Comparative Study Of Rolled Steel Shapes Rebars Manufactured In Lahore

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Abstract – Steel is an alloy of iron and nonmetallic elements like carbon, Phosphorous Silicon and Manganese. By the variation of carbon percentage and addition of the above compounds in different proportions the properties of steel are affected. Although the elements have a great effect on the property of steel yet their quantity in steel is very small. For example the carbon content in steel is 0.20% to 0.3% only.

This study has been carried out to make a comparison of rolled steel shapes and rebars manufactured in Lahore and to check the percentage values of different elements in them. The investigation consists of two phases. First phase pertains to collection of samples of steel from different government approved manufactures in Lahore. In the second phase samples are tested for tension, compression, impact and hardness. Chemical analysis has also been performed to know the percentage values of different elements in each sample. These values are then compared with standard ASTM values to determine variation, if any.

The effect of variation of the elements like C, Mn, Si, P, S, Cu and Fe upon the strength and ductility and other properties of steel are observed. It is noticed that variation from standard values is very small. *(Abstract)*

Keywords- Rolled Steel Shapes, Manufacturing of Steel, Steel Rebars.

I. INTRODUCTION

Steel is one of the most common materials in the construction industry. It is a major component in buildings, infrastructure. Mechanical properties of structural steel and industrialized steel are affected by constituents of steel [1,2,3].the effect of copper on microstructures and mechanical properties of construction is described by olatude [4]. Bridge steel and their mechanical properties are explained in "Bridge Design Hand Book-2015[5]. A comparison is made by [6] between mechanical properties and in micro structures of deformed bars (grade 60) locally manufactured in Pakistan with ASTM standards. Effect of temperature upon different grades of stainless steel is studied by Hamza Zafar [7]. Steel as a material for bridge is explained by ISDATGURU [8].

The carbon in typical steel may constitute up to 0.3% of its weight. Varying the amount of alloying elements, their formation in the steel either as solute elements or as precipitated form retards the removal of those dislocators that make iron comparatively ductile and weak, and thus controls qualities such as the hardness, ductility, and tensile strength of the resulting steel.

The presence of carbon increases its strength but yet reduces its ductility also. The ASTM standard specifies the percentage of steel constituents like carbon, silicon and manganese etc. permissible for various grades of structural steel. (Table-1)

Following Table-1 specifies the maximum level of certain elements in the American steel grade:

TABLE-1: MAXIMUM VALUES OF ELEMENTS IN AMERICAN STEEL GRADE

Element	Content
Carbon, C	0.30 %
Copper, Cu	0.20 %
Iron, Fe	98.00 %
Manganese, Mn	1.70 %
Phosphorous, P	0.04 %
Silicon, Si	0.04 %
Sulphur, S	0.05 %

In Europe, structural steel is manufactured in accordance with EN10025 governed by ECISS (European Committee for Iron and Steel Standardization).In most of the countries in the world steel is regulated and required to meet the criterion for shape, size, chemical composition and strength.

In buildings and other steel construction the most important performance factor is the size, weights and structural steel shape. A grade of steel is specified depending upon the minimum strength and weight and the sectional shapes for a particular usage.

This study is aimed at making a comparative study of rolled steel shapes manufactured in Lahore, Pakistan by different manufacturers preferred by the government. The samples of different shapes collected from the mills were tested for physical, mechanical and chemical properties. The results were then compared with the ASTM standard values. The percentage variations from the standard values were determined and effect upon the strength, ductility and hardness were noticed. It is observed that percentage variation is very small.

A. Sample collection and their testing:

Samples from 8 steel manufacturers were taken. Out of which samples of 3 manufacturers were selected for this project. Due to privacy reasons, these manufacturers have been named as A, B & C.

The angular, channel and girder sections and hot rolled steel bars were collected from the manufacturers and only government preferred steel mills were selected for testing.

The samples were prepared as specified by the code for the following tests.

1. Tensile and bending test
2. Impact test
3. Hardness test
4. Chemical analysis
5. Tensile and bending test for reinforcing bars.

The tests were performed in the laboratories of PCSIR and UET Lahore. Three samples of each of the structural shapes were prepared for each TEST given above. The result of every test is shown in the tables:

TABLE 1: CHEMICAL COMPOSITION COMPARISON OF DIFFERENT STEEL'S MANUFACTURER IN LAHORE.

Elements	Symbol	Percentage by Weight				Remarks
		A	B	C	Standard Range	
Carbon	C	0.293	0.258	0.369	0.15-0.30	Sample of C Steel not within standard range
Maganese	Mn	1.305	0.755	0.541	0.5-1.7	within standard range
Phodphorous	P	0.032	0.044	0.034	0.01-0.05	within standard range
Sulphur	S	0.036	0.021	0.030	0.01-0.05	within standard range
Silicon	Si	0.447	0.322	0.308	0-4	within standard range
Copper	Cu	0.17	0.18	0.17	0.15-0.20	within standard range
Iron	Fe	98.143	98.429	98.533	Min 98	within standard range

TABLE 2: IMPACT TEST COMPARISON OF DIFFERENT STEEL'S MANUFACTURER IN LAHORE.

Sr No	Shape	Average Reading			Max limit
		A	B	C	
1	TR section	131	113	129	138
2	Angle section	129	124	121	138
3	Channel section	131	128	128	138
4	Girder section	124	132	130	138

TABLE 3: HARDNESS TEST OF DIFFERENT STEEL'S MANUFACTURER IN LAHORE.

Sr No	Shape	Average Reading			Max limit
		A	B	C	
1	TR	85.33	84.66	85	100
2	Angle	76.5	74	75	100
3	Channel	74.17	72.83	74.33	100
4	Girder	88.67	89.67	87.5	100

TABLE 4: TENSILE AND BENDING TEST ON SHAPES MANUFACTURED IN LAHORE.

Sr No	Shape	Size	A				B				C			
			Thick-ness	Yield Load	Ultimate Load	% Elong	Thick-ness	Yield Load	Ultimate Load	% Elong	Thick-ness	Yield Load	Ultimate Load	% Elong
1	TR	20	4	35.7	55	30	3.5	36.4	56.5	30	3.3	35.2	54.8	30
2	Angle	20	4.7	35.2	55.7	40	4.4	36	57.9	40	4.8	4.4	53.8	40
3	Channel	20	6.5	47	72.7	50	6.4	46	74	50	6.2	45.5	76	50
4	Girder	20	3.3	26	40.7	40	3.5	30.1	47	40	3	24	37.2	40

TABLE 5: TENSILE AND BENDING TEST ON DEFORMED BARS MANUFACTURED IN LAHORE.

Sr No	Wt	Manu-facturer	Diameter	Area	F_y	F_u	Nominal Yield Strength	Calculated Yield Strength	Nominal Ultimate Strength	Calculated Ultimate Strength	% Elong
			In	In^2	tons	Tons	Psi	Psi	Psi	Psi	
1	1.485	A	6	0.44	11.21	17.3	56210	56720	86710	87510	13.50
2	1.487		6	0.44	10.91	16.89	54670	55050	84670	85250	21.30
3	0.647		4	0.2	3.77	5.4	41590	41510	59580	62710	17.50
4	1.454	B	6	0.44	11.42	17.69	57230	58970	88650	91350	15.00
5	1.45		6	0.44	11.52	17.97	57740	59640	90030	92990	13.80
6	0.673		4	0.2	4.58	7.24	57550	57550	72320	72320	18.75
7	1.336	C	6	0.44	9.84	15.92	49310	55610	79810	89360	13.80
8	1.354		6	0.44	9.73	15.75	48800	53950	78940	87270	17.50
9	0.682		4	0.2	6.94	10.19	71610	55110	72410	72410	20.00

II. RESULTS AND DISCUSSION:

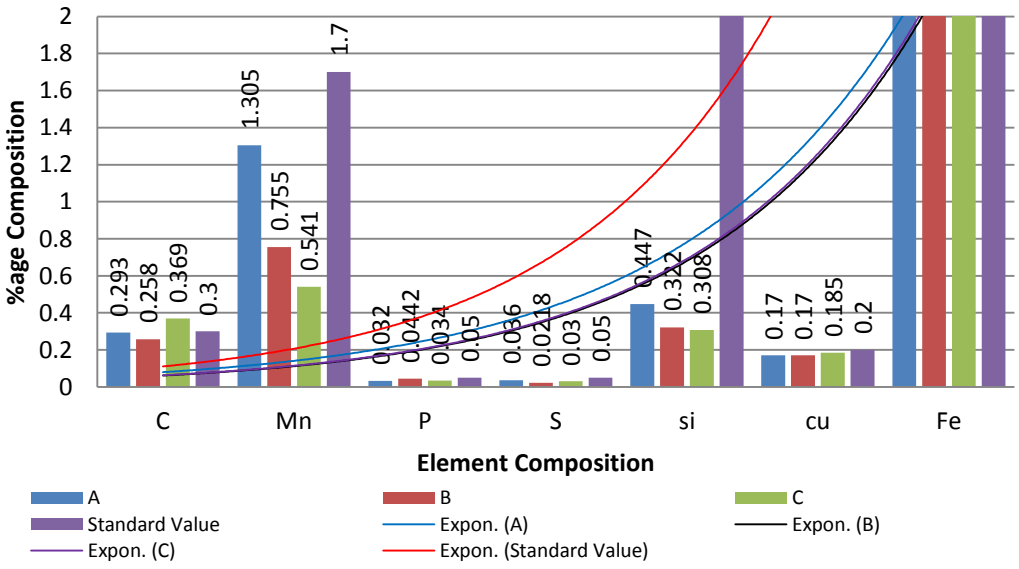

Fig 1: Chemical Composition of Elements of Different Manufacturers in Lahore.

1. Carbon is the most important chemical element in steel which mainly affects its strength and ductility. The quantity of carbon in structural steel varies from 0.25 to 0.30 %. If the carbon content is more than the standard value, the ductility will decrease and the value less than 0.15% the strength will be unsatisfactory. The graphs show that the carbon content of A & B are 0.293% & 0.258% respectively which are within standard range of ASTM. Whereas carbon content of C is 0.369% which exceeds the standard value of 0.3%.

2. The Mn content of A, B and C is 1.305, 0.755%and 0.541%respectively which is within standard range of 1.7% and the graph shows specific hardening ability and tensile strength of the material. In the results it can be seen that C shows similar strength to others although the function of the manganese is same as that of carbon. It is seen that if carbon content in C is

increased the manganese content is reduced which controls the ductility and strength as well.

3. Phosphorus increases strength and hardness, but at the expense of ductility and impact to toughness, especially in high carbon steels. Phosphorus content of over 0.04% the effect of weld ability is brittle and increases the tendency to early cracking. The surface tension of the molten weld metal is lowered, making it difficult to control. The P content of A, B and C is 0.032%, 0.0442% and 0.034% respectively. In terms of welding, phosphorus content of B is over 0.04% makes weld brittle and increases the tendency to crack.
4. Sulphur improves machine-ability but lowers transverse ductility and notched impact to toughness and has little effects on the mechanical properties. Its content is limited to 0.05% which shows that its weld-ability decreases with increase in sulphur content.. The Sulphur content of A, B and C is 0.036%, 0.021% and 0.030% respectively. The above test results show that the weld-ability of B steel is lowest amongst the three.

5. Silicon increases strength and hardness but to a lesser extent than manganese. It is one of the principal deoxidizers used in the making of steels to improve its durability. Its content can be up to 0.4%. The Si content of A, B and C is 0.447 %, 0.332 % and 0.332 % respectively which is within the standard range. This shows that it is good deoxidizers as compared to others.

6. Copper (Cu**)** is corrosion resistance element. Its percentage in anticorrosion steel is about 0.2% which is the main dominant factor in steel. The Cu content of A, B and C is 0.17 %, 0.18 % and 0.17 % respectively which is within the allowable limits.

7. The carbon and other elements in typical steel alloys are up to 2.0 %. Varying the amount of these elements, their presence in the steel either as solute elements, or as precipitated phases, make iron comparatively ductile, weak, and thus controls its qualities such as the hardness, ductility, and tensile strength of the resulting steel.

The iron content of A, B and C is 98.143%,98.249% and 98.533%respectively showing that steel manufactured by these companies are within acceptable limits.

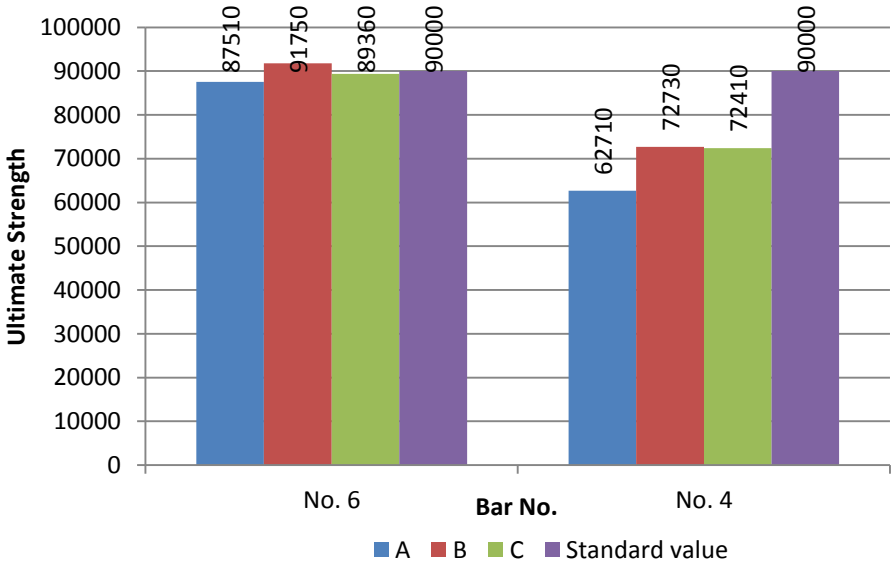

Fig 2: Comparison of Ultimate Strength of Deformed Bars

This reveals that the ultimate of bar no 6 of B and C is almost equal to the standard values but A shows comparatively less values. In bar no 2 the change is similar to bar no 6 which depends upon the value of C and Mn.

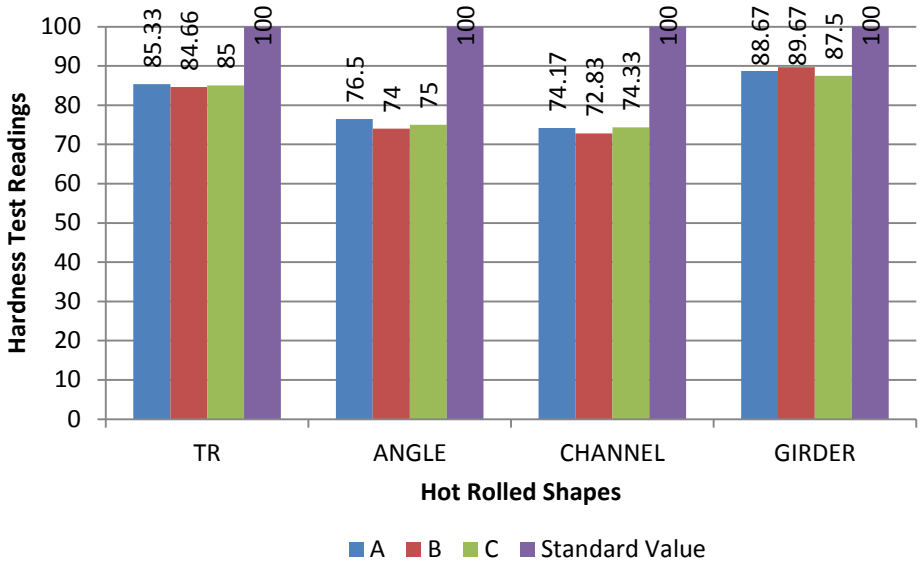

Fig3: Results of Hardness Test Performed on Samples of Steel.

Hardness is the property of the material to absorb energy and show deformation before fracture. The above fig shows that the hardness value of all the manufacturers are less than standard values. The hardness values mostly dependent on C and Mn values in steel which is apparent from fig 1 where C and Mn values are less than standard values.

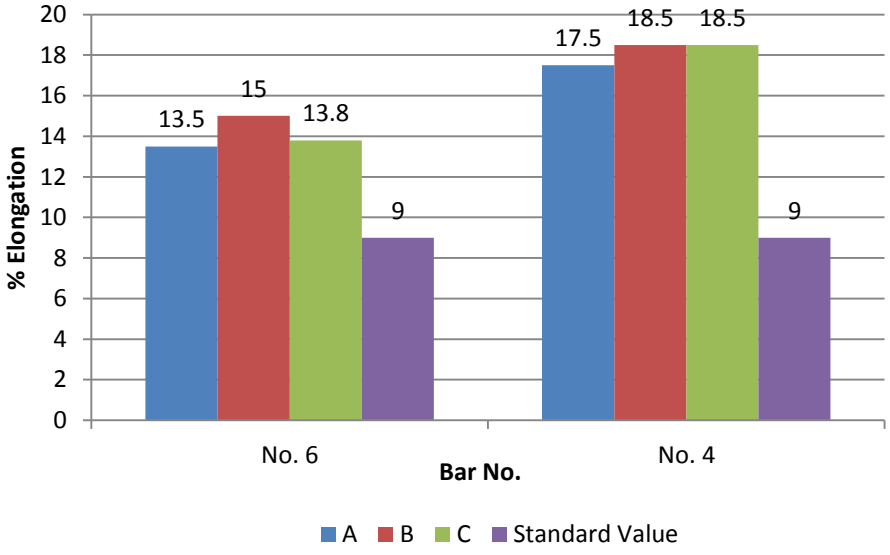

Fig 4: Comparison of % elongation Test Performed on Samples of Steel

Percentage elongation is the measure of ductility of specific steel which is directly related with the steel constituents. Elongation of samples collected from from A, B and C steel is comparatively more than standard values which are further confirmed by the low % value of C in fig4

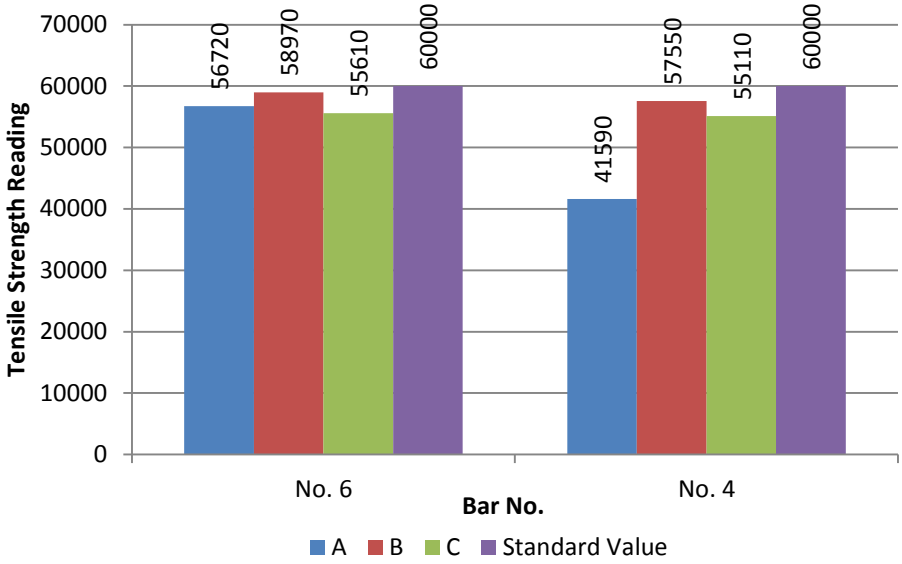

Fig 5: Comparison of Tensile Test Performed on Samples of Steel.

Steels are normally designated by their yield strength. ASTM provides standard steel like A36 where A stands for American standards of testing and materials and 36 is yield strength in Ksi. The above fig shows the yield strength of deformed bars of C and A have lesser value than specified value by the standard but B has comparatively higher value. The ultimate strength value also varies in a similar fashion (Fig 2).

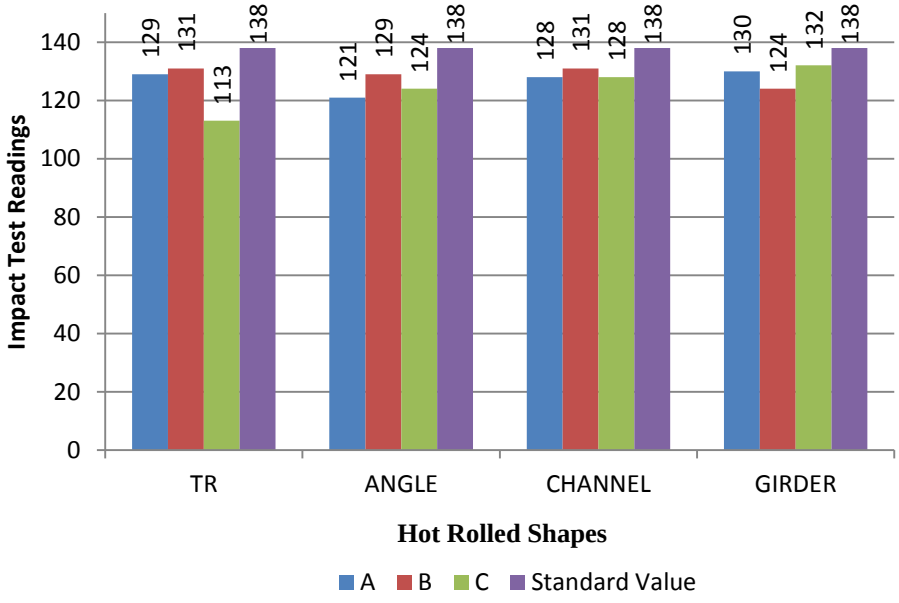

Fig 6: Comparison of Impact Test Performed on Samples Steel.

Impact value is performed to measure the toughness of material which is the resistance of material against sudden impact load. It is actually the energy per unit volume of material when it is loaded from zero to failure. The above Fig-6 shows that the values obtained from all samples are less than the standard value. However, C comparatively gives higher value in girder section, whereas in TR, channel and angle sections B gives higher values.

III. CONCLUSIONS

On the basis of the test results on samples collected from different manufacturers in Lahore we reached to the following conclusions.

i. Steel manufactured like A, B & C show variable values of C, Mn, P, S and Si (carbon, manganese, phosphors , sulphur & silicon respectively). Contents which directly or indirectly affect the strength, hardness, impact & other properties like ductility, elongation & bend test. It is recommended that proper quality control must be maintained by the manufacturers.

ii. The variations of steel contents affect the physical and mechanical properties of steel resulting in change on ductility & the durability of the steel structure.

iii. Manufacturers using scrap steel as raw material should be analysed and checked.

iv. The government should ensure the quality control of steel products. Availability of the raw material for the manufacturers should be easy so that steel of good quality would be available in the market.

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