AN IN-DEPTH ANALYSIS OF TENSILE STRENGTH TESTS OF REINFORCEMENT STEEL BARS (RSB) USED IN SELECTED AREAS OF NORTH WESTERN NIGERIA FOR CONSTRUCTION PURPOSES

[1]Muhammad Yanda, [2] Ibrahim Bawale [3]Musa Umar, [4]Tukur Alkali and [5]Bello Ahmad Gidadadawa

[1,5]Civil Engineering Department, [2,3,4]Mechanical Engineering Department
Umaru Ali Shinkafi Polytechnic, Sokoto
Email: mymyanda7@gmail.com

ABSTRACT

Reinforcement Steel Bars (RSB) are materials used for different constructional purposes. They are used mostly in building constructions in collaboration with concrete to bear both the dead and live loads from the buildings effectively, as concrete is said to be weak in terms of tension while steel is weak, on the other hand in terms of compression. In this research, efforts were made to analyse some results computed from steel tensile strength tests conducted on some batches of reinforcement bars used by selected construction companies within North-western Nigeria region. Four companies were selected and their results were analysed from the tensile tests conducted at the Engineering Central Workshop of Umaru Ali Shinkafi Polytechnic, Sokoto, Nigeria. From the analysis, it was concluded that all the selected companies are using reinforcement bars that conform with the prescribe strength characteristics in the British Standard. Furthermore, it was seen from the results that Company A has the highest Tensile Stress/Yield Stress ratio of 1.38, followed by Company D, 1.25, then Company C, 1.19, and lastly Company B.

Keywords: Construction, Mechanical Properties, Reinforcement, Tensile Stress, Yield.

INTRODUCTION

The use of iron has started since around 1500 B.C., during the primitive era when furnace was used to heat the ore in a mere charcoal fire. In the 18th century, furnace was advanced, when ferrous metals were produced on a relatively small scale. The advancement of technology in the second half of 19th century gave rise to the development of basic oxygen furnace and the contentious casting methods. In recent times, computer-controlled manufacturing is in increase in terms of efficiency and reduction in the cost of steel production (Mamlouk and Zaniewski, 2011).

British Standard (BSI-4449, 2005) defines reinforcing steel as “Steel product with circular or practically circular cross-section which is suitable for the reinforcement of concrete”. Reinforcement bars are important element of reinforced concrete as the tensile loads are taken by them due the fact that concrete is very poor in tension (El-Reedy, 2009).

Steel reinforcement bars or rebars are used alongside with concrete to improve the strength of the concrete members. Concrete is known to be weak in tension, but good in compression, while on the other hand, steel is good in tension but bad in compression, hence the need to combine the two in other to achieve the required strength for concrete members (theconstructor.org, 2019).

According to Tavio, and Kusuma (2018), "High strength steels (YS > 450MPa) have a significant potential contribution which still remains largely unrealized. This is predominantly due to design code limitations, the upper allowable limit of yield stress/ultimate stress ratio being particularly severe".

Aim and Objectives of the Research

This research is aimed at conducting an in-depth analysis of some tests carried out on reinforcement that are being used for building constructions in the North-western Nigeria. The objectives include;

- Determination of the physical properties of reinforcements samples from different construction companies through weighing and measurement.
- Conducting tensile tests on each of the sample at different occasions.
- Computing the results at different occasions.
- Analysis of the entire results obtained from the tests for the selected samples.

Types of Reinforcement Steel Bars (RSB)

There are different types of steel bars in use. The following are the commonest types (enggpro.com, 2022).

- Mild steel bars which contain low carbon steel content and without any significant element except iron and ferrite. Its physical appearance is round in shape without any form of deformation, which makes it very weak in bond with the concrete materials surrounding it. They are available in marketplaces in sizes ranging from 6mm to 50mm.the advantage it has over other forms of reinforcement steels is that it can easily be cut and bent without any damage.
- Deformed steel bars which possesses rough surface. It contains ribs and ridges on their surfaces due to deformations which gives it a high bond with the concrete and result to a greater strength when compare to the mild steel.
- Thermo Mechanically Treated Bars (TMT Bars), which is hot treated bars made up of two layers, the core layer and the outer layer, in terms of its structure. The core layer is of soft ferrite pearlite while the outer layer is made of tempered martensite. This bar has high tensile and elongation strength which makes it special.
- High Yeild Strength Bars (HYSD Bar) known as cold twisted steel bars. They contain high carbon content than mild steel bars. They possess ribs on the surface that provides a better grip which makes them more suitable for heavy construction projects. The bars also give increased tensile strength and malleable which makes it more efficient in use.
- Carbon Steel Bars which is made of carbon steel and known as black steel as a result of its colour due to presence of carbon. This is the commonest reinforcement used in construction industry in Nigeria and most parts of the world. This is as a result of its cheap rate. The very big disadvantage it has is that it uncoated, hence it corrodes or oxidises quickly when in contact with moisture.
- Epoxy-coated Rebar. This is a special type of steel that is coated with epoxy to protect it from getting affected when in contact with moisture. This type of bar is used for

corrosion resistance purposes. It is used in buildings and industrial buildings foundation, bridges, highway barriers and so on.

- Stainless Steel Rebars. This is the best of all reinforcements. It is highly resistant to corrosion and the best for all. They are very expensive due to its nature but delivers the best work than any other rebar. It provides great welding capability and high strength which makes it most widely used irrespective of its high cost.

Researches on Steel Tensile Tests

Hadi (2008), conducted study on the use of high strength steel bar on a beam reinforcement concrete. The steel reinforcement bars used throughout were 500 MPa grade steel with nominal diameters of 12, 16, 20, 25, 28, 32, 36 mm. For each reinforcing bar size two different concrete sizes of 240 and 300 mm in diameter were cast. All reinforcing bars were tested for their tensile strength. One strain gauge was placed on each size of the bar surface to measure the strain value during the tensile test. The change in length was recorded in millimetres at the completion of the test. The results from the tests are shown in Figure 1. The results of tensile test show that the bars were able to produce high value of strength in every specimen, except in the case of 32 mm bars where the bar failed suddenly during the test.

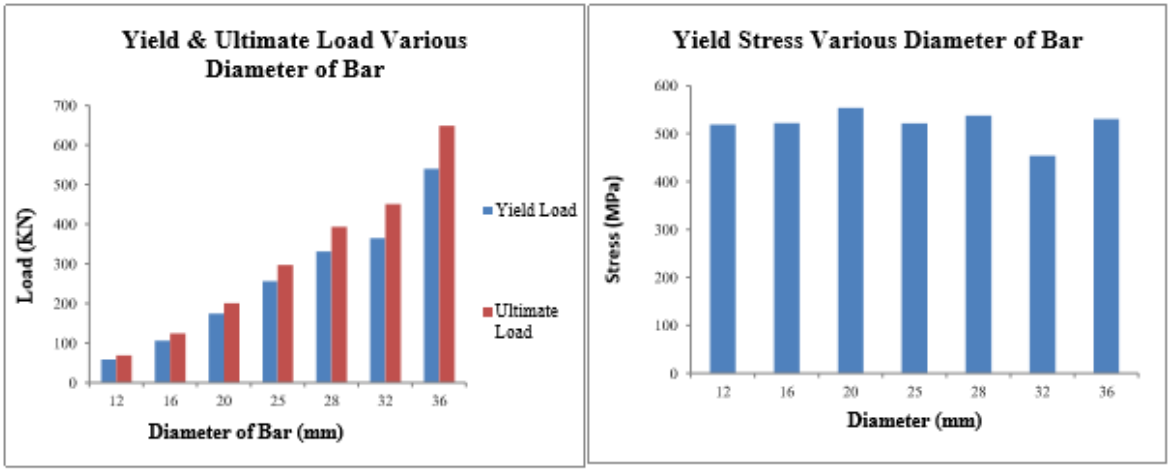

Figure 1: (a) Yield and Ultimate Loads of Various Bar Diameters; (b) Yield Stress of Various Bar Diameters (Hadi, 2008)

Prabir et al., (2004) conducted their research on the characteristics of steel reinforcement for Reinforced Concrete structures. They mentioned that good strength, bond with concrete, thermal expansion characteristics (similar to concrete) and bendability are prime attributes which make steel reinforcement bars most effective reinforcing material for engineering of Reinforced Concrete structures. Besides strength, the durability of the structure depends upon rebar quality. Durability is the ability of the structure to maintain safety and serviceability criteria during its design life. Durability is dependent on the condition of concrete and reinforcement. Corrosion of reinforcement is one of the main factors that could impair durability. Corrosion can be either owing to chloride intrusion or the effect of carbonation. Chemical composition of reinforcement plays a very important role in this respect. The mechanical properties of reinforcement bars, whose minimum values are

generally given in most of the specifications, are yield strength, ultimate strength (or maximum tensile strength) and elongation as parameters for characterization. Following observations could be made from the comparative study.

MATERIAL AND METHOD

Materials

(a) Testing machine: Universal compression /tension machine motorised was used with the capacity minimum 100 kN for compression and 500 kN for tension, 220-240V, 50 Hz, 1 phase. Suitable for tension testing of reinforcing base up to 25 mm diameter. All accessories for tension testing including universal grip holders were included.

(b) Gripping devices:

(i) General: Various types of gripping devices were used to transmit the measured load applied by the testing machine to the test specimens. To ensure axial tensile stress within the gauge length, the axis of the test specimen was coinciding with the centre line of the heads of the testing machine.

(ii) Loading: It is the function of the gripping or holding device of the testing machine that transmitted the load from the heads of the machine to the specimen under test. The essential requirement is that the load shall be transmitted axially. This implies that the centres of the action of the grips was in alignment, in so far as practicable, with the axis of the specimen at the beginning and during the test, and that bending or twisting was held to a minimum. Gripping of the specimen was restricted to the section outside the gauge length.

(iii) Wedge Grips: Testing machines usually are equipped with wedge grips. These wedge grips generally furnish a satisfactory means of gripping long specimens of ductile metal. For proper gripping, it is desirable that the entire length of the serrated face of each wedge be in contact with the specimen.

c) Other Apparatus

Double Pointed Centre Punch or Scribe Marks: For marking of round specimen. Special Scale: For direct reading of % elongation (for particular gauge length) special pointed scale may be used. Minimum division of 0.5% is sufficient for this purpose. Extensometer: Extensometer with gauge length equal to or shorter than the nominal gauge length of the specimen is used to determine the yield phenomenon. Slide callipers.

Methods

The diameter of the specimen was Measured by the slide callipers. The extensometer constant and gage length was recorded. The specimen was fixed at the centre of the properly placed grip of the machine. The extensometer was fixed with the specimen. After completion of all arrangements as per requirement (described earlier) and setting the speed of machine, etc. the machine was switched on. Load was increased gradually and automatically until the specimen fails by tensile force. Then the yield and ultimate strength and elongation etc were determined.

Plate 1: Working with the Universal Steel Tensile Testing Machine

RESULTS AND DISCUSSION

Results

Based on tension testing, ratio TS/YS (obtained from Tensile Stress divided by Yield Stress) of specimen for grade 500 reinforcing bars used by different construction companies are shown in Table 1. It shown value of yield strength, tensile strength, and ratio TS/YS for the 500 grade of steel reinforcing bars. There are selected samples from four different companies tagged as Company A, Company B, Company C and Company D.

Table 1: Tensile Stress/Yield Stress Ratio

Company	Yield Stress (MPa)	Tensile Stress (MPa)	Ratio TS/YS	Average ration TS/YS
A	503.58	697.26	1.38	1.38
	507.21	694.97	1.37	
	497.26	698.15	1.40	
B	578.13	671.14	1.16	1.18
	573.22	672.98	1.17	
	555.69	675.17	1.22	
C	440.35	539.35	1.23	1.19
	457.86	550.30	1.20	
	468.46	532.84	1.14	
D	435.35	543.50	1.25	1.25
	418.47	532.29	1.27	
	428.57	523.82	1.22	

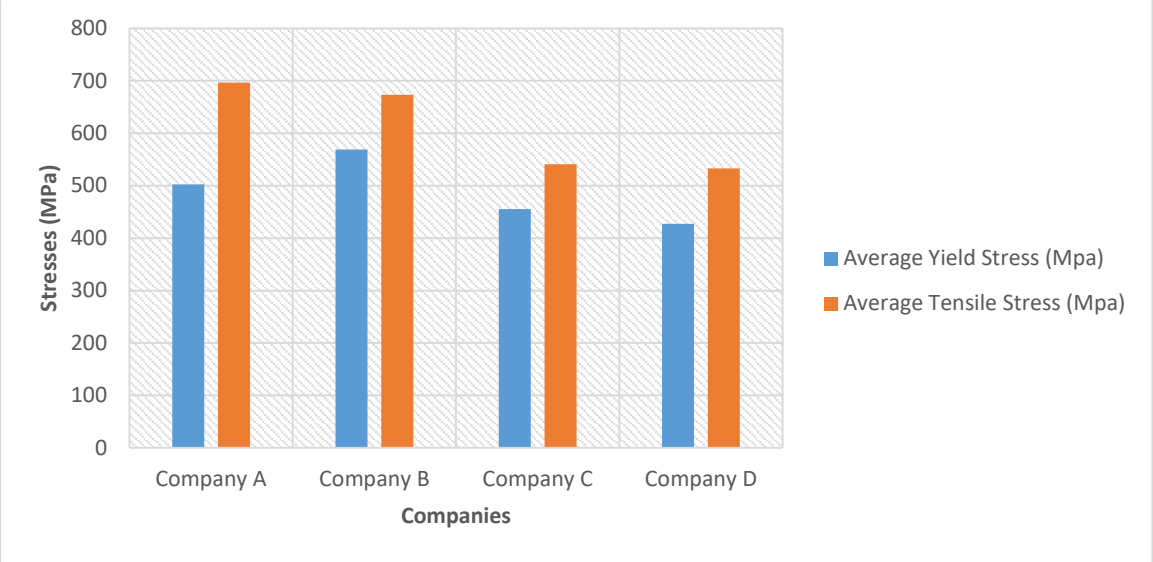

Figure 2: Average Yield and Tensile Stresses

Discussion

Table 1 presents the values of yield stress and tensile stresses. Ratio TS/YS was then calculated from dividing the tensile stress by yield stress. Looking at the values of TS/YS ratios for reinforcement bars used by the different companies, it could be observed that they are within the permissible range as the specified characteristic tensile strength properties according to BSI 4449-2005 is 1.05 for TS/YS ratios of Grade 500 reinforcement. Company A could be said to have higher ratio followed by Company D, Company C and then Company B. This has also been confirmed from figure 2 in that it could be seen clearly the difference between the Average Tensile Stresses and the Average Yield Stresses across the reinforcement bars used by the different Companies.

CONCLUSION

From the study it can be concluded that all the construction companies are using standard reinforcement bars in accordance British Standards, and that Company A performs higher in terms of strength of reinforcement, followed by Company D, then Company C and lastly Company B.

REFERENCES

British Standard 4449 (2005). Steel for Reinforcement of Concrete – Weldable Reinforcing Steel – Bar, Coil, De-coiled Product Specifications. Institution of Standard Engineers, London

El-Reedy, M. A. (2009). Advanced Materials and Techniques for Reinforced Concrete Structures, First Edition, Taylor & Francis Group, Unite States.

Hadi, M. (2008). Bond of High Strength Concrete with High Strength Reinforcing Steel, The Open Civil Engineering Journal, 2, 143-147 Faculty of Engineering, University of Wollongong, Wollongong 2522, Australia.

Mamlouk, M. S. and Zanieski J. P. (2011). Materials for Civil and Construction Engineers. Third Edition, Prentice Hall, New York. ISBN-13: 978-0-13-611058-3 ISBN-10: 0-13-611058-4

Prabir C. Basu, Shylamoni P. and Roshan A. D. January, (2004). "Characterization of steel reinforcement for RC structure The Indian Concrete Journal An overview and related issues", The Indian Concrete Journal,78 (1), pp.

Tavio, S. P, and Kusuma.B., (2008). "Strength and Ductility Enhancement of reinforced HSC Columns Confined with High strength Transverse Steel," Proceeding of the eleventh East Asia Pacific Conference on Structural Engineering & Construction (EASEC-11), Taipei International Convention Cetre, pp350-351

www.theconstructor.org

www.enggpro.com