International Journal of Innovative Technology and Interdisciplinary Sciences
www.IJITIS.org
ISSN: 2613-7305
Volume 2, Issue 3, pp. 253-258, 2019
DOI: https://doi.org/10.15157/IJITIS.2019.2.3.253-258
Received August 16, 2019; Accepted September 19, 2019

Tensile Testing Analysis of the HRB400 Steel Reinforcement Bar

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ABSTRACT

Many of the engineering applications have been focused on the tensile testing of steels for several reasons and wide usage. Mechanical properties of the steel plays a key role for ensuring the quality of this material after the manufacturing process. One of the important tests for determination the mechanical properties of steel has been focused on the results of the tensile test. Based on it, we can have important information for selecting steel material in different engineering applications such as civil engineering for constructions application, manufacturing industries for machinery details etc. The tensile properties has been used and measured during development of new material or other processes. In our research work we have been focused on the usage of the tensile testing analysis of HRB400 Steel Bar after heat treatment process.

Keywords: Tensile test, hot rolled steel, heat treatment process, engineering applications.

1. INTRODUCTION

Nowadays a HRB400 steel bar has been widely used in many engineering applications. Most of the engineering applications of the HRB400 steel bar have been focused in construction industry [1-5]. During the last decade Albania is accelerating urbanization process by supporting building steel industry for the guarantee of the construction structure safety. Most of the steel manufacturing in Albania have been focused on hot rolled ribbed (HRB400) steel bar. The largest manufactures of HRB400 steel are mainly located in the centre part whose out-puts products amount more than 70% of the total amount of HRB400 steel bar products in Albania. The biggest manufacturing company is called “Kurum ltd” which covers almost all the request of Albanian markets and the rest is going out in Europe. Furthermore there are many factors influencing the quality and mechanical properties of the manufactured product HRB400 steel bar which are listed below:

- chemical components of HRB400 steel bar
- all the conditions of casting and molten of HRB400 steel bar
- heating and cooling in the rolling speed process of HRB400 steel bar
- specification process of the HRB400 steel bar by checking the sampling position, internal stress and artificial errors
- uniaxial tensile testing analysis of the HRB400 steel bar

The factors mentioned above should be taken into account prior the products going in the markets for assuring the quality and avoiding technical barriers in European countries. Based on it, our research work will be focused on the uniaxial tensile testing analysis of the HRB400 steel bar after heat treatment process [2-5]. The main reason is that tensile properties has been used and measured during development of new material or other processes.

2. MATERIALS

One of the important request for reinforcement of the cement in accordance of the standard SSH ISO 6935-2:2015 has been focused in application of the steel delivered in the form of bars, coils and de-coiled products [8]. Based on it, our aim is to study after heat treatment process only the tensile testing analysis of the HRB400 steel bar with different diameters that varied from 8 mm till 20 mm. The standard range of the chemical properties of materials HRB400 steel bar are shown in the Table 1.

Table 1. Chemical properties of material HRB400 steel bar.

Chemical properties of materials					
C	Si	Mn	P	S	Ceq
≤0.25	≤0.80	≤1.60	≤0.045	≤0.045	≤0.54

Furthermore, before starting tensile testing analysis, we have collected many of the random samples with above standard chemical properties of the HRB400 steel bar products.

3. MEASUREMENT METHODS

A tensile testing method was performed for HRB400 steel bar samples. The standard SSH EN ISO 6892-1 has been used for this measurement methods [9]. This method specifies a procedure for determining the tensile testing resistance by applying static force at normal temperature of HRB400 steel bar sample. Quasi-static testing was carried out using a universal electromechanical “Controls” testing machine with a maximum load bearing capacity of 1000 kN as can be seen in the Figure 1 [7].

Figure 1. Universal tensile testing machine "Control".

From the Figure 1 we have applied a constant rate load with a constant rate until the maximum breaking load has been reached. The tensile test will help us to determine an Ultimate Tensile Strength (UTS), Fracture/ Breaking Strength (BS) and Percentage Elongation (PE). The results from the tensile test were analysed by using the following equations (1)-(3):

$$\mathrm{UTS} = \frac{\mathrm{ML}}{A_0} \tag{1}$$

$$\mathrm{BS} = \frac{\mathrm{BL}}{A_0} \tag{2}$$

$$\mathrm{PE} = [\frac{(L_1 - L_0)}{L_0}] \cdot 100 \tag{3}$$

Afterward we have calculated in equation 4 the ratio between fracture/breaking strength and ultimate tensile strength.

$$\mathrm{Ratio} = \frac{\mathrm{UTS}}{\mathrm{BS}} \tag{4}$$

4. MEASUREMENT RESULTS

The results of the tensile testing analyses of the HRB400 steel bar samples are shown in the Table 2.

Table 2. Tensile testing results of HRB400 steel bar samples

N°	*d* ø (mm)	weight (g)	Length (mm)	Linear mass (Kg/lm)	UTS		BS		PE			Ratio
					kN	N/mm^2	kN	N/mm^2	base	total	%	
1	**8.07**	181	451	0.401	33.8 648.2	648.2	38.1 731.7	731.72	**40**	47.5	19	1.129
2	**7.92**	174.2	450	0.387	32.4 645.5	645.5	36.7 730.8	730.77	**40**	47.0	17	1.132
1	**9.43**	245	447	0.548	40.3 566.2	566.2	48.0 674.4	674.42	**50**	60.5	21	1.191
2	**9.46**	246.2	446	0.552	40.4 564.1	564.1	48.0 669.0	669.02	**50**	61.5	23	1.186
1	**11.93**	390	445	0.876	63.0 553.1	553.1	74.2 652.4	652.35	**60**	72.5	21	1.179
2	**11.87**	387.1	446	0.868	61.7 547.5	547.5	72.3 641.7	641.74	**60**	71.0	18	1.172
1	**14.09**	559	457	1.223	81.0 510.2	510.2	100.7 634.1	634.05	**70**	84.5	21	1.243
2	**14.20**	563.1	453	1.243	82.1 508.5	508.5	101.4 628.0	627.99	**70**	86.0	23	1.235
1	**15.93**	710	454	1.564	114.4 563.0	563.1	139.1 685.2	685.19	**80**	95.5	19	1.217
2	**15.93**	704.9	451	1.563	112.9 556.4	556.4	136.8 673.8	673.82	**80**	95.0	19	1.211
1	**20.03**	1120	453	2.472	166.2 517.7	517.7	199.7 622.0	622.04	**100**	120. 5	20	1.201
2	**20.02**	1131	458	2.470	163.9 511.1	511.1	197.7 616.4	616.44	**100**	121. 5	21	1.206

The above results have shown that are in accordance of the SSH EN ISO 6892-1 where the ratio value varied from 1.13% – 1.25%.

5. SUMMARY AND CONCLUSIONS

The "Kurum ltd" steel manufacturing industry have been identified as one of the most important sectors that dictate the level of economic development of Albanian nation. Most of the usage of HRB400 steel bar has play an important role in the usage of this materials in construction sectors. For assuring the quality of this material we have realized analysis of the tensile testing of the HRB400 steel bar after heat treatment process. Our research results have concluded that HRB400 steel bar product fulfil all the

requirements in accordance of the standard SSH EN ISO 6892-1. Furthermore, the ratio value between fracture/breaking strength and ultimate tensile strength varied from 1.13% – 1.25%.

AKNOWLEDGMENT

This study is supported by "Kurum ltd international". Author would like to thank Polytechnic University of Tirana for supporting this research work.

NOMENCLATURE

ML	Maximum Load
UTS	Ultimate Tensile Strength
BS	Breaking Strength
BL	Breaking Loads
C	Carbon
Si	Silicon
Mn	Manganese
P	Phosphorous
S	Sulfur
Ceq	Carbon Equivalent
A_0	Nominal Area
L_1	Length after breaking load and
L_0	Length before starting the tensile test
d	Diameter

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