

A STATISTICAL ANALYSIS OF MECHANICAL PROPERTIES OF LOCALLY MANUFACTURED STEEL PRODUCT

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ABSTRACT

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1. INTRODUCTION

Carbon steel is an alloy of iron with small amount of carbon. Its mechanical properties depend greatly on the heat treatment, manufacturing process and chemical composition. Steel has a major influence on our lives, the cars we drive, the buildings we work in, the homes in which we live and countless other facets in between.

At the moment, there are various steel industries in Bangladesh. Among them the product of a particular industry has been selected to study its most important mechanical properties such as, tensile strength, yield strength, percentage elongation, hardness, etc. and chemical composition. A reasonable number of samples were considered for the experiment in order to perform statistical analyses.

For many reasons the steel industry cannot maintain the quality of its product according to international standard i.e. ASTM, BS etc. This idea has created curiosity to conduct experimental investigation of mechanical properties of this product available in the local market. It could have been a better work if almost all the locally available steel products of different industries could be taken into consideration for the investigation. As a preliminary step only steel product (deformed bar) of one industry has been chosen. In future the steel products of other industries may be taken into consideration for the study.

The test for mechanical properties has been conducted in accordance with the ASTM standard [1]. For the determination of tensile strength, yield strength and percentage elongation a universal testing machine of 20 ton capacity is used. Rockwell hardness testing machine is used for determination of hardness according to the ASTM standard [1]. An optical emission spectrometer is used for determining the chemical composition of steel. A similar study was

conducted on locally available PVC pipe Hossain M. A. et. al [2].

2. STATISTICAL PARAMETERS

Mean: If x_1, x_2, \dots, x_N represent the values of N number of samples then the sample mean is computed from the formula,

$$\mu = \frac{\sum_{j=1}^N x_j}{N} \quad (1)$$

where, N is the number of samples.

Standard Deviation: The expression of the sample variance can be obtained as,

$$\begin{aligned} \sigma^2 &= \frac{x_1 - \mu^2 + x_2 - \mu^2 + \dots + x_N - \mu^2}{N - 1} \\ &= \frac{1}{N - 1} \sum_{j=1}^N x_j - \mu^2 \end{aligned} \quad (2)$$

The sample standard deviation can be expressed as,

$$\sigma = \sqrt{\frac{1}{N - 1} \sum_{j=1}^N x_j - \mu^2} \quad (3)$$

Normal distribution: The most important continuous probability distribution in the entire field of statistics is the normal distribution. If x is the normal random variable with mean μ and standard deviation σ , then the expression of the normal distribution curve is,

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{x-\mu}{2\sigma^2}} \text{ for } -\infty \leq x \leq +\infty \quad (4)$$

3. RESULTS AND DISCUSSION

Figure 1 shows the histogram of the ultimate tensile strength. A sample size of 120 is considered in the experiment.

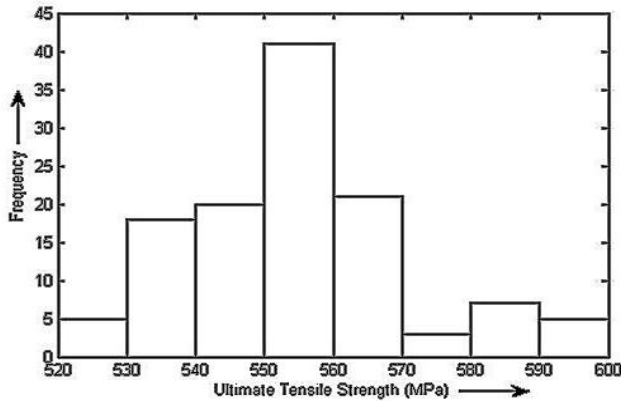


Fig 1. Histogram of Ultimate Tensile Strength.

The mean and standard deviation are obtained as 554.90 MPa and 15.8 MPa respectively. The standard deviation of the product appears to be high indicating wide variation in the tensile strength. Figures 2 and 3 respectively show the frequency polygon and cumulative frequency of tensile strength values.

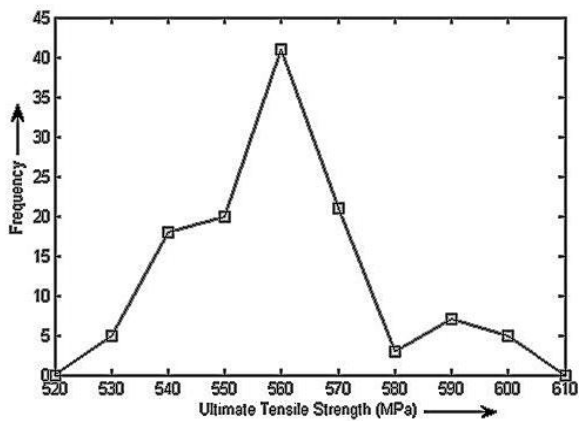


Fig 2. Frequency Polygon of Ultimate Tensile Strength.

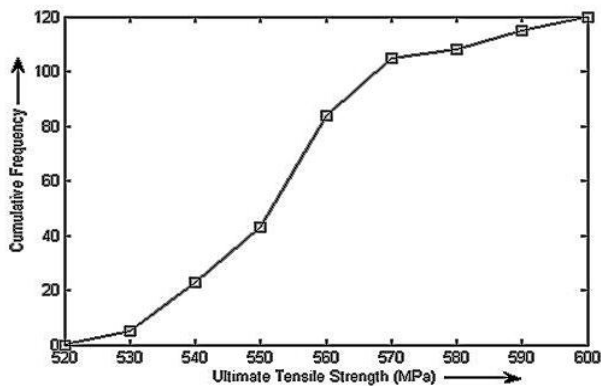


Fig 3. Cumulative Frequency of Ultimate Tensile Strength.

The normal distribution curve of tensile strength is shown in Figure 4.

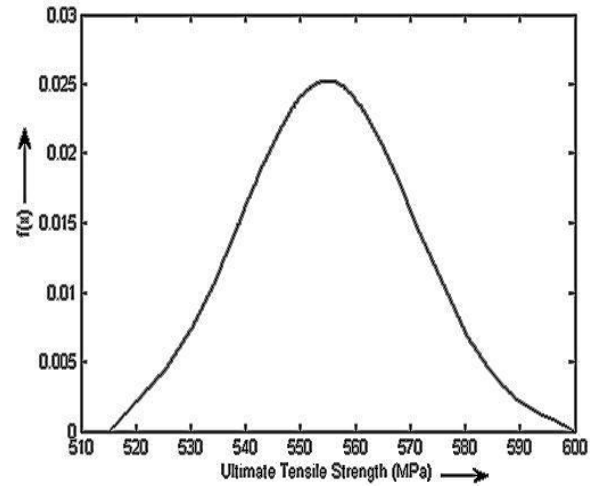


Fig 4. Normal Distribution curve for Ultimate Tensile Strength.

The histogram, frequency polygon, cumulative frequency and normal distribution of yield strength have been shown in Figures 5, 6, 7 and 8 respectively. The mean and standard deviation of yield strength are respectively 376.90 MPa and 17.8 MPa. The standard deviation is high indicating that the dispersion in yield strength is wider.

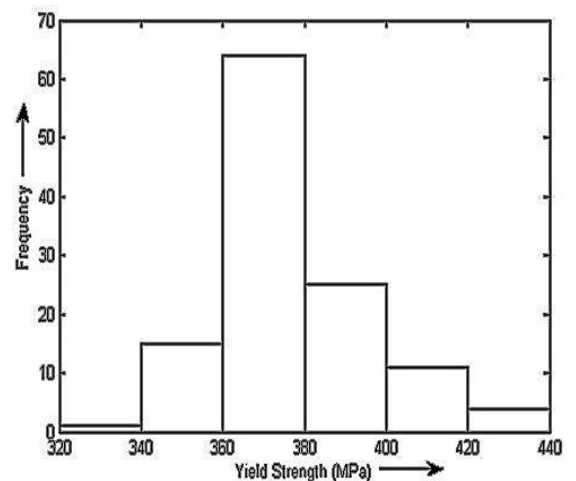


Fig 5. Histogram of Yield Strength.

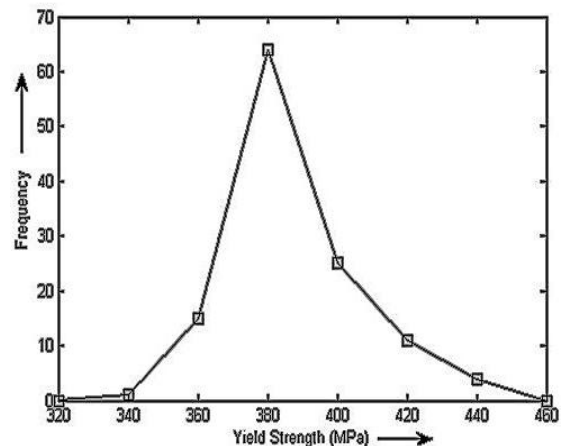


Fig 6. Frequency Polygon of Yield Strength.

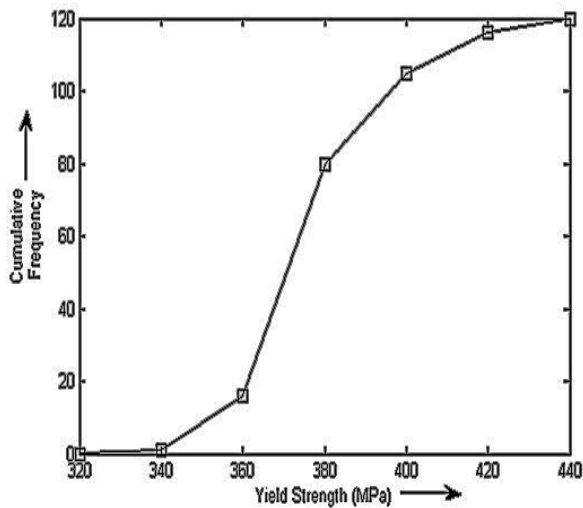


Fig 7. Cumulative Frequency plot of Yield Strength.

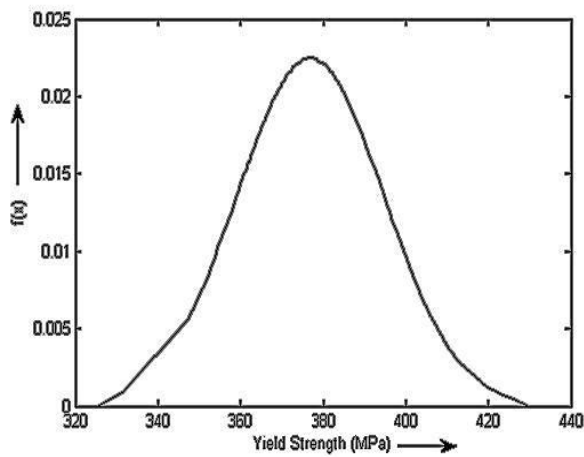


Fig 8. Normal Distribution curve for Yield Strength.

Figures 9, 10, 11 and 12 respectively show the histogram, frequency polygon, cumulative frequency and normal distribution of percentage elongation.

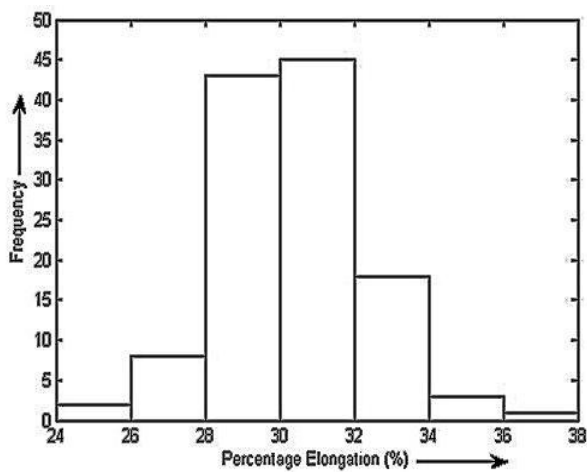


Fig 9. Histogram of Percentage Elongation.

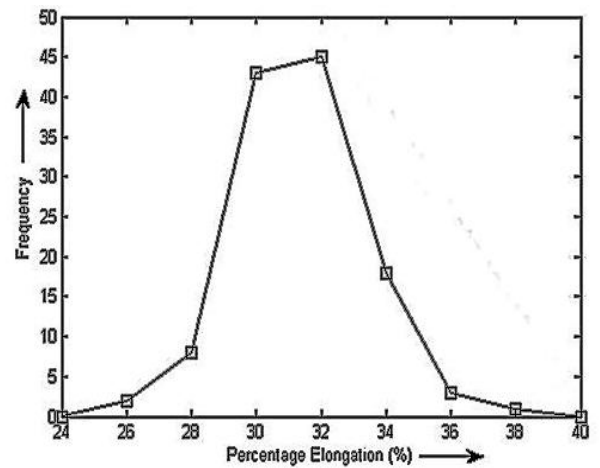


Fig 10. Frequency Polygon of Percentage Elongation.

The mean and standard deviation of 120 samples are respectively 30.4% and 1.93%. From the standard deviation of the sample it is observed that the dispersion of the percentage elongation is a bit wider.

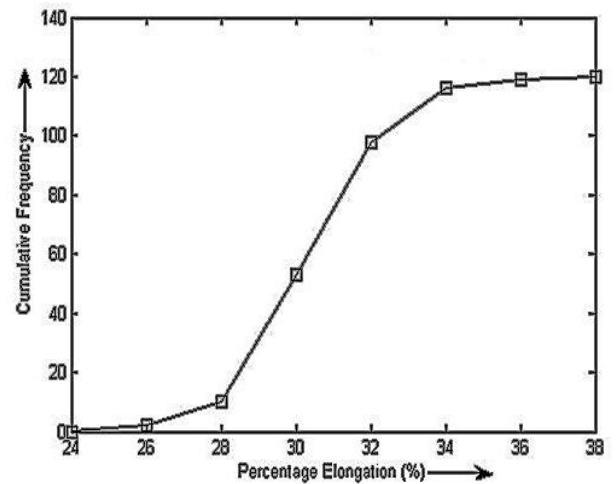


Fig 11. Cumulative Frequency plot of Percentage Elongation.

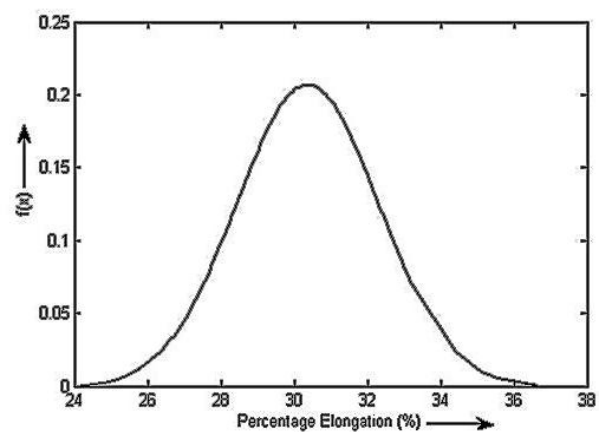


Fig 12. Normal Distribution curve for Percentage Elongation.

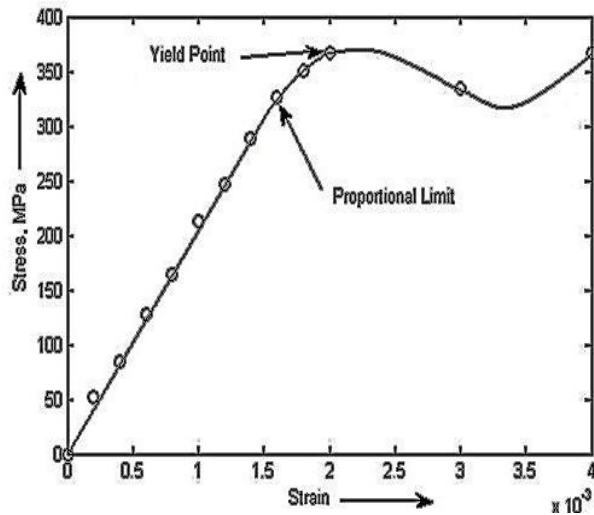


Fig 13. Stress-Strain curve.

Stress-strain curve is showed in figure 13. From the stress-strain diagram, the value of the modulus of elasticity is obtained. It is 204 GPa. The median hardness value is obtained from 5 samples as 86 HRB.

Chemical compositions of the product are obtained as, mean iron 98.74%, carbon 0.24%, silicon 0.13%, manganese 0.76%, phosphorus 0.068%, sulphur 0.048%, copper 0.01%, chromium 0.007%.

4. CONCLUSIONS

1. Available steel product (deformed bar) in the local market satisfies the mechanical properties reasonably.
2. Standard deviations of mechanical properties of the product are seen to be relatively higher.
3. From the chemical composition it is seen that this product is the mild steel.

5. REFERENCES

1. ASTM A370-97a, "Standard Test Methods and Definitions for Mechanical Testing of Steel Products".
2. Hossain, M. A., Mohonta, A. K. R. and Mandal, A. C., "An Experimental Investigation of Mechanical Properties of Locally Manufactured PVC Pipe", International Conference on Mechanical Engineering, December 26-28, 2001, Dhaka.

6. MAILING ADDRESS

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