ISSN: 2395-0560
International Research Journal of Innovative Engineering
www.irjie.com
Volume1, Issue 3 of March 2015

Assessment of Quality of Steel Reinforcing Bars Used in Lagos, Nigeria

Anthony Nkem Ede (PhD), Emmanuel Oluwabukunmi Egunjobi, Gideon Olukunle Bamigboye, and Jadesola Ogundeji

Department of Civil Engineering, Covenant University, Canaan Land, Ota, Nigeria.

Abstract The process of designing a building structure starts with the selection of materials based on their properties and the type of stresses to be supported. For the design of reinforced concrete structure, which is one of the most built structures around the world, the choice will fall on concrete and steel reinforcing bars. The quality of concrete and steel reinforcement bars chosen must have adequate strength to guarantee a ductile behavior expected of reinforced concrete structure, so that the structure will be safe and functional to fulfil the purpose for which it is built. But this is not often the case in Nigeria, where the collapse of reinforced concrete structures have been very frequent. Possible causes of the failures are many including the quality of steel and concrete adopted. This research studies the strength of steel reinforcing bars used in 10 Local Government Areas of Lagos State, Nigeria. Samples of 10mm, 12mm, 16mm, 20mm and 25mm diameter bars were collected from building sites and tested in the State Laboratory. Results obtained show that an average of 70% of the 1325 samples considered met the BS8110 code specifications.

Keywords Concrete, Steel Reinforcing Bars, Reinforced Concrete, Building Collapse, Tensile Strength.

1. Introduction

Buildings are designed to support certain loads without deforming excessively. The loads are made up principally of dead loads comprising weights of people and permanent objects and imposed loads consisting of temporary loads deriving from usage and environmental effects such as rain, snow and wind pressure. The process of designing a building starts with the selection of materials based on their properties and the type of stresses to be supported. A structural material is a material that carries its self-weight and tributary load transferred from other structural members. The material to be selected must be capable to withstand the stresses generated by the design loads. Over the ages, the world has experienced a continuous growth and improvement in every area of human endeavor and the built environment is not left out in the process. Construction materials have evolved over the years till the real breakthroughs in the construction industries of the present day that offer variety of materials with versatile options and ease of combined applications of different materials [1]. As the world has transited through the primitive age to the current information/knowledge worker's age, so have the dominant construction materials changed through the ages from earth to wood, to stone to concrete, to steel to FRP composites. The type of material used will determine the type of structure obtained in each period of human existence. Today the most common type of structures is concrete structures. The two commonly used structural materials for concrete structures are concrete and steel.

ISSN: 2395-0560
International Research Journal of Innovative Engineering
www.irjie.com
Volume1, Issue 3 of March 2015

Concrete is composed of aggregates embedded in a cement matrix which fills the space between the aggregates and bind them together. Concrete is a very strong building material, and the use of concrete predates back before the Roman Empire. It was widely used in the Middle East, Greece and Egypt for buildings before the Romans made wide use it for road construction. In each of these usages, the components of concrete varied. From the mid-eighteenth century till date, concrete has been the most common building material. After the patent of Portland cement in the 1824 by Joseph Aspdin, concrete became the most adopted material for the construction of infrastructure and buildings in the advanced world. As there has not been a better alternative over the years, modern structures in developed and developing nations are mostly built in concrete. The evolution of concrete has pass through plain concrete, reinforced concrete, precast concrete, pre-stressed concrete to the contemporary concretes. Plain concrete made of Portland cement, coarse and fine aggregate and water is usually called the first generation of concrete while the steel bar-reinforced concrete is the second generation concrete. Concrete development have been accompanied by the search for increase of its compressive strength and the best approach is by reducing cement/water ratio to the limit that permits good workability.]

The production of concrete for structural applications comes in a very rudimentary way and its quality varies considerably. The quality of concrete can hardly be certified because of many other factors such as aggregates, mixing procedures, and skills of the operators, placement, and consolidation. It varies according to so many variables such as quality of constituent materials (cement, aggregates, water and admixtures), skill of the manufactures, management/placement procedure and environmental issues. Today, the versatility of concrete have greatly increased [2] with the addition of steel reinforcement to compensate for the tensile weakness of concrete. The combined mix of concrete and steel reinforcement is called reinforced concrete, which is the second generation of concrete. It is the form in which it is mostly used all over the world. Reinforced concrete is a composite material per excellence [3] and is widely used because of the complimentary properties of concrete and steel. Very good concrete compressive strength with its poor tensile strength (about 10% of the compressive strength) is efficiently combined with the high tensile strength of steel, thereby providing the most accepted material that have built the world’s most buildings and infrastructures. Concrete and steel provide complementary support to each other, compensating for the weaknesses in the properties of the two materials [4], [5], [6] thereby making it a universal construction material. Although, a variety of materials such as glass fibers and plastic filaments have been used as reinforcement, most concrete members are reinforced with steel in the form of bars, wire mesh and strand because of its high strength, ductility and stiffness. Steel reinforcement imparts great strength and toughness to concrete. Reinforcement also reduces creep and minimizes the width of cracks, [7]. Steel serves as a suitable reinforcement material because its coefficient of thermal expansion (5.8×10^{-6} to 6.4×10^{-6}) is nearly the same as that of concrete (5×10^{-6} to 7×10^{-6}). This means that there will be no relative movement between embedded bars and concrete in the reinforced concrete work due to temperature changes [8]. Other advantages of steel as a reinforcing material for concrete include the fact that it is not easily corroded in the cement environment and it forms a relatively strong adhesive bond with cured concrete.

Steel is produced from two key components: iron which is one of Earth’s most abundant elements and recycled steel. Its combination of strength, recyclability, availability, versatility and affordability makes steel unique.

ISSN: 2395-0560
International Research Journal of Innovative Engineering
www.irjie.com
Volume1, Issue 3 of March 2015

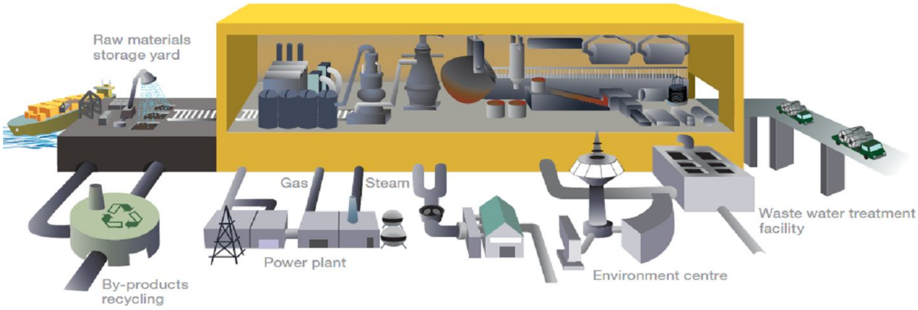

Figure1: Steelmaking facility [9].

Steel is manufactured under carefully controlled conditions in specialized plants as shown in figure1. The properties of every type of steel are determined in a laboratory and described in a manufacturer's certificate. Thus, the designer only specifies the steel complying with a relevant standard, and the builder ensures that the correct steel is used appropriately [9]. The quality of cement, the binder of concrete, is also produced in a specialized factory similar to steel factories and is guaranteed by the manufacturer in a manner similar to that of steel. Unlike the choice of steel, the choice of concrete mixes is virtually infinite and therefore the selection has to be made with a sound knowledge of the properties and behavior of concrete. Concrete of specified quality can be obtained from a ready-mix supplier but the final quality of the structure will depend on transporting, placing and compaction.

The application of reinforced concrete material is not without attending challenges in different parts of the world. In Nigeria where building collapse is common, it turns out that most of the collapsed buildings are concrete structures [11]. Every components of concrete material has an enormous effect on the quality such that the general compressive strength is very easily compromised [12]. Also, the quality of steel reinforcement used must be adequate to guarantee a ductile behavior expected of reinforced concrete structure.

In Nigeria, reported cases of structural failure have become very frequent, especially for buildings. Several researchers have investigated into the causes of building collapse [13]. One of the most frequently adduced causes is the non-conformance of structural properties of materials used to the actual design specifications [14], [15].

In Nigeria, it has become a common practice to design concrete with the reinforcement steel's characteristic yield strength (F_y) of 410 N/mm^2 in place of BS8110 code [16] specification of 460 N/mm^2. This drop in quality itself has become a reckless habit as most contractors even provide reinforcement with characteristic yield strength lower than 410 N/mm^2. There is a growing concern that the steel being used on sites may have been falling short of the design expectation as stipulated in the standards, because of lack of testing equipment for control and compliance purposes on sites. Steel reinforcing bars available in the Nigeria's Construction Industry are obtained from both internal and external sources. The internal sources come mainly from both the indigenous major plants and the mini mills located in different parts of the country. Imported steel bars coming into the country are mainly from Russia and Ukraine. Others are those procured for specific uses by multinational companies for some specific projects, and are imported directly by the multinational company concerned [17].

The importance of steel in structures cannot be neglected as the proper combination of both steel and concrete form the major components that ensures a structure is in perfect condition.

ISSN: 2395-0560
International Research Journal of Innovative Engineering
www.irjie.com
Volume1, Issue 3 of March 2015

In recent times, it is observed that the quality of steel bars used in Nigeria has diminished due to various reasons. Therefore, the aim of this research is to evaluate the quality of steel reinforcing bars as it affects the Nigerian society. This research bases its study on carrying out the required experiments to determine the quality of steel reinforcing bars used in building constructions in Nigeria and also to ensure that the quality of materials used are not deleterious and ultimately prevent premature collapse of buildings, preventing loss of life and property.

MATERIAL AND METHOD

Numerous samples of steel bars were collected and tested in Lagos State Material Testing Laboratory from various construction sites in 10 Local Government areas of Lagos State from January to September 2010. Tensile tests were carried out on 1325 reinforcement bars of which 344 are Ø10 steel bars, 443 are Ø12 steel bars, 432 are Ø16 steel bars, 83 are Ø 20 steel bars and 23 Ø25 bars. Procedures of this research is similar to the work of [18]. The Universal Testing Machine (UTM) was used to determine the mechanical properties of the specimens. Each specimen was subjected to tension in accordance with the BS4449:1997 [19] provisions, and after fracture, the average Yield Strength (YS), average Ultimate Tensile Strength (UTS) and the Percentage Elongation (%E) were obtained according to the formulas:

$$\text{Yield Strength } (N/mm^2) = \frac{Yield\ Force}{Original\ Cross\ Sectional\ Area} \quad (1)$$

$$\text{Ultimate Tensile Strength } (N/mm^2) = \frac{Maximum\ Force\ the\ specimen\ can\ withstand}{Original\ Cross\ Sectional\ Area} \quad (2)$$

$$\text{Percentage Elongation } (\%) = \frac{Final\ Length - Original\ Length}{Original\ Length} X\ 100 \quad (3)$$

RESULT AND DISCUSSIONS

The results obtained from laboratory tests were used to determine the percentage pass and failure rate of the materials being tested using a standard of 460N/mm^2 from BS 4449: 1997 Table 7. But in Nigeria, structural designers are forced to adopt a yield strength of 410N/mm^2 due to the substandard quality of reinforcement produced within the country and imported from other countries. The permissible elongation (%) stated by BS 4449: 1997 Table 7 is 14% for grade 460B^d steel reinforcement.

The **red** line indicates a yield stress from 460N/mm^2 while the **blue** line indicates a yield stress of 410N/mm^2. Very good = 460 above. Satisfactory = 410 - 460, Bad = 410 below for yield stress. For elongation, 14% above = above code, 13.9% below = below code.

Samples that failed in elongation should not be used in reinforcement as they will not give warning prior to failure due to low ductility. This lack of ductility usually leads to sudden collapse without warning. Some of the results obtained are shown in figures 2 to In summary of all the result analyzed above, the tables below shows a breakdown of the percentage failure and pass of the specimen.

ISSN: 2395-0560
International Research Journal of Innovative Engineering
www.irjie.com
Volume1, Issue 3 of March 2015

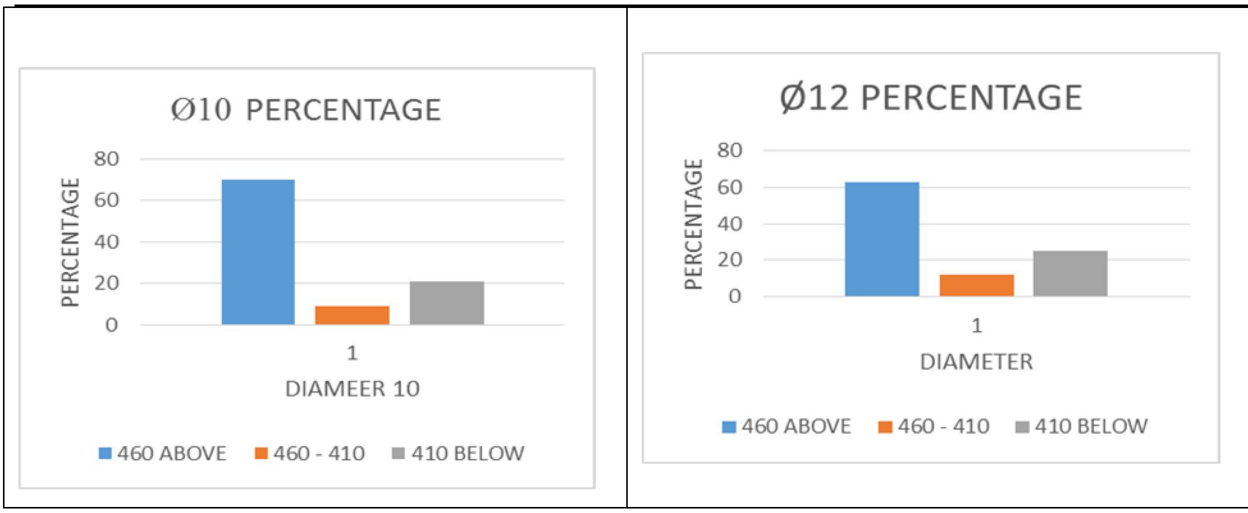

Figure 2: Diameters 10 and 12's percentage passed and failed samples

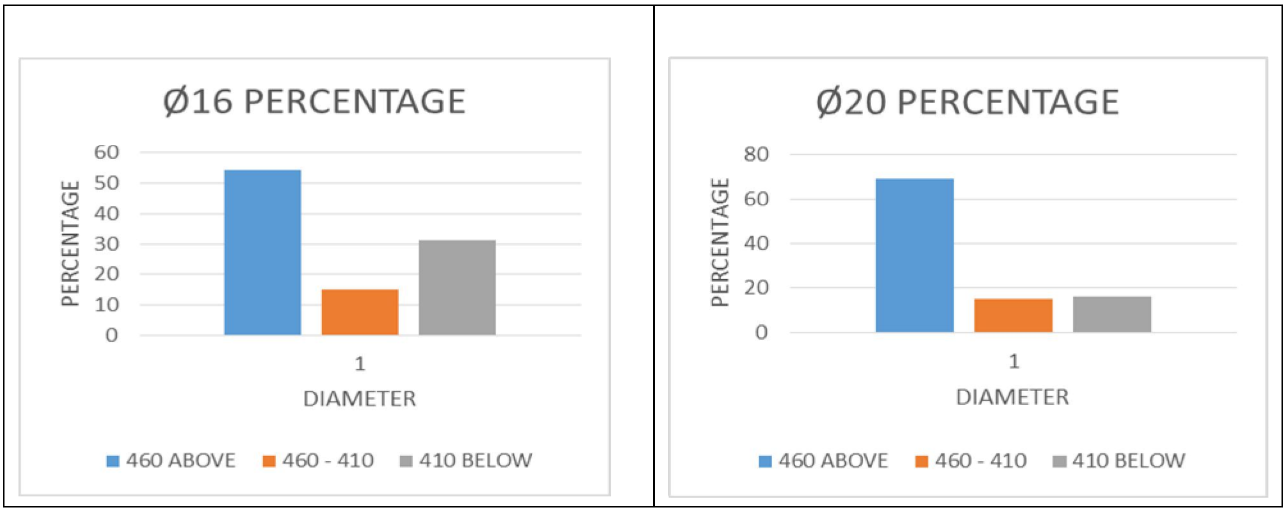

Figure 3: Diameters 16 and 20's percentage passed and failed samples

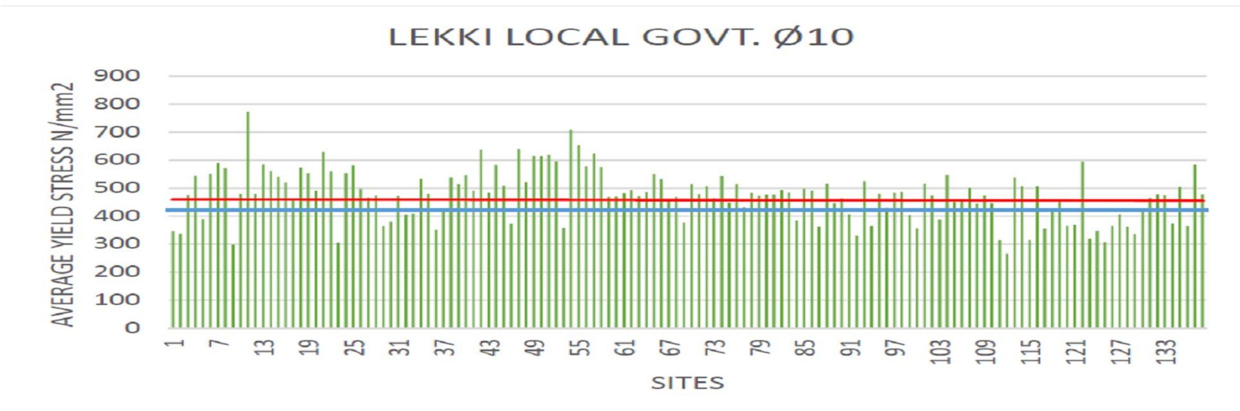

Figure 4: Results of the 10mm test samples for Lekki LGA.

ISSN: 2395-0560
International Research Journal of Innovative Engineering
www.irjie.com
Volume1, Issue 3 of March 2015

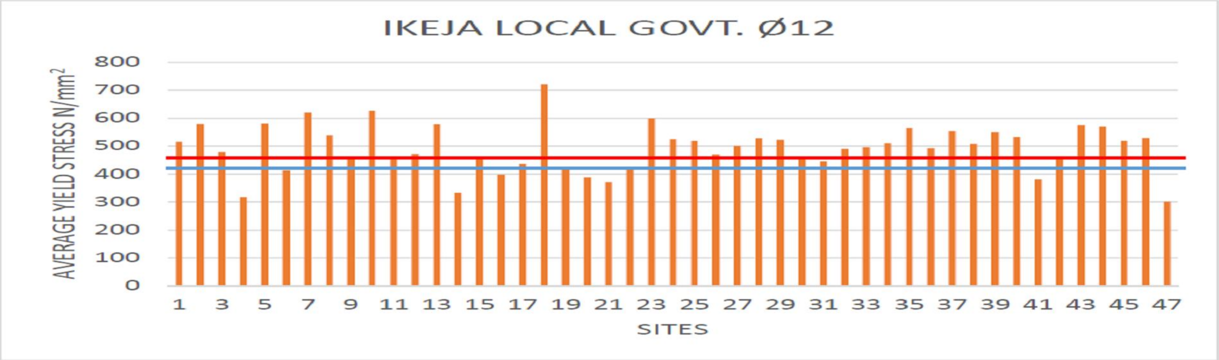

Figure 5: Results of the 12mm test samples for Ikeja LGA.

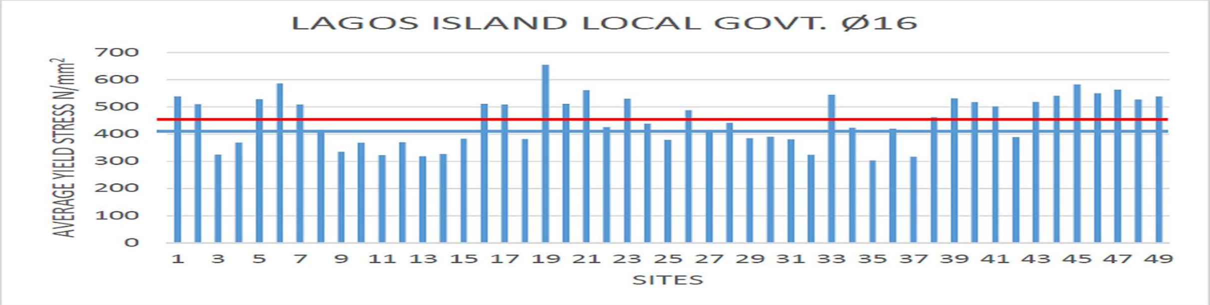

Figure 6: Results of the 16mm test samples for Lagos Island LGA.

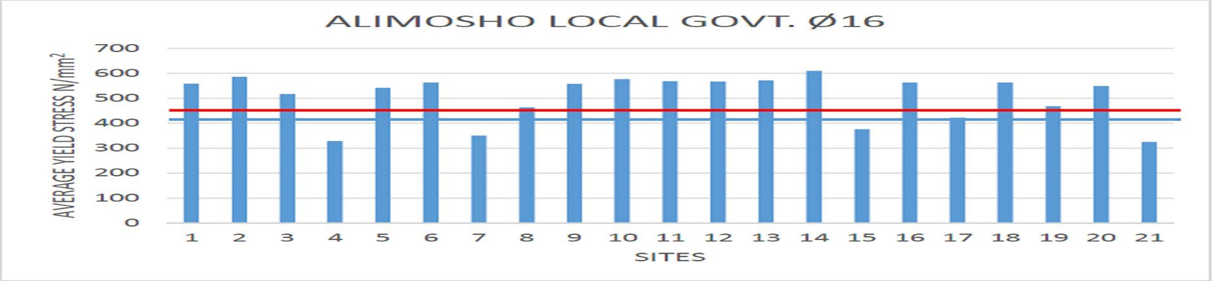

Figure 7: Results of the 16mm test samples for Alimosho LGA.

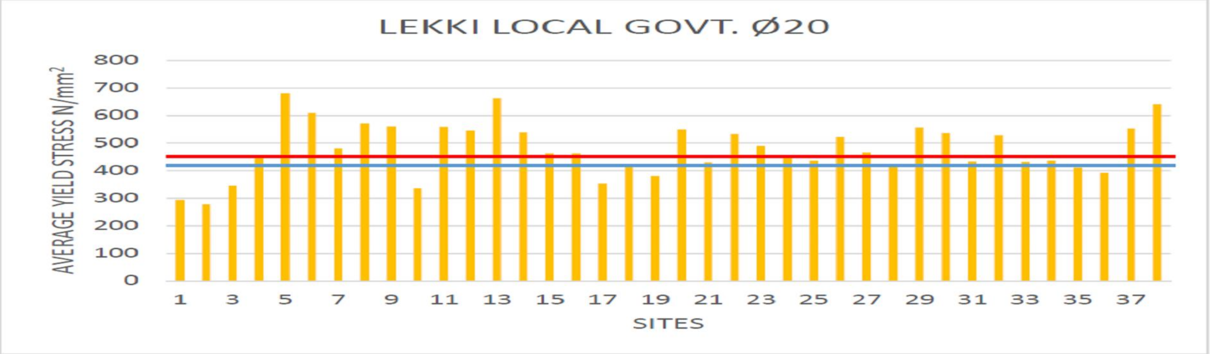

Figure 8: Results of the 20 mm test samples for Lekki LGA.

ISSN: 2395-0560
International Research Journal of Innovative Engineering
www.irjie.com
Volume1, Issue 3 of March 2015

CONCLUSION

Based on the tensile test conducted and the analysis carried out on 1325 samples collected from construction sites at 10 Local Government in Lagos Nigeria, the following conclusions were made. The characteristic high yield stress of diameter 10 samples tested had a total of **70%** above 460N/mm^2 conforming to BS4449:1997, **9%** was between 410 and 460N/mm^2, **21%** was below the standard code. The characteristic high yield stress of diameter 12 samples tested had a total of **63%** above 460N/mm^2 conforming to BS 4449:1997, **12%** was between 410 and 460N/mm^2, **25%** was below the standard code. The characteristic high yield stress of diameter 16 samples tested had a total of **54%** above 460N/mm^2 conforming to BS 4449:1997, **15%** was between 410 and 460N/mm^2, **31%** was completely below the standard code. The characteristic high yield stress of diameter 20 samples tested had a total of **69%** above 460N/mm^2 conforming to BS 4449:1997, **15%** was between 410 and 460N/mm^2, **16%** was completely below the standard code. The characteristic high yield stress of diameter 25 samples tested had a total of **95%** above 460N/mm^2 conforming to BS 4449:1997, **0%** was between 410 and 460N/mm^2, **5%** was completely below the standard code. A large percentage of the bars tested were found to comply with the standard code BS 4449:1997 in the aspect of yield stress at 460 N/mm^2 and % elongation at 14%. From the results gathered, Alimosho had the highest percentage of reinforcement meeting the appropriate standard while Bariga had the lowest. More of diameter 12 bars were used during construction for slabs and more of diameter 16 would be used for the beams, columns and foundations. This research recommends that the code specification of 460N/mm^2 be enforced and efforts should be geared towards upgrading the code to Euro code since BS codes are no longer renewable codes since 2009.

ACKNOWLEDGMENT

The authors wish to thank the Chancellor and the Management of Covenant University for the platform made available for this research.

REFERENCES

[1] A.N. Ede and A. Ogundiran, "Thermal Behavior and Admissible Compressive Strength of Expanded Polystyrene Wall Panels of Varying Thickness", Current Trends in Technology and Science ISSN: 2279-0535. 2014, Vol.: 3, Issue: 2.

[2] L. Zongjin, L, Advanced Concrete Technology (John Wiley & Sons, Inc., Hoboken, New Jersey, 2011).

[3]A.N. Ede, and J.O. Agbede, Use of Coconut Husk Fibre for Improved Compressive and Flexural Strength of Concrete, International Journal of Scientific and Engineering Research, 6(1), 2015.

[4]C. Arya, Design of Structural Elements: Concrete, Steelwork, Masonry, and Timber Designs to British Standards and Euro codes, (3rd Edition; Taylor & Francis, London, 2009).

[5]Vlack L.H.V. (1982). Materials for the Engineer, Materials for Engineering: Concept and Application, Addison – Westley Publishing Company Reading, Massachusetts; pp.4.

[6]Marrel P. (1977). Design of Reinforced Concrete Elements; Crosby Lockwood Staples, London

[7]Leet K. and Bernal D. (1997). Reinforced Concrete Design; the Mc Graw-Hill Companies Inc., New York, 3rd Edition, pp.1 – 36.

[8]Rao K.L. (1961). Calculation, Design and Testing of Reinforced Concrete; Isaac Pitman Ltd.; London; pp.1 – 21.

[9]WSA (World Steel Association), 2012 "Sustainable-steel-at-the-core-of-a-green-economy", http://www.worldsteel.org/, accessed 28 January, 2015.

[10]Neville, A. M., and Brooks, J. J., (1993) *Concrete technology*, Essex, England: Longman Scientific and Technical.

[11] A.N. Ede and J.O. Okundaye, Appraisal of Timber as Structural Members for Residential Buildings in Nigeria, International Journal of Engineering & Technology IJET-IJENS Vol:14 No:01,2014, pp.108-112.

[12]W. Pansuk, W, Properties of Hardened Concrete, (New York: Pergamon Press, 2011, Vol 2; Pp. 24).

[13]A.N. Ede, Building Collapse in Nigeria: the Trend of Casualties in the Last Decade (2000 -2010), *International Journal of Civil & Environmental Engineering*, 10(6), 2010, pp32-42.

[14]A.N. Ede, O.M. Olofinnade, O. Joshua, Experimental Investigation of Yield Strengths of Steel Reinforcing Bars Used in Nigerian Concrete Structures, International Journal of Scientific & Engineering Research, 2014, 5(4).

[15]O. Joshua, K.O.O. Olusola, C. Ayegba and A.I. Yusuf, **"**Assessment of the quality steel reinforcement bars available in Nigerian market**"**, AEI 2013, ASCE, 2013, pp.295-304.

[16]BS 8110-1: 1997. Structural use of concrete — Part 1: Code of practice for design and construction.

[17]Ejeh, S.P and Jibrin, M.U. (2012). Tensile Tests on Reinforcing Steel Bars in the Nigerian Construction Industry. IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE). ISSN: 2278-1684 Volume 4, Issue 2 (Nov. - Dec. 2012), PP 06-12.

[18]Egunjobi Emmanuel Oluwabukunmi, 2014. "Evaluating the quality of steel reinforcing bars", Unpublished final year student project, Department of Civil Engineering, Covenant University, Ota, Nigeria.

[19]BS 4449:1997. Specification for Carbon steel bars for the reinforcement of concrete: British Standards Institution.

