Assessment of the Quality of Steel Rods Available in Onitcha Market: In View of the Role of Poor Quality Rods in Building Failures in Nigeria.

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ABSTRACT

The mechanical properties of 16mm steel ribbed rods have been studied. Standard methods were adopted for Tensile test using Extensometer; Impact test using Izod testing machine; and Hardness test using Rockwell testing machine. Also metallography was carried out using the standard techniques. Results obtained from the tests showed that the Ultimate tensile strength (UTS) (590N/mm^2 and 410 N/mm^2) for Universal-Steel and African-Steel, respectively. Appreciable impact strength of 78J was recorded for Universal-Steel against 27J for African-Steel. Hardness test result showed (43HRC and 56HRC) for Universal-Steel and African-Steel respectively. A good correlation was established between the microstructure and mechanical properties of the samples studied. The investigated properties proved that Universal-Steel is far better than African-Steel, and therefore recommended.

(Keywords: mechanical properties, structures, steel rods, reinforced concrete, failure, construction, metallography)

INTRODUCTION

The collapse of buildings has become a recurring problem in most cities of Nigeria (Nigerian Tribune, 2008). One must appreciate the heavy casualties usually recorded whenever a building, completed or under construction, collapses. Apart from the personal tragedies resulting from premature death or injury, the consequent loss of working hours and resources is a serious obstacle to a nation like ours faced with ever increasing competition for economic survival.

It has been identified that the use of poor quality and substandard steel rods are among the causes of building failure in Nigeria (Ayininuola, et al., 2004). Plain concrete is a brittle material with low strength and strain capabilities. It possesses appreciable compressive strength but little tensile strength. The use of reinforcement has helped to overcome this problem. Among engineering materials like fibers, aluminum, clays, woods, etc., steel is now the most widely used material for reinforcement of concrete due to its high tensile strength. From the available literature, much work has been done on mechanical properties (tensile strength, impact strength, hardness, etc.) of different dimensions of steel rods in Nigeria (Nnuka, et al., 2008). However, less emphasis has been placed on 16mm steel rods. Again, most authors obtained their samples from companies, but in this present work, samples were collected from the Onitcha Head Bridge Market (OHBM) in the Eastern part of Nigeria. This market is the largest in the Eastern part of Nigeria, and as such supplies over 80% of steel rods use in this part of the country.

Therefore it is necessary to assess the properties of this important material so as to get better information on the quality of this product available in our market.

Building Failure/ Collapse

Buildings must be properly planned, designed and erected to obtain desired characteristics. The factors to be considered in building construction include durability and adequate stability to prevent its failure.

Failure is an unacceptable difference between expected and observed performance. A failure can be considered as occurring in a component when that component can no longer be relied upon to fulfill its principal functions.

Applications of Steel Rods

Concrete is made up of sand, cement, and stone. When iron bars (rods) are added, it is called reinforced concrete (Uzokwe, 2001). The use of steel rods for reinforcing concrete has gained wide popularity since many decades ago. To the construction industries, steel rods are very important because of their strength and adherence to concrete and as such the most suitable for reinforcing concrete structures. Steel rods are used in beams and have also found wide applications in arches, columns, slabs, walls, etc. Steel reinforced concretes are a capital intensive hence the quality of steel rods should not be compromised at all by manufactures.

Mechanical Properties

Tensile strength, impact strength, and hardness are some of the useful mechanical properties of a material which determines how such a material would behave while in use. Mechanical properties of materials are ascertained by performing carefully designed laboratory experiments that replicate as nearly as possible the service conditions.

MATERIALS AND METHODS

16mm steel rods samples were collected from two different depots in (OHBM). Specimens from depot A are referred to as Universal-Steel while that from depot B is referred to as African-Steel. The samples were subjected to tensile, impact, hardness, and micrographic tests. Standard specimens were prepared according to the requirement of each test. Apart from the micrographic test, each test was conducted three times and the average taken.

Tensile Test

This test was conducted using a hydraulic extensometer. The samples were machined to standard shape using lathe machine. Each specimen has gauge length of 50mm and gauge diameter of about 13mm.

From the tensile test, the yield and tensile strength, the percentage elongation (ductility), were determined. The tensile strength is given according to (Dieter, 1988) as:

$$S_u = \frac{P_{max}}{A_O} \qquad \textbf{(1)}$$

where,

$S_u = Ultimate\ tensile\ strenght\ (N/mm^2)$
$P_{max} = Maximum\ load\ applied\ (KN)$
$A_O = Original\ Crosssectional\ area\ (mm)$

The percentage elongation (ductility %) after fracture (e_f) is given as:

$$e_f = \frac{L_f - L_o}{L_O} \times 100 \qquad \textbf{(2)}$$

where,

$L_f = Guage\ lenght\ at\ fracture\ (mm)$
$L_O = The\ original\ guage\ lenght (mm)$

Impact Test

Impact strength test was carried out using an Izod test technique. The Izod test is the most commonly used method for steel (Davis, et al., 1964). For both samples, three standard specimens were tested three times and the average value recorded. The specimen was clamped in a horizontal position with the centre of the notch in line with the upper face of the jaws. A weighted pendulum was released from the rest position and allowed to strike the notched specimen held in the vice. The energy absorbed to fracture the specimen was read and recorded. The process was repeated three times for each sample and the average value recorded.

Hardness Test

This test was conducted using a Rockwell hardness testing machine. The specimen was placed with the surface on the anvil, and by slowly turning the hard wheel; the specimen was raised until it touched the indenter. The numbers were read from the dial indicator and converted to the Rockwell number. The entire process was repeated three times for each sample and the average value taken.

Micrograph

The standard test technique was used in conducting this test. A table size metallographic microscope was used to study the specimens. The micrograph images were captured at magnifications 200 and 500 for each specimen. One specimen from each of the sample was grounded roughly, finely and finally polished and etched. Abrasive of 320, 400, and 600 grits were used in fine grinding, with the corresponding particles sizes of silicon carbide of 33, 23 and 17 microns respectively (Nnuka, et al., 2008). While powdered diamond dust abrasives of 6 micron size, was used in rough polishing. This was poured on emerald cloth covering the surface of the rotating polish wheel. Final polishing was done using alumina of particle size- 0.05µ. It was also poured on the emerald cloth covered wheel and distilled water served as lubricant. Etching was done using natal (2% solution of nitric acid in alcohol). The etching of each specimen lasted for about 3 seconds.

RESULTS AND DISCUSSION

The results of the mechanical properties of the studied 16mm steel rods are shown in Table 1, while the micrographs are displayed in Plates 1 to 4.

The Ultimate tensile strength (UTS) recorded in both samples is 590N/mm^2 and 410N/mm^2 respectively. This shows that Universal-Steel has significantly higher tensile strength than African-Steel; though the tensile strength obtained from both sample fell within the Nigerian Industrial Standard (NIS,1992) recommended value of 410N/mm^2. The higher tensile strength recorded by Universal-Steel, could be attributed to the fine grained microstructure as shown in Plate 1. Fine grained microstructure results in higher strength in alloys.

Universal-Steel also recorded better ductility or percentage elongation (28.6%) than African-Steel (19.6%). NIS, (1992), recommended 10% as the minimum elongation. Comparing Plates 2 and 4, it could be observed that Plate 4 showed more pearlite concentration than Plate 2. Honeycombe et al. (1995) stated that pearlite has adverse effect on ductility, as it provides sites for easy nucleation of cracks.

Impact Test Result

The impact strength result is shown in Table 1. It showed that the impact strength obtained from Universal-Steel is 78J while African-Steel recorded 27J. This strength is an indication of the level of toughness of the material. Again a look at plates 2 and 4 tend to justify the claim made by Honeycombe and Co that low energy absorbed in impact test on pearlite structures arise from the fact that many crack nuclei can occur at the pearlite interfaces which could restrict plastic deformation.

Hardness Test Result

The hardness valued obtained in African-Steel is significantly higher than that of Universal-Steel. This could be identified in the micrograph (Plate 4). Plate 4 showed many darker cementites that are very hard compared with softer white ferrites (Callister, 2006).

Table 1: Mechanical Properties of 16mm Steel Ribbed Rods.

Test	Universal-Steel			African-Steel		
	UTS (N/mm^2)	Yield strength	Ductility (%)	UTS (N/mm^2)	Yield strength	Ductility (%)
Tensile Strength and Ductility	590	418	28.6	410	380	18.7
Impact Strength	Energy Absorbed (J)					
	78			27		
Hardness	Hardness (HRC)					
	43			56		

Micrograph Result

Plates 1 and 2, showed fine grain structures that is evenly distributed, which is evident in the higher mechanical properties recorded by Universal-Steel. In Plate 3, coarse grains were observed which may have affected the mechanical properties of African-Steel.

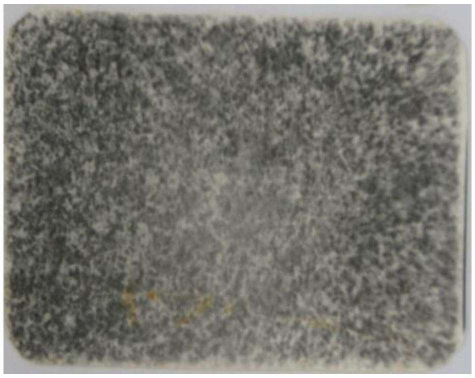

Plate 1: Microstructure of 16mm Steel Rod (Universal-Steel), x 200.

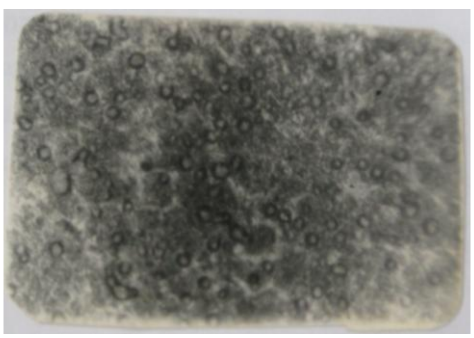

Plate 2: Microstructure of 16mm Steel Rod (Universal-Steel), x 500.

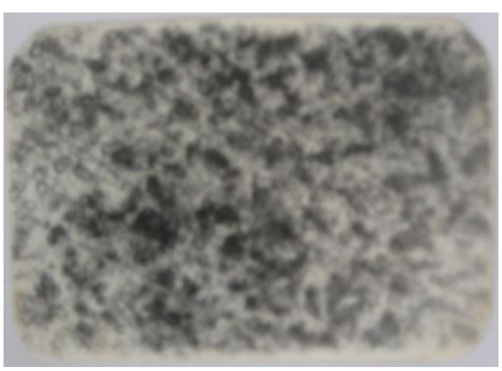

Plate3: Microstructure of 16mm Steel Rod (African-Steel), x 200.

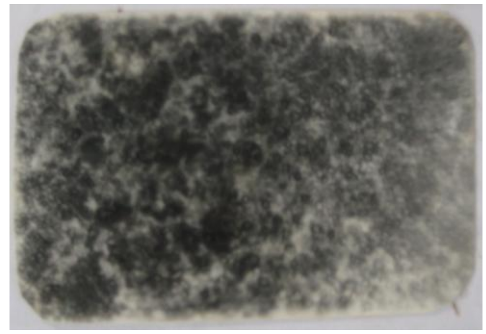

Plate 4: Microstructure of 16mm Steel Rod (African-Steel), x 500.

CONCLUSION

It can be concluded that of the mechanical properties of the two samples studied, Universal-Steel out classed African-Steel, except in hardness. Since tensile strength, ductility, and impact strength are the properties of interest in most engineering applications of steel rods, Universal-Steel is therefore recommended. But when hardness is the desired property, African-Steel may be considered. The government at both federal and state level should establish institutions to test steel rods before any construction as a way of checking building failures in Nigeria.

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