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Assessment of Stabilized Earth Blocks (STEB) Strength to Sandcrete Blocks Used in Housing Construction

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Abstract: Shelter has been considered as the basic physiological need of a man after food and clothing. The use of stabilized earth soil as construction materials have solved and sustained the housing need of most communities because of its affordability prior to the use of the recent sandcrete block work in our modern construction technology. The research work aimed at collecting and running test samples of red earth soils at minimum of five different location i.e. one per state in the south eastern geopolitical zone of Nigeria, to carry out comparative analysis of stabilized red earth soil blocks and sancrete blocks' strength in the each of the five states of south east as materials for walls in housing construction. The test samples were mixed with ordinary Portland cement and water at stated proportion, moulded and cured for fourteen (14) days. The weight, force and compressive strength of each of these blocks were tested at seven (7) days, fourteen (14) days, twenty one (21) days and twenty-eight (28) days. This is to ascertain the rate at which they gain strength and their ultimate strength in twenty-eight (28) days. The test sampled crushed at standard organization of Nigeria (SON) workshop laboratory at Enugu Office. The result of the compressive strength shows that all the tested samples attained above 1.50N/mm^2 at twenty-eight (28) days but varies with the selected collection sample location. The graph/histogram of their respective weight, force and strength were plotted against period of gaining strength. The result also shows that the stabilized earth blocks with mix proportion of 1:12 yield twice the quantity of blocks compared to solid sandcrete blocks (SSB). The strength of the stabilized earth blocks (STEB) compared favourably to solid sancrete blocks (SSB) and can be used as substitute for housing construction for low income group in the area.

Keywords: Construction, Low Income Housing, Sandcrete Blocks (SSB), Stabilized Earth Blocks (STEB), Strength

1. Introduction

1.1. Background

The use of stabilized earth soil as a construction material for shelter dates back to ancient times when our ancestors used it for housing construction. These soil are excavated at source location, pounded and used to erect walls of building structures. There is virtually no location in this country, Nigeria where you cannot get the availability of this material. It depends on the location and culture of the people but this practice spread over the nook and crannies of Nigeria and beyond [1]. The difference is that some communities may add some additives depending on the texture of the soil where they are excavated to suit the same purpose. These practices have span from, North east, North West, south south, south west and south eastern states and all the geographical zones of Nigeria. There is virtually no part of Nigeria you will not see mud walls constructed prior to advent of this modernized construction technology methods. These are the major access to the provision of shelter in ancient times.

These locally constructed houses are achieved through self-help community efforts. The passage of time led to the invention of block mould for moulding the stabilized earth blocks for the purpose of erecting walls of buildings.

1.2. Statement of the Problem

UN Paris agreement is concerned about making the environment more habitable; devoid of overcrowding and thus, preventing hazard of home dwellers. To meet up with this standard implies that efforts must be geared towards provision of the affordable, environment friendly and sustainable housing units for the masses. The housing provision of over 30million people population in the study area cannot rely on man-made materials which are not sufficient, affordable and assessable while neglecting the one that could meet their need.

The construction industry is guilty of neglecting the relevance and benefit of some building materials like earth and nurturing into use of manmade (expensive) building materials to construct houses that most masses could not afford [2]. This is partly due to lack of knowledge of how to make earth durable and aesthetic [3]. Construction is based on the tenets of cost, time, strength and sustainability. There is need to uncover what could make the provision of housing using earth materials low and unpopular.

1.3. Aim and Objectives of the Study

The aim of this work is to assess the strength of stabilized earth blocks and carry out comparative analysis compared to sandcrete blocks as alternative to sandcrete blockwork in order to reduce the cost of construction in the study area. The objectives of the study include;

a) To determine the strength characteristics of stabilized earth blocks (STEB) at a ratio of 1:12 mix in order to yield up to seventy blocks (70) per bag of cement compared to mix ratio of 1:6 for sharp sand which gives about thirty five (35) blocks per bag of cement.
b) To compare the strength of sharp sand and stabilized earth harvested at various location of south eastern states of Nigeria.
c) To determine that rate at which these various mixes of stabilized earth and sharp sand gain strength in from age 7 days to 28 days.

2. Review of Related Literature

Some developing countries like Kenya has modified her building codes to include earth block as a building material. The cooperation between the Nigerian National Commission for Museum and Monument and the French Embassy in Lagos in 1997 has led to the revival and development of the use of earth building materials for low income housing [4]. The compressed earth blocks is formed by compressed earth in mould by means of a small pestle or ramming energetically with a heavy lid to the mould [5]. The stabilization of earth is modifying the properties of earth in relation to its water, texture and air system in order to obtain permanent properties compatible with a particular application. Stabilization of compressed earth has been achieved by the use of binders, which include cement, lime, pulverized fuel ash, earth worm cast and others [4].

Stabilized soil block technology was introduced within in Sudan programme was considered to be environmental friendly and termed ‘woodless’ technology [6]. They asserted that blocks have proven to be a good quality and cheaper; it generate employment, enhances transfer of technology, create social cohesion, thus laying the foundation for lasting peace and sustainable and transparency and accountability in rebuilding economic development of Darfur.

Hollow sandcrete blocks containing a mixture of sand, cement and water are used extensively in many countries of the world especially in Africa [7]. In many parts of Nigeria, sandcrete block is the major cost component of the most common buildings. The high and increasing cost of constituent materials of sandcrete blocks has contributed to the non-realization of adequate housing for both urban and rural dwellers. Hence, availability of alternatives to these materials for construction is very desirable in both short and long terms as a stimulant for socio-economic development proposed to replace the stabilized earth blocks. Although the earth soil are stabilized with different types of materials depends on the need of the users and what they want to achieve, the use of sharp sand and cement mixture for moulding of sancrete blocks was in vogue. The arduous process of extracting earth soil manually discouraged many from its use because sharp sand can easily be harvested [8]. The use of stabilized earth blocks extracted from natural sources are more sustainable in terms of thermal comfort and other advantages. Some of these stabilized earth soils are moulded in their natural forms, allowed to dry or burnt in fire (fired) and used for constructing walls in buildings without additions of any binding agent like cement.

In some communities the earth soil is mixed with some plant and grass leaves which helps to improve on the building properties for moulding as blocks. The arduous process of extraction of earth soils can be alleviated by the use of modern excavation equipment. Although the practice of the use of earth soils for walls of buildings are phasing out because of changes in technology, recent studies have shown that they are still relevant when cement is added as binding agent to reduce the cost of building houses for low income group.

The stabilized earth building blocks when mixed with cement in a proportion twice or more depending on the source location, yields more blocks that compares with that of sandcrete cement blocks which in turn reduce the cost of housing construction. The cost of cement and modern construction materials makes it difficult for low income earners to own a house of their own. Despite the modern building technology, the old practice of self-help construction in some villages persists. Shelter is considered as the basic physiological need of a man after food and clothing [9]. The use of stabilized earth soil as construction materials have solved and sustained the housing need of most communities because of its affordability prior to the use of the recent sandcrete block work in our modern construction technology. Since time immemorial, earth block houses have been found to be very efficient and responsive to natural surroundings in terms of protection against heat and cold. This obviously calls for the search for cheap acute feasible materials which can be used to solve the consequent problem of acute housing shortage for the ever increasing population [4].

It is necessary therefore to carry out a comparative study of strength of conventional blocks and stabilized earth blocks in South east Nigeria. The designers can always determine the standard of workmanship for standard sandcrete blocks and clay bricks but stabilized earth blocks does not have statutory recognition. The assessment of stabilized earth blocks (STEB) strength and sandcrete blocks used in housing construction can serve as a platform for integrating stabilized earth blocks (STEB) into the design and development process of the building industry. This will enhance the realization of the government on housing for all especially the low income group. Stabilized soil block technology is cost and environmentally friendly [10]. The stabilized soil block is at least 18 per cent cheaper to produce than burned bricks, since firewood is not used and the process requires less water. The stabilized soil block technology can cut regional and local government expenditure while providing the needed housing and social facilities for residents.

3. Research Methodology

The methodology was based on experimental research sponsored by IBF Tetfund and literature review of relevant journals, textbooks, articles of conference papers, standard specifications e.t.c. to enable us realize the objectives of this research. Soil samples were collected at different locations and used for the production of the stabilized earth blocks. The soil samples used for the stabilized earth blocks were collected at two locations in Enugu State and one location each in Anambra, Abia, Ebonyi and Imo States. The locations collection points were captured respectively as follows:

Enugu State: a. Behind Primary Health Centre Amutenyi in Obollo Eke, Udenu Local Government Area; Latitude: 6.937662 and Longitude: 7.519797 and b. Law School Quarters, Agbani in Nkanu West LGA, Enugu; Latitude: 6.322725, Longitude: 7.543568.

Anambra State at Umuokpu Awka by Enugu Onitsha Express way, Awka South LGA.

Abia State at Umuanyi Uturu in Isikwuato LGA, Abia State (Okigwe-Afikpo road),

Latitude: 5.821792 (5°49′18″.4N); Longitude: 7.420424 (7°25′13.5″E).

Ebonyi State- Sharp sand – Uwana beach, Afikpo North LGA, Ebonyi State.

Latitude: 5.791856 (5°47′30.7″.4N); Longitude: 7.937815. (7°56′16.1″E).

Red Soil-Ogbu Edda, Afikpo South LGA Ebonyi State; Latitude: 5.822811 (5°49′22.1″N); Longitude: 7.892510 (7°53′30.0″E).

Imo State at Obioha in Ihube Okigwe LGA (Beside SETRACO, along Enugu-Umuahia road). Latitude: 5.880657 (5°52′50.4″N); Longitude: 7.381957 (7°22′55.0″E).

The red soil collected were mixed with cement at a mix ratio of 1:12 to get blocks of 450 × 225 × 100 mm while the mix ratio for cement and sharp sand is 1:6. The sandcrete blocks and stabilized earth blocks were cured for fourteen (14) days while the test was carried out. The crushing to determine the compressive strength was done for seven (7) days, fourteen (14) days, twenty one (21) days and twenty eight (28) days respectively. These tests were carried out at Standard Organization of Nigeria (SON) office in Enugu with their universal testing machine/automatic compression machine. The results obtained were analyzed and compared with the standard values.

4. Results and Findings

4.1. Data Presentation

The results were as shown in the Table 1 for seven (7) days, fourteen (14) days, twenty one (21) days and twenty eight (28) days. The following tables contain excerpts of the results as analyzed.

Table 1. *Results of weight of stabilized earth blocks test samples.*

Location	Periods in days			
	7 days	14 days	21 days	28 days
Amutenyi	17.00	16.97	5.40	15.38
Agbani	23.80	23.78	21.90	21.19
Ebonyi	21.24	21.23	20.94	20.29
Imo	22.86	22.85	21.27	20.34
Anambra	22.82	22.82	21.45	20.34
Abia	26.31	26.31	24.41	20.09

The results showed a minimal reduction in weight from 7 to 14 days and from 21 to 28 days. The rate of reduction as the strength increases from 14 to 21 days is higher comparatively. The weight of stabilized earth blocks in seven days is highest in Abia State (26:31 kg) followed by 23.8 kg from Agbani in Enugu State 22.86 kg in Imo State, 22.82 kg in Anambra State, 21.24 kg in Ebonyi State, and least is 17 kg from Amutenyi in Enugu State.

Table 2. *Results of force in KN of stabilized earth blocks test samples.*

Location	Period in days			
	7 days	14 days	21 days	28 days
Amutenyi	30.68	33.04	59.34	69.00
Agbani	16.52	19.78	63.45	76.36
Ebonyi	30.68	36.45	45.92	71.30
Imo	25.96	30.42	53.81	72.68
Anambra	28.32	34.02	54.28	74.52
Abia	30.68	36.24	59.48	68.54

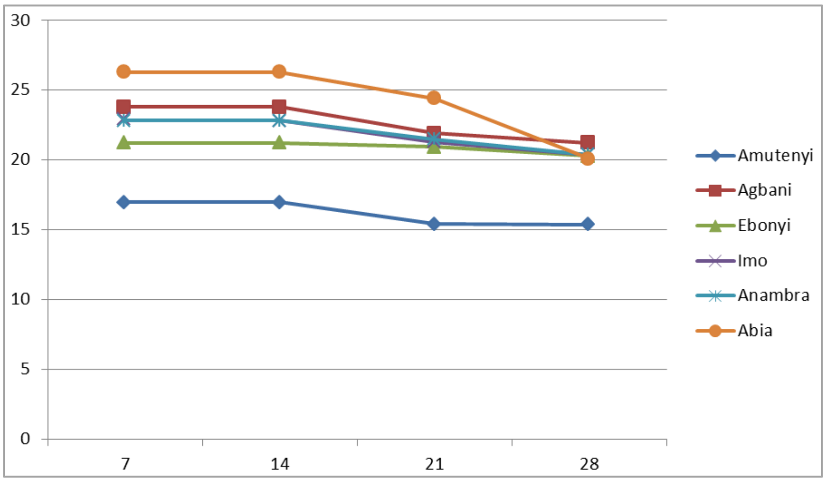

Figure 1. *Graph of weight of the stabilized earth blocks test samples (within 7, 14, 21 and 28) days.*

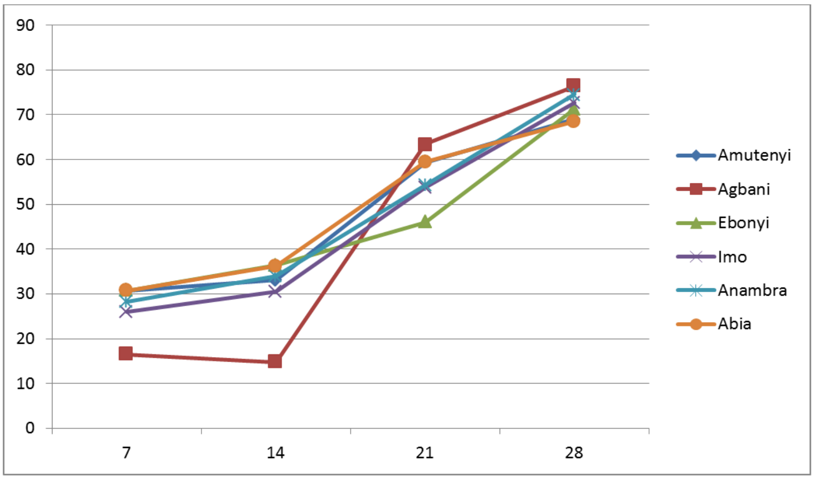

Figure 2. *Graph of force in KN of stabilized earth blocks test samples.*

The results showed an upward trend from seven (7) days to twenty eight (28) days for the samples collected in all the locations. There is always a quantum jump in force developed from fourteen (14) days to twenty eight (28) days. The result for samples of 30.68 KN from Amutenyi in Enugu, Ebonyi and Abia states are the same while we have 28.32KN in Anambra, 25.9 KN and 16.52 KN in Imo state and Agbani in Enugu state in seven (7) days respectively. However at twenty eight (28) days we have 76.36, 74.52, 72.68, 71.30, 69.00 and 68.54, from Agbani in Enugu state, Anambra, Imo, Ebonyi, Amutenyi in Enugu and Abia states respectively.

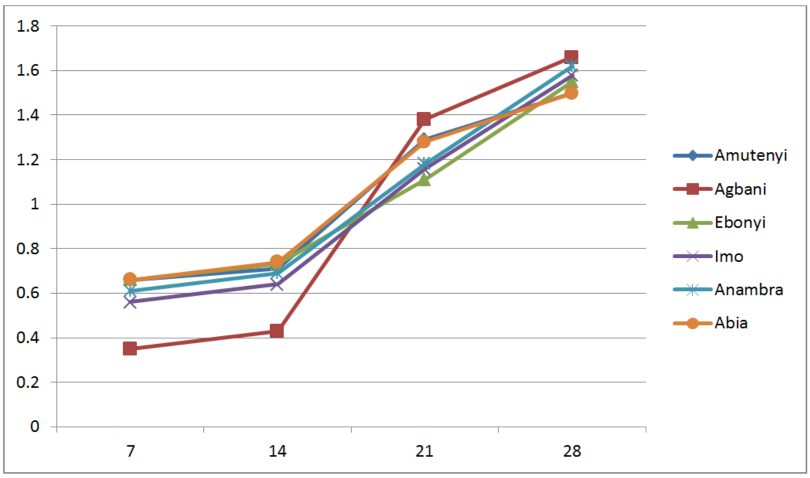

Figure 3. *Graph of strength in N/mm^2 of stabilized earth blocks test samples.*

Table 3. *Results of strength in N/mm^2 of stabilized earth blocks test samples.*

Location	Period in days			
	7 days	14 days	21 days	28 days
Amutenyi	0.66	0.71	1.29	1.50
Agbani	0.35	0.43	1.38	1.66
Ebonyi	0.66	0.73	1.11	1.55
Imo	0.56	0.64	1.16	1.58
Anambra	0.61	0.69	1.18	1.62
Abia	0.66	0.74	1.28	1.50

At seven (7) days the strength (0.66) is the same for Amutenyi in Enugu, Ebonyi and Abia State while others are 0.61, 0.56 and 0.35 in Anambra, Imo and Agbani in Enugu state respectively. At twenty eight days the strength are 1.66 for Agbani in Enugu, 1.62 for Anambra, 1.58 for Imo, 1.55 for Ebonyi and 1.50 each for Amutenyi in Enugu and Abia State.

Table 4. *Results of weights in kg of sancrete blocks test samples.*

Location	Period in days			
	7 days	14 days	21 days	28 days
Enugu	23.04	23.03	21.33	20.98
Ebonyi	18.21	18.21	16.50	16.01
Imo	22.91	22.90	21.16	20.96
Anambra	22.10	22.10	20.36	20.01
Abia	19.50	19.50	17.71	17.10

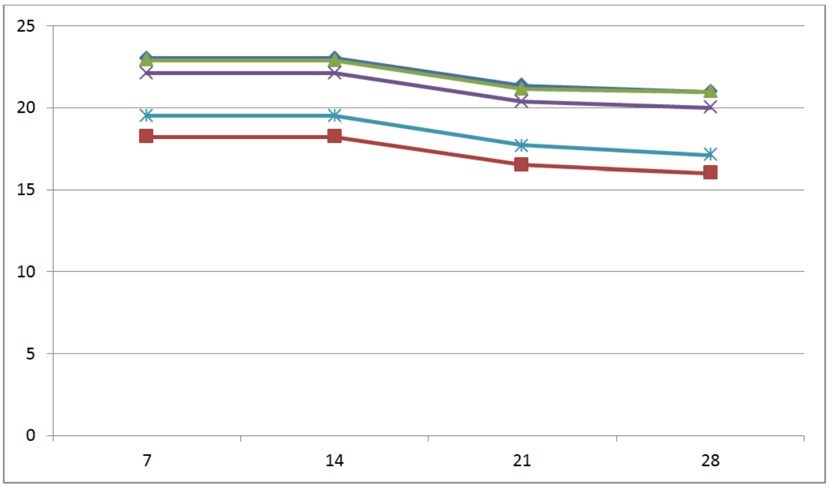

Figure 4. *Graph of weights in kg of sancrete blocks test samples.*

The weights show a gradual reduction in all the test samples as the age of the sandcrete blocks increases from seven (7) days to twenty eight (28) days. For Enugu the weight was 23.04 kg in seven (7) days and 20.98 kg in twenty eight (28) days. It reduces as the blocks gain strength. This shows that as the blocks loose water (moisture) it gains more strength. Moreover, it aligned with [11] investigation of the compressive strength properties of sandcrete blocks produced within the Calabar metropolis and cured for 3, 7, 14 and 28days. The results showed that the 28-day compressive strengths of sandcrete blocks produced in Calabar block industry range between 0.23N/mm^2 and 0.58N/mm^2. These values are below the minimum requirements of 1.75N/mm^2 by the Nigerian National Building Code (2006) for individual block, and 2.0N/mm^2 by the British Standard for non-load bearing walls which was fulfilled by the analysis carried out and discussed in this paper.

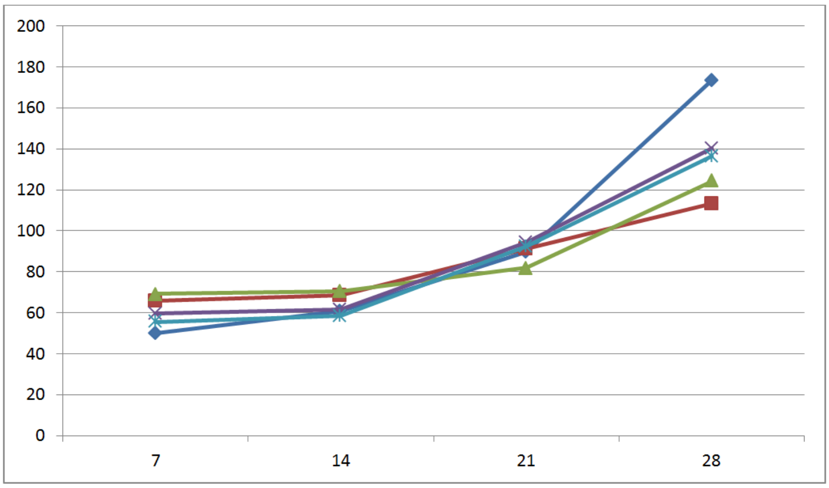

Figure 5. *Graph of force in KN of sancrete blocks test samples.*

Table 5. *Results of force in KN of sandcrete blocks test samples.*

Location	**Period in days**			
	7 days	**14 days**	**21 days**	**28 days**
Enugu	50.23	60.72	89.70	173.40
Ebonyi	66.03	68.44	91.20	113.20
Imo	69.20	70.40	81.88	124.20
Anambra	59.80	61.52	94.32	140.20
Abia	55.60	58.48	92.46	136.40

The result shows a gradual increase in force in kilo-Newton of the sandcrete blocks obtained at various location in south east Nigeria with age. For example the samples collected in Enugu was 50.23KN in seven (7) days, but increased to 173.40 KN in 28 days. All the results show a progressive increase in force for the sandcrete blocks from age 7 days to 28 days.

Table 6. *Results of strength in N/mm^2 of sandcrete blocks test samples.*

Location	**Period in days**			
	7 days	**14 days**	**21 days**	**28 days**
Enugu	1.02	1.32	1.55	2.39
Ebonyi	1.14	1.42	1.71	2.46
Imo	1.18	1.46	1.78	2.68
Anambra	1.16	1.44	2.12	3.01
Abia	1.12	1.38	2.01	3.05

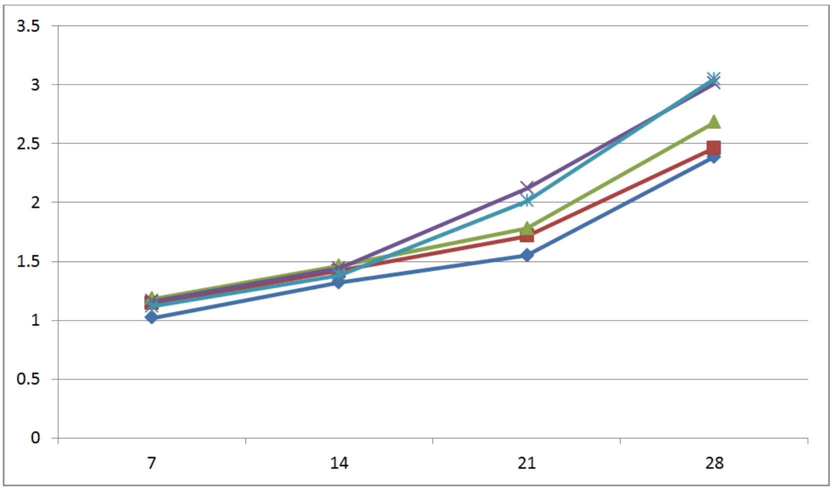

Figure 6. *Graph of strength in N/mm^2 of sandcrete blocks test samples.*

The result of the test shows the strength of the sandcrete blocks obtained at various location in south eastern Nigeria increases with age. At age of the twenty eight (28) days. Abia state has 3.05 while Anambra, Imo, Ebonyi and Enugu have 3.01 N/mm^2, 2.68 N/mm^2, 2.46 N/mm^2 and 2.39 N/mm^2 respectively.

The standard is that a minimum of 1.50N/mm^2 is suitable for blockwork in housing construction. This is in agreement with UNESCO report that concluded that the Al Haj Yousif experimental prototype school, build of compressed stabilized soil blocks in Khartoum, was cost-effective by the Sudanese standards. The total savings achieved through the project were at approximately 40 per cent.

Table 7. *Comparison of Ultimate Strength in 28 days for stabilized Earth Blocks (STEB) (X variables) and Solid Sandcrete Blocks (SSB) (Y variables).*

Location	**X**	**X-$\bar{X}$**	**(X-$\bar{X}$)^2**	**Location**	**Y**	**Y-$\bar{Y}$**	**(Y-$\bar{Y}$)^2**
Amutenyi	1.50	- 0.07	0.0049	Enugu	2.39	-0.33	0.1089
Agbani	1.66	0.09	0.0081	Ebonyi	2.46	-0.26	0.0676
Ebonyi	1.55	- 0.02	0.0004	Imo	2.68	-0.04	0.0016
Imo	1.58	0.01	0.0001	Anambra	3.01	0.29	0.0841
Anambra	1.62	0.05	0.00025	Abia	3.05	0.33	0.1089
Abia	1.50	-0.07	0.0049	Total	13.58		0.3711
Total	9.40		0.01865				

$$\text{Mean} = \frac{9.4}{6} = 1.57N/MM2$$

Thus,

$$\text{Mean} = \frac{13.58}{5} = 2.72N/MM2$$

Comparison of the ultimate strength of STEB and SSB at various site locations are indicated in the following analysis

$$\text{Mean value of STEB} = 1.57N/MM2$$

$$\text{Variance } (S_X^2) = \frac{\sum(X-X)2}{N} = \frac{0.01865}{6} = 0.00311$$

$$\text{Standard deviation } (S_X) = \sqrt{\frac{\sum (X-X)2}{N}} = \sqrt{\frac{0.01865}{6}} = \sqrt{0.00311} = 0.0056$$

$$\text{Mean value of SSB} = \frac{13.58}{5} = 2.72N/MM2$$

$$\text{Variance } (S_y^2) = \frac{\sum (y-y)2}{N} = \frac{0.3711}{5} = 0.07422$$

$$\text{Standard deviation } (S_y) = \sqrt{\frac{\sum (y-y)2}{N}} = \sqrt{\frac{0.3711}{5}} = \sqrt{0.07422} = 0.2724$$

When computing a regression equation, the average results of the two locations for stabilized earth blocks were used to compare the strength of sandcrete blocks in Enugu i.e. 1.66 + 1.50= 3.16 ÷ 2 = 1.58.

4.2. Regression and Correlation Analysis of STEB and SSB

Let the results of the sandcrete blocks strength in 28 days be X and stabilized earth blocks (STEB) at various location be Y.

Table 8. *Regression table at different locations.*

S/N	Location	SSB (X)	STEB (Y)	XY	X^2	Y^2	Y_x
1	Enugu	2.39	1.58	3.78	5.71	2.50	1.50
2	Ebonyi	2.46	1.55	3.81	6.05	2.40	1.51
3	Imo	2.68	1.58	4.23	7.18	2.50	1.56
4	Anambra	3.01	1.62	5.02	9.06	2.62	1.63
5	Abia	3.05	1.50	4.58	9.30	2.25	1.64
	Total	13.59	7.83	21.42	37.30	12.27	

$$\text{Mean} = X = \frac{13.59}{5} = 2.72, Y = \frac{7.83}{5} = 1.57$$

The equation for linear regression is Y_x= a +bx. The constant, a, represents the intercept on the Y-axis and parameter b, which represents the slope of the regression line is the regression coefficient of Y on X. The coefficient of regression, b, is very important parameter for the regression function. It measures the average change in the variable, Y as a result of a unit change in X.

Y_x, represents the average value of Y computed from the relationship for any given value of X. Although it is an imperfect relationship, it only expresses the average relationship between X and Y.

From the above data, the arithmetic means as calculated are

$$\text{Mean} = X = 2.72, Y = 1.57$$

To find the value of a and b in the straight line formula,

$$b = \frac{\sum xy - nxy}{\sum x2 - nx2} = \frac{21.42-(5)(2.72)(1.57)}{37.3-(5\ x\ 2.72)2} = 0.22$$

a = y – bx; Substituting the values for y, x, and b, we have, a = 1.57 – 0.22(2.72) = 0.971 ≈ 0.97.

$$\therefore Y_x = .97 + 0.22\ X$$

4.3. Testing the Variables

A test can now be done to discover the measure of the degree of association between the two variables i.e. how well they are correlated. The measure usually adopted for this purpose is the "sample coefficient of determination"(r^2) which is given by the following formula:

$$r^2 = a\frac{\sum xy + \sum xy - ny2}{\sum y2 - ny2}$$

Source: Hamburg, M NBasic Statistics (Harcourt Brace and Jovanovich Inc.).

$$r^2 = \frac{0.97(7.83)+0.22\ (21.42)-(5\ (1.57)2}{12.27-5\ (1.57)2} = 0.3119$$

$$r = \sqrt{r^2} = \sqrt{0.3119} = 0.5584 \text{ or } 55.84\%$$

This shows that approximately 31.19% of the total variation in the dependent variable (stabilized earth blocks) is explained by the relationships between the sandcrete blocks and STEB (Y) expressed in the regression line.

Using another measure, the "coefficient of correlation (r)" which is the positive square root of the coefficient of determination, it confirms the result from the first test.

This measures the probability that there is a genuine relationship between the variables and that it has not risen by chance i.e. $r = \sqrt{r^2} = \sqrt{0.3119} = 0.5584$ or 55.84%.

Note: The closer the values of r are to plus one or minus one, the narrower the range of predicted values of the dependent variable. In estimating r or r^2, values over 0.9 should be expected, which should be preferably higher still if a multiplier is to be applied to the resultant estimate.

Referring to the values of r^2 = 0.3119 and r = 0873.5585, additional variable require to be introduced which suggest that it is not a linear relationship.

4.4. The Coefficient of Non Determination

The value of ($1-r^2$) is called the coefficient of non-determination. It measures the proportion of the variability of the Y values that has been explained by the regression equation, that is, the variation in Y due to factors other than X. the square root of the coefficient of non- determination, T = $\sqrt{1-r^2}$ is called the Coefficient of alienation. This measures the extent of departure from perfect correlation. Using the above data, the coefficient of non- determination $1-r^2$ = 1- 0.3119=0.6881 or 68.81%. The coefficient of alienation of T = $\sqrt{1-r^2}$ = $\sqrt{0.6881}$ = 0.8295 or 82.95%.

4.5. Interpretation

The computed coefficient of determination (r^2 =0.3119) shows that 31.19% of the total variation in the strength of STEB used in the analysis is explain by the variation in the strength of sandcrete blocks while 68.81 percent of the variation in STEB is attributable to the influence of other factors not explained by the regression function (the coefficient of non –determination, $1\text{-}r^2 = 0.6881$).

The computed coefficient of correlation (r=0.5585) shows that there are 55.85 percent probability that a genuine relationship exists between the variable and that it has not risen by chance. The coefficient of alienation (T=0.8295) shows that there is 82.95 percent departure from perfect correlation.

Referring to the value of r^2 ie 0.3119 and r i.e. 0.5585; $1\text{-}r^2 = 0.6881$ and T= 0.8295 indicates that there are additional variables that affects the strength of STEB obtained at various site location compared to the strength of sandcrete blocks at similar location hence the relationship is not a linear one. Compressed Stabilized Blocks might be used as a locally available alternative building material to meet housing needs in Nigeria in an affordable manner [12]. The authors see the materials to be available, affordable and have enough strength to make it an alternative material for use. The discussion of this paper is also in agreement with evaluation of stabilized-earth (TEK) block for housing provision and construction in Ghana and concluded that the material have ability to withstand the vagaries of the weather due to appropriate design parameters such as wide overhangs, extensive plinth areas and high pitched roof forms [13]. It is appropriate for government and the building industry in Ghana to adopt and utilized having succeeded for over forty years.

5. Conclusion and Recommendations

The test carried out shows that stabilized earth soil which were obtained from various locations in all the five states in the south eastern Nigeria with a mixed ratio of 1:12 is suitable for walls in housing construction. Instead of mixed ratio of 1:6 for sandcrete blocks, 1:12 mixed ratio were used for cement and red soil (stabilized earth soil) which yields two times the quantity of stabilized earth blocks. The results of the test samples shows that the strength is comparable to sandcrete blocks. Although, there are little variation in strength based on source location as shown in table 3 and table 6 at early strength of 7 days, the ultimate strength in 28 days are all above the minimum of 1.50 N/mm^2.

The standard deviation of the ultimate strength of stabilized earth blocks is 0.056 and the mean value is 1.57 N/mm^2 while the standard deviation of the sancrete blocks is 0.272 and the mean value is 2.72 N/mm^2 of various locations where the stabilized earth blocks and sandcrete blocks were obtained. Meanwhile, compressive strength of the blocks ranged from 0.21N/mm^2 to 1.26N/mm^2 for 225mm wide blocks and from 0.28N/mm^2 to 0.95N/mm^2 for 150mm wide blocks [14]. The densities of these blocks were found to be satisfactory with the requirements of the standard. Earth materials is recommended for housing construction because of its accessibility, affordability, it requires lesser technology and has the ability to regulate weather, control noise and withstand fire and encourages independent construction due to lots advantages of building with earth [15, 16]. Finally, the test results show that since the STEB produced twice the quantity of block, it can reduce the cost of construction of housing especially for low income group. Public housing units are recommended to be built of earth soil while professional bodies are encouraged to create more awareness of the structural and cost advantage of earth block over the conventional blocks.

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