Comprehensive Journal of Science
Volume (9), Issue (36), (Sept 2025)
ISSN: 3014-6266

مجلة العلوم الشاملة
المجلد(9) ملحق العدد (36) (سبتمبر 2025)
ردمد: 3014-6266

Evaluation of the mechanical properties of reinforcing steel in Libyan private sector factories

1-Abdurhman.M. Dardur -2- Ahmad .S. Alkweldi

Received: 14-08-2025; Revised: 11-09-2025; Accepted: 17-09-2025; Published 23 -09-2025

Abstract:
The mechanical properties of reinforcing steel bars are critical to the longevity and performance of architectural structures, including buildings, skyscrapers, and bridges. The integrity and endurance of reinforced concrete constructions heavily rely on specific properties of the reinforcing bars, such as tensile strength, bendability, fatigue resistance, weldability, and ductility. Steel exhibits a wide range of mechanical characteristics of which the strength factor is the dominant property. Engineering strength is evaluated in terms of yield strength YS, ultimate tensile strength UTS, modulus of elasticity, percentage elongation and impact strength. Thus, any increase in strength characteristics of steel will enhance the reliability and durability of the structure in which it is used. Low strength characteristics often result in short life span of the structure, undesirable deflection and even collapse. The methodology for this study involved research is to perform a comparative analysis of the mechanical properties of steel bars diameter 14mm for produced by Seedy Al-Saih Steel Factory (SASF) and Zliten Steel Factory (ZSF), focusing on adherence to international standards. And local standards
(SASF) steel bars manufactured locally in Libya from recycled scrap showed that the mechanical properties (yield strength, ultimate tensile strength, elongation, hardness, , chemical composition) were consistent with Libyan and international standards (ASTM). In contrast, for the Zliten Iron and Steel Factory, which also uses scrap in the production of steel bars, the value average mechanical properties (yield strength, tensile strength, elongation, hardness, and chemical composition) were slightly higher than the Libyan standard LY and the international standard ASTM. And It is strongly advised that additional advancements be made in the chemical composition, which primarily influences the mechanical characteristics of steel bars, in order to grow the Libyan steel industry and keep the quality of lightweight goods within regional and global standards.

1. INTRODUCTION

The mechanical properties of reinforcing steel bars play an important role in the service life of building structures such as buildings, skyscrapers and bridges. The strength and durability of reinforced concrete structures depend to a large extent on certain properties of reinforcing bars such as tensile strength, bend-ability, fatigue, weld-ability and ductility [1].

Steel exhibits a wide range of mechanical characteristics of which the strength factor is the dominant property. Engineering strength is evaluated in terms of yield strength YS, ultimate tensile strength UTS, modulus of elasticity, percentage elongation and impact strength. Thus, any increase in strength characteristics of steel will enhance the reliability and durability of the structure in which it is used. Low strength characteristics often result in short life span of the structure, undesirable deflection and even collapse. The ductile behavior of reinforced concrete structures are strongly influenced by the mechanical characteristics of the steel used for their reinforcement. In particular, the total elongation at maximum force, and the strain hardening ratio, (defined as the ratio between the tensile strength and the 0.2 proof strength) of the steel play a decisive role in determining dissipative capacity of reinforced concrete sections and structural members [2].

The standards for reinforcing bars are set by International Standard Organization (ISO) and local statutory bodies. The manufacturing process has an effect on the mechanical properties of reinforcing steels. If the alloying elements are not well controlled, they can have a severe effect on the quality of the bar resulting in a substandard reinforcing steel.[3]

Researcher Apeh Abah Joseph (2013) presented a study on the evaluation of the mechanical properties of reinforcing steel used in construction works in the Federal Capital Territory, Abuja, where the results of the tensile stress test showed that they did not conform to local and international standards.[4]

Emmanuel K. Banini a* and Charles K, Kankam(2022).presented a study on the Strength, Ductility and Chemical Properties of Reinforcing Steel Bars in Ghana's Building Construction Industry All the reinforcing bars test Chemical Properties showed carbon contents higher than the maximum requirement of 0.24% and 0.22 - 0.32% in the British and Ghana specifications, respectively.[5]

- **NSCSM 75:2013,** established by the Libyan National Center for Standardization and Metrology, delineates the specifications necessary for hot-rolled steel bars utilized in concrete reinforcement within construction applications. It also encompasses various construction methodologies, along with the protocols for inspection and testing[6]

- **ASTM (A-615:2005) Standard**: This specification covers deformed and plain carbon-steel bars for concrete reinforcements in cut lengths and coils. Materials considered under this specification are available in Grades 40, 60 and 75. Steel samples shall be rolled from properly identified heats of mold cast or strand cast steel using electric-furnace, basic-oxygen, or open-hearth. Heat analysis shall be performed wherein steel materials shall conform to required compositions of carbon, manganese, phosphorus and sulfur. Steel specimens shall also undergo tensile tests and shall conform to required values of tensile strength, yield strength, and elongation. Steel samples shall also undergo deformation test, tension test and bend tests. Final products shall be marked by a tag [7].

- **ISO (6935-2:2015)** : This part of ISO 6935 specifies technical requirements for ribbed bars to be used as reinforcement in concrete [8]

Due to the high demand of this type of product (steel), now days in west part of Libya there are about five privet steel factories. One of these factories is Seedy Al-Saih factory for reinforced steel which located at the west part of Libya (about 40 km far of Tripoli at west) and it has a production capacity more than 200,000 Ton per year. And zlitan factory for reinforced steel and it has a production capacity also more than 1300,000 Ton.

In this research, a comparison will be made between the mechanical and properties of steel bars of is Seedy Al-Saih Steel Factory (SASF) Reinforced Steel Factory and Zliten Steel Factory (ZSF) according to international standards.

Since last decade construction work using concrete increasing sharply. The only proved steel produced by Libyan iron and steel company become not enough to satisfy the local market for this type of construction material. This encourage some business men to build their own steel factories to meet the requirement of local market of steel. It is well known that the products of Libyan iron and steel company has high quality. However, privet steel factories developed latterly do not have such certificate and don't have the same level of quality. In addition to that the products of these privet steel factories are available now in Libyan market and it is spread largely in all parts of Libya. Due to that, there are a high need to study and test the products of these private steel factories according to national specification and international standard. one of these private steel factories is Seedy Al-Saih Steel Factory (SASF), and factories is zleten steel factory (ZSF)which are the latest among all the private factories, and it is expected to be the most modern one.

Seedy Al-Saih steel factory produces reinforcing bars (SASF) and zleten steel factory (ZSF) with a diameters of 12 mm and 14 mm. These products are the most kinds which are widely used in the construction processes. Quality of such products are very important and it affects the safety of the people for short and long term. In addition to that this private sector factories started production stages at difficult situation passed the country. The circumstances for Libya since four years ago helping business men to avoid extra expenses for quality assurance of their factories. This was the motivation behind this research.

The method of approach adopted in the current study involves visiting Seedy Al-Saih steel factory and chick the routine tested performed, then random specimens were taken from the production with a diameter of 14 mm only. These specimens will be subjected to serious of mechanical standard tests , that include requirements on , chemical composition, and mechanical properties as for the results of the zliten factory for reinforced steel tests .with a diameter of 14 mm they were taken from a previous study conducted by researcher Mohamed alhamrouni through the Libyan academy. The results of both factories were compared with the Libyan specifications and international standards [9].

In this research, a comparison will be made between the mechanical and properties of steel bars diameter 14 mm is Seedy Al-Saih Steel Factory (SASF) Reinforced Steel Factory and Zliten Steel Factory (ZSF) according to international standards and local .

2. Experiment Work:

2.1. Materials

The samples which used in this research were 14mm diameter reinforced steel bars. These samples were obtained from Seedy Al-Saih Steel Factory (SASF) and zleten steel factory (ZSF) products.

2.2 Tensile test:

Tensile testing serves as a fundamental mechanical assessment technique for metals, with a particular emphasis on iron. This process is vital for determining the quality and characteristics of the materials being analyzed, encompassing important parameters such as yield strength, ultimate tensile strength, and elongation. The results obtained from this testing will be compared against the Libyan standard (LNS-74) as well as the ASTM standard.

2. 3 Hardness testing

In this research, the hardness value was assessed using the Rockwell hardness test. This method is characterized by its accuracy, sensitivity, and ease of execution, making it suitable for determining hardness within production lines. The results obtained from this study were compared against the standards outlined in ISO 6935-2:2015.

2 .4 Chemical analysis

Chemical analysis serves to ascertain the proportions of elements present in the reinforcing steel utilized in construction applications. The primary constituents of reinforcing steel, specifically carbon, sulfur, and magnesium, are evaluated in this study against the Libyan standard (LNS-74) and the ASTM standard (A-615).

3. Result and Discussion:

3.1 Yield strength for steel bars of Ø14 mm:

The results obtained of yield strength for Ø14mm steel bars were summarized in Table (1). The average of results were compared with Libyan specifications and ASTM standard and plotted graphically as shown in figure. 1.

Table 1: Comparison values of the yield strength for steel bars of **Ø14mm** with Libyan standard and ASTM standard

Production batches	Specimen No	YS (N/mm^2) SASF	YS (N/mm^2) ZSF	LY Stand (N/mm^2), min	ASTM Stand (N/mm^2), min
First batch	1	375	430	300	300
	2	375	422	300	300
	3	375	423	300	300
	AVE	375	425	300	300

Second batch	1	345	450	300	300
	2	350	435	300	300
	3	341	438	300	300
	AVE	345	442	300	300
Third batch	1	350	450	300	300
	2	342	452	300	300
	3	330	449	300	300
	AVE	340	451	300	300

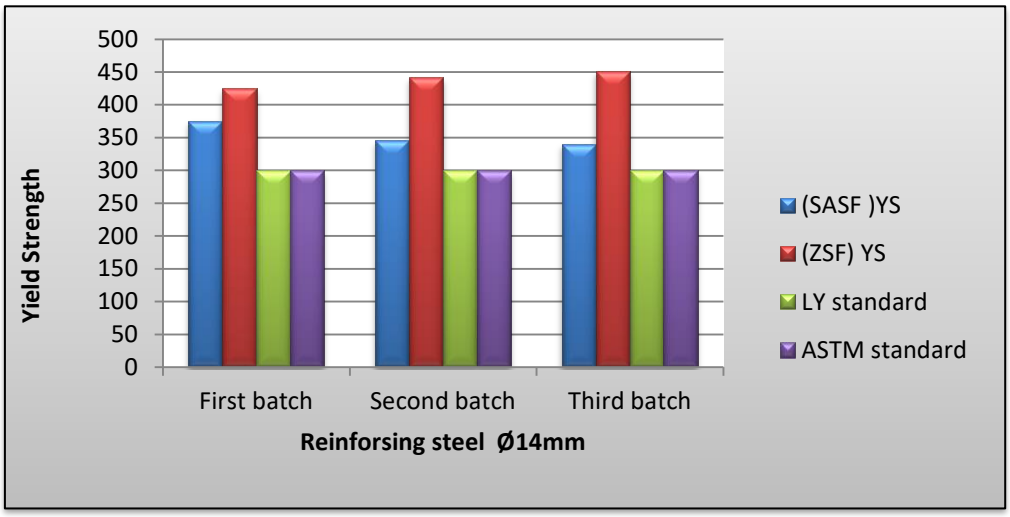


Figure1: Comparison of average yield strength for steel bars samples of Ø14mm with Libyan standard and ASTM standard

Since the minimum value of yield strength according to Libyan specification and ASTM standard is 300 (N/mm2), it is found that the results obtained for Ø14mm have an average yield strength of 375 N/mm2 , 345 (N/mm2), and 340 N/mm2 for first, second and third tested batches respectively. The results were plotted graphically as shown in figure 1. According to the standards the yield strength results for reinforced steel bars produced by SASF were acceptable ,and ZSF products of reinforced steel bars it is found that the results obtained for Ø14mm have an average yield strength of 425 N/mm2 , 442 (N/mm2), and 451 N/mm2 for first, second and third tested batches... According to the standards the yield strength results for reinforced steel bars produced by ZSF. It were increase compared to the specifications LY and ASTM standard .

3.2 Ultimate tensile strength (UTS) for steel bars of Ø14mm:

Ultimate strength is one of the important results of tensile test. For tested samples of SASF and ZSF products, it is found that reinforced steel of Ø14mm has an ultimate strength within the standards. As shown in table(2), although there is a difference of a minimum value of ultimate strength

between Libyan specification and (ASTM) standard, results showed that products of (SASF) and (ZSF) have ultimate strength higher than the minimum value mentioned in both standards.

Table 2: Comparison of average ultimate tensile strength for steel bars of Ø14mm with Libyan standard and ASTM standard

Production batches	Specimen No	UTS (N/mm^2) SASF	UTS (N/mm^2) ZSF	LY Standard (N/mm^2), min	ASTM Standard (N/mm^2), min
First batch	1	558	620	420	500
	2	558	615	420	500
	3	559	621	420	500
	AVE	558	618	420	500
Second batch	1	534	570	420	500
	2	532	630	420	500
	3	533	597	420	500
	AVE	533	600	420	500
Third batch	1	541	664	420	500
	2	540	670	420	500
	3	540	668	420	500
	AVE	540	667	420	500

The average value of ultimate strength for the three batches have been plotted graphically beside the corresponding values given by the standards. It is found that recorded values of UTS for steel rods of Ø14mm for products SASF is almost similar, UTS values varied between 532 N/mm2 and 559 N/mm2 . However, all tested samples of SASF recorded values of ultimate strength higher than the minimum values specified in the standards. It is found that recorded values of UTS for steel rods of Ø14mm for products ZSF values varied between 532 N/mm2 and 559 N/mm2 all samples from the (ZSF) factory also recorded maximum strength values higher than the values specified for standards.

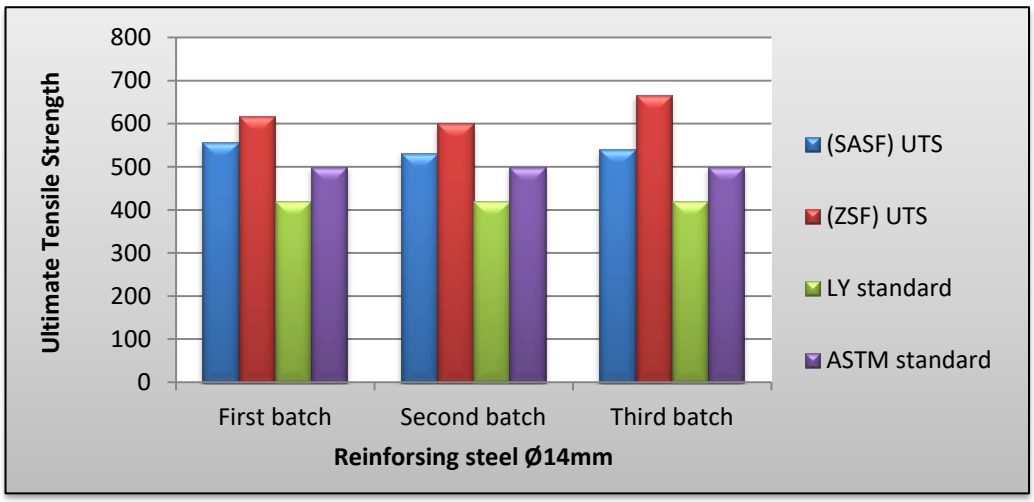


Figure 2: Comparison of the ultimate tensile strength for the steel bars samples of Ø14mm for produces (SASF), (ZSF) with Libyan standards LY) and (ASTM) standard

3.3Elongation for steel bars of Ø14mm :

As shown in Table(3), the average elongation value of 14 mm diameter steel bars products SASF of the first, second and third batches are 12.7%, 13.1% and 11.6% respectively. Products. While the average value for ZSF products were are 14.3%, 14.6% and13.6% respectively. Figure 3 clearly shows the elongation of steel bars of products SASF and ZFA.

In general it can be said that all tested samples For products SASF and ZSF exhibited higher than results with compare to standards. Figure 4: plotted graphically the results of elongation for steel bars of Ø14mm.

After test before test

Figure (3): steel bar sample Elongation test

Table 3: comparison of the percentage elongation for steel bars of Ø14mm with Libyan standard and ASTM standard

Production batches	Specimen No	Elongation ΔL (%) SASF	Elongation ΔL (%) ZSF	LY Standard (%), min	ASTM Standard (%), min
First batch	1	11.2	15.5	12	11
	2	13.7	13	12	11

	3	13.4	14.4	12	11
	AVE	12.7	14.3	12	11
Second batch	1	14	14	12	11
	2	13	13.9	12	11
	3	12.5	15.2	12	11
	AVE	13.1	14.6	12	11
Third batch	1	11.7	12.2	12	11
	2	11.2	15	12	11
	3	12	14	12	11
	AVE	11.6	13.6	12	11

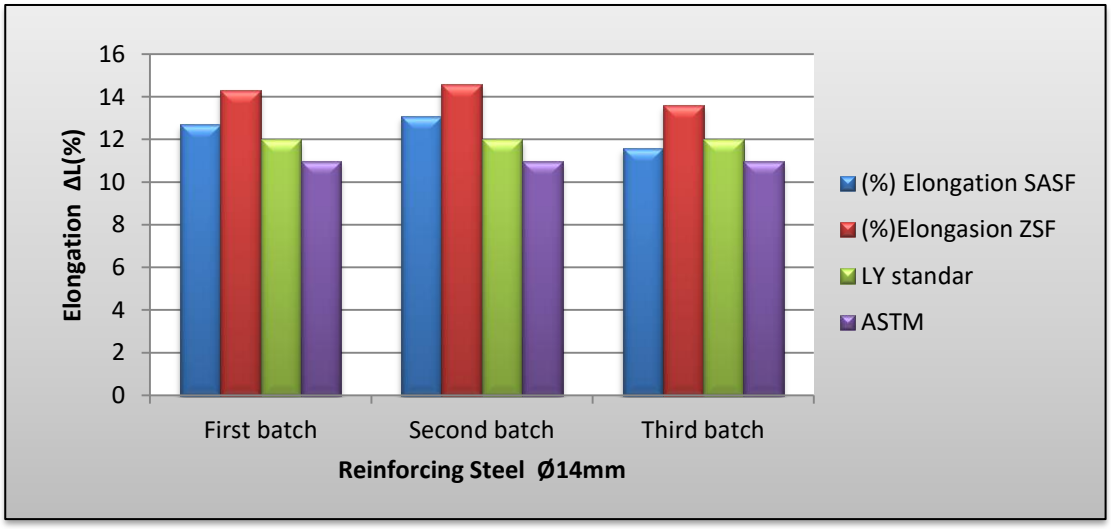


Figure 4: Comparison of elongation for steel bars of Ø14mm with Libyan standard and ASTM standard

3.4 **Hardness testing**:

Rockwell hardness tester was used to test the hardness of specimens steel bars of SASF and ZSF products. The surfaces of the specimen were smoothed using sand paper for the upper and lower surfaces. Hardness measurements were made by applying a major load of 100 kg. An average value of three readings for both Factories was recorded and comparing by ISO 6935-2 standards, as given in table (4).As can be seen in figure (5) Recorded values of hardness test were found within the range of the standard values.

Table 4: Results of hardness tests for steel bars of Ø14mm.

Size (mm)	Locations			AVE (HRB)	ISO standard
	A	B	C		

14 (mm)SASF	89	86	87	87.3HRB	70-94
14 (mm)ZSF	86	85	87	86.3HRB	70-94

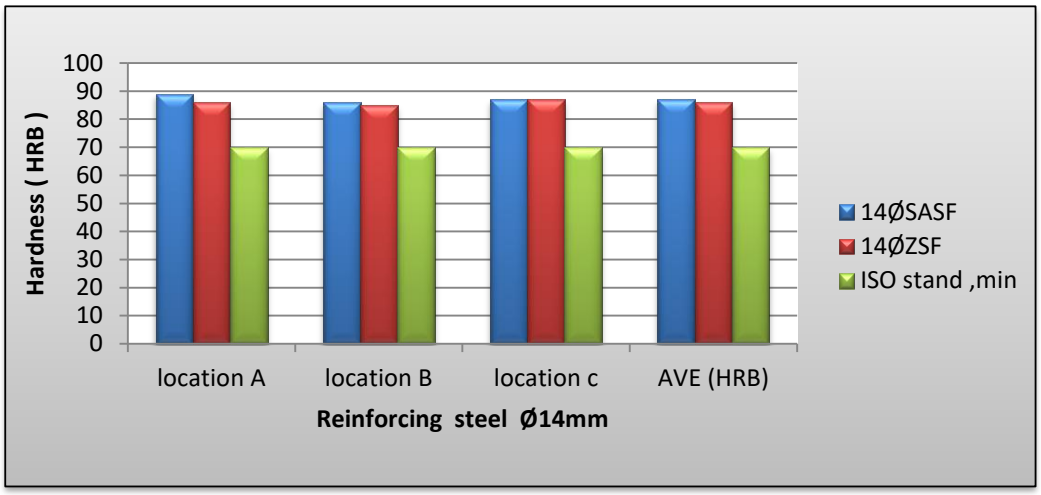


Figure 5: hardness for steel bars of Ø14mm.

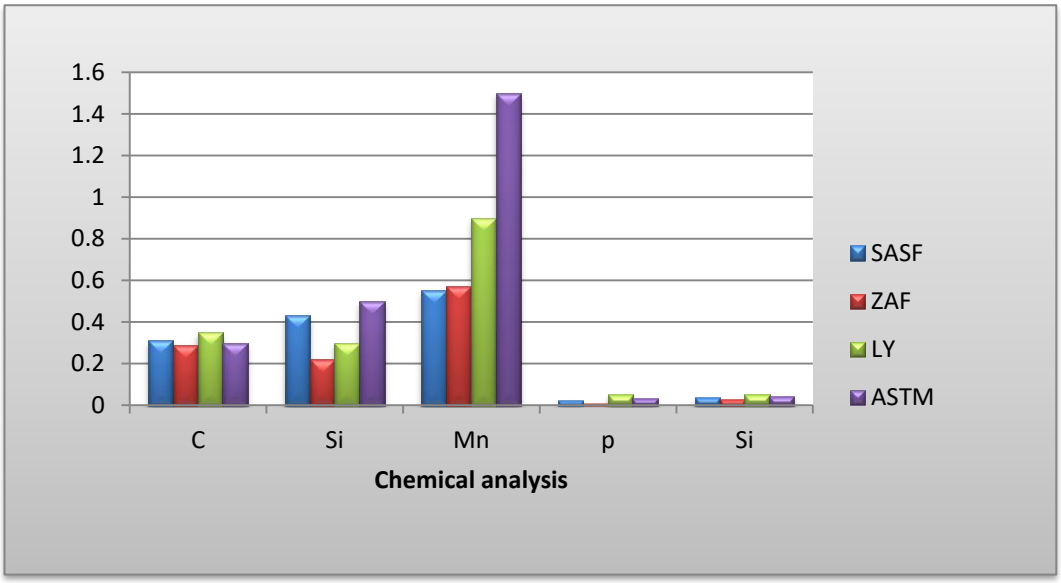
3.5 Chemical analysis

The chemical compositions of tested samples for SASF and ZSF were known by optical emission spectroscopy, and are presented in Table (5)

The analysis conducted reveals that the reinforcement steel bars produced by SASF and ZSF were composed of five distinct types of materials. According to the ASTM and Libyan standards, the percentage of these materials was found to be largely within the permissible limits of both local and international standards. However, a decrease in the manganese content was observed in the SASF and ZSF products when compared to the Libyan standard and ASTM see figure 6. Additionally, there was no strong indication of the presence of silicon, sulfur, phosphorus, or a combination of these elements in most of the samples tested. This suggests a normal distribution of the chemical elements that constitute the steel, with carbon being a particularly significant factor in determining the hardness of the steel.

Table 5: Chemical Composition of SASF products.

elements	SASF%	ZSF%	LYstandard% max	ASTM Standard % max
C	0.31	0290	0.35	0.30
Si	0.43	0.226	0.30	0.50
Mn	0.55	0.571	0.90	1.50
P	0.024	0.0089	0.05	0.035
S	0.038	0.0296	0.05	0.045



Figure(4.12): Layout of chemical compositions of SASF products with comparison to Libyan standard and ASTM standard

4.1 Conclusions

The primary goal of the research has been accomplished. A number of experimental tests were carried out to study the products bars diameter 14mm for produced by Seedy Al-Saih Steel Factory (SASF) and Zliten Steel Factory (ZSF) for reinforced steel bars. Based on the findings of mechanical experimental testing and chemical composition.

SASF steel bars manufactured locally in Libya from recycled scrap showed that the mechanical properties (yield strength, ultimate tensile strength, elongation, hardness, , chemical composition) were consistent with Libyan and international standards (ASTM). In contrast, for the Zliten Iron and Steel Factory, which also uses scrap in the production of steel bars, the value average mechanical properties (yield strength, tensile strength, elongation, hardness, and chemical composition) were slightly higher than the Libyan standard LY and the international standard ASTM. And It is strongly advised that additional advancements be made in the chemical composition, which primarily influences the mechanical characteristics of steel bars, in order to grow the Libyan steel industry and keep the quality of lightweight goods within regional and global standards.

REFERENCES

[1] Allen D. E, “Statistical study of the mechanical properties of reinforcing bars Division of Building Research, National Research Council of Canada Ottawa, April 1972.

[2] Barbara M., Walter S. and Renzo V., "Dual-phase steel rebars for high-ductile R. C. structures, Part 1: Microstructural and mechanical characterization of steel rebars," Engineering Structures, 2007.

[3] International Standards Organization ISO 6935-2: Steel for the reinforcement of concrete.2007.

[4] Apeh. Abah .Joseph evaluation of mechanical properties of reinforcing steel used in construction works in the Federal Capital Territory, Abuja, (2013)

[5] Emmanuel K. Banini a* and Charles K, Kankam. Strength, Ductility and Chemical Properties of Reinforcing Steel Bars in Ghana's Building Construction Industry (2022)

[6] Libyan standard (LNCSM 74:) Libyan National Center for Standardization and Metrology 2008.

[7] ASTM A615/A615M-14: standard specification for deformed and plain carbon steel bars for concrete reinforcement 2005.

[8] ISO 15630-1:steel for the reinforcement and prestressing of concrete – test methods 2015.

[9] Mohamed alhamrouni Testing of mechanical properties of steel rods produced by zletin factory for reinforced steel 2017.