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INVESTIGATION INTO THE STRENGTH CHARACTERISTICS OF REINFORCEMENT STEEL RODS IN SOKOTO MARKET, SOKOTO STATE NIGERIA

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Abstract: Reinforcement has been identified as a method of increasing the strength properties of reinforced concrete structural members. Steel rods of different diameters have also been prescribed for use in reinforcing our concrete which up till today has being in use. However, for any reinforcing steel rod to be adequate for its action as reinforcing material, it should satisfy basic characteristics such as yield strength, ultimate strength, percentage elongation and nominal diameter. Steel rods are used everyday in different construction sites in Sokoto city but their suitability is still not confirmed. This therefore prompted the researcher in selecting 10 samples of Y_{10} and Y_{16} for strength analysis. It was observed that none of the selected samples meet the nominal diameter criteria as average diameters were 9.68mm for Y_{10} and 15.76mm for Y_{16}mm. Average values of yield strength were 448 N/mm^2 and 409 N/mm^2 as against 460 N/mm^2 dictated by the BS8110 and BS4449. Percentage elongation was 15% for both Y_{10} and Y_{16}. It was therefore recommended that the appropriate authorities should enforce the laws guiding production and distribution of reinforcement in the country for optimum safety.
Keywords; BS Standard, Concrete, Nominal Diameter, Reinforcement, Yield Strength.

1.0 Introduction

Steel is the time proven match for reinforcing concrete structures. Reinforced concrete structure is designed on the principle that steel and concrete act together to withstand induced forces. The properties of thermal expansion for both steel and concrete are approximately the same; this along with excellent bendability property makes steel the best material as reinforcement in concrete structures. Another reason steel works effectively as reinforcement is that it bonds well with concrete. When passive reinforcement (steel bars) is employed, the structure is known as reinforced concrete (RC) structure. In prestressed concrete structure, the reinforcement (steel wire) is stressed prior to subjecting the structure to loading, which may be viewed as active reinforcement. Passive steel reinforcing bars, also known as rebars, should necessarily be strong in tension and, at the same time, be ductile enough to be shaped or bent (Prabir *et'al*, 2004). 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, (Leet and Bernal, 1997). 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 (Rao, 1961). 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. This adhesion may be enhanced with the incorporation of contours unto the surface of the steel member which permits a greater degree of mechanical interlocking (Arther *et. al*, 2004). Further bond or adhesion is provided by the natural roughness of the mill scale of hot rolled reinforcing bars (Callister, 1997). Steel is a crystalline alloy of iron, carbon and other elements, which hardens when quenched over its critical temperature. It contains no slag and may be cast, rolled or forged. Carbon is the most important constituents because of its stability to increase the hardness and strength of the steel. More mass of steel is used than all other metals combined in structural applications. Steel can be classified according to the alloying elements. Attributes of reinforcements such as bond with concrete, strength, ductility and resistance against corrosion are important for engineering of sound and durable RC structures (Alabi and Onyeji, 2010).

In Nigeria, steel bars (both locally made and imported) have been used extensively in construction. However, different building failure and collapses have been reported in different part of the country of which causes were yet to be ascertained. As one of the most important constituent of reinforced concrete, steel bars must maintain appropriate strength quality so as to remain useful as expected. In Sokoto city and its environ, a lot of construction works have been identified which invariably means steel rods have been purchased in the market for the purpose of reinforcing concrete. Based on this fact, there is a need to investigate the appropriateness of these steel bars in terms of strength and ultimately to ensure safety in our construction work.

2.0 Methodology

The specimens used in the investigation were randomly selected from steel dealers within Sokoto city. The following dealers were visited for the sample of steel rods.

- i. Okeke iron and Steel
- ii. Samuel Dike and Sons
- iii. Alhaji Buhari steels
- iv. Dogoyaro and Sons steels and
- v. O B J and Co steel dealer.

From each of these dealers, two most patronised steel types were sought in the diameter of 10mm and 16 mm which make four (4) specimens from each of the dealers. Samples were collected on the 22nd October, 2014 and were transported to Thammar Engineering Laboratory for test. The following tests were carefully performed under the laboratory conditions;

1. Percentage elongation
2. Yield strength
3. Ultimate Strength and
4. Nominal Diameter in accordance with BS 4449.

All the samples of Y_{10} were labelled LNL/Y10/01 to LNL/Y10/10 and that of Y_{16} were labelled as LNL/Y16/01 – LNL/Y16/10 for easy identification.

3.0 Results

Going by the laboratory tests carried out on the samples the following tables were generated for the two types of reinforcement bars sampled from the market in Sokoto city. The results are thereby presented as follows

3.1 Results for Y_{10} bars

Table 3.1; Characteristics of Y10 bars sampled from Sokoto market

s/n	Identification No	Nominal diameter (mm)	Area (mm^2)	Yield Stress (N/mm^2)	Ultimate Stress (N/mm^2)	% elongation
1	LNL/Y10/01	9.68	73.59	448.4	638.7	13.3
2	LNL/Y10/02	9.68	73.59	448.4	638.7	15.0
3	LNL/Y10/03	9.65	73.15	440.6	635.6	15.5
4	LNL/Y10/04	9.66	73.29	445.3	637.5	15.0
5	LNL/Y10/05	9.66	73.29	445.3	637.5	16.7
6	LNL/Y10/06	9.68	73.59	448.4	652.3	15.0
7	LNL/Y10/07	9.68	73.59	448.4	638.6	16.7
8	LNL/Y10/08	9.65	73.15	440.6	633.1	16.7
9	LNL/Y10/09	9.70	73.90	449.2	652.3	15.9
10	LNL/Y10/10	9.70	73.90	449.2	652.3	15.9

Source ;(Lab. Result, 2014)

From the table above, it could be seen that the parameters measured vary among all samples, the nominal diameter varies from a value of 9.65mm up to 9.70mm this affects the values of area to vary accordingly. Yield stress also varies from a value of 440.1N/mm^2 up to a value of 449.2 N/mm^2.

Equally the values for ultimate yield stress varied with the highest value obtained as 652.3 N/mm^2 and the lowest value was 633.1 N/mm^2. The percentage elongation also varied from 13.3% to 16.7%.

3.2, Results for Y16 bars

Table 3.2; Characteristics of Y16 bars sampled from Sokoto market.

s/n	Identification No	Nominal Diameter (mm)	Area (mm^2)	Yield Stress (N/mm^2)	Ultimate stress (N/mm^2)	Percentage elongation (%)
1	LNL/Y16/01	15.76	195.08	420.3	620.3	15.0
2	LNL/Y16/02	15.76	195.08	410.1	610.0	15.0
3	LNL/Y16/03	15.76	195.08	420.3	635.6	13.3
4	LNL/Y16/04	15.76	195.08	420.3	625.4	13.3
5	LNL/Y16/05	15.76	195.08	420.3	625.4	20.0
6	LNL/Y16/06	15.76	195.08	420.3	625.4	13.3
7	LNL/Y16/07	15.76	195.08	410.1	615.1	16.7
8	LNL/Y16/08	15.76	195.08	430.6	635.6	15.0
9	LNL/Y16/09	15.76	195.08	430.6	635.6	16.7
10	LNL/Y16/10	15.76	195.08	430.6	630.5	13.3

Source ;(Lab. Result, 2014)

From table 3.2 above, it could be seen that the parameters measured vary among all samples, the nominal diameter is uniform on a value of 15.76mm this make the values of area to be 195.08 mm^2 accordingly. Yield stress in its own case varied from a value of 410.1N/mm^2 up to a value of 430.6 N/mm^2. Equally the values for ultimate yield stress varied with the highest value obtained as 635.6 N/mm^2 and the lowest value was 610.0 N/mm^2. The percentage elongation also varied from 13.3% to 20.0%.

Table 3.3; Average values of strength characteristics as obtained from the laboratory results.

Parameters/ Magnitude	Values for Y10 Bars	Values for Y16 Bars	Standard values
Characteristic Strength	448 N/mm^2	409 N/mm^2	460 N/mm^2 (High yield) 250 N/mm^2 (Mild steel)
Average elongation	15%	15%	14%
Average ultimate strength	640 N/mm^2	620 N/mm^2	Varies
Nominal Diameter	9.68mm	15.76mm	10mm and 16mm

From the table 3.3 above, it is shown that the average values of characteristic strength of both Y10 and Y16 steel rods were 448 N/mm^2 and 409 N/mm^2 respectively which is lower than the value dictated by the BS standard value of 460 N/mm^2 as obtained in the BS8110 part 1, 1997. Average elongation was obtained to be 15% for both steel rods and it is greater than the minimum elongation stated by the code of practice BS 4449, 1985 which stated that the minimum elongation should be 14 %.

4.0 Conclusion and Recommendations

4.1 Conclusion

From the work so far, the following conclusions can be derived;

1. The average characteristic strength of Y10 diameter bar sampled within Sokoto retailer's shops were below standard.
2. The average characteristic strength of Y16 diameter bars selected around the Sokoto retailer's shops were below standard.
3. The Nominal diameter for the samples selected were below standard
4. The percentage elongation were above minimum in both cases and
5. The values of these strength characteristics were above the design strengths for high yield steel.

4.2 Recommendations

The following recommendations were deemed necessary for the observations made in the laboratory.

1. The regulatory bodies such as SON (Standard organisation of Nigeria) should try and intensify effort at enforcing compliance with the standard by the manufacturers.

2. Designers, civil / structural Engineers should try and introduce factors of safety in their designs as some parameters will not be accurate.
3. General material testing should be encouraged on construction sites so that disparities in the theoretical values and the available materials can be correlated.

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