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Article

Appraising the potentials of reusing plastic bottles as building blocks for housing construction at Paipe village Abuja Nigeria

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Abstract: Plastic bottles package a multitude of commodities consumed worldwide. Upon consumption of the commodity, the disposed plastic bottles accumulate as waste, having impacts on both the aquatic and terrestrial environment. In a bid to convert such waste to wealth, plastic bottles are creatively reused for different applications, such as pedestrian bridge boats and street furniture, amongst others. Another application of reusing plastic bottles is their serving as building blocks for housing construction. Reports and research in Nigeria confirm the proliferation of plastic bottles littering the environment, which if reused in housing construction has the potential to contribute to achieving both UN Sustainable Development Goals (SDG) 11 (making human settlements sustainable) and 12 (ensuring sustainable consumption and production). Although Nigeria is traced to being the first country in Africa to reuse plastic bottles in housing construction, not much research output exists from practitioners' experience on the potentials of reusing plastic bottles as a sustainable construction material as practiced in countries like Vietnam, India, and the Philippines, among others. As such, this study investigates the potential factors driving the practice of reusing plastic bottles in Nigeria with a view to ascertaining the satisfaction derived from the practice for sustainable housing construction. Primary data was collected using a structured questionnaire from 41 respondents identified as having experience in using plastic bottles in construction (5 staffs of Awonto Konsult as well as 36 staffs of Brains and Hammers Construction). Data was analysed descriptively using both IBM SPSS Statistics 23 as well as MS Excel to compute the Mean Score as well as the Relative Satisfaction Index (RSI). Only 30 questionnaires were successfully retrieved and fully answered. Amongst the 10 potential factors studied driving reusing plastic bottles, results show that almost all respondents tend to be 'satisfied' with both 'strength and stability' (having a Mean Value of 4.70 and RSI of 0.94) as well as 'durability' (having a Mean Value of 4.50; RSI of 0.90) of buildings built with plastic bottles. These two factors recorded the highest 'satisfaction' ratings, leaning towards 'very satisfied'. Regarding the factor 'fire resistance' of buildings built with plastic bottles (having a Mean Value of 3.40; RSI of 0.68), results reveal that 50 percent of the respondents are 'unsure' if it is a satisfactory factor driving reusing plastic bottles or not. The study found that the satisfaction ratings of technical and environmental factors have higher appeal to respondents compared to health and safety and also financial factors. It is recommended that Awonto Konsult and also Brains and Hammers Construction invest more in information related to the fire resistance of plastic bottles used in construction because fire outbreaks pose great threats to buildings. Equally, wider empirical research on plastic bottle wastes, if undertaken, could support the development of policies for waste management, particularly in developing countries. This research has the potential to convert waste into wealth in a bid to minimising environmental impacts of disposed plastic bottles as well as contribute to sustainable materials, particularly for rural housing. Since this study was based on a survey, experimental studies of potentials driving the reuse of plastic bottles in housing construction will reveal results that could enable more sustainable housing construction in Nigeria.

Keywords: building blocks; Nigeria; plastic bottles; reuse

1. Introduction

Our consumption pattern is characterised by the reliance on plastic bottles used for packaging commodities such as drinking water, soft drinks, cooking oil, and milk, among others. Such consumption is done on a daily basis by a large number of people around the world. According to [1], key factors driving the reliance on using plastic bottles are economic development and population growth. Most often than not, plastic bottles of consumed commodities are disposed of, which eventually end up as waste that accumulates in the natural environment, dumped in rivers, buried, as well as being burned. Once the plastic product is utilized, it is discarded and called plastic waste. It is reported that about 70% of the plastic, used for packaging purposes, ends up as plastic waste in a short span of time [2]. According to [3], about 353 million tons of plastic waste were produced globally in 2019, which is projected to increase to 1.014 billion tons by 2060. Such waste, if not efficiently managed, has consequences as reported by [4] and also [5] that plastic bottle waste (among other plastic wastes) causes littering of land and water, air pollution (if plastic bottle waste is burnt), erosion, irrigation blockages, as well as health-related problems that impact both terrestrial and aquatic habitation. In fact, plastic bottle waste is compounded by their insolubility or period of biodegradation, estimated to be between 300 and 450 years [6–10]. These consequences do not only affect the environment but also humans and animals as well. Accordingly, consequences derived from plastic bottle waste have not only become a source of concern in many countries but also propagated topical issues leading to serious considerations in the reuse of plastic bottles. Besides, reuse of plastic bottles saves a lot of energy cost compared to the production of new plastic bottles [8]. Indeed, the consideration to reuse plastic bottles is novel considering the drive towards sustainable development. Each application has succeeded in converting plastic bottle waste to wealth. There are several accounts regarding applications of plastic bottles being reused and/or recycled. Specific to reuse, numerous trials by different countries are adopting innovative technologies to reuse plastic waste in different applications, and the construction industry is one of these sectors [11]. Plastic bottles have been reused in the construction of pedestrian bridges, boats, and street furniture [12], as a light-weight geotechnical material used for building roadway embankments, and as a backfill above buried pipelines [13]. While these do not directly apply to housing construction, there are equally applications of reusing plastic bottles in housing construction. For instance, [14], [1], and also [15] all claim that the reuse of plastic bottles can be applied as an innovative material in wall and ceiling construction. Equally, [12], [4], and [16] all assert that countries such as India, South and Central America, and the Philippines have all adopted the reuse of plastic bottles for housing wall construction. The works of [17] also cover the use of plastic bottles for housing construction in tropical areas. Apart from the adoption of reusing plastic bottles in construction, the practice has been recorded as successful, owning to its great potentials, as reported by [18]. Furthermore, [19] as well as [3] all submit that the practice is eco-friendly, thereby sustainable. These studies are indications of the growing research interests on the reuse of plastic bottles in housing construction across the world. In fact, [20] assert that more widespread use of plastic bottles in construction applications has huge benefits, which both in the short and long term are sustainable.

Nigeria has been ranked the 9th plastic polluter country in the world [9]. To curb the pollution, considerations were made on recycling waste plastic bottles to use as construction material to control the overgrowing concern over plastic pollution. In Nigeria, the first plastic bottle house was constructed in the village of Yelwa in Nigeria by Andreas Forese, whereby plastic bottles instead of the conventional blocks or bricks were used to construct a house [9,21]. Afterwards, a non-governmental association (NGO) based in Nigeria named The Development Association for Renewable Energies also built a two-bedroom bungalow entirely out of plastic bottles [22]. According to [3], these projects adopted a user-centred design approach for the design and construction of an affordable, sustainable home from upcycled materials; the walls were constructed using plastic bottles, the ceiling from used bamboo scaffolding, and the floor was created from recycled tiles. These exemplary projects could be deemed milestones in the quest to reusing plastic bottles towards providing sustainable housing and probably bridging some gap in existing housing deficits not only prevailing but equally growing across the country (housing deficit estimated to be over 30 million in 2020 by [23]. Such projects also support the position of [24], where he posits that efforts at ensuring sound and sustainable national and economic development cannot ignore the importance of sustainable practices implemented to address prevailing problems in housing. Similarly, they support the proposition of [25], who claims that housing policies in Nigeria will certainly succeed if conceived as tools designed to achieve sustainable housing, thereby addressing housing deficits.

The process of reusing plastic bottles for housing wall construction consists of several steps. According to [18,22,26], and also [7], the steps involved consist of: gathering/collection; filling of plastic bottles with the screened soil or sand and tamping at intervals for compaction; tight capping and sealing of plastic bottles; stacking and linking plastic bottles together at the neck by an intricate network of strings; filling spaces in-between bottles with mortar as is done for brick construction; plastering thereafter applied as a finish material. It is worthy to state that details of each of these steps outlined consist of other technical considerations. Interestingly, the work of [18] provides a plastic bottle construction manual whereby the technical details of each of these outlined steps are extensively discussed.

There exist several studies that have evaluated the functional requirements of walls built with plastic bottles, which include: weather insulation [8,17,27]; safety and security [28]; sound insulation [15,26]; eco-friendly/environmentally friendly [4,29]; mechanical properties [11,27]; light weight or mass [16,20,30]; as well as construction cost/economical [29]. Although there exists variability in the findings on the extent to which each functional requirement is fulfilled across the afore-presented studies, they all attest to the practice evolving and becoming sustainable.

Although Nigeria is confirmed to be the first country in Africa to have reused plastic bottles in housing construction, as claimed by [21], most references on the projects are from non-Nigerian authors [works of 4,12,18,21,22,29,31]. Moreover, the works that cited the projects are devoid of empirical data; rather, some basic information on the projects was mentioned. An exception to this, however, is the work of [17] as well as [3], which primarily focused on the thermal comfort of the house built with reused plastic bottles in Paipe village, Abuja, from the perspective of occupants. Therefore, not much local research exists in Nigeria on the reuse of plastic bottles in housing construction. After all, [22] attest that there is a serious housing shortage in developing countries but no shortage of plastic bottles littering the environment. Similarly, [18] affirm that the reuse of plastic bottles in construction in countries like Vietnam and Nigeria is ideal due to the hot climate, whereby the plastic bottle construction provides great insulation to a home. As such, this study evaluated the functional requirements driving the reuse of plastic bottles as building blocks for housing construction from the perspective of industry practitioners with a view to ascertain the potentials that could be derived from the reuse of plastic bottles for sustainable housing construction in Nigeria.

2. Impacts of plastic bottle disposal and their potentials for reuse

Plastic bottles are produced from oil, which is a non-renewable resource [14,15,21]. With an incremental consumption rate based on population growth all compounded with massive production of commodities packaged in plastic bottles (drinking water, soft drinks, cooking oil, among others), the disposal of plastic bottles whose packaged commodity has been consumed is already a topical issue based on its accumulation as waste as well as the impact it poses to the environment as well as humans and animals alike.

The negative impact of plastic bottle disposal has been reported to be in several dimensions. Their impacts on the environment include littering and/or pollution of land and water [8,9,14,22,28,29,]; air pollution, especially when plastic bottles are burnt [28,32]; irrigation blockages [12,4]. Another dimension of the negative impact is its toll on health, which includes: [14] cautions that reusing plastic bottles poses potential health risk associated with high bacterial levels found in the bottle and leaching of plastic compounds from beverages; Similarly, [15] warns that although reusing plastic bottles may seem safe, a chemical known as biphenyl found in reusable plastic bottles is suspected of posing a health risk to humans. Also, the unsafe practice of reusing plastic bottles could have health risks to humans as well as animals [4,12,18,22]. While acknowledging these health hazards when plastic bottles are reused, the reuse of plastic bottles as a construction material may pose minimum health risk as compared to its reuse for repackaging.

A strategy to achieve positive impact of plastic waste disposal is the adoption of plastic waste management principles. According to [33], plastic waste management, if employed, has both economic, ecological, and health-related impacts on the economy of a nation. Although plastic waste management principles are broad, several studies have ventured into the potentials of reusing and recycling plastic in the plastic waste disposal hierarchy. After all, reusability and recyclability are significant benefits of using plastic-based products in the waste hierarchy [34]. These authors further stress that alternatives to waste disposal can be a veritable source of raw material reduction and achieving sustainability.

Specific to reuse, [13] glued plastic bottles together in their original post-consumer form and used them for building roadway embankments and as backfill above buried pipelines. Likewise, [8] posits that reusing plastic bottles can be applied in the production of plastic containers. Furthermore, [12] report that plastic bottles have been reused to construct pedestrian bridges, street furniture, boats, and also ambient lighting, as depicted in **Figure 1**.

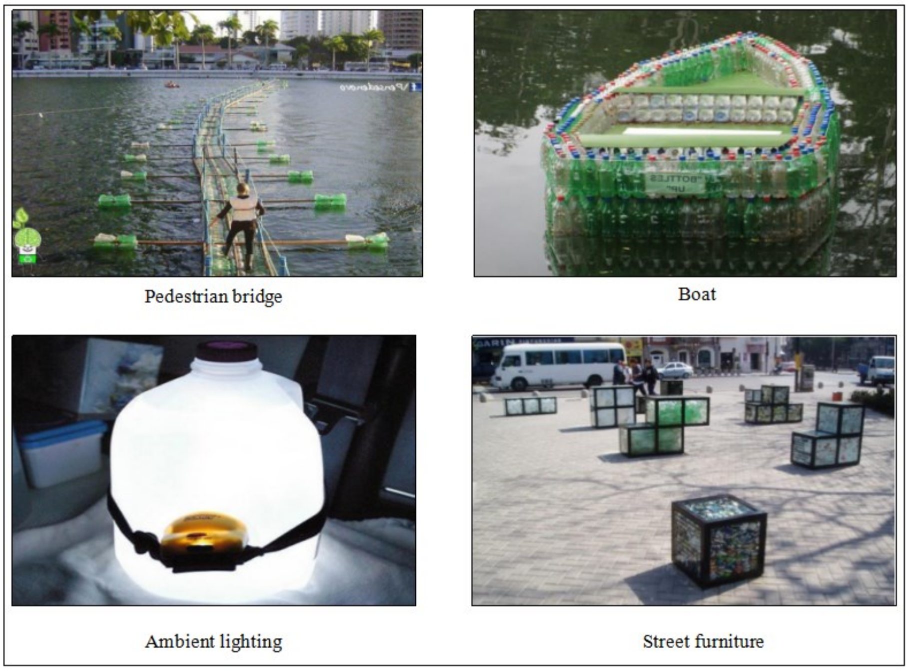

Figure 1. Applications for reusing of plastic bottles [10].

However, irrespective of the application on the reuse of plastic bottles, there are reports on the accrued benefits of the practice. Reusing plastic bottles consumes eight times less energy than the energy required for manufacturing new plastic bottles [8,14, 22,28,29]. Thus, reusing plastic bottles saves a lot of cost.

3. The process of reusing plastic bottles for housing construction and its application in Nigeria

The practice of reusing plastic bottles for housing construction is gradually evolving. This is evident from its reported applications in countries such as India, Vietnam, South and Central America, and the Philippines, which have all adopted the practice [4,12]. Furthermore, the success in the practice can be attributed to the works of [18], which outlined and extensively discussed the use of a manual discussing the technical details of reusing plastic bottles for housing construction. Indeed, such developments in the practice have contributed to the literature on the reuse of plastic bottles for housing construction. The process of reusing plastic bottles for housing construction consists of several steps. According to [7,18,22,26], the steps involved are: gathering/collection of plastic bottles; screening of locally available material like soil or sand; filling of plastic bottles with screened soil or sand with tamping at intervals for compaction; tight capping and sealing of plastic bottles; bottles are stacked and linked together at the neck by an intricate network of strings; spaces in-between bottles are filled with mortar as is done for brick construction; plaster is applied as a finish material. Some of these steps are as depicted in **Figure 2a–d**.

(a) Gathering/collection of plastic bottles. **(b)** Filling plastic bottles with soil or sand. **(c)** Bottles stacked and linked with strings. **(d)** Bottles laid and spaces filled with mortar.

Figure 2. Steps in reusing plastic bottles for housing construction [4,7,15].

Documenting the details of these steps are clear manifestations in the quest to standardise the application of reusing plastic bottles as an alternative material, which Nigeria is gradually using in construction. According to [21], the first plastic bottle housing in Africa was constructed in the village of Yelwa in Nigeria by Andreas Forese in 2011. The building project is depicted in **Figure 3**.

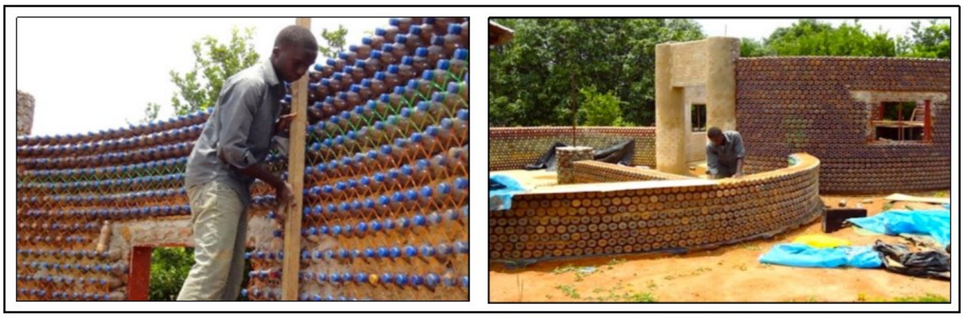

Figure 3. First plastic bottle housing constructed in Nigeria [35].

Afterwards, the Development Association for Renewable Energies (an NGO based in Nigeria) also built a two-bedroom bungalow entirely out of plastic bottles [22]. Similarly, [36] reported that in 2017, plastic bottles were used for the construction of residential buildings at Paipe village, Abuja, Nigeria, whereby the project is a joint collaboration between DEMOFORT University and the Royal College of Engineering Leicester, England, and Ahmadu Bello University, Zaria, Nigeria. The building project in Paipe village is depicted in **Figure 4**.

Figure 4. Plastic bottle house construction in Paipe village Abuja [36].

The project was contracted to Awonto Konsult and also Brains and Hammers. Both are contracting firms with head offices in Abuja, Nigeria. The community in Paipe was involved in the project, whereby they sourced the plastic bottles, filled them with laterite, and provided the labour force for the housing construction.

Aside from this process, there are existing works on reusing plastic bottles as an integral component of bricks produced for construction. This was reported in the works of [9] as well as [37]. **Figure 5** depicts the process.

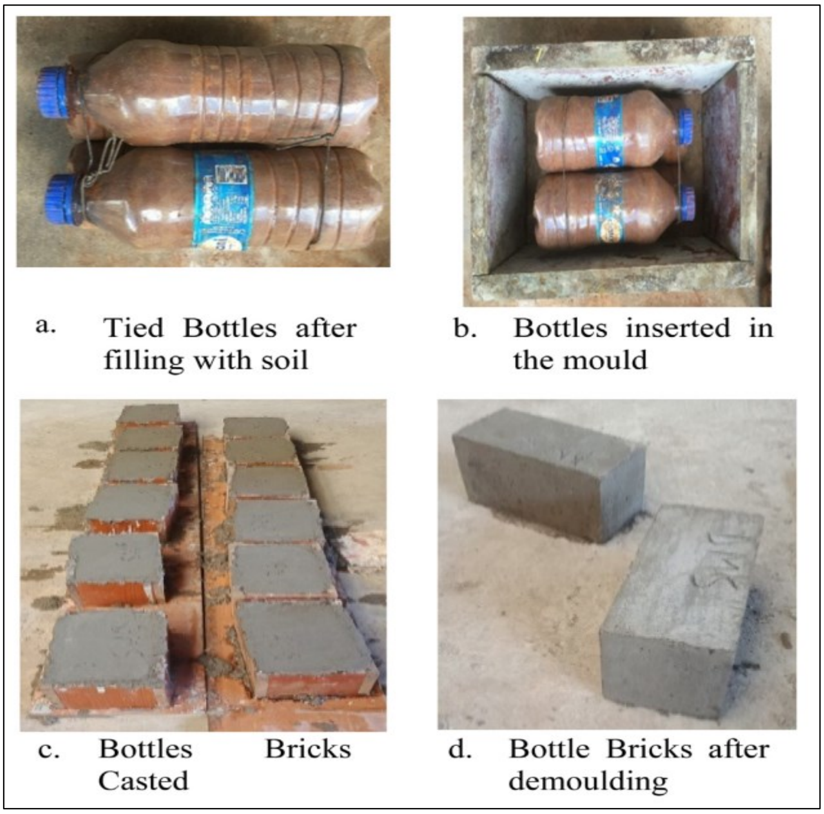

Figure 5. Plastic Bottle Reused as an Integral Component of Bricks [37].

Variable soil types and also test types have been explored to develop the material. Interestingly, results were satisfactory, thereby reaffirming the sustainability of reusing plastic bottle waste in construction.

4. Functional requirements driving the reuse of plastic bottles in housing construction

Similar to food and clothing, housing is a crucial human need. Beyond the basics of shelter and accommodation, housing is supposed to provide functional support to its inhabitants relative to security, physical health, and privacy [38–40]. By extension, the elements used for housing provision should pose functional requirements that can facilitate the attainment of the functional support expected from housing. Although functional requirements across elements may vary, they all collectively contribute towards ensuring some basic functionality of housing for inhabitants is attained.

The development in the reuse of plastic bottles as a building block for housing construction has brought about several authors reporting the functional requirements driving its reuse. Some functional requirements are presented in **Table 1**.

Some of these functional requirements driving the reuse of plastic bottles in housing construction have been qualified from previous research conducted. Specific to weather insulation, [18] as well as [8] opine that the material has good weather insulation in hot climates. According to [41], insulation when using plastic bottles for construction covers the flow of heat into or out of the building. Similarly, [9] reports that safety and security in using plastic bottles for buildings refer to safety and security relative to minimising hazards in the built environment. These authors also use quality sound insulation to refer to good absorption (acoustic) of unwarranted sound or noise. Furthermore, availability of the plastic bottles, according to [42], refers to the ease of sourcing as raw materials for use in construction. Durability in the use of plastic bottles refers to their longevity potentials, owning to the long period for their insolubility and biodegradation [8,9]. This attribute is also a qualification of their eco/environmental friendliness [4,29]. According to [29] and [33], the low construction cost derived from reusing plastic bottles is relative to their availability as well as comparative advantage in cement use. These qualifications seemingly depict some positive implication in reusing plastic bottles for housing construction. They equally support the idea derived from reusing plastic bottles, whereby the practice converts waste into wealth.

Table 1. Functional requirements driving the reuse of plastic bottles in housing construction.

S/No	Factor	Authors
1	Weather (thermal) insulation to building	13,18,21,22,1,8,37,39,17,3
2	Safety and Security to building	14,22,28,30
3	Sound insulation to building	13,21,22,26,15
4	Availability of plastic bottle materials	4,18,21,26,3
5	Availability of skills/workmanship for construction using plastic bottles	1218,22
6	Construction Cost/Economical benefit of construction using plastic bottles	14,12,4,18,22,6,26,29,7,37,19,3
7	Fire resistance	14,22,29,40
8	Strength and stability/good construction ability	14,12,4,21,22,1
9	Durability of building	14,18,28,22,1,7
10	Eco- friendly /Environmentally friendly of building	4,18,22,28,1,26,29,32,15,3

5. Methodology

Data collection in this study deployed two techniques used sequentially. The first was through literature review. This technique identified the functional requirements driving the reuse of plastic bottles in housing construction from a host of sources. Afterwards, the second used the identified functional requirements to design a questionnaire used to collect data by means of a survey. Using this second technique, the response on satisfaction level for each functional requirement driving the reuse of plastic bottles as building blocks for housing construction was sought using a 5-point Likert-type with categories as: Very Satisfied (5); Satisfied (4); Unsure (3); Dissatisfied (2); and Very Dissatisfied (1). Specific to surveys on satisfaction levels, [43] and also [44] all recommend the use of this scale. The two companies identified to have participated in the construction of buildings using plastic bottles at Paipe village, Abuja, Nigeria, are Awonto Konsult and also Brains and Hammers Construction. Both companies have their head offices in Abuja. While it was gathered that 5 staff of Awonto Konsult participated in the project, 36 staff of Brains and Hammers Construction participated. Therefore, the population for the study is the 41 staff. Considering the population is not large, data was collected from all 41 staff using the drop-now and collect-later technique. Judgmental sampling was adopted because

[45,46] all recommend judgmental sampling when a researcher intends to use some informed judgement to select respondents that are particularly informative in fulfilling the research objectives.

The procedure for data analysis used two techniques. Both employed descriptive statistics. The first used frequencies to analyse the demographic data. Afterwards, the second computed both the mean score and relative satisfaction index (RSI) for each functional requirement driving the reuse of plastic bottles as building blocks for housing construction. Both IBM SPSS Statistics 23 as well as MS Excel were used as tools for data analysis. The mean score measure has been used in construction management research, whereby [47] expresses it as:

$$\bar{X} = \frac{\sum X_i}{n}$$

where: *X* denotes the mean score. $\sum X_i$ is the sum of the number of responses and score awarded a variable (V_i; for $5 \geq V_i \geq 1$). *n* denotes the total number of responses.

Furthermore, The RSI has been used in construction management researches whereby [48,49] express it as:

$$\text{RSI}= \frac{1n_1 + 2n_2 + \cdots + An_4 \cdots (0 \leq RIS \leq 1)}{\text{AN}}$$

where: $n_1, n_2, ..., n_A$ = number of respondents scoring response stem integers 1 to Amax (5), respectively.

A = largest integer on the response item (5 for this research)

N = total number of respondents

The results of the mean score and RSI portrayed the extent of satisfaction of each functional requirements studied. Furthermore, the results enabled ranking of the functional requirements studied. Such analysis helps in drawing inferences for purposes of evaluating the scoring profiles for within and across the functional requirements studied [refer to 50–54].

6. Discussion of results

Out of the 41 staff who were each administered a questionnaire, only 30 questionnaires were successfully retrieved, constituting 73.17 percent return rate. From the demographics of the respondents presented in **Table 2**, 25 questionnaires (83.33 percent) were from Brains and Hammers, while 5 questionnaires (16.67 percent) were from Awonto Konsult. It must be noted that all 5 staff of Awonto Konsult who were administered questionnaires filled and returned their questionnaires. However, out of the 36 staff of Brains and Hammers Construction that were administered questionnaires, 25 staff filled and returned their questionnaires. All retrieved questionnaires were fully answered.

Results of the academic qualification of the respondents show that all have post-secondary qualification. The distribution in ascending order is: 2 respondents (6.67 percent) have a Higher National Diploma; 4 respondents (13.33 percent) have a national diploma; 8 respondents (26.67 percent) have a Post Graduate Degree; and 16 respondents (53.33 percent) have a B. Sc. Likewise, results of the working experience of the respondents indicate that: 13 respondents (43.33 percent) have an experience of 1–5 years; and 17 respondents (56.67 percent) have an experience of 6–10 years.

Furthermore, results depict that 27 respondents (90 percent) are technical staff, 2 respondents (6.6 percent) are administrative staff, and 1 respondent (3.33 percent) is finance staff. From these results, while over three-quarters (86.67 percent) of the respondents are graduates, over half (56.67 percent) have over 5 years of working experience. Similarly, 90 percent of the respondents are construction professionals. These results are presumed to add reliability to the opinions obtained from the survey.

Table 2. Demographics of respondents.

Demography	Number of respondents	Percentage
Firm of respondent		
Brains and Hammers	25	83.33
Awonto Konsult	5	16.67
Total	30	100
Maximum academic qualification		
SSCE	0	0
ND	4	13.33
HND	2	6.67
BSc	16	53.33
Post Graduate Degree	8	26.67
Total	30	100
Working experience		
1–5 years	13	43.33
6–10 years	17	56.67
Total	30	100
Unit		
Technical (construction professional)	27	90
Administrative	2	6.67
Finance	1	3.33
Other unit	0	0
Total	30	100

Table 3 depicts the results of the respondent's level of satisfaction with the 10 functional requirement driving the reuse of plastic bottles as building blocks for housing construction. While strength and stability ranked 1st (with a mean value of 4.70; RSI of 0.94), durability ranked 2nd (with a mean value of 4.50; RSI of 0.90). Also, while environmentally friendliness ranked 3rd (with a mean value of 4.40; RSI of 0.88), the availability of materials ranked 4th (with a mean value of 4.37; RSI of 0.87). Likewise, while weather/thermal insulation ranked 5th (with a mean value of 4.27; RSI of 0.85), safety and security ranked 6th (with a mean value of 4.20; RSI of 0.84). Also, while sound insulation ranked 7th (with a mean value of 4.17; RSI of 0.83), the availability of skills and workmanship ranked 8th (with a mean value of 4.07; RSI of 0.81). Similarly, while economic consideration ranked 9th (with a mean value of 3.80; RSI of 0.76), fire resistance ranked 10th (with a mean value of 3.40; RSI of 0.68).

Table 3. Results of the satisfaction of functional requirements driving the reuse of plastic bottles as building blocks for housing construction.

Factor	Frequency of responses					Total	Scores below median	Scores above median	Mean score	RSI	Rank
	5 VS	4 S	3 U	2 D	1 VD						
Strength and stability/good construction ability	21	9	0	0	0	30	0	30	4.70	0.94	1st
Durability	16	13	1	0	0	30	0	29	4.50	0.90	2nd
Eco-friendly/Environmentally friendly	15	13	1	1	0	30	1	28	4.40	0.88	3rd
Availability of material	15	12	2	1	0	30	1	27	4.37	0.87	4th
Weather (thermal) insulation	14	10	6	0	0	30	0	24	4.27	0.85	5th
Safety and Security	12	12	6	0	0	30	0	24	4.20	0.84	6th
Sound insulation	13	11	4	2	0	30	2	24	4.17	0.83	7th
Available skills/workmanship	8	16	6	0	0	30	0	24	4.07	0.81	8th
Economic considerations	9	9	9	3	0	30	3	18	3.80	0.76	9th
Fire resistance	3	9	15	3	0	30	3	12	3.40	0.68	10th

Legend: 5-Very Satisfied (VS), 4-Satisfied (S), 3-Unsure (U), 2-Dissatisfied (D), 1-Very Dissatisfied (VD).

Results of scores below and above the median are used to ascertain where the opinions of respondents tend towards on the Likert scale. The opinion of all respondents on ‘strength and stability’ tends towards ‘satisfied’. Similarly, the opinions of 90 percent and above of the respondents on ‘durability’, ‘eco-friendly/environmentally friendly', and ‘availability of material’ tend towards ‘Satisfied’ with few respondents being ‘unsure’ of these performance requirements and the opinion of a few respondents tending towards ‘dissatisfied’. Furthermore, the opinions of 80 percent of the respondents on ‘weather (thermal) insulation’, ‘safety and security’, ‘sound insulation’ and ‘available skills/workmanship’ tend towards ‘Satisfied’ with several respondents being ‘unsure’ of these performance requirements and the opinion of a few respondents tending towards ‘dissatisfied’. Also, the opinion of 60 percent of the respondents on ‘economic considerations’ tends towards ‘satisfied’ with several respondents being unsure of these performance requirements and the opinion of a few respondents tending towards ‘dissatisfied’. Only 40 percent of the respondents had an opinion that tended towards ‘satisfied’ on ‘fire resistance’ with 50 percent of the respondents ‘unsure’ of these performance requirements and the opinion of a few respondents tending towards ‘dissatisfied’.

7. Findings

Overall, with the exception of the functional requirements ‘economic consideration’ and ‘fire resistance’, the opinion of majority (90 percent and above) of the respondents on the other eight functional requirement studied tended towards ‘Satisfied’. This supports the works of [8,12,13,15,18,21,26,29,32] who all claim that these functional requirements covered in this study are satisfactory when considering the reuse of plastic bottles for housing construction. Furthermore, the overwhelming 'satisfaction' of the functional requirements 'strength and stability' as well as 'durability' supports the claim by [22] that durability, strength and stability are important considerations when using plastic bottles in construction. This is also in line with the reports that the durability of plastic bottles is commendable because it takes over 300 years for plastic bottles to degrade [4,6,7,9,12,14,18,21,22,29]. All these indicate that the reuse of plastic bottles as building blocks for housing construction could indeed have potentials in not only contributing towards addressing the existing housing deficit challenges but equally harnessing plastic bottles littering the environment thereby converting them from waste to wealth.

8. Conclusion and recommendations

Respondents tend to be more sceptical on expressing their opinion on 'economic consideration' and 'fire resistance' whereby quite a number are 'Unsure' of each of these functional requirements to being drivers in the reuse of plastic bottles as building blocks for housing construction. With 90 percent of respondents being technical staff (construction professionals) and up to 50 percent being 'Unsure' and an additional 10 percent "Disagreeing' on fire resistance to being a functional requirement driving the reuse of plastic bottles as building blocks for housing construction, this implies there is a lot unknown about the fire resistance property of the material. As such, there is need for both experiments and trainings on the fire resistance properties of reused bottles at Awonto Konsult and also Brains and Hammers Construction. Similarly, orientations on the economic considerations of reused plastic bottles are necessary. Equally, wider empirical researches on plastic wastes if undertaken alongside agricultural wastes and also fibre wastes could support the development of policies for waste management particularly in developing countries. Moreover, an effective plastic waste management strategy will facilitate driving the quest to achieving a circular economy which is a good global practice.

This research has the potential to convert waste into wealth in a bid to minimising environmental impacts of disposed plastic bottles as well as contribute to sustainable materials, particularly for rural housing. This is in line with [55], who stress that alternatives to waste disposal (such as reusing plastic bottles) can be a veritable source of raw material reduction and achieving sustainability. Besides, projects using such materials can create livelihoods for rural dwellers and present a source for circular economy. This will key into Nigeria's quest to achieve UN Sustainable Development Goals (SDG) 11 (making human settlements sustainable) and 12 (ensuring sustainable consumption and production).

However, since this study covered staff of both Awonto Konsult and also Brains and Hammers Construction who participated in the construction of buildings using plastic bottles in Paipe village Abuja Nigeria, future studies could assess the performance of the built houses from the perspective of occupants. Also, rather than surveys, experiments if conducted can provide further empirical data on the functional requirement driving the reuse of plastic bottles as building blocks for housing construction suitable for the Nigerian practice. Equally, studies on design parameters of the material if conducted will provide valuable data that can improve the practice.

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