

Quality Assessment of Commercially Available Reinforced Steel Rods in Nigeria Markets

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Abstract

The mechanical properties of 10mm and 12mm diameter ribbed reinforced steel rods locally produced was obtained from markets in Lokoja, Kogi state and Oshodi, Lagos State both of Nigeria have been investigated. Steel rod imported from China was also obtained and studied. Tensile, hardness, Impact and metallography test was carried out on the sample in accordance with ASTM A706. The results obtained from the tests which ranged from $399 \times 106 \text{ N/m}^2$ - $429 \times 106 \text{ N/m}^2$, $648 \times 106 \text{ N/m}^2$ - $748 \times 106 \text{ N/m}^2$, $599 \times 106 \text{ N/m}^2$ - $719 \times 106 \text{ N/m}^2$, 19%-23%, 170BHN – 217BHN, and 30.09J – 44.74J for the yield strength, ultimate tensile strength, breaking strength, percentage elongation, hardness and energy absorbed respectively met the ASTM A706 recommended standard. We can conclude that the available steel rods in Nigeria Markets are suitable for structural purpose. The data from this study it is hoped will enrich the information on materials already available to engineers, manufacturers and marketers in other to make well informed decision about steel rods utilisation in Nigeria. It will also help the engineers and designers have adequate knowledge of materials and its properties in other to avoid the use of inferior quality and substandard steel rods that may lead to engineering failure and construction collapse.

Keywords: steel rods, mechanical properties, quality, assessment, Nigeria market.

INTRODUCTION

Demands for safer materials have forced engineers to become knowledgeable in the field of materials. Steel is one of the most common construction materials in the world and is a major component in buildings, infrastructures, tools, ships, automobiles, machines and appliances (Grospe et al, 2010). The ability of the steel bars to function as expected in these areas of applications is dictated by the mechanical properties. Therefore, the production of the steel bars to meet service requirements and estimation of the mechanical properties are very imperative (Williams, 2000, Llewellyn, 1992).

Steel rods are used mainly for construction projects, in manufacturing and fabricating industries. For effective utilization, the mechanical properties of steel must meet up with the quality specifications and standards of standard codes of practice on which designs are based.

There is lot of materials available to the engineers. Each of these materials has its characteristics, applications, advantages, limitations and cost. The task of knowing the properties and behaviour of all types of available material becomes enormous and challenging. That means that adequate knowledge of materials and properties will no doubt help the engineers and designers to avoid mistakes that may lead to engineering failure. An understanding of the

properties of materials is essential in both design and applications in any engineering project if it is to prove satisfactory for its intended purpose (Neil and Ravindra, 1996). The ability of a material to adequately perform in service demonstrates several mechanical properties of the material (Vernon, 1977).

In Nigeria the steel reinforcement bars need for structural purpose is partly produced by the country inland rolling mills while the balance is sourced through imports, which are carried out by private entrepreneurs (Nwabuokei, 2007). It has been identified that the use of inferior quality and substandard steel rods are among the causes of construction collapse and failures (Ayininuola, et al, 2004). Chukwudi et al (2010) carried out a study to assess the quality of 12mm steel rods obtained from onitsha market he obtained yield strength and ultimate tensile strength of $418 \times 10^6 \text{ N/m}^2$ and $655 \times 10^6 \text{ N/m}^2$ respectively. Arum, 2008 investigated the mechanical properties of 12mm steel rod from some part of Nigeria and obtained yield strength, ultimate tensile strength and percentage elongation of $540 \times 10^6 \text{ N/m}^2$, $410 \times 10^6 \text{ N/m}^2$ and 12% respectively. Alabi and Onyeji, 2010 carried out a comparative assessment of the chemical and mechanical properties of locally produced reinforcing steel bars for structural purposes from four indigenous steel industries that use scraps as their

major raw materials in Lagos State ,Nigeria. Their result shows that most steel rod locally manufactured in Nigeria are suitable for construction projects in Nigeria.

From available literature, much work has been done on the mechanical properties of available steel rods in Nigeria. However most authors obtained their samples from companies (Chukwudi et al, 2010) but in this work, samples were collected from major marketers of steel rods in Lokoja , Kogi state and Oshodi, Lagos State both of Nigeria. Thus, the need to ensure the availability of quality steel rods in the steel market cannot be over-emphasized because of their importance in engineering projects.

This study is therefore limited to the quality assessment of commercially available reinforced steel rods of diameter 10mm and 12mm from Nigeria markets in Lokoja,Kogi state and Oshodi, Lagos State and to ascertain their conformity with standard.

MATERIALS AND METHODS

The 10mm and 12mm diameter ribbed carbon steel rods used for the research work were obtained from retailers of steel rods in Lokoja, Kogi state and Oshodi, lagos State both in Nigeria. Foreign steel rod imported from China was also tested.

The samples were machined into various standard test specimens and the hardness, tensile, impact and metallograpy tests performed in accordance with Oyetungi, 2007 and ASTM A706. The hardness, tensile test and Impact tests were performed with the aid of a Brinell hardness testing device, Monsanto Tensometer and V-notch pendulum-type impact testing machine respectively. The strain (e), yield strength (YS), ultimate tensile strength (UTS),

breaking strength (BS), percentage elongation (E) were determined using Equations 1-5 respectively.

$$\text{Strain (e)} = \frac{\delta L_o}{L} = \frac{L_f - L_o}{L_o} \quad (1)$$

Where, L_f = final length, L_o = Original length

$$\text{Yield Strength (YS)} = \frac{\text{Yield Force}}{\text{Original Cross Sectional Area}} \quad (2)$$

$$\text{Ultimate Tensile Strength (UTS)} = \frac{\text{Maximum Force the Specimen can Withstand}}{\text{Original Cross-Sectional Area}} \quad (3)$$

$$\text{Breaking Strength (BS)} = \frac{\text{Yield Force}}{\text{Original Cross Sectional Area}} \quad (4)$$

$$\text{Percentage Elongation (\%EL)} = \frac{L_f - L_o}{L_o} \times 100\% \quad (5)$$

Where, L_f = Final length, L_o = Original length

RESULTS AND DISCUSSION

The results of the tests of mechanical properties (Yield Strength, Ultimate tensile strength ,Breaking Strength, percentage elongation and strain) is shown in Table 1 ,while Table 2 shows Hardness and Impact Test results. The microstructure for Kogi, Lagos and imported steel rods are shown in Fig .1, Fig.2 and Fig.3 respectively.

Table 1: Tensile Tests Result

SAMPLE RESULT	IMPORTED STEEL		KOGI STEEL		LAGOS STEEL		ASTM Standard
	10mm	12mm	10mm	12mm	10mm	12mm	
Yield Strength (N/m ²)	459 x 10 ⁶	469 x 10 ⁶	441 x 10 ⁶	399 x 10 ⁶	479 x 10 ⁶	449 x 10 ⁶	414 x 10 ⁶
UTS (N/m ²)	778 x 10 ⁶	738 x 10 ⁶	648 x 10 ⁶	649 x 10 ⁶	729 x 10 ⁶	748 x 10 ⁶	620 x 10 ⁶
Breaking Strength (N/m ²)	699 x 10 ⁶	618 x 10 ⁶	599 x 10 ⁶	629 x 10 ⁶	649 x 10 ⁶	719 x 10 ⁶	
%EL	21.5%	20.0%	23.0%	22.2%	19.0%	21.5%	10%
Strain E	0.215	0.200	0.230	0.222	0.190	0.215	

Table 2: Hardness and Impart energy Tests Results

SAMPLE RESULT	IMPORTED STEEL		KOGI STEEL		LAGOS STEEL		ASTM Standard
	10mm	12mm	10mm	12mm	10mm	12mm	
Hardness (BHN)	226	227	187	170	217	207	179
Impact Energy (J)	36.90	36.30	42.03	44.74	35.0	30.09	27

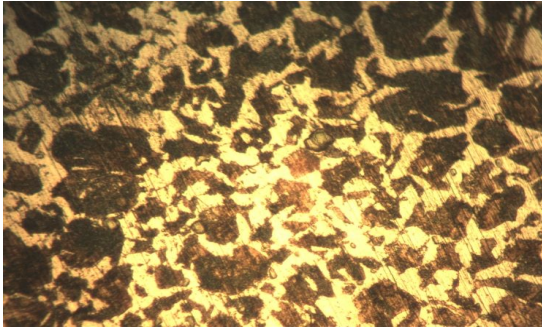


Fig.1: The Microstructure of Kogi Steel x400 Etched

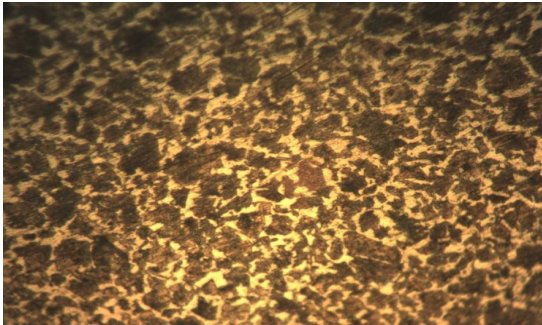


Fig. 2: The Microstructure of Lagos Steel x400 Etched

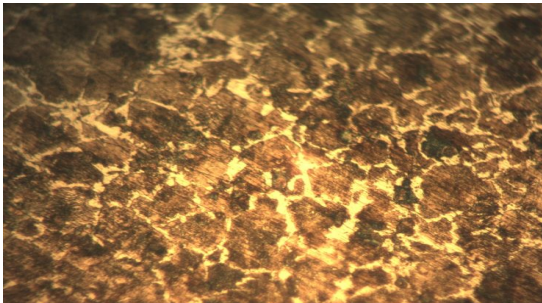


Fig. 3: The Microstructure of Imported Steel x400 Etched

Yield Strength: From the tensile test results, the yield strength of the 10mm and 12mm steel rods respectively are $459 \times 10^6 \text{ N/m}^2$ and $469 \times 10^6 \text{ N/m}^2$ for the imported rods; $441 \times 10^6 \text{ N/m}^2$ and $399 \times 10^6 \text{ N/m}^2$ for the Kogi steel and $479 \times 10^6 \text{ N/m}^2$ and $449 \times 10^6 \text{ N/m}^2$ for the Lagos steel. All these rods met the minimum standard requirement of ASTM A760 for medium carbon which is $414 \times 10^6 \text{ N/m}^2$, except that of Kogi steel 12mm rod which fell short by about 3.62% (Table 1). This compare favourably with the results obtained by Chukwudi et al (2010) of $418 \times 10^6 \text{ N/m}^2$ for steel rods obtained from onitsha market, Nigeria and Alabi and Onyeji, 2010 for rods obtained from steel Industries in Lagos with values ranging from $340 \times 10^6 \text{ N/m}^2$ to $450 \times 10^6 \text{ N/m}^2$ but are less than the values of the steel of obtained from some part of Nigeria from the study carried out by Arum (2008), of $525 \times 10^6 \text{ N/m}^2$ and $540 \times 10^6 \text{ N/m}^2$.

Ultimate Tensile Strength (UTS) : The UTS results from Table 1 shows that the values for the 10mm and 12mm rods of the imported steel are $778 \times 10^6 \text{ N/m}^2$ and $738 \times 10^6 \text{ N/m}^2$ respectively; $648 \times 10^6 \text{ N/m}^2$ and $649 \times 10^6 \text{ N/m}^2$ for the Kogi steel and $729 \times 10^6 \text{ N/m}^2$ and $748 \times 10^6 \text{ N/m}^2$ for the Lagos steel. All these steel rods met the minimum standard requirement by ASTM A760 of $620 \times 10^6 \text{ N/m}^2$. The results also compare favourably with the works of Chukwudi et al (2010) who obtained a UTS values of $628 \times 10^6 \text{ N/m}^2$ and $655 \times 10^6 \text{ N/m}^2$ for 10mm and 12mm respectively for steel rods from onitsha market and Alabi and Onyeji, 2010 with values ranging from $600 \times 10^6 \text{ N/m}^2$ to $700 \times 10^6 \text{ N/m}^2$ and Arum, 2009 was $590 \times 10^6 \text{ N/m}^2$ and $410 \times 10^6 \text{ N/m}^2$ respectively from some parts of Nigeria.

Percentage Elongation (%EL) : The %EL results show that all the samples are very ductile having all their values greater than the required minimum value of 10% by ASTM A760 requirements (Table 1). The %EL values for 10mm and 12mm are 21.5% and 20.0% for the imported steel; 23.0% and 22.2% for the Kogi steel and; 19.0% and 21.5% for the Lagos steel (Table 1). The results also compare favourably with the works Alabi and Onyeji, 2010 with values ranging from 18% to 27%. This is also seen to be greater than the values obtained by Arum (2008) of 15% and 12% respectively from steel rods from some parts of Nigeria..

Hardness : The hardness value for the 10mm and 12mm imported steel are 226 BHN and 227 BHN respectively; while that for the Kogi steel are 187 BHN and 170 BHN and that for the Lagos steel are 217 BHN and 207 BHN (Table 2). The minimum required value of Brinell Hardness Number (BHN) for carbon steel by ASTM A760 is 179 BHN. The 12mm steel rod from Kogi state which had a hardness value of 170 BHN did not meet standard. However, all other samples met the minimum requirement.

Impact Energy: The energy absorbed from are 36.90J and 36.30J respectively for the imported rods; 42.03J and 44.74J for the Kogi steel and; 35.00J and 30.09J for the Lagos steel (Table 2). All these energy absorbed by the samples values are greater than the required minimum value by ASTM A760 standard of 27J. However, it is observed that the Kogi steel has the highest absorbed energy than the others and this may due to the fact that it had the lowest hardness value and best ductile material observed from the %E results.

Microstructure: The mechanical properties of plain carbon steel, are usually dictated by the combined effect of composition and grain refinement (Brandt, 1985). It is often difficult to quantify the individual contributions to the strength. Critical observation of the micrograph (Fig.1 – 3), reveals that the micro-

structures consist of pre-eutectoid ferrite and pearlite with Fig.1 having the largest concentration of ferrites. The pearlites are the grey (dark) coloured while the ferrites are the white (light) coloured portion of the microstructure. From the results Kogi Steel recorded better ductility (percentage elongation) than the other samples. This can be confirmed from their micrograph plates (Fig.1), which shows lesser pearlites compared to the other micrograph plates. Pearlitic structures are known to have adverse effect on ductility, as it provides sites for easy nucleation of cracks (Honeycombe et al, 1995). Also, these darker pearlitic structures accounts for the higher hardness value in the Imported as well as the Lagos Steel rods compared to the Kogi Steel rods, because they are very hard compared with the softer white ferrites (Callister, 2006). From the micrographs (Fig.1-3), the impact test values can also be justified, that the low energy absorbed in impact test on pearlitic structures arise from the fact that many crack nuclei can occur at the pearlitic interfaces which could restrict plastic deformation (Honeycombe et al, 1995).

CONCLUSION

The mechanical properties of 10mm and 12mm diameter ribbed reinforced steel rods locally produced was obtained from markets in Lokoja and Oshodi in Kogi and Lagos state of Nigeria have been studied. The results obtained from the tests which ranged from $399 \times 106 \text{ N/m}^2$ - $429 \times 106 \text{ N/m}^2$, $648 \times 106 \text{ N/m}^2$ - $748 \times 106 \text{ N/m}^2$, $599 \times 106 \text{ N/m}^2$ - $719 \times 106 \text{ N/m}^2$, 19%-23%, 170BHN – 217BHN, and 30.09J – 44.74J for the yield strength, ultimate tensile strength, breaking strength, percentage elongation, hardness and energy absorbed respectively met the ASTM A706 recommended standard.

From the results obtained from the study, it can be concluded that the available steel rods in Nigeria Markets are suitable for structural purpose. The data from this study it is hoped will enrich the information on materials already available to engineers, designers, manufacturers and marketers in order to make well informed decision about steel rods utilisation in Nigeria.

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