REVISTA MATÉRIA V.29 N.2
ISSN 1517-7076 articles e20240087, 2024

Investigation on structural behavior for steel & tubes with light weight concrete using HLN aid of MKHO

Neelamegam Pitchaipillai[1], Suresh Kumar Paramasivam[2]

[1]SRM Valliammai Engineering College, Department of Civil Engineering. Chennai, Tamilnadu, India.
[2]University College of Engineering, Department of Civil Engineering. Panruti, Tamilnadu, India.
e-mail: neelamegamp.civil@srmvalliammai.ac.in, erpsuresh@rediffmail.com

ABSTRACT

Composite CST with lightweight concrete as infill for three light concrete grades such as M20 to M40 with different loading conditions. The optimal solutions as standard concrete and natural aggregate, waste material from the quarry are collected and added for replacement of natural sand in construction. While causing the experiment, cost and time will be extended, and the structural lightweight concrete mixes attain these can be designed. In present study, lightweight concrete materials are used to prepare the concrete mix with different proportion by replacement of quarry dust instead of sand and analysed the mechanical and other properties using machine learning techniques. The materials used in the present study were cured at the interval of 7 and 28 days, to train the Neural Network (NN) with Hidden layer neuron (HLN) maximization process Modified Krill Herd Optimization (MKHO) model used and these are initially considered. All the ideal results in the planned system demonstrate how the achieved mistake values among the different trail mixes and the predicted value of various mix proportion are obtained as zero and equivalent to zero. Based on the present study results, optimal model exactness is around 98.78% with other machine learning models.

Keywords: Lightweight concrete-filled Steel Tubes; Neural Network; Optimization; Krill herd; Dynamic behavior.

1. INTRODUCTION

Concrete-filled steel tubes (CFSTs) are generally utilized as segments in numerous underlying frameworks. In CFSTs, internal clasping disfigurements of the steel tube are forestalled by the substantial center, however debasement in steel imprisonment, strength and pliability can result from inelastic outward nearby clasping [1]. When utilized as sections exposed to joined hub and sidelong loads, the basic districts are the finishes of the segment where the minutes are the biggest. Under seismic stacking, plastic pivots structure at the section finishes and enormous plastic turns without critical debasement in firmness and strength are requested [2]. The high strength concrete is the raising brittleness with the increasing strength is the primary concern. For example, flexure strengthening can prompt a shear disappointment as disputed to giving the craved bearing limit; the technique's preferences and downsides can differ among the items [3–5]. They must dependably be conceived. Usually, to evaluate the compressive strength of LWSCC does the other mechanical properties is a fundamental parameter. Lightweight total is in many cases characterized as any total with a dry free mass thickness of under 1200 kg/m^3 [6–8]. Lightweight aggregates are utilized to deliver lower thickness cements, which are profitable in decreasing oneself weight of designs and furthermore have preferred warm protection over typical weight concrete [9]. The lightweight of the total is expected to the cell or profoundly permeable microstructure. Pumice, a normally happening volcanic stone of low thickness, has been utilized since Roman times, yet it is just accessible at a couple of areas, and fake lightweight aggregates are currently generally accessible [10–12].

For each situation, both fine and coarse aggregates can be delivered, and different items are accessible in numerous nations [13]. Since they all accomplish lower explicit gravity by expanded porosity, they are more fragile than the ordinary thickness aggregates, and the use of lightweight total by and large outcomes in a general bringing down in the substantial strength [14–16]. The quality and properties of various aggregates shift impressively, and in this manner produce different strength/thickness proportions [17]. Lightweight aggregates are not generally so unbending as would be expected weight aggregates, and in this way produce concrete with a lower versatile modulus and higher wet blanket and shrinkage. A few exceptionally permeable aggregates

Corresponding Author: Pitchaipillai Neelamegam Received on 29/02/2024 Accepted on 20/05/2024

DOI: https://doi.org/10.1590/1517-7076-RMAT-2024-0087

are for the most part powerless and are hence more reasonable for making nonstructural protecting cements, rather than an underlying part [18]. The strength of lightweight cement relies upon the lightweight total sort and source, and furthermore whether lightweight fine aggregates as well as normal sands are utilized.

Concrete filled steel tubular columns (CFST) with standard cross segments, for example, square, rectangular and round are intensely used all through the development business given their predominant primary attributes. The underlying way of behaving of such part is legitimate, since various investigations have been directed to concentrate on their way of behaving like those carried out by recent researchers [19–21]. Although the decision of the CFST segment cross-segment is principally represented by cost, accessibility of material and development techniques, still and much of the time, the models of stylish and design prerequisites may likewise assume a significant part in picking the segment [22–24]. Subsequently, and in many tasks different shapes are being utilized as of late. Self-compacting concrete-filled steel tube (SCCFST) bar addresses an empty steel tube loaded up with self-compacting concrete. Self-compacting concrete (SCC) releases under its weight and fill in the formwork without the requirement for any compaction endeavors and results in a diminishing in development time and work cost [25]. Research on SCCFST bars and columns demonstrated that the underlying way of behaving of these composite members is like that of CFST members.

An amplified quantitative model for proportioning concrete blends laid out on concrete substance, watercement proportion and level of recycled aggregate substitution permitting to favored Recycled Brick Aggregate Concrete (RBAC) compressive strength have been gotten to the next level [26–29]. A data set made from 147 trial of RBAC compressive strength was treated by neural network modeling to accomplish a solid forecast, which was asked by three-crease approval. The exhibition of the agent neural network model was declared by parametric examination with a short survey of the impact of each RBAC part [30]. The concentrates of the primary outcomes is improvement of the neural network modeling results and appropriately new translation and conceptualization for hypothetical progression and pragmatic utilized in research on RBAC concrete substance.

The utilization of reused material safeguards essential natural substances. The environment influencing gases can't hence be diminished. At the point when utilized, the good ways from the purpose in substantial destruction and its handling should be offset with the good ways from new cement to forestall a bounce back impact. Fine reused block aggregates recuperated from obliterated workmanship designs can be used in the assembling of new substantial combinations [31]. At along these lines, it is feasible to decrease the issue of development and destruction squander capacity, and to lessen the utilization of regular materials. The use of workmanship squander and of squashed block as an aggregate in mortar and cement would emphatically affect the economy moreover. To be specific, a safeguarding of normal materials is huge for a naturally mindful and economical building that would be savvy moreover. This sort of building suggests a utilization of minimal expense materials that can be utilized with practically no adverse consequence on the climate [32–35].

Opposition based Learning (OBL) is another idea in machine learning, motivated from the contrary relationship among elements. In 2005, interestingly the idea of resistance was presented which has drawn in a ton of exploration endeavors somewhat recently. Assortment of delicate processing calculations, for example, enhancement strategies, support learning, counterfeit brain organizations, and fuzzy systems have previously used the idea of OBL to work on their presentation [36]. This study has been directed on three classes of OBL endeavors: a) hypothetical, including the numerical hypotheses and principal definitions, b) formative, zeroing in on the plan of the unique OBL-based plans, and c) true utilizations of OBL.

ANNs in present review utilized information focuses acquired from writing for preparing and approval of the organization. These ANNs were used to anticipate tentatively resolved chloride entrance level and compressive strength of SCC blend examples. The ANNs have been utilized in past for expectation of different critical substantial properties in view of various info boundaries. ANN isn't the main system for expectation of cement compressive strength and chloride infiltration level [37]. A few scientists have utilized relapse models as a guide to ANN calculations. The back-proliferation calculation is the most normally used ANN learning calculation in examinations connected with forecast of chloride particle entrance and mechanical properties of cement. ANNs actually must integrate proper information boundaries that straightforwardly impact the precision of the result. To upgrade the forecast precision of ANN models different agents additionally utilized various designs of stowed away layers other than information and result layers [38].

2. MATERIALS AND METHODS

The detailed methodology of the present study is represented in Figure 1. In present study, materials used are ordinary Portland cement (OPC) as binding material, manufacturing sand as fine aggregate, light weight coarse aggregate, alccofine, granite waste by product and glenium stream.

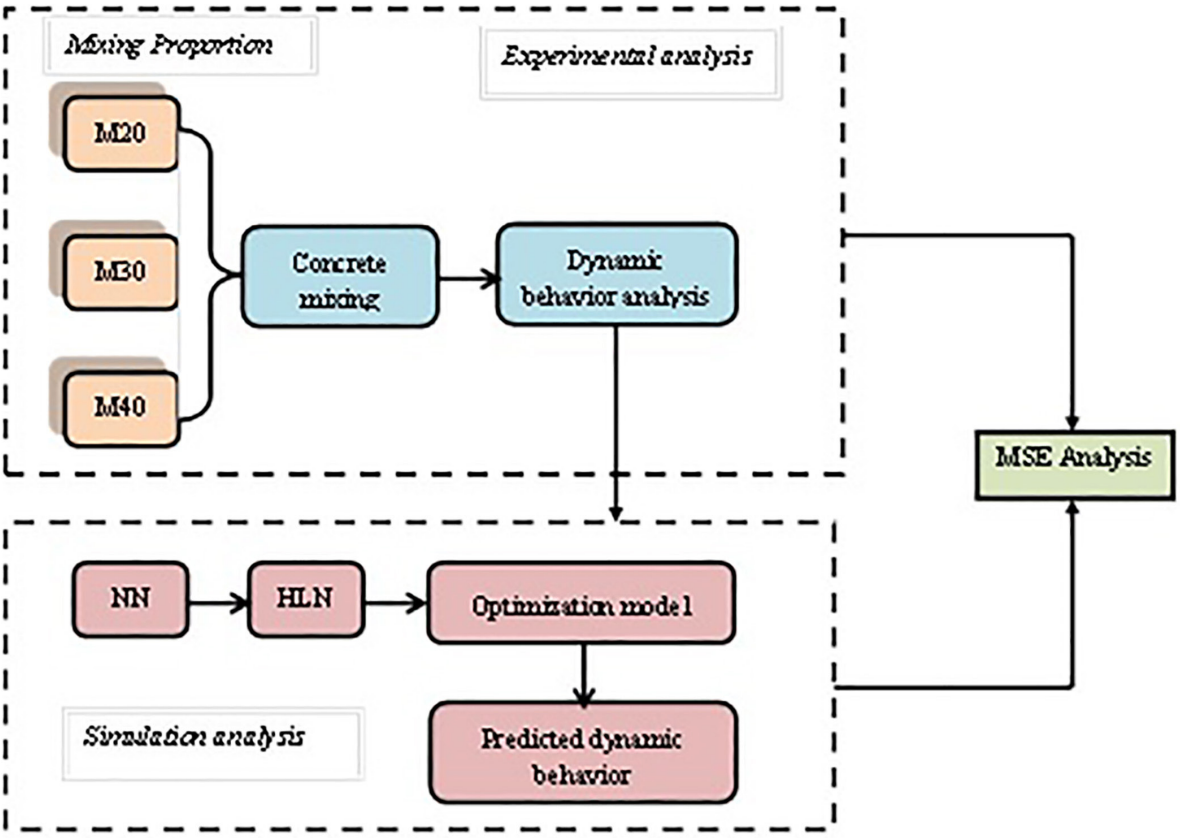

Figure 1: Block diagram for proposed method.

2.1. Experimental analysis

On seven axially constrained non-composite steel concrete panels are executed for high impact energy tests. Concrete mix proportion M20, M30 and M40 are conceived for dynamic behavior analysis. The mixing materials regard as coarse aggregate ordinary Portland cement (OPC) with 53 grades, light weight aggregate, steel tube, and so on. In the trial examination, round and hollow or the concrete solid shape is applied to analyze the properties of the OPC with the all materials [39]. Their compressive strength, split rigidity of concrete discussed for 7 days, 28 days. Water ingestion of light weight aggregate with an excessive amount of pores is substantially more than common aggregates (stream aggregates). Finish of measure of water assimilation in these sorts of aggregates, since of changing measure of retained water is troublesome. For impacting how much every fixing in light weight concrete combination (alongside how much retained water in light weight aggregates, particularly those with an excessive amount of pores with harsh and precise surface, by making various blends) one can utilize the normal plan strategies for customary concrete blend. Materials subtleties are shown underneath.

2.2. Ordinary Portland cement (OPC)

The cement with 95% is the essential type of standard Portland cement of it comprising clinker and 5% being gypsum which is added as an added substance to expand the setting season of the cement to a useful 30 minutes odd or something like that [40]. Gypsum controls are the essential setting season of the cement. The cement would set when water is included cement when the gypsum isn't added. The cement (OPC53grade) has a particular gravity of 3.10, began and last setting seasons of the cement were 38 minutes has been applied by this exploration.

2.3. Fine aggregate

The fine aggregate is 0.075 mm is the minimum particle size. Due to different weathering actions, it is organized by decompositions of sand stones. Fine aggregate keeps shrinkage of concrete and the mortar. The properties of the fine aggregate has been recorded such as specific gravity 2.3 and finess modulus is 2.67.

Table 1: Mix proportion for different grades.

MIXING PROPORTION	CEMENT (kg/m^3)	FINE AGGREGATE (kg/m^3)	COARSE AGGREGATE (kg/m^3)	WATER (kg/m^3)
M20	332	760.75	608	186
M30	401.85	646.3	589.6	217
M40	504	544.2	589.6	217

2.4. Light weight coarse aggregate

Lightweight aggregates LWAs are not another material since it has been known on the grounds that the beginning of the Roman Realm. These days LWA is fabricated applying either counterfeit or regular LWA as opposed to of standard typical weight aggregates; it has many benefits over typical weight concrete NWC. The coarse aggregate particles in a lightweight-aggregate blend are managing the cost of the issue by drifting to the highest point of the lift all through vibration.

2.5. Structural light weight aggregate

The light weight coarse aggregate will made for the concrete. A wetting preceding use to achieve the serious level of immersion will normally require for the light weight aggregates [41]. The underlying utilization of primary light weight concrete is to diminish the dead heap of a concrete design. Applying the exceptionally large size light weight aggregate with a lower strength results into a lower strength of the light weight concrete; hence, greatest size of the light weight aggregate should be restricted to 25 mm probably.

2.6. Mixing proportion model

The mix proportion for different grades are presented in Table 1.

3. DYNAMIC BEHAVIOR ANALYSIS USING SIMULATION MODEL

3.1. Neural network (NN)

An effort to display the data handling abilities of nervous systems is the brain networks. Subsequently, the necessity properties of natural brain networks from the perspective of data handling are will require in regards to by first. This will allow us to configuration unique models of fake brain networks exhibit in Figure 2, which can then be analyzed and reenacted [42, 43]. Despite the fact that to explain the design of the mind and the nervous systems of certain creatures are different in many regards, there is a typical agreement that the quintessence of the activity of brain outfits is “control through correspondence” have been recommended the models. These conduct expectation processes boost hidden neuron and hidden layer of the NN structure.

3.2. Hidden neuron

The blunder on the hubs to which their result is related will decide for the hidden neuron. The mistake will be assessed for the solidness of brain organization. The negligible mistake reflects higher blunder reflects and better solidness most terrible dependability [44, 45]. The unnecessary hidden neurons will incite over fitting; that is, the brain networks have misjudged the intricacy of the objective difficulty. It extraordinarily corrupts the speculation capacity to contribute with significant deviation in expectation.

3.3. Hidden layer

The hidden layer is the get-together of neurons which has actuation capability involved on it as well as renders a moderate layer among the information layer and the result layer. To assessing the quantity of neurons in the hidden layer yet at the same time none was precise will laid out by a few scientists [46–49]. Under fitting happens when there are too couple of neurons in the hidden layers to enough find the signs in a muddled informational index. In the event that pointless more neurons are present in the organization, “Over fitting” may occur.

3.4. Hidden layer neuron (HLN) optimization

Influence the neuron for NN and inquire dynamic behavior of steel tube concrete process and optimal hidden layer. To the novel algorithm, this optimal model evidence is afforded which offers theoretical support. To absolve our new method will carried out for the experiments, which is adopted by a below section [50].

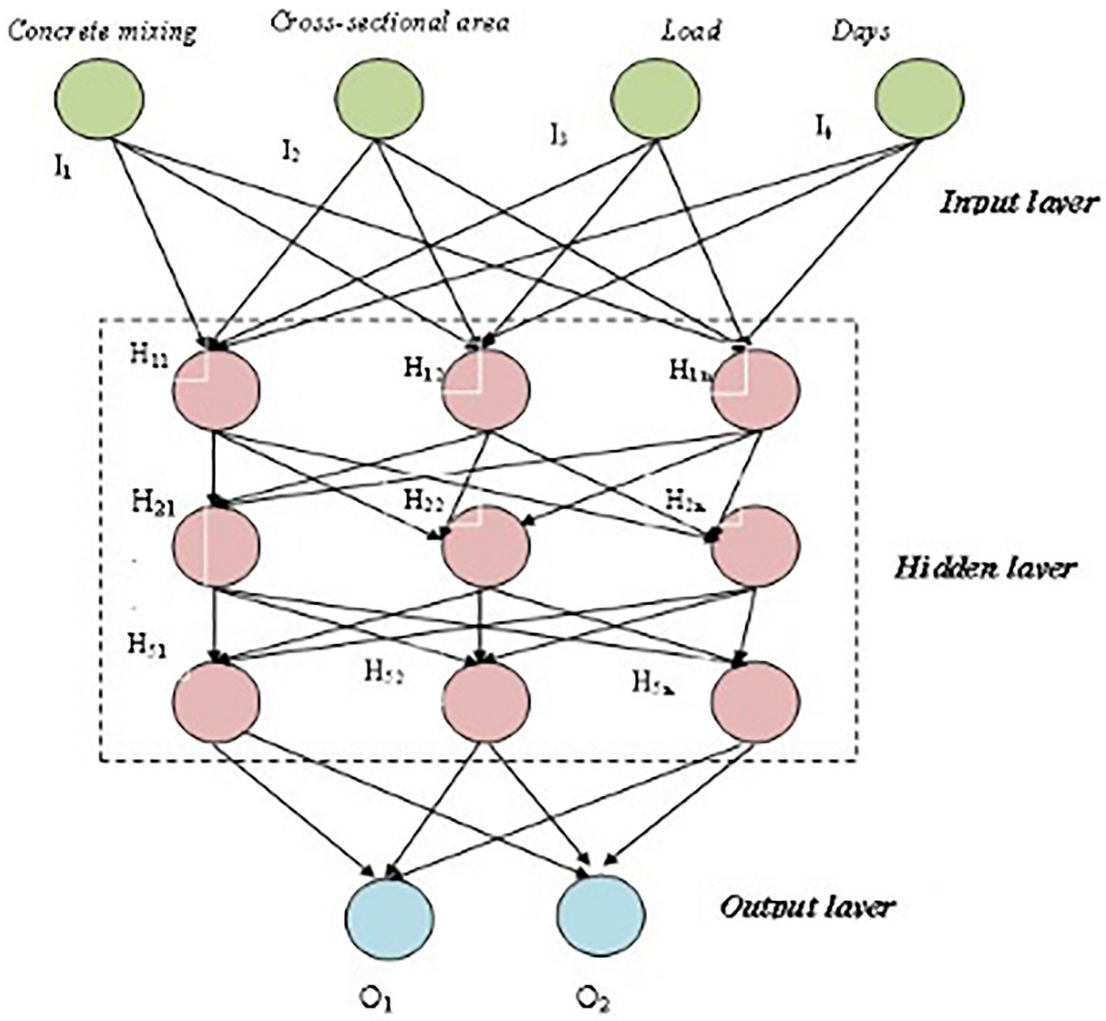

Figure 2: NN structure.

This optimization model applying the Krill herd Optimization (KHO) with Cauchy mutation process held that is Modified Krill Herd Optimization (MKHO) technique applied. Step 1: NN structure with weights values, Step 2: On the input and output layer will directly implemented for the Linear Activation function, Step 3: Fitness evaluation, Step 4: Updating process and Step 5: Find the optimal HLN for behavior analysis.

3.5. Modified krill herd optimization (MKHO)

MKHO calculation improves the haphazardly resolved secret layer input weight upholds in WELM organization. The two principle objectives are conceived by this KHO, this optimization model having mutation part and crossover we will change this mutation as Cauchy mutation conceived. In the improvement, of the course of development of a krill individual is settled both by the local multitude thickness (nearby effect), a goal swarm thickness (target influence) and an unpleasant multitude thickness (frightful impact). To the extent that two crucial fruitful boundaries, the searching development is figured [51]. The first is the food region and the subsequent one is the previous experience about the sustenance region. To be a sporadic technique, the actual scattering of the krill individuals is thought. To the extent that a most outrageous scattering speed and a sporadic directional vector is displayed by this development [52–55]. The hybrid administrator is first applied in GA as a suitable technique for overall upgrade. A vectorized type of the half and half is moreover applied as a piece of DE which can be imagined as a further improvement to GA. The half and half rate calculation as takes later. A few tests have demonstrated that the krill in KH will change somewhat among the around the worldwide best krill before it get last best arrangement, the Cauchy transformation administrator to disregard falling into neighborhood ideal. The calculation ends its execution provided that the arrangement which is holding the best wellness esteem as lower and the bigger number of cycles is accomplished. The ideal loads based gauge the unique ways of behaving.

4. RESULT AND DISCUSSION

This part examines the exploratory and reproduction examination of dynamic way of behaving of light weight concrete in stell tube. This reproduction cycle executed by MATLAB 2015 a with 4GB slam and i5 processor, Similar examination of CS and TS likewise examined in this part.

The accompanying recommendation rate mixing is thought of as in to represent different Burden in 3D squares, Cross sectional area of block compressive strength as for 7 days and 28 days to such an extent that dry weight specimen used to chamber shape as for up to referenced days for deciding split tensile strength [56]. The M20, M30 and M40 mixing proportion raise with decline in specimen weight yet in strength perspective amplify in mixing rate will absolutely diminish the strength achieve in both compressive and split tensile or in other hand while the mixing proportion isn't partake (for example at the point when it is "Zero") then the heaviness of the specimen is high liken to the mixing proportion is mixed these are discussed in Table 2. The CS and TS of steel light weight substantial model are exhibited for Figure 3(b) and 4(b), compressive strength examination for various mixing rate from the previously mentioned chart continuous specimen test for 28 days and 56 days produce practically comparative qualities while their outstanding in Table 2, here compressive strength separate from (0–55) N/mm^2 in every one of the four assessment expansion in mixing rate will limit each of the four boundaries dry weight, 7 days, 28 days [57, 58]. In Figure 4 is similar to the Cylindrical specimen shape and its strength examination are laid out while those projections. In Figures 3(a) and 4(a) will exhibits for the shape block and cylindrical shape are, additionally in this split tensile strength examination raise in mixing rate will surely limit the weight yet additionally diminish the strengthen factors. From the front two shapes (cubic and chamber) as that of compressive and split tensile strength investigation practically the projected outcome examination is comparative we should see the Dramatic acting and its relapse condition for compressive strength and split tensile strength.

Table 2: Dynamic behaviors of concrete.

CONCRETE MIX	SPECIMEN	LOAD IN CUBES (TONNES)	CROSS SECTIONAL AREA OF CUBE (mm^2)	CS OF CONCRETE (N/mm^2)		LOAD IN CYLINDER (TONNES)	CROSS-SECTIONAL AREA OF CYLINDER (mm^2)	TS OF CONCRETE (N/mm^2)	
				7 Days	28 Days			7 Days	28 Days
M20	1	28	225	12.44	15.56	24	150*300	2.28	3.88
	2	30		12.33	21.23	28		2.85	3.21
	3	32		13.25	24.2	26		2.22	3.56
M30	1	48		20.2	30.5	28		2.88	4.2
	2	52		18.56	61.9	31		3.2	4.6
	3	45		21.6	34.2	32		3.22	3.2
M40	1	42		22.25	48.22	37		3.45	3.4
	2	94		29.56	42.2	32		3.45	5.45
	3	96		30.22	46.22	38		3.6	5.45

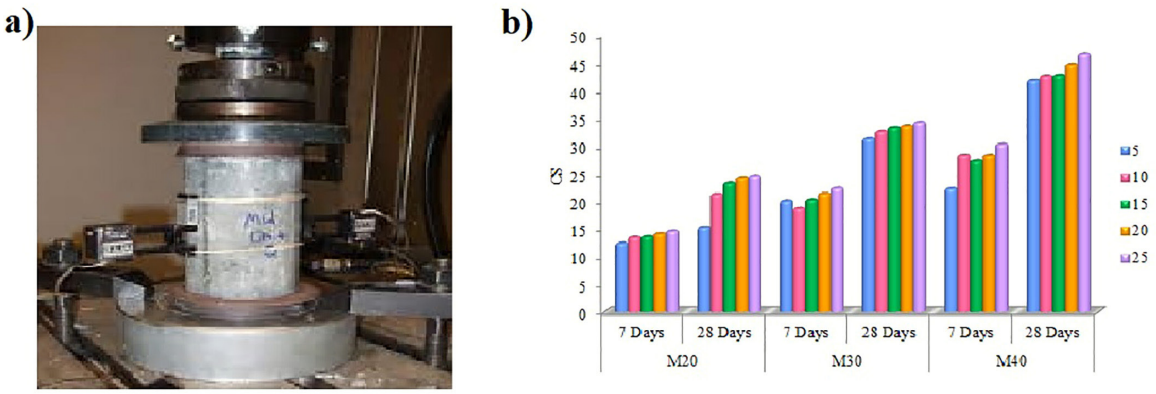

Figure 3: (a) Cube shape for CS. (b) Compressive strength analysis vs varying mixing percentage.

4.1. Simulation results

In Figures 5 and 6 laid out that the gauge upsides of the compressive strength through the 20% test information is applied. From that point, the estimate values are analyzed, broke down, and counterpointed with the first qualities to show up basically blunder of every single plan in regard of the info and out values. The testing values and preparing are spread to decide the goal elements of the numerical displaying. A similar technique is executed for 7 days and 28 days separately. On account of the flexural strength, the strength is switched around to 29, and here the anticipated worth is high though the real worth is low [59]. The trial results are compared to anticipated results the mistake has a base worth. Figure 6 likewise settled the TS examination of anticipated Versus genuine qualities, Besides in this split tensile strength examination raise in mixing rate will positively diminish the weight yet in addition decline the strengthen factors. The NN model with the maximization method has been capable to attain the least error value of the strength for 7, 28 days for various techniques in accordance with the input values are demonstrated in Table 3. The MSE value is influenced by means of the forecast values and the test data values. The compressive strength (CS-7) (CS-28); split tensile strength (TS-7) (TS-28).

The compressive strength for 7 days minimum MSE value of the MKHO is 0.240 which when equated with the other algorithm the difference is 83.72.3%. After 28 days of the analyzing process, the minimum error value is equated with the IGWO which is raised as 48.25%. For the split tensile strength the minimum error value for the MKHO process in 7 days examining is 0.86 which when equated to the IGWO is 20.3%. Thus, in all the sides of the MKHO develops the minimum MSE with better accuracy. The percentage variation as mechanical properties established on three strategies are presented for Figures 7 and 8. The bar graph demonstrated the error accuracy for TS and CS by applying SCG, GWO, IGWO, and MKHO. In CS, the minimum accuracy

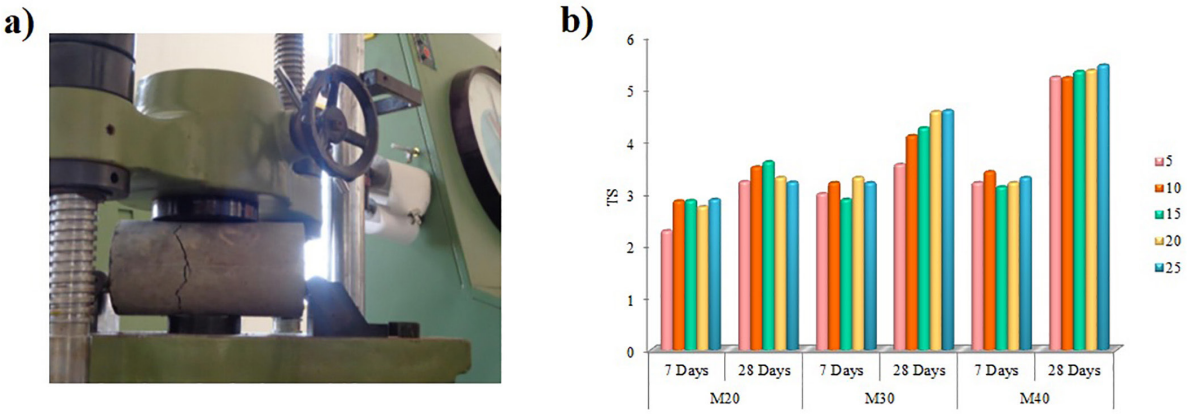

Figure 4: (a) Cylinder shape for TS. (b) Tensile strength analysis vs varying mixing percentage.

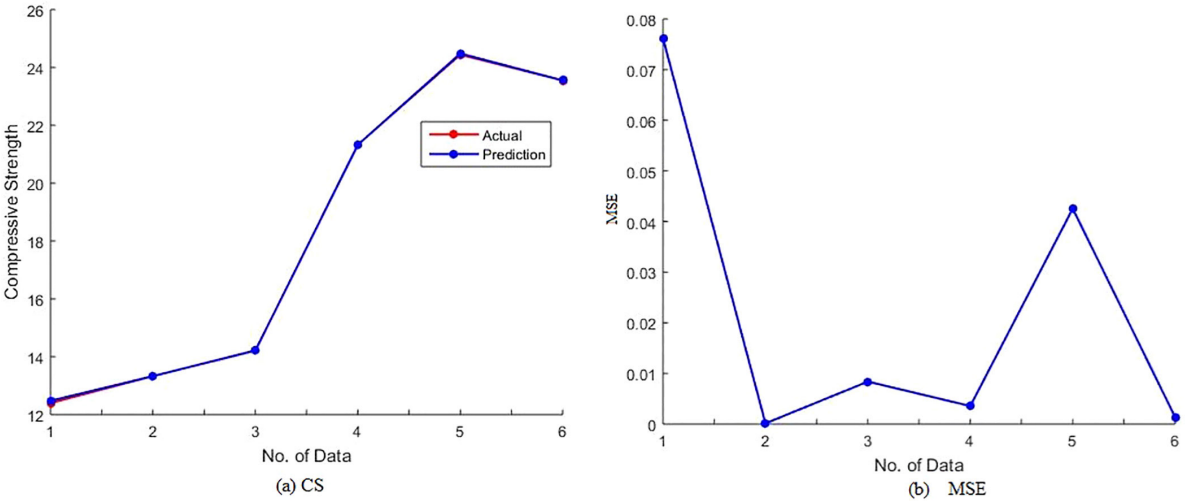

Figure 5: Comparative analysis for predicted CS.

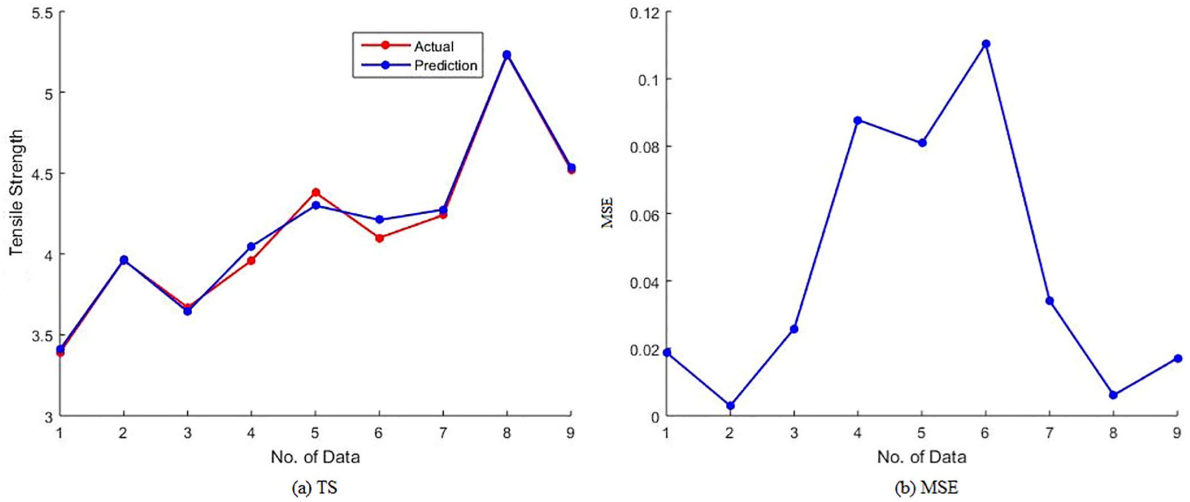

Figure 6: Comparative analysis for predicted TS.

Table 3: Predicted result for CS and TS.

MIXING	SPECIMENS	CS PREDICTED VALUES				TS PREDICTED VALUES			
		IGWO		MKHO		IGWO		MKHO	
		7 days	28 days	7 days	28 days	7 days	28 days	7 days	28 days
M20	1	12.59	15.58	12.45	15.5	3.22	4.22	2.30	3.90
	2	12.59	21.89	12.5	22.3	3.85	3.52	2.90	3.25
	3	13.55	25.2	13.2	24.32	3	3.60	2.25	3.58
M30	1	20.56	32.3	21.6	30.2	3.5	4.5	2.95	4.25
	2	19.6	62.3	22.89	62.2	3.5	4.9	3.5	4.62
	3	22.3	35.22	30.2	35.2	3.52	3.56	3.29	3.45
M40	1	28.22	49.6	23.2	48.2	3.52	3.8	3.50	5.48
	2	29.46	48.21	29.3	43.55	3.55	5.59	3.50	5.48
	3	42.22	50.22	30	47.2	3.77	5.58	3.62	5.45

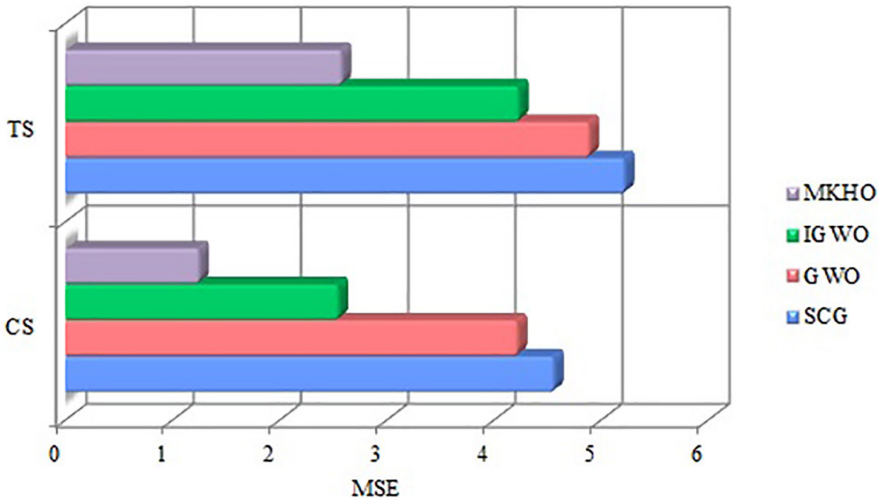

Figure 7: Comparative analysis for MSE.

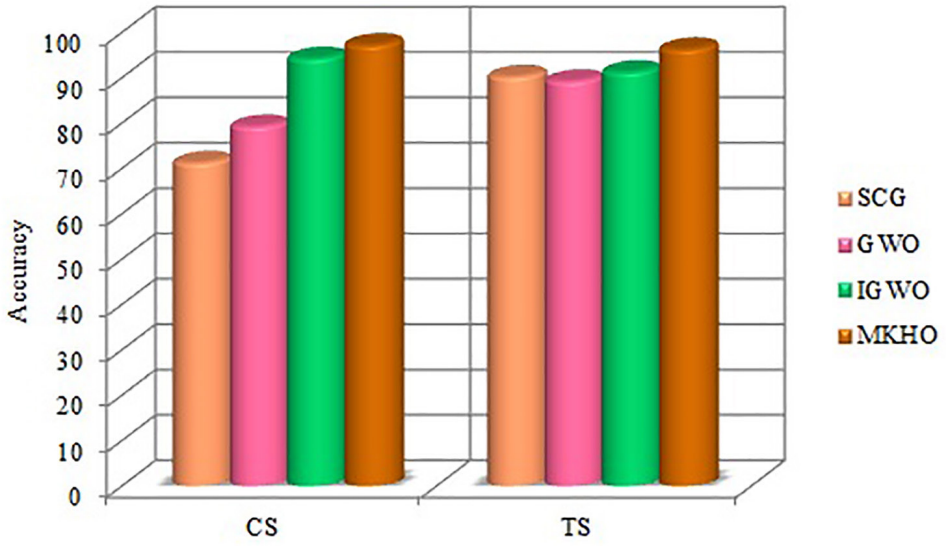

Figure 8: Comparative analysis for accuracy.

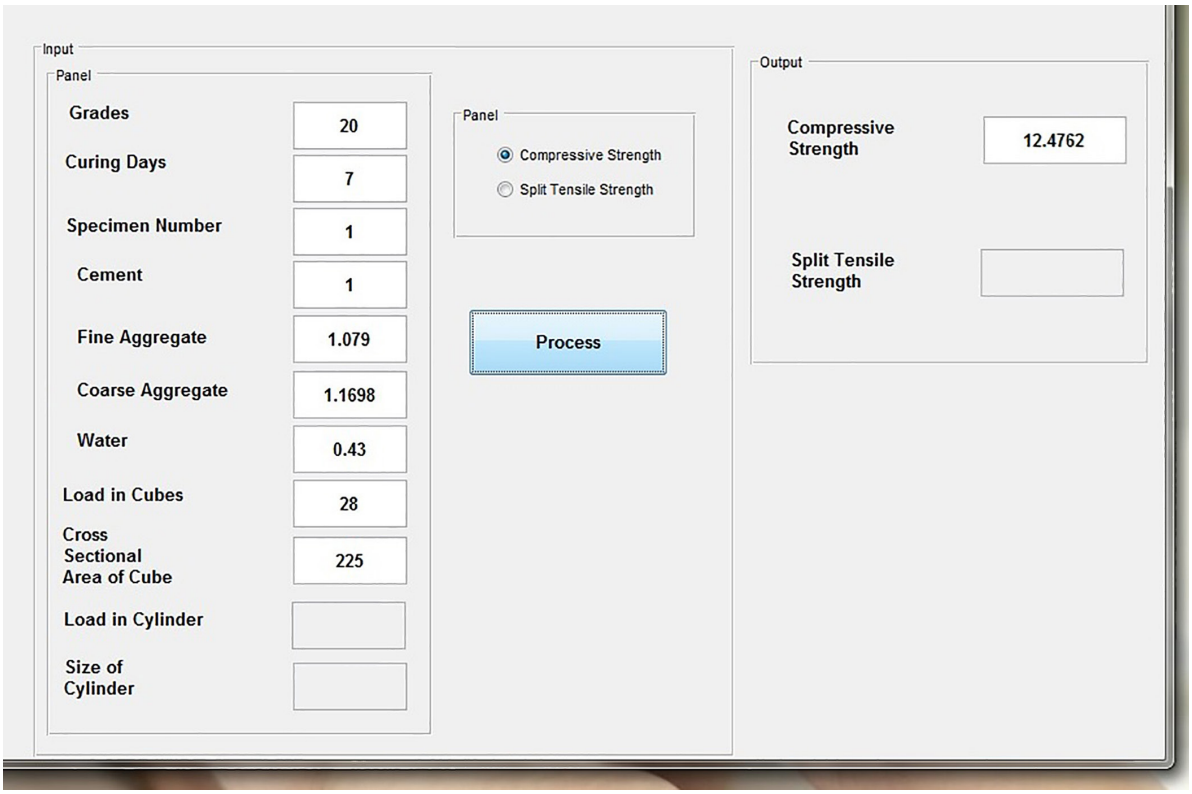

Figure 9: GUI for CS.

accomplishes in SCG i.e. 71.23%, GWO as 79.3%, IGWO accomplishes 91.23%. The maximum value that is 96.33% is accomplishes by the suggested model [60]. Here, for the comparison of MKHO has found maximum accuracy than other two techniques. Similary, the maximum accuracy for TS is 90%, it attains in MKHO. But, other two achieves 89% and 91% it is minimum then suggested model.

The characteristic Figures 9 and 10 instances one set of input values of the procedure among the performance technique is carried out in the MATLAB programming showed on the relative graph [61]. With the input established on several techniques the performance of the light weight technology performance parameters are

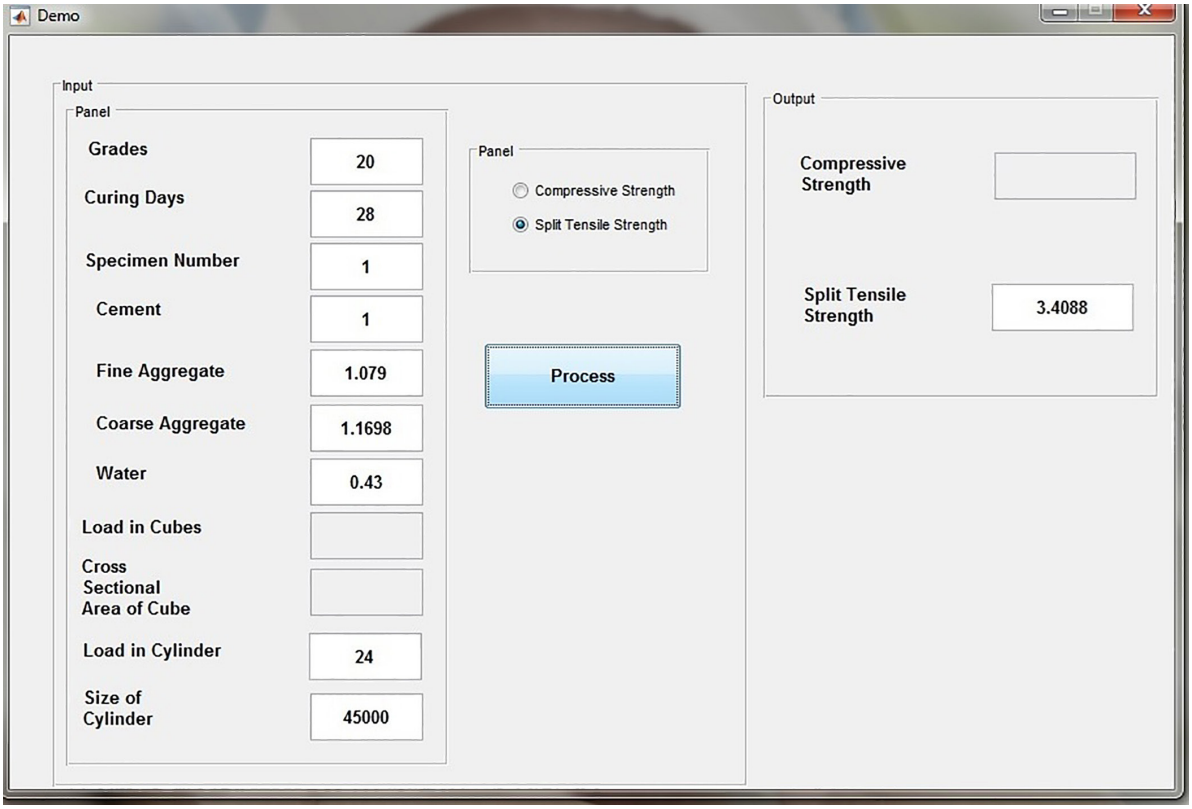

Figure 10: GUI for TS.

named. This figure like an enterprise resource planning based model process of the structural process. In this Graphical User Interface (GUI) based approach, the input values are alter and the corresponding outputs are estimated.

5. CONCLUSION

With analyzing the mechanical properties in the effect of light weight concrete filled with steel tubular columns are regarded by the research work. The study analyses various grades of concrete M20, M30 and M40, cured with 7 days and 28 days for cube and 28 days for cylinder. The multivariable optimization issues ushers in the universal optimum solution and instances the adaptability to select the design variables established on the weights. Throughout the operation of the system the tensile strength (TS), the compressive strength (CS), with the data sets. The convincing results are discovered to be nearly equal to the data set minimum MSE value accomplished in the NN optimization method. The maximum accuracy is 96.23% in CS and 97.55% in TS. MKHO optimization algorithm determine the strength of the concrete with minimum MSE and maximum prediction level equated to SCG training algorithm and GWO optimization techniques are accomplished by the suggested model. In the future the mathematical model investigators will look towards further unbelievable development for methodologies for the production of decreased errors with their excellent techniques for the strength estimation in the concrete.

6. BIBLIOGRAPHY

[1] NGUYEN, H.Q., LY, H.-B., TRAN, V.Q., *et al*., "Optimization of artificial intelligence system by evolutionary algorithm for prediction of axial capacity of rectangular concrete filled steel tubes under compression", *Materials*, vol. 13, no. 5, pp. 1205, 2020. doi: https://doi.org/10.3390/ma13051205.

[2] NAGARAJAN, D., RAJAGOPAL, T., MEYYAPAN, N., "A comparative study on prediction models for strength properties of LWA concrete using artificial neural network", *Revista de la Construcción*, v. 19, n. 1, pp. 103–111, 2020. doi: http://doi.org/10.7764/rdlc.19.1.103-111.

[3] SALAR, P.B., PATIL, P.S., Expermental investigation on high strength light weight concrete filled steel tube strut under axial compression. *INAE Letters*, v. 4, pp. 207–214, 2019. doi: http://doi.org/10.1007/s41403-019-00077-7.

[4] CHOPRA, P., SHARMA, R.K., KUMAR, M., *et al*., "Comparision of machine learning techniques for the prediction of compressive strength of concrete", *Advances in Civil Engineering*, v. 28, pp. 5481705, 2018. doi: https://doi.org/10.1155/2018/5481705.

[5] PATEL, V.I., HASSANEIN, M.F., THAI, H.T., *et al*., "Behavior of axially loaded circular concrete-filled bimetallic stainless-carbon steel tubular short columns", *Engineering Structures*, v. 147, pp. 583–597, 2017. doi: http://doi.org/10.1016/j.engstruct.2017.05.064.

[6] MOHANTA, N.R., SAMANTARAY, S., "Study of combined effect of metakaolin and steel fiber on mechanical properties of concrete", *Pertanika Journal of Science & Technology*, v. 27, n. 3, 2019.

[7] KUMAR, M.H., MACHARYULU, I.S., RAY, T., *et al*., "Effect of water absorption and curing period on strength and porosity of triple blended concrete", *Materials Today: Proceedings*, v. 43, pp. 2162–2169, 2021. doi: http://doi.org/10.1016/j.matpr.2020.12.092.

[8] RAY, T., MOHANTA, N.R., KUMAR, M.H., *et al*., "Study of effect of temperature on behavior of alkali activated slag concrete", *Materials Today: Proceedings*, v. 43, pp. 1352–1357, 2021. doi: http://doi.org/10.1016/j.matpr.2020.09.169.

[9] OUYANG, Y., KWAN, A.K.H., LO, S.H., *et al*., "Finite element analysis of concrete-filled steel tube (CFST) columns with circular sections under eccentric load", *Engineering Structures*, v. 48, pp. 387–398, 2017. doi: http://doi.org/10.1016/j.engstruct.2017.06.064.

[10] KUMAR, M.H., SAIKRISHNAMACHARYULU, I., MOHANTA, N.R., *et al*., "Mechanical behaviour of high strength concrete modified with triple blend of fly ash, silica fume and steel fibers", *Materials Today: Proceedings*, v. 65, pp. 933–942, 2022. doi: http://doi.org/10.1016/j.matpr.2022.03.528.

[11] KUMAR, M.H., MOHANTA, N.R., SAMANTARAY, S., *et al*., "Combined effect of waste glass powder and recycled steel fibers on mechanical behavior of concrete", *SN Applied Sciences*, v. 3, n. 3, pp. 350, 2021. doi: http://doi.org/10.1007/s42452-021-04353-6.

[12] KUMAR, M.H., MOHANTA, N.R., PATEL, N., *et al*., "Impact of fly ash and metakaoline on the crack resistance and shrinkage of concrete", *Civil Engineering (Shiraz)*, v. 46, n. 3, pp. 2011–2026, 2022. doi: http://doi.org/10.1007/s40996-021-00748-y.

[13] CHEN, J., WANG, J., LI, W., "Experimental behavior of reinforced concrete-filled steel tubes under eccentric tension", *Journal of Constructional Steel Research*, v. 36, pp. 91–100, 2017. doi: http://doi.org/10.1016/j.jcsr.2017.05.004.

[14] MAHGUB, M., ASHOUR, A., LAM, D., *et al*., "Tests of self-compacting concrete filled elliptical steel tube columns", *Thin-walled Structures*, v. 110, pp. 27–34, 2017. doi: http://doi.org/10.1016/j.tws.2016.10.015.

[15] KUMAR, M.H., SAIKRISHNAMACHARYULU, I., KUMAR, U., *et al*., "Coupling effect of fly ash, metakaoline and different types of steel fibers on mechanical performance of concrete", *AIP Conference Proceedings*, v. 2417, pp. 020014, 2021. doi: http://doi.org/10.1063/5.0072573.

[16] SINGH, P., DASH, H.K., SAMANTARAY, S., "Effect of silica fume on engineering properties of expansive soil", *Materials Today: Proceedings*, v. 33, pp. 5035–5040, 2020. doi: http://doi.org/10.1016/j.matpr.2020.02.839.

[17] YAN, F., LIN, Z., WANG, X., *et al*., "Evaluation and prediction of bond strength of GFRP-bar reinforced concrete using artificial neural network optimized with genetic algorithm", *Composite Structures*, v. 161, pp. 441–452, 2017. doi: http://doi.org/10.1016/j.compstruct.2016.11.068.

[18] VAFAEENEZHAD, H., ASADOLAHPOUR, S.R., NAYEBPASHAEE, N., *et al*., "Intelligent use of data to optimize compressive strength of cellulose-derived composites", *Applied Soft Computing*, v. 40, pp. 594–602, 2016. doi: http://doi.org/10.1016/j.asoc.2015.12.029.

[19] YAMAN, M.A., ELATY, M.A., TAMAN, M., "Predicting the ingredients of self compacting concrete using artificial neural network", *Alexandria Engineering Journal*, v. 56, n. 4, pp. 523–532, 2017. doi: https://doi.org/10.1016/j.aej.2017.04.007.

[20] SAMANTARAY, S., SAHOO, A., GHOSE, D.K., *Watershed management and applications of AI*. Boca Raton: CRC Press, 2021. doi: http://doi.org/10.1201/9781003168041.

[21] SAMANTARAY, S., SAHOO, A., "Prediction of suspended sediment concentration using hybrid SVM-WOA approaches", *Geocarto International*, v. 37, n. 19, pp. 5609–5635, 2022. doi: http://doi.org/10.1080/10106049.2021.1920638.

[22] SAMANTARAY, S., DAS, S.S., SAHOO, A., *et al*., "Monthly runoff prediction at Baitarani river basin by support vector machine based on Salp swarm algorithm", *Ain Shams Engineering Journal*, v. 13, n. 5, pp. 101732, 2022. doi: http://doi.org/10.1016/j.asej.2022.101732.

[23] SAMANTARAY, S., SAHOO, P., SAHOO, A., *et al*., "Flood discharge prediction using improved ANFIS model combined with hybrid particle swarm optimisation and slime mould algorithm", *Environmental Science and Pollution Research International*, v. 30, n. 35, pp. 83845–83872, 2023. doi: http://doi.org/10.1007/s11356-023-27844-y. PMid:37351742.

[24] ŠIPOŠ, T.K., MILIČEVIĆ, I., SIDDIQUE, R., "Model for mix design of brick aggregate concrete based on neural network modelling", *Construction & Building Materials*, v. 148, pp. 757–769, 2017. doi: http://doi.org/10.1016/j.conbuildmat.2017.05.111.

[25] TRENTADUE, F., QUARANTA, G., MARANO, G.C., "Closed-form approximations of interaction diagrams for assessment and design of reinforced concrete columns and concrete-filled steel tubes with circular cross-section", *Engineering Structures*, v. 27, pp. 594–601, 2016. doi: http://doi.org/10.1016/j.engstruct.2016.08.059.

[26] MALIK, P., SINGH, A.,"Evaluation of characteristics strength of concrete using crushed stone dust as fine aggregate", *Journal of Enhanced Research in Science Technology & Engineering*, v. 3, n. 6, pp. 119–121.

[27] WANG, G.G., DEB, S., GANDOMI, A.H., *et al*., "Opposition-based krill herd algorithm with Cauchy mutation and position clamping", *Neurocomputing*, v. 177, pp. 147–157, 2016. doi: http://doi.org/10.1016/j.neucom.2015.11.018.

[28] SAMANTARAY, S., SAHOO, A., "Prediction of flow discharge in Mahanadi River Basin, India, based on novel hybrid SVM approaches", *Environment, Development and Sustainability*, pp. 1–25, 2023. doi: http://doi.org/10.1007/s10668-023-03412-9.

[29] TAO, H., ABBA, S.I., AL-AREEQ, A.M., *et al*., "Hybridized artificial intelligence models with nature-inspired algorithms for river flow modeling: a comprehensive review, assessment, and possible future research directions", *Engineering Applications of Artificial Intelligence*, v. 129, pp. 107559, 2024. doi: http://doi.org/10.1016/j.engappai.2023.107559.

[30] SAMANTARAY, S., SAHOO, A., BALIARSINGH, F., "Groundwater level prediction using an improved SVR model integrated with hybrid particle swarm optimization and firefly algorithm", *Cleaner Water*, v. 1, pp. 100003, 2024. doi: http://doi.org/10.1016/j.clwat.2024.100003.

[31] ZHOU, Q., ZHU, F., YANG, X., *et al*., "Shear capacity estimation of fully grouted reinforced concrete masonry walls using neural network and adaptive neuro-fuzzy inference system models", *Construction & Building Materials*, v. 153, pp. 937–947, 2017. doi: http://doi.org/10.1016/j.conbuildmat.2017.07.171.

[32] KHASHMAN, A., AKPINAR, P., "Non-destructive prediction of concrete compressive strength using neural networks", *Procedia Computer Science*, v. 108, pp. 2358–2362, 2017. doi: http://doi.org/10.1016/j.procs.2017.05.039.

[33] ABUALIGAH, L.M., KHADER, A.T., AL-BETAR, M.A., *et al*., "A novel hybridization strategy for krill herd algorithm applied to clustering techniques", *Applied Soft Computing*, v. 60, pp. 423–435, 2017. doi: http://doi.org/10.1016/j.asoc.2017.06.059.

[34] GANDOMI, A.H., ALAVI, A.H., "Krill herd: a new bio-inspired optimization algorithm", *Communications in Nonlinear Science and Numerical Simulation*, v. 17, n. 12, pp. 4831–4845, 2012. doi: http://doi.org/10.1016/j.cnsns.2012.05.010.

[35] SAMANTARAY, S., GHOSE, D.K., "Prediction of S12-MKII rainfall simulator experimental runoff data sets using hybrid PSR-SVM-FFA approaches", *Journal of Water and Climate Change*, v. 13, n. 2, pp. 707–734, 2022. doi: http://doi.org/10.2166/wcc.2021.221.

[36] SAMANTARAY, S., GHOSE, D.K., Modelling runoff in an arid watershed through integrated support vector machine. *H2Open Journal*, v. 3, n. 1, pp. 256–275, 2020. doi: https://doi.org/10.2166/h2oj.2020.005.

[37] SAMANTARAY, S., GHOSE, D.K., "Sediment assessment for a watershed in arid region via neural networks", *Sadhana*, v. 44, n. 10, pp. 219, 2019. doi: http://doi.org/10.1007/s12046-019-1199-5.

[38] YANG, L., YE, M., HUANG, Y., *et al*., "Study on mechanical properties of displacement-amplified mild steel bar joint damper", *Civil Engineering (Shiraz)*, v.1, pp. 1–14, 2023. doi: http://doi.org/10.1007/s40996-023-01268-7.

[39] HE, H., SHI, J., YU, S., *et al*., "Exploring green and efficient zero-dimensional carbon-based inhibitors for carbon steel: From performance to mechanism", *Construction & Building Materials*, v. 411, pp. 134334, 2024. doi: http://doi.org/10.1016/j.conbuildmat.2023.134334.

[40] CAO, J., HE, H., ZHANG, Y., *et al*., "Crack detection in ultrahigh-performance concrete using robust principal component analysis and characteristic evaluation in the frequency domain", *Structural Health Monitoring*, v. 23, n. 2, pp. 1013–1024, 2023. doi: http://doi.org/10.1177/14759217231178457.

[41] SHAN, H.E.S., ZHAO, R., MIAO, Y., *et al*., "Effect of carbon dots with different sizes on chloride binding of cement", *Construction & Building Materials*, v. 425, pp. 136103, 2024. doi: http://doi.org/10.1016/j.conbuildmat.2024.136103.

[42] SHE, A., WANG, L., PENG, Y., *et al*., "Structural reliability analysis based on improved wolf pack algorithm AK-SS", *Structures*, v. 57, pp. 105289, 2023. doi: http://doi.org/10.1016/j.istruc.2023.105289.

[43] WEI, J., YING, H., YANG, Y., *et al*., "Seismic performance of concrete-filled steel tubular composite columns with ultra high-performance concrete plates", *Engineering Structures*, v. 278, pp. 115500, 2023. doi: http://doi.org/10.1016/j.engstruct.2022.115500.

[44] ZHANG, C., "The active rotary inertia driver system for flutter vibration control of bridges and various promising applications", *Science China Technological Sciences*, v. 66, n. 2, pp. 390–405, 2023. doi: http://doi.org/10.1007/s11431-022-2228-0.

[45] ZHANG, C., DUAN, C., SUN, L., "Inter-storey isolation versus base isolation using friction pendulum systems", *International Journal of Structural Stability and Dynamics*, pp. 2450022, 2023. doi: http://doi.org/10.1142/S0219455424500226.

[46] HUANG, H., HUANG, M., ZHANG, W., *et al*., "Experimental study of predamaged columns strengthened by HPFL and BSP under combined load cases", *Structure and Infrastructure Engineering*, v. 17, n. 9, pp. 1210-1227, 2021. doi: http://doi.org/10.1080/15732479.2020.1801768.

[47] HUANG, H., HUANG, M., ZHANG, W., *et al*., "Experimental investigation on rehabilitation of corroded RC columns with BSP and HPFL under combined loadings", *Journal of Structural Engineering*, v. 146, n. 8, pp. 04020157, 2020. doi: http://doi.org/10.1061/(ASCE)ST.1943-541X.0002725.

[48] HUANG, H., GUO, M., ZHANG, W., *et al*., "Numerical investigation on the bearing capacity of RC columns strengthened by HPFL-BSP under combined loadings", *Journal of Building Engineering*, v. 39, pp. 102266, 2021. doi: http://doi.org/10.1016/j.jobe.2021.102266.

[49] HUANG, H., XUE, C., ZHANG, W., *et al*., "Torsion design of CFRP-CFST columns using a data-driven optimization approach", *Engineering Structures*, v. 251, pp. 113479, 2022. doi: http://doi.org/10.1016/j.engstruct.2021.113479.

[50] HUANG, H., YAO, Y., LIANG, C., *et al*., "Experimental study on cyclic performance of steel-hollow core partially encased composite spliced frame beam", *Soil Dynamics and Earthquake Engineering*, v. 163, pp. 107499, 2022. doi: http://doi.org/10.1016/j.soildyn.2022.107499.

[51] SU, Y., WANG, J., LI, D., *et al*., "End-to-end deep learning model for underground utilities localization using GPR", *Automation in Construction*, v. 149, pp. 104776, 2023. doi: http://doi.org/10.1016/j.autcon.2023.104776.

[52] ZHANG, X., LIU, X., ZHANG, S., *et al*., "Analysis on displacement-based seismic design method of recycled aggregate concrete-filled square steel tube frame structures", *Structural Concrete*, v. 24, n. 3, pp. 3461–3475, 2023. doi: http://doi.org/10.1002/suco.202200720.

[53] LU, D., ZHOU, X., DU, X., *et al*., "A 3D fractional elastoplastic constitutive model for concrete material", *International Journal of Solids and Structures*, v. 165, pp. 160–175, 2019. doi: http://doi.org/10.1016/j.ijsolstr.2019.02.004.

[54] LU, D., ZHOU, X., DU, X., *et al*., "3D dynamic elastoplastic constitutive model of concrete within the framework of rate-dependent consistency condition", *Journal of Engineering Mechanics*, v. 146, n. 11, pp. 04020124, 2020. doi: http://doi.org/10.1061/(ASCE)EM.1943-7889.0001854.

[55] ZENG, H., JIN, M., LI, W., *et al*., "Performance evolution of low heat cement under thermal cycling fatigue: a comparative study with moderate heat cement and ordinary Portland cement", *Construction & Building Materials*, v. 412, pp. 134863, 2024. doi: http://doi.org/10.1016/j.conbuildmat.2024.134863.

[56] RODRIGUES, H.K.S., OLIVEIRA, H.A.D., MELO, F.M.C.D., *et al*., "Properties of structural lightweight concrete with expanded clay and the granite cut waste", *Matéria (Rio de Janeiro)*, v. 27, pp. e13153, 2022. doi: http://doi.org/10.1590/s1517-707620220001.1353.

[57] OLIVEIRA, J.C.M.D., SILVA, F.J.D.S., MARQUES, L.F.N., *et al*., "Influence of aggregate granulometry on the thermal shock resistance of high alumina refractory", *Matéria (Rio de Janeiro)*, v. 27, pp. e13207, 2023. doi: http://doi.org/10.1590/s1517-707620220002.1307.

[58] RICHETTI, F., GRINGS, K.J.O., RIBEIRO, F.R.C., *et al*., "Production of granilite concrete plates with recycled aggregates and ornamental rock processing sludge", *Matéria (Rio de Janeiro)*, v. 27, n. 3, pp. e20220078, 2022. doi: http://doi.org/10.1590/1517-7076-rmat-2022-0078.

[59] FURIAN, B.O., PIMENTEL, L.L., FORTI, N., *et al*., "Mechanical behavior analysis of concrete with recycled aggregate and addition of steel and AR glass fiber", *Matéria (Rio de Janeiro)*, v. 27, pp. e202145749, 2022. doi: http://doi.org/10.1590/1517-7076-rmat-2021-45749.

[60] SANTOS, C.C.D., MOLIN, D.C.C.D., ISAIA, G.C., *et al*., "Effects of coarse aggregates shape and modulus of elasticity, mix design parameters and their interactions on concrete modulus of elasticity", *Matéria (Rio de Janeiro)*, v. 27, pp. e13155, 2022. doi: http://doi.org/10.1590/s1517-707620220001.1355.

[61] NANYA, C.S., FERREIRA, F.G.S., CAPUZZO, V.M.S., "Mechanical and durability properties of recycled aggregate concrete", *Matéria (Rio de Janeiro)*, v. 26, n. 4, pp. e13073, 2021. doi: http://doi.org/10.1590/s1517-707620210004.1373.