Exponential Mathematical Model for Prediction of Steel Fibre Reinforced Concrete Flexural Strength By Using 3 Independent Pie Terms

Dr.A.M.Shende[1, a], Dr.K.P.Yadav[2,b] Dr.A.M.Pande [3,c]

Dr.C.N.Sakhale [4,d]

[1] principal, priyadarshini.J.L.College of Engineering, Nagpur, Maharastra, India.

[2]Vice chancellor, sangam University, Bhilwara, Rajasthan, India

[3]Director R &D,Y.C.C.E, Nagpur, India.

Abstract:

The object of the present research paper is to develop Exponential Mathematical Model from Three independent pi terms. (Aspect ratio, Water-cement ratio and percentage of fibre) for prediction of SFRC flexural strength. The output of this Mathematical model can be evaluated by comparing it with experimental strength. The study becomes more fruitful when Analysis from indices of the models. The indices of the model are the indicator of how the phenomenon is getting affected because of the interaction of various independent pi terms in the models.

Kew words: Exponential model; 3 independent π Terms: predicted SFRC flexural strength.

1. Introduction:

To arrive at mathematical model, the course of action started with development of some fundamental 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) Three Different Grade of concrete 2) Three Different Aspect Ratio 3) Percentage of steel fibres 0%, 1%, 2% and 3%.The mathematical modeling to calculate predicted flexural 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 flexural strength .

1.1 Formulation of Experimental Data Based Model

In Experimental data based model of prediction of steel fibre reinforced concrete strength that is flexural strength the three independent pi terms (i.e. π1, π2, π3,) and one dependent pi terms (π01) have been identified in the design of experimental data based experimentation and are available for the model formulation.

Independent π terms = (π1, π2, π3,) π1=water cement ratio , π2= percentage of fiber , π3= Aspect ratio (A.R.)

Dependent π terms = (π01), π01= prediction of steel fibre reinforced concrete (SFRC) strength.

Each dependent π is assumed to be function of the available independent π terms

Predicted Flexural Strength Model =19.39099 x (W/C Ratio) $^{0.0163}$ x (% of Fibre) $^{0.008}$ x (A.R.) $^{-0.1856}$

Table 1: Comparison of Experimental and predicted strength with % of Error (out of 121 reading first 15 are reported here) [4]

Sr NO	π_1w/c	% of $\pi_2$fibre	π_3AR	Experimental strength	Predicted strength	**% of Error**
1	0.4	1	55	7.5	**9.08**	1.580343
2	0.4	0.5	55	7.3	**9.03**	1.73013
3	0.4	0.75	55	8.2	**9.06**	0.859469
4	0.3	0.5	50	7.87	**9.15**	1.278292
5	0.3	1	50	8.17	**9.20**	1.029162
6	0.3	1.5	50	9.13	**9.23**	0.099049
7	0.3	2	50	8.91	**9.25**	0.340314
8	0.36	0.5	80	7.04	**8.41**	1.369032
9	0.36	1	80	7.64	**8.46**	0.815791
10	0.36	1.5	80	7.98	**8.48**	0.503264
11	0.36	2	80	8.51	**8.50**	0.00719
12	0.36	2.5	80	8.3	**8.52**	0.218002
13	0.25	0.5	80	7.15	**8.36**	1.209199
14	0.25	1	80	7.73	**8.41**	0.675681
15	0.25	1.5	80	8.13	**8.43**	0.302991

Table 2: Comparison of Experimental and predicted strength (out of 121 reading Last 15 are reported here) [4]

Sr No	π_1w/c	% of $\pi_2$fibre	π_3AR	Experimental strength	Predicted strength	**% of Error**
106	0.5	1E-12	67	7.2	**7.04**	0.15674
107	0.5	1E-12	67	7.2	**7.04**	0.15674
108	0.5	1E-12	67	6.8	**7.04**	0.24326
109	0.43	1E-12	50	7.2	**7.42**	0.218169
110	0.43	1E-12	50	7.6	**7.42**	0.181831
111	0.43	1E-12	50	6.8	**7.42**	0.618169
112	0.43	1E-12	60	7.2	**7.17**	0.028654
113	0.43	1E-12	60	7.6	**7.17**	0.428654
114	0.43	1E-12	60	6.8	**7.17**	0.371346
115	0.43	1E-12	67	7.2	**7.03**	0.174034
116	0.43	1E-12	67	7.6	**7.03**	0.574034
117	0.43	1E-12	67	6.8	**7.03**	0.225966
118	0.35	1E-12	50	7.6	**7.39**	0.20668
119	0.35	1E-12	50	7.2	**7.39**	0.19332
120	0.35	1E-12	50	7.6	**7.39**	0.20668
121	0.5	1E-12	67	7.2	**7.04**	0.15674

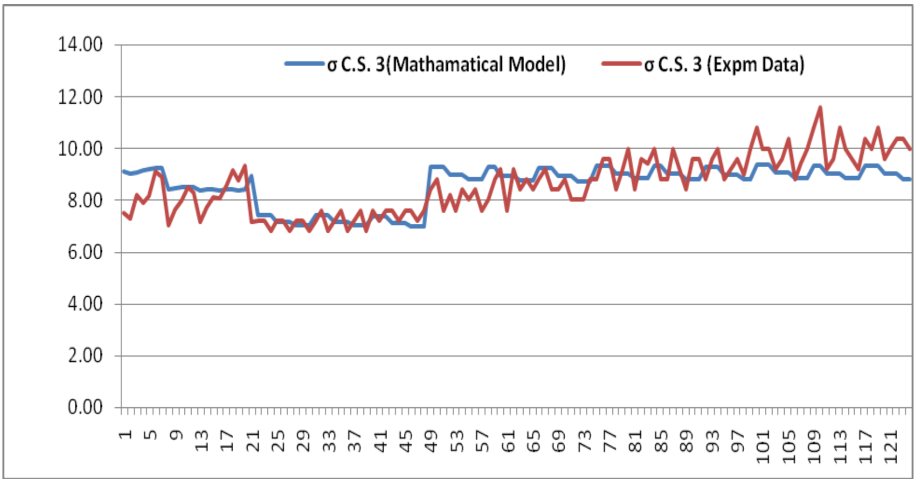

Figure 1 comparison between Experimental Strength and Predicted SFRC strength.

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 predicted SFRC Strength.**

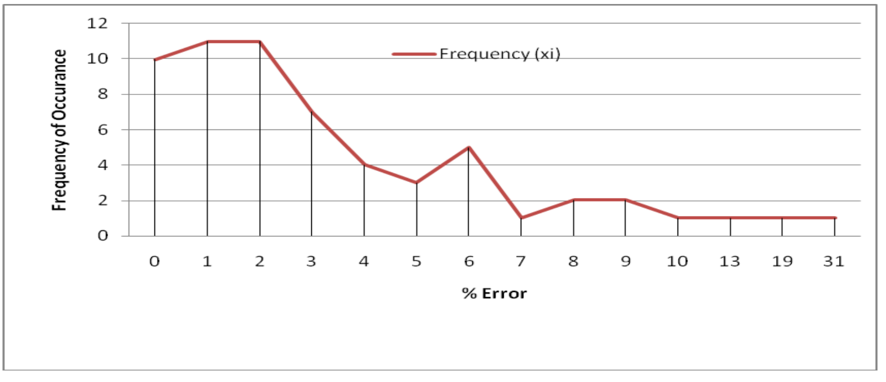

Figure 2: % Error vs Frequency graph for predicted SFRC Strength

3 Analysis from indices of the models

The indices of the model are the indicator of how the phenomenon is getting affected because of the interaction of various independent pi terms in the models. The influence of indices of the various independent pi terms on each dependent pi term is shown in figure 3 and discussed below. The constants and indices of independent pi terms on dependent pi terms are given in Table 3.

Table 3: Constant and Indices of Response variable

Pi terms	Predicted SFRC strength
K	**19.39**
Π_1	**0.0163**
Π_2	**0.008**
Π_3	**-0.1856**

3.1 Analysis of the model for dependent pi term predicted SFRC Strength - π_{01}. The model for the dependent pi term π_{01} is as under:

Predicted Flexural Strength Model =19.39099 x (W/C Ratio) $^{0.0163}$ x (% of Fibre) $^{0.008}$ x (A.R.) $^{-0.1856}$

π_{01}=19.39x($\pi_{1)}$0.0163(π_2)$^{0.008}$ (π_3) $^{-0.1856}$ … (3.1)

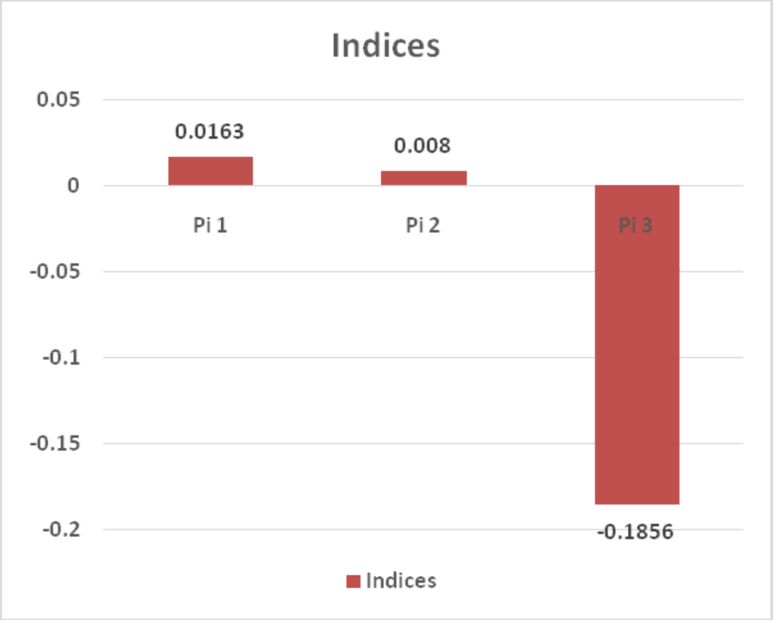

Figure 3 Indices of dependent pi term π_{01} – predicted SFRC strength

The deduced equation for this pi term is given by,

π_{01} = **Predicted SFRC Strength** . It would be seen that the equation 3 and Figure 3 is a model of a pi term containing **Predicted SFRC Strength** as a response variable. The following primary conclusion drawn appears to be justified from the above model.

(i)The absolute index of π_1 is highest viz.0.0163. The factor 'π_1' is related to water cement ratio which is the most influencing term in this model. Another value of this index is positive indicating involvement of percentage of steel π_2 variables has strong impact on π_{01} and π_{01} is directly varying with respect to $\pi_{1.\text{and}}$ $\pi_{2.}$

(ii) The absolute index π3 is lowest viz. -0.1856. Thus π3, the term related to aspect ratio which is the least influencing term in this model.

4 CONCLUSIONS

Exponential mathematical model developed for predicting strength of SFRC, using percentage of fibres, aspect ratio, and water cement ratio can very well be used in prediction of flexural 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.

From The indices of the model it is clear that the most influencing pie term is (π_1) that is water cement ration who contribute more in prediction of SFRC strength.

References

[1] *P. Modak & Mrs. S. D. Moghe, "Design & Development of a Human Powered Machine for the Manufacture of Lime-Fly-ash-Sand-Bricks" Human Power Vol. 13, pp 3-8, 1998, Journal of International Human Powered Vehicle Association, U.S.A.*

[2] *R. Bapat, "Experimental Optimization of a Manually Driven Flywheel Motor" M.E. (By Research) Thesis of Nagpur University 1989, under the supervision of Dr. J. P. Modak.*

[3] *Undirwade .S. K.et al, "Formulation of Mathematical Model for Resistive Torque Required for Bamboo Sliver Cutting Using HPFM", International conference on Electrical, Electronics Engineering Trends in Communication, Optimization and Sciences (EEECOS), 28 March 2015, Shri Sunflower College of Engineering, Machchalipattanam, Vijaywada.*

[4] Shende .A.M. The investigation and comparative study on properties of steel fibre reinforced concrete members, Ph.DThesis

[5] Clifford N. MacDonald, Julian Trangsrud, 2004, Steel Fibre Reinforced Concrete Pre-Cast Pipe, Proceedings of ICFRC, Vol I, pp 19-28.

[6] Coutts R.S.P., 2005, A review of Australian research into natural fibre cement composites Cement & Concrete Composites. 27, pp 518-526.

[7] Shende A.M. & Pande A.M., 2011, 'Experimental study and prediction of Tensile Strength for Steel Fiber Reinforced Concrete', International Journal of Civil and Structural Engineering", Vol.1, No 4, pp 910-917

[8] Haroon S.A., Nur Yazdani & Kamal Tawfiq, 2004, Properties of Fibre Reinforced Concrete for Florida Applications, Proceedings of ICFRC, Vol I, pp 135-144.

[9] Jagannathan, 2010, Flexural Strength Characteristics of Hybrid Fibre Reinforced Cementitious Matrix, Proceeding of International conference on Innovation, Vol I, pp 347-353.

[10] Shende A.M. & Pande A.M., 2011, 'Mathematical Model to Calculate Predicted Compressive Strength and Its Comparison with Observed Strength', International Journal of Multidisciplinary Research and Advances in Engg. (IJMRAE), Application, Vol. 3, No. IV, pp 145-156

[11] Sashidhar C., Rao H. S. & Ramana N.V., 2004, Strength Characteristics of Fiber- Reinforced Concrete with Metakaolin, Proceedings of ICFRC, Vol I, pp 247-256.

[12] Shende A.M. & Pande A.M., 2011, 'Comparative study on Steel fibre reinforced cum control concrete under flexural and deflection',

International Journal of Applied Engineering Research", Vol. 1, No 4, pp 942-950.

[13] Undirwade S. K., Ph.D, thesis on "Formulation of An Approximate Generalized Experimental Data Based Model For Sliver Cutting From Bamboo Energized By Human Powered Flywheel Motor", June -2015.

[14] Shende A.M. & Pande A.M., 2011, 'Investigation and Comparative Study of Properties of Steel Fibre Reinforced Concrete Member', Proceeding of International Conference in Innovation World of Structural Engineering (ICIWSE -2010), Aurangabad, Maharashtra, India, Vol. 1, pp 391-397

[15] Shende A.M. & Pande A.M., 2012, 'Experimental study on Steel Fibre Reinforced Concrete for M-40 grade', International refereed Journal of Engineering and Science, Vol. 1, Issue 1, pp 001-006.

[16] Shende A.M. & Pande A.M., 2012, 'Comparative study on Steel Fibre Reinforced Cum Control Concrete under Flexural', International Journal of Emerging trends in Engineering and Development, Vol. 2, Issue 2, pp 215-222.