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Effects of Aqueous Solutions on Tensile Properties of local and imported steel in Southwest, Nigeria.

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Abstract: *The recurrent premature failures of public infrastructure which render most constructed facilities structurally deficient and functionally obsolete require urgent attention and the degree of uncertainty or dispersion in the size geometry of local and imported bars is very fundamental to the development of reliable standard of practice for building and civil engineering industry. From findings, the degree of uncertainty in the geometric size of local bars was six times higher than the imported bars, while the degree of uncertainty in bar sizes was smaller in Lagos than that of Ibadan. Also, weekly durability assessment of the rebar specimens were evaluated to determine the mass loss and the mechanical properties when fully immersed in distilled water and 5% solution of H_2SO_4, HCl, NaOH, Na_2SO_4 in soluble water over a period of six weeks. The severity of aqueous solutions on rebar strength was in the order HCl> H_2SO_4 >NaOH> H_2O > Na_2SO_4 and HCl> H_2SO_4>NaOH> Na_2SO_4> H_2O for imported and local respectively.*

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I. Introduction

Structural integrity of reinforced concrete structures is hinged on the reliability of the characteristic strength and ductility parameters of ribbed reinforcing bars in the Nigeria bar market with a view to determining the extent to which they conform to the requirements of various National Standards for Standardization and Characterization.[1,2]. Hence, the degree of compliance or discordance with the design specifications in terms of geometric sizing and tensile strength parameters is a good measure to determine whether or not they contribute to the incidence of building failures in the country. [3,4]. Whether the rebar is made of steel or fiber reinforced polymers, tensile stresses must be transferred from the concrete to the rebar. The transfer of stress from the concrete to the rebar is accomplished through bond between the two materials. A structure with sound analysis and design could still fail if the quality of the material used for the construction is poor[5,6]. Statistics have shown that a significant number of structural failures can be attributed to poor material quality, influx of quacks and/or unethical professional practices, poor construction methodology, workmanship and unverified newly introduced reinforcement [7,8,9]. The two main materials used for constructional purposes in reinforced concrete structures are concrete and reinforcement steel bars. Setting a benchmark for the applicability of building material especially the steel reinforcement, investigation on the short-term and long-term behaviour of locally manufactured reinforcement bars are very imperative to safeguard the integrity of existing and new structure.[10,11]. To eradicate frequent collapse of building that result into unexpected loss of lives and investment as a result of catastrophic structural failure, thorough evaluation of material properties cannot be underemphasized.[5,12,13]. Investigations have shown that building components tend to fail at different rates depending on quality of materials, designs and construction method, environmental conditions and the use of the building. However, substandard materials and design errors were identified as to major causes of component or element failures. The specific causes of failure of building components, aside substandard materials and design errors, revolve round the construction method and the component materials.

II. Material And Methods

The method used in carrying out this research work is field survey and laboratory tests. The laboratory tests includes the chemical behavior of such rebars under varying host environment such as sodium sulphate (Na_2SO_4), hydrochloric acid (HCI), tetraoxosulphate VI (H_2SO_4) acid, sodium hydroxide (NaOH), and distilled water (H_2O) in order to study the resistance to corrosion of the steel types. Weekly durability assessment of the rebar specimens were evaluated to determine the mass loss and the mechanical properties when fully immersed in distilled water, and 5% solution of H_2SO_4, HCl, NaOH, Na_2SO_4 in soluble water over a total period of six weeks.

III. Result

3.1 Degree of Uncertainty

The degrees of uncertainty in the geometric size of steel bars are exhibited in Figure 1.

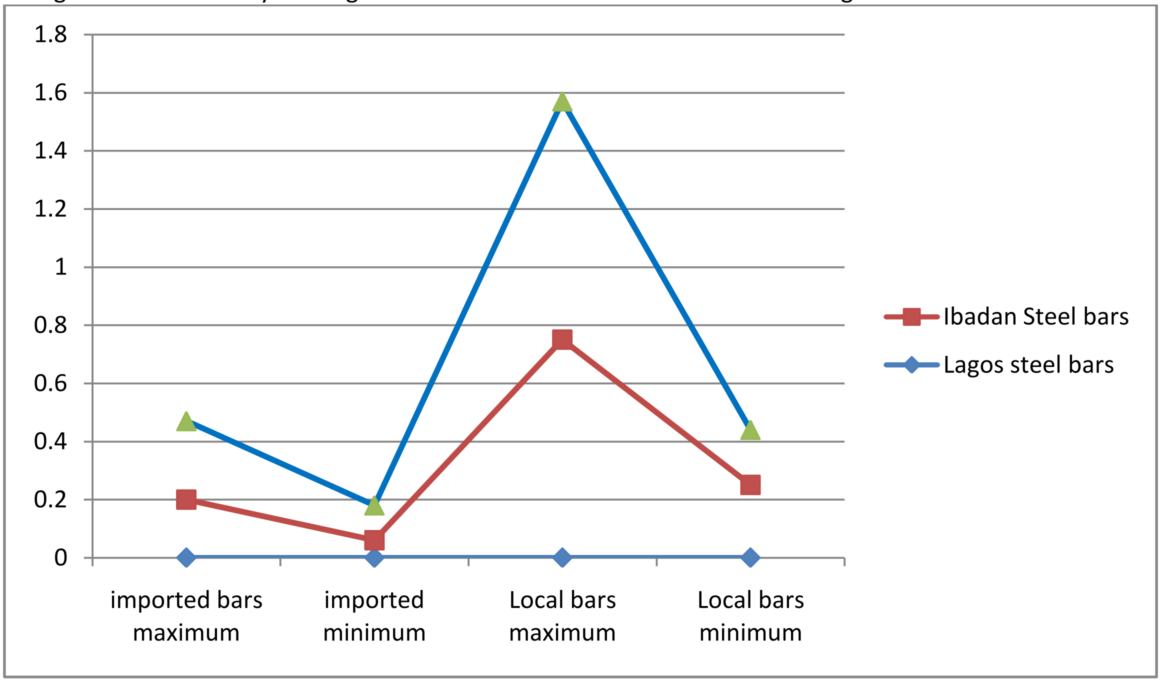

Figure1. Chart of degree of uncertainty for Lagos and Ibadan steel bars immersed in solutions.

Figure 1 revealed that the degree of uncertainty in the geometric size of local bars was six times higher than the imported. It is obvious that in Lagos metropolis, the mean bar sizes for the different diameter of rebars considered for the imported are higher in diameter that the corresponding local types, with a very small margin. Also, there is a smaller degree of uncertainty in the imported reinforcing bars size having COV in the range of 0.06 to 0.20 and the local reinforcing bars in the range of 0.25 to 0.75 for the same diameter size range. The finding during random survey of steel rebars size distribution in Ibadan and indicated that the COV for imported steel falls within range 0.12 to 0.27, while the corresponding local steel was within the range of 0.19 to 0.812. The degree of uncertainty in bar sizes was smaller in Lagos than that of Ibadan. However, if we have to consider the sizes of steel made with imported billet and thermo mechanically treated (TMT product), the degree of uncertainty is almost the same.

3.2 Tensile parameters

3.2.1 Tensile parameters percentage loss

The tensile parameters percentage loss value of steel bars immersed in various solutions are presented in Figure 2.

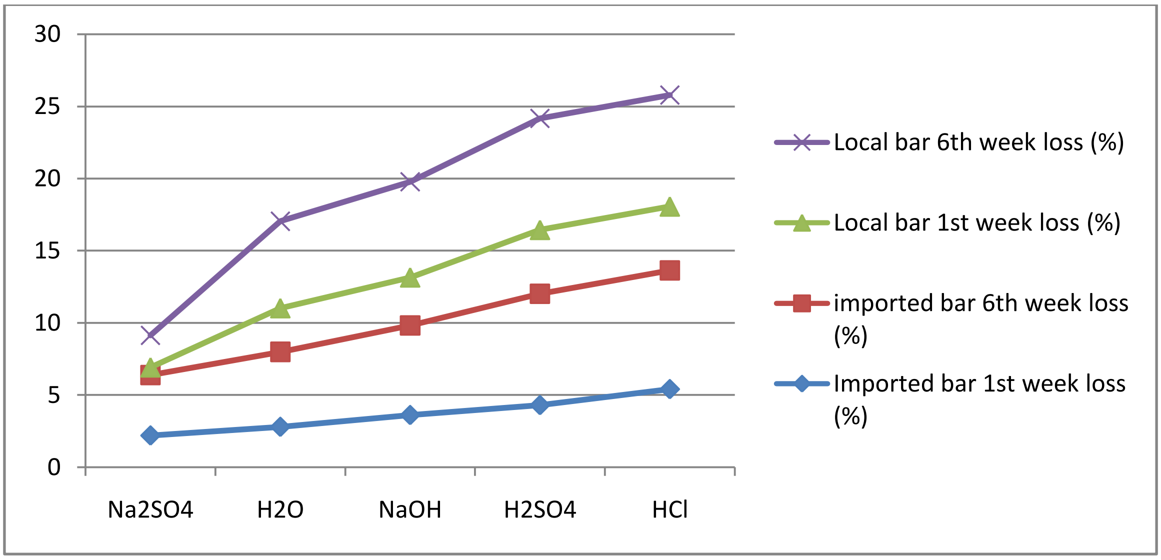

Figure2. Chart of percentage loss for imported and local steel bar immersed in solutions.

Figure 2 demonstrated percentage loss for the imported and local bars from tensile strength parameters namely yield strength (YS), ultimate tensile strength (UTS) and Young's modulus (YM) that was investigated for the local and imported steel bar specimens for the 6-week study, have average yield strength in air for imported and local steel rebars were 490 N/mm^2 and 364 N/mm^2 respectively. Surprisingly, NaOH which had neither obvious colour change nor measurable mass loss clearly affected the tensile properties of the steel rebars. The severity of the aqueous solution on the YS of imported bars is in the order HCl> H_2SO_4 >NaOH> H_2O > Na_2SO_4 for imported bars. For the imported steel, the percentage loss of YS at the end of the 1st and 6th week were 2.2 - 4.2% (Na_2SO_4), 2.8 – 5.2% (H_2O), 3.62 – 6.2% (NaOH), 4.3 – 7.7% (H_2SO_4), and 5.42 – 8.22% (HCl). The percentage loss of YS at the end of the 1st and 6th week were 0.52 - 2.22% (H_2O), 3.02 – 6.02% (Na_2SO_4), 3.32 – 6.62% (NaOH), and 4.42 – 7.72% (HCl and H_2SO_4).

3.2.2 Tensile yield strength

The tensile parameters yield strength of steel bars immersed in various solutions are presented in Figure 3.

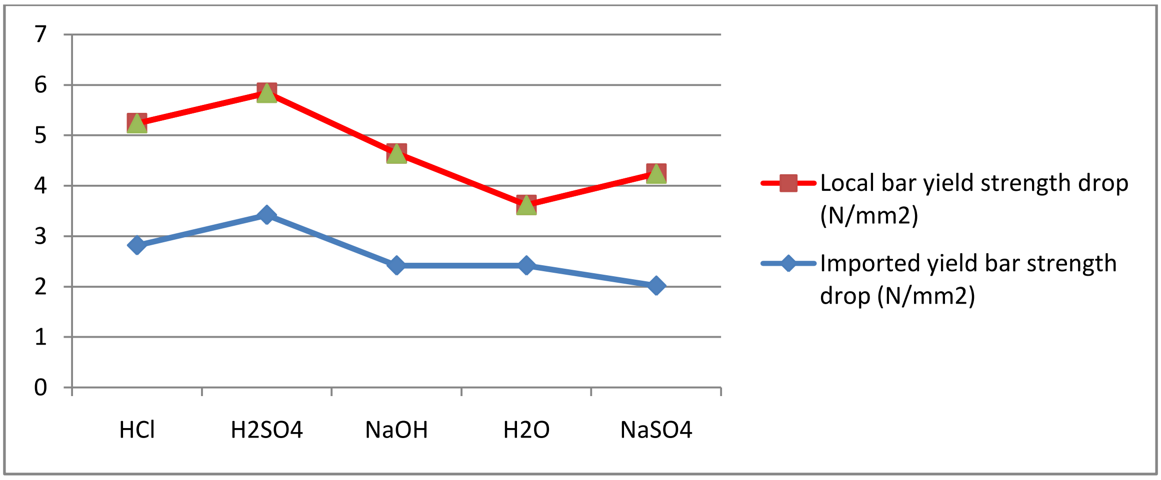

Figure 3. Yield strength for imported and local steel bar immersed in solutions.

Figure 3 reveals that the yield strength dropped by 2.82 N/mm^2 per week (HCl), 3.42 N/mm^2 per week (H_2SO_4), 2.42 N/mm^2 per week (NaOH), 2.42 N/mm^2 per week (H_2O), and 2.02 N/mm^2 per week (Na_2SO_4). Conversely, the harshness of the aqueous solution is in the order $H_2SO_4 \geq$ HCl>NaOH $\geq Na_2SO_4$> H_2O for local steel bars. The yield strength of local steel bar specimens dropped by 2.42 N/mm^2 per week (HCl and H_2SO_4), 2.22 N/mm^2 per week (NaOH and Na_2SO_4), and 1.20 N/mm^2 per week (H_2O), the extent of deterioration measured in terms of the UTS on the imported steel rebars was H_2SO_4 >NaOH> H_2O >HCl> Na_2SO_4, while HCl>NaOH> H_2SO_4 > Na_2SO_4> H_2O for the local steel bars.

3.2.3 Tensile ultimate yield strength (UTS)

The tensile ultimate yield strength of steel bars immersed in various solutions is showed in Figure 4.

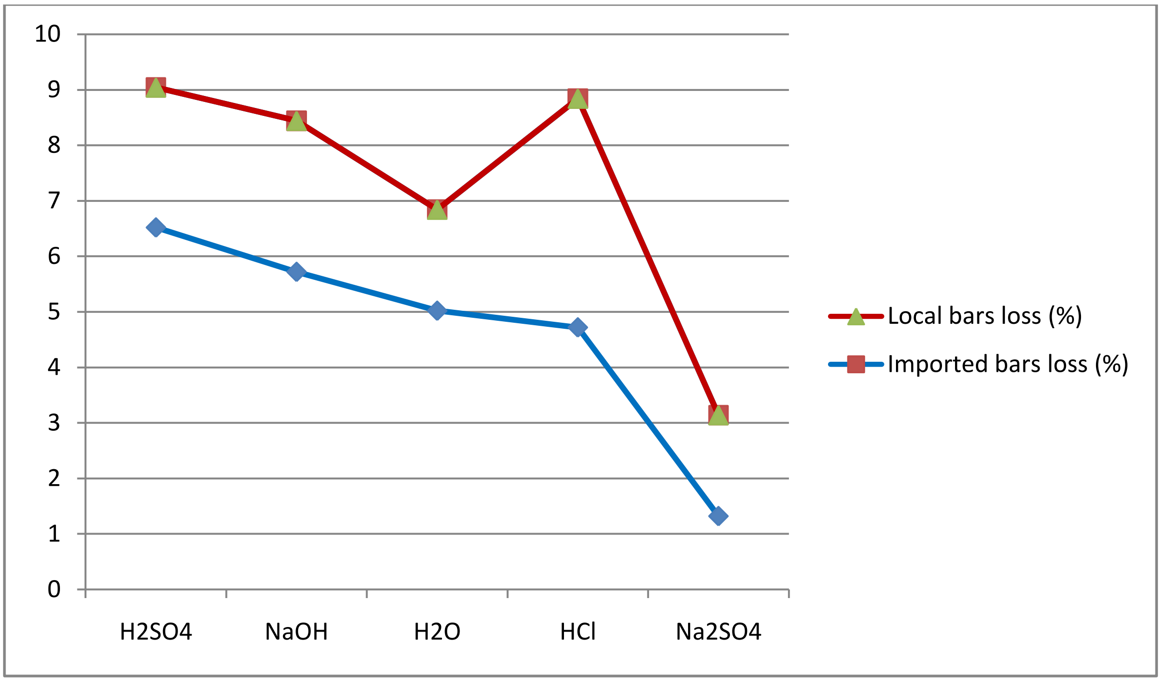

Figure 4. Ultimate yield strength for imported and local steel bar immersed in solutions.

Figure 4 indicates the trend for ultimate yield strength for both local and foreign steel bars, the mean percentage loss of UTS over exposure duration of six weeks were 6.52% (H_2SO_4), 5.72% (NaOH), 5.02% (H_2O), 4.7% (HCl), and 1.3% (Na_2SO_4) for the imported steel bars, while 4.1% (HCl), 2.7% (NaOH), 2.52% (H_2SO_4), 1.82% (Na_2SO_4), and 1.82% (H_2O) for the local bars. With the exception exposure of rebars specimens to Na_2SO_4 solution, the aqueous solutions was averagely about 87.2% more severe on imported bars than the local in terms of loss of UTS.

3.2.4 Modulus of elasticity

The modulus of elasticity of steel bars immersed in various solutions is displayed in Figure 5.

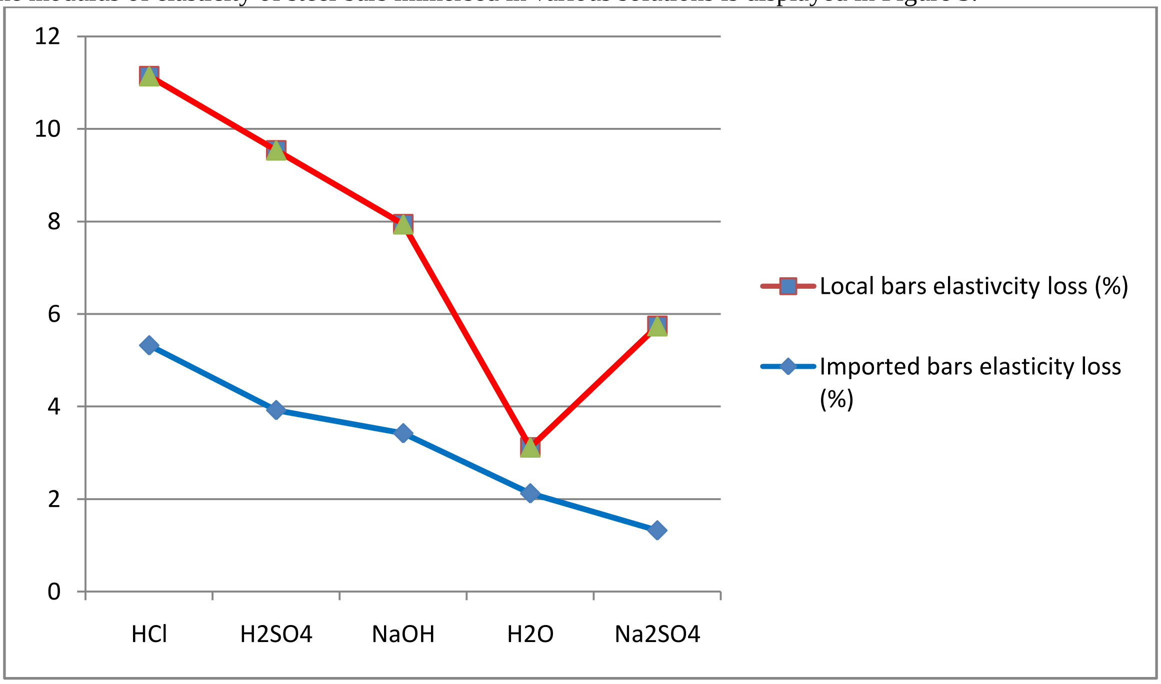

Figure 5. Young modulus for imported and local steel bar immersed in solutions.

The exposure condition obviously affected the Young's modulus (YM) of the steel bars as shown in Figure 5. The degree of deterioration measured in terms of the loss of elastic modulus of the imported steel rebars was HCl> H_2SO_4 >NaOH> H_2O > Na_2SO_4, while HCl> H_2SO_4 >NaOH> Na_2SO_4> H_2O for the local steel bars. The mean percentage loss of UTS over exposure duration of six weeks were 5.3% (HCl), 3.9% (H_2SO_4), 3.4% (NaOH), 2.1% (H_2O), and 1.3% (Na_2SO_4) for the imported steel bars, while 5.8% (HCl), 5.6% (H_2SO_4), 4.5% (NaOH), 4.4% (Na_2SO_4), and 1.0% (H_2O) for the local bars.The modulus of elasticity of imported and local steel samples decreased linearly with the duration of exposure. Aside natural moisture, that is water environment, where imported bars percentage loss of YM was about twice the local types, other aqueous chemical exposures were averagely about 54.2% more severe on local bars than the imported in terms of loss of YM.

IV. Conclusion

This paper showed that the degree of uncertainty in the geometric size of local bars was six times higher than the imported. It is obvious that in Lagos metropolis, the mean bar sizes for the different diameter of rebars considered for the imported are higher in diameter that the corresponding local types, with a very small margin. Also, there is a smaller degree of uncertainty in the imported reinforcing bars size having COV in the range of 0.06 to 0.20 and the local reinforcing bars in the range of 0.25 to 0.75 for the same diameter size range. The finding during random survey of steel rebars size distribution in Ibadan and indicated that the COV for imported steel falls within range 0.12 to 0.27, while the corresponding local steel was within the range of 0.19 to 0.812. The degree of uncertainty in bar sizes was smaller in Lagos than that of Ibadan. However, if we have to consider the sizes of steel made with imported billet and thermo mechanically treated (TMT product), the degree of uncertainty is almost the same. All the steel bars experienced deterioration due mass loss characterized by colour change in all the solutions except NaOH solution where no visible reaction took place as H^+ in the aqueous solution could not Na^+ which is higher in the electrochemical series. The severity of aqueous solutions on rebar strength was in the order HCl> H_2SO_4 >NaOH> H_2O > Na_2SO_4 and HCl> H_2SO_4>NaOH> Na_2SO_4> H_2O for imported and local respectively. The effect of HCl on the studied steel rebar types was the second most severe after the H_2SO_4. The ratio of the severity of local to imported steel rebars in water, Na_2SO_4, H_2SO_4 and HCl were 1.59, 1.26, 1.79 and 1.20 respectively. At the end of the 6-week immersion of steel bars in Na_2SO_4 solution, local bars had over 30% mass loss higher than the imported bars. The mean percentage loss of tensile strength over exposure duration of six weeks were 6.52% (H_2SO_4), 5.7% (NaOH), 5.02% (H_2O), 4.72% (HCl), and 1.32% (Na_2SO_4) for the imported steel bars, while 4.12% (HCl), 2.72% (NaOH), 2.52% (H_2SO_4), 1.82% (Na_2SO_4), and 1.82% (H_2O) for the local bars. With the exception exposure of rebars specimens to Na_2SO_4 solution, the aqueous solutions was averagely about 87.2% more severe on imported bars than the local.

References

[1]. Basu P. C, Shylamoni P, Roshan A. D (2004) Characterisation of steel reinforcement for RC structures: An overview and related issues.Indian Concrete Journal. 78(1): 19-30.
[2]. Balogh .T and L. G. Vigh. (2013), Cost Optimization of Concentric Braced Steel Building Structures. World Academy of Science, Engineering and Technology. Vol. 78, Pp. 06-21.
[3]. BS 4449 (2001) Specification for carbon steel bars for the reinforcement of concrete.
[4]. Castro C, Rodriguez F.J, Belzunce A. F, Canteli O (2002) Stainless Steel Rebar for Concrete Reinforcement.
[5]. Chahrour A, Soudki K (2005) Flexural response of reinforce concrete beams strengthened with end –anchored partially bonded carbon fiber-reinforced polymer strips, Journal of Composites for Construction. **9**(2):170-177.
[6]. Ede A. A (2010), Building Collapse in Nigeria, International Journal for Civil and Environmental Vol. 10 No. 0632.
[7]. Erhard G (2006) Designing with Plastics. African Journal of Science and Technology (AJST). 7(3):73-78.
[8]. Hashemi S.H (2006). Analytical and experimental study of HSC members strengthened with CFRP. PhD Thesis, Kerman University, Kerman, Iran.
[9]. Kankam C. K, Adom-Asamoah M (2002) Strength and ductility characteristics of reinforcing steel bars milled from scrap metals. Materials and Design, 2**3**: 537–545.
[10]. Kaushik S.K, Singh B (2002) Influence of steel-making processes on the quality of reinforcement, The Indian Concrete Journal, 76(7): 407-412.
[11]. Kosmatka S. H, Kerkhoff B, Panarese W. C (2003) Design and Control of Concrete Mixtures, 14th Edition.Portland Cement Association, Skokie, Illinois, USA.
[12]. NIS 117 – 1992, (1992), Specification for steel bars for reinforcement of concrete. Nigerian Industrial Standards Organization of Nigeria (SON) Abuja, Nigeria.Nigerian Standard (1994) Raw Materials and Specifications for Federal Government Steel Companies, 1st Edition.
[13]. Philips E. O (1998). Steel for General Structural Purposes"paper presented at the National Seminar on Structural Codes of Practice by the Nigerian Society of Engineers (Structural Engineering Division).

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