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Prediction of SFRC compressive strength by using 5 independent pie terms

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Abstract:-
The object of the present research paper is to develop Exponential Mathematical Model from five independent pi terms. (Aspect ratio, Water-cement ratio, Percentage of fibre, Control strength & Aggregate Cement Ratio) for prediction of SFRC compressive strength. The output of this Mathematical model can be evaluated by comparing it with experimental strength. The study becomes more fruitful when Sensitivity Analysis of various independent π terms has been studied by analyzing the indices of the various pi terms in the models through the technique of sensitivity Analysis.

Keywords: Exponential model; 5 independent π Terms: predicted SFRC Compressive strength.

1. INTRODUCTION:

To arrive at mathematical model, the course of action started with development of some basic mathematical relations and then arriving at some single generalized equations.

Mathematical models are developed to predict the strength of SFRC for different grade of concrete, for different Aspect ratio and different percentage of steel [5-8] [9-13]

Shende .A.M et.al [7-10] studied the investigation for 1) Grade of concreteM20, M30 and M40 2) Aspect Ratio 50, 60 and 67 3) Percentage of steel fibres 0%, 1%, 2% and 3%.

The mathematical modeling to calculate predicted compressive strength, flexural strength and split tensile strength of SFRC are studied by shende [4] in 2013.In this paper an effort is made to extend the work by developing Exponential mathematical model without control strength by using three independent π terms that is percentage of steel fibre, Aspect ratio and water cement ratio for the prediction of steel fibre reinforced concrete compressive strength.

1.1 Formulation of Experimental Data Based Model

In Experimental data based model of prediction of steel fibre reinforced concrete strength that is compressive strength , flexural strength and split tensile strengths the five independent pi terms (i.e. $\pi_1, \pi_2, \pi_3, \pi_4, \pi_5$) and one dependent pi terms (π_{01}) have been identified in the design of experimentaldata based experimentation and are available for the model formulation.

Independent π terms = ($\pi_1, \pi_2, \pi_3, \pi_4, \pi_5$) π_1=water cement ratio, π_2=Aggregate cement ratio, π_3=percentage of fibers,, π_4=Aspect ratio (A.R.), π_5=Control Strength Dependent π terms = (π_{01}),π_{01}= prediction of steel fibre reinforced concrete (SFRC) strength Each dependent π is assumed to be function of the available independent π terms.

Predicted SFRC Strength π_{01} (M1)=0.595799 x (W/C Ratio) $^{-0.0917}$ x (Agg.Cem.Ratio)$^{0.117}$ x (*% of Fibre)$^{0.0076}$ x (Aspect Ratio) $^{0.1159}$x (Control Strength)$^{0.981}$

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Table 1: Comparison of Experimental and predicted strength with % of Error [4]

S.N.	π1	π2	π3	π4	π5	Experimental strength =π_0	Predicted strength	% of Error
1	0.43	3	1.00	60	30.45	35.9	33.57538	6.475251
2	0.43	3	1.50	60	30.45	39.06	33.67901	13.77622
3	0.43	3	2.00	60	30.45	39.74	33.75272	15.06612
4	0.43	3	0.75	60	30.45	39.6	33.50206	15.39885
5	0.43	3	0.50	60	30.45	35.3	33.39898	5.385333
6	0.43	3	1.13	60	30.45	42	33.60545	19.98702
7	0.43	3	0.75	60	30.45	36.83	33.50206	9.035959
8	0.43	3	1.50	60	30.45	42.74	33.67901	21.20026
9	0.43	3	1.00	60	30.45	37.21	33.57538	9.767845
10	0.43	3	0.50	60	30.45	34.9	33.39898	4.300924
11	0.45	3.5	0.50	50	36.6	38.43	39.71496	3.343634
12	0.45	3.5	0.75	50	36.6	37.4	39.83753	6.517461
13	0.45	3.5	1.00	50	36.6	37.5	39.92473	6.465935
14	0.4	4.68	0.50	55	43.75	45.47	50.02989	10.02835
15	0.4	4.68	0.75	55	43.75	47.54	50.1843	5.562256
16	0.4	4.68	1.00	55	43.75	50.64	50.29414	0.682981
17	0.4	4.68	0.50	55	43.75	50.3	50.02989	0.536999
18	0.4	4.68	0.75	55	43.75	50.99	50.1843	1.580121
19	0.4	4.68	1.00	55	43.75	51.74	50.29414	2.794475
20	0.5	4.94	1.00	50	41.03	42.07	46.05043	9.461452
21	0.5	4.94	1.00	50	41.03	42.81	46.05043	7.569336
22	0.5	4.94	1.00	50	41.03	40.88	46.05043	12.64783
23	0.5	4.94	1.00	50	41.03	42.22	46.05043	9.072555
24	0.5	4.94	1.00	50	41.03	41.73	46.05043	10.3533
25	0.5	4.94	1.00	50	41.03	43.11	46.05043	6.820767
26	0.5	4.94	1.00	50	41.03	44.44	46.05043	3.623836
27	0.5	4.94	1.00	50	41.03	40.58	46.05043	13.48061
28	0.5	4.94	1.00	50	41.03	43.11	46.05043	6.820767
29	0.49	3.84	0.50	50	34.1	42	37.1647	11.51262
30	0.49	3.84	1.00	70	34.1	45	38.84675	13.67389
31	0.49	3.84	1.50	90	34.1	39.5	40.11833	1.565386

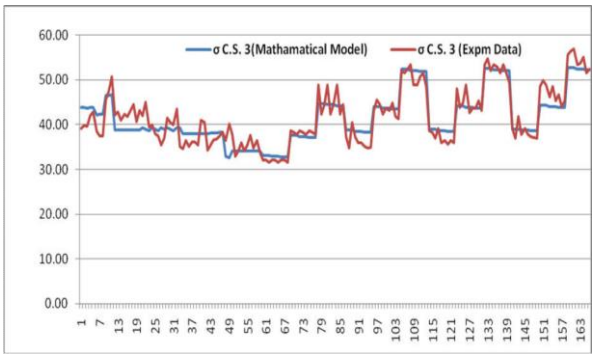

Figure 1: Comparison between Experimental Strength and Predicted SFRC strength.

2. ERROR FREQUENCY DISTRIBUTION

In our experimental data observation, we have one value i.e. experimental strength data and computed values of predicted SFRC Strength The difference of these two values provides the error. Frequencies of occurrence of specific errors are estimated for model of prediction of SFRC strength as representative sample.

The significance of this model can very well be seen from **%Error vs Frequency graph for**

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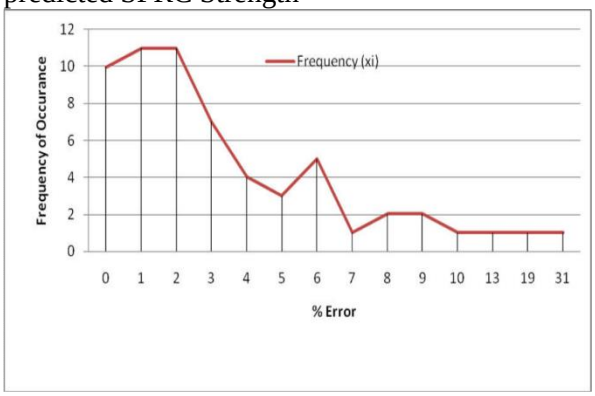
predicted SFRC Strength.

Figure 2: % Error vs Frequency graph for predicted SFRC Strength



3. SENSITIVITY ANALYSES

The influences of various independent π terms have been studied by analyzing the indices of the various pi terms in the models. Through the technique of sensitivity analysis, the change in the value of a dependent π term caused due to an introduced change in the value of individual independent πterm is evaluated.. These values are plotted on the on the Graph in figures 3 as shown below.

Table 3 Sensitivity analysis for prediction of SFRC strength

	Pi 1	Pi 2	Pi 3	Pi 4	Pi 5	Pi02
Avg	**0.437802**	**4.883424**	**1.35392**	**61.09533**	**16.6156**	**19.67434906**
10%	**0.481582**	4.883424	1.35392	61.09533	16.6156	**19.5031456**
-10%	**0.394021**	4.883424	1.35392	61.09533	16.6156	**19.86535517**
					% Change	**1.841024403**
Avg	**0.437802**	**4.883424**	**1.35392**	**61.09533**	**16.6156**	**19.67434906**
10%	0.437802	**5.371767**	1.35392	61.09533	16.6156	**19.89497127**
-10%	0.437802	**4.395082**	1.35392	61.09533	16.6156	**19.43330853**
					% Change	**2.346521033**
Avg	**0.437802**	**4.883424**	**1.35392**	**61.09533**	**16.6156**	**19.67434906**
10%	0.437802	4.883424	**1.489312**	61.09533	16.6156	**19.68860548**
-10%	0.437802	4.883424	**1.218528**	61.09533	16.6156	**19.65860132**
					% Change	**0.152503919**
Avg	**0.437802**	**4.883424**	**1.35392**	**61.09533**	**16.6156**	**19.67434906**
10%	0.437802	4.883424	1.35392	**67.20486**	16.6156	**19.89288557**
-10%	0.437802	4.883424	1.35392	**54.9858**	16.6156	**19.43556092**
					% Change	**2.324471574**
Avg	**0.437802**	**4.883424**	**1.35392**	**61.09533**	**16.6156**	**19.67434906**
10%	0.437802	4.883424	1.35392	61.09533	**18.27716**	**21.60262846**
-10%	0.437802	4.883424	1.35392	61.09533	**14.95404**	**17.74239624**
		% Change				**19.62063504**

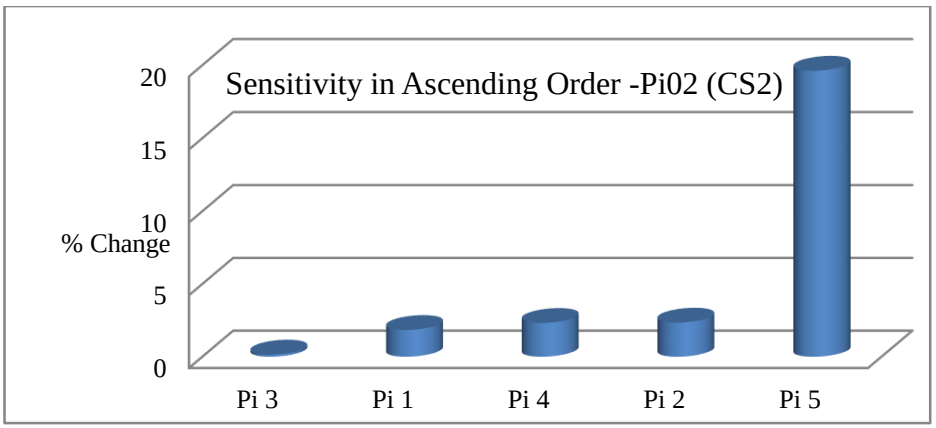


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Figure 3 Sensitivity of π terms in Ascending Order

4. CONCLUSIONS

Exponential mathematical model developed for predicting strength of SFRC, using percentage of fibres, aspect ratio, water cement ratio, control strength & aggregate cement ratio can very well be used in prediction of compressive strength of SFRC using the three parameters listed above.

The significance of this model can very well be seen from the data presented in column experimental strength and the predicted SFRC strength.

The significance of this model can very well be seen from %Error vs Frequency graph for predicted SFRC Strength.

The mathematical models have been developed for the phenomenon. The ultimate objective of this work is not merely developing the models but to find out the best set of variables, which will result in maximization/minimization of the response variables.

Estimation of Limiting Values:

Two Mathematical models have been developed for the phenomenon. The ultimate objective of this work is not merely developing the models, but to find out the best set of variables which will result in maximization/ minimization of the response variables. In this section, attempt is made to find out the limiting values of two response variables Viz. **prediction of SFRC Strength** To achieve this, limiting values of independent π terms Viz. π_1, π_2,π_3,π_4 and π_5 are put in the respective models. In the process of maximization, maximum value of independent π term is put in the model if the index of the term is positive and minimum value is put if the index of the term is negative. In the process of minimization, minimum value of independent π term is put in the model, if the index of the term is positive and maximum value is put if the index of the term is negative.

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