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Investigation of Bend Characterices of Reinforcing Steel Used In the Nigerian Construction Industries

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Abstract: *This paper examines the mechanical properties of the reinforcing steel bars used in the Nigerian Construction Industry. Tensile test were conducted to ascertain the tensile characteristics of the steel bars with regards to their level of conformity to the BS 4449: 1997 provisions. Four hundred and eighteen samples of bars from fourteen steel producing companies were used in the experiment and seven hundred and sixty test results obtained. It was found that eighty five percent of the samples tested fell short of BS 4449: 1997 provision. The research draws the attention of the regulatory bodies to the quality of reinforcing steel bars in the market. The study finally recommends that all imported reinforcing steel bars should be checked for quality compliance with an accredited certificate before entering into the country*

Keywords*: Steel bar, Tensile tests, BS4449:1975, Mechanical properties, Percentage elongation) Chukwudi, B.C and Onyeka, J.O.*

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I. Introduction

Steel is an important solid substance needed by people to meet their needs and desires. It is part of everyday operations, in urban development, rural development, the developed and developing countries. It is extensively used in automobiles and railroads, small housing to large multi-family dwellings, construction industries, delivering energy such as electricity and natural gas, and supplying water through pumps and pipelines. Steel is an iron-based material containing low amounts of carbon and alloying elements that can be made into thousands of compositions with exacting properties to meet a wide range of needs. Between twenty-four to twenty-six different elements are used in various proportions and combinations in the manufacture of both carbon and low alloy structural steels. However, all finished steel bars for reinforced work are ensured sound, free from cracks, neatly rolled to the dimension and weight as specified. Several studies have been carried out on improving the mechanical properties of steel. Arum, C. (2007) did a study on methods to classify defects such as cracks, dark spots, and sharp marks, of steel Bar Coil (BIC) with cylindrical shape. Each of these defects was qualified serious, and could harm the quality of the product relatively. Amir and Morteza (2013) did a study and presented comparative experimental data on the mechanical properties of reinforcing steel rods. The URW1050 steel fibres and HPP45 synthetic fibres, both with the same concrete design mix, were used to make cube specimens for compression tests, cylinders for tensile split tests and beam specimens for flexural tests. The experimental data demonstrated the steel fibre reinforced concrete is stronger in flexure at early stages, while both fibre reinforced concrete types displayed comparatively the same performance in compression, tensile splitting and 28-day flexural strength. In terms of post-crack control, HPP45 was found to be preferable. This work is a comparative study of the mechanical properties such as yield strength, ultimate tensile strength, percentage elongation and hardness, of locally made steel bars from scraps and imported steel bars. These properties are then compared to the values provided by the BS code to ascertain the level of conformity.

II. Literature Review

2.1 Requirements for Reinforcing Steel

The UK Certification Authority for Reinforcing Steels, Part one 1999 has prescribed that satisfactory reinforcing steel must be able to:-

1. Be bent into shape with precision to fit complicated structures.
2. Possess a minimum strength to discharge its load bearing function.
3. Possess ductility to satisfy formability requirements to be bent into the designed shape and also sufficient ductility to provide progressive failure under certain conditions.
4. Possess good weldability in part, for site fabrications and in part to minimize damage. For many structures of particular design, possess good fatigue properties.

5. Possess good bond properties.

2.2 Mechanical Properties of Reinforcing Bars

According to the BS 4449 (1997), the main mechanical properties of reinforcing steel bars are shown in table 1.0

Table 2.1 Tensile Properties of Reinforcing Bars

Grade	Yield Strength N/mm2	Tensile Yield Ratio	Elongation at fracture %	Total elongation at Maximum Force %
250	250	1.15	22	-
460A	460	1.05	12	2.5
460B	460	1.08	14	5

Source: BS4449 (1997)

According to Alabi, A.G.F and Onyeji L.I; (2010), tensile properties indicate how reinforcing steel bar will react when subjected to tensile forces. A tensile test is a fundamental mechanical test where a carefully prepared specimen is loaded in a very controlled manner while measuring the applied load and the elongation of the specimen over some distance. Tensile tests results are used to deduce the modulus of elasticity, elastic limit, elongation, proportional limit, reduction in area, tensile strength, yield point, yield strength amongst various others.

III. Materials And Method

3.1 Samples Collection

Samples were collected from fourteen different sources. Six of the sources were foreign and their actual names were not known, but only the countries of origin were specified. Thus, there were nineteen samples from fourteen different companies including the foreign ones which were considered in the test. The samples of bars collected from different sources are as shown in table 3.1

Table 3.1 Steel Reinforcing Bar Samples Collection and Identification

S/NO	Company/Country	Identification	Diameter Collected (mm)
01	Sunflage Steel Company, Lagos, Nigeria.	A	10,12
02	Universal Steel Company, Lagos, Nigeria	B	8, 10
03	Mayor Steel Company, Lagos, Nigeria	C	8, 10, 16
04	Sankyo. Lagos, Nigeria	D	20, 25
05	Nigeria-Spanish. Kano	E	12
06	Katsina Steel Rolling Mill. Katsina. Nigeria	F	12
07	Delta Steel Company Ltd. Warri. Nigeria	G	16
08	Oshogbo Steel Rolling Company Ltd. Oshogbo. Nigeria	H	12
09	Ukraine. Asia	I	8
10	Cote D’’ivoire, West Africa.	J	8
11	Russia, Asia	K	12
12	Brazil, South America.	M	10
13	Holland, Europe.	N	16
14	Unknown-Foreign Source	O	10

3.2 Sample Labelling

The fourteen companies from which samples were collected have been labelled in an alphabetical order such as A, B, C, D, E, F, G, H, I, J, K, M, N and O for identification purposes (Table 3.1)

3.3 Sample Preparation

For the tension test, ten samples were tested for each diameter and consists a length of five hundred millimetres (500mm) each. The sample diameter was measured in three places and the average was taken as the sample diameter. The results are as shown in Table 3.2. The tests were done in accordance with BS 4449: 1997, clause 1.9 and BS 4449 (1969) clause 15.

3.4 Basic Equations

The basic equations used in this research are

Effective cross sectional area Aeff = M/ 0.0785 (i)

Alternatively, Area $= \frac{\pi d^2}{4}$ (ii)

Yield Stress $= \frac{Yield\ Load}{Cross-Sectional\ Area}$ (N/mm^2) (iii)

Ultimate Stress $= \frac{Ultimate\ Load}{Cross-Sectional\ Area}$ (N/mm^2) (iv)

Ultimate/Yield Ratio $= \frac{Ultimate\ Stress}{Yield\ Stress}$(N/mm^2)
Characteristic strength: $f_c = f_m - 1.64\ ð$ (v)
Average Mean Strength (F_m) $= \frac{\sum Yield\ Strss}{Number\ of\ Specimen(N)}$ (vi)
Stress $= \frac{Load}{Area}$ (vii)
Design strength $= \frac{Characteristics\ strength\ \mathrm{fc}}{Partial\ factor\ of\ safety\ ym}$ (viii)
Average Elongation$= \frac{\sum Elongation}{Nunber\ of\ Specimen(N)}$(ix)
Percentage Elongation (e_f) $= \frac{L_{f-L_o}}{Lo} \times 100$ (x)
Average Ultimate strength $= \frac{\sum Ultimate\ Stress}{\sum N}$
Standard deviation (ð) $= \sqrt{\frac{\sum fd^2}{\sum f}}$ (xi)

Table 3.2 Measured Diameters and Cross Sectional Areas for Samples

S/NO	Mark	Market Assumed Diameter (mm)	Average Measured Diameter (mm)	Average Mass (kg)	Average Cross-Sectional Area (mm2)
01	$A_{12}T$	12.00	11.88	0.338	86.14
02	$A_{10}T$	10.00	9.65	0.282	71.96
03	$B_{10}T$	10.00	9.65	0.279	70.98
04	B_8T	8.00	7.44	0.189	48.37
05	$C_{16}T$	16.00	15.82	0.629	160.14
06	$C_{10}T$	10.00	9.55	0.284	72.42
07	$E_{25}T$	25.00	24.56	1.244	316.93
08	$E_{20}T$	20.00	19.57	1.103	281.13
09	$F_{12}T$	12.00	11.40	0.349	88.84
10	$G_{12}T$	12.00	11.48	0.334	85.17
11	$H_{16}T$	16.00	15.52	0.376	95.77
12	$I_{12}T$	12.00	11.40	0.343	87.47
13	$K_{10}T$	10.00	9.36	0.276	70.12
14	$L_{12}T$	12.00	11.82	0.430	110.30
15	$M_{10}T$	10.00	9.23	0.282	71.71
16	$N_{16}T$	16.00	15.60	0.829	211.28

IV. Results And Discussions

4.1 Bend Test

The bend test was carried out to prescriptions and in accordance to the BS 4449:1997 provisions.

Table 4.1 Twelve Millimetre Diameter Bars from Company A (Sample 1-10)

S/No.	Identification Number	Bar Size (mm)	Former Diameter	Observations After Test	Remarks
01	$A_{12}B_1$	12.0	39.0	No Cracks	Ok
02	$A_{12}B_2$	12.0	39.0	No Cracks	Ok
03	$A_{12}B_3$	12.0	39.0	No Cracks	Ok
04	$A_{12}B_4$	12.0	39.0	No Cracks	Ok
05	$A_{12}B_5$	12.0	39.0	No Cracks	Ok
06	$A_{12}B_6$	12.0	39.0	No Cracks	Ok
07	$A_{12}B_7$	12.0	39.0	No Cracks	Ok
08	$A_{12}B_8$	12.0	39.0	No Cracks	Ok
09	$A_{12}B_9$	12.0	39.0	No Cracks	Ok
10	$A_{12}B_{10}$	12.0	39.0	No Cracks	Ok

In the entire specimen tested for 12mm and gauge diameter of 39mm, no cracks were observed.

Table 4.2 Ten Millimetre Diameter Bars from Company A (Sample 1-10)

S/No.	Identification Number	Bar Size (mm)	Former Diameter	Observations After Test	Remarks
01	$A_{10}B_1$	10.0	33.0	No Cracks	Ok
02	$A_{10}B_2$	10.0	33.0	No Cracks	Ok
03	$A_{10}B_3$	10.0	33.0	No Cracks	Ok
04	$A_{10}B_4$	10.0	33.0	No Cracks	Ok
05	$A_{10}B_5$	10.0	33.0	No Cracks	Ok
06	$A_{10}B_6$	10.0	33.0	No Cracks	Ok

07	$A_{10}B_7$	10.0	33.0	No Cracks	Ok
08	$A_{10}B_8$	10.0	33.0	No Cracks	Ok
09	$A_{10}B_9$	10.0	33.0	No Cracks	Ok
10	$A_{10}B_{10}$	10.0	33.0	No Cracks	Ok

In the entire specimen tested for 10mm and gauge diameter of 33mm, no cracks were observed

Table 4.3 Ten Millimetre Diameter Bars from Company B (Sample 1-10)

S/No.	Identification Number	Bar Size (mm)	Former Diameter	Observations After Test	Remarks
01	$B_{10}B_1$	10.0	33.0	No Cracks	Ok
02	$B_{10}B_2$	10.0	33.0	No Cracks	Ok
03	$B_{10}B_3$	10.0	33.0	No Cracks	Ok
04	$B_{10}B_4$	10.0	33.0	No Cracks	Ok
05	$B_{10}B_5$	10.0	33.0	No Cracks	Ok
06	$B_{10}B_6$	10.0	33.0	No Cracks	Ok
07	$B_{10}B_7$	10.0	33.0	No Cracks	Ok
08	$B_{10}B_8$	10.0	33.0	No Cracks	Ok
09	$B_{10}B_9$	10.0	33.0	No Cracks	Ok
10	$B_{10}B_{10}$	10.0	33.0	No Cracks	Ok

In the entire specimen tested for 10mm and gauge diameter of 33mm, no cracks were observed

Table 4.4 Sixteen Millimetre Diameter Bars from Company C (Sample 1-10)

S/No.	Identification Number	Bar Size (mm)	Former Diameter	Observations After Test	Remarks
01	$C_{16}B_1$	16.0	51.0	Total Breakage	Not Ok
02	$C_{16}B_2$	16.0	51.0	Total Breakage	Not Ok
03	$C_{16}B_3$	16.0	51.0	Total Breakage	Not Ok
04	$C_{16}B_4$	16.0	51.0	Total Breakage	Not Ok
05	$C_{16}B_5$	16.0	51.0	Total Breakage	Not Ok
06	$C_{16}B_6$	16.0	51.0	Total Breakage	Not Ok
07	$C_{16}B_7$	16.0	51.0	Total Breakage	Not Ok
08	$C_{16}B_8$	16.0	51.0	Total Breakage	Not Ok
09	$C_{16}B_9$	16.0	51.0	Total Breakage	Not Ok
10	$C_{16}B_{10}$	16.0	51.0	Total Breakage	Not Ok

In the entire specimen tested for 16mm and gauge diameter of 51mm, no cracks were observed

Table 4.5 Ten Millimetre Diameter Bars from Company C (Sample 1-10)

S/No.	Identification Number	Bar Size (mm)	Former Diameter	Observations After Test	Remarks
01	$C_{10}B_1$	10.0	33.0	No Cracks	Ok
02	$C_{10}B_2$	10.0	33.0	No Cracks	Ok
03	$C_{10}B_3$	10.0	33.0	No Cracks	Ok
04	$C_{10}B_4$	10.0	33.0	No Cracks	Ok
05	$C_{10}B_5$	10.0	33.0	No Cracks	Ok
06	$C_{10}B_6$	10.0	33.0	No Cracks	Ok
07	$C_{10}B_7$	10.0	33.0	No Cracks	Ok
08	$C_{10}B_8$	10.0	33.0	No Cracks	Ok
09	$C_{10}B_9$	10.0	33.0	No Cracks	Ok
10	$C_{10}B_{10}$	10.0	33.0	No Cracks	Ok

In the entire specimen tested for 10mm and gauge diameter of 33mm, no cracks were observed

Table 4.6 Twenty Millimetre Diameter Bars from Company E (Sample 1-10)

S/No.	Identification Number	Bar Size (mm)	Former Diameter	Observations After Test	Remarks
01	$E_{25}B_1$	25.0	78.0	No Cracks	Ok
02	$E_{25}B_2$	25.0	78.0	No Cracks	Ok
03	$E_{25}B_3$	25.0	78.0	No Cracks	Ok
04	$E_{25}B_4$	25.0	78.0	No Cracks	Ok
05	$E_{25}B_5$	25.0	78.0	No Cracks	Ok
06	$E_{25}B_6$	25.0	78.0	No Cracks	Ok
07	$E_{25}B_7$	25.0	78.0	No Cracks	Ok
08	$E_{25}B_8$	25.0	78.0	No Cracks	Ok
09	$E_{25}B_9$	25.0	78.0	No Cracks	Ok
10	$E_{25}B_{10}$	25.0	78.0	No Cracks	Ok

In the entire specimen tested for 25mm and gauge diameter of 78mm, no cracks were observed

Table 4.7 Twenty Millimetre Diameter Bars from Company E (Sample 1-10)

S/No.	Identification Number	Bar Size (mm)	Former Diameter	Observations After Test	Remarks
01	$E_{20}B_1$	20.0	63.0	No Cracks	Ok
02	$E_{20}B_2$	20.0	63.0	No Cracks	Ok
03	$E_{20}B_3$	20.0	63.0	No Cracks	Ok
04	$E_{20}B_4$	20.0	63.0	No Cracks	Ok
05	$E_{20}B_5$	20.0	63.0	No Cracks	Ok
06	$E_{20}B_6$	20.0	63.0	No Cracks	Ok
07	$E_{20}B_7$	20.0	63.0	No Cracks	Ok
08	$E_{20}B_8$	20.0	63.0	No Cracks	Ok
09	$E_{20}B_9$	20.0	63.0	No Cracks	Ok
10	$E_{20}B_{10}$	20.0	63.0	No Cracks	Ok

In the entire specimen tested for 20mm and gauge diameter of 63mm, no cracks were observed

Table 4.8 Twelve Millimetre Diameter Bars from Company F (Sample 1-10)

S/No.	Identification Number	Bar Size (mm)	Former Diameter	Observations After Test	Remarks
01	$F_{12}B_1$	12.0	39.0	No Cracks	Ok
02	$F_{12}B_2$	12.0	39.0	No Cracks	Ok
03	$F_{12}B_3$	12.0	39.0	No Cracks	Ok
04	$F_{12}B_4$	12.0	39.0	No Cracks	Ok
05	$F_{12}B_5$	12.0	39.0	No Cracks	Ok
06	$F_{12}B_6$	12.0	39.0	No Cracks	Ok
07	$F_{12}B_7$	12.0	39.0	No Cracks	Ok
08	$F_{12}B_8$	12.0	39.0	No Cracks	Ok
09	$F_{12}B_9$	12.0	39.0	No Cracks	Ok
10	$F_{12}B_{10}$	12.0	39.0	No Cracks	Ok

In the entire specimen tested for 12mm and gauge diameter of 39mm, no cracks were observed

Table 4.9 Twelve Millimetre Diameter Bars from Company H (Sample 1-10)

S/No.	Identification Number	Bar Size (mm)	Former Diameter	Observations After Test	Remarks
01	$H_{12}B_1$	12.0	39.0	No Cracks	Ok
02	$H_{12}B_1$	12.0	39.0	No Cracks	Ok
03	$H_{12}B_1$	12.0	39.0	No Cracks	Ok
04	$H_{12}B_1$	12.0	39.0	No Cracks	Ok
05	$H_{12}B_1$	12.0	39.0	No Cracks	Ok
06	$H_{12}B_1$	12.0	39.0	No Cracks	Ok
07	$H_{12}B_1$	12.0	39.0	No Cracks	Ok
08	$H_{12}B_1$	12.0	39.0	No Cracks	Ok
09	$H_{12}B_1$	12.0	39.0	No Cracks	Ok
10	$H_{12}B_1$	12.0	39.0	No Cracks	Ok

In the entire specimen tested for 12mm and gauge diameter of 39mm, no cracks were observed

Table 4.10 Sixteen Millimetre Diameter Bars from Company I (Sample 1-10)

S/No.	Identification Number	Bar Size (mm)	Former Diameter	Observations After Test	Remarks
01	$I_{16}B_1$	16.0	51.0	No Cracks	Ok
02	$I_{16}B_2$	16.0	51.0	No Cracks	Ok
03	$I_{16}B_3$	16.0	51.0	No Cracks	Ok
04	$I_{16}B_4$	16.0	51.0	No Cracks	Ok
05	$I_{16}B_5$	16.0	51.0	No Cracks	Ok
06	$I_{16}B_6$	16.0	51.0	No Cracks	Ok
07	$I_{16}B_7$	16.0	51.0	No Cracks	Ok
08	$I_{16}B_8$	16.0	51.0	No Cracks	Ok
09	$I_{16}B_9$	16.0	51.0	No Cracks	Ok
10	$I_{16}B_{10}$	16.0	51.0	No Cracks	Ok

In the entire specimen tested for 16mm and gauge diameter of 51mm, no cracks were observed

Table 4.11 Twelve Millimetre Diameter Bars from Company J (Sample 1-10)

S/No.	Identification Number	Bar Size (mm)	Former Diameter	Observations After Test	Remarks
01	$J_{12}B_1$	12.0	39.0	No Cracks	Ok
02	$J_{12}B_2$	12.0	39.0	No Cracks	Ok
03	$J_{12}B_3$	12.0	39.0	No Cracks	Ok
04	$J_{12}B_4$	12.0	39.0	No Cracks	Ok
05	$J_{12}B_5$	12.0	39.0	No Cracks	Ok
06	$J_{12}B_6$	12.0	39.0	No Cracks	Ok
07	$J_{12}B_7$	12.0	39.0	No Cracks	Ok
08	$J_{12}B_8$	12.0	39.0	No Cracks	Ok
09	$J_{12}B_9$	12.0	39.0	No Cracks	Ok
10	$J_{12}B_{10}$	12.0	39.0	No Cracks	Ok

In the entire specimen tested for 12mm and gauge diameter of 39mm, no cracks were observed

Table 4.12 Ten Millimetre Diameter Bars from Company K (Sample 1-10)

S/No.	Identification Number	Bar Size (mm)	Former Diameter	Observations After Test	Remarks
01	$K_{10}B_1$	10.0	33.0	No Cracks	Ok
02	$K_{10}B_2$	10.0	33.0	No Cracks	Ok
03	$K_{10}B_3$	10.0	33.0	No Cracks	Ok
04	$K_{10}B_4$	10.0	33.0	No Cracks	Ok
05	$K_{10}B_5$	10.0	33.0	No Cracks	Ok
06	$K_{10}B_6$	10.0	33.0	No Cracks	Ok
07	$K_{10}B_7$	10.0	33.0	No Cracks	Ok
08	$K_{10}B_8$	10.0	33.0	No Cracks	Ok
09	$K_{10}B_9$	10.0	33.0	No Cracks	Ok
10	$K_{10}B_{10}$	10.0	33.0	No Cracks	Ok

In the entire specimen tested for 10mm and gauge diameter of 33mm, no cracks were observed

Table 4.13 Ten Millimetre Diameter Bars from Company M (Sample 1-10)

S/No.	Identification Number	Bar Size (mm)	Former Diameter	Observations After Test	Remarks
01	$M_{10}B_1$	10.0	33.0	No Cracks	Ok
02	$M_{10}B_2$	10.0	33.0	No Cracks	Ok
03	$M_{10}B_3$	10.0	33.0	No Cracks	Ok
04	$M_{10}B_4$	10.0	33.0	No Cracks	Ok
05	$M_{10}B_5$	10.0	33.0	No Cracks	Ok
06	$M_{10}B_6$	10.0	33.0	No Cracks	Ok
07	$M_{10}B_7$	10.0	33.0	No Cracks	Ok
08	$M_{10}B_8$	10.0	33.0	No Cracks	Ok
09	$M_{10}B_9$	10.0	33.0	No Cracks	Ok
10	$M_{10}B_{10}$	10.0	33.0	No Cracks	Ok

In the entire specimen tested for 10mm and gauge diameter of 33mm, no cracks were observed

Table 4.14 Sixteen Millimetre Diameter Bars from Company N (Sample 1-10)

S/No.	Identification Number	Bar Size (mm)	Former Diameter	Observations After Test	Remarks
01	$N_{16}B_1$	16.0	51.0	No Cracks	Ok
02	$N_{16}B_2$	16.0	51.0	No Cracks	Ok
03	$N_{16}B_3$	16.0	51.0	No Cracks	Ok
04	$N_{16}B_4$	16.0	51.0	No Cracks	Ok
05	$N_{16}B_5$	16.0	51.0	No Cracks	Ok
06	$N_{16}B_6$	16.0	51.0	No Cracks	Ok
07	$N_{16}B_7$	16.0	51.0	No Cracks	Ok
08	$N_{16}B_8$	16.0	51.0	No Cracks	Ok
09	$N_{16}B_9$	16.0	51.0	No Cracks	Ok
10	$N_{16}B_{10}$	16.0	51.0	No Cracks	Ok

In the entire specimen tested for 16mm and gauge diameter of 51mm, no cracks were observed

Table 4.15: Bend Test Results for Fourteen Companies

S/No	Identification No.	Bar Size (mm)	Former Diameter	Observations	Remarks
1.	$A_{12}B$	12.0	39.0	No Cracks	Satisfactory
2.	$A_{10}B$	10.0	33.0	No Cracks	Satisfactory
3.	$B_{10}B$	10.0	33.0	No Cracks	Satisfactory
4.	$C_{16}B$	16.0	51.0	Total Breakage	Satisfactory
5.	$C_{10}B$	10.0	33.0	No Cracks	Satisfactory
6.	$C_{12}B$	12.0	33.0	No Cracks	Satisfactory
7.	$E_{25}B$	25.0	78.0	No Cracks	Satisfactory
8.	$E_{20}B$	20.0	63.0	No Cracks	Satisfactory
9.	$F_{12}B$	12.0	39.0	No Cracks	Satisfactory
10.	$G_{12}B$	12.0	39.0	No Cracks	Satisfactory
11.	$H_{16}B$	16.0	51.0	No Cracks	Satisfactory
12.	$I_{12}B$	12.0	39.0	No Cracks	Satisfactory
13.	$K_{10}B$	10.0	33.0	No Cracks	Satisfactory
14.	$L_{12}B$	12.0	39.0	No Cracks	Satisfactory
15.	$M_{10}B$	10.0	33.0	No Cracks	Satisfactory
16.	$N_{16}B$	16.0	51.0	No Cracks	Satisfactory

Fifteen out of the sixteen samples have passed the bend test, as neither micro cracks was observed, nor any form of unacceptable deformation. However, the ten specimens constituting sample $C_{16}B$ as reflected in table 4.15 did not complied with the codes requirement.

Table 4.16: Testing of Selected Tensile and Bend Test Parameters

S/No	Mark	Source	Percentage Elongation	Bend Test	Remarks
1.	$A_{12}T$	Local	T	T	Not Satisfactory
2.	$A_{10}T$	Local	X	T	Not Satisfactory
3.	$B_{10}T$	Local	T	T	Not Satisfactory
4.	$C_{16}T$	Local	X	T	Not Satisfactory
5.	$C_{10}T$	Local	T	T	Not Satisfactory
6.	$E_{25}T$	Local	T	T	Not Satisfactory
7.	$E_{20}T$	Local	T	T	Not Satisfactory
8.	$F_{12}T$	Local	T	T	Not Satisfactory
9.	$G_{12}T$	Local	T	T	Not Satisfactory
10.	$H_{16}T$	Local	T	T	Not Satisfactory
11.	$I_{12}T$	Local	T	T	Not Satisfactory
12.	$K_{10}T$	Foreign	X	T	Not Satisfactory
13.	$L_{12}T$	Foreign	T	T	Not Satisfactory
14.	$M_{10}T$	Foreign	T	T	Not Satisfactory
15.	$N_{16}T$	Foreign	X	T	Not Satisfactory

Legend: T=>Within Code Provision: X=> Outside Code Provision: $_*$=>No Trace of the Element

Nine companies out of eleven local company bars are within the range of code provision,, while two companies' bars are outside code provision in percentage elongation. Three companies out of five foreign company bars are within the range of code provision, while two companies bar are outside code provision in percentage elongation.

V. Conclusion And Recommendations

5.1 Conclusion

Based on the results of the tests conducted, the following conclusions were made.

1. Most of the bars could not comply with the rolling deviations over and under nominal mass as provided by BS 4449:1969, 1995 and 1997 respectively.
2. The characteristic strength values for 92% of the locally produced bar samples are low , compared to the BS 4449:1969, 1995 and 1997 standards for high tensile steel which is 460N/mm^2 minimum value.
3. The characteristic strength values in respect of the local bars suggest similarities to that of mild steel as determined by the tensile test. This implies that products are actually mild steel rolled and openly sold as high tensile steel after rethreading.
4. 95 % of the reinforcement bar samples complied with the minimum ultimate to yield strength ratio as specified by BS 4449, (1969) and (1997) code provisions.
5. The percentage elongation values for the locally produced bar samples are within acceptable code limits of 92%.
6. The percentage elongation values for 67 % of the foreign bar samples are below 33% of the minimum standard provisions.

5.2 Recommendations

On the basis of the findings of this study, the following recommendations are made:

1. There is a need to develop a local standard which will give clear guidelines based on characteristics strength, bend tests, elongation and percentage elemental compositions as determined in the laboratory for applications in structural design.
2. There should be technical information on all steel reinforcement sold in the open markets so as to guide the designers on their strength and deformation characteristics.
3. Regulatory authorities such as the Standards Organisation of Nigeria, Council for the Regulation of Engineering in Nigeria and tertiary institutions should strengthen their collaborations on ensuring quality standards through materials testing.
4. Steel rolling mills in the country should be compelled to make their quality testing facilities available to regulatory and other quality enforcement agencies for periodic inspection and compliance.
5. All imported reinforcement steel must be checked for quality compliance prior to accepting such consignment into the country and such must be accompanied with an accredited certification.

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