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The Influence of the Insurgency on the Qualities, Availability of Construction Materials and Local Coarse Aggregates in Maiduguri

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Abstract The qualities of construction materials and the influence of insurgency on the availability of local coarse aggregates for production of concrete in Maiduguri were assessed in this study. Ten block production industries were selected from major wards in Maiduguri metropolis, while the brands of cement sold in Maiduguri including Dangote 3X (i.e. Obajana) and Ashaka, of grades 42.5N and 32.5N respectively were selected with two different sizes of blocks. Four sizes of reinforcement bars; 10 mm, 12 mm, 16 mm and 20 mm; were randomly selected. Local aggregates and water were used during the investigations. Microsoft Excel was used to analyse and interpret the data. The results show that, the dry compressive strength of the sandcrete blocks samples for the 150 mm blocks were 0.016 to 0.999 N/mm^2 which is less than between 0.03 to 98.44 % of the recommended minimum of 1.0N/mm^2 at age 7 days; similarly, the average compressive strength of the sampled 225 mm blocks were also 0.253 to 0.634 N/mm^2 which is less than between 57.73 to 83.14 % of the recommended minimum of 1.5N/mm^2 at the age of 7 days. The highest value of 0.634 N/mm^2 was less than the recommended value of 1.5N/mm^2 for load bearing walls. The diameters of all the steel reinforcements were 1.42 to 3.09% less than the specifications; characteristic strengths of 10 mm steel reinforcement proved to be 506.7N/mm^2 which is greater than 460N/mm^2 the recommended value. A factor of safety of 1.115 was recommended instead of 1.15. The insurgency in the north eastern part has negatively impacted the quality and availability of construction material as well as the local coarse aggregates in the building industry.

Keywords: *Bama Gravel, construction materials, compressive strength, insurgency, Portland cement, yield stress*

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1. Introduction

Various parts of the world have been rocked by insurgencies such as the FARC in Colombia, Afghanistan, Somalia, Mali and Nigeria among others. Several impacts of these insurgencies have been studied by authors in various fields [1-6]. The insurgency in the North Eastern Nigeria started in 2002 but it became dramatically more destructive between 2010 and 2016. During this period, Borno state was the most affected and at the peak of the crisis, Maiduguri the state capital, located on latitude 11.85° North and longitude 13.08° East, received the greatest influx of the refugees. Construction activities continued in the state capital even though it was with a lot of difficulties, mainly due to the fact that majority of sites of building materials such as local coarse aggregates referred to as Bama gravel, named after the town located 75 km from Maiduguri, the state capital, could no longer be safely accessed by the aggregates vendors since travelling outside Maiduguri most especially beyond Konduga along the southern flag of the metropolis was risky, if not impossible. Other gravels are also found in large quantities around Madube, Kawuri and Konduga [7].

Concrete is a composite material composed of aggregate bonded together with fluid cement which hardens over time. Most use of the term "concrete" refers to Portland cement concrete or to concretes made with other hydraulic cements, such as ciment fondu [8,9].

Aggregates are essential materials in civil engineering construction processes; their inclusion in concrete and asphalt mixes has always made their production to be more economical [10]. Aggregate characteristics comprise of shape, texture, and grading. They together influence workability, finish ability, pump ability, segregation, physical, mechanical properties of fresh and hardened concrete. Construction and durability problems have been reported due to poor mix proportioning and variation on grading [11,12]. It is therefore not surprising that the quality of these materials is of considerable importance and hence it is useful to establish the quality of aggregate from time to time to ensure quality control and be able to specify materials correctly and ensure materials will perform accordingly [13].

Except for water, aggregate is the cheapest component of concrete. On the other hand, cement and reinforcements are the most expensive components; consequently, they are responsible for about 85 percent of the total cost of materials for reinforced concrete production. Therefore, it becomes reasonable and expedient that quality research assessment be made on the locally available aggregate materials because of its quantity, availability and nearness to site of use to verify the quality and suitability for medium grade concrete production [8,14].

According to Ahamadu [15] and ASTM C 125 [16] and ACI 116 [17], the maximum size of coarse aggregate used in concrete has a bearing on the economy and strength of concrete. Usually more water and cement are required for small-size aggregates than for large sizes, due to an increase in total aggregate surface area otherwise referred to as the “aggregate specific surface”, for a given water-cement ratio. The amount of cement required decreases as the maximum size of coarse aggregate increases. Furthermore, aggregates of different maximum sizes may give slightly different concrete strengths for the same water-cement ratio. In some instances, at the same water-cement ratio, concrete with a smaller maximum-size aggregate could have higher compressive strength. This is especially true for high-strength concrete. The optimum maximum size of coarse aggregate for higher strength depends on factors such as relative strength of the cement paste, cement aggregate bond, and strength of the aggregate particles [16,17].

Previous studies on this fluviolalustine gravel [18] indicate that Bama gravel has an average size of 10 mm interspersed with intermediate sizes ranging from 6-2mm. Its origin is linked to the Bama-ridge that began at the Cameroon plains, passing the northern tip of the Mandara Mountains in Nigeria and extending some 300 km northwards towards Bama and Maiduguri. Bama gravel is thus a natural product of weathering on the granitic rocks of Mubi and Gwoza, and transported to the riverbed by run-off because of falling rains and other agents of transportation. As a result of the scarcity and high cost of crushed stones (chippings) in most parts of North-East (Borno,Yobe, Adamawa and Taraba states), Bama gravel has long been used as one of the aggregates for concrete making.

Previous studies carried out shows that, large percentage of the aggregate is less than 10mm in diameter. Onundi *et al.*, [7] have successfully categorised the Bama gravel into three specific groups A, B and C as a function of their particle size distributions for concrete production. Since, minimizing the aggregates voids content should be one of the objectives of optimization of concrete mixtures; mixture proportioning methods should encourage concrete optimization or aggregate optimization.

This paper attempts to identify and categorise the Bama gravel; determine the qualities of construction materials and the influence of insurgency on the availability of local coarse aggregates in Maiduguri. The objectives of the research are to provide insight and solutions into some of the critical areas that poses toothing problems to young engineers and students when important decisions must be taken to achieve a successful project delivery.

2. Materials and Methods

Ten block production industries were selected from major wards in Maiduguri metropolis, while the brands of cement sold in Maiduguri including Dangote 3X (i.e. Obajana) and Ashaka, of grades 42.5N and 32.5N respectively were selected as shown in Table 1, with two (2) different sizes of blocks. Four sizes of reinforcement bars (i.e. 10 mm, 12 mm, 16 mm and 20 mm) were randomly selected from sites in Maiduguri. Local aggregates (i.e. coarse and fine grades) and water were used during the investigations. Microsoft Excel was used to analyse and interpret the data.

Table 1. Summary of selected sandcrete blocks industries in Maiduguri

Industry/Location	Size of Block (mm)	Block Price; ₦	Curing Period (Days)/Method	Source of Sand	Cement Type	Source of Water
Q /Bulumkutu	225	145	3/sprinkling	River/Outlay	Dangote 3X (42.5N)	Borehole
	150	120	3/sprinkling	River/Outlay	Dangote 3X (42.5N)	Borehole
R /Abuja Talaka	225	135	3/sprinkling	River/Outlay	Dangote 3X (42.5N)	Borehole
	150	120	3/sprinkling	River/Outlay	Dangote 3X (42.5N)	Borehole
S /Damboa Road	225	130	3/sprinkling	River/Outlay	Dangote 3X (42.5N)	Borehole
	150	100	3/sprinkling	River/Outlay	Dangote 3X (42.5N)	Borehole
T/Polo	225	135	3/sprinkling	River/Outlay	Dangote 3X (42.5N)	Borehole
	150	110	3/sprinkling	River/Outlay	Dangote 3X (42.5N)	Borehole
U/Lagos Street	225	135	3/sprinkling	River/Outlay	Dangote 3X (42.5N)	Borehole
	150	115	3/sprinkling	River/Outlay	Dangote 3X (42.5N)	Borehole
V/Baga Road	225	130	3/sprinkling	River/Outlay	Dangote 3X (42.5N)	Borehole
	150	100	3/sprinkling	River/Outlay	Dangote 3X (42.5N)	Borehole
W/RuwanZafi	225	130	3/sprinkling	River/Outlay	Dangote 3X (42.5N)	Borehole
	150	120	3/sprinkling	River/Outlay	Dangote 3X (42.5N)	Borehole
X/Dalori	225	130	3/sprinkling	River/Outlay	Dangote 3X (42.5N)	Borehole
	150	120	3/sprinkling	River/Outlay	Dangote 3X (42.5N)	Borehole
Y/Mairi	225	130	3/sprinkling	River/Outlay	Dangote 3X (42.5N)	Borehole
Kuwait	150	100	3/sprinkling	River/Outlay	Dangote 3X (42.5N)	Borehole
Z/Fori	225	130	3/sprinkling	River/Outlay	Dangote 3X (42.5N)	Borehole
	150	100	3/sprinkling	River/Outlay	Dangote 3X (42.5N)	Borehole

2.1 British Structural Use of Concrete and other Materials

a. BS8110 [19], Clause 2.4.2.1 discussed "Characteristic strengths of materials" and recommended that:

The characteristic strength of concrete f_{cu}, is given by

$$f_{cu} = f_m - 1.64\,S, \quad (1)$$

where,
f_m = mean strength,
S = standard deviation (8.0 N/mm^2 for samples less than 40 and 4.0 N/mm^2 for samples more than 40),
whereas, the target mean strength f_m

$$f_m = f_{cu} + 1.64\,S. \quad (2)$$

The characteristic strength f_{cu} (i.e. 95% success or confidence limit is assumed).

The average or mean strength for any design only ensures 50% success and 50% failure confidence limit and is considered too risky for a reliable structural design.

2.2. Determination of the Nominal High Yield Steel

Still quoting many of the relevant international normative adaptations on this subject matter, regardless of the governing body, the information provided in most global and local standards is quite detailed and intended to help the user understand the following basic testing requirements [20,21].

a. equipment required
b. associated terminology and symbols
c. specimen preparation
d. testing procedures or methods
e. calculations or results to be determined.

For rebar tensile testing, it is helpful to break down the tensile test into the separate stages of the test. This applies regardless of which test standard is being followed [19,20].

The five basic regions are:

a. pretest
b. preload
c. elastic region
d. yielding
e. plastic region.

2.2.1. Elastic Region (before Yielding)

AC133-(2010) [20] and ASTM A706/A706M-14 [21] give the elastic region or straight line portion of the test as seen on the Stress-Strain plot.

2.2.2. Yielding

AC133-(2010) [20] and ASTM A706/A706M-14 [21] similarly, once yielding begins, many rebar grades exhibit a defined yield point that is seen as an abrupt bend in the Stress-Strain test curve.

2.3. Determination of the Steel Factor of Safety (FoS)

There are two definitions for the factor of safety:

a. One as a ratio of absolute strength (structural capacity) to actual applied load, measure of the reliability of a particular design(i.e. reliability index).This is a variable measure of degree of reliability or structural capacity and is usually considered at the ultimate or collapse limit state.
b. Factor of Safety(FoS) is a constant value imposed by law, standard, specification, contract or custom to which a structure must conform or exceed. This is a constant value of factor of safety which is usually considered at the serviceability or elastic limit state.

$$\text{Factor of Safety} = \frac{\text{Yield stress}}{\text{Working stress}}. \quad (3)$$

3. Results and Discussion

3.1. Codified Validated Results of Tested Construction Materials

The Bama gravels possess almost the same value for most of its physical parameters such as specific gravity (SG), silt content (SC), aggregates crushing value (A.C.V) and aggregates impact value (A.I.V). The values of each of these parameters are within the limits as shown in Table 2.

Table 2. Physical parameters of the classified aggregates [7]

Sample	S.G	S.C (%)	A.I.V (%)	A.C. V (%)	Remark
Madube 1	2.76	2.3	22	22	Within the BS limit
Madube 2	2.59	2.3	23	26	Within the BS limit
GuduKurmi	2.57	2.3	28	26	Within the BS limit
Bama 1	2.64	2.2	23	25	Within the BS limit
BakinGada	2.58	2.4	25	26	Within the BS limit
Bama 2	2.61	2.3	25	25	Within the BS limit
Firgi	2.56	2.3	28	27	Within the BS limit
Kawuri	2.59	2.6	28	26	Within the BS limit
Bama 3	2.56	2.6	27	21	Within the BS limit
Mean Value	2.61	2.3	26	25	Within the BS limit

3.2. The Nominal High Yield Steel

3.2.1. Elastic Region (before Yielding)

The elastic region or straight line portion of the test as seen on the Stress-Strain plot in Figure 1a can often exhibit some non-linear behaviour initially due to further straightening of the rebar specimen. In using an extensometer, this may show up as slightly negative strain at the beginning of the test and is generally considered normal for rebar and should not be seen as critical error in the experimental process.

3.2.2. Yielding

Once yielding begins, many rebar grades exhibit a defined yield point that is seen as an abrupt bend in the Stress- Strain test curve in Figure 1a. It is then followed by a period of specimen elongation with little or no increase in force. Because of this, servo-controlled systems must be controlled using crosshead or actuator displacement feedback in order to maintain a constant rate of travel throughout yielding. It is very important to note that using stress control during yielding will cause the test to accelerate excessively, which is in direct violation of the standards. This can also cause the yield point (upper yield) to be masked or smoothened and cause yield strength results to be higher than expected. Likewise, strain control from an extensometer can also become erratic during yielding and, is therefore, not recommended when testing rebar. Figure 1a, Figure 1b, Figure 1c & Figure 1d show the wrong and correct results interpretations for the determination of the yield stresses of tested steel materials which serves as guides for practising engineers, researchers and students of Structural and Mechanical Engineering.

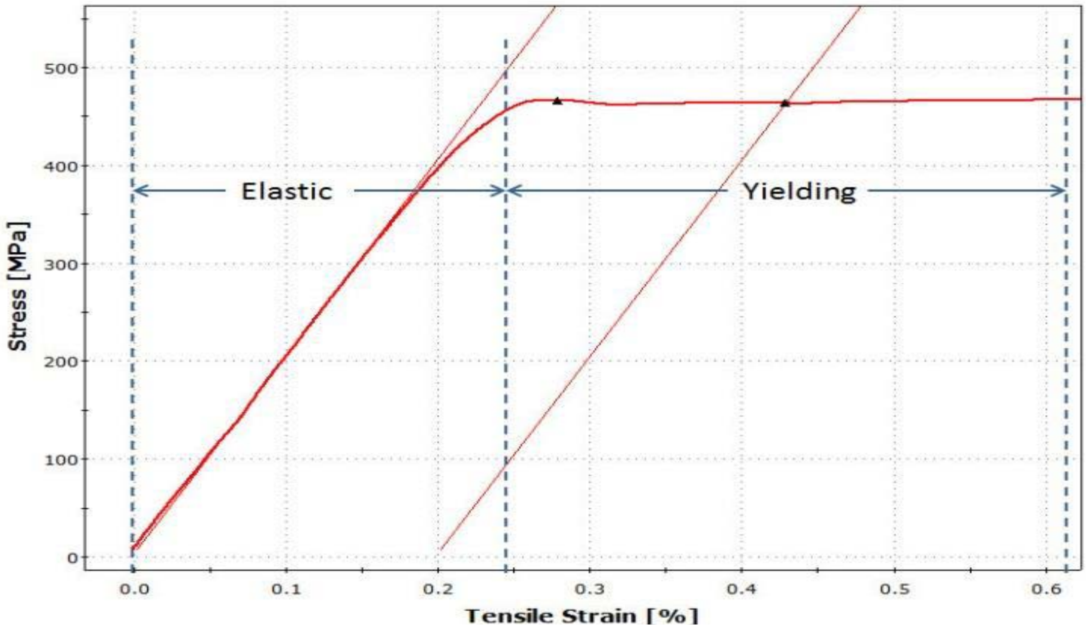

Figure 1a. Elastic and Yielding zones in Stress-Strain curve of a Tested Steel Bar [20,21]

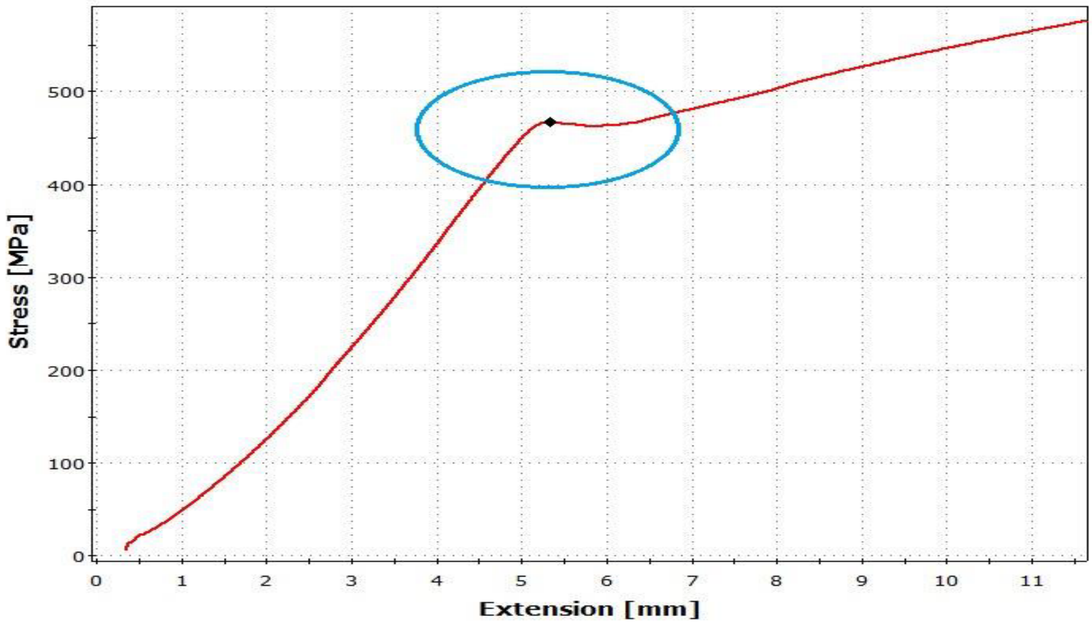

Figure 1b. Elastic and Yielding zones in Stress-Strain curve of a Tested Steel Bar with Unacceptable Result [20,21]

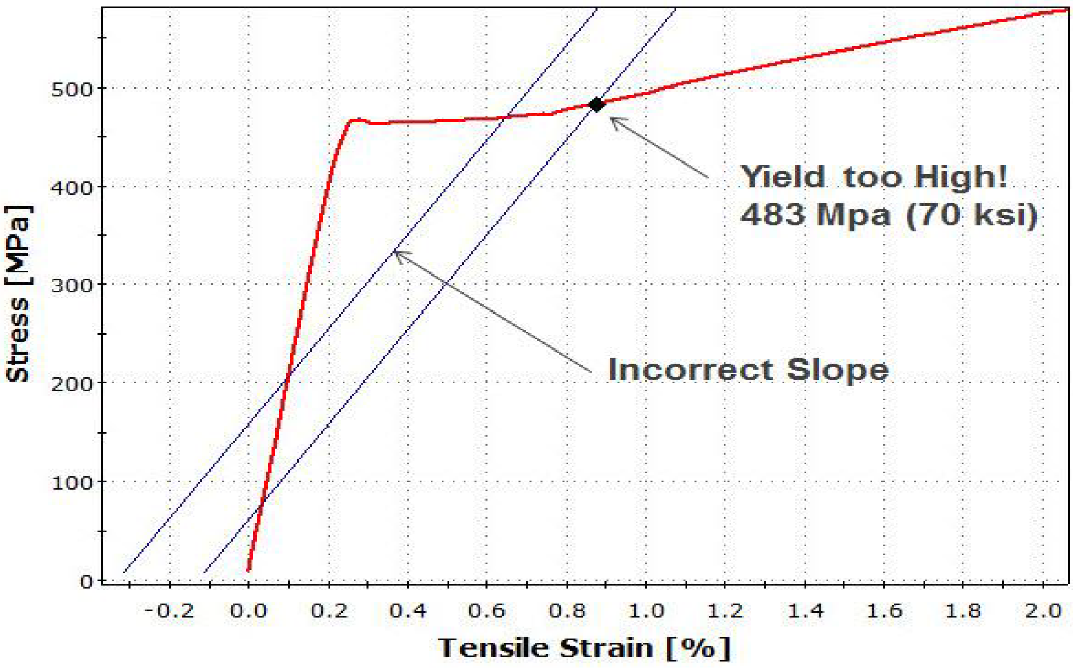

Figure 1c. Incorrect Linear Slope line and Resulting Offset Yield (Rp0.2) [20,21]

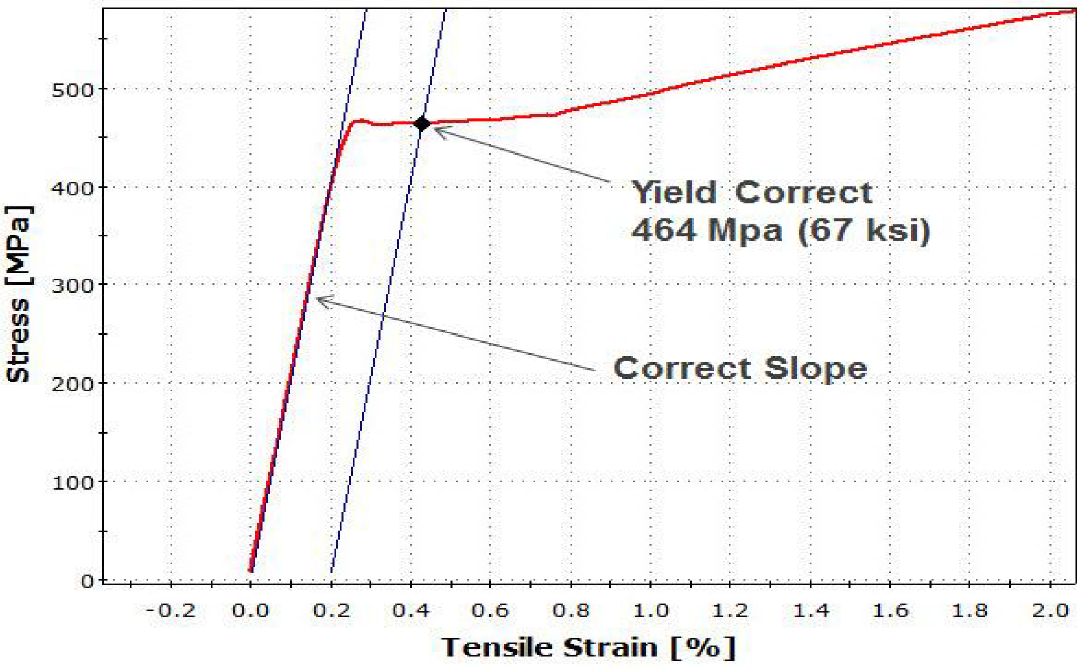

Figure 1d. Correct Linear Slope line and resulting Offset Yield (Rp0.2) [20,21]

Table 3a, Table 3b & Table 3c are the results of research conducted on the steel diameters **Ø**, characteristic strength $\mathbf{f_y}$, partial materials safety factor $\boldsymbol{\Upsilon_m}$ and % strain e, they show that the characteristic parameters of the reinforcements used in Maiduguri are not complying with the recommended values by the BS 8110 (1997) [19].

3.3. Determination of the Steel Factor of Safety (FoS)

From equation (3),

$$the\ factor\ of\ safety = \frac{\text{Yield stress}}{\text{working stress}} = \frac{460}{400} = 1.15.$$

From the above results, since the steel characteristic values are below the standard specifications, the recommended factor of safety for Nigerian National Annex from the normative conditions for Euro code is:

$$Factor\ of\ safety = \frac{\text{Yield stress}}{\text{working stress}} = \frac{390}{350} = 1.115.$$

3.4. The Portland Cements

Table 4 shows the laboratory test results of the Portland cements in Maiduguri with the following interpretations and implications.

Table 3a. Analysis of laboratory result of a high yield 10mm nominal steel

Description	Nominal Diameter mm	Area mm^2	Yield Stress N/mm^2	Ultimate Stress N/mm^2	Elongation %	Partial Factor of safety	BS4449(1997) Min. Provisions	Remark
Y10/i	9.86	76.36	510.8	668	6.7	1.166	438	Above Code Value
Y10/ii	9.86	76.36	510.8	668	8.3	1.166	438	Above Code Value
Y10/iii	9.86	76.36	523.9	668	6.7	1.196	438	Above Code Value
Y10/iv	9.86	76.36	523.9	681.1	10	1.196	438	Above Code Value
Y10/v	9.86	76.36	523.9	668	6.7	1.196	438	Above Code Value
Y10/vi	9.86	76.36	537	668	6.7	1.226	438	Above Code Value
Y10/vii	9.86	76.36	510.8	654.9	6.7	1.166	438	Above Code Value
Y10/viii	9.86	76.36	537	681.1	8.3	1.226	438	Above Code Value
Y10/ix	9.86	76.36	523.9	681.1	11.7	1.196	438	Above Code Value
Y10/x	9.86	76.36	523.9	668	10	1.196	438	Above Code Value
Average	9.86	76.36	522.59	670.62	8.18	1.193	438.0	Above Code Value
Standard Deviation	0	0	9.67	8.29	1.83	0.022		
Variance	0%	0%	2%	1%	22%	1.85%		

Summary	Yield		Ultimate
Characteristic Strength, $\mathbf{f_y}$=	**522.59**	N/mm^2	506.74
Average Elongation =	**8.18**	%	5.186
Average Ultimate Stress =	**670.62**	N/mm^2	657.03
Measured Diameters, **Ø** =	**9.86**	mm	
Difference	**14.55**	**%**	14.552

Standard

BS 8110 1997 - Characteristic Strength, $\mathbf{f_y}$ = 460 N/mm^2.
BS 4449 1985 - Minimum Elongation = 14%.
BS 8110 1997- Design.
Strength i. Mild Steel = 218 N/mm^2,
ii. High/Tensile Steel = 400 N/mm^2.

Table 3b. Analysis of laboratory results of characteristic high yield nominal diameters of steel

Nominal Diameters	Average Measured Diameters	Difference in Diameters	Measured Characteristic Strengths	Recommended Characteristic Strengths	Difference in Characteristic Strengths	Remarks
$\mathbf{Ø_n}$, mm	$\mathbf{Ø_m}$, mm	%	$\mathbf{f_{ym}}$; N/mm^2	$\mathbf{f_{yr}}$; N/mm^2	%	
10	9.86	1.42	506.7	460	10.152	Satisfactory
12	11.65	3.0	430.6	460	-6.391	Not Satisfactory
15.52	15.52	3.09	302.7	460	-34.196	Not Satisfactory
20	19.62	1.94	390.2	460	-15.174	Not Satisfactory

Table 3c. Results of partial safety factor and elongation for high yield steel

Nominal Diameters	Measured partial safety factor	Recommended partial materials safety factor	Difference in partial materials safety factor	Measured elongation (strain)	Recommended strain	Difference in strain
$\mathbf{Ø_n}$, mm	Υ_m	Υ_m	%	e ; %	e ; %	%
10	1.157	1.05	10.190	5.19	14	62.929
12	0.938	1.05	-10.667	2.19	14	84.357
15.52	0.682	1.05	-35.048	11.79	14	15.786
20	0.891	1.05	-15.143	9.25	14	33.929

Remarks: Positive (+); satisfactory whereas Negative (-); not satisfactory.

Table 4. Physical properties and characteristic parameters of the Portland Cements

Cements	Ashaka, C1	Obajana, C2	Specifications	Remarks
Fineness; %	2.87	1.73	≤ 10	Satisfactory
Consistency; %	29.7	29.0	≥ 26 ≤ 33	Satisfactory
Initial Setting; mins	980.0	97.0	≥ 60	Satisfactory
Final setting; mins	208.0	206.0	≤ 600	Satisfactory
Soundness; mm	0.80	0.50	≤ 10	Satisfactory

3.4.1. Effect of Fine Cement on the Rate of Hydration and Hence the Rate of Gain of Strength

- Fineness of cement increases the rate of evolution of heat.
- Finer cement offers a great surface area for hydration and hence faster the development of strength.
- Increase in fineness of cement also increases the drying shrinkage of concrete and hence creates cracks in structures.
- Excessive fineness requirement increases cost of grinding.
- Excessive fine cement requires more water for hydration, resulting reduced strength and durability.
- Fineness of cement affects properties like gypsum requirement, workability of fresh concrete and long term construction time.
- Coarse cement particles settle down in concrete to causes bleeding.

3.4.2. Determination of the Expansion of Cements According to BS EN 196-3: 1992 [22] and BS EN 197-1 [23] Standards

- Volume expansion (i.e. Soundness) in cement mortar in concrete is caused by the presence of unburnt lime (CaO), dead burnt MgO and also $CaSO_4$.
- By Le-chatelier method we can only find out presence of unburnt lime (CaO); Presence of unburnt lime may develop cracks in the cement because of increase in volume.
- Free lime (CaO) and magnesia (MgO) are known to react with water very slowly and increase in volume considerably, which result in cracking, distortion and disintegration of mortar and concrete.

3.4.3. Consistency of the Portland Cements

Consistency limit of Portland cement indicates the quantity of mixing water to form a paste of workable material matrix or cement paste, the viscosity of which will be such that the Vicat's plunger penetrates up to a point 5 to 7 mm from the bottom of the Vicat's mould.

3.4.4. Initial and Final Setting or Hardening Time of Portland Cements

These tests were conducted in accordance with the recommendations of BS EN 196-3 [22]. The setting time of Ordinary Portland Cements (OPC), as specified by the standards requires that an initial set time of not less than 60 minutes, and a final set or hardening time of not more than 600 minutes. These values are to serve as important guides to prevent cement from setting too quickly as to affect the intended strength and long time delay before hardening or gaining enough strength for the shuttering to be removed to facilitate early completion of projects.

3.5. The Sandcrete Hollow Blocks

3.5.1. Assessment of Sandcrete Hollow Blocks Produced in Maiduguri

Costs of production were mostly affected by industry's policies which were influenced by demand, supply and other economic factors leading to the variations in prices. Raheem *et al.*, [24] (2012) estimated that the cost of a piece of 225 mm sandcrete hollow blocks of mix ratio of 1:9 would be ₦195. It can thus be deduced according to Sule [25] (2016) that blocks are produced to meet market demand as against required quality, because, if the cost is higher to improve the sandcrete block quality, most customers are so poor that patronage would be poor and that could lead to the closure of the block industry. This survey also noted through the producers that, they (the producers) know the appropriate mix proportion that could improve the general production of good quality blocks but if the cost of sale is high they lose most customers that would not care about quality but cost of unit block. The cost which influences the sale-ability by the industry is mostly a driving factor for increased patronage and quality of blocks being produced in Maiduguri.

All the ten sampled industries had unskilled labour but very experience in block production since, experience teaches best; they have the capability to produce higher quality blocks. Unfortunately, lack of skilled staff and the paramount aim of maximizing profit by the vendors have also prevented quality control in the industry. Most of the particles of the fine aggregates used for the production of the local sandcrete hollow blocks were classified as Zone 2 as presented in Figure 2, except for industry X (Dalori) which is coarser fell in Zone 3.

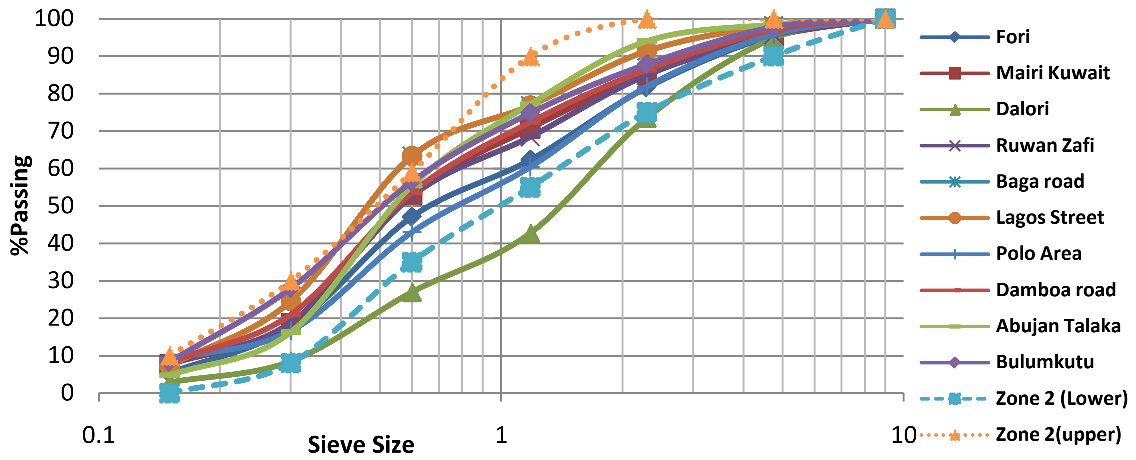

Figure 2. Particle size distribution for Sand samples used and Zone limit.

Table 5a. Compressive strength for 150 mm sandcrete block samples in Maiduguri

Industry	Notation	Average Strength (N/mm^2)	Standard Deviation	Coefficient of Variance (%)	Recommended 7 day Strength (N/mm^2)	Difference (%)
1. Abuja Talaka	Q	0.123	0.058	19.55	1.0	87.71
2. Baga road	R	0.166	0.044	14.76	1.0	83.44
3. Bulumkutu	S	0.452	0.052	17.37	1.0	54.79
4. Dalori	T	0.079	0.073	24.46	1.0	92.09
5. Damboa road	U	0.279	0.006	2.07	1.0	72.13
6. Fori	V	0.317	0.007	2.21	1.0	68.31
7. Lagos Street	W	0.382	0.028	9.49	1.0	61.82
8. Mairi Kuwait	X	0.999	0.234	78.80	1.0	0.03
9. Polo Area	Y	0.159	0.046	15.44	1.0	84.05
10. RuwanZafi	Z	0.016	0.094	31.59	1.0	98.44

Table 5b. Compressive strength for 225 mm sandcrete block samples in Maiduguri

Industry	Notation	Average Strength (N/mm^2)	Standard Deviation	Coefficient of Variance (%)	Recommended 7 day Strength (N/mm^2)	Difference (%)
1. Abuja Talaka	Q	0.496	0.008	1.64	1.5	66.93
2. Baga road	R	0.579	0.035	7.47	1.5	61.42
3. Bulumkutu	S	0.627	0.051	10.87	1.5	58.21
4. Dalori	T	0.459	0.005	0.97	1.5	69.40
5. Damboa road	U	0.537	0.022	4.56	1.5	64.17
6. Fori	V	0.634	0.054	11.37	1.5	57.73
7. Lagos Street	W	0.450	0.008	1.60	1.5	69.99
8. Mairi Kuwait	X	0.269	0.068	14.38	1.5	82.08
9. Polo Area	Y	0.253	0.073	15.50	1.5	83.14
10. RuwanZafi	Z	0.424	0.016	3.45	1.5	71.74

3.5.2. Dry Compressive Strength of Sandcrete Blocks

The dry compressive strength analyses of the sandcrete blocks samples are presented in Table 5a & Table 5b), the average compressive strength of the sampled 150mm blocks ranged from 0.016 to 0.999 N/mm^2 which is less than between 0.03 to 98.44 % of the recommended minimum value of 1.0N/mm^2 at age 7days. Similarly, the average compressive strength of the sampled 225mm blocks ranged from 0.253 to 0.634 N/mm^2 which is also less than between 57.73 to 83.14 % of the recommended minimum value of 1.5N/mm^2 at the age of 7 days of the allowable value by Nigerian Industrial Standard. This deviation shows that many of the sandcrete blocks cannot be used for loading blocks; since, the highest value of 0.634 N/mm^2 is less than the recommended standard value of 1.5N/mm^2 for load bearing walls. These confirm the reason we have many buildings with series of cracks and various deformations on our buildings along Damboa roads where the soil is of soft clay.

3.6. Local Coarse Aggregates used for Production of Medium Grade Concrete in Maiduguri

The test results of the local aggregate are shown in Figures (3a, b, c & d). For aggregates to be considered as coarse, they must be higher than or retained on a 5mm diameter sieve. Therefore,

1. C_A is the best aggregate category (i.e. Madube 1 and 2) =76-80% retained on 5mm sieve, they can no longer be accessed due to insurgency
2. Figure 3b & Figure 3d, C_D (i.e. Bama Bakingada, Chabbal 1 & 2) = 2% retained on 5mm sieve cannot be recognised as coarse aggregates but the locals use them because they are cheaper.
3. Figure 3c, C_C is family of aggregates that can no longer be accessed.
4. The local aggregates currently sustaining Maiduguri is C_B shown in Figure 3b & Figure 3d respectively. C_B = 25-55% retained on 5mm diameter sieve.

a. Produces medium grades concrete (i.e. 20-25N/mm^2).
b. Appropriate sizes of crushed stones must be combined with these categorise of locally available coarse aggregates for higher grades of concrete that are more than 25 N/mm^2 to be successfully produced.
c. The most appropriate mix ratio in Borno since there is peculiar local coarse aggregate which may warrant having a mix ratio that are in four part (e.g.1:1:1:4 or 1:1½:1½:3 and other most appropriate after trial mix proportions) instead of the conventional mixes that are three as reported by Ahamadu [15].

There were thirteen (13) different types of naturally occurring aggregates available now on the Maiduguri market, among which six (6) are obtained from Konduga, four (4) from Maiduguri and only three (3) are from Bama. According to gravel vendors the three (3) materials from Bama are an old stock because no one goes to Bama area to fetch the materials because of the security challenges caused by the insecurity; therefore the prefix of Bama gravel should be replaced with Konduga and Maiduguri gravels. Furthermore:

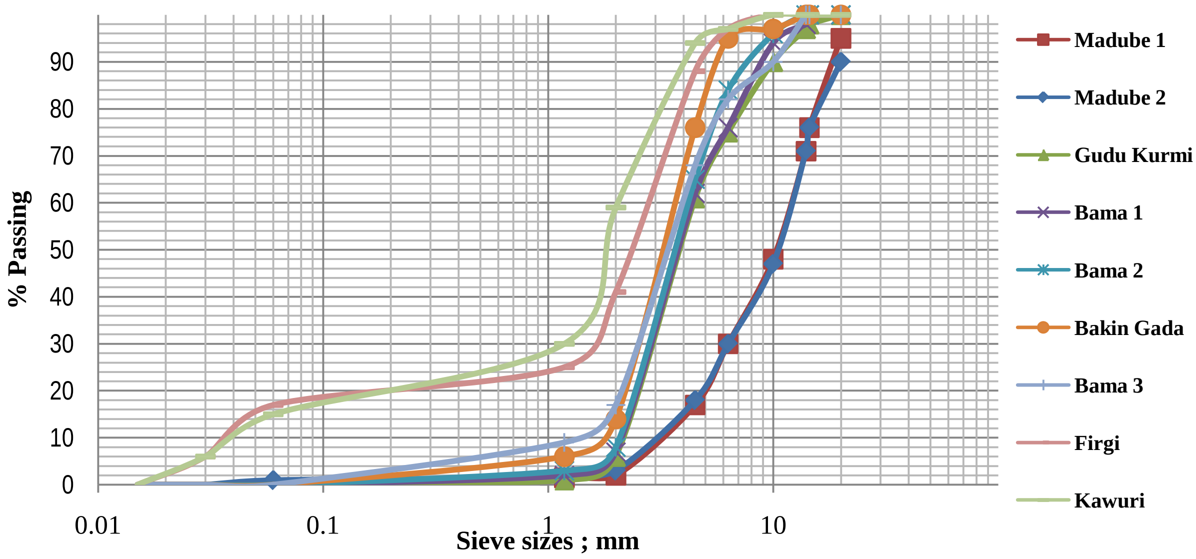

Figure 3a. The Ogive Curves for the Pre-Insurgency Coarse Aggregates in Maiduguri

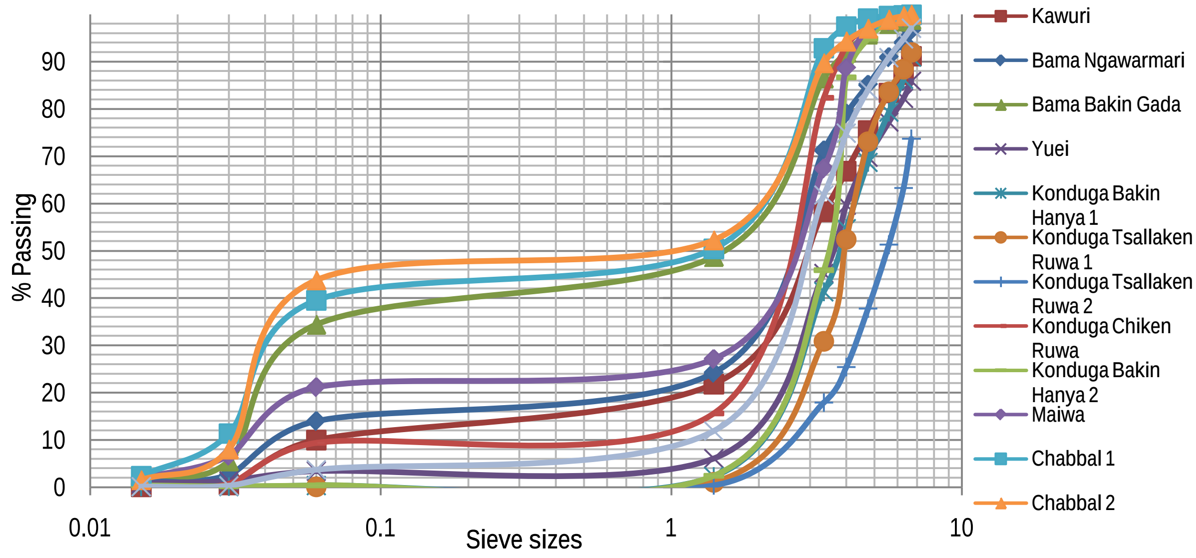

Figure 3b. The Ogive Curves for the Current Aggregates Used in Maiduguri

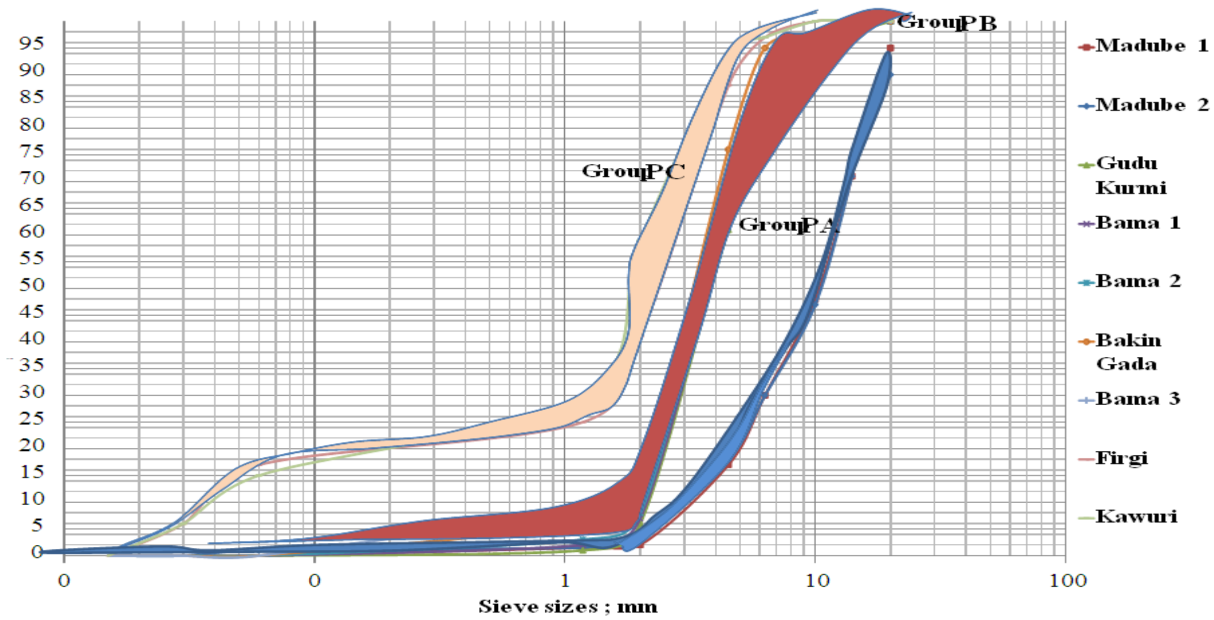

Figure 3c. The Original Classification of Bama Gravel Used as Coarse Aggregates in Maiduguri

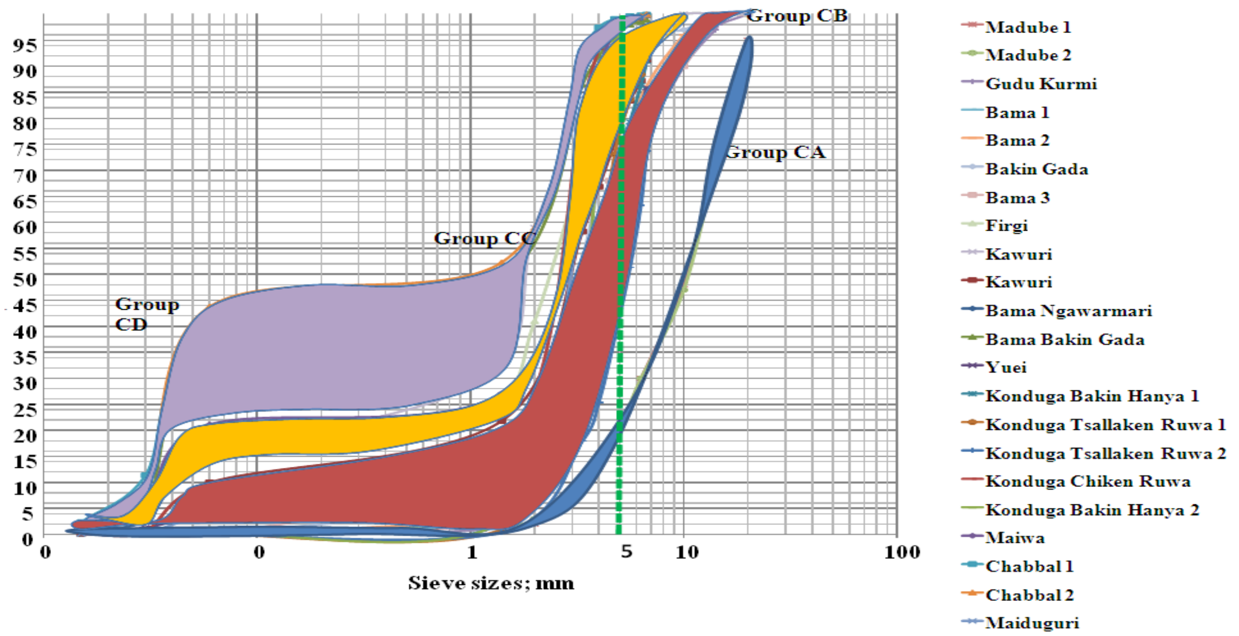

Figure 3d. Classification of Ogive Curves for all the Natural Coarse Aggregates Used in Maiduguri

1. Using the BS 882 [26] the materials are mainly fine aggregates as more 95 percent of the sample passed through sieve 4.75 mm (i.e. approximately 5 mm), this is further proven by the fact that more than 70 % of the particle size distribution curves of these samples fall into the Zone 1 standard envelop of fine aggregate. Although the remaining materials did not satisfy the BS standard as none of the particle size distribution curve fall into the standard zone of coarse aggregate. Based on USCS only two materials from Konduga Tsallaken Ruwa and Maiduguri are classified as well graded materials, two materials From Chabbal 1 Chabbal 2 and Bama Bakingada are classified as Gravel-Sand-Silt materials while the remaining 8 materials are classified as poorly Graded materials.
2. There were no significant changes in the categorization done by the previous scholars, although the groups remain the same as it were A, B and C with the materials maintaining their previous group. The only changes are the behaviour of the pattern of the particle size distribution curves produced because of the difference in the type of graph used. Madube 1 and Madube 2 were classified as well graded materials having their average coefficient of uniformity (CU) and coefficient of concavity (CC) as 4.17 and 1.06 as against the previous USCS classification which classified Madube 1 and Madube 2 as poorly graded having an average CU and CC as 3.4 and 1.12 respectively.
3. When all the newly identified materials were combined with the old ones as they may still be available in the market when the security improves; then four groups of gravels were majorly identified in Maiduguri market (i.e. Groups C_A, C_B, C_C, C_D) but C_A is currently not available in the market because of insurgency and security related problems and C_D is proved to be technically fine aggregate. Finally, we have Groups C_B and C_C as currently locally used aggregates in Maiduguri markets for construction purposes by the locals for production of medium grade concrete. It must be emphasised that these group of aggregates must be combined with crushed stones of various sizes for us to produce higher grade of concrete.
4. The most appropriate mix ratio in Borno, since there is a peculiar local coarse aggregate which may warrant having a mix ratio that are in four part (e.g.1:1:1:4 or 1:1½:1½:3 and other most appropriate after trial mix proportions) instead of the conventional mixes that are three.

The summaries of results of tested steel reinforcements selected in Maiduguri have shown that:

1. the diameters, **Ø** of all the steel reinforcements are less than the specifications by between 1.42 to 3.09%;
2. the characteristic strengths, $\mathbf{f_y}$ of diameter 10mm steel reinforcement proved to be 506.7>460N/mm^2 than recommended value, whereas, all other diameters of 12,16,and 20mm steel reinforcements proved to be between 302.7 to 430<460N/mm^2 which is the recommended value;
3. similarly, the partial material safety factors, $\boldsymbol{\Upsilon_m}$ of diameter 10mm of the steel reinforcement 1.157>1.05 of recommended value, but, all other diameters of 12,16,and 20mm steel reinforcements proved to be between 0.682 to 0.938<1.05 which is the recommended value; and
4. the relative elongation for all the steel reinforcements proved to be between 2.19 to 11.79<14% which is the recommended value.

Therefore, it is only 10mm steel reinforcement that successfully passed the laboratory test, but all other category of steels failed and they were considered not satisfactory. They would under-perform and endanger the life and property of the public when used for construction purposes. While the Portland cement in Maiduguri are satisfactory in terms of the tests conducted for fineness, consistency, initial and final Setting time and Soundness; these deviations experienced from the results of the sandcrete blocks show that many of the 225 mm sandcrete blocks cannot be used as loading blocks; since, the highest value of 0.634 N/mm^2 is less than the recommended standard value of $1.5N/mm^2$ for load bearing walls. This survey also noted through the producers that, the sandcrete block producers know the appropriate mix proportion that could improve good quality blocks but if the cost of sale is high, they lose most customers that would not care about quality but cost of unit block. Although, all the samples of Ashaka and Obajana Dangote cements tested were satisfactory with respect to fineness, consistency, initial and final setting, and soundness respectively. These confirm the reason why there are many buildings with series of cracks and various deformations on buildings along Damboa road where the soil is of soft clay. Similar tests must be conducted in the country; since if this trend is replicated in many cities in Nigeria, it can be a major contributory factor towards the incessant collapse of buildings in many parts of Nigeria.

4. Conclusion

The following conclusions were draw at the end of this research work:

a). The recommended factor of safety for Nigerian National Annex from the normative conditions for Euro code is: 1.115.

b). The Bama gravels values for most of its physical parameters such as specific gravity, silt content, aggregates crushing value and aggregates impact value; are within the limits of the BS 882.

c). The insurgency in the North Eastern part of Nigeria has negatively impacted the quality and availability of construction material as well as the local coarse aggregates in the building industry.

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References

[1] Ikyase, J. T. and Egberi A. E.. Ethnic Militias and Insurgency in Nigeria: A Threat to National Development; *International Journal of Humanities and Social Science; 5*(2):206-212; February 2015.

[2] Egharevba, M.E. and Iruonagbe, C.T.. Ethnic/Religious Insurgencies and Nation-Building in Nigeria; *International Affairs and Global Strategy*; ISSN 2224-574X (Paper) ISSN 2224-895 1 (Online), 29: 40-52, 2015.

[3] Ahmadu S. M., Hussaini M. W. & Wilson W. M.. Effects of Insurgency on the Physical and Socio-Economic Activities in Maiduguri; *International Journal of Scientific Research in Educational Studies & Social Development,* ISSN Print: 2597-1052|ISSN Online: 2579-1060, 2(2): 32-42, December 2017.

[4] Mike Omilusi. The Multi-Dimensional Impacts of Insurgency and Armed Conflicts on Nigeria; *Asian Journal of Social Sciences, Arts and Humanities,* 4(2): 29-39, 2016; ISSN 2311-3782 www.multidisciplinaryjournals.com.

[5] Maureen O. M., Blessing N. O.. Insurgency and its implication on Nigeria economic growth; *International Journal of Development and Sustainability,* 7(2): 492-501; 2018; ISSN: 2186-8662 www.isdsnet.com/ijds.

[6] Louise W. M.. Counter-insurgency in the Somali territories: the 'grey zone' between peace and pacification; *International Affairs,* 94(2):319-341, 2018.

[7] Onundi L.O., Izam, Y.D and Umar S.G.. "The Categorization and Assessment of a local aggregate, Bama Gravel for the production of a medium grade concrete". Nigerian Journal of Tropical Engineering; ISSN 1595-5397 1(1): 22-32, 1999.

[8] Hudson B.J.. "Modification to the Fine Aggregate Angularity Test." Proceedings, Seventh Annual International Center for Aggregates Research Symposium, Austin, TX, 1999.

[9] Scrivener, K.L. and Kirkpatrick, R.J.. "Innovation in Use and Research on Cementitious Materials", Cement and Concrete Research. 38(2):128-136, 2008.

[10] Neville, A. M.. "Properties of Concrete", London ELBS/Longman, 1981.

[11] Lafrenz, J.L.. "Aggregate Grading Control for PCC Pavements: Improving Constructability of Concrete Pavements by Assuring Consistency of Mixes," Proceedings, Fifth Annual International Center for Aggregates Research Symposium, Austin, Texas, 1997.

[12] Quiroga, *P. N.*, Fowler, D. W.. "The effects of aggregates characteristics on the performance of Portland cement concrete". Retrieved from the net on 14th July 2018, through pdf.citeseerx.ist.pst.edu.viewdoc.download, 2004.

[13] Amartey, Y. D., Otuoze, H. S., Sada, B. H., Modibbo, I.. "Evaluation of Natural Aggregate found in Zaria", Nigeria World Journal of Engineering and Pure and Applied Science. 3(1):16, 2013.

[14] Shilstone, James M., Sr.. "Concrete Mixture Optimization," *Concrete International,* American Concrete Institute, Farmington Hills, Michigan, June 1994.

[15] Ahamadu, Audu. "Categorization of the Local Coarse Aggregates presently used for the production of medium grade concrete in Maiduguri". A non-Thesis Seminar Presented to The Department of Civil and Water Resources Engineering, University of Maiduguri in Partial Fulfilment for the Award of M. Eng.,2018.

[16] ASTM C 125-18. Standard Terminology Relating to Concrete and Concrete Aggregates. Retrieved from the net on 14th July 2018, through http:"//www.astm.org>Standard>C125.

[17] ACI 116R. "Cement and Concrete Terminology", Retrieved from the net on 14th July 2018, through http://www.scribd.com>Document>A…., 1990.

[18] Ibrahim, R. D.. "Geology of Bama Ridge near Maiduguri", Unpublished Final Year Project, Dept. of Geology, University of Maiduguri, 1986.

[19] British Standard Institution B.S.8110. "Structural use of concrete". Code of Practice for design and construction, Part 1, Building and Civil Engineering Sector Board, United Kingdom, 1997.

[20] AC133. Acceptance Criteria for Mechanical Connector Systems for Steel Reinforcing Bars. Retrieved from the net on 7th July 2018 through https://www.astm.org> Standards >, 2010.

[21] ASTM A706/A706M-14. Standard Specification for deformed and Plain Low-Alloy Steel Bars for Concrete Reinforcement. Retrieved from the net on 14th July 2018, through http:"//www.sefinda.org>Steel-reinforcement>.

[22] BS EN 196-3. Method of Testing Cement, Determination of setting time and soundness. British Standard Institute, London, 1995.

[23] BS 197-1. Composition, Specification and Conformity Criteria for common Cement; British Standard Institution London, 2000.

[24] Raheem AA., Momoh A., and Soyingbe AA.. Comparative Analysis of Sandcrete Hollow Block and Laterite Interlocking blocks as Walling Elements, international Journal Of Sustainable Construction Engineering and Technology, (ISSN: 2180-3242), 3(1): 79-88, 2012.

[25] Sule SS.. Quality Assessment of Sandcrete Hollow Blocks Produced in Yobe State, Nigeria. M. Eng Project Submitted to the Department of Civil and Water Resources Engineering, university of Maiduguri, 2016.

[26] BS 882. Specification for aggregates from natural source, British Standard Institute, 1992.