Prediction of Properties of M25 SCC for 20 mm & 12.5 mm Size Coarse Aggregate Blends Using Neural Networks

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Abstract*: *Design of Self Compacting Concrete (SCC) mix for particular strength and fresh properties requires some trails. To reduce time and cost of mix design, Artificial Neural Networks (ANN) tool is used. Present work establishes the use of ANN for prediction of properties of M25 SCC for various sizes of coarse aggregates blends. The range of error for predicted compressive strengths compared to graph and ANN values is from 2.1% to 5.0%.

Index Terms*: *ANN; coarse aggregate blends; compressive strength; fresh properties of SCC; Nan-Su Mix Design; M25 SCC ANN; coarse aggregate blends; compressive strength; fresh properties of SCC; Nan-Su Mix Design; M25 SCC

I. INTRODUCTION

Design of Self Compacting Concrete (SCC) mix for particular fresh properties and strength requires trials. The number of trials is increased with changing aggregate, cement and admixtures. Ashraf M. Heniegal [1] studied the application of Artificial Neural Networks (ANN) to design the SCC mix. A total of 225 specimens from 34 researchers is considered for analysis. The inputs are slump flow and compressive strength and targets are SCC mix components. The system was trained and validated using 150 training mixes chosen randomly from the data set and tested using the remaining 75 mixes. With another 20 experimental mixes results of simulation are compared. The study indicated the use of ANN in prediction of SCC mix components. Abdul Raheman et.al [2], studied ANN modeling to predict the properties of SCC on experimental data. The input parameters are cement, sand, coarse aggregate, fly ash, water contents and water/powder ratio (W/P), super plasticizer (SP) dosage. The output parameter is compressive strengths at 7 days, 28 days, 90 days, slump flow, T50 cm, V-funnel and L-Box respectively. The study predicted the parameters of SCC with very low root mean square error.

II. EXPERIMENTAL INVESTIGATION

A. Mix Design of M25 SCC

Nan Sue Mix Design[7] is used for M25 SCC. Coarse aggregate (CA) blends used are combination of 20 mm and 12.5 mm with varying percentages. Trial mixes are used to fix the W/P ratio and SP dosage. Six mix proportions C1 to C6 are used in the investigation. The mixes considered for investigation are shown in Table 1. Slump flow, T_{50} slump flow, J- Ring test, V-funnel and L-box tests are conducted for all the mixes to find fresh properties of SCC. All the fresh properties obtained for all the mixes satisfied the EFNARC guidelines for SCC.

Table.1 Mix Proportions C1 – C6

Mixes C1- C6						
Mix	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**
%20:%12.5 mm	100:0	80:20	60:40	40:60	20:80	0:100
Packing Factor	1.14	1.14	1.14	1.14	1.14	1.14
CA kg/m^3	795.5	795.5	795.5	795.5	795.5	795.5
FA kg/m^3	903.1	903.1	903.1	903.1	903.1	903.1
W/P Ratio	0.4	0.4	0.4	0.4	0.4	0.4
Cement, kg/m^3	230	230	230	230	230	230
Fly Ash, kg/m^3	199	199	199	199	199	199
GGBS, kg/m^3	85.3	85.3	85.3	85.3	85.3	85.3
SP Dosage (%)	1.7	1.7	1.7	1.7	1.7	1.7
SP Content, kg/m^3	2.49	2.49	2.49	2.49	2.49	2.49
Water, kg/m^3	204.9	204.9	204.9	204.9	204.9	204.9
Days	28	28	28	28	28	28

A. Compressive Strength of Mixes

Five cubes are casted for each mix to determine the 28 days compressive strength. The compressive strength of five cubes for the mixes C1 – C6 is shown in Table 2.

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Table.2 Compressive Strength of Mixes C1 – C6

Mix	Each Cube Compressive Strength, N/mm^2				
	1	2	3	4	5
C1	31.2	30.1	28.2	32.2	35.4
C2	25.9	28.9	31.4	26.3	27.9
C3	25.1	26.6	26.2	25.7	25.1
C4	39.5	40.0	38.2	38.0	37.6
C5	37.2	35.6	32.7	38.1	35.6
C6	29.0	29.2	23.3	26.0	27.3

The average compressive strength of three cubes for the mixes C1- C6 is calculated, by taking 1,2,3; 2,3,4; 3,4,5; 4.5,1 & 5,1,2 cube compressive strengths and shown in Table 3.

Table.3 Average Compressive Strength of Mixes C1 – C6

Mix	Average of Three Cubes Compressive Strength, N/mm^2					
	1	2	3	4	5	Average
C1	29.9	30.2	31.9	32.9	32.3	31.4
C2	28.7	28.9	28.6	26.7	27.6	28.1
C3	26.0	26.2	25.7	25.3	25.6	25.8
C4	39.2	38.8	37.9	38.4	39.0	38.7
C5	35.1	35.4	35.4	37.0	36.1	35.8
C6	27.2	26.2	25.5	27.4	28.5	27.0

A graph is plotted taking the percentage of coarse aggregates 12.5 mm on X-axis and average compressive strength on Y-axis and is shown in Fig: 1.

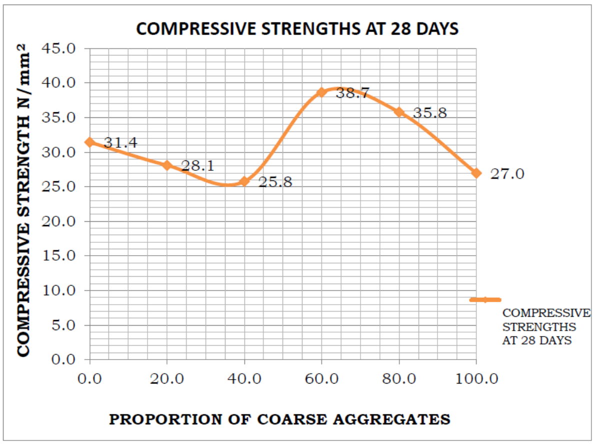

Fig: 1: Variation of Compressive Strength with Mixes C1-C6

III. TRAINING & PREDICTION OF COMPRESSIVE STRENGTH FROM ANN

The parameters as shown in the Table 1 are considered as inputs and compressive strengths as shown in Table 3 are considered as outputs. By using neural networks tool in MATLAB, a feed-forward back prop is created taking training function as TRAINLM, adaption learning function as LEARNGDM, performance function as MSE, training function as TANSIG and number of hidden neurons as 38.

A. Training the Network

Network is trained for the compressive strength values of samples 1, 2 and 3 as shown in Table No: 3 for all the proportions of coarse aggregate blends. After training the network, 60% of output values are obtained and is shown in Table 4. Table 4 shows comparison compressive obtained from experiment ANN after training for mixes C1-C6. Error is calculated between the experimental results and obtained ANN results. The range of error observed between experimental values and ANN values is from 0% to 3.3%.

Table.4 Comparison of Compressive Strength obtained from Experiment and ANN after Training for Mixes C1-C6

Mix	Coarse Aggregate Blends (20 mm:12.5 mm)	Compressive Strength, N/mm^2		% Error
		Experimental Results	ANN	
C1	100:0	29.9	-	-
C1	100:0	30.2	31.2	3.3
C1	100:0	31.9	31.2	2.2
C2	80:20	28.7	28.8	0.3
C2	80:20	28.9	28.8	0.3
C2	80:20	28.6	-	-
C3	60:40	26.0	26.4	1.5
C3	60:40	26.2	-	-
C3	60:40	25.7	-	-
C4	40:60	39.2	-	-
C4	40:60	38.8	38.8	0
C4	40:60	37.9	-	-
C5	20:80	35.1	-	-
C5	20:80	35.4	35.2	0.6
C5	20:80	35.4	35.2	0.6
C6	0:100	27.2	27.7	1.8
C6	0:100	26.2	27.7	3.3
C6	0:100	25.5	-	-

B. Predicting from the Network

The network trained using samples 1, 2 and 3 is simulated to predict the values of compressive strengths for samples 4 and 5 as shown in Table 3 for all mixes C1-C6. After simulation, the predicted values for samples 4 and 5 are represented by ANN in the Table 5. The range of error observed between experimental values and ANN values is from 0.5% to 7.9%.

Table.5 Comparison of Compressive Strength obtained from Experiment and ANN after Simulation for Mixes C1-C6

Mix	Coarse Aggregate Blends (20 mm:12.5 mm)	Compressive Strength, N/mm^2		% Error
		Experimental Results	ANN	
C1	100:0	32.9	31.2	5.2
C1	100:0	32.3	31.2	3.4
C2	80:20	26.7	28.8	7.9
C2	80:20	27.6	28.8	4.3
C3	60:40	25.3	26.4	4.3
C3	60:40	25.6	26.4	3.1
C4	40:60	38.4	38.8	1.0
C4	40:60	39.0	38.8	0.5
C5	20:80	37.0	35.2	4.9
C5	20:80	36.1	35.2	2.5
C6	0:100	27.4	27.7	1.1
C6	0:100	28.5	27.7	2.8

C. Predicting the Compressive Strength for non-Experimental mixes

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The trained network is simulated to find the compressive strength values for non-experimental mixes with coarse aggregate blends (20 mm: 12.5 mm) at 90:10, 70:30, 50:50, 30:70 and 10:90 proportions and is shown in Table 6. The compressive strength obtained from ANN is compared with graphical values in Fig 1. The range of error observed between graphical values and ANN values is from 2.1% to 5.0%.

Table.6 Comparison of Compressive Strength for non-Experimental Mixes

Coarse Aggregate Blends (20 mm:12.5 mm)	Compressive Strength, N/mm²		% Error
	Graph Values	ANN	
90:10	29.5	30.5	3.4
70:30	26.0	27.2	4.6
50:50	32.0	30.4	5.0
30:70	38.5	37.7	2.1
10:90	32.0	33.3	4.1

IV. CONCLUSION

- Properly trained ANN can be used to predict the properties of SCC.
- The range of error obtained from experimental results and ANN values of M25 SCC for different mixes C1-C6 after training and simulating are 0% to 3.3% and 0.5% to 7.9% respectively.
- The range of error for non-Experimental mixes obtained from graph and ANN values is from 2.1% to 5.0%.

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