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Predicting the tensile properties of low carbon reinforced Sri Lankan TMT steel bars within the manufacturing stages

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Steel is the most widely used category of engineering metals, mainly due to its favourable mechanical and processing properties as well as the reasonably low cost. Steel properties should be maintained within acceptable ranges within manufacturing stages also, as per the specified standards. In Sri Lanka, for steel concrete reinforcing bars, chemical composition, physical parameters and mechanical properties should be complied with according to Sri Lanka Standard, 375: 2009. Usually, the chemical composition of steel is tested during melt stages, and mechanical properties are tested for finished products. Tested mechanical properties essentially include tensile properties, while tested physical parameters include mass per unit length. Though all, chemical composition and specified properties need to be tested to comply with product requirements, there are instances in steel manufacturing processes where approximate values of mechanical properties are sufficient, when quick analyses are involved during in-process inspections. Data science techniques can be used to determine the mechanical properties of steel, enabling steel manufacturers to save valuable quality assurance time and manpower spent on experiments. Therefore, the objective of this study is to predict tensile properties of yield strength (YS), ultimate tensile strength (UTS), elongation at maximum force (EMF) and elongation at fracture point (EF) with the use of chemical composition and physical parameters, as input variables. Forty mechanical test reports based on SLS 375: 2009 standards were collected from a steel manufacturing organisation, for 12 mm nominal diameter, thermo-mechanically treated (TMT) concrete reinforcing bars. Each test report is of 15 samples from the respective batch as per the standard requirement and consists of corresponding chemical composition and physical parameters also. Multiple regression analysis was applied, using Minitab software for each batch separately, to predict YS, UTS, EMF and EF, and mass per unit length and percentages of carbon and manganese were the input variables. According to the results, linear relationships were derived, and YS, EMF and EF show positive correlations with C percentage; UTS shows negative correlations with all the variables. It is noted the P–value of each variable is greater than 0.05, implying that association in each case is not statistically significant, and this might have occurred due to the encountered limitations such as the quantity of the test reports used, calculation of chemical composition for each batch instead for each sample, not focusing on non-linear relationships, assumption of all process parameters to remain unchanged for all batches of the products, considering only major chemical elements of the composition during the study etc. Apart, instead of considering Mn content as an independent variable, carbon equivalent value would have been considered. However, since approximate values are sufficient, each of the derived linear relationships can be used to determine each tensile property during in-process quick analysis. Further improvements and modelling can be used to obtain more accurate relationships, and this research was an initiation of the approach to reduce the time consumption during the in-process inspection.

Keywords: Chemical composition, Low carbon reinforcing steel bars, Mass per unit length, Multiple linear regression analysis, Tensile properties