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Research Article

Arithmetical Modelling for Evaluating the Performance of Concrete Strength with the Aid of Optimization Techniques

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Abstract: The aim of study is to frame a mathematical modeling with aid of optimization techniques predict the concrete parameters. In these combines the presentation of the concrete is given by the designer however the mix proportions are found out by the producer of concrete, apart from that the minimum cement content can be placed down. Fly ash and bottom ash is an important role on the follow of such invention. In improving countries like India and other countries the employ of extensive reinforced construction works from the low cost building materials such as fly ash, bottom ash and other components in RCC construction. Mathematical modelling is done by minimizing the cost and time consumed in the case of extension of the real time experiment. Mathematical modelling is utilized to predict the Compressive Strength (CS), Split Tensile Strength (STS) for 7, 28 and 56 days and deflection (D) of the concrete with load. The different optimization algorithms such as Particle Swarm Optimization (PSO), Harmony Search (HS) and Artificial Fish Swarm Optimization (AFSO) are utilized to find the optimal weights α and β of the mathematical modelling. All optimum results demonstrate that the attained error values between the output of the experimental values and the predicted values are closely equal to zero in the designed model. From the results, the minimum error 93.766% is determined by mathematical modelling to attain in AFSO algorithm.

Keywords: Artificial Fish Swarm Optimization (AFSO), Compressive strength, deflection, light weight concrete, mathematical modeling, Ordinary Portland Cement (OPC), split tensile strength

INTRODUCTION

By employing conventional materials and normal mixing, placing and curing practices High Performance Concrete is described as concrete which fills distinctive performance and stability necessities that can never be all the time evaluated often. Concrete is widely carried out construction materials, usually chases the classic bathtub hazard rate function curve (Patel and Shah, 2013). The concrete have high compressive strength comes different properties, such as high abrasion resistance, stiffness, low permeability, higher durability, higher early strength gain and lower cost per unit load (Hoe and Ramli, 2010). Ordinary Portland Cement (OPC) is an important material in the production of concrete which perform as its binder to bind all the amassed. OPC requires the burning of large quantities of fuel and decay of limestone (Al Bakri *et al*., 2011a). The Portland cement concrete industry will employ fly ash if the Loss-On-Ignition (LOI) values are less than 6%. The fly ash comprises of the crystalline and amorphous constituents and as well unburnt carbon. The fly ash comprises different quantity of unburnt carbon which may achieve up to 17%. (Al Bakri *et al*., 2011b). In India the power sector based on coal based thermal power stations which forms a vast amount of fly ash and expected to be around 110 million tonnes yearly. The exploitation of fly ash is about 30% as dissimilar engineering properties requirements (Sivakumar and Gomathi, 2012)."As the cost of disposing of fly ash prolongs to increase, strategies for the recycling of fly ash is environmentally and economically significant. It is employed to the source materials are two appearing areas for the recycling of coal fly ash (Oh *et al*., 2011). Ignition of coal to produce electricity in a boiler produces about 80% of the unburned material or ash which is entrained in the flue gas and is incarcerated and recuperated as fly ash. The left over 20% of the ash is dry bottom ash, a dark grey, granular, porous, mainly sand size material that is gathered in water (Chen *et al*., 2012). The course united occupies the most important volume of concrete which leads to the reduction of natural rock deposits. The ordinary aggregate with simulated aggregates which is made from other sources like industrial wastes (Priyadharshini *et al*., 2012). Due

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to a number of improved properties lightweight concrete has been favoured over usual concrete. The most presented benefit of lightweight concrete is reduced structural dead weight. The reduce of dead weight could lead to decreased construction Cost (Kim *et al*., 2012). The Self-Compacting Normal weight aggregate Concrete (SCNC). Only the production and its characterization of Self-compacting Lightweight Aggregate Concrete (SCLC) is attained. The raise in the production cost of SCLC is below for SCNC (Boga *et al*., 2012). Lightweight aggregate concrete deadweight is 15~30% lighter than ordinary concrete, which till meets the mechanical properties that roadway support requires on certain density degree (Meng and Jin-Yang, 2013). The employ of Lightweight Aggregates (LWA) in concrete offers numerous positive aspects. The low-density of concrete influenced by the lightweight aggregates facilitates to reduce dead load of structures, footings size and dimensions of columns, slabs and beams (Fraj *et al*., 2010). The tensile strength of a model concrete is typically higher than that of prototype concrete. It is so imperative to comprehend the tensile properties of model concrete in the overall modelling process (Franklin, 2010). The surface texture of aggregates has significant impact on the bonding agent properties of road aggregates. The adhesive strength is obtained from cohesion in the binder and interlocking properties of the aggregates. The inter-locking properties of aggregates rely on angularity, flatness and elongation (Okonta, 2012). To improve the fracture resistance of cementitious materials, fibres are frequently added, hence forming a multiple material compressive strength and tensile strengths. Flexural strength is given for pavement applications (Ramadoss, 2012) while the compressive strength is individual for structural applications. The normal Portland Cements (OPC) is partly restored by the fly ash, bottom ash, fine aggregate, coarse aggregate and Light Expanded Clay Aggregate (LECA) by weights of 5, 10, 15, 20, 25, 30 and 35% correspondingly. This proposed methodology is to develop the mathematical modeling with optimization process predicts the compressive strength, divide tensile strength and flexural strength with the assist of recognized input values in OPC mixing concrete

LITERATURE REVIEW

Abubakar and Baharudin (2013) have suggested this large amount usage of Coal Bottom Ash (CBA) seeing that fine mixture with somewhat revising fly ash with cement in concrete generation. The particular studies were prepared which encloses study from the real with chemical properties of CBA aggregates, workability of the concrete, compressive power and density. The specific workability had been placed to reduce seeing that vast number of CBA had been used, this compressive power had been enhanced with a hike in the curing length. With the development throughout proportion replacing the particular density had been reduced. In the results, this density had been raised at decrease water/cement percentage, as a result of cohesiveness from the mix and the relationship power among the cement with mixture unlike at increased water/cement percentage wherever a great deal of water had been forced to achieve the necessary workability.

Yusuf and Jimoh (2013) have advised the tactic on the transfer models of compressive to tensile, flexural and as well elastic properties of palm kernel shell concrete. The kinetic durability boundaries on numerous affordable incorporates of 1:1:2, 1:11/2:3, 1:2:4 and 1:3:6 for the PKS concrete were inspired under the laboratory work recovering disorders meant for 3, 7, 14, 28, 56 and 91 days. Through the results, the specific coefficient of deviation was reduced inside 0.001 and 0.06% that was symptomatic on the dependability of probably explanation considered, the particular qualities tested and/or both. The statistical replica and the kinetic property of flexural, cracking tensile and as well modulus of elasticity according to the compressive durability instigated on extreme coefficient of correlation. The associated ideals on the– characteristics are commonly 0.399, 0.043 and 0.001 while the n-values were 0.591, 0.056 and 0.549.

Kabir *et al*. (2013) have proposed the particular Strength Prediction Model for Concrete and the uncomplicated exact statistical model seemed to be competent for finding out the compressive energy related with concrete in any period seemed to be advised regarding equally stone along with local combination concrete. The particular devised style seemed to be proved regarding commonly employed stone combination concrete plus regarding local (brick) combination concrete. Through the results, the specific advised style seemed to be made known the advantages related with a pair of constants p and q, that find out the concrete strength rising features with era along with relation among p value with all the concrete strength of a particular day and the exact relationship with p value with strength at 3 days, 7 days and 14 days were being identified. The particular recommended style is checked with different information resources which show a good performance for you to predict concrete strength and it as well should bring economic system for the task along with conserve equally time and the cost.

Abubakar and Baharudin (2012) have proposed the employ of particular components related with fly ash that's has improved the components connected with coal bottom ash concrete. The Partial alternative linked with CBA and fly ash had been prepared in several percentages, by means of different integrates making use of fly ash as alternative for cement and coal bottom ash concerning to very good aggregates along with the dirt-free concrete components, toughness and density were examined. From the results, the workability from the dirt-free concrete had been calculated when it comes to disadvantage and compacting factor reduced for the reason that proportion alternative had been enhanced. To achieve greatest compressive toughness an expansion inside alleviating time frame had been necessary; your exact toughness had been attained from 56 days alleviating period for all the proportion substitutions. The actual air-dried density from the concrete had been proved the prominent decline as a result of low specific gravity linked with the two fly ash and CBA.

John *et al*. (2012) get advised the process associated with statistical modeling pertaining to sturdiness qualities linked with fly ash concrete. Every statistical type was brought in to anticipate the real saturated water absorption, permeability, sorpitivity and acid resistance of the concrete made up of fly ash as a substitute linked with cement at a range of 0, 10, 20, 30, 40 and 50%, respectively. The specific type was good pertaining to mixes with cement quantity 208 to 416 kg/m3, water cement ratio 0.38 to 0.76, fly ash 0 to 208 kg/m^3 in addition to cement/entire blend proportion differing through 0. 11 to 0.22. Fly ash content also to water cement proportion will be the most important parameters which in turn manipulate the actual sturdiness qualities. The particular forecasted statistical type pertaining to saturated water absorption, permeability, sorpitivity and acid resistance finished off being developed the real precise results with the particular ages as soon as it was contrasted with the fresh consequence.

Franklin (2010) have proposed the tactic regarding creating suited type concrete mixes for your examine in the punching problem. Many exchange fresh methods which vary from the employment of light and portable aggregates to assist a mix of crushed basalt and as well a pair of degrees concerning fine sand was considered. This mixes, data regarding water-cement and as well aggregate-cement proportions ought to be from regular prototype pattern and as well scaled lower grading figure to experience the particular workability. On the effects, the employment of a pair of degrees concerning fine sand-a BS 882 Zone 2 crushed stone with a coarser range, in partnership with crushed basalt, promise a superb means of attaining representative model mixes and as well data regarding water-cement and as well get worse bare cement proportions pertaining to this kind of type mixes has to be from regular prototype pattern and as well scaled lower grading figure for the ideal workability. The compressive and as well tensile benefits in the model concrete finished off away from the prototype.

PROPOSED METHODOLOGY

The objective of the work to predict the Compressive Strength (CS) Split Tensile Strength (STS) and Deflection of the concrete by utilizes the mathematical modelling. The recognized inputs are considered as concrete mix proportion such as fly ash, bottom ash, fine aggregate, coarse aggregate and Light Expanded Clay Aggregate (LECA), load and dry weight of the specimens. From the experimental investigation the concrete mix proportion of M20 grade is done by 0% replacement of cement with fly ash, fine aggregate with bottom ash and coarse aggregate with LECA at the rates of 5, 10, 15, 20, 25, 30 and 35%, respectively. They are employed by the mathematical modelling with the optimization technique for evaluating the ideal outputs of the strength and deflection. In the arithmetical demonstration, it is aptly utilized to locate the ideal mathematical statement for finding out the ideal arrangement of the concrete strength evaluation process. Whereas in the preparation of the methodology 80% of the dataset is employed for training function and the remaining 20% of the dataset is utilized for the purpose of authentication of the scientific model. The mathematical modelling with Optimization comes out with flying colors by ushering in the optimal weight α and β. Several optimization techniques which are Harmony Search (HS), Artificial Fish Swarm Optimization (AFSO) and Particle Swarm Optimization algorithm (PSO) are effectively employed to ascertain the optimal weight of the system. The optimal values based minimize the error and predict the CS, STS and deflection of the concrete which minimize the economic cost and the time interval in the designed network. It is worth-mentioning that the entire procedure gets well-implemented in the working platform of MATLAB 2014 software. The following Fig. 1 shows the flow chart for the mathematical modelling with AFSO.

Mathematical modeling: In mathematical modelling, the known input and output datasets are used to train the network for finding the optimal output equation of the proposed method. In this process input as various percentage of concrete mixing, load and dry weight of specimen (cube and cylinder) and output as Compressive Strength (CS), Split Tensile Strength (STS) for 7, 28, 56 days and deflection. Initially the random weights α and β are assigned in the network within the range. After the data set preparation the data set have 80:20 range for training and testing purpose. Mathematical modelling the optimization techniques is deployed to arrive at the optimal weight α and β of the system for minimize the error value of the model various optimization techniques are effectively employed to ascertain the optimal weight of the system the optimal weight attained in AFSO. The data sets are organized by the system for realizing the base slip by exploiting the weights α and β, which are altered for the purpose of determining the output of the input constraints. In mathematical modelling, the known inputs with the optimal weights are comprised and taken as Eq. (1). The mathematical modelling is usually

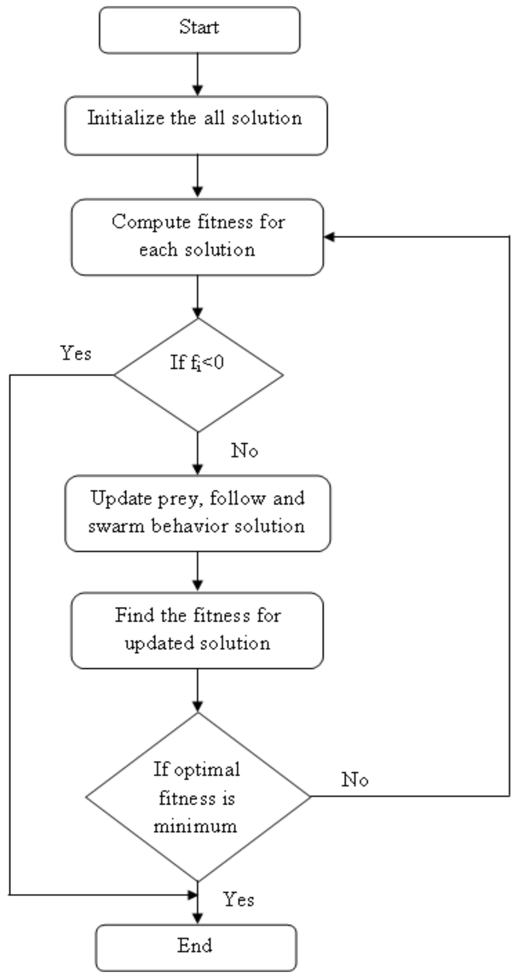

Fig. 1: Flow chart for mathematical modelling with AFSO

based on several optimizations of the weights. In this arithmetical demonstration Artificial Fish Swarm Optimization (AFSO) strategy is observed to achieve the optimal weight.

Artificial Fish Swarm Optimization (AFSO): In nature, the fish can find out the more nutritious area by individual search or following after other fish, the area with much more fish is commonly most nutritious. The fundamental idea of the AFSO is to reproduce the fish behaviours such as praying, swarming and following with local search of fish individual for attaining the global optimum. The environment where an AF lives is chiefly the solution space and is the conditions of other AFs. Its next behaviour relies on its current condition and its local environmental state (including the quality of the question solutions at present and the states of nearby companions). An AF would manipulate the environment through its own activities and its companions' activities.

Figure 2 the AF comprehends external perception by its vision is shown. Z is the current condition of AF, Visual is the visual distance and Zv is the visual position at some instant. If the condition at the visual position is better than the current condition, it goes forward a step in this direction and attains the Z_{next} state or else, prolongs an inspecting tour in the vision. The greater number of inspecting tour the AF does, the more knowledge about overall conditions of the vision the AF attains. Definitely, it does not require travelling throughout complex or infinite conditions, which is supportive to find the global optimum by allowing definite local optimum with some indecision.

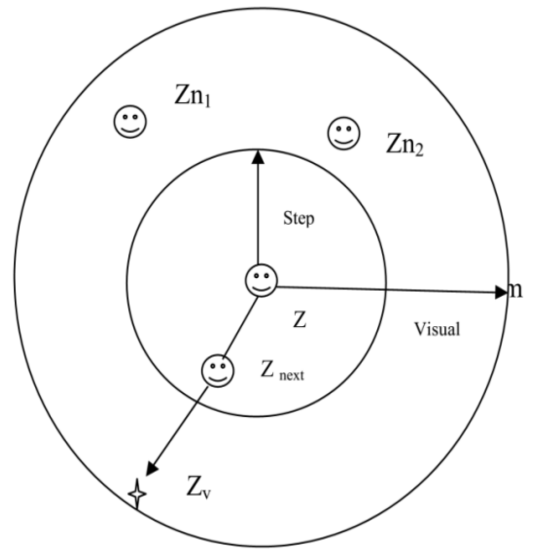

Fig. 2: Vision of artificial fish swarm algorithm

Initialization: Initialize the input parameters such as weight α and β which is defined as the α_i, β_i is an initial solution of fish and i is a number of solutions and also initialize the parameters such as step, this process is known as initialization process:

$$Z_i = (Z_{0j}, Z_{1j} .....Z_{nj})$$

where, Z_i defines an initial solution, i ε [1, 2, … 10] and jε [1, 2, … 140]. Since, i^{th} value is considered as the number of solution and j^{th} value is considered as length of solution:

$$Z_i = \begin{bmatrix} (No \quad of \quad hidden \quad neuron * No \quad of \quad input \quad data) + \\ No \quad of \quad hidden \quad neuron \end{bmatrix} \quad (1)$$

Fitness function: Evaluate the fitness value of each fish solution by using Eq. (2) and then calculate the best solution values:

$$F_i = \sum_{j=1}^{h} \alpha_i \frac{2}{\left[1 + \cosh \sum_{i=1}^{N} (Z_i \beta_{ij}) - \exp \sum_{i=1}^{N} (Z_i \beta_{ij})\right] - 1} \quad (2)$$

Here,

$$\cosh(Z) = \frac{\exp(Z_i \beta_{ij}) + \exp(-Z_i \beta_{ij})}{2} \quad (3)$$

where,
α and β : Weights
Z : The input parameters
i : The number of inputs
j : The number of weights
N : A number of the input data
h : The number of hidden neurons

Find the new solutions for the process update the new fishes based on the prey, follow and swarm behavior.

Prey behavior: This is a fundamental biological behaviour that tends to the food. Supposed the condition of artificial fish is Z_i choosing a state Z_j inside its sensing range arbitrarily. If Z_j superior to Z_i , then move to Z_j on the contrary, selected arbitrarily condition Z_i and find out whether to meet the forward conditions, repeated several time, if still not satisfied forward conditions, then move one step randomly. The food concentration in this position of fish is stated as, objective function value. The distance between the artificial fish is $d_{i,j} = \| Z_i - Z_j \|$ here I and j is random fish:

$$Z_j = Z_i + visual \ . rand \ () \quad (4)$$

$$Z_i^{(t+1)} = Z_i^{(t)} + \frac{Z_j - Z_i^{(t)}}{\| Z_j - Z_i^{(t)} \|} . step.rand \quad (5)$$

where, produces random numbers between 0 and 1 and Step means maximum step size of artificial fish. Visual is the visual distance, the artificial fish occurs only in the inner radius of the circle to the length of the field of vision various acts.

Swarm behavior: Supposed the current state of artificial fish is $Z_i(d_{i,j} < Visual)$ number of artificial fish is $n_f if(n_f < \delta)$ indicates the partners have more food and less crowded, if F_c better than F_i, then go forward toward the centre of the direction of the partnership, otherwise prey behavior:

$$Z_i^{(t+1)} = Z_i^{(t)} + \frac{Z_c - Z_i^{(t)}}{\| Z_c - Z_i^{(t)} \|} . step.rand \quad (6)$$

Follow behavior: Supposed the state of artificial fish is Z_i explore its optimal state Z_{max} from Visual neighbors, the number of partner of Z_{max} is if(n_f<δ) indicates that near distance have more food and not too crowed further move to the front of Z_{max} position; otherwise perform foraging behaviour by using Eq. (5).

Optimal solution: Based on above mention process attain the optimal weights and also find the optimal fitness which is defined as $F_{optimal}$ in this optimal fitness based find the output. The optimal equation based on predict the output which are Compressive Strength (CS), Split Tensile Strength (STS) and deflection on left, right and middle of the concrete:

$$F_{i(optimal)} = \sum_{j=1}^{h} \alpha_{(optimal)i} \frac{2}{\left[1 + \cosh \sum_{i=1}^{N} (Z_i \beta_{(optimal)ij}) - \exp \sum_{i=1}^{N} (Z_i \beta_{(optimal)ij})\right] - 1} \quad (7)$$

where, α and β are weights range from -500 to 500, X is the input parameters, i is the number of inputs, j is the number of weights and h is the number of hidden neurons. Then find the error value by use Eq. (8):

$$E_i = \sqrt{\frac{\sum_{i=1}^{ND} (D_i - P_i)^2}{ND}} \quad (8)$$

where,
ND : The number of the data,
D : The desired value
P : The predicted value, i = 1, 2,….n.

By using this formula, the error value is getting from the difference between desired value and predicted value.

RESULTS AND DISCUSSION

Various inputs which are the percentages of the concrete mix with the dry weight (cube and cylinder) and the load with the output parameters represent the Compressive Strength (CS), Split Tensile Strength (STS) with different days such as 7, 28 and 56 days and the deflection of the concrete. The mathematical modelling combined with the Artificial Fish Swarm Optimization (AFSO) elegantly performs the fascinating function of finding the optimal solutions of α and β. Subsequently, the optimal solutions of the weights with input constraints are arrived at with the assistance of the amazing AFSO process. The output is modified for the least error value by the mathematical model. The major objective of the model is to forecast the output resembling the realtime experiment. In other

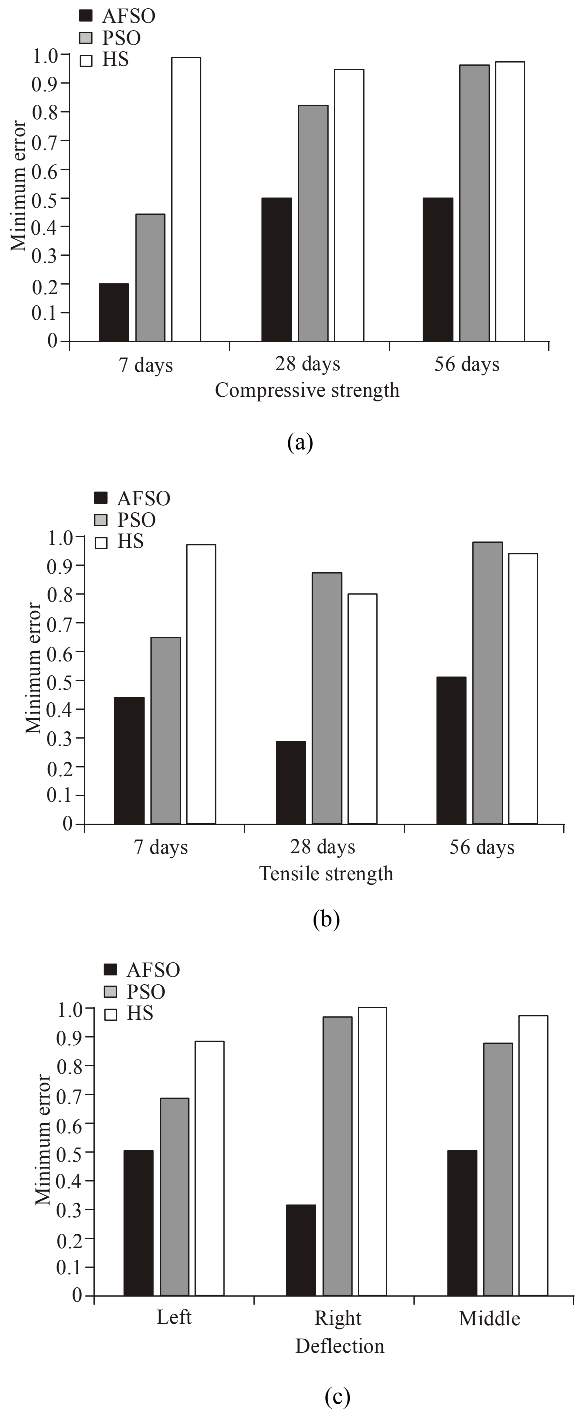

Fig. 3: Error graph for different techniques; (a): Compressive strength; (b): Tensile strength; (c): Deflection

words the differential error between realtime output and the attained output from the mathmatical model is found to be nearly equal to zero.With the result, the related output is evaluated by utilizing the different strengths and the deflection of the concrete.

Mathematical modeling with Optimization techniques: The mathematical modelling with the optimization methods like the AFSO, HS and PSO yields the least error value for the optimal equation with the optimal weights α and β. In the captioned techniques the least error is better achieved in the Artificial Fish Swarm Optimization (AFSO) techniques compared to the other techniques. Figure 3 elegantly exhibits the least error value of the different strengths and deflection for the mathematical modelling with the various optimization approaches which are extensively employed to evaluate the error value of the mathematical modeling:

Figure 3 makes it absolutely clear that the mathematical model with the optimization method has been able to achieve the least error value of the strength for 7, 28 and 56 days and the deflection for various techniques in accordance with the input values. The error value is determined by means of test data values and the forecast values. The error graph shows that the AFSO minimizes the error value in the compressive strength (CS-7) (CS-28); (CS-56) split tensile strength (TS-7) (TS-28), (TS-56). The compressive strength for 7 days minimum error value of the AFSO is 0.240 which when compared with the other algorithm the difference is 73.863%. Then for 28 days of the testing process the minimum error value is compared with the PSO which is increased as 40.25% and also the HS is 47.86%. Similarly for 56 days of the process the error is increased by 49.23%. Totally the compressive strength in 7,28,56 days for the testing process the error value of AFSO compared with HS And PSO is minimized as 75.69%. For the split tensile strength the minimum error value for the AFSO process in 7 days testing is 0.526 which when compared to the HS and PSO is 47.876%. Then for the 28 days process the minimum error is 0.356 which when compared with the other algorithm difference is 56.23%. Similarly for the 56 days tensile strength process totally the CS and STS minimum error of AFSO is minimized by 65.39% in the HS and PSO techniques. In the case of the deflection in the right, left and the middle of the concrete when the load is applied on the concrete the deflection occurs on the concrete with the minimum value in the AFSO process compared with the other two techniques. The deflection in the middle, left and the right of the concrete, the error value of the PSO and HS is 75.6% in 0% and 5% replacements of the concrete mix in the AFSO and this when compared with the other techniques the difference is 82.369%. Thus, in all the sides of the deflection, the AFSO produces the minimum error.

Convergence graph: The graphs appearing below effectively demonstrate the strength and deflection graphs for each iteration of the HS, PSO and AFSO by altering the weights in the range of -500 to 500 and consequently the error values are ascertained. The error

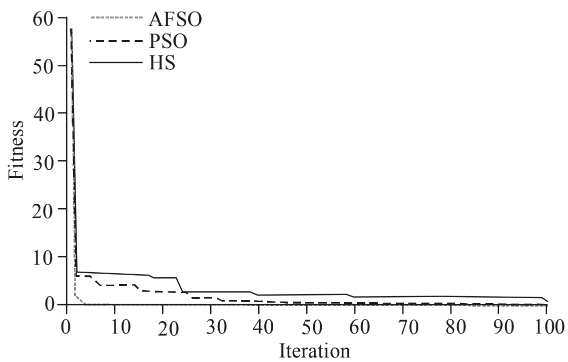

Fig. 4: Convergence graph for different techniques

graph is drawn with the iteration represented in the X-axis and fitness in the Y-axis.

Figure 4 shows that the convergence graph is plotted between the iteration and fitness estimations of the various strategies, for HS, PSO and AFSO. This graph basically resolves that the AFSO procedure gives the minimum fitness in the least iteration. Through the chart, the AFSO strategy takes the minimum iteration for providing the ideal result and it achieves the greatest estimation of the fitness. The minimum error value of AFSO viz. 0.858747 is attained in 15th iteration and in the initial iteration the fitness value is 58.63. When the iteration is varied the fitness value is decreased. When the minimum fitness value of the proposed approach is compared to the PSO the error difference is 1.4202. Overall the maximum fitness of 1.518 is attained in the HS technique whereas the efficiency of the AFSO process is 85.8% .Through the graph the artificial fish swarm Optimization strategy clearly specifies the ideal fitness value with the efficient results.

Predicted Values For Different Algorithm: The mathematical modelling process is home to two divergent procedures such as the training and testing process. In the training process, 80% of data is deftly used by duly modifying the weights and the remainder 20% effectively employed in the testing process. In this procedure, the Compressive Strength (CS), Split Tensile Strength (STS) and Deflection (D) for several techniques like the PSO, HS and AFSO are evaluated. The relative data set values in terms of the input embrace the percentage replacement of the concrete mix and dry weight and the load.

Table 1 shows the forecast values of the compressive strength by means of the 20% test data used. Thereafter, the forecast values are tested, analyzed and contrasted with the original values to arrive at the least error of each and every approach in respect of the input and out values. In the initial data values, in respect of the forecast velocity in all approaches the average difference in the original values is found to be 0.1003 for the 7 days. In the case of all the testing data the difference is 0.240 for AFSO techniques compared to the other techniques viz 0.55 and 1.23 respectively. Then for the 28 days testing process of 30% replacement with the dry weight 8.13 the predicted best compressive strength of 9.85 is attained in the AFSO process. Similarly for the 56 days also the predicted value of AFSO is nearly equal to the experimental value of the compressive strength.

Table 2 shows the testing data for the split tensile strength of predicted values in 0% replacement with the dry weight of14.35. The original value is 1.60 and the best value of the algorithm is 1.53 which when compared with the other techniques the error value is increased as 0.983 for 7 days testing. Then for 28 days in 27% replacements the predicted value and the experiment result difference is 0.19. Similarly in the other testing data also the minimum error value occurs in the AFSO algorithm.

Table 3 and 4 show the predicted values of the testing data with the 0 and 5 percentage replacements of fly ash, bottom ash, LECA of concrete mix where after

Table 1: Predicted values of compressive strength for different algorithm

Inputs		Output (N/mm^2)		
		Original values		
Percentage replacement	Dry weight of specimen (Cube) in kg	7 Days	28 Days	56 Days
5	9.18	17.94	26.89	26.97
15	8.54	16.06	24.09	24.11
30	8.24	10.19	15.26	15.23
35	8.13	9.730	14.57	14.58

Inputs	Predicted values								
	AFSO			PSO			HS		
Percentage replacement	7 Days	28 Days	56 Days	7 Days	28 Days	56 Days	7 Days	28 Days	56 Days
5	17.80	27.25	26.93	18.79	26.95	27.01	18.59	26.46	26.96
15	16.28	25.34	22.61	15.03	24.39	18.54	19.03	21.07	24.99
30	10.73	14.76	16.08	11.08	15.29	15.70	10.21	15.55	18.33
35	9.601	14.71	14.36	9.850	15.35	14.79	10.12	12.60	18.10

Table 2: Predicted values of split tensile strength for different algorithm

Inputs		Output (N/mm^2)		
		Original values		
Percentage replacement	Dry weight of specimen (Cylinder) in kg	7 Days	28 Days	56 Days
0	14.35	1.60	2.54	2.57
10	13.85	1.5	2.32	2.33
20	13.40	1.4	2.11	2.12
25	13.15	1.35	2.05	2.06

Inputs	Predicted values								
	AFSO			PSO			HS		
Percentage replacement	7 Days	28 Days	56 Days	7 Days	28 Days	56 Days	7 Days	28 Days	56 Days
0	1.53	2.86	2.46	0.511	7.628	2.88	1.82	2.42	2.70
10	1.41	2.66	2.46	1.96	3.82	3.18	1.72	2.85	0.88
20	1.54	2.19	1.80	0.39	2.51	2.58	1.77	1.29	5.32
25	1.48	2.19	1.86	0.12	2.42	2.69	2.50	0.95	2.16

Table 3: Predicted values of 0% replacement of concrete mix deflection for different algorithm

Input	Output (N/mm^2)											
	Original			AFSO			PSO			HS		
Load (KN)	Left	Middle	Right	Left	Middle	Right	Left	Middle	Right	Left	Middle	Right
3.92	0.194	0.194	0.21	0.696	1.873	1.386	6.212	5.949	3.119285	1.241	1.88	6.011
7.84	0.284	0.284	0.284	1.024	0.373	0.21	3.292	4.234	3.054631	1.86	1.472	3.318
11.77	0.5	0.5	0.42	1.101	1.402	0.59	1.437	3.186	2.858	2.048	1.210	1.415
15.69	0.631	0.631	0.58	0.938	1.656	1.169	0.296	2.565635	2.586	1.898017	1.003	0.086
19.62	0.785	0.785	0.745	0.57	1.427	1.586	0.366	2.219943	2.264	1.492758	0.796	0.820
82.41	3.396	3.396	3.46	4.410	3.136	6.712	3.069	7.702151	7.200	12.80551	8.448	10.17

Table 4: Predicted values of 5% replacement of concrete mix deflection for different algorithm

Input	Output (N/mm^2)											
	Original			AFSO			PSO			HS		
Load (KN)	Left	Middle	Right	Left	Middle	Right	Left	Middle	Right	Left	Middle	Right
3.92	0.207	0.207	0.205	0.167	0.663	1.592	2.663	3.849	6.356	0.900	4.323	4.178
7.84	0.285	0.285	0.29	0.934	1.494	2.106	0.303	2.480	5.737	1.9575	3.757	1.556
74.56	2.838	2.838	2.84	0.900	2.306	5.903	2.072	5.230	4.591	2.374	6.772	4.751
78.48	3.115	3.115	3.11	1.039	3.852	6.460	2.389	6.023	5.511	0.138	7.519	6.344
82.41	3.400	5.965	3.40	3.711	5.056	3.821	2.690	6.923	6.558	3.901	8.338	8.0961

applying the load the deflection is calculated .The deflection in the concrete mix on the left, middle and right the deflection is calculated. In the 0 % replacement process when the load 3.92 is applied in the concrete the original deflection in the left is 0.194 and the predicted value is 0.69 which is nearly the value of the process. In the deflection of the left and right of the concrete the deflection error is 1.2116 in various loads applied in the process. This value when compared to the PSO the error difference is 0.453. Similarly in the HS technique the difference is 1.08. When the load of 82.41 is applied the deflection of the concrete is 4.410 which is a predicted value in the AFSO algorithm and the corresponding values are 3.09 and 12.88 respectively for the PSO and HS techniques. In the 5% replacement of the concrete mix when the load is 7.84 the original value is 3.92 and nearly the predicted value of the process is 0.167 which when compared to the PSO the error of the process is 1.86. Similarly when the load is increased on the concrete mix the deflection is also increased in each side of the process. In the case of the concrete mix in 0 and 5% replacement of the concrete with all the loads the predicted deflection value is equal to that of the artificial fish swarm optimization process.

Error values of output parameters in different algorithm: In this section, the number of data is varied and the error calculated for some input data such as the compressive strength, split tensile strength for 7, 28 and 56 days and the deflection of the concrete mix error values are shown in Fig. 5.

Figure 5 shows the number of data with the error value for the compressive strength for 7, 28 and 56 days in the proposed method. In the concrete mix testing process for 7 days in respect of data 1 the error value of the AFSOP is 0.100 and the value when compared to the PSO and HS the error differences are 0.102 and

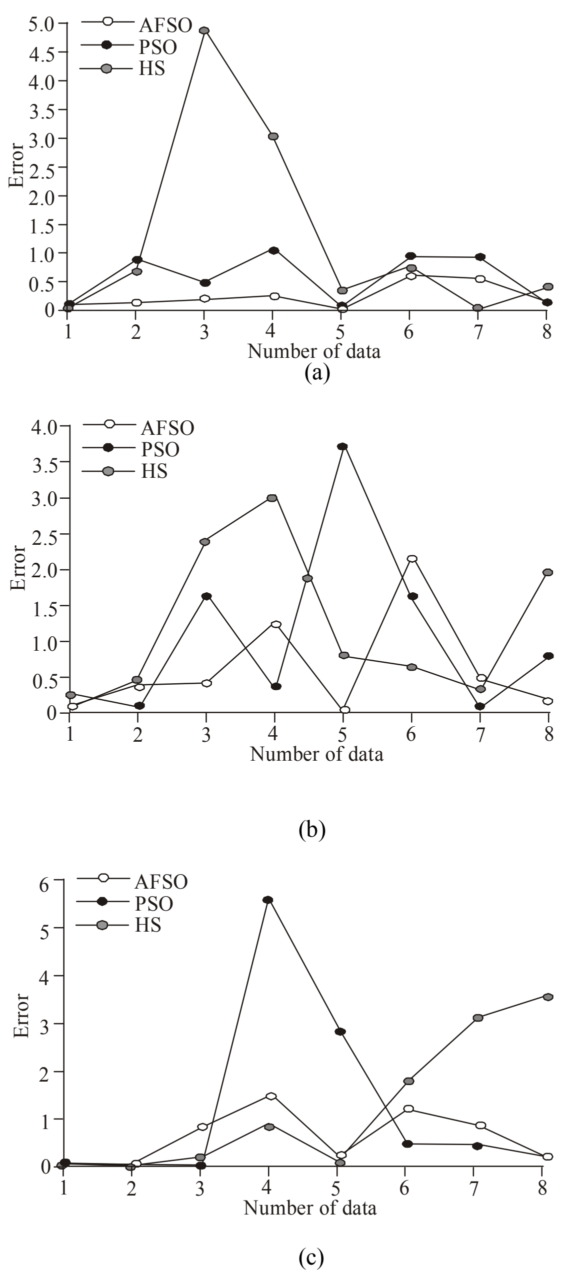

Fig. 5: Number of data based error in Compressive strength; (a): CS_7 days; (b): CS_28 days; (c): CS_56 days

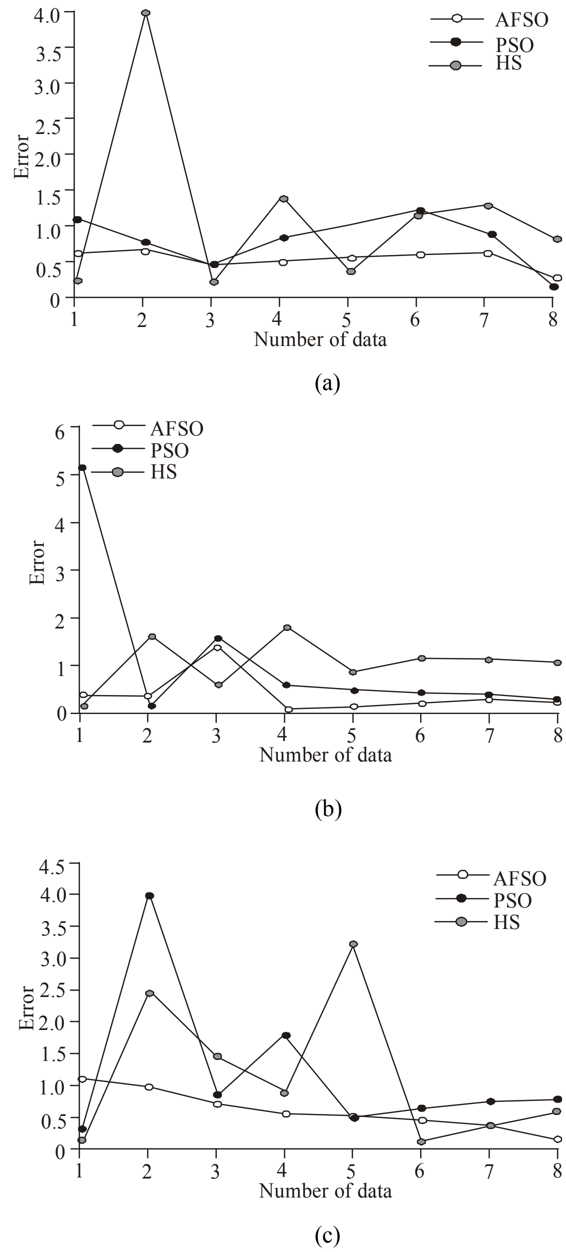

Fig. 6: Number of data based error in split tensile strength (a): TS_7 days; (b): TS_28 days; (c): TS_56 days

0.02 respectively. In respect of data 2 the minimum error value is 0.131 in the AFSO process. In the case of Data 3 and 4 also the minimum error value of 0.23 is attained in the AFSO technique which when compared to the PSO the error difference is 0.465. The HS achieves a value of 0.756 in all the data values in the 7 days process. Then in the case of the 28 days testing process for all the data values the minimum error is 0.63 in the AFSO which when compared to the other techniques is minimized as 63.56 and 65.23% in the PSO and HS respectively. Similarly in the 56 days testing process a higher accuracy performance of 62.35% is achieved in the AFSO process.

Figure 6 shows the split tensile strength values for all the data in 7, 28, 56 days for the AFSO algorithm. In the 7 days testing process for Data 1 the predicted error value is 0.61 which when compared with the PSO and HS techniques the error values are minimized as 66.235 and 68.33%, respectively. In the case of Data 2 also the minimum error difference is high when compared to the PSO and HS techniques. As regards the performance of the 7 days process the graph is nonlinear as the performance is based on the number of data used in the process. In Data 1 the error is increased whereas for Data 2 it is decreased to increase the value. For the 28 days process Data 1 error is 0.322 which when

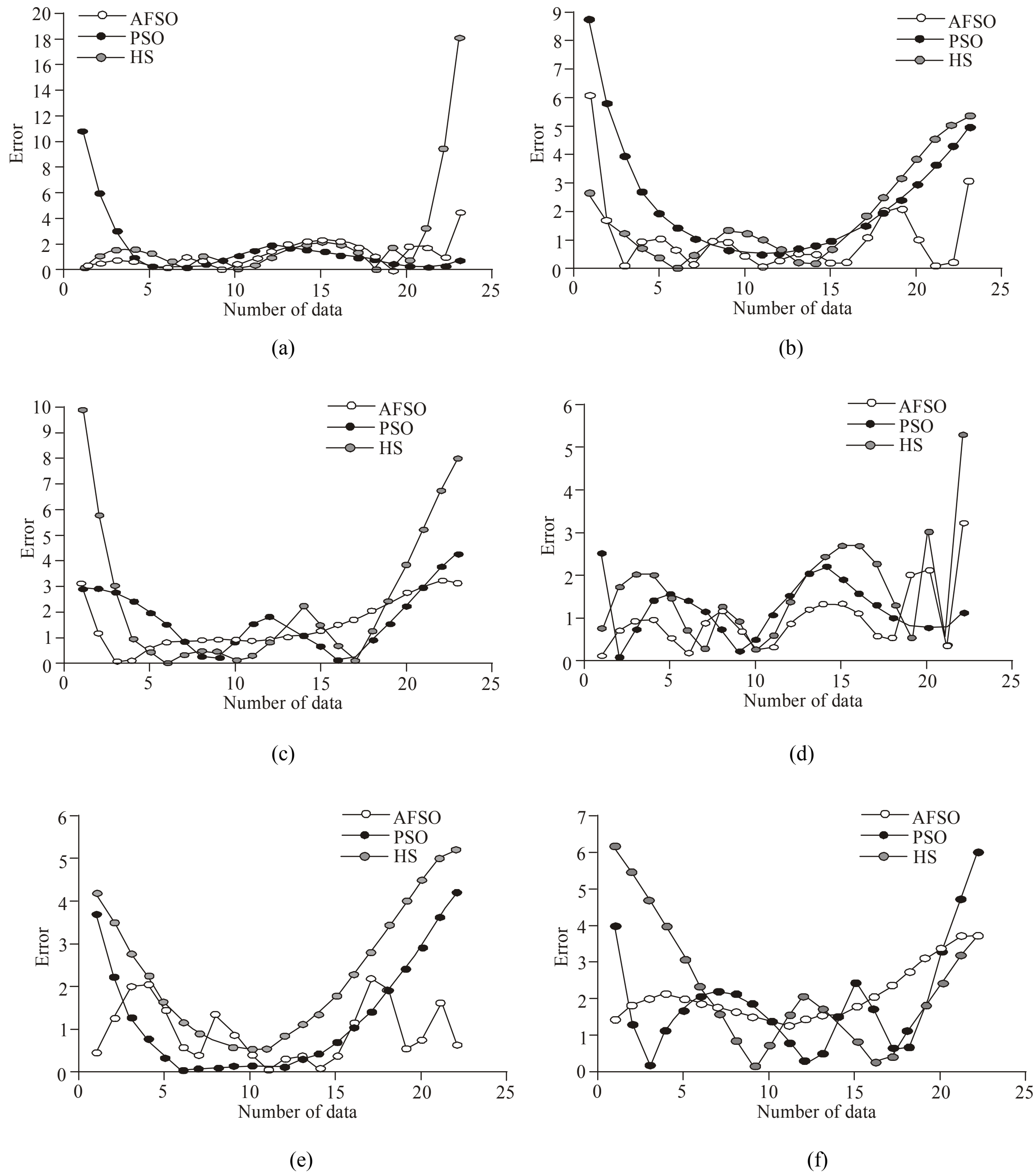

Fig. 7: Number of data based error in deflection; (a): Deflection_Left; (b): Deflection_Middle; (c): Deflection_Right; (d): Deflection _ Left; (e): Deflection _ Middle; (f): Deflection _Right

compared with the other techniques the difference is 72.36% varying. Similarly for the number data base for 28 days testing process the minimum error of the AFSO is 0.326. In the case of the PSO and HS difference is 0.63 and 0.758 and the average minimum error value is attained in the AFSO Process.

The above Fig. 7 shows the deflection of the left, right and middle of the concrete based on loads applied on the different algorithm in 0% and 5% replacement of the concrete mix and the error values are calculated for different data. In the case of 0% replacement of concrete mix for the left side deflection the error value is 0.1711 which is a minimum error achieved by the AFSO technique which when compared to the PSO the error is increased as 0.96 and for the HS the corresponding figure is 0.111. In the case of Data 2 also the AFSO value when compared to the PSO the difference is 91.23% and for the HS it is 60.59%. Similarly for all the data values in the left of the concrete mix the minimum error is 97.23%. And for the deflection on the middle side the minimum error is 6.15 in the AFSO process which when compared with the

PSO and HS are 2.56% and 4.289% respectively. Thus for all the input data when the load is varied, the deflection also increased and the error is minimized based on the iteration. In the case of the Deflection on the Right side also the minimum error is attained in the AFSO technique. Totally for the 0% replacement of concrete mix the minimum error is attained in AFSO which is 83.94%. Then for the 5% replacement of concrete mix the deflection on left side in Data 1 the error is 0.949 which when compared with the other techniques the difference is 5.56. Totally the error difference attained in the AFSO is 69.56%. In the case of 5% replacement of concrete mix the deflection on middle side total difference is 1.03. In the case of the concrete mix replacement 0% and 5% replacement error efficiency is 83.56% in the AFSO technique.

CONCLUSION

This study elegantly explains the mathematical modelling technique crowned with the mighty Artificial Fish Swarm Optimization (AFSO) technique which amazingly attains the accurate ideal values of the weights in model. The multivariable optimization issues ushers in the universal optimum solution and illustrates the adaptability to choose the design variables based on the weights. During the operation of the system the Compressive Strength (CS), Split Tensile Strength (STS) and Deflection are assessed with the data sets. The convincing results are observed to be nearly equal to the data set minimum error value achieved in the optimization method. The minimum errors of mathematical modelling with AFSO process in the case of the compressive strength, split tensile strength and deflection are 96.5, 91.2 and 93.63%, respectively. Based on the concrete mix the performance is also changing. In the future the mathematical model investigators will look towards further unbelievable improvement methodologies for the production of diminished errors with their excellent techniques for the strength evaluation in the concrete.

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