaporation of the distilled water, the container should be covered. After that the brick is removed from the container and left to dry for the same amount of time wherein the same amount of water must have evaporated from the open container without the brick or the sheet.

The efflorescence test shows excellence performance from the PWSB1 and PWSB2 samples. There was no presence of grey or a white deposit on PWSB surfaces for all ratios. This result is consistent with studies done by Wahid et al., (2015) and Chauhan et al, 2019. It was shown that all of the sand bricks indicate absence of soluble salts or alkali. From this test, we can conclude that no alkalis was presence in PWSB.

F. Mass and Bulk Density for PWSB Samples

From Figure 6 it can be seen that the mass in kilogram of PWSB1 was found to be 10.5Kg, 14.5Kg and 15.5Kg for hollow 150mm×225mm, solid 450mm×150mm and hollow 450mm×225mm geometries respectively and for PWSB2 the mass was found to be 11.5Kg, 16.7Kg and 16.9Kg for the Hollow150mm×225mm, Solid 450mm×225mm and Hollow 450mm×225mm geometries. It can be seen that the mass of PWSB2 is higher than that of PWSB1, this can be attributed to the higher sand content in the PWSB2 specimen which has a 1:4 plastic to sand ratio. From the Bulk Densities results shown in Figure 7 It was also observed that the maximum density of PWSB at 1945.90Kg/m³ was less than that of the control sample at 2110.95Kg/m³; both PWSB1 and PWSB2 specimens were seen to be lighter than that of the control specimens. Theses results show that PWSB is a lightweight masonry unit which has considerable strength that exceeds conventional blocks.

V. CONCLUSION

- The decomposition of plastic such as PET and HDPE takes between 20 to 500years and this constitutes a great environmental pollution especially due to the release of toxins which cause harm to both animals and humans. This research, however, has demonstrated that the construction industry can greatly contribute in managing plastic waste by incorporating it in the production of masonry units such as Plastic Waste Sand Blocks PWSB.
- The acceptance of new sustainable strategies and technologies by clients and end users is slow and sometimes it is rejected due to unavailability of data and information on how to use such strategies and technologies. This has hindered the seamlessly transition from conventional products to sustainable new technologies. This research demonstrates that PWSB can be made to conform to conventional standards and this strategy can greatly encourage the use of plastic waste sand blocks.
- The compressive strength of PWSB in 1:3 and 1:4 Plastic to Sand ratio is impressive and exceeds strengths of conventional blocks by between 177% to 355%. All geometries of PWSB can be used for load bearing walls
- The negligible water absorption of PWSB makes it ideal for use at foundation level or for construction of walls without DPC. PWSB inherently prevents capillary action of water that is common in the tiny pores present in conventional blocks.
- The lower block density of PWSB makes it lighter in weight yet stronger than conventional blocks. This information will increase the appeal of PWSB to end users because using PWSB reduces the dead load on a building while increasing strength.

It is therefore recommended that PWSB produced to conform to conventional geometry is ideal for construction of walls as well as managing plastic waste. It should be immediately implemented by concerned authorities who may come across this study for construction purposes.

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