International Journal of Current Science Research and Review
ISSN: 2581-8341
Volume 07 Issue 09 September 2024
DOI: 10.47191/ijcsrr/V7-i9-52, Impact Factor: 7.943
IJCSRR @ 2024
www.ijcsrr.org

Evaluation of the Quality of Reinforcing Bars on the Market in the City of Lubumbashi in DR Congo

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ABSTRACT: This research highlights the evaluation of the chemical and mechanical quality of reinforcing bars on the Lubumbashi market including bars imported from South Africa (FA), Zambia (FZ) and those produced locally (FC) by the only steel industry, in the former province of Katanga, the iron processing company SOTRAFER, in acronym.

Indeed, this iron production sector is unexplored in the Democratic Republic of Congo while we are in the era of its reconstruction. Consequently, this sector leads us to an almost total dependence on imported iron (steel) because the latter is known throughout the world as the engine of development of modern societies. The samples of the locally produced reinforcing bars (FC) were collected at SOTRAFER at the end of production, while the samples of the FA and FZ reinforcing bars were taken randomly on the Lushois market in a hardware store specializing in sales to avoid errors.

The chemical characterization showed that the three natures of the reinforcing bars are similar with all the elements in the ISO 9001 standards which are Fe, Mn, Cu, Si, C, Cr, Ni, Mo, P, S, Nb, Co, Ti, V and Al except three chemical elements such as Mo, Ni and Cu. This difference is, however, attenuated by the equivalent carbon content. The mechanical characterization showed that all the different materials studied comply with the ISO 6898 standard. The high values of the elastic limit resistances of 16, 12 and 10mm in diameter are observed respectively in the FC samples (436N/mm²); FA (450N/mm²); FC (475 N/mm²). These behaviors are also observed in the plastic phase.

KEYWORDS: Bars, Elastic strength, Equivalent carbon, Plastic resistance.

INTRODUCTION

Steel is known throughout the world as an engine of development for modern societies. This is the case for Europe. It is mainly used in the field of construction such as the manufacture of beams as well as for the production of utensils.[1] In fact, it is simply essential because its production is summarized in the steel industry processing oxidized iron ore,[2]

Often rich by reductive fusion to obtain an iron-carbon alloy called steel or cast iron depending on the grade of carbon content [1,3]

In view of its numerous uses, specific additives are often added to metals to obtain so-called alloy steels with particularly sought-after specific properties (www.degruyter.com). At the end of their life, steels are a special category of waste in the sense that they can be 100% recycled while retaining the same properties as the initial materials.[4] Recycling is often carried out in an induction furnace and currently in view of environmental problems; the iron market is crowded with so-called “recycled” steels, especially since recycling has the advantage of saving so much raw materials.[5]

While our country, the Democratic Republic of Congo, does not appear on any list of countries classified as steel producers, Australia and the Republic of South Africa come respectively in first position at the global and African levels. This observation is a paradox because our country is full of iron ore resources, particularly in Haut-Katanga and in the western part of Congo, along the border with Cameroon and Gabon. [6]

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We need even more as we are in the reconstruction phase of our country. The consequence is that we are called upon to import steel. On the Lubumbashi market, our study area, there are mainly steels imported from Zambia (FZ) and those from South Africa (FA).

However, let us point out that our country has a history in the production of iron with the megaproject initiated at the time by President MOBUTU of the Maluku steelworks in Kinshasa which should be powered by vehicle scrap but it unfortunately fell into disuse after few years of operation. [7, 8]

Currently, efforts are being made to produce construction materials locally. [9, 10]
This is particularly the case for cement with the relaunch of CARILU in 2020 in Kolwezi and GCKA in 2022 in Likasi. [11] In the field of steelmaking, it should be noted that there is to date just one steelmaking company in the province of Haut-Katanga, the iron processing company, SOTRAFER in acronym. This Indian capital company partly produces of iron since 2007, after three years of construction of the factory and the start of the project, from the recycling of scrap iron in the form of waste in our environment. Its production is mainly concrete iron (bar) used in construction. [12]

II. MATERIALS AND METHODS

The analyze of the different samples were carried out within the SOTRAFER company. The production plant is located at latitude of 8711500 South, longitude of 554750 East and an altitude of 1245 m. Its head office is located at No. 34, Avenue Savonnier at the intersection with Avenue Victimes de la Rébellion, in the commune of Kampemba, city of Lubumbashi, Province of Haut-Katanga, in the Democratic Republic of Congo.

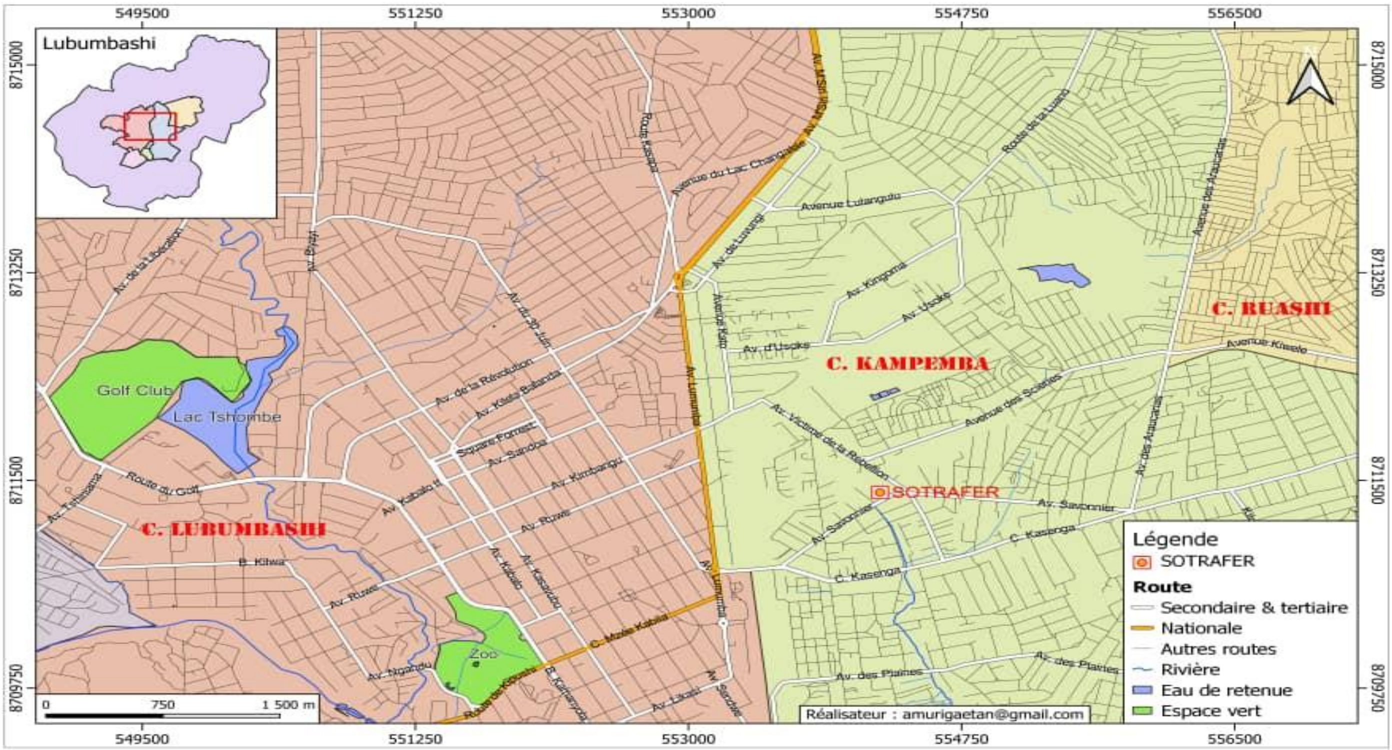

Fig. 1. Mapping the location of the company SOTRAFER/Lubumbashi (AMURI GAETAN)

The sampling of rebar's from South Africa, Zambia and those produced in the DRC, more precisely from the SOTRAFER Company in Lubumbashi, was carried out randomly, once, for three years(2020, 2021 and 2022) in order to avoid estimation errors.

The procedure consisted firstly of collecting by sampling the three types FA, FC and FZ with dimensions of 10, 12 and 16 mm in diameter, used extensively in construction. For reasons of convenience, the FC samples were taken in the SOTRAFER facilities after production while the FA and FZ samples were taken randomly on the Lubumbashi market in a hardware store

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specializing in the sale of steels. These bars from different sources were studied to assess the quality with a view to establishing a clear diagnosis aimed at promoting this sector. These samples were characterized chemically, mechanically and microstructurally, accompanied by a statistical analysis of the results.

The rebar's from Zambia (FZ) and South Africa (FA) were purchased from the Lushois market, selecting three pieces of 6m length from 268 pieces of bars of 10 mm in diameter constituting one ton, 3 pieces of 6m in length in 188 pieces of 12mm in diameter constituting one ton and 3 pieces of 6m in length in 128 pieces of 16mm in diameter constituting one ton. For those of SOTRAFER (FC), the selection was made on the day of production of the 10 mm, 12 mm and 16 mm diameter reinforcing bars. This selection was made because of 3 pieces of 6m length of reinforcing bars in a batch of 300 pieces diameter for all three dimensions. These different bars were designated FA from South Africa, FZ from Zambia and FC from the Democratic Republic of Congo.

Fig.2. Samples of reinforcing bars of 10, 12 and 16mm diameter

The bars taken from the SOTRAFER installations after production as well as the various rebar's purchased on the Lubumbashi market were sent to the chemical and mechanical analysis laboratory of the Society de Transformation de Fir (SOTRAFER) followed by a microstructural analysis carried out in the metallographic analysis laboratory of the Polytechnic Faculty of the University of Lubumbashi where a cutting was carried out following the operating mode of each analysis.
Chemical characterization was carried out using the atomic emission spectrometer, [13,14]. This device was accompanied by the sample preparation machine; the sample smoothing machine called sample machine.[15,16]
The mechanical characterization was carried out using the Universal machine testing. [17, 18]

III. RESULTS

III.1. Results of chemical characterization

The results of the chemical characterization of the 10, 12 and 16 mm diameter the bars of FA, FZ and FC are presented in Figure 3, 4.

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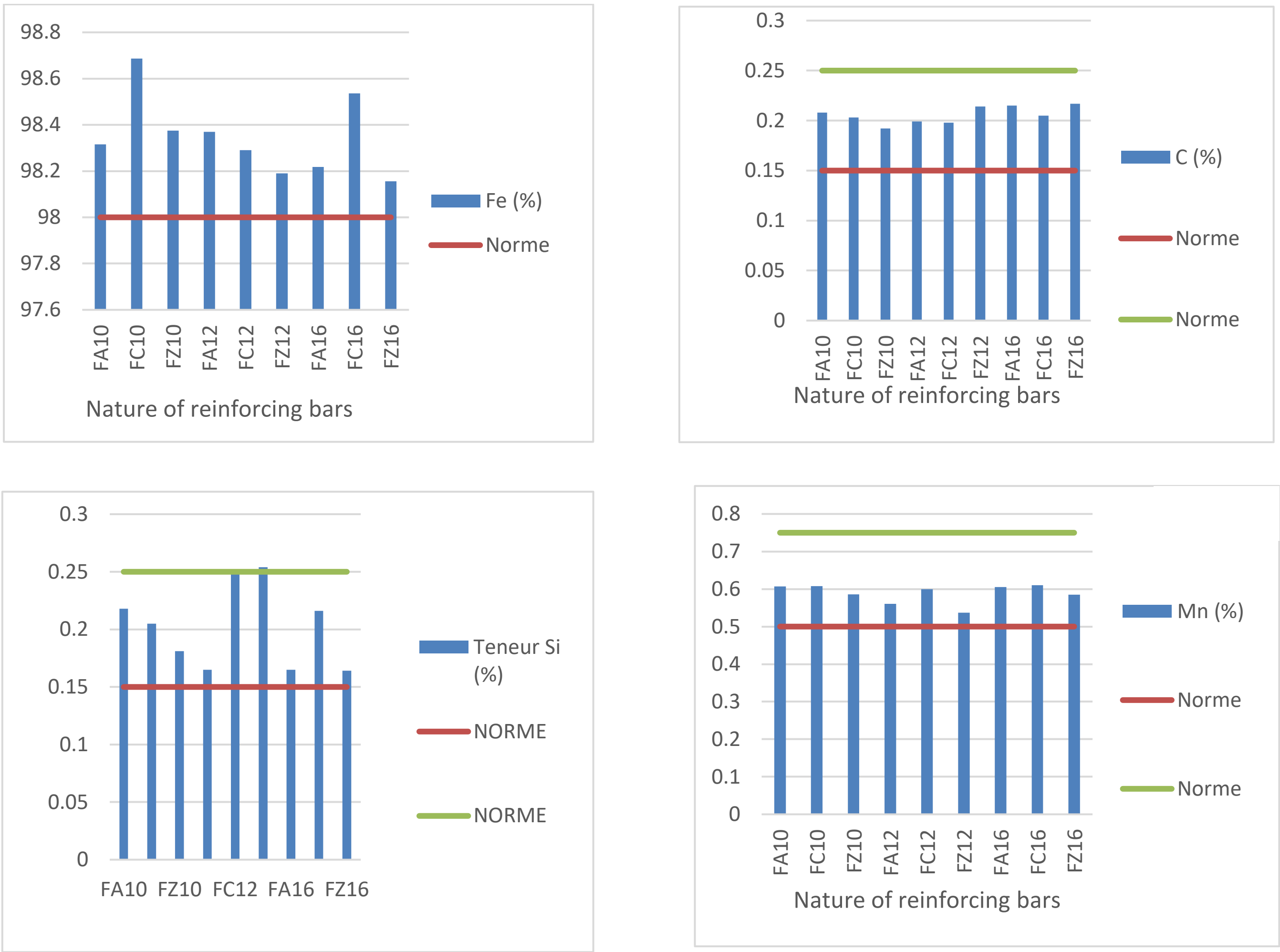
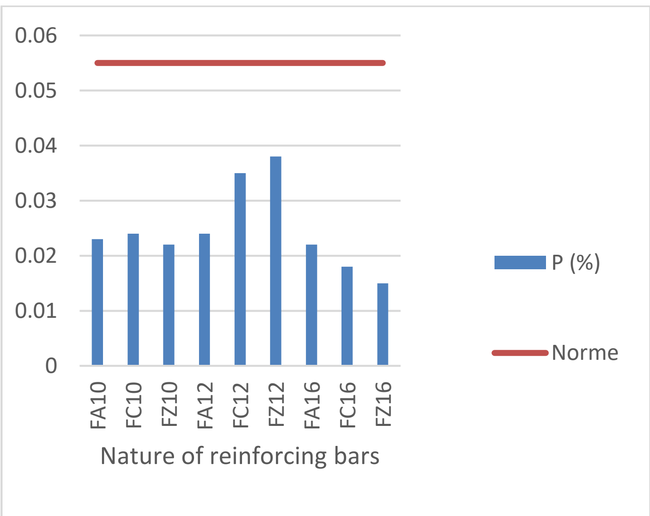
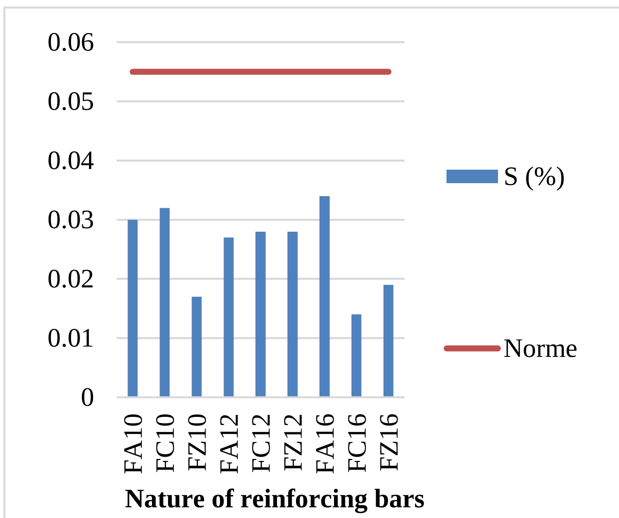


Fig.3. Elements in the standard





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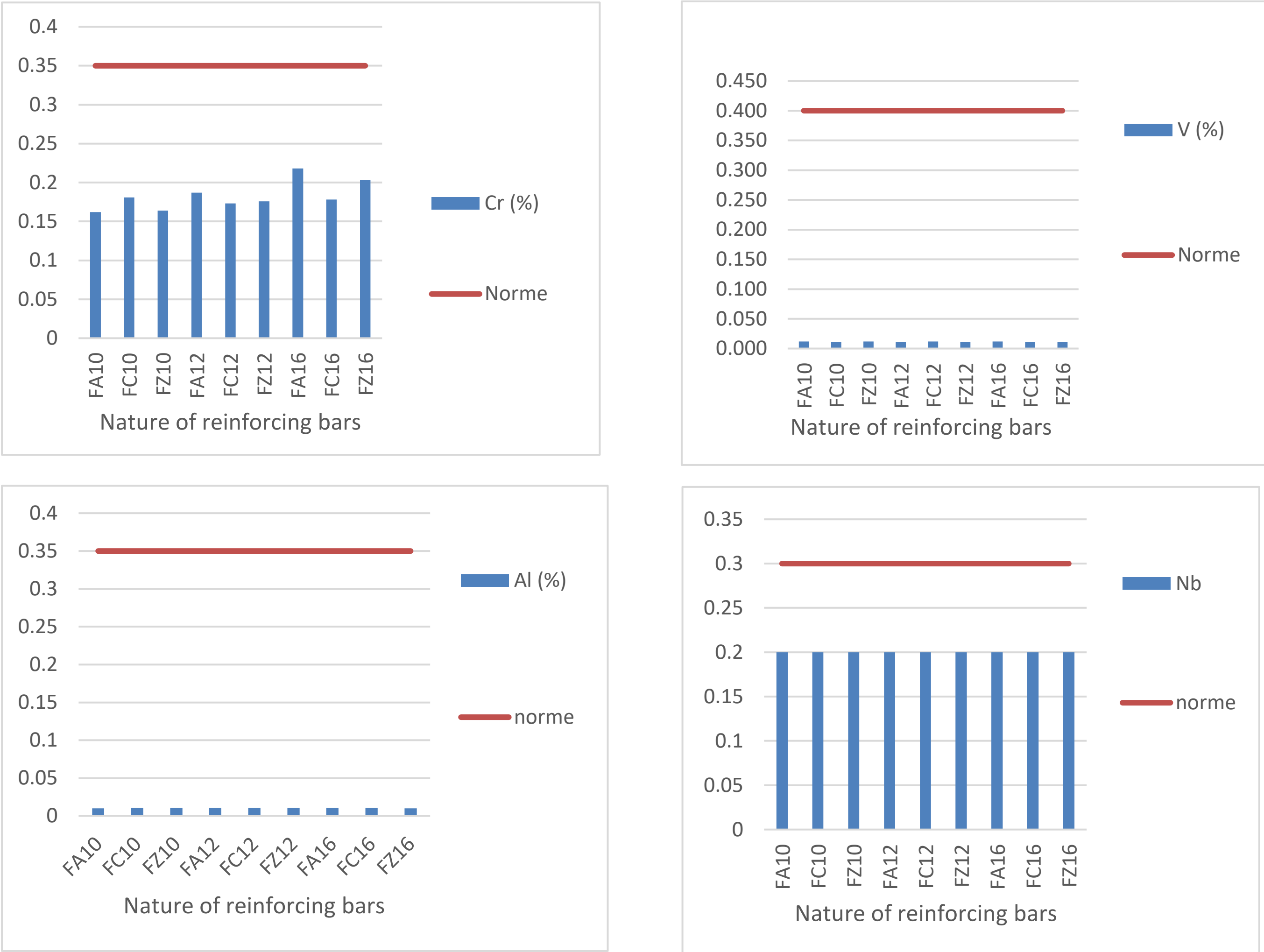

Fig.4. Sequences of elements in the standard

Examination of the results obtained in Figures 3 and 4 show that 12 chemical elements are within the margin of the international standard ISO 9001. Indeed, of all these elements, we note that iron is the most abundant element with a percentage beyond 98%. For steels, the most important main elements are iron and carbon which lead to the characterization of several grades. [19]

In our case, the iron content is beyond 98% while the carbon content varies from 0.19 to 0.22 confirming compared to the standard that we are in the presence of low alloy steels, i.e.; the iron and carbon content are within the margin of the standard used. Other chemical elements such as Mn, Si, S, P, Mo and Cr are accompanying elements which give the steels the desired properties and precisely determine good low alloy steel compared to the standard used. ISO 9001. This standard represents the limit of each chemical element. [20,21]

Comparing the results obtained with the standard, we note that the carbon content impacts weldability, hardness, corrosion resistance, tensile strength, resistance to weld decomposition, yield strength. On steels [22]

The presence of manganese in our samples contributes to the mechanical strength and forms sulfides improving machinability while moderately increasing hardenability in cast iron and for steels this element prevents graphitization by strengthening the atomic bonds between iron and carbon and acting as an anti-dote to sulfur because sulfur is less harmful in the

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form of manganese sulfide but harmful in the form of iron sulfide or free sulfur. [23] Speaking of silicon, the content is in the range of 0.16 to 0.25 which is within the standard.

This element does not completely influence the properties of the steel but makes it more homogeneous during casting thanks to its power to reduce the formation of sulphides. Its importance when encountered in large quantities allows good deoxidation of the steel and improves the electrical resistivity, the resistance to oxidation of certain refractor steels and the crystalline orientation required of magnetic steel. Phosphorus has a content of 0.015 to 0.38 in accordance with the standard.

The latter is a harmful element for steel when it exceeds the required standard and can cause enlargement of the ferrite grain by increasing the brittleness of the steel and the fracture load while considerably reducing plasticity and ductility. As for sulfur, its content varies from 0.014 to 0.034, which also complies with the standard. This element is also harmful at high contents because it significantly influences the mechanical resistance of steels. [24] On the other hand, the high vanadium content increases resistance to wear due to hard carbides as well as heat resistance for hot working.

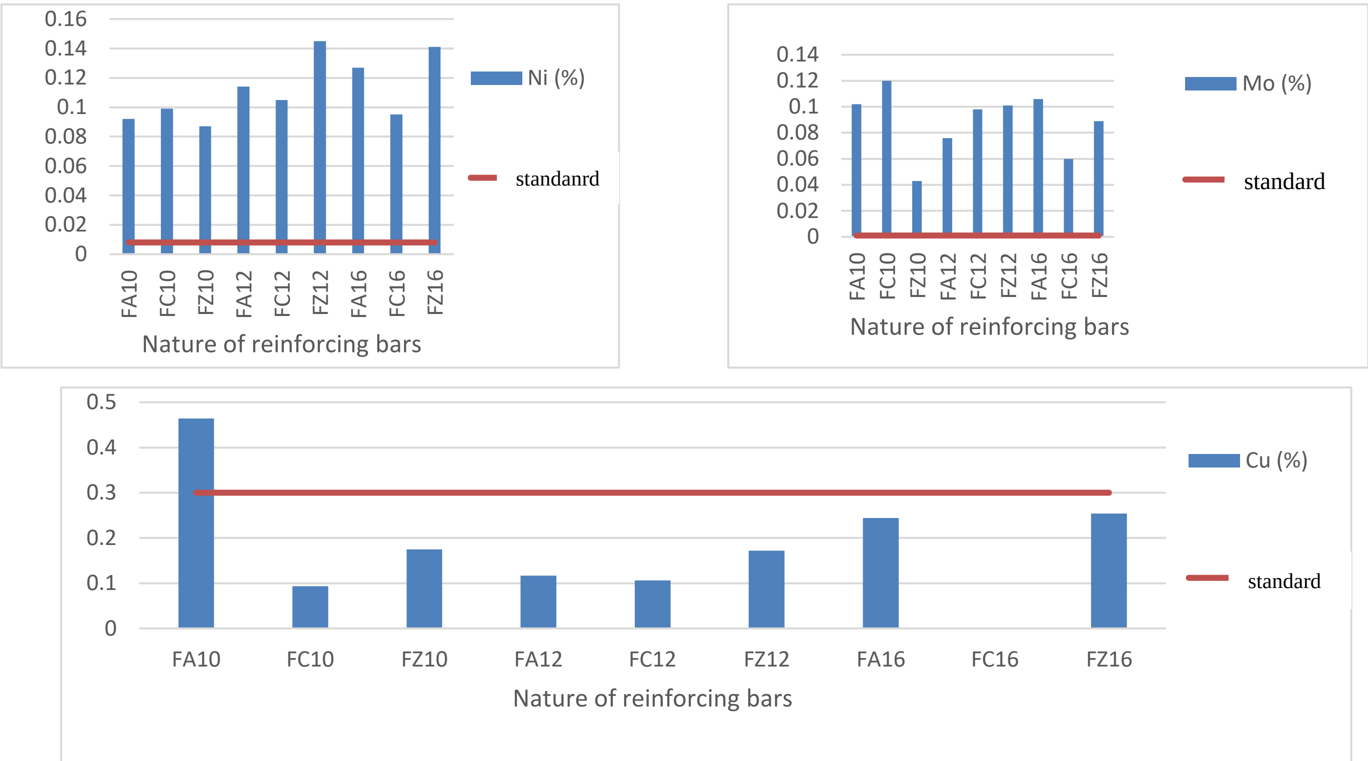

Fig.5. Chemical characterization of elements outside the ISO 9001 standard

Examination of the results obtained in Figure 5 show that 3 chemical elements (Ni, Mo, Cu) are outside the ISO 9001 standard. The high molybdenum content predisposes the materials to corrosion and reinforces the mechanical quality by improving ductility and tensile test measurement. [25, 26]

Molybdenum even enters at levels of 7% in most standard stainless steels, even more in special stainless steels such as C-22 (13%) and C-276 (16%) and from some % to 9% in super alloys. [27]

The high Ni content causes the steel to move from the face-centered cubic structure (little or no Ni) to the face-centered cubic structure (at least 6%) much more in stainless steels. [28] The Nickel content varies from 0.09 to 0.15 also higher than 0.008% and that of Copper significantly higher from 0 to 0.46 for the 10mm the bars from South Africa compared to the standard set at 0.3%.

III.2. Statistical analysis

Table I. Statistical analyzes of the chemical characterization of FA, FC and FZ reinforcing bars of 10, 12 and 16mm diameter

DETAILED REPORT

Group	Number of sample	Sum	Mean	Variance
C (%)	9	1,85	0,21	7,70
Si (%)	9	1,82	0,20	0,00
Mn (%)	9	5,29	0,59	0,00
P (%)	9	0,22	0,03	5,46
S (%)	9	0,23	0,03	4,92
Cr (%)	9	1,64	0,18	0,00
Mo (%)	9	0,79	0,09	0,00
Ni (%)	9	1,00	0,11	0,00
Cu (%)	9	1,63	0,18	0,02
Al (%)	9	0,00	0,00	0,00
Nb (%)	9	0,00	0,00	0,00
Ti (%)	9	0,00	0,00	0,00
Co (%)	9	0,15	0,02	1,22
V (%)	9	0,00	0,00	0,00
Fe (%)	9	885,14	98,35	0,03
CE (%)	9	3,37	0,38	0,00

III.2.1. Variance analysis

Table II. Analysis of variance on the chemical elements of FA, FZ, and FC reinforcement bars of 16 mm diameter

Variation of source	Squares of sum	Degree of freedom	Mean squares	F	Probability	Critical value for F
Between Groups	81393,78	15	5426,25	1721639,18	0	2,13
A inside the groups	0,40	128	0,00			
Total	81394,18	143				

By examining Table's I and II of the chemical characterization of the 10, 12 and 16mm reinforcement bars of FA, FC and FZ, the chemical elements that constitute these reinforcement bars do not represent any influence because the value of the probability found which is zero is greater than the significance threshold (0.05). By checking the calculated Fischer factor F(1721639.18), this value is greater compared to the critical Fischer factor which is F(2.13). Therefore, we can say that the origins of the manufacturing have the same behavior on the chemical level.

Table III. Analysis of variance on the chemical elements of FA, FZ, and FC reinforcement bars of 10 mm diameter

Variation of source	**Squares of sum**	**Degree of freedom**	**Mean squares**	**F**	**Probability**	**Critical value for F**
Between Groups	0,01	2,00	0,01	5,97	0,99	4,30
0	26560,07	33,00	804,85			
Total	**26560,08**	**35,00**				

The values obtained in Table III relating to the analysis of variance on the chemical characterization of the reinforcement bars of 10 of FA, FZ, FC show that the value obtained of file factor F (5.97) calculated and confirmed by the software used in this work (Excel), is higher than the critical file factor F (4.30) read in the tables. Therefore, we can say that there is not a significant difference on the three reinforcing bars studied according to the null hypothesis.

Table IV. Analysis of variance on chemical elements of 12mm diameter FA, FZ, FC reinforcing

variation of source	Sum of squares	Freedom of degree	Squares Mean	F	Probability	Critical value of F
Groups of between	0,0002	2	7,53	9,39	0,99	4,30
Inside the groups	26467,89	33	802,06			
Total	**26467,89**	**35**				

The values obtained in Table IV relating to the analysis of the variance of the chemical characterization of the FA, FZ, FC reinforcing bars of 12mm diameter show that the value obtained of Fischer factor F (9.39) calculated and confirmed by the software used in this work (Excel), is greater than the critical Fischer factor F (4.30) read in the tables. Therefore, we can say that there is not a significant difference on the three reinforcing bars studied according to the null hypothesis.

IV.3. Results of the mechanical characterization of FA, FZ and FC reinforcement bars of 16, 12, 10 mm diameter

The results of the mechanical characterization of the 10, 12 and 16 mm diameter reinforcement bars of FA, FZ and FC are given in Table V

Table V. Results of mechanical characterization of 16, 12, 10 mm FA, FZ and FC reinforcement bars

HEAT	SIZE	SECTION	SAMPLE	HOLDING LENGTH	MASS/m	GAUGE LENGTH mm	MAX LOAD N	UTS	DISPLAY mm	ELONGATION %	YIELD LOAD	YIELD STRESS	$1-\frac{YS}{UTS}$x10
	Mm	mm²	Mm	Mm	Kg			N/mm²				N/mm²	
F.A 16 mm	15,69	193,10	500	250	1,55	78,42	102553,33	531,00	96,17	22,67	81630,00	422,67	20,33
F.Z 16mm	15,73	194,36	500	250	1,56	78,67	106243,33	546,33	93,67	18,67	82746,67	425,67	22,00
F.C 16mm	16,00	201,04	500	250	1,58	80,03	112400,00	559,00	97,00	21,00	87760,00	436,33	21,67
F.A 12 mm	11,72	107,78	500	250	0,86	58,57	63553,33	590,00	70,47	20,33	207263,33	450,00	23,67
F.Z 12mm	11,72	107,83	500	250	0,86	58,60	61103,33	566,67	69,33	18,00	46093,33	427,67	24,33
F.C 12mm	11,95	112,16	500	250	0,88	59,77	65610,00	584,67	71,90	20,00	49653,33	442,33	24,67
F.A 10 mm	9,76	74,73	500	250	0,60	48,77	45736,67	612,00	60,00	22,67	35113,33	470,00	23,33
F.Z 10mm	9,86	76,27	500	250	0,61	49,28	45720,00	600,00	59,33	20,33	35903,33	470,67	21,33
F.C 10 mm	10,02	78,74	500	250	0,62	50,08	48483,33	615,67	60,13	20,33	37423,33	475,33	22,67

YOUNG MODULE MPa	FA 10	FZ10	FC 10	FA 12	FZ12	FC 12	FA 16	FZ16	FC 16
	1036376,83	1162790,70	1168907,07	207063,33	4761904,76	119076,19	934579,44	113636,36	1041666,67

Looking at Table V, we note that the three tests of 16 mm diameter reinforcing bars from South Africa, Zambia and the DRC have an average maximum force respectively of 102553 N, 106243, 33N, 112400N and a minimum force of 81630 N; 82746.67N; 87760N.

these test pieces have an average of the following parameters: a surface area of 193.10 mm², a diameter of 15.69mm, a mass of 1.55 Kg, a maximum stress or resistance to attraction (UTS) of 531 N/mm², a minimum stress or elastic limit resistance (YIELD STRESS) of 422.67 N/mm², an elongation of 22.67% and a modulus of elasticity (Young's modulus) of 934579.44 MPa for the bars frames from South Africa : an area of 194.36 mm², a diameter of 15.73mm, a mass of 1.56 kg, a maximum stress or resistance to attraction (UTS) of 546.33 N/mm², a minimum stress or yield strength (YIELD STRESS) of 425.67 N/mm², an elongation of 18.67% and a modulus of elasticity (Young's modulus) of 113636.36MPa for the bars of Zambia and for the DRC, the area is 201.04 mm², a diameter of 16 mm, a mass of 1.58 kg, a maximum stress or resistance to attraction (UTS) of 559 N/mm², a minimum stress or yield strength (YIELD STRESS) of 436 ... elongation of 21% and a modulus of elasticity (Young's modulus) of 1041616.67 MPa .

These results show that the elastic phase is observed at an elastic limit stress respectively for each material of 422.67 N/mm²; 425.67 N/mm², 436.33 N/mm² exceeded this elastic limit, a plastic phase is observed at a maximum strength or resistance to attraction of 531 N/mm²; 546.33 N/mm² and 559 N/mm² with a relative deformation of 22.67%, 18.67% and 21% which corroborates the SABS 6898 standard set from 420 to 800 (N/mm²).

The information provided in Figure 29 shows that the elastic phase of the specimen is observed at a certain elastic limit. Beyond this elastic limit, we find ourselves in a plastic phase which is reached at a maximum resistance or resistance to attraction with a very precise elongation. These results show that these materials of different origins remain compliant with the ISO6828 standard.

Table VI. Statistical analyzes by ANOVA of the mechanical characterization of 12mm diameter FA, FZ, FC reinforcing bars

Groups	Number of samples	Sum	Mean	Variance	Standard deviation
FA12	12	272900,1	20992,31	3,44	58643,84
FC12	12	117341,7	9026,28	4,76	21817,12
FZ12	12	109231,7	8402,44	4,12	20292,11

Table VI shows that the average mechanical strength of 12 mm bars ranges from 8402.44 for the Zambian product to 20992.31 for the South African product. The standard deviations of the products are different from each other with high variability for the South African product.

Table VII. Results of statistical analyzes by ANOVA of the mechanical characterization of FA, FZ, FC reinforcing bars with a diameter of 10mm

Groups	Number of samples	Sum	Mean	Variance	Standard deviation
FA10	12	82921,85	6378,60	233065319	15266,48
FC10	12	87990,26	6768,48	263042486	16218,59
FZ10	12	83681,018	6437,00	236801640	15388,36

Table VII shows that the average of the components of the 10 mm diameter bars vary from 6378.60 to 6768.48 for the South African and Congolese products. The standard deviations of the South African and Zambian bars are relatively close while those of the DRC are slightly high, at 16218.59.

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IV.4. Comparative study of different reinforcement bars

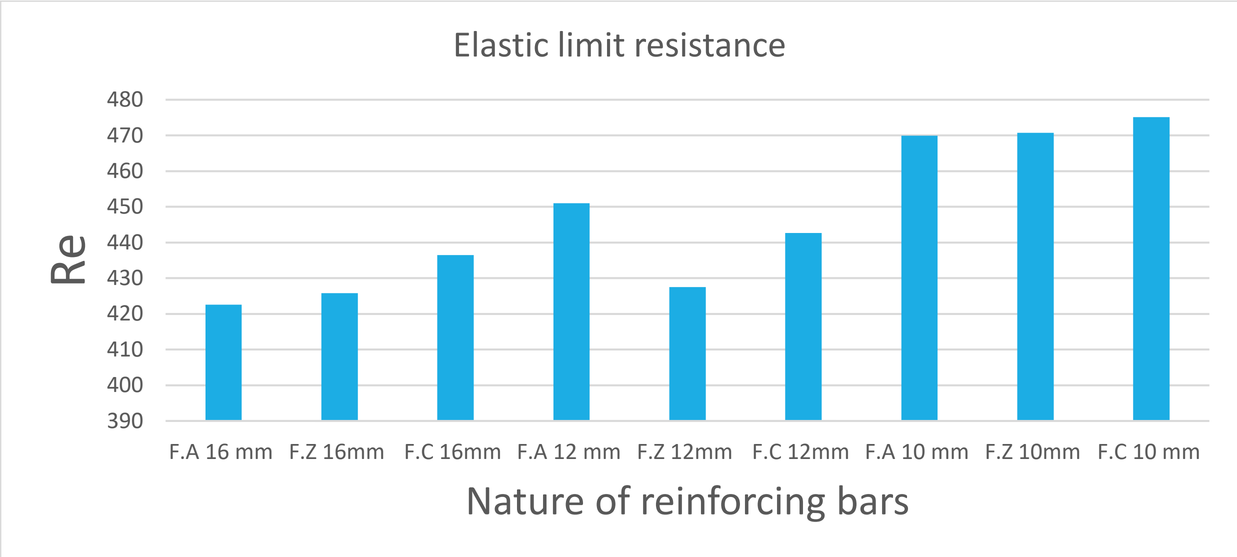

FIG. 6. Mechanical characterization comparison

Looking at Figure 10 of the mechanical characterization of reinforcing bars from different sources of 16, 12 and 10 mm in diameter, we see that the larger the diameter, the more the resistance decreases. The diameter also has a positive impact on the resistance of the reinforcement bars. Therefore, non-compliance with required diameter leads to a negative influence on mechanical strength. In general, these results show a better resistance of FC reinforcement bars of the dimensions of 10mm and 16mm diameter and FA of the dimension of 12mm diameter.

CONCLUSION

This study aimed to assess the quality of bars on the Lubumbashi market, including bars imported from South Africa (FA), Zambia (FZ) and those produced locally (FC) by the only steel industry in the Haut-Katanga province, the Society de Transformation de Fir (SOTRAFER).

Indeed, the samples of the locally produced reinforcing bars (FC) were collected at SOTRAFER at the end of production, while the samples of the FA and FZ reinforcing bars were taken on the Lushois market in a hardware store. Specialized in sales.

The chemical characterization showed that the three natures of the reinforcing bars are similar with all the elements in the ISO 9001 standards which are Fe, Mn, Cu, Si, C, Cr, Ni, Mo, P, S, Nb, Co, Ti, V and Al, except three chemical elements: Mo, Ni and Cu. This gap is however attenuated by the equivalent carbon content. The mechanical characterization showed that all the different materials studied comply with the ISO 6898 standard. The high values of the elastic limit resistances of 16, 12 and 10mm in diameter are observed respectively in the FC samples (436N/mm²); FA (450 N/mm²); FC (475 N/mm²). These behaviors are also observed in the plastic phase.

The results obtained from the variance analyses of different materials of the dimensions of 10, 12 and 16 mm revealed that at the level of chemical and mechanical analyses, there was no significant difference on all the parameters studied and that all the reinforcing bars could perfectly be used in construction. Finally, the survey reveals that FA is reputed to be of better quality for several reasons, including the psychological one although its price is lower than that produced locally.

REFERENCES

1. Ademe (2000). Direction de l'industrie, département de prévention et de valorisation des déchets, bilan 2000 de l'accord-cadre de 1993 sur le traitement des VHU pp 23-30.
2. Jean-Pierre Birat. (2022). La décarbonation de la filière siderurgique : Les enjeux du défi de l'acier vert dans annales des mines-réalités industrielles, pp 25, pp77-80

3. J.P Birât et A. Zaoui (2003), *le recyclage de fer, revue de métallurgie internationale*, journal of metallurgy, PP33-100.
4. Dotchamou, Elodie (2022), *comparaison des impacts environnementaux d'une structure biomimétique et d'une structure en poteaux-poutre béton d'un bâtiment tertiaire*, mémoire, faculté des sciences appliquées, Université de liège Belge, P50
5. Anthony N. K. (2018). *Investir dans le secteur industriel en République Démocratique du Congo*, Cahier Sectoriel à Kinshasa, revue, pp 5-28.
6. *https:/www. investindrc.cd/fr/mines* (Consulté, le 10 juillet 2022)
7. Joel Baraka, Aymar Nyenezi Bisoka, An Ansoms.(2016). Zone économiques spéciales vers l'accaparement des terres, perceptions des paysans du site pilote de MALUKU P5.
8. https://www.radiookapi.net, 2016 ; Consulté, le 29 décembre 2023)
9. https://fr.scribd.com , Consulté, le 12 février 2023)
10. https://repository.uneca.org ; Consulté, le 15 mars 2023)
11. https://www.financialafrik.com; Consulté, le 15mars 2023)
12. https://zoom-eco.net ; Consulté, le 17 juillet 2023)
13. Laskminarayanan A.K. et Vasudevan M. (2018). *Advances in Materials and Metallurgy*, lecture notes in Mechanical Engineering, p 3.
14. Akinsola S. I., Issa I. O., Adegoke M. A., Ojo V. O. and Alabi A. B. (2016). *Characterization of Low Carbon Steel Bar Used For Reinforcing*, p19, Journal of the Environment, Vol. 10.
15. Alaneme K.K. (2011). *Desing of a Cantilever-Type Rotating Bending Fatigue Testing Maching, Department of Metallurgical and Materials Engeneering*, Federal University of Technology, Akure, Nigeria, PMB704, vol 10, No 11, pp1027-1039.
16. Ying J., Xiaofei C., Hangji L., Xianghua R. et Yue Y. L. (2021). *Structural Design of Steel Bar Bending Machine*, p 6.
17. Sudarsham D. B. (2021). *An experiment & FEA of cross sectional area of automotive center consol mounting bracket*, Pradnya Surya Engineering Works, Pvt. Ltd., Solapur, Maharashtra, India, p10.
18. Saty D. et Rajeev S. (2021). *Optimization of fused deposition modeling (FDM) process parameters for flexural Strength, Department of Mechanical Engineering, Matilal Nehru National Institute of Technology*. Allahabad, Prayagraj 21004. volume 44, part 2, pp 3012-3016.
19. BEN-FREDJ (2019). *Evolution de la microsctructure des aciers à haute resistance mécanique durant le traitement thermique de trempe*, thèse, Université de Québec, Ecole Supérieure de Technologie, pp10-32.
20. Ndiaye M. B. (2006). *Le recyclage de métaux d'origine industrielle au Sénégal. Thèse en Génie des matériaux*, Ecole Doctorale Matériaux de Lyon, p 16.
21. Hantcherli M. (2010). *Influence d'éléments d'addition sur les transformations de la martensite revenue dans les aciers faiblement alliés*. Thèse, Ecole Nationale Supérieure des Mines de Saint Etienne, France, p 125.
22. Sekfali S. (2004). *Influence de la microstructure sur le comportement local dans les aciers 16MND5*. Thèse, Ecole centrale des Arts et Manufactures, Paris, pp 185.
23. Bensaada S. (2014). *Traitement thermique, classification et désignation des aciers et fontes*, livre, Algérie, pp 113.
24. Bensaada S. (2019). *Elaboration des métaux ferreux, mémoire, Université de Biskra*, Algérie, pp 19-52.
25. Mohammed A. (2020). *Relation entre la microstructure et les propriétés mécaniques d'acier Duperduplex, influence de la topologie et la fraction de phase inoxydable*, livre, Paris, pp 57.
26. Akram A. (2017). *Caractérisation de l'effet du cuivre pré-allié et pré-mélangé sur la trempabilité des aciers en métallurgie des poudres*, mémoire, Université de Laval au Québec, Canada, pp 19.
27. http://infterre.brgm.fr; Consulté, le 25 juillet 2023)
28. Naoun M. (2014). *Influence du peroxyde d'hydrogène sur la susceptibilité à la corrosion des aciers inoxydables en milieu salin*. Thèse, Université Hadj Lakhdar de Batna, p 9.

Cite this Article: Kunyonga Z.C., Luhembwe B.J., Beya K.M., Ilunga Ndala W., Tshimanga E., Kalaka Mayur C.(2024). Evaluation of the Quality of Reinforcing Bars on the Market in the City of Lubumbashi in DR Congo. International Journal of Current Science Research and Review, 7(9), 7344-7354, DOI: https://doi.org/10.47191/ijcsrr/V7-i9-52