Estimation of 28-day Compressive Strength of Self-compacting Concrete using Multi Expression Programming (MEP): An Artificial Intelligence approach

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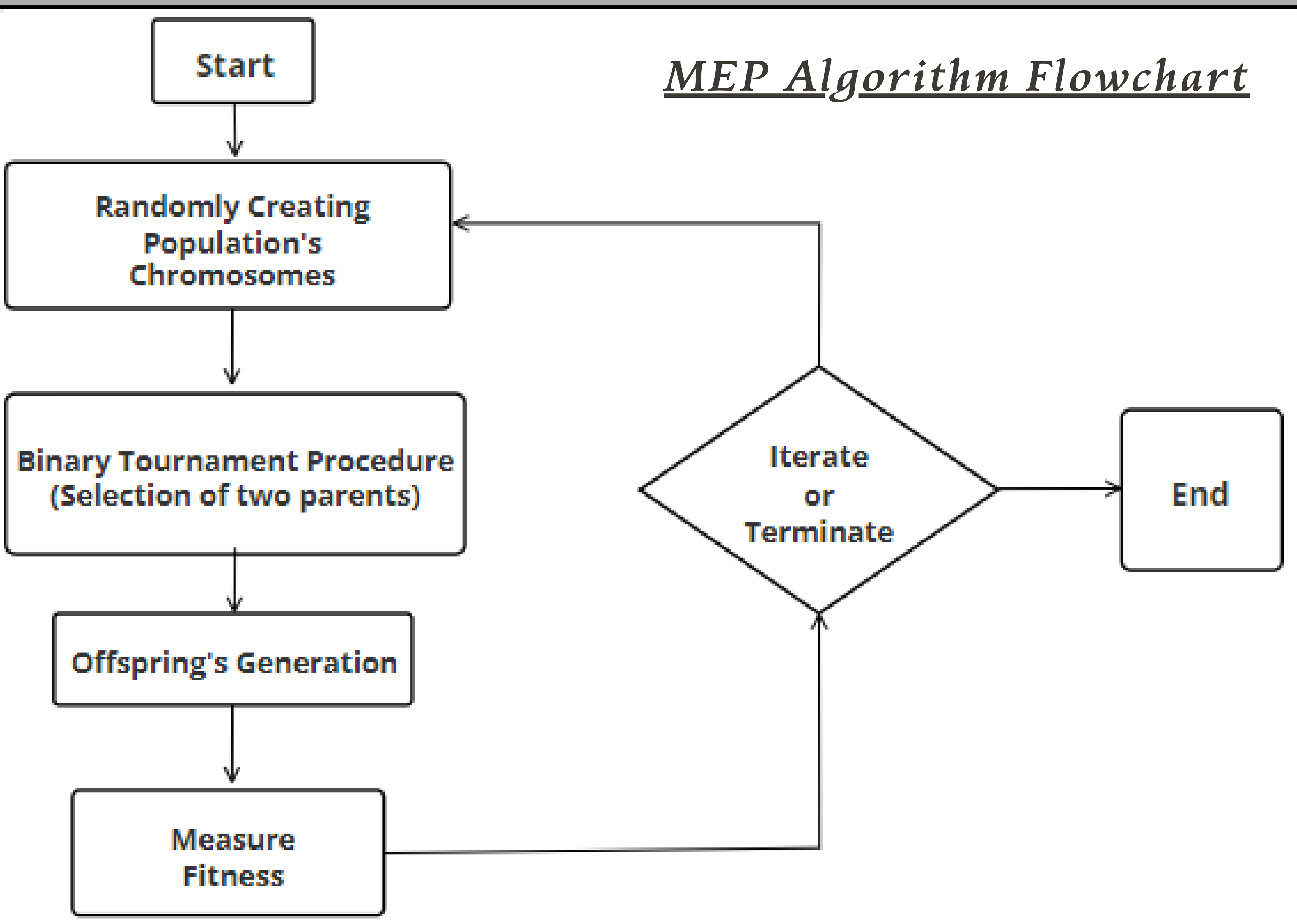


MEP Algorithm Flowchart

01. Introduction

Self-compacting Concrete (SCC) is a concrete having special properties such as good segregation resistance, enhanced flowability and it can compact itself without requiring external vibrations.

The use of SCC containing different industrial wastes can result in reduced carbon emissions and good quality construction.

02. Problem

Despite the widespread use of SCC in the construction industry, there is a lack of work focusing on estimating the 28-day compressive strength of SCC based on its mixture composition It is due to the non-linear behavior of SCC.

03. Objective

The aim of this study is to develop a robust quantitative method to predict the 28-day compressive strength of SCC using Multi-Expression Programming (MEP).

04. MEP

- MEP is a recently developed variant of Genetic Programming (GEP).
- It is based on Darwin's principle of Natural Selection.
- It solves a problem by generating a population of solutions and selects the best performing solution using a set of evolutionary rules.

05. Data Collection

- 216 data points collected from extensive literature search.
- There are six input parameters and one output parameter.
- 70% of the data is used for training and 30% is used for validation of the algorithm.

06. Error Metrices

The accuracy of the algorithm is accessed by calculating the following error metrices for both training and validation datasets.

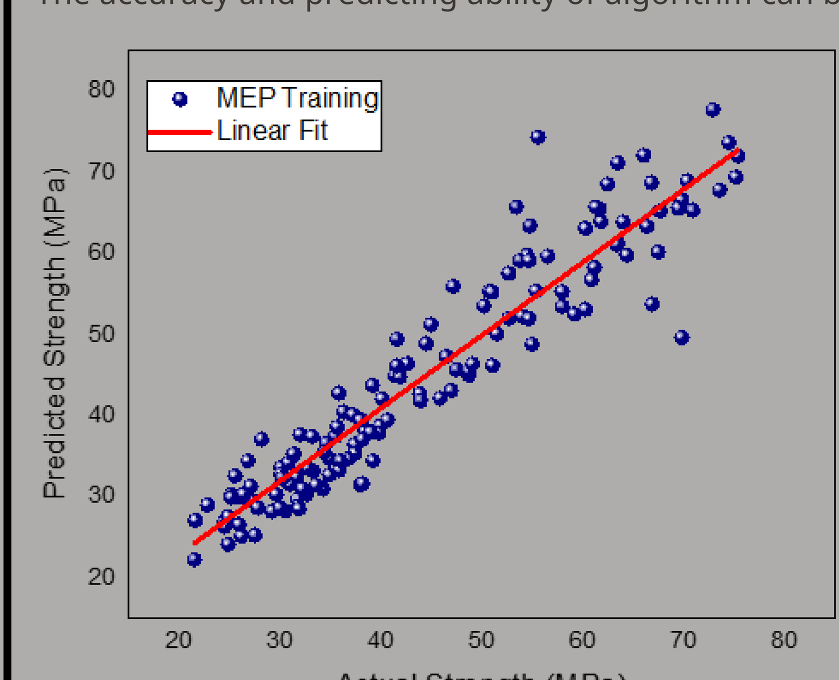
Error Metric	Training	Validation
MAE	3.66	3.15
RMSE	4.68	3.69
R	0.94	0.96

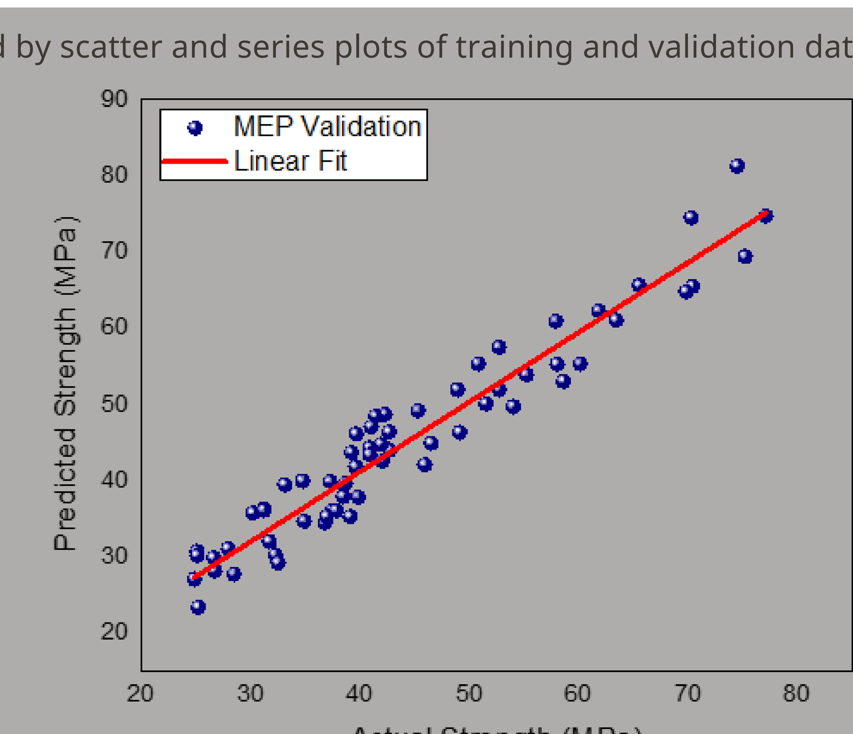
07. Results

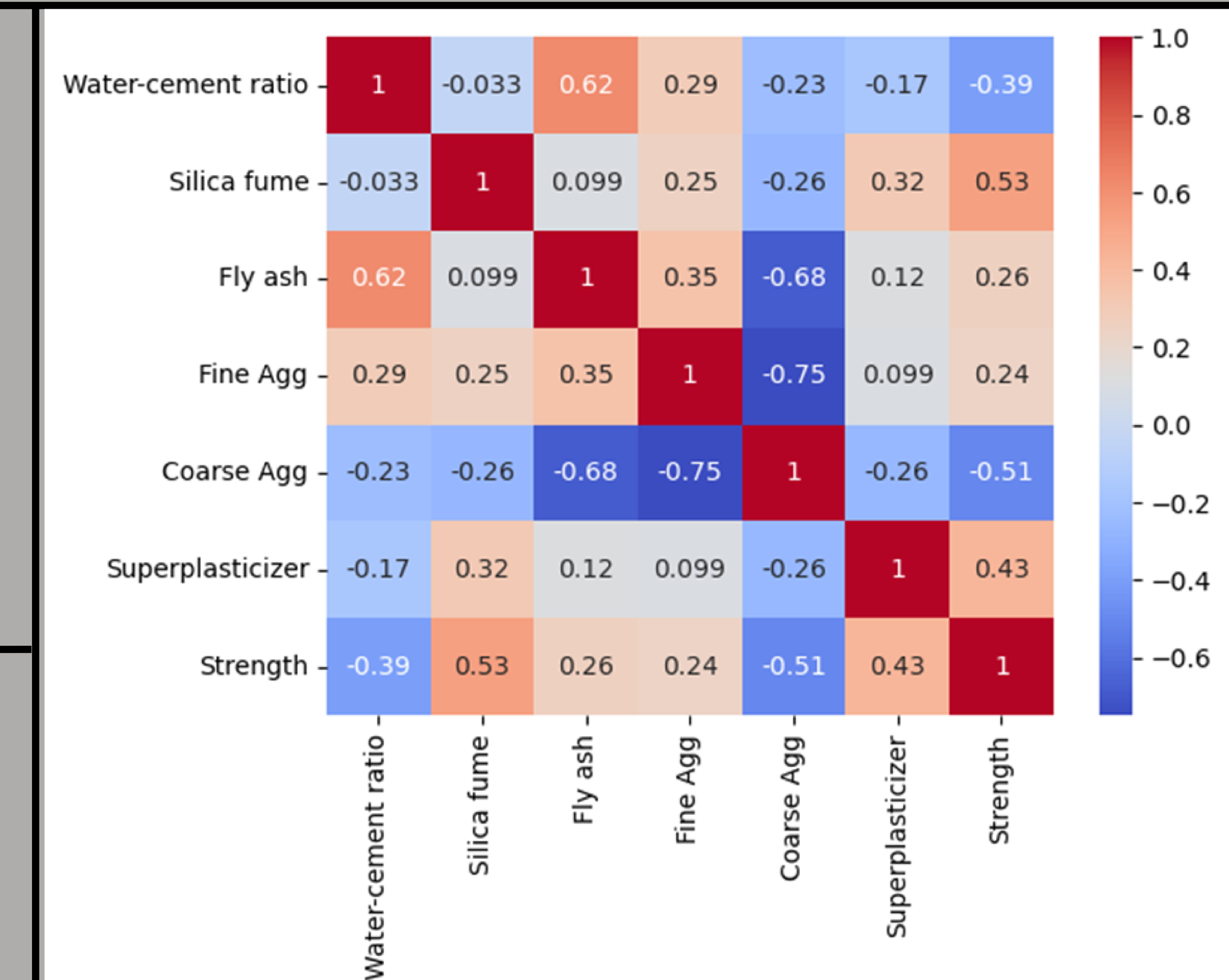
The output of the MEP algorithm is shown in the form of an empirical equation:

$$y = \frac{(x_1x_5+x_2)+[(x_1\sqrt{\sqrt{x_3+x_4}})-\sqrt{x_3+x_4}]+(\frac{x_1+x_2+x_3}{x_0})}{(\sqrt{x_3+x_4})+(\tan(\sin(x_4)))^2} - \cos(x_1)$$

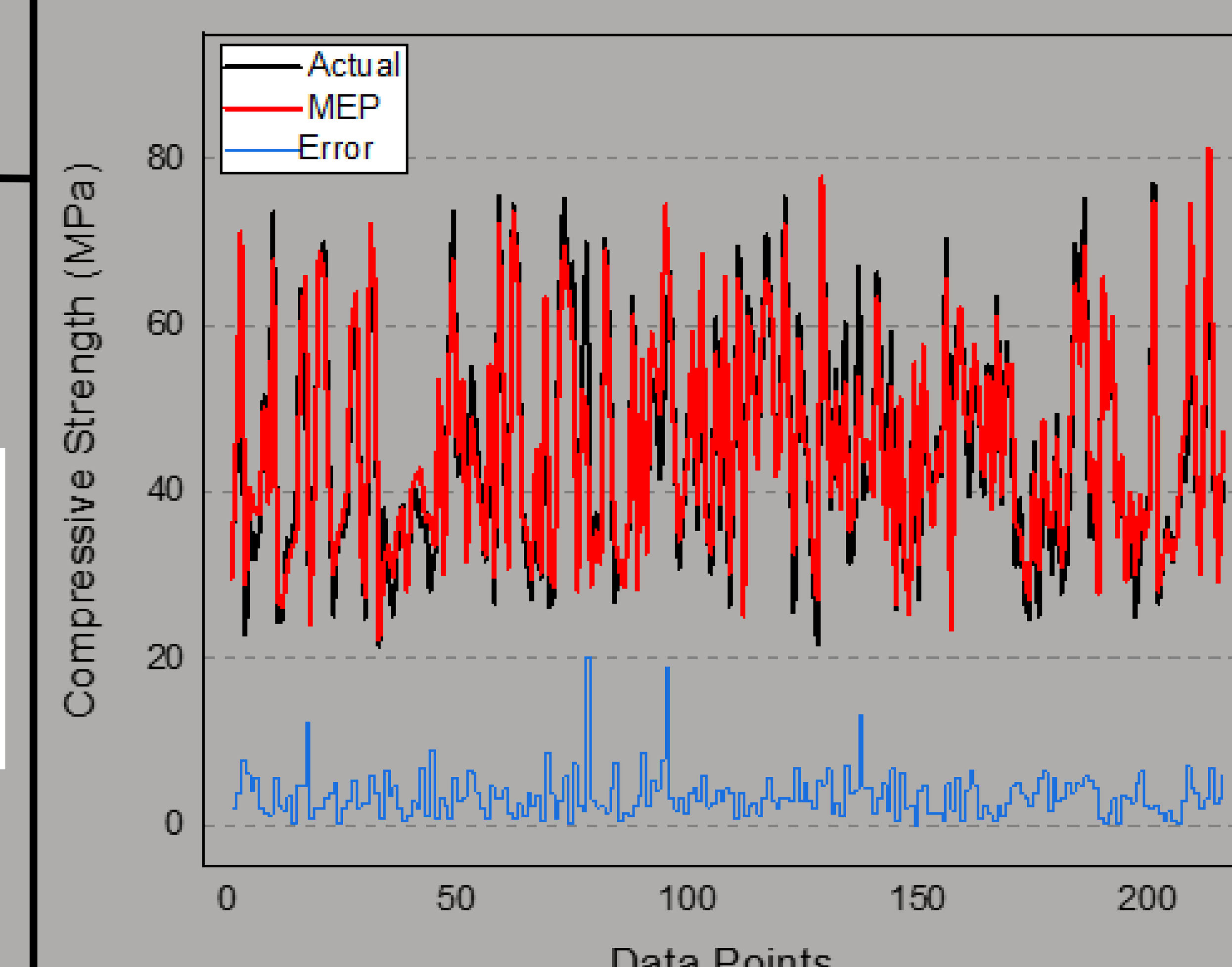
The accuracy and predicting ability of algorithm can be visualized by scatter and series plots of training and validation datasets as shown:







Correlation Matrix of Variables Used



08. Conclusion

- This study presented a novel technique to accurately predict the strength of SCC using MEP.
- The algorithm performed well on both training and validation data sets which is indicated by the error metrices and scatter plots.