KPU International Journal of Engineering & Technology
Volume 3, Issue1, Sep. 2023
e-ISSN:2790-0819, p-ISSN:2790-0800

Date Received: 2023-06-06
Date Accepted: 2023-08-09
Date Published: 2023-09-15

Comparing the Elongation and Tensile capacity of Khan steel Reinforcement bar with the Esfahan and Tashkent companies

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Abstract

The present work studies and compares the tensile capacity of reinforcement bar, yield stress, ultimate stress, and elongation of reinforcement bar from different manufacturing companies (Khan Steel, Esfahan and Tashkent). The aims of this investigating is the yield and ultimate stress, tensile capacity, and elongation of steel bars under tensile stress used according to the standard in the members of reinforced concrete buildings. The laboratory test of yield, ultimate stress, and elongation on of reinforcement bar has been performed according to the (ASTM, A615) standard, the obtained result has been compered and the shows the tensile strength does not have a direct effect on the elongation, but in the other hand, tensile capacity, tensile strength and elongation of reinforcement bar considering the (ASTM, A615) standard is acceptable.

Keywords: Elongation, Reinforcement bar, Tensile capacity, Ultimate Stress, Yield Stress.

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1. Introduction

Reinforcement bar (rebar) is a steel product in the form of rod or cable, which is used to strengthen tensile strength of concrete members. [7].

Steel rebar is a material with high tensile strength, the characteristics of steel rebar make it the best option to combine with concrete and strengthen its tensile strength; for this reason the use of suitable steel rebar in concrete buildings is very important for the stability of the building [7].

Tensile capacity and elongation of steel rebar is called the ability to change longitudinal shape under tensile axial loads, because if additional loads are applied to the buildings, the rebar will significantly change shape, and in this way, they control the way of spreading cracks in concrete[9].

On the other hand, the amount of elongation for the rebar is related to the nominal diameter and tensile capacity.

Investigations about the tensile capacity and elongation which mentioned tool as reinforcement bar show that the same grade of rebar, but produced by different companies, have different capacity and elongations that should be checked before using them in the building structure.

Since the beginning of using rebar in the structure of buildings, various tests have been conducted on reinforcement bar to select the best rebar.

In this research, in order to support the domestic products of Afghanistan and introduce the quality of domestic products to those who use reinforcement bar, a comparison has been made between the tensile capacity and elongation of Khan Steel with Esfahan and Tashkent rebar's.

The results of the tests show that Khan Steel rebar have met the American (ASTM, A615) standard and can be a good alternative, for use in the structure of buildings instead of the aforementioned imported steel rebar's.

2. Experimental Work

2.1. Methods

To test steel rebar, there are different methods in different standards, the most important standards in the world for testing steel rebar are listed below.

- American standard (ASTM).
- German standard (DIN).
- Russian standard (GOST).

In this research, the American standard (ASTM, A615) is used.

2.2. Materials

The reinforcement bar used in the structure members of reinforcement concrete buildings is a steel product that is artificially produced in the factory, the composition of steel reinforcement bar according to (ASTM, A33) standard is 95% to 99% iron along with other chemical elements mentioned in table (1)[3].

Table 1. Chemical composition of steel reinforcement bar

Elements	*Minimum amount %*	*Maximum amount %*
Carbon	0.42	0.50
Silicon	---	0.40
Manganese	0.50	0.80
Phosphorus	---	0.03
Sulfur	---	0.035

Chemical elements are used in steel with a specific purpose, the quality and grade of steel reinforcement bar depends on the composition of these elements. As stated below each of the mentioned elements has a specific effect on the formation of steel reinforcement bar[3].

Manganese (MN): this element reduces hardness and increases strength in steel and increases wear resistance[3].

Carbon (c): this element is one of the most important constituents of steel and increases tensile strength, hardness and wear resistance, but reduces ductility in steel[1].

Phosphorus (P): this element increases strength and hardness and improves ductility, yet adds a certain brittleness to the steel.

Silicone (Si): this element increases tensile strength, yield strength of steel[3].

Sulfur (S): this element improves ductility, but without sufficient manganese it causes brittleness in steel[3].

The steel reinforcement bars that have been subjected to this research and their tensile capacity and elongation have been tested are grade 60 in different diameters of 25 mm, 22 mm, 18 mm, 14 mm, 12 mm, and 10 mm, which belong to three production companies (Khan steel, Esfahan and Tashkent).

2.3. Experimental procedure & Model tests

In order to obtain information about the characteristics of steel reinforcement bar and to answer the questions of whether the manufactured steel reinforcement bar meet the desired standard specifications or not, it is necessary to test the characteristics of reinforcement bar, mentioned below[4]:

- Tensile test
- Bending test
- Fatigue test
- Testing in terms of geometric characteristics
- Testing in terms of chemical composition

All the experimental model tests in this research were done in the Sky Geotechnical Material Laboratories. Kabul Afghanistan.

Testing the tensile capacity and elongation of steel reinforcement bar is one of the most important and main tests that must be done for the reinforcement bar [5].

For this purpose, the test of tensile capacity and elongation of steel reinforcement bar was carried out according to (ASTM, A615) standard, according to mentioned standard, 40 cm of steel reinforcement bar were prepared from each sample that was tested and in a laboratory experimental device as shown in figure (1). It is shown to be placed, which is 10 cm from the reinforcement the top knot and 10 cm in the bottom knot of the device and 20 cm in the middle are left free; after that, the device pulls the inserted reinforcement bar with a certain force until it breaks. And this force, which causes tearing, determines the tensile capacity of the tested steel reinforcement bar section.
Later, the tensile capacity determined by the machine for the tested samples for grade 60 reinforcement bar, we compared the results of the tests, with the values mentioned in (ASTM, A615) standard, it was found that all the reinforcement bars that were tested are acceptable to the standard[1].



Figure 1. Steel reinforcement bar tensile experimental machine

3. Result and Discussion

3.1. Laboratory modal tests result

The results of the test conducted on the tested reinforcement bar of three manufacturing companies are shown in figures 2, 3 and 4.

The test result show important things, which include:

- Effective diameter of the reinforcement bar
- Yield stress of reinforcement bar
- Ultimate stress of reinforcement bar
- Elongations of reinforcement bar under tensile axial stress.

SKY GEOTECHNICAL CONSTRUCTION MATERIAL LABORATORIES

Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A615/A 615M -09a

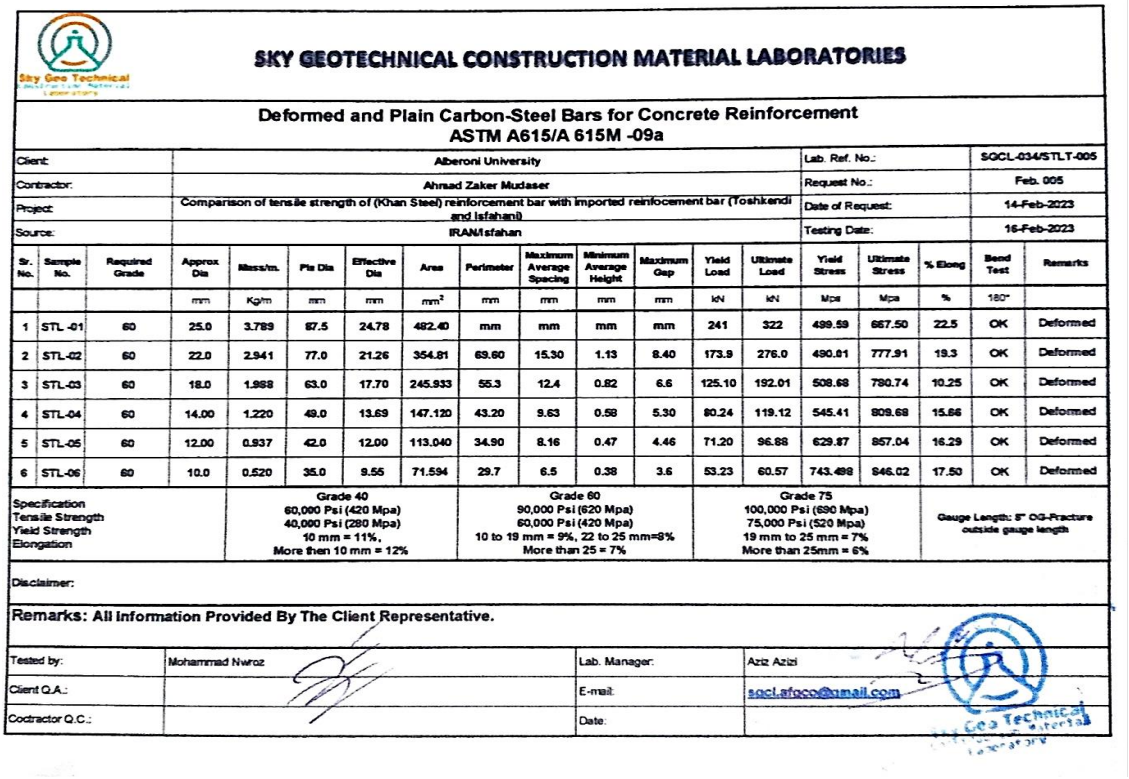
Client:			Alberoni University										Lab. Ref. No.:			SGCL-034/STLT-005		
Contractor:			Ahmad Zaker Mudaser										Request No.:			Feb. 005		
Project:			Comparison of tensile strength of (Khan Steel) reinforcement bar with imported reinfocement bar (Toshkendi and Isfahani)										Date of Request:			14-Feb-2023		
Source:			Khan Steel Mill/Afghanistan										Testing Date:			18-Feb-2023		
Sr. No.	Sample No.	Required Grade	Approx Dia	Mass/m.	Pie Dia	Effective Dia	Area	Perimeter	Maximum Average Spacing	Minimum Average Height	Maximum Gap	Yield Load	Ultimate Load	Yield Stress	Ultimate Stress	% Elong	Bend Test	Remarks
			mm	Kg/m	mm	mm	mm^2	mm	mm	mm	mm	kN	kN	Mpa	Mpa	%	180°	
1	STL-01	60	25.0	3.845	87.5	24.90	482.806	79.7	17.5	1.22	9.7	246.79	325.50	511.16	674.18	11.25	OK	Deformed
2	STL-02	60	22.0	3.005	77.0	21.70	369.649	69.7	15.6	1.09	8.6	206.86	273.24	559.61	739.19	10.21	OK	Deformed
3	STL-03	60	18.0	1.972	63.0	17.80	248.719	56.8	12.0	0.83	6.7	113.02	172.11	454.41	691.98	9.52	OK	Deformed
4	STL-04	60	14.0	1.203	49.0	13.97	153.201	40.4	9.7	0.54	5.5	72.89	110.04	475.78	718.27	10.03	OK	Deformed
5	STL-05	60	12.0	0.873	42.0	11.97	112.476	35.3	8.0	0.41	4.1	57.02	79.53	506.95	707.09	12.56	OK	Deformed
6	STL-06	60	10.0	0.521	35.0	9.88	76.627	29.7	6.5	0.38	3.6	51.65	58.46	674.042	762.91	19.50	OK	Deformed
Specification Tensile Strength Yield Strength Elongation				Grade 40 60,000 Psi (420 Mpa) 40,000 Psi (280 Mpa) 10 mm = 11%, More then 10 mm = 12%				Grade 60 90,000 Psi (620 Mpa) 60,000 Psi (420 Mpa) 10 to 19 mm = 9%, 22 to 25 mm=8% More than 25 = 7%				Grade 75 100,000 Psi (690 Mpa) 75,000 Psi (520 Mpa) 19 mm to 25 mm = 7% More than 25mm = 6%				Gauge Length: 8" OG-Fracture outside gauge length		

Disclaimer:

Remarks: All Information Provided By The Client Representative.

Tested by:	Mohmmad Nwroz	Lab. Manager:	Aziz Azizi
Client Q.A.:		E-mail:	sgcl.afgco@gmail.com
Cocntractor Q.C.:		Date:	

Figure 2. The result of laboratory test (Khan Steel) reinforcement bar



SKY GEOTECHNICAL CONSTRUCTION MATERIAL LABORATORIES

Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A615/A 615M -09a

Client:	Alberoni University	Lab. Ref. No.:	SQCL-034/STLT-005
Contractor:	Ahmad Zaker Mudaser	Request No.:	Feb. 005
Project:	Comparison of tensile strength of (Khan Steel) reinforcement bar with imported reinforcement bar (Toshkendi and Isfahanli)	Date of Request:	14-Feb-2023
Source:	IRAN/Isfahan	Testing Date:	16-Feb-2023

Sr. No.	Sample No.	Required Grade	Approx Dia	Mass/m.	Pin Dia	Effective Dia	Area	Perimeter	Maximum Average Spacing	Minimum Average Height	Maximum Gap	Yield Load	Ultimate Load	Yield Stress	Ultimate Stress	% Elong	Bend Test	Remarks
			mm	Kg/m	mm	mm	mm^2	mm	mm	mm	mm	kN	kN	Mpa	Mpa	%	180°	
1	STL -01	60	25.0	3.789	87.5	24.78	482.40	mm	mm	mm	mm	241	322	499.59	667.50	22.5	OK	Deformed
2	STL-02	60	22.0	2.941	77.0	21.26	354.81	69.60	15.30	1.13	8.40	173.9	276.0	490.01	777.91	19.3	OK	Deformed
3	STL-03	60	18.0	1.988	63.0	17.70	245.933	55.3	12.4	0.82	6.6	125.10	192.01	508.68	780.74	10.25	OK	Deformed
4	STL-04	60	14.00	1.220	49.0	13.69	147.120	43.20	9.63	0.58	5.30	80.24	119.12	545.41	809.68	15.66	OK	Deformed
5	STL-05	60	12.00	0.937	42.0	12.00	113.040	34.90	8.16	0.47	4.46	71.20	96.88	629.87	857.04	16.29	OK	Deformed
6	STL-06	60	10.0	0.520	35.0	9.55	71.594	29.7	6.5	0.38	3.6	53.23	60.57	743.498	846.02	17.50	OK	Deformed

Specification	Grade 40	Grade 60	Grade 75	
Tensile Strength	60,000 Psi (420 Mpa)	90,000 Psi (620 Mpa)	100,000 Psi (690 Mpa)	Gauge Length: 8" OG-Fracture outside gauge length
Yield Strength	40,000 Psi (280 Mpa)	60,000 Psi (420 Mpa)	75,000 Psi (520 Mpa)	
Elongation	10 mm = 11%, More then 10 mm = 12%	10 to 19 mm = 9%, 22 to 25 mm=8% More than 25 = 7%	19 mm to 25 mm = 7% More than 25mm = 6%	

Disclaimer:

Remarks: All information Provided By The Client Representative.

Tested by:	Mohammad Nwroz	Lab. Manager:	Aziz Azizi
Client Q.A.:		E-mail:	sacl.afgco@gmail.com
Cocntractor Q.C.:		Date:	

Figure 3. The result of laboratory test (Isfahan) reinforcement bar

SKY GEOTECHNICAL CONSTRUCTION MATERIAL LABORATORIES

Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A615/A 615M -09a

Client:			Alberoni University										Lab. Ref. No.:			SGCL-034/STLT-005		
Contractor:			Ahmad Zaker Mudaser										Request No.:			Feb. 005		
Project:			Comparison of tensile strength of (Khan Steel) reinforcement bar with imported reinforcement bar (Toshkendi and Isfahani)										Date of Request:			15-Feb-2023		
Source:			Uzbekistan/(Toshkendi)										Testing Date:			16-Feb-2023		
Sr. No.	Sample No.	Required Grade	Approx Dia	Mass/m.	Pis Dia	Effective Dia	Area	Perimeter	Maximum Average Spacing	Minimum Average Height	Maximum Gap	Yield Load	Ultimate Load	Yield Stress	Ultimate Stress	% Elong	Bend Test	Remarks
			mm	Kg/m	mm	mm	mm^2	mm	mm	mm	mm	kN	kN	Mpa	Mpa	%	180°	
1	STL-01	60	25	3.7270	87.50	24.58	474.566	69.1	15.5	1.12	8.5	211	328	444.617	691.158	17.8	OK	Deformed
2	STL-02	60	22.0	2.992	77.0	21.50	362.866	69.4	15.4	1.10	8.4	169.16	265.65	466.18	732.09	11.84	OK	Deformed
3	STL-03	60	18.0	1.893	63.0	17.60	243.162	52.7	12.1	0.83	6.7	116.95	177.34	480.96	729.31	12.25	OK	Deformed
4	STL-04	60	14.0	1.218	49.00	13.71	147.560	43.20	9.63	0.58	5.30	77.73	120.18	526.80	814.50	15.25	OK	Deformed
5	STL-05	60	12.0	0.828	42.0	11.61	105.812	34.1	7.9	0.44	4.3	54.77	79.26	517.62	749.07	12.41	OK	Deformed
6	STL 06	60	10.0	0.579	35.0	9.60	72.3456	29.7	6.7	0.35	3.1	38.09	60.87	526.501	841.378	11.68	OK	Deformed

Specification	Grade 40	Grade 60	Grade 75	
Tensile Strength	60,000 Psi (420 Mpa)	90,000 Psi (620 Mpa)	100,000 Psi (690 Mpa)	Gauge Length: 8" OG-Fracture outside gauge length
Yield Strength	40,000 Psi (280 Mpa)	60,000 Psi (420 Mpa)	75,000 Psi (520 Mpa)	
Elongation	10 mm = 11%, More then 10 mm = 12%	10 to 19 mm = 9%, 22 to 25 mm=8% More than 25 = 7%	19 mm to 25 mm = 7% More than 25mm = 6%	

Disclaimer:

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Tested by:	Mohmmad Nwroz	Lab. Manager:	Aziz Azizi
Client Q.A.:		E-mail:	sgcl.afgco@gmail.com
Coctractor Q.C.:		Date:	

Figure 4. The result of laboratory test (Tashkent) reinforcement bar

3.2. Effective diameter

Reinforcement bars are manufactured according to (ASTM, A615) standard in specific approximate diameters from 6 mm to 50 mm. but the approximate diameters are different from the actual diameter of the reinforcement bar, the diameter that shows the size of the reinforcement after the manufacturing is called the effective diameter[5].

The effective diameter should be obtained by careful testing. And this effective diameter is considered by the designer engineer in the design of building members.

One of the parts of this research which is effective in the tensile capacity and elongation of the reinforcement bar is to get the effective diameter of the rebar.

This research, whose experimental models are made of the approximate diameters of the rebar's of 25mm, 22mm,18mm, 14mm, 12mm and 10mm, after testing the models, obtained the effective diameters of the rebar's and showed them in the table 2 and figure 5.

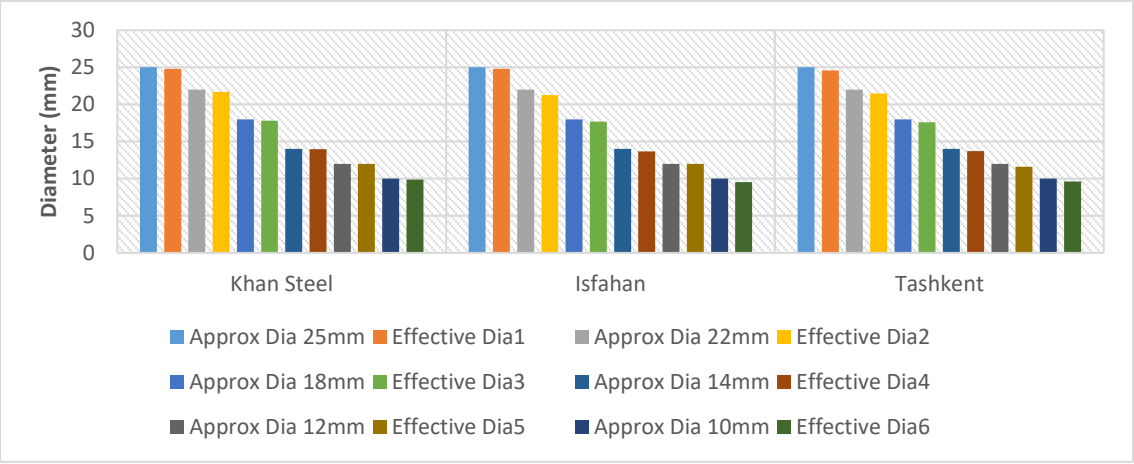


Figure 5. Approximate and effective diameters of the tested models reinforcement bars

Table 2. Approximate and effective diameters of the tested models reinforcement bars

Khan Steel	*Approximate Diameter*	25	22	18	14	12	10
	Effective Diameter	24.80	21.70	17.80	13.97	11.97	9.88
Isfahan	*Approximate Diameter*	25	22	18	14	12	10
	Effective Diameter	24.78	21.26	17.70	13.69	12	9.55
Tashkent	*Approximate Diameter*	25	22	18	14	12	10
	Effective Diameter	24.58	21.50	17.60	13.71	11.61	9.60

Values in figure 5. and table 2, shows the result of laboratory testing of specific models, that the reinforcement bars produced by khan steel company have larger effective diameters than the reinforcement bars produced by (Isfahan and Tashkent) companies; this indicates a better feature of (Khan steel) reinforcement bars.

3.3. Yield stress of reinforcement bar

The yield stress represents the maximum force that can be applied without causing permanent deformation in steel; this properties are one of the good features of steel[11]. Point B in figure 6, shows the location of the yield stress.

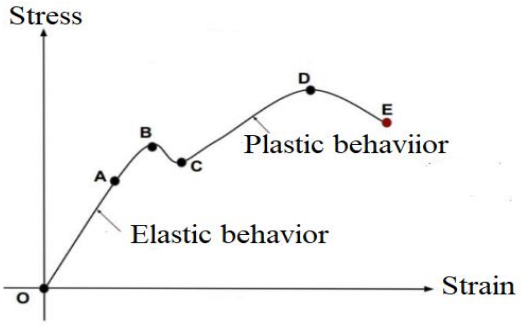


Figure 6. Stress and strain curve

According to (ASTM, A615) standard, the yield stress of grade 60 reinforcement bars is 420 Mpa. However, the tested models can be acceptable when they have a minimum yield stress of 420 Mpa[1].
In this research, all the tested, models meet the yield stress required in the (ASTM, A615) standard, which is shown in figure 7 and table 3.

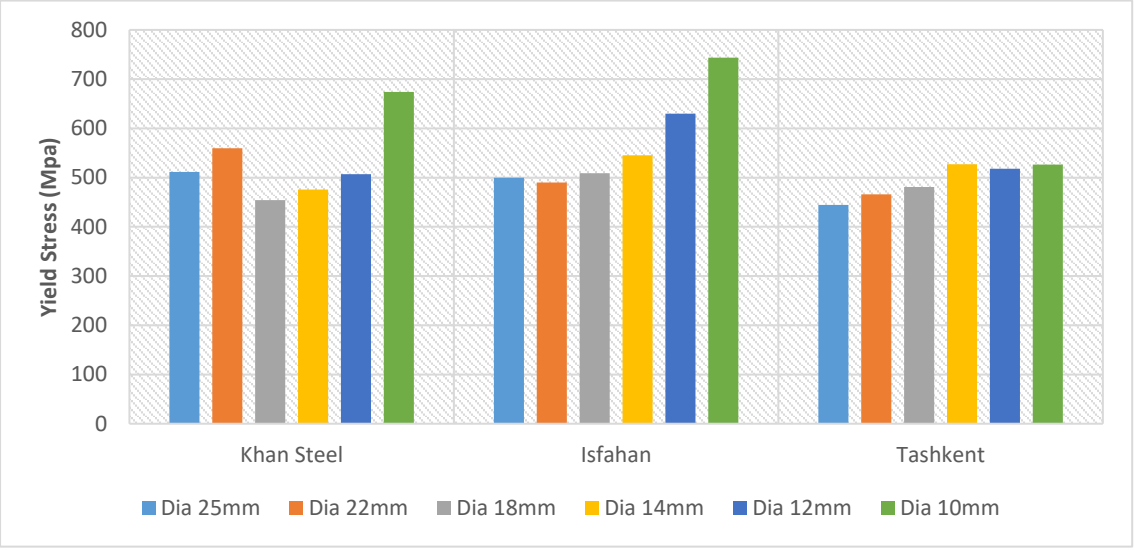


Figure 7. Yield stress of tested models

Table 3. Yield stress of tested models

Diameter (mm)		25	22	18	14	12	10
Khan Steel	*Yield Stress (Mpa)*	511.16	559.61	454.41	475.78	506.95	674.042
Isfahan	*Yield Stress (Mpa)*	499.59	490.01	508.68	545.41	629.87	743.498
Tashkent	*Yield Stress (Mpa)*	444.617	466.18	480.96	526.80	517.62	526.501

values in figure 7. and table 3, shows the result of laboratory testing of specific models, that the reinforcement bars produced by Khan steel company have better yield stress in some cases and similar yield stress in some cases compared to the reinforcement bars

produced by (Isfahan and Tashkent) companies, and it should be remembered that Isfahani 10 mm diameter reinforcement bar shows excellent yield stress among reinforcement bar from two other companies.

3.4. Ultimate stress of reinforcement bar

The maximum force that steel tolerates before failure is called ultimate stress. After the yield point, with increasing stress, the strain increases and the material exhibits plastic behavior, Point D in figure 6. Shows the location of the ultimate stress[8].

According to (ASTM, A615) standard, the ultimate stress of grade 60 reinforcement bars is 620 Mpa. However, the tested models can be acceptable when they have a minimum ultimate stress of 620 Mpa[1].

In this research, all the tested models meet the ultimate stress required in the (ASTM, A615) standard, which is shown in figure 8 and table 4.

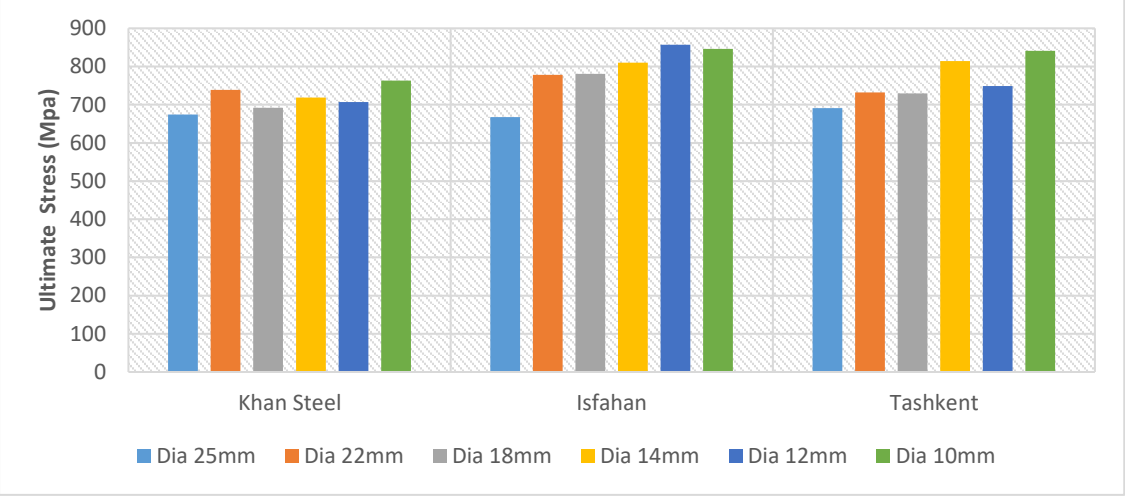


Figure 8. Ultimate stress of tested models

Table 4. Ultimate stress of tested models

Diameter (mm)		25	22	18	14	12	10
Khan Steel	*Ultimate Stress (Mpa)*	674.18	739.19	691.98	718.27	707.09	762.91
Isfahan	*Ultimate Stress (Mpa)*	667.50	777.91	780.74	809.68	857.04	846.02
Tashkent	*Ultimate Stress (Mpa)*	691.158	732.09	729.31	814.50	749.07	841.378

Values in figure 8. and table 4, shows the result of laboratory testing of specific models, that the reinforcement bars produced by khan steel company have better ultimate stress in some cases, similar ultimate stress in some cases and lower ultimate stress in some cases compared to the reinforcement bars produced by (Isfahan and Tashkent).

3.5. Elongation

Elongation refers to the ability to change longitudinal shape under tensile axial loads[2]. The part that can be seen in figure 3, steel after ultimate stress, it has a decrease in width and an increase in length; and finally it breaks at a point where the stress is less than the ultimate stress; this point is called failure stress, shows in figure 9&10[8].

Considering the above, research has shown that steels have different elongation, and this elongation changes due to their physical, chemical and mechanicals properties.

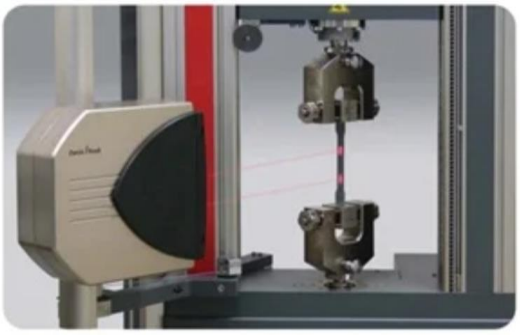


Figure 9. Reinforcement bar in the state of stretching under the experimental machine

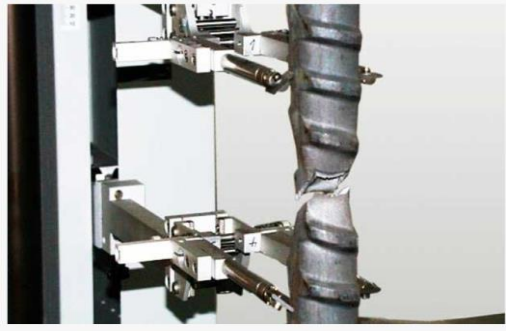


Figure 10. Reinforcement bar is broken due to tensile axial load under the experimental

Research's show that the greater the longitudinal deformability; in case of applying additional loads on reinforcement concrete buildings, the steel reinforcement bars are significantly deformed, thus preventing the spread of cracks in concrete [6].

(ASTM, A615) standard has determined the minimum elongation of grade 60 steel reinforcement bar according to the diameter of the reinforcement bar as follows: reinforcement bars with a diameter of 10 mm to 19 mm have minimum elongation of 9%, reinforcement bars with a diameter of 22 mm to 25 mm have minimum elongation of 8% and reinforcement bars more than diameter of 25 mm have minimum elongation of 7%[1].

In this research, all tested models, meet the percentage of minimum elongation required in the (ASTM, A615) standard, which is shown in figure 11 and table 5.

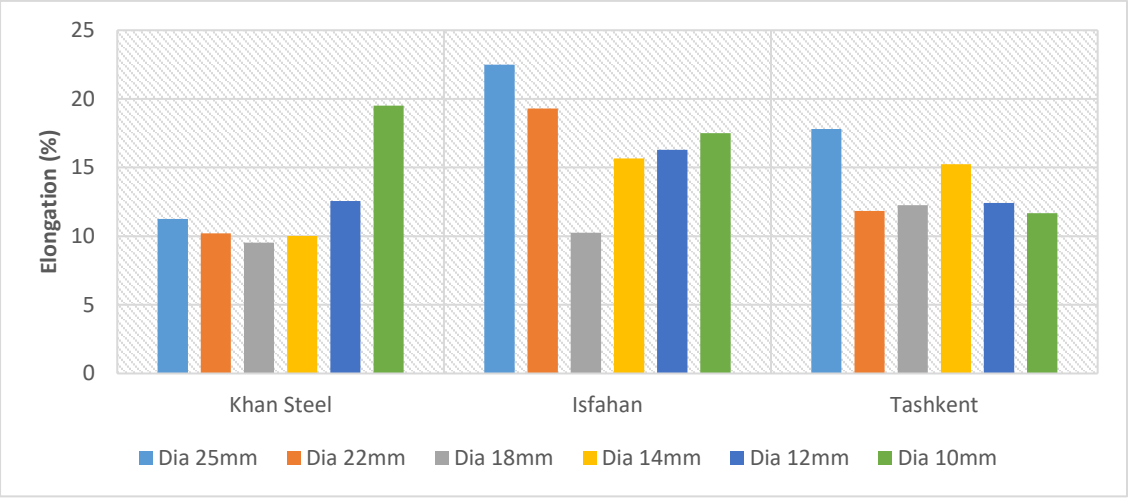


Figure 11. Elongation of tested models

Table 5. Elongation of tested models

Diameter (mm)		25	22	18	14	12	10
Khan Steel	*Elongation (%)*	11.25	10.21	9.52	10.03	12.56	19.50
Isfahan	*Elongation (%)*	22.5	19.3	10.25	15.66	16.29	17.50
Tashkent	*Elongation (%)*	17.8	11.84	12.25	15.25	12.41	11.68

Values in figure 11. And table 5, which shows the result of laboratory testing of specific models, that the reinforcement bars produced by Isfahan Company have better elongation compared than the reinforcement bars produced by (Khan Steel and Tashkent) companies. But elongation of the reinforcement bars of the other two mentioned companies also meet the (ASTM, A615) standard.

4. Conclusion

The testing of the tensile capacity and elongation of the reinforcement bar, which was performed on the tested models from three reinforcement manufacturing companies (Khan Steel, Esfahan and Tashkent), considering the (ASTM) standards, the results of the models testing were acceptable, and it can be used in the structure of the buildings.
Also, considering the results of the research, the following points can be mentioned:

- The reinforcement bars produced by Khan Steel Company have more effective diameter than the reinforcement bars produced by the other two mentioned companies.
- In diameters 25 mm and 22 mm, the yield stress of reinforcement bars produced by Khan Steel Company is better, and in diameters 18 mm, 14 mm, 12 mm and 10 mm the yield stress of reinforcement bars produced by Isfahan Company is better. But production reinforcement bars of all three company meet the (ASTM, A615) standard requirement in terms of yield stress.
- The ultimate stress of the reinforcement bars produced by all three companies (Khan Steel, Isfahan and Tashkent) is suitable.

- The elongation of reinforcement bars to produce by Isfahan Company is better. But production reinforcement bars of all three company meet the (ASTM, A615) standard requirement in terms of elongation.
- Khan Steel, as a construction material produced in Afghanistan, can have a good competition in terms of quality with imported steel (Esfahan and Tashkent).

5. Suggestion

After studies and research on the tensile capacity and elongation of the reinforcement produced by Afghanistan, (Khan Steel) and the imported reinforcement that are widely used in Afghanistan such as (Esfahan and Tashkent) reinforcement, the following suggestions can be made:

- Conducting unbiased research by experts and professionals in the field of quality of domestic products.
- The use of domestic products, especially the production of construction materials, because on the one hand it has good quality and on the other hand it has direct impact on economical growth of the country.
- Bringing such research and accurate information to people about better quality of building materials in every possible way.

6. Acknowledgement

I would like to express my gratitude to the professors of Kabul Polytechnic University who have increased the effectiveness and quality of this scientific article with their review and guidance.

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