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The Impact of Soil Types on The Mechanical Properties of Sustainable Bottle Bricks

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Abstract: Bottle bricks offer quantity general solutions to the problem of meeting the increasing demands for bricks at a reduced cost and at the same time reducing the environmental impact of industries that are vital to economic development, As natural resources are becoming scarce and the majority of the abandoned waste are causing certain serious environmental problems in many parts of the world, urgent concerns are being raised by professionals in the building industry on the measures to alleviate the trend and possible utilization of waste in the construction process and in the production of masonry units, because of that, this study employed a parametric experimental study to investigate the mechanical properties of sustainable bottle bricks of sharp sand, stone dust, and laterite to produce a low-cost composite bottle brick as a building material, An experimental investigation has been carried out to determine the impact of the soil types, compaction and moisture content on the compressive strength property of the bottle bricks used. The study found that the stone dust and laterite are viable resources for manufacturing bottle bricks, while sharp sand cannot be used as it does reach the minimum compressive strength.

Keywords: Bottle Bricks, Mechanical Properties, Soil, Moisture content, Compressive Strength, Compaction

I. INTRODUCTION

Brick is one of the most common masonry materials in building, its manufacturing history dates back to 6000BC using a soft mud process in which a relatively moist clay is pressed into simple rectangular molds by hands. To keep the sticky clay from adhering to the molds, the molds were usually dipped in water immediately before being filled, producing brick with a relatively smooth, dense, surface known as the water struck brick (Allen and Hallo, 2011).

Bricks manufacturing gradually advanced from the sift mud process to the dry press process. The dry process was used for clay that shrinks while drying to improve the quality of brick. The process involves placing a mixture of Clay then compacted before being cured in the open to improve the property. However, the brick produced from the process had several shortfalls on the mechanical properties, which cured further advancement of sun-dried (Beall, 2004). Further advances lead to the production of fire bricks which chudley and green (2006), described as involving the firing of a stack of a loose array of mixed clay in molds.

Venta (2000) noted that brick curing at very high temperatures is energy consuming and a major contribution to greenhouse gas. Reducing greenhouse gas emission and the total carbon footprint of the construction is vital to the improvement of the built environment to address the concern; several studies a being conducted to explore the potential of producing brick without much firing or without firing at all. Muhammad (1987) investigated the properties of clay-sand-rice ash bricks. Demir, Serhat, and Mehmet (2005) examined the utilization of Kraft pulp residue in clay brick production in another study which involved the application of submerged arc welding flux slag as raw material and bricks. (caroline, Dylmar, jose and Ronaldo 2009) linear shrinkage, water absorption, apparent porosity, apparent density, and flexural strength were determined.

(Hendry and Khalaf, 2001) Despite curing the bricks produced in a number of these studies at a restively low temperature, the result shows that further important is necessary not only to climate the firing process but also to improve the mechanical and durability properties. Besides, recent innovations in the construction industry are geared towards incorporating the basic principles of sustainability. The basic principle of sustainability is reduced, reuse, and recycle.

The recycling aspect of sustainability is concerned with converting waste into useable products. The built environment in many developing countries is faced with challenges of management of municipal waste whose 50% composition is plastics. (Mamlouk and Zaniewski, 2006).

The huge plastics waste emerging in the built environment could alleviate the excessive consumption of virgin resources in the production of bricks if the amazing properties of plastic adequately harness. However, the concern confronting the application of plastics in the production of bricks is the doubt of its satisfactory performance as a composite material. The study, therefore, investigates the properties of bricks manufactured with plastics bricks (Marotta and Herubin, 1997).

A. *Need for The Research*

Turgut and Bulent, (2008) noted the dangerous impacts of bricks manufacture have been a serious problem that has alarmed environmental protection agencies and dragged substantial attention from researchers.

Instead of using traditional brick, a plastic bottle can be used which is maybe from water or oil that is considered as a nonrenewable resource (Saidu, 2013). Because plastic has the insolubility about 300 years in nature, it is considered as a sustainable waste and environmental pollutant. So, reusing or recycling it can be effectual in mitigation of environmental impacts relating to it. When society gets affected, then it will be uneconomical for the nation to create sustainable development (Chusid, Miller, and Rapoport. (2009).

Plastic bottles can assist to obtain a social equity by avoiding the gap between the rich and the poor people in society. With population growth in today's world, the need for the building has increased, and to respond to this demand, the countries tend to use the industrial building materials and decline the use of indigenous and traditional materials. These factors despite increasing the energy consumption in the industry section, they can also raise the cost of homes and are considered as the barrier for users to obtain the basic needs of the life (Mojtab, Azin, and Shakiba, 2013).

B. *Aim and Objectives of The Study*

The study is aimed at investigating the impact of the soil types, compaction, and moisture content on the mechanical behaviour of sustainable bottle bricks. The aim of the research is addressed through the pursuance realization of the following objectives;

- To examine the impacts of soil types on the compressive strength properties of bottle bricks
- To determine the influence of compaction on mechanical properties of sustainable bottle bricks
- To assess the effects of moisture contents on the properties of bottle bricks

C. *Significance of The Study*

The use of bottle bricks will helps in reducing the overall cost of the buildings, these bricks are manufactured by using a non-bio-degradable waste such as plastic bottles, plastic bags, and other non-bio-degradable substances, Plastic is a non-bio-degradable substance that takes thousands of years to decompose and hence creating land and water pollution, because of that, a new concept of bottle bricks (also known as eco-bricks) have been introduced, these bricks are cheaper to make and can help to reduce the rate of our environmental pollution, thereby making an eco-friendly building at a cheaper amount of money.

D. *Definition of Key Terms*

i. ***Bottle*****:** a bottle is a rigid container with a neck that is narrower than the body and a mouth which are typical to store liquid such as water, soft drink, motor oil, cooking oil, medicine, shampoo, milk, and ink.

ii. ***Bricks***: Brick is a building material used to make walls, pavements and other elements in masonry construction

iii. ***Sharp Sand*****:** sharp sand is angular grained, jagged sand, not round like beach sand. It is often recommended in large quantities as an amendment to loosen clay soil along with compost or to mix with sphagnum peat moss to create potting or starting medium. It is also called builders sand.

iv. ***Stone Dust***: stone dust is a multipurpose material for yard construction. A compacted layer of stone dust is well suited to a yard or passageway surface. It is also a great choice for the sub-base in laying paving blocks and slabs, and for jointing natural stone, such as slate.

v. ***Laterite*****:** is a soil layer that is rich in iron oxide and derived from a wide variety of rocks weathering under strongly oxidizing and leaching conditions. It forms in tropical and subtropical regions where the climate is humid.

II. LITERATURE REVIEW

Using bottles for construction of walls dates back into the early 20th Century, specifically, 1902 in Tonopah, Nevada, USA. where William Peck used glass beer bottles to build a house (Suyog, 2016). It was not until the 21st century where lots of plastic bottle waste has been generated that Andreas Forese, the founder of Eco-Tec Environmental Solution, established the innovation of building plastic bottle houses in 2001 resulting in the construction of the first plastic bottles house in Honduras in 2002 (MAWAD24, 2013), this environmentally friendly building is roofed with a 30ton green roof ECO-TEC Environmental Solutions led by Forese came out with this innovation when they realized that about 80% of plastic produced every year in Honduras could not be recycled, and was able to achieve this through clean-up exercises and have since constructed over 50 buildings including residential houses, schools, churches and parks in Bolivia, Columbia, Honduras, Mexico, India, Nigeria and Uganda (MAWAD24, 2013).

Thinking along that line, a German national Andreas Froese invented the technique BI4PVS, which involves the use of disposable PET bottles, debris, and earth as raw material for construction, PET bottles are filled with sand or soil or landfill dirt or mud and are used as bricks to construct houses and even water tanks, the technology was quickly adopted in different countries including Nigeria, South Africa, Norway, the Philippines, and India. His campaign to date has recovered and reused more than 300,000 PET bottles and has used these in more than 50 construction projects in Honduras, Columbia, Bolivia, When filled with soil or sand Froese's plastic bottles work as bricks and can be used in walls or pillars replacing conventional bricks, these walls can be of different sizes and orientations. Froese also measured the compression strength of his bricks when filled with the weakest filling material e.g. sand, his plastic bottle walls can take up to 4.3 N/mm² (Raut *et al.*, 2015).
The plaster made of clay or a cement mixture used to hold the bottles in place to build these walls carry two-thirds of the load while the bottles bear one-third. The roof of these bottle houses can be made of wood or corrugated metal sheets. Since these houses are made of locally sourced materials with much shorter construction periods, they are far less cheap compared to conventional houses. Houses built with such bricks have been labeled as "more durable, earthquake resistant, naturally insulated, low cost and environmentally friendly". Moreover, they have so far been proved to be earthquake resistant (www.eco-tecnologia.com).Using this same technique, a Nigerian NGO 'Development Association for Renewable Energies' successfully built a two-bedroom house entirely out of plastic bottles, which is said to be "bullet and fireproof, earthquake resistant, and maintains a comfortable interior temperature of 64° F year-round". Raut *et al.* (2015) concluded that, in many ways such as time of execution, load capacity, flexibility, waste and cost reduction, and energy efficiency, plastic bottle bricks can be better compared to some conventional building materials such as brick, concrete and ceramic blocks.
Shoubi *et al.* (2013) reported that being lighter, plastic bottle walls can be better against earthquakes; due to the compaction of filling material in the bottles, they are 20 times more load resistant than conventional bricks; these filling materials also make these walls bulletproof. These walls can also support themselves. When these bottles are filled with sand, gravel, and cork or wood particles, these bottle walls also have the great insulating capability, the walls can absorb abrupt shock loads, being non-brittle, they produce much less construction waste compared to conventional bricks. They also reported that compared to brick and concrete block walls, plastic bottle walls cost 75% less. Raut *et al.* (2015) compared the cost of a 10m2 brick and masonry wall to a plastic bottle masonry wall and concluded that the bottle wall cost roughly 50% less than the brick wall.
Given its wide range of benefits over conventional construction materials, Ramaraj and Nagammal, (2014) believe that possibilities of using PET bottles as structural members, foundation, retaining walls, and secondary elements like street furniture, road dividers, pavements, and other landscape elements should be explored. There should be extensive research and encouragement from different Government and non-Government sectors to publicize and popularize this non-conventional construction material. Bangladesh currently has a huge solid waste management problem with unsightly dumping grounds across the country. Moreover, an ever-increasing number of people migrating to the cities in search of a better future has led to the development of slums in the already highly populated city landscapes. Houses built with bottle bricks can offer them low-cost alternatives which could also provide several other benefits.

III.MATERIALS AND METHODOLOGY

In this study, the first step taken was the collection of waste bottles from the waste collectors and other possible sources. After that, the collected bottles were clean and filled with the desired types of soil (sharp sand, stone dust and laterite), and then compacted to determine the influences of compaction on the sustainable bottle bricks, the effects of moisture content and the impacts of soil type on the compressive strength properties of the bottle bricks.

A. *Materials*

In this study, materials like bottles, tape, steel rule, weighing machine, compressive strength machine, and veneer calliper were utilized to test the compressive strength of bottle bricks manufactured with sharp sand, stone dust, and laterite in bottles.

1. Sharp sand: was purchased from the aggregate merchant in the Ota area of Ogun state.
2. Stone dust: was purchased from the aggregate merchant in the Ota area of Ogun state.
3. Laterite: was gotten from an under-construction church in Bells University of Technology Ota,
4. Plastic bottles**:** was gotten from different waste bin around the Bells University of Technology Ota. The bottles used were of the same type (50cl waste bottles).

B. *Standard Area of the Plastics bottles used*

The area is obtained by cutting the top portion of the plastic bottles, and then the height, the top and bottom diameter of each of the samples were measured and recorded. After that, the area is computed manually using the equation
$A= \frac{1}{2}(B+C) \times H$ as describe in the figure below;

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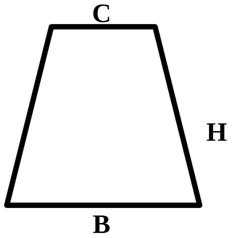

C. ***Filling***

The bottles are filled with sharp sand, laterite, and stone dust by categorizing each of the samples into non-layer, two layers, and three-layer with six bottles in each of the categories. The total number of the bottles used in this study was 96 bottles.

Steps taken to fill the bottle brick is stated as follows;

Step 1. Before the filling, glows, shoes, masks were worn.

Step 2. The bottles from each sample were weighed after the filling

Step 3. Then, the nonwatery absorbing and smooth surface was made for filling.

Step 4. The bottle cover was then closed very well and stack aside for the same moment before carrying out the compressive test.

Step 5. The bottles were measured vertically and horizontally from each sample after the filling using a plumb level, tape, steel rule, and veneer calliper for accurate measurement.

D. ***Filling Proportion***

The experiment is carried out by considering five compactions after each of the layers.

Table 1: Filling proportions

Samples	Non- layer	Two layers	Three layers
Sharp sand	6	6	6
Laterite	6	6	6
Stone dust	6	6	6

E. ***Laboratory Tests***

1) Moisture content test

Apparatus

- weighing machine
- Bow and bucket used for fetching while weighing the percentage of i.e. 10% and 20%
- Silver plate container, containing water place on weighing machine while weighing

Test Procedure

Place the Silver plate container on weighing machine, weigh and record the amount of water that should be added to each for 10% and 20%. The water is added to the sample and mixed very well

Calculation Moisture Content

The moisture content of each of the samples is expressed as a percentage of the dry bottle brick mass and wet bottle brick, using the following equation; Moisture content, (%) = A – B/B x 100

Where

A - Dry bottle brick mass of unit in kg,

B – Wet bottle brick mass of unit in kg,

The computed Percentages of the moisture content is shown in the table below;

Table 2: Moisture Contents

samples	non-layer	two-layer	Three-layer	% of Water	% of Water
SS0	6	6	6	10%	20%
SS2	6	6	6	10%	20%
SS3	6	6	6	10%	20%
SD0	6	6	6	10%	20%
SD2	6	6	6	10%	20%
SD3	6	6	6	10%	20%
LT0	6	6	6	10%	20%
LT2	6	6	6	10%	20%
LT3	6	6	6	10%	20%

2) Compressive strength Test

The compressive strength test was carried out as per code BS 1881 part 116, 1983, using a universal testing machine techno test kb 1500kn capacity.

The following steps were followed for compressive strength testing.

- The mass and dimension of each specimen were taken and recorded
- The bottle brick was placed centrally on the bottom plate of the universal testing machine.
- Then the upper plate of the universal testing machine was lowered down up to the brick was hold tightly without any movement.
- A load was then applied axially at a uniform rate
- This load was applied till the half of the bottle brick.
- Initial time and load were noted when the machine started sound
- Final time and load were noted when the bottle brick failed
- Six bottle bricks from the same sample were tested every time.

The compressive strength was calculated by the formula, Compression strength = (load/surface area)

Plate1: bottle bricks after filling

Plate2: bottle bricks after crushing

IV. PRESENTATION AND DISCUSSION OF FINDINGS

The results of the preliminary tests conducted to understand the performance of sharp sand, stone dust and laterite in sustainable bottle brick based on the provisions of BS 3921 are presented below;

A. *Effect of Soil Type on The Compressive Strength of Bottle Bricks*.

Table 3: Average result of compressive strength of bottle bricks produced with stone dust, sharp sand and laterite without compaction

S/N	Soil types	Mass (kg)	Compressive Strength. (N/mm^2)
1	Stone dust	1.31	12.18
2	Sharp sand	1.19	3.38
3	Laterite	0.92	31.92

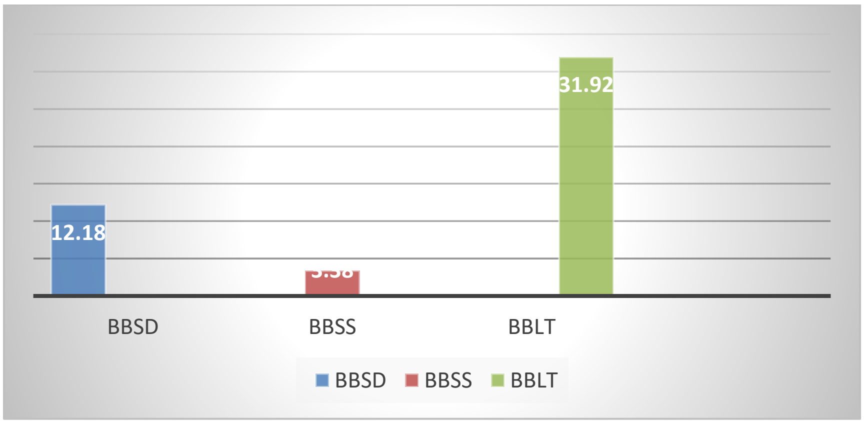

fig 1: average compressive strength test result

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The effects of the soil type on the compressive strength of bottle bricks were examined, the result of compression tests carried out on bottle bricks produced with three types of soil, namely stone dust, sharp sand, and laterite is presented above.
The Samples (bottle bricks) filled with stone dust are denoted with BBSD, samples made with sharp sand were represented as BBSS, and BBLT was used to represent bottle bricks samples made with laterite.
In fig 1. the average compressive strength of stone dust and laterite 12.14 N/mm^2 and 31.92 N/mm^2 respectively, satisfied the minimum compressive strength limit of 5N/mm^2 recommended, while sharp sand with compressive strength of 3.38 N/mm^2 did not pass the minimum strength requirement.

B. ***Impact of Compaction on The Compressive Strength of Bottle Bricks***

Table 4: Average result of bottle bricks manufactured with stone dust with various levels of compaction

S/N	Samples	Mass (kg)	Compressive Strength. (N/mm^2)
1	BBSD0	1.31	12.18
2	BBSD2	1.41	7.99
3	BBSD3	1.45	6.51

In Table 4, the average compressive strength of stone dust non-layer (BBSD0), two-layer (BBSD2), and three-layer (BBSD3) compaction samples are 12.18 N/ mm^2, 7.99 N/ mm^2, and 6.51 N/ mm^2.respectively this show that the compressive strength decreases with an increase in compaction, A partial increase in mass with an increase of compaction is also detected, However, the average compressive strength of stone dust shown above satisfied the 5N/mm^2 compressive strength limit recommended by BS 3921 1985.6.

Table 5: Average results of bottle bricks manufactured with sharp sand with various levels of compaction

S/N	Samples	Mass (kg)	Compressive Strength **(N/mm^2)**
1	BBSS0	1.19	3.38
2	BBSS2	1.26	2.42
3	BBSS3	1.32	2.17

In Table 5, the average compressive strength of sharp sand non-layer (BBSS0), two-layer (BBSS2) and three-layer (BBSS3) compaction samples are 3.38 N/mm^2, 2.42 N/mm^2 and 2.17 N/mm^2 respectively, this shows that the compressive strength decreases with an increase in compaction, a partial increase in mass with an increase in compaction is also detected. The average compressive strength of sharp sand shown above did not passes the 5N/mm^2 compressive strength limit recommended by BS 3921 1985.6

Table 6: Average results of bottle bricks manufactured with laterite with various levels of compaction

S/N	Samples	Mass (kg)	Compressive Strength **(N/mm^2)**
1	BBLT0	1.19	31.92
2	BBLT2	1.26	40.91
3	BBLT3	1.32	46.79

In Table 6, the average compressive strength of laterite non-layer (BBLL0), two-layerBBLL2), and three-layer (BBLL3) compaction samples are 31.92 N/mm^2, 40.91 N/mm^2, and 46.79 N/mm^2 respectively, this shows that the compressive strength increase with an increase in compaction, A partial increase in mass with an increase of compaction is also detected. The average compressive strength of laterite shown above passes the 5N/mm^2 compressive strength limit recommended by BS 3921 1985.6

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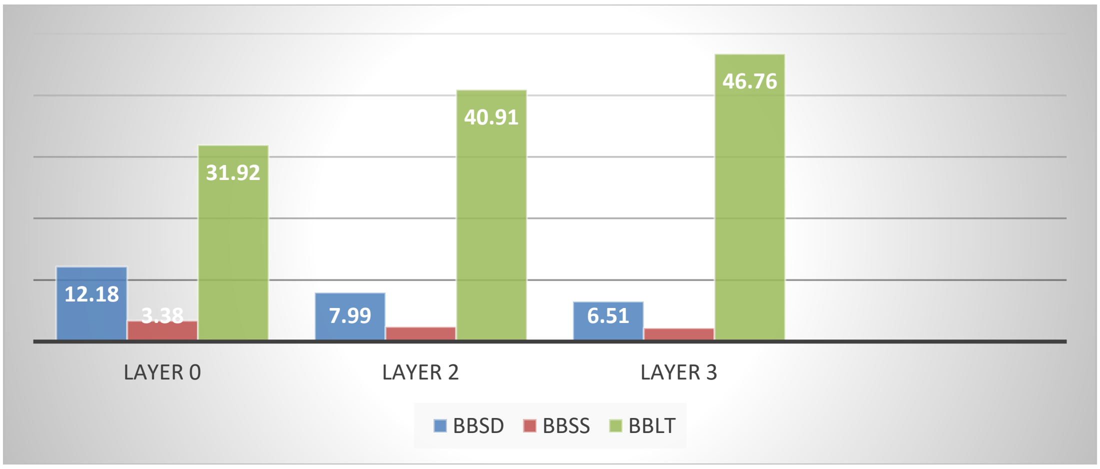

fig 2: average compressive strength of compacted samples

Generally, the compressive strength of stone dust, and laterite for non-layer, two-layer and three-layer showed in table 4 to 6, and in fig 2 above passes the minimum compressive strength limit recommended by BS 3921 1985.6 while in the other hand sharp sand of non-layer, two-layer and three-layer shown in table 5 above did not pass the minimum compressive strength limit recommended by BS 3921 1985.6C.

C. *To Assess the Effects of Moisture Content on The Properties of Bottle Bricks*

Table 7: average results of bottle bricks manufactured with stone dust containing moisture of different percentages without compaction

S/N	Samples	Mass (kg)	Compressive Strength(N/mm^2)
1	BBSD0	1.31	12.18
2	BBSD10	0.85	39.05
3	BBSD20	0.75	41.12

In Table 7, the average compressive strength of stone dust, containing 0% (BBSD0), 10%(BBSD10) and 20% (BBSD20) moisture content are 12.18 N/mm^2, 39.05 N/mm^2 and 41.12 N/mm^2 respectively. This shows that the compressive strength increases with an increase in moisture content in stone dust, and a Partial decrease in mass with an increase in moisture content. The average compressive strength of stone dust shown above passes the minimum compressive strength limit recommended by BS 3921 1985.6

Table 8: average results of bottle bricks manufactured with sharp sand contain moisture with several percentages Without compaction

S/N	Samples	Mass (kg)	Compressive Strength (N/mm^2)
1	BBSS0	1.19	3.38
2	BBSS10	0.90	29.53
3	BBSS20	0.80	30.50

In Table 8, the average compressive strength of sharp sand containing 0% (BBSS0), 10% (BBSS10) and 20% (BBSS20) moisture contents are 3.38 N/mm^2, 29.53 N/mm^2 and 30.50 N/mm^2 respectively. this shows that the compressive strength increases with an increase in moisture content in sharp sand, and decreases partially in mass with an increase of moisture content. The average compressive strength of sharp sand for 10% and 20% moisture contents as shown above passes the 5N/mm^2 minimum compressive strength limit recommended by BS 3921 1985.6 while 0% did not.

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Table 9: average results of bottle bricks manufactured with laterite contain moisture with several percentages Without compaction

S/N	Samples	Mass (kg)	Compressive Strength (N/mm^2)
1	BBLL0	0.92	31.92
2	BBLL10	0.70	2.60
3	BBLL20	0.60	1.93

In Table 9, the average compressive strength of laterite, containing 0% (BBLL0), 10% (BBLL10) and 20% (BBLL20) moisture contents are 31.92 N/mm^2, 2.60 N/mm^2 and 1.93 N/mm^2 respectively, this shows that compressive strength decreases with an increase in moisture content in laterite, and decreases partially in mass with an increase of moisture content. The average compressive strength of laterite for 0% shown above passes the minimum compressive strength limit recommended by BS 3921 1985.6 while 10% and 20% did not.

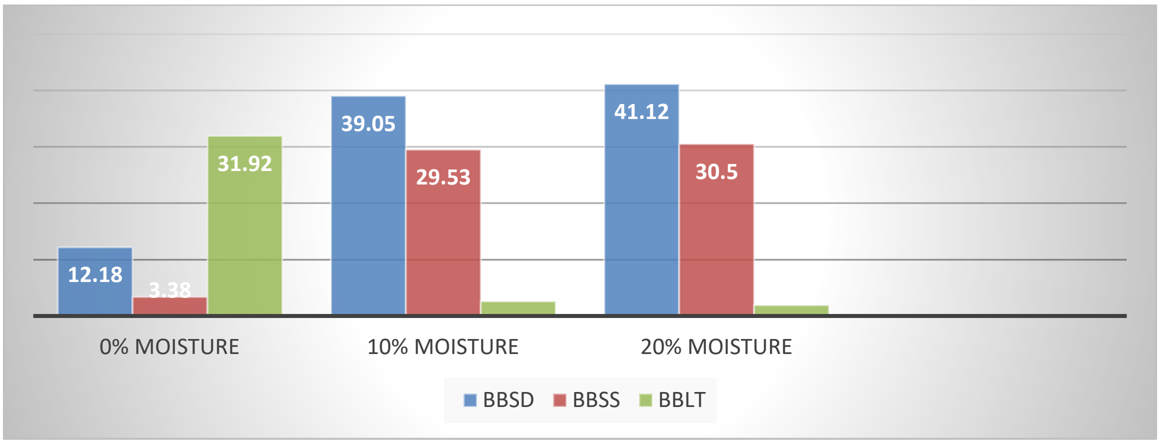

fig 3: average compressive strength containing moisture

In General, all the percentages of stone dust, 10% and 20% of sharp sand and 0% of laterite shown above pass the 5N/mm^2 compressive strength limit recommended by BS 3921 1985.6 while 0% of sharp sand, 10% and 20% of laterite did not pass the minimum requirement.

D. Discussion of Finding

From the Compressive strength test results of uncompacted soil samples studied, it can be observe that the stone dust and laterite are viable resources for manufacturing bottle bricks as they have passed the 5N/mm2 minimum compressive strength limit recommended by BS 3921 1985.6 while sharp sand cannot be used as it does reach the minimum limits.
The compressive strength of compacted stone dust, and laterite for non-layer, two-layer, and three-layer passes the minimum compressive strength limit recommended by BS 3921 1985.6 while on the other hand, sharp sand of non-layer, two-layer, and three-layer did not pass the minimum compressive strength limit.
Also, the compressive strength test results of uncompacted Moisture soil samples for all the percentages of stone dust, 10% and 20% of sharp sand and 0% of laterite passes the 5N/mm2 compressive strength limit recommended by BS 3921 1985.6 while 0% of sharp sand, 10% and 20% of laterite did not pass the minimum requirement.

V. CONCLUSION

Bottle bricks offer solutions to the problems of meeting the increasing demands of a sustainable bricks, at a reduced or no additional cost and at the same time reducing the environmental impact of plastic and construction industries that are vital to economic development. The study found that the stone dust and laterite are viable resources for manufacturing bottle bricks, while sharp sand cannot be used as it does reach the recommended minimum compressive strength. Compaction influence the bottle bricks with a decrease in compressive strength, and partial increase in the mass of stone dust, and sharp sand samples for all the layers of compaction, while on the other hand, it increases both the compressive strength, and the mass of a laterite samples. The higher the percentages of the moisture content in stone dust and sharp sand, the higher the compressive strength and the lower the mass of the sample, while on the other hand, an increase in the percentage of the moisture content resulted in a decrease of the compressive strength, and the mass for all the laterite samples.

A. ***Research Gap for Future***

A further research study should be carried out to determine the effects on the other mechanical properties of sustainable bottle bricks.

REFERENCES

[1] Andam, K.A. (2002). Compressive Strength of Commercial Sand Crete Blocks. *Proceedings* of the 4th International Conference on Structural Engineering Analysis and Modelling (*SEAM 4);* University of Science and Technology, Kumasi, Ghana, 1(3), 282-285.Auroville, (2016*).* Compressed Stabilized Earth Block. Http Auroville.com/compressed_ *stabilised_earth_block_en.php. Accessed*: 20th December,2016.

[2] Bamfo-Agyei, E. (2011). Establishing the compressive strength of sand Crete blocks produced in the Central Region, Ghana. Proceedings of West Africa Built Environment Research (WABER) 2011 Conference 1(1), 427-429.

[3] BS 812: part 107: (1995). Method for determination of particle density and water absorption. BSI, London. UK.

[4] BS 812: part 103, 1: (1985). *Method for determination of crushing value*. BSI, London, UK.

[5] Caroline EV, Dylmar PD, Jose N, Ronaldo P. (2009) "The use of submerged-arc welding flux Slag as raw material for the fabrication of multiple-use mortars and bricks*", Soldagem Insp. Sao Palo*, 14(3), 257–262.

[6] Christine B. (2004) Masonry Design and Detailing: For Architects and Contractors. 5th Edition. New York, McGraw Hill

[7] Clara, Piccirillo (2011), Cork: A Versatile Material Employed in Many Different Sectors‖, 13 (4), 302-315

[8] CraTerre, (1989). General Specifications for Compressed Earth Blocks. CraTerre, VilleFontaine.

[9] Demir I, Serhat M, Mehmet O. (2005) "Utilization of kraft pulp production residues in clay brick Production", *Building and Environment*, Vol. 40, 1533–1537.

[10] Dhote, S. U. (2016), Investigating the Use of PET Bottles as a Sustainable Material in Construction, International Journal of Research in Advent Technology 02(02), 2321-9637.

[11] Dobson, S. (2004). Continuity of Tradition: New Earth Building. *Earth Building Research Forum*, University of Technology Sydney, Australia.

[12] Edward Allen, Robert Hallo. (2004) *Fundamental Of residential Construction* (3rd edition), Pages. 672-673.

[13] Hendry, W. A. & Khalaf M. F. (2001). *Masonry Wall Construction*. London and New York, Taylor& Francis Group, Spon Press.

[14] Jeorge J. Venta, P.Eng. (2000) "Life cycle analysis of brick and mortar products*", Journal of* Engineering and Applied Sciences, 2 (1), 1-5.

[15] Mamlouk J.P & Zaniewski, M.S. (2006). Materials for Civil and Construction Engineers.2nd Edition. Upper Saddle River, New Jersey, Pearson Prentice Hall.

[16] Manisha N, Goyal (2016). *Constructing structure using eco brick.* International journal of recent trends in Engineering and Research. 02(04), 2455-1457.

[17] Marotta T.W & Herubin, C. A. (1997). *Basic Construction Materials.* 5th Edition. New Jersey, Prentice Hall

[18] Mawad24, (2013). *Plastic Bottle Homes*. HTTPs://beneficialtrends.wordpress.com/2013/11/25/ Plastic-bottle-homes-2/ Accessed: 16th October.

[19] Michael Chusid, Steven H Miller, Julie Rapoport. (2009) "The Building Bricks of Sustainability", *The Construction Specifier*, Vol. 1(3).30-40,

[20] Mojtaba Shoubi, V. Masoud Shoubi, and S. Azin Barough (jan.2013). Investigating the Application of Plastic Bottle as a Sustainable Material in the Building Construction. International Journal of Science, Engineering and Technology Research. 2 (1), 2278 – 7798

[21] Mojtaba Valinejad Shoubi, Masoud Valinejad Shoubi, Azin Shakiba Barough, (2013)*"* Investigating the Application of Plastic Bottle as a Sustainable Material in the Building Construction" *International Journal of Science,* Engineering and Technology Research Volume 2, pp: 28-34

[22] Mokhtar, M., Sahat, S., Hamid, B., Kaamin, M., Kesot, J., Wen, L. C., Xin, L. Y., Ng PeiLing, N. P., & Lei, V. S. J. (2015). Application of Plastic Bottle as a Wall Structure for Green House. Asian Research Publishing Network (ARPN) Journal of Engineering and Applied Sciences, 2 (1), 1-5.

[23] Odeyemi, S. O., Otunola, O.O., Adeyemi, A. O., W. O. Oyeniyan, W. O., & Olawuyi. M. Y. (2015). Compressive Strength of Manual and Machine Compacted Sand Crete Hollow Blocks Produced from Brands of Nigerian Cement. *American Journal of Civil Engineering. Special* Issue: Predictive Estimation by ANSYS for Laminated Wood Deep Beam. 3 (2-3), 6-9. Doi: 10.11648/j.ajce.s.2015030203.1

[24] Raheem, A.A., Bello, O.A., Makinde, O.A., 2010. A comparative study of cement and lime Stabilized lateritic interlocking blocks. Pac. Journal of Science and Technology.11 (2), 27–34.

[25] Rahman M.A. (1987) "Properties of clay-sand-rice husk ash mixed bricks*", International* Journal of Cement Composite Lightweight Concrete, 9(2), 105–108.

[26] Ramaraj A, Nagammal J (2014). Exploring the Current Practices of Post-Consumer PET Bottles and the Innovative Applications as a Sustainable Building Material–*A Way Ahead.* 30th International Plea Conference 5(2), 16-18.

[27] Raut, A., Patel, M. S., Jadhwar, N. B., Khan, U., & Dhengare, S. W. (2015). Investigating the Application of Waste Plastic Bottle as a Construction Material- A Review, *Journal of The* International Association of Advanced Technology and Science, 16 (12), Www.jiaats.com. Accessed: 12th October, 2015

[28] Roy chudley (2004), Roger Greeno. *Construction Technology* (4thedition), 634-635 pages. Prentice Hill,

[29] Sanisah S. (2013) Sustaining Sustainability," Palaver: Sense and Sustainability" in Proceedings International Journal of Advances in Engineering & Technology, (IJAET) Malaysian Town Plan Journal. 01(2), 60-70.

[30] Shoubi MV, Shoubi MV, Barough AS (2013). Investigating the Application of Plastic Bottle as a Sustainable Material in the Building Construction. *Journal of Science and Technology* 9(2), 105–108.

[31] Sinthaworn, S., & Nimityongskul, P. (2009). Quick monitoring of pozzolanic reactivity of waste ashes. *Waste Management*, 29(5), 1526–1531.

[32] Standards Association of Australia. AS 1289 B1.1-1977. Determination of the Moisture Content of a Soil: Oven Drying Method (standard method).

[33] Turgut P, Bulent Y (2008). "Physics-mechanical and thermal performances of newly develop Rubber- added bricks", *Energy and Building*, 40(3), 679–688.

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