International Journal of Advanced Trends in Computer Applications
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Prediction of Steel Fibre Reinforced Concrete Strength by Artificial Neural Network (ANN) using 5 and 3 independent pie terms

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Abstract: *The object of the present research paper is to develop Artificial Neural Network Simulation and by using five and three independent π-term from five independent pi terms. (Aspect ratio, aggregate-cement ratio, water-cement ratio, percentage of fibre and control strength)) for prediction of SFRC strength. From three independent pie terms control strength, percentage of fibre and Aspect ratio. The output of this network can be evaluated by comparing it with experimental strength and the predicted ANN simulation strength. The study becomes more fruitful when most influencing π-term is calculated for the prediction of SFRC strength. The beauty of both the models is that we can predict compressive strength, flexural strength and split tensile strength by using same model.*

Keywords: ANN model; 5 independent π Terms: 3 independent π, predicted SFRC strength.

I. INTRODUCTION

To arrive at mathematical model, the process started with development of some preliminary 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].

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 attempt is made to extend the work by developing artificial neural network model by using five independent π terms that is control strength ,percentage of steel fibre, Aspect ratio, water cement ratio and Aggregate cement ratio for the prediction of steel fibre reinforced concrete compressive strength ,flexural And split tensile strength and three independent pie terms that is control strength ,percentage of steel fibre and Aspect ratio for the prediction of steel fibre reinforced concrete compressive strength ,flexural And split tensile strength.

Artificial Neural Network Simulation is developed to predict strength of SFRC by using Control Strength, percentage of fibers, Aspect ratio, water cement ration and Aggregate cement ration. The Experimental data-based modelling has been achieved through mathematical models for the five independent pi terms. In such complex phenomenon involving non-linear systems it is also planned to develop artificial neural network (ANN). The output of this network can be evaluated by comparing it with observed data. For development of ANN, the designer has to recognize the inherent pie terms that are predicted SFRC strength. Same ANN Simulation model can predict compressive strength, flexural strength and split tensile strength.

An artificial neural network (ANN) consists of three layers i.e. the input layer, the hidden layer and the output layer. Its nodes represent neurons of the brain. The specific mapping performed depends upon the architecture and synaptic weight values between the neurons of ANN network. An artificial neural network is highly distributed representation and transformation that works in parallel. The control is distributed by highly interconnected. It is utmost important to compare the data generated through, experimentally observed data and ANN data to validate the phenomenon.

II. PROCEDURE FOR ARTIFICIAL NEURAL NETWORK PHENOMENON

The observed data from the experimentation is separated into two parts viz. input data or the data of independent pi terms and the output data or the data of dependent pi terms. The input data and output data are imported to the program respectively. Through principle component analysis the normalized data is uncorrelated. This is achieved by using "prestd" function. The input and output data is then categorized in three categories viz. testing, validation and training. The common practice is to select initial 75% training, last 75% data for validation and middle overlapping 50% data for testing. This is achieved by developing a proper code.

1. The data is then stored in structures for training, testing and validation.
2. Looking at the pattern of the data feed forward back propagation type neural network is chosen.
3. This network is then trained using the training data. The computational errors in the actual and target data are computed and then the network is simulated.
4. The uncorrelated output data is again transformed on to the original form by using "poststd" function.
5. After simulating the ANN, it is found that experimentally observed values are very close and in good agreement with the ANN predicted values.

Figure 1 shows simple multilayer feed forward network for ANN and Figure 2 shows the flow diagram of ANN simulation.

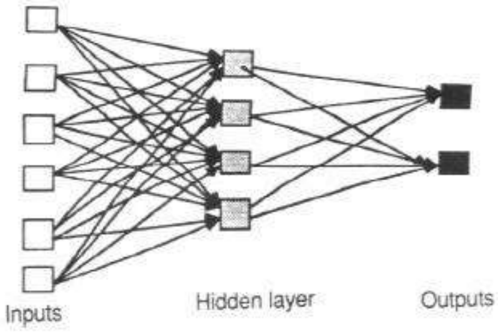

Figure 1: Simple multilayer feed forward network (ANN)

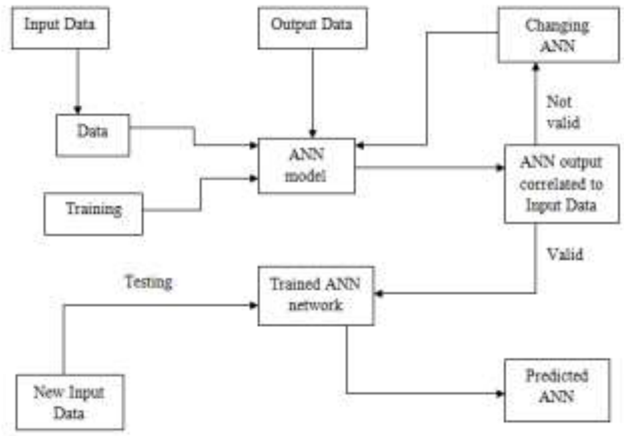

Figure 2: ANN Simulation flow diagram

Table 1 shows comparison of the values of dependent pi terms computed by experimentation, and ANN and. The values of R squared error in ANN, number of iterations, values of the regression coefficients for dependent pi terms and the plots of the actual data and target data for the dependent pi terms are shown in Figures for all response/ dependent variables.

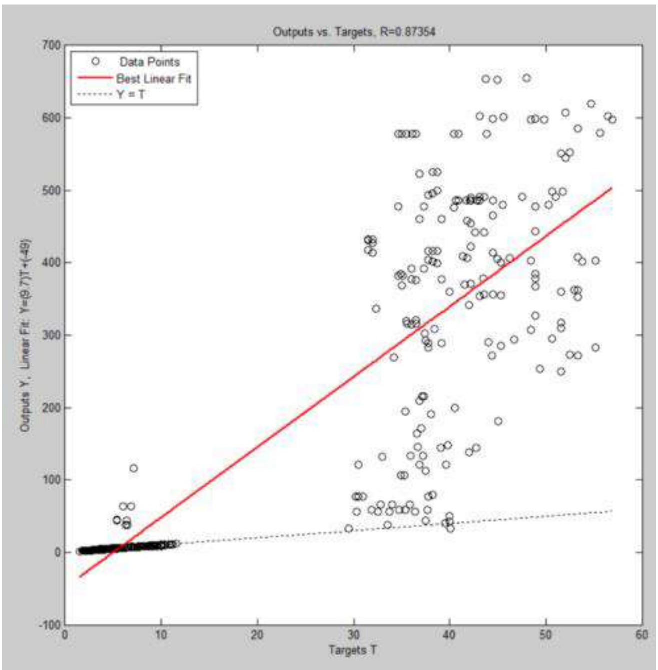

Figure 3: Target vs output graph (R_2=0.7569)

It can be seen that the highest change takes place in strength, because of the π term π5(control strength) whereas the least change takes place due to Aggregate cement ratio and water cement ratio that's why n second ANN model is developed without Aggregate cement ratio and water cement ratio.

Table 1: Performance analysis of ANN and Comparison of Experimental and predicted strength (out of 511 reading first 30 are reported here) [4]

Sr No	Expem	ANN 5	ANN 3	Sr No	Expem	ANN 5	ANN 3
1	35.9	38.5987	37.2403	16	50.64	43.2541	50.9043
2	39.06	39.2254	36.9118	17	50.3	34.9614	46.624
3	39.74	39.1644	39.1505	18	50.99	38.7512	55.1993
4	39.6	37.3213	40.8643	19	51.74	43.2541	50.9043
5	35.3	34.3013	38.6548	20	42.07	25.3025	46.624
6	42	38.9383	31.1791	21	42.81	25.3025	59.48
7	36.83	37.3213	40.8643	22	40.88	25.3025	1.8392
8	42.74	39.2254	36.9118	23	42.22	25.3025	2.1779
9	37.21	38.5987	37.2403	24	41.73	25.3025	-0.7193
10	34.9	34.3013	38.6548	25	43.11	25.3025	1.2454
11	38.43	27.745	60.7727	26	44.44	25.3025	2.7512
12	37.4	28.8231	50.7577	27	40.58	25.3025	2.6315
13	37.5	30.2178	49.2182	28	43.11	25.3025	2.5019
14	45.47	34.9614	55.1993	29	42	21.6538	0.1407
15	47.54	38.7512	37.2403	30	45	29.5809	50.9043

Table 2: Performance analysis of ANN and Comparison of Experimental and predicted strength (out of 511 reading Last 30 are reported here)

Sr No	Expem	ANN 5	ANN 3	Sr No	Expem	ANN 5	ANN 3
480	2.94	7.5136	1.8392	496	2.48	-7.951	2.2051
481	2.87	7.3098	2.1779	497	2.15	-5.080	2.0139
482	2.77	7.0995	-0.7193	498	3.68	3.3104	1.8363
483	3.04	5.1728	1.2454	499	3.11	3.0076	3.2107
484	2.69	4.8827	2.7512	500	3.33	2.7036	3.2899
485	2.55	4.5849	2.6315	501	3.4	4.4983	0.7712
486	3.82	5.1421	2.5019	502	2.97	4.3142	1.288
487	3.82	5.3294	0.1407	503	3.14	4.1259	1.5865
488	4.1	5.4323	-0.0465	504	3.18	4.2223	2.8198
489	3.96	8.6742	-0.2153	505	2.83	4.0866	3.3003
490	3.54	8.874	1.8392	506	3.04	3.9522	3.5706
491	3.54	8.9836	3.5606	507	4.25	11.1336	9787.11
492	3.54	9.3628	3.5606	508	4.39	11.2961	122.33
493	3.96	9.6801	2.0139	509	4.25	11.5593	2.2051
494	2.55	-5.885	2.6315	510	4.1	11.7152	2.0139
495	2.26	-5.163	2.2151	511	4.39	11.8019	1.8363

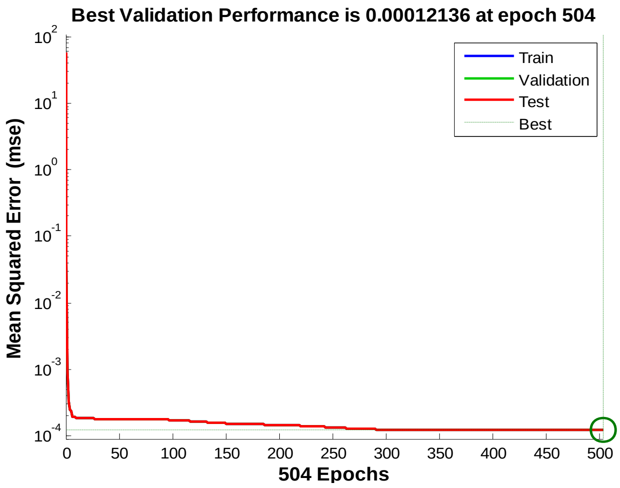

Figure 4: Shows best validation performance

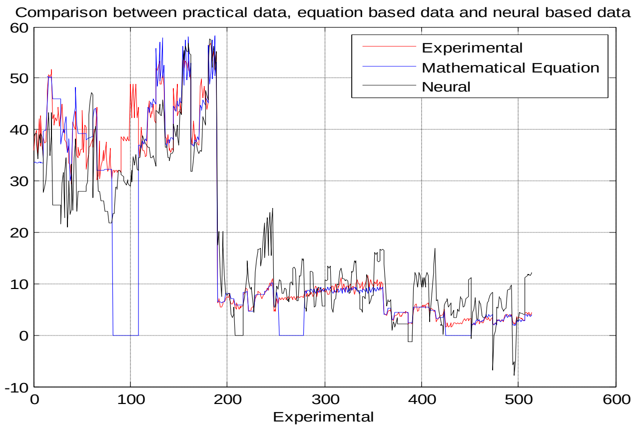

Figure 5: Comparisons between experimental data and ANN predicted strength 5 pie

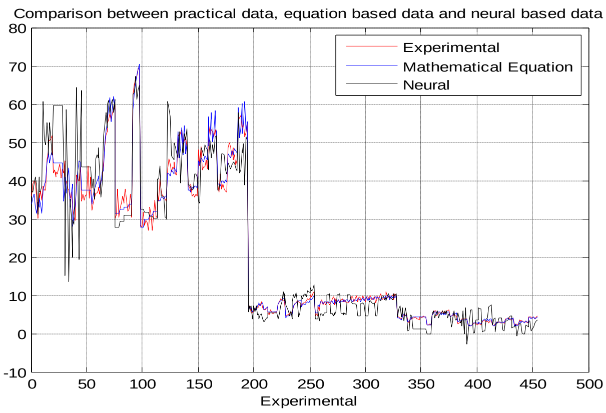

Figure 6: Comparisons between experimental data and ANN predicted strength 3 pie

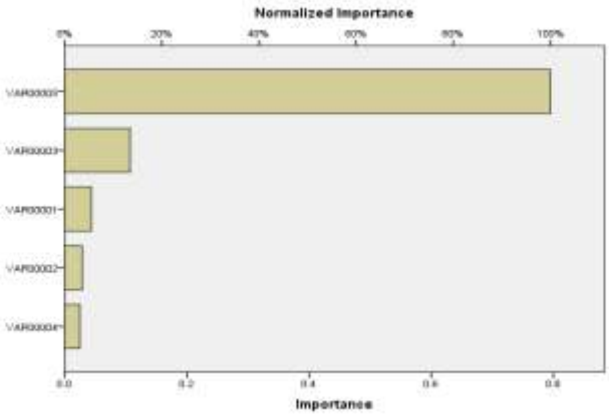

Figure 7: Shows the importance of π terms in ascending order (5 pie Terms)

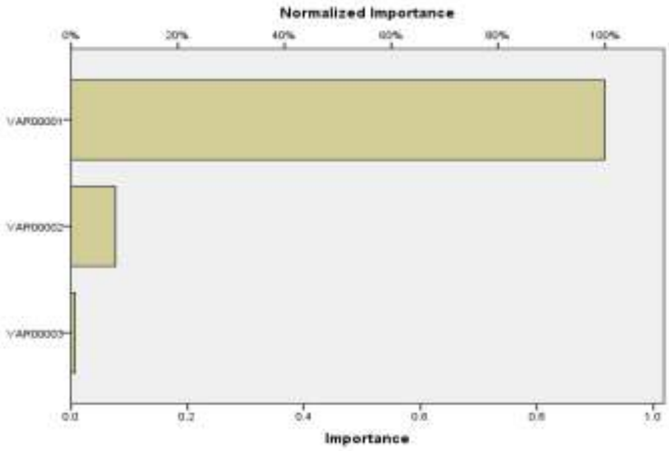

Figure 8: Shows the importance of π terms in ascending order (3 pie Terms)

III.CONCLUSION

- ANN Simulation model developed for prediction of SFRC strength, using strength of controlled concrete, percentage of fibres, aspect ratio, aggregate cement ratio and water cement ratio can very well be used in prediction of compressive strength, flexural strength and split tensile strength of SFRC using the five parameters listed above.
- ANN Simulation model developed for prediction of SFRC strength, using strength of controlled concrete, percentage of fibres, and aspect ratio can very well be used in prediction of compressive strength, flexural strength and split tensile strength of SFRC using the three parameters listed above.
- The significance of both the model can very well be seen from the data presented in column experimental strength and the predicted ANN simulation strength in table no1and table No 2.
- From fig no 5 and fig no 6 it is clear that ANN simulation model developed for prediction of compressive strength, Flexural strength and split

tensile strength when compared with experimental strength it is observed that predicted strengths and observed experimental strength are close to each other

- Figure 7 and 8 shows the importance of independent π terms. Control strength is the most influencing terms in both the models.

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