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Hybrid adaptive neuro fuzzy inference system for optimization mechanical behaviors of nanocomposite reinforced concrete

Yong Huang[1,2,3,4,5] and Shengbin Wu*[6]

[1]*State Key Laboratory of Chemistry and Utilization of Carbon Based Energy Resources, College of Chemistry, Xinjiang University, Urumqi 830017, Xinjiang, China*
[2]*Xinjiang Communication Construction Co. Ltd. (XCCG), Urumqi 830000, Xinjiang, China*
[3]*Chengdu University of Technology, Chengdu 610000, Sichuan, China*
[4]*Transpotation Industry Highway Maintenance Collaborative Innovation Platform under Complicated Conditions of Western China, Urumqi 830000, Xinjiang, China*
[5]*Western Sub-Alliance of Zhongguancun Zhongke Highway Maintenance Technology Innovation Alliance, Urumqi 830000, Xinjiang, China*
[6]*Center of Modern Educational Technology, Guizhou University of Finance and Economics, Guiyang 550000, Guizhou, China*

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Abstract. The application of fibers in concrete obviously enhances the properties of concrete, also the application of natural fibers in concrete is raising due to the availability, low cost and environmentally friendly. Besides, predicting the mechanical properties of concrete in general and shear strength in particular is highly significant in concrete mixture with fiber nanocomposite reinforced concrete (FRC) in construction projects. Despite numerous studies in shear strength, determining this strength still needs more investigations. In this research, Adaptive Neuro-Fuzzy Inference System (ANFIS) have been employed to determine the strength of reinforced concrete with fiber. 180 empirical data were gathered from reliable literature to develop the methods. Models were developed, validated and their statistical results were compared through the root mean squared error (*RMSE*), determination coefficient (R^2), mean absolute error (*MAE*) and Pearson correlation coefficient (r). Comparing the *RMSE* of PSO (0.8859) and ANFIS (0.6047) have emphasized the significant role of structural parameters on the shear strength of concrete, also effective depth, web width, and a clear depth rate are essential parameters in modeling the shear capacity of FRC. Considering the accuracy of our models in determining the shear strength of FRC, the outcomes have shown that the R^2 values of PSO (0.7487) was better than ANFIS (2.4048). Thus, in this research, PSO has demonstrated better performance than ANFIS in predicting the shear strength of FRC in case of accuracy and the least error ratio. Thus, PSO could be applied as a proper tool to maximum accuracy predict the shear strength of FRC.
Keywords: ANFIS; FRC; PSO; shear strength

1. Introduction

There are initial methods that construction and building experts can enhance energy effectiveness by applying extra designs and construction models that decrease the cost of project, duration, design and labor expenses beside the internal saving energy say heating, cooling, ventilation and lighting energy consumption (Ma *et al*. 2021, Zhao *et al*. 2021, Hou *et al*. 2021, Huang *et al*. 2021c, d, Jiao *et al*. 2021, Liu *et al*. 2021d, Moradi *et al*. 2021, Xu *et al*. 2021b, Yu *et al*. 2022). Effective energy is highly progressing as a significant issue in the world because of the relation between the growing energy demand(s), global warming and greenhouse gas emissions (Hashemi *et al*. 2019, Al-Furjan *et al*. 2020e, o, q, s, Bai *et al*. 2020, Cheshmeh *et al*. 2020, Li *et al*. 2020b, Lori *et al*. 2020, Najaafi *et al*. 2020, Shariati *et al*. 2020c, Zhang *et al*. 2020b, Guo *et al*. 2021b, Liu *et al*. 2021a). A huge part of energy usages in construction projects is related to the mechanical part applied in earthworks, lifting, transportation, levelling and compacting and mixing as the embodied energy in materials extraction (Liu *et al*. 2020a, Wang *et al*. 2020b, Zhou *et al*. 2020, Dai *et al*. 2021a, Guo *et al*. 2021a, Shao *et al*. 2021, Wu and Habibi 2021). The knowledge of processes and activities using huge energy is highly essential to define the energy usages in construction procedures. Transportation, hoisting, demolition, and excavation are among the processes using high amounts of energy in construction projects (Habibi *et al*. 2016, 2018a, b, 2019b, d, e, Ebrahimi *et al*. 2019a, Esmailpoor Hajilak *et al*. 2019, Li *et al*. 2019b, Pourjabari *et al*. 2019, Safarpour *et al*. 2019a).

Despite the high use of concrete in construction, concrete faces with a weakness in tensile strength and shear resistance (Habibi *et al*. 2017, 2019a, c, Safarpour *et al*. 2018, 2019b, 2020, Alipour *et al*. 2020, Ebrahimi *et al*. 2020a, Ghazanfari *et al*. 2020, Chen *et al*. 2022). In this case, few researches were done while cast additional focus on the reinforced concrete's components. Beside all, fibers could absorb the researchers' attention as an improvement potential to the concrete's mechanical properties e.g., vitreous, steel or carbon and synthetic are considered as common fibers mixed into concrete to improve the properties of concrete (Shariati 2008, Hamidian *et al*. 2011, Shariati *et al*. 2011c, 2019b, Toghroli *et al*. 2017, 2018, 2020, Li *et al*. 2019a, Hosseini and Toghroli 2021, Mehrabi

*Corresponding author, Professor,
E-mail: wushengbin@mail.gufe.edu.cn

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et al. 2021). Since 1972, It was noted that steel fibers (SFs) should replace the conventional shear reinforcement methods in reinforced and pre stressed concrete (Ferrara and Meda 2006, Zhang *et al*. 2019b). Therefore, SFs have been applied to control the plastic shrinkage and drying in concrete. Based on literature, adding fibers in concrete highly decrease the cracking, ductile behavior, flexural toughness and tensile strength, absorbing energy capacity and the enhancement of shear behavior. In this case, FRC usage is commonly seen in different construction projects as the slabs of concrete sewer pipes, large industrial buildings, upper layers and tunnel shells (Lantsoght 2019, Abedini *et al*. 2020). Regardless of the merits of FRC, the design of its structures still faces complications because defining the critical shear capacity by traditional models is difficult. Few studies have been performed on FRC, investigating the shear strength capacity. Özcan *et al*. has experimented few tests and used finite element model (Ebrahimi *et al*. 2019b, c, 2020b, Hashemi *et al*. 2019, Moayedi *et al*. 2019, 2020a, b, Mohammadgholiha *et al*. 2019, Mohammadi *et al*. 2019, Habibi *et al*. 2020, Oyarhossein *et al*. 2020, Shariati *et al*. 2020a, b, Shokrgozar *et al*. 2020) by ANSYS software (Version 15) to investigate the final FRC beams' behavior. Additionally, a mechanical based equation was proposed for predicting the shear strength of FRC through the slenderness proportion. Many shear tests have been performed on prismatic beams toward FRC (Hanai and Holanda 2008, Sun *et al*. 2019). Generally, many experimental formulations were provided to predict the FRC shear strength in past few decades (Mohammadhassani *et al*. 2013b, 2014a, Heydari and Shariati 2018, Shariat *et al*. 2018, Luo *et al*. 2019, Xie *et al*. 2019). Whilst, there is an essential discrepancy between the prediction formulations and existing empirical outcomes because of the uniformity and accuracy of the proposed equations (Arslan 2014). Additionally, mechanical simulations or laboratory tests could be used in confined cases because empirical tests are high cost and time-consuming, then predicting these strength needs a robust numerical method (Shariati *et al*. 2011b, 2019a Sinaei *et al*. 2011, Shahabi *et al*. 2016, Khorramian *et al*. 2017) for better and quicker results like learning (ML) models.

Nowadays, the use of concrete aggregates is common, then the strength of individuals in the plan and conduct of shear strength is an imperative issue in auxiliary outline (Adamian *et al*. 2020, Al-Furjan *et al*. 2020c, d, Li *et al*. 2020c, Liu *et al*. 2020b, Zare *et al*. 2020, Dai *et al*. 2021b, Habibi *et al*. 2021, He *et al*. 2021, Huang *et al*. 2021b, Liu *et al*. 2021b, Zhang *et al*. 2021b). There are a few methods in concrete auxiliary individuals (Zhang and Wang 2019). Shear disappointment is a standout among the most important disappointment's models due to the delicacy of concrete structures. Thus, Reinforced Concrete (RC) are used against the shear disappointment (Shariati *et al*. 2011a, 2019e, Nosrati *et al*. 2018, Ziaei-Nia *et al*. 2018, Milovancevic *et al*. 2019, Sajedi and Shariati 2019, Trung *et al*. 2019a, Afshar *et al*. 2020). Few researches have been done recently for prediction the shear capacity (V) of RC. Bresler and Scordelis offered a method to delineate the RC shear behavior (Bresler and Scordelis 1963, Abedini *et al*. 2019). Zsutty by combining the statistical regression analyses and dimensional methods has tried to provide a technique to compute the RC beams strength. Based on the related studies, some components as size effect significantly affect the shear strength, which is raised by the steel plates usage (Shioya and Kawasaki 1985, Adhikary *et al*. 2000). Shear strength requires more care for having adequate shear potential for deep beams with web opening. Zhang *et al*. has investigated the RC shear, while others have studied the parameters' impact on the shear strength of RC beams exposed with FRC (Al-Rousan and Issa 2016, Zhang *et al*. 2016, Fayez *et al*. 2019, Yin and Zuo 2020, Feng *et al*. 2021, Shi *et al*. 2022). Align with Lisantono *et al*. (2017), Coo and Pheeraphan (2016) have investigated the impact of limestone powder and fly ash on the shear strength of FRC, showing that using this can decrease the shear strength. Yoo and Yang (2018) has reported the impact of some factors as the size of beam or steel fiber on the shear strength of RC beams. Kristiawan *et al*. (2017) has studied the shear failures in RC beams patched with polyester resin mortar with no web reinforcements, showing that these beam are sensitive after diagonal crack propagates with a weak shear. Lu *et al*. (2018) has used prediction methods for RC beam shear with corrosion damages. The flexural shear strength of RC beams with diverse crumbed rubber proportions were

Fig. 1 Fiber reinforced concrete

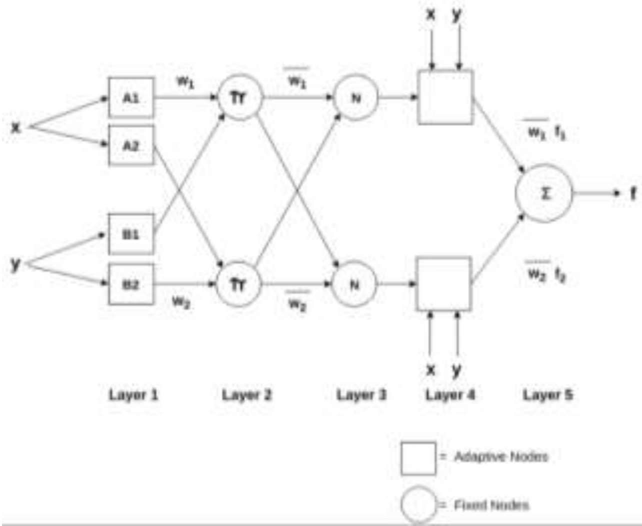

Fig. 2 ANFIS architecture

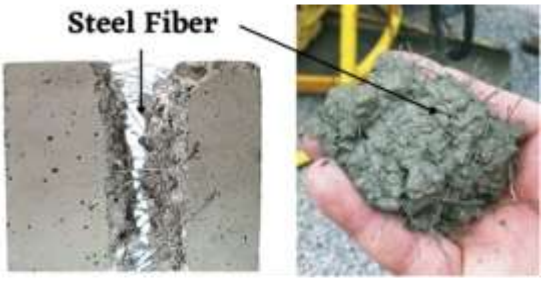

Fig. 3 Steel fiber reinforced concrete

Fig. 4 Glass fiber reinforced concrete

studied. Artificial intelligent (AI) models was applied to compute the shear strength of FRC concrete, resulting the outstanding performance of soft computing models.

AI models could learn, set goals, solves the defects, find new solutions and unknown behaviors without extra help from other models. All has used various assumptions with its own limitations. Being flexible and global predictor of performance developed and fitted into the data are the key parameters of machine learning (ML). Understanding the role of complexity and nonlinearity in the global prediction of performances is one of the key complications in ML (Li *et al*. 2020a, Wang *et al*. 2020a). In this research, two nonlinear methods as ANFIS and PSO were used to show their potential in learning of various performances. Complex nonlinear models generally show an infinite diversity of dynamical performances and functions that is applied in engineering, science and physical systems for robust, adaptive behaviors and operations. Accordingly, Fuzzy Logic concept (near to human perception capability due to its usages of linguistic terms) allows the membership degrees to the variables (Xu *et al*. 2018, Wu *et al*. 2020). In fuzzy logic, various input sets are verified based on if-then rules that help to optimize the outputs much closer to the target outputs (Al-Furjan *et al*. 2020a, b, g, f, h, i, j, k, l, m, n, p, r, t, u, v, 2021a, b). ANFIS was originally presented by Jang in 1993 and building the optimum results for the system needs more experience (Jang 1993). ANFIS as a simple data learning applies Fuzzy Logic to change the inputs into a favored output by a highly interconnected information connections weighted and Neural Network (NN) for mapping the inputs into one output. ANFIS is the combination of two ML (Fuzzy Logic, NN) into one model to tune the Fuzzy Inference System (FIS) parameters (Jang 1993, Mansouri *et al*. 2016, Sedghi *et al*. 2018b, Shariati *et al*. 2019d, f, Trung *et al*. 2019b, Yazdani *et al*. 2020). ANFIS performs great if it uses 1) IF-THEN rules to explain the complex system's behavior 2) without human interference and easy implementation, 3) enabling the fast and accurate learning, 4) offering favored data set 5) higher selection of membership functions to use 6) good description of facilities by fuzzy rules 7) strong generalization capabilities and 8) easy incorporation of numeric and linguistic knowledge to solve the problems (Mohammadhassani *et al*. 2013a, Toghroli *et al*. 2014, 2016, Safa *et al*. 2016, 2020, Sadeghipour Chahnasir *et al*. 2018, Sedghi *et al*. 2018a, Katebi *et al*. 2019, Shariati *et al*. 2020e, g).

As evolutionary computational algorithm and population based optimizer, Particle swarm optimization (PSO) depends on the swarm's intelligence, proposed by. At first, a set of potential solutions is randomly initialized in PSO that is followed by looking for the optimum repetitively (Mohammadhassani *et al*. 2014b, Shariati *et al*. 2019c, Shariati *et al*. 2020d, Shariati *et al*. 2020f, Shariati *et al*. 2021). By following the best particles in PSO algorithm, the optimum position is gained. PSO has profound an easy intelligent background compared to the evolutionary algorithms (EAs). PSO is commonly used in real and life science shortcomings as the optimization and evolutionary computing etc. According to, PSO under the family of swarm intelligence group is for solving global optimization shortcomings while basically proposed as a social behavior model, adding that it was initially offered as optimization model in 1995. Indeed, PSO is related to the theories of simulation of social behaviors, swarming and EAs. Regarding the benefits of PSO, its implementation is easy, low cost and needs low speed and low memory for CPU, also doesn't need data about the objective performance, but requires its variable (Zhang *et al*. 2018). Unlike other EA's difficulties, PSO is proved as an impressive model to solve diverse global optimization defects.

2. Problem statement

Understanding the shear strength of concrete is important to the design of FRC and sustainability in construction projects (Huang *et al*. 2021a, Ning *et al*. 2021, Zhang and Tang 2021, Zhao *et al*. 2021a, Zhang and Abedini 2022). Predicting this strength in experimental tests needs more time and high expenses, besides that gathering the raw data is highly difficult and not feasible (Liu *et al*. 2021c, 2022, Lu *et al*. 2021, Luo *et al*. 2021). However, using soft computing could predict this faster and more accurate with the least error percentages (Xu *et al*. 2021a, Zhang *et al*. 2021a, Ma *et al*. 2022, Xiao *et al*. 2022). Thus, this research by the use of PSO and ANFIS has tried for prediction of the shear strength of FRC.

2.1 Methodology

2.1.1 Materials

180 empirical datasets have been collected on FRC from the reliable literature comprising the input values of fiber information, concrete mixtures and one output values as the final shear strength of concrete.

2.1.2 ANFIS

ANFIS as a sub-family of ANN carries the advantageous principles of NN and fuzzy logic. ANFIS developed by Jang is to define non-linear components, predict chaotic time series and to model non-linear functions. According to Takagi–Sugeno fuzzy inference system (IF-THEN rules), ANFIS could construct an input-output mapping and is popular, regarding its advantages, such as rapid learning, adaptation capability and able to gain the nonlinear structure of a procedure. Regarding ANFIS with five layers (Fig. 5), its central core is a FIS. The first layer gains inputs (x and y in Fig. 5) while, through the membership functions (MFs), converting them to fuzzy variables (Zhang *et al*. 2019a, 2020a).

The rule base includes two fuzzy IF-THEN rules of Takagi's and Sugeno's type:

$$\boldsymbol{Rule\ 1}: if\ x\ is\ A_1\ and\ y\ is\ B_1, then\ f_1 = p_1\, x + q_1\, y + r_1,$$

$$\boldsymbol{Rule\ 2}: if\ x\ is\ A_2\ and\ y\ is\ B_2, then\ f_2 = p_2\, x + q_2\, y + r_2,$$

In 1th layer, each node is chosen as an adaptive node with a node function,

$$O_i^1 = \mu A_i(x) \quad (1)$$

Usually, bell-shaped membership functions are applied in ANFIS because these functions have a great potential in onlinear data regression. A bell-shaped membership parameter with the highest value of 1 and the least value of 0 is as Eq. (3). The first layer's parameters are named *premise parameters*.

$$\mu(x) = bell(x, a_i, b_i, c_i) = \frac{1}{1 + \left[\left(\frac{x-c_i}{a_i}\right)^2\right]^{b_i}} \quad (2)$$

$\{a_i, b_i, c_i, d_i$ = *parameters set*

x = *input*

The 2nd layer multiplies the incoming signals while transferring their output to the next layer e.g.,

$$w_i = \mu A_i(x) \times \mu B_i(y), \quad i = 1, 2. \quad (3)$$

Each output of the nodes shows a rule's firing strength. In 3rd layer (rule layer), the i^{th} node firing strength of rule to those of the other nodes is calculated as

$$w_i^* = \frac{w_i}{w_1 + w_2} \qquad i = 1, 2. \quad (4)$$

normalized firing strength as the outcomes w_i^*

In defuzzification layer (4th layer), each node has a node function as eq. (6):

$$O_i^4 = w_i^* f_i = w_i^*(p_i x + q_i y + r_i) \quad (6)$$

In output layer (5th layer), the overall output is computed by summing all the incoming signals as Eq. (7):

$$O_1^5 = f = \sum_i w_i^* f_i \quad (7)$$

A threshold variable between the output and real variable is set in this process. Later, the consequent parameters are gained by the least-squares model and one error for each data is achieved. *Premise parameters* are updated through a gradient descent method, if this variable is greater than the considered threshold. The procedure is kept on up to when the error is lower than threshold because of the simultaneous using of two algorithms as the least squares and gradient descent algorithms (hybrid algorithm) (Hu *et al*. 2020, Zhang *et al*. 2020d).

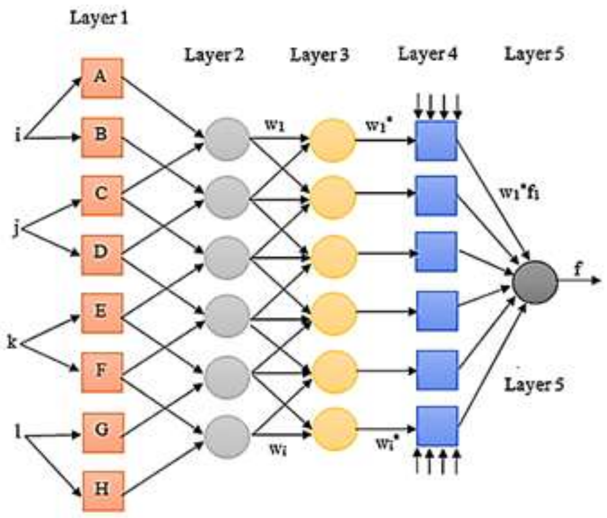

Fig. 5 Five layers of ANFIS

2.1.3 Particle swarm optimization (PSO)

The optimization model, PSO is delineated in 6 steps:

1. A set of random possible solutions is defined as the searching space. Assuming that

N = *the number of particles*

D = *the dimensions of searching space*

Both is applied as the random of "velocity" (vi^k) and "position" (X_i^k) of ith particle at iteration k as Eqs. (8) and (9) (Singh *et al*. 2011, Ran *et al*. 2020).

$$v_i^k(t+1) = wv_i^k(t) + C_1.rand\,()\left(p_i^k(t) - X_i^k\,(t)\right) + C_2.rand\,()\,(g_i^k(t) - x_i^K\,(t)) \quad (8)$$

$$x_i^K\,(t+1) = x_i^K\,(t) + v_i^k(t+1)\ 1 \le i \le N, 1 \le k \le D \quad (9)$$

2. Measuring each particle's fitness in the swarm

3. Compare each particle's fitness to its prior best achieved fitness p_i^k in every iteration (Zhang *et al*. 2020c, Zhao *et al*. 2020). If the existed parameter is better than p_i^k, then p_i^k is gained as the existed value and p_i^k positon as the existed position in *d*-dimensional space.

4. Compare the p_i^k of particles with each other and updating the swarm global best position with the most fitness g_i^k.

5. Each particle's velocity is changed to its p_i^k and g_i^k (Yang *et al*. 2015, Huang *et al*. 2019). In the solution space, a new location is computed for each particle by adding a new velocity value to each component of the particle's position vector.

6. Repeat steps (2)-(5) till the convergence is gained on the basis of appropriate parameter.

3. Results

The two algorithms were developed and their outcomes

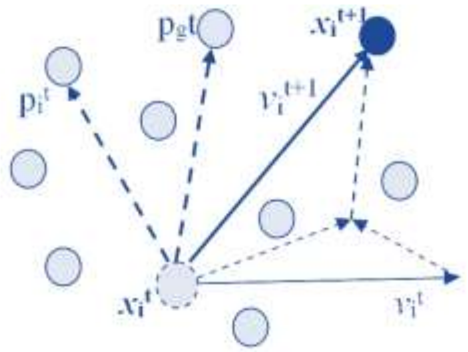

Fig. 6 Architecture of PSO

were compared in this research. These methods include an ANFIS and PSO. Figs. 5 and 6 briefly show the flowchart of the models.

3.1 Model performance indicators

To measure the algorithms' performance, **30**% of data was applied in testing phase and 70% in training phase. All data were randomly and individually selected. The measurement indicators were determination coefficient (R^2), (*RMSE*), (*r*), and (*MAE*):

$$r = \frac{N(\sum_{i=1}^{N} O_i . P_i) - (\sum_{i=1}^{N} O_i).(\sum_{i=1}^{N} P_i)}{\sqrt{(N \sum_{i=1}^{N} O_i^2 - (\sum_{i=1}^{N} O_i)^2).(N \sum_{i=1}^{N} P_i^2 - (\sum_{i=1}^{N} P_i)^2)}} \quad (10)$$

$$R^2 = \frac{[\sum_{i=1}^{N} (O_i - \bar{O}).(P_i - \bar{P})]^2}{\sum_{i=1}^{N} (O_i - \bar{O}).\sum_{i=1}^{N} (P_i - \bar{P})} \quad (11)$$

$$RMSE = \sqrt{\sum_{i=1}^{N} \frac{1}{N} (O_i - P_i)^2} \quad (12)$$

$$MAE = \frac{1}{N} \sum_{i=1}^{N} |O_i - P_i| \quad (13)$$

Figs. 7 and 8 represents the comparison of predicted and observed values of shear strength for PSO and ANFIS in test phase, respectively. Accordingly, the population numbers applied for all two models is 180, adding that the iteration of our test is 50. In these charts (Figs. 7 and 8), the vertical axis presents the predicted shear strength (MPa) and the horizontal axis shows the testing samples' number (Figs. 7 and 8). Also, the blue line shows 100% correlation between the predicted and observed values (Ideal form), however, the radial lines shows 15% - 30% discrepancy from the blue line (Figs. 7 and 8), showing the less accuracy of models (PSO, ANFIS). Any overlap between the blue line and the red line means that our method gained its best form with the lowest error ratio (R2 equals 1) and high preciseness. It means that in both models, there is no 100% prediction of shear strength of FRC, however, there is 15-30% differential between the target variables and predicted variables.

Fig. 7 shows the RMSE of PSO between -200-200, in which there is an established wave among the inputs of RMSE. Fig. 8 indicates the RMSE of ANFIS from -150-100. Figs. 9 and 10 show the error distribution, in which

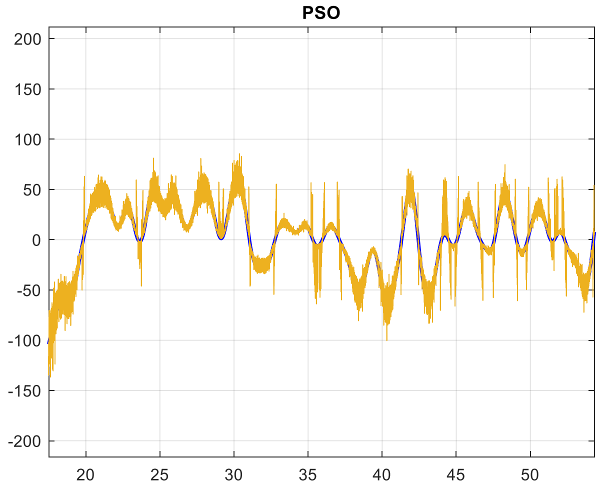

Fig. 7 Comparison of predicted and observed of shear strength for PSO H axis = number of testing samples (diagram d) V axis = shear strength (MPa) (diagram d)

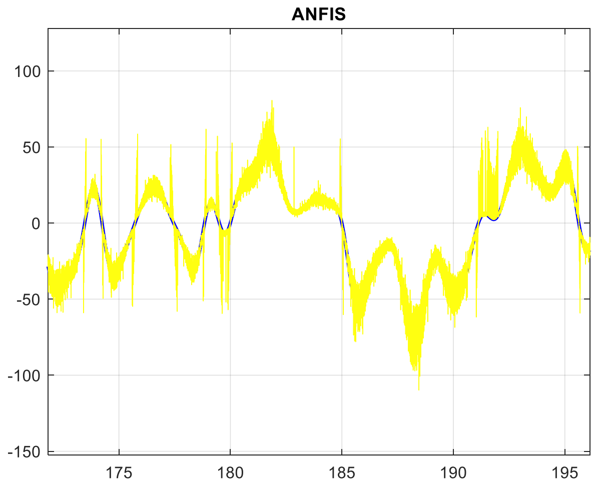

Fig. 8 Comparison of observed and predicted of shear strength for ANFIS H axis = number of testing samples (diagram d) V axis = shear strength (MPa) (diagram d)

the highest error is seen in 350,500 with 20 data in ANFIS. Considering PSO, the maximum error is in 3-4 with 18 data. There is a high value in input 180-185 with RMSE value of roughly 70. The lowest value is seen in 185-190 with RMSE value -100. Figs. 9 and 10 show the error distribution of both models. In Fig. 9, the mean of value (μ) is 0.3421 while the variance of value (σ) is 0.1342 in PSO. In Fig. 10, the (σ) = 5.643 while (μ) = -0.068 for ANFIS. Despite the training phase results, all data were analyzed in test phase as well. Looking at the *R-square* of train and test phase in both models (Tables 2 and 3), the *RMSE* of PSO is 0.6859 and the *RMSE* of ANFIS is 0.8047 in testing phase. Therefore, the nearest value to 0 is the best performance, in which PSO shows better performance than ANFIS. By comparing the R^2 values of PSO (0.7487) and ANFIS (2.4048), the nearest value to 1 is accepted as the best performance, in which PSO shows better performance than ANFIS in predicting the shear strength of FRC in term of more accuracy and the least error percentages.

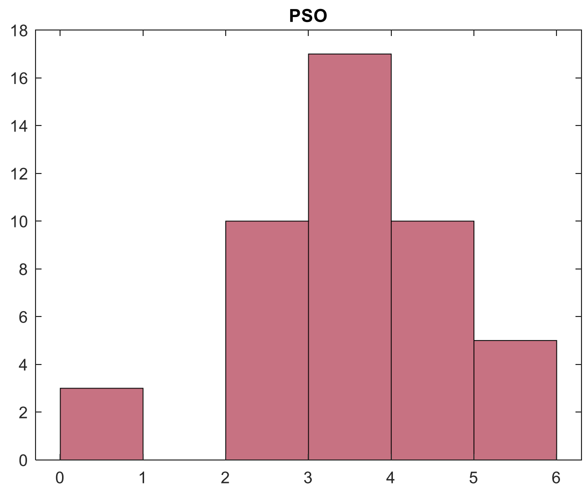

Fig. 9 Error distribution of PSO

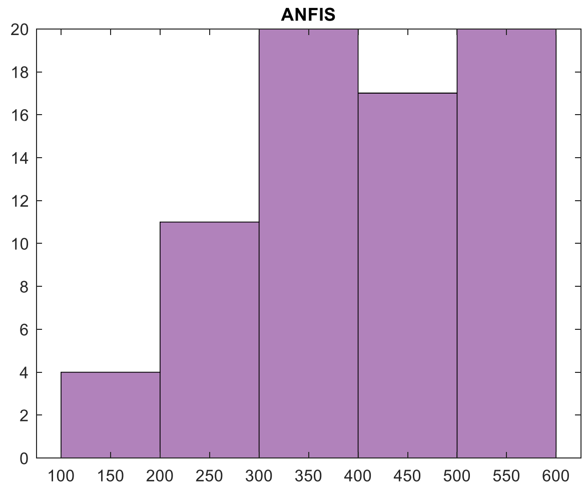

Fig. 10 Error distribution of ANFIS

Table 2 Comparing the training phase outcomes of the two models (PSO, ANFIS)

Training phase				
AI Models	*RMSE*	*r*	R^2	*MAE*
PSO	0.9059	0.9890	3.677	0.6987
ANFIS	0.8947	0.9870	1.3788	0.7980

Table 3 Comparing the testing phase outcomes of the two models (PSO, ANFIS)

Training phase				
AI Models	*RMSE*	*r*	R^2	*MAE*
PSO	**0.6859**	0.9904	**0.7487**	0.9976
ANFIS	**0.8047**	0.9955	**2.4048**	0.9989

4. Conclusions

In this study, the two models of PSO and ANFIS have been built and used for the prediction of shear strength of FRC. 180 empirical datasets were collected from the literature comprising the input values as concrete mixture, and fiber information and one output value as the shear strength of FRC was developed and analyzed. The statistical indicators of R^2, r, *RMSE*, and *MAE* were used to valid the training and testing datasets to measure the predictive abilities of the proposed algorithms. Comparing the RMSE values in both models in testing phase has shown that PSO could perform better than ANFIS in predicting the shear strength of FRC. As a result, PSO is a promising tool and method to predict the shear strength of FRC. Results have shown that web width and impressive depth were the most significant parameters effectively affect the shear capacity and the most important factors to model the shear capacities of FRC. It is also concluded that PSO could be applied as a proper tool to accurately predicting the shear strength of FRC. Results showed that PSO gives a superior prediction of shear quality than ANFIS.

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References

Abedini, M., Mutalib, A.A., Mehrmashhadi, J., Raman, S.N., Alipour, R., Momeni, T. and Mussa, M.H. (2019), “Large deflection behavior effect in reinforced concrete columns exposed to extreme dynamic loads”, *Front. Struct. Civil Eng.*, **14**(2), 532-553. https://doi.org/10.1007/s11709-020-0604-9.

Abedini, M., Zhang, C., Mehrmashhadi, J. and Akhlaghi, E. (2020), “Comparison of ALE, LBE and pressure time history methods to evaluate extreme loading effects in RC column”, *Structures*, **28**, 456-466 https://doi.org/10.1016/j.istruc.2020.08.084.

Adamian, A., Safari, K.H., Sheikholeslami, M., Habibi, M., Al-Furjan, M. and Chen, G. (2020), “Critical temperature and frequency characteristics of GPLs-reinforced composite doubly curved panel”, *Appl. Sci.*, **10**(9), 3251. https://doi.org/10.3390/app10093251.

Adhikary, B.B., Mutsuyoshi, H. and Sano, M. (2000), “Shear strengthening of reinforced concrete beams using steel plates bonded on beam web: experiments and analysis”, *Constr. Build. Mater.*, **14**(5), 237-244. https://doi.org/10.1016/j.conbuildmat.2005.01.024.

Afshar, A., Jahandari, S., Rasekh, H., Shariati, M., Afshar, A. and Shokrgozar, A. (2020), “Corrosion resistance evaluation of rebars with various primers and coatings in concrete modified with different additives”, *Constr. Build. Mater.*, **262**, 120034. https://doi.org/12003410.1016/j.conbuildmat.2020.120034.

Al-Furjan, M., Alzahrani, B., Shan, L., Habibi, M. and Jung, D.W. (2020a), “Nonlinear forced vibrations of nanocomposite-reinforced viscoelastic thick annular system under hygrothermal environment”, *Mech. Based Des. Struct.*, 1-27. https://doi.org/10.1080/15397734.2020.1824795.

Al-Furjan, M., Bolandi, S.Y., Shan, L., Habibi, M. and Jung, D.W. (2020b), “On the vibrations of a high-speed rotating multi-hybrid nanocomposite reinforced cantilevered microdisk”, *Mech. Based Des. Struct.*, 1-29.

https://doi.org/10.1016/j.compstruct.2020.113152.
Al-Furjan, M., Dehini, R., Khorami, M., Habibi, M. and won Jung, D. (2020c), "On the dynamics of the ultra-fast rotating cantilever orthotropic piezoelectric nanodisk based on nonlocal strain gradient theory", *Compos. Struct.*, 112990. https://doi.org/10.1016/j.compstruct.2020.112990.
Al-Furjan, M., Fereidouni, M., Habibi, M., Abd Ali, R., Ni, J. and Safarpour, M. (2020d), "Influence of in-plane loading on the vibrations of the fully symmetric mechanical systems via dynamic simulation and generalized differential quadrature framework", *Eng. Comput.*, 1-23. https://doi.org/10.1007/s00366-020-01177-7.
Al-Furjan, M., Fereidouni, M., Sedghiyan, D., Habibi, M. and won Jung, D. (2020e), "Three-dimensional frequency response of the CNT-Carbon-Fiber reinforced laminated circular/annular plates under initially stresses", *Compos. Struct.*, 113146. https://doi.org/10.1016/j.compstruct.2020.113146.
Al-Furjan, M., Habibi, M., Chen, G., Safarpour, H., Safarpour, M. and Tounsi, A. (2020f), "Chaotic oscillation of a multi-scale hybrid nano-composites reinforced disk under harmonic excitation via GDQM", *Compos. Struct.*, **252**, 112737. https://doi.org/10.1016/j.compstruct.2020.112737.
Al-Furjan, M., Habibi, M., Chen, G., Safarpour, H., Safarpour, M. and Tounsi, A. (2020g), "Chaotic simulation of the multi-phase reinforced thermo-elastic disk using GDQM", *Eng. Comput.*, 1-24. https://doi.org/10.1007/s00366-020-01144-2.
Al-Furjan, M., Habibi, M., Ebrahimi, F., Chen, G., Safarpour, M. and Safarpour, H. (2020h), "A coupled thermomechanics approach for frequency information of electrically composite microshell using heat-transfer continuum problem", *Eur. Phys. J. Plus*, **135**(10), 1-45. https://doi.org/10.1140/epjp/s13360-020-00764-3.
Al-Furjan, M., Habibi, M., Ebrahimi, F., Mohammadi, K. and Safarpour, H. (2020i), "Wave dispersion characteristics of high-speed-rotating laminated nanocomposite cylindrical shells based on four continuum mechanics theories", *Wave. Random Complex Med.*, 1-27. https://doi.org/10.1080/17455030.2020.1831099.
Al-Furjan, M., Habibi, M., Ni, J., won Jung, D. and Tounsi, A. (2020j), "Frequency simulation of viscoelastic multi-phase reinforced fully symmetric systems", *Eng. Comput.*, 1-17. https://doi.org/10.1007/s00366-020-01200-x
Al-Furjan, M., Habibi, M. and Safarpour, H. (2020k), "Vibration control of a smart shell reinforced by graphene nanoplatelets", *Int. J. Appl. Mech.*, **12**(06), 2050066. https://doi.org/10.1142/S1758825120500660.
Al-Furjan, M., Habibi, M., Shan, L. and Tounsi, A. (2020l), "On the vibrations of the imperfect sandwich higher-order disk with a lactic core using generalize differential quadrature method", *Compos. Struct.*, 113150. https://doi.org/10.1016/j.compstruct.2020.113150.
Al-Furjan, M., Habibi, M., Won Jung, D., Chen, G., Safarpour, M. and Safarpour, H. (2020m), "Chaotic responses and nonlinear dynamics of the graphene nanoplatelets reinforced doubly-curved panel", *Eur. J. Mech. A Solid.*, **85**, 104091. https://doi.org/10.1016/j.euromechsol.2020.104091.
Al-Furjan, M., Habibi, M., won Jung, D., Sadeghi, S., Safarpour, H., Tounsi, A. and Chen, G. (2020n), "A computational framework for propagated waves in a sandwich doubly curved nanocomposite panel", *Eng. Comput.*, 1-18. https://doi.org/10.1007/s00366-020-01130-8.
Al-Furjan, M., Habibi, M., won Jung, D. and Safarpour, H. (2020o), "Vibrational characteristics of a higher-order laminated composite viscoelastic annular microplate via modified couple stress theory", *Compos. Struct.*, 113152. https://doi.org/10.1016/j.compstruct.2020.113152.
Al-Furjan, M., Habibi, M., Won Jung, D., Safarpour, H. and Safarpour, M. (2020p), "On the buckling of the polymer-CNT-fiber nanocomposite annular system under thermo-mechanical loads", *Mech. Based Des. Struct.*, 1-21. https://doi.org/10.1080/15397734.2020.1830106.
Al-Furjan, M., Moghadam, S.A., Dehini, R., Shan, L., Habibi, M. and Safarpour, H. (2020q), "Vibration control of a smart shell reinforced by graphene nanoplatelets under external load: Semi-numerical and finite element modeling", *Thin Wall. Struct.*, 107242. https://doi.org/10.1016/j.tws.2020.107242.
Al-Furjan, M., Mohammadgholiha, M., Alarifi, I.M., Habibi, M. and Safarpour, H. (2020r), "On the phase velocity simulation of the multi curved viscoelastic system via an exact solution framework", *Eng. Comput.*, 1-17. https://doi.org/10.1007/s00366-020-01152-2.
Al-Furjan, M., Oyarhossein, M.A., Habibi, M., Safarpour, H. and Jung, D.W. (2020s), "Frequency and critical angular velocity characteristics of rotary laminated cantilever microdisk via two-dimensional analysis", *Thin Wall. Struct.*, **157**, 107111. https://doi.org/10.1016/j.tws.2020.107111.
Al-Furjan, M., Oyarhossein, M.A., Habibi, M., Safarpour, H. and Jung, D.W. (2020t), "Wave propagation simulation in an electrically open shell reinforced with multi-phase nanocomposites", *Eng. Comput.*, 1-17. https://doi.org/10.1007/s00366-020-01167-9.
Al-Furjan, M., Oyarhossein, M.A., Habibi, M., Safarpour, H., Jung, D.W. and Tounsi, A. (2020u), "On the wave propagation of the multi-scale hybrid nanocomposite doubly curved viscoelastic panel", *Compos. Struct.*, 112947. https://doi.org/10.1016/j.compstruct.2020.112947.
Al-Furjan, M., Safarpour, H., Habibi, M., Safarpour, M. and Tounsi, A. (2020v), "A comprehensive computational approach for nonlinear thermal instability of the electrically FG-GPLRC disk based on GDQ method", *Eng. Comput.*, 1-18. https://doi.org/10.1007/s00366-020-01088-7.
Al-Furjan, M., Bolandi, S.Y., Habibi, M., Ebrahimi, F., Chen, G. and Safarpour, H. (2021a), "Enhancing vibration performance of a spinning smart nanocomposite reinforced microstructure conveying fluid flow", *Eng. Comput.*, 1-16. https://doi.org/10.1007/s00366-020-01255-w.
Al-Furjan, M.S.H., Dehini, R., Paknahad, M., Habibi, M. and Safarpour, H. (2021b), "On the nonlinear dynamics of the multi-scale hybrid nanocomposite-reinforced annular plate under hygro-thermal environment", *Arch. Civil Mech. Eng.*, **21**(1), 4. https://doi.org/10.1007/s43452-020-00151-w.
Al-Rousan, R.Z. and Issa, M.A. (2016), "The effect of beam depth on the shear behavior of reinforced concrete beams externally strengthened with carbon fiber–reinforced polymer composites", *Adv. Struct. Eng.*, **19**(11), 1769-1779. https://doi.org/10.1177/1369433216649386.
Alipour, M., Torabi, M.A., Sareban, M., Lashini, H., Sadeghi, E., Fazaeli, A., Habibi, M. and Hashemi, R. (2020), "Finite element and experimental method for analyzing the effects of martensite morphologies on the formability of DP steels", *Mech. Based Des. Struct.*, **48**(5), 525-541. https://doi.org/10.1080/15397734.2019.1633343.
Arslan, G. (2014), "Shear strength of steel fiber reinforced concrete (SFRC) slender beams", *KSCE J. Civil Eng.*, **18**(2), 587-594. https://doi.org/10.1007/s12205-014-0320-x.
Bai, Y., Alzahrani, B., Baharom, S. and Habibi, M. (2020), "Semi-numerical simulation for vibrational responses of the viscoelastic imperfect annular system with honeycomb core under residual pressure", *Eng. Comput.*, 1-26. https://doi.org/10.1007/s00366-020-01191-9.
Bresler, B. and Scordelis, A.C. (1963). "Shear strength of reinforced concrete beams", *J. Proceedings*, **60**(1), 51-74. https://doi.org/10.1007/s43452-020-00151-w.
Chen, F., Chen, J., Duan, R., Habibi, M. and Khadimallah, M.A.

(2022), "Investigation on dynamic stability and aeroelastic characteristics of composite curved pipes with any yawed angle", *Compos. Struct.*, 115195. https://doi.org/10.1016/j.compstruct.2022.115195.

Cheshmeh, E., Karbon, M., Eyvazian, A., Jung, D.w., Habibi, M. and Safarpour, M. (2020), "Buckling and vibration analysis of FG-CNTRC plate subjected to thermo-mechanical load based on higher order shear deformation theory", *Mech. Based Des. Struct.*, 1-24. https://doi.org/10.1007/s00366-020-01166-w.

Coo, M. and Pheeraphan, T. (2016), "Effect of sand, fly ash and limestone powder on preplaced aggregate concrete mechanical properties and reinforced beam shear capacity", *Constr. Build. Mater.*, **120**, 581-592. https://doi.org/10.1016/j.conbuildmat.2016.05.128.

Dai, Z., Jiang, Z., Zhang, L. and Habibi, M. (2021a), "Frequency characteristics and sensitivity analysis of a size-dependent laminated nanoshell", *Adv. Nano Res.*, **10**(2), 175-189. https://doi.org/10.12989/anr.2021.10.2.175.

Dai, Z., Zhang, L., Bolandi, S.Y. and Habibi, M. (2021b), "On the vibrations of the non-polynomial viscoelastic composite open-type shell under residual stresses", *Compos. Struct.*, 113599. https://doi.org/10.1016/j.compstruct.2021.113599.

Ebrahimi, F., Habibi, M. and Safarpour, H. (2019a), "On modeling of wave propagation in a thermally affected GNP-reinforced imperfect nanocomposite shell", *Eng. Comput.*, **35**(4), 1375-1389. https://doi.org/10.1007/s00366-018-0669-4.

Ebrahimi, F., Hajilak, Z.E., Habibi, M. and Safarpour, H. (2019b), "Buckling and vibration characteristics of a carbon nanotube-reinforced spinning cantilever cylindrical 3D shell conveying viscous fluid flow and carrying spring-mass systems under various temperature distributions", *Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science*, **233**(13), 4590-4605. https://doi.org/10.1177/0954406219832323.

Ebrahimi, F., Mohammadi, K., Barouti, M.M. and Habibi, M. (2019c), "Wave propagation analysis of a spinning porous graphene nanoplatelet-reinforced nanoshell", *Wave. Random Complex Med.*, 1-27. https://doi.org/10.1080/17455030.2019.1694729.

Ebrahimi, F., Hashemabadi, D., Habibi, M. and Safarpour, H. (2020a), "Thermal buckling and forced vibration characteristics of a porous GNP reinforced nanocomposite cylindrical shell", *Microsyst. Technol.*, **26**(2), 461-473. https://doi.org/10.1007/s00542-019-04542-9.

Ebrahimi, F., Supeni, E.E.B., Habibi, M. and Safarpour, H. (2020b), "Frequency characteristics of a GPL-reinforced composite microdisk coupled with a piezoelectric layer", *Eur. Phys. J. Plus*, **135**(2), 144. https://doi.org/10.1140/epjp/s13360-020-00217-x.

Esmailpoor Hajilak, Z., Pourghader, J., Hashemabadi, D., Sharifi Bagh, F., Habibi, M. and Safarpour, H. (2019), "Multilayer GPLRC composite cylindrical nanoshell using modified strain gradient theory", *Mech. Based Des. Struct.*, **47**(5), 521-545. https://doi.org/10.1080/15397734.2019.1566743.

Fayez, M., Mandor, M., El-Hadidy, M. and Bendary, F. (2019), "Fuzzy logic based dynamic braking scheme for stabilization of inter-area", *Acta Electronica Malaysia (AEM)*, **3**(2), 16-22. http://doi.org/10.26480/aem.02.2019.16.22.

Feng, J., Chen, B., Sun, W. and Wang, Y. (2021), "Microbial induced calcium carbonate precipitation study using Bacillus subtilis with application to self-healing concrete preparation and characterization", *Constr. Build. Mater.*, **280**, 122460. https://doi.org/10.1016/j.conbuildmat.2021.122460.

Ferrara, L. and Meda, A. (2006), "Relationships between fibre distribution, workability and the mechanical properties of SFRC applied to precast roof elements", *Mater. Struct.*, **39**(4), 411-420. https://doi.org/10.1617/s11527-005-9017-4.

Ghazanfari, A., Soleimani, S.S., Keshavarzzadeh, M., Habibi, M., Assempuor, A. and Hashemi, R. (2020), "Prediction of FLD for sheet metal by considering through-thickness shear stresses", *Mech. Based Des. Struct.*, **48**(6), 755-772. https://doi.org/10.1080/15397734.2019.1662310.

Guo, J., Baharvand, A., Tazeddinova, D., Habibi, M., Safarpour, H., Roco-Videla, A. and Selmi, A. (2021a), "An intelligent computer method for vibration responses of the spinning multi-layer symmetric nanosystem using multi-physics modeling", *Eng. Comput.*, 1-22. https://doi.org/10.1007/s00366-021-01433-4.

Guo, Y., Mi, H. and Habibi, M. (2021b), "Electromechanical energy absorption, resonance frequency, and low-velocity impact analysis of the piezoelectric doubly curved system", *Mech. Syst. Signal Pr.*. **157**, 107723. https://doi.org/10.1016/j.ymssp.2021.107723.

Habibi, M., Hashemi, R., Sadeghi, E., Fazaeli, A., Ghazanfari, A. and Lashini, H. (2016), "Enhancing the mechanical properties and formability of low carbon steel with dual-phase microstructures", *J. Mater. Eng. Perform.*, **25**(2), 382-389. https://doi.org/10.1007/s11665-016-1882-1.

Habibi, M., Ghazanfari, A., Assempour, A., Naghdabadi, R. and Hashemi, R. (2017), "Determination of forming limit diagram using two modified finite element models", *Mech. Eng.*, **48**(4), 141-144. https://doi.org/10.1016/j.euromechsol.2022.104638.

Habibi, M., Hashemi, R., Ghazanfari, A., Naghdabadi, R. and Assempour, A. (2018a), "Forming limit diagrams by including the M–K model in finite element simulation considering the effect of bending", *Proceedings of the Institution of Mechanical Engineers, Part L: Journal of Materials: Design and Applications*. **232**(8), 625-636. https://doi.org/10.1177/1464420716642258.

Habibi, M., Hashemi, R., Tafti, M.F. and Assempour, A. (2018b), "Experimental investigation of mechanical properties, formability and forming limit diagrams for tailor-welded blanks produced by friction stir welding", *J. Manuf. Proc.*, **31**, 310-323. https://doi.org/10.1016/j.jmapro.2017.11.009.

Habibi, M., Hashemabadi, D. and Safarpour, H. (2019a), "Vibration analysis of a high-speed rotating GPLRC nanostructure coupled with a piezoelectric actuator", *Eur. Phys. J. Plus*, **134**(6), 307. https://doi.org/10.1140/epjp/i2019-12742-7.

Habibi, M., Mohammadgholiha, M. and Safarpour, H. (2019b), "Wave propagation characteristics of the electrically GNP-reinforced nanocomposite cylindrical shell", *J. Brazil. Soc. Mech. Sci. Eng.*, **41**(5), 221. https://doi.org/10.1007/s40430-019-1715-x.

Habibi, M., Mohammadi, A., Safarpour, H. and Ghadiri, M. (2019c), "Effect of porosity on buckling and vibrational characteristics of the imperfect GPLRC composite nanoshell", *Mech. Based Des. Struct.*, 1-30. https://doi.org/10.1080/15397734.2019.1701490.

Habibi, M., Mohammadi, A., Safarpour, H., Shavalipour, A. and Ghadiri, M. (2019d), "Wave propagation analysis of the laminated cylindrical nanoshell coupled with a piezoelectric actuator", *Mech. Based Des. Struct.*, 1-19. https://doi.org/10.1080/15397734.2019.1697932.

Habibi, M., Taghdir, A. and Safarpour, H. (2019e), "Stability analysis of an electrically cylindrical nanoshell reinforced with graphene nanoplatelets", *Compos. Part B Eng.*, **175**, 107125. https://doi.org/10.1016/j.compositesb.2019.107125.

Habibi, M., Safarpour, M. and Safarpour, H. (2020), "Vibrational characteristics of a FG-GPLRC viscoelastic thick annular plate using fourth-order Runge-Kutta and GDQ methods", *Mech. Based Des. Struct.*, 1-22. https://doi.org/10.1080/15397734.2020.1779086.

Habibi, M., Darabi, R., Sa, J.C.D. and Reis, A. (2021), "An innovation in finite element simulation via crystal plasticity assessment of grain morphology effect on sheet metal formability", *Proceedings of the Institution of Mechanical Engineers, Part L: Journal of Materials: Design and Applications*. **235**(8), 1937-1951. https://doi.org/10.1177/14644207211024686.

Hamidian, M., Shariati, M., Arabnejad, M. and Sinaei, H. (2011), "Assessment of high strength and light weight aggregate concrete properties using ultrasonic pulse velocity technique", *Int. J. Phys. Sci.*, **6**(22), 5261-5266. https://doi.org/10.5897/IJPS11.1081.

Hanai, J.D. and Holanda, K. (2008), "Similarities between punching and shear strength of steel fiber reinforced concrete (SFRC) slabs and beams", *Revista Ibracon de Estruturas e Materiais*, **1**(1), 1-16. https://doi.org/10.1680/jmacr.21.00135.

Hashemi, H.R., Alizadeh, A.a., Oyarhossein, M.A., Shavalipour, A., Makkiabadi, M. and Habibi, M. (2019), "Influence of imperfection on amplitude and resonance frequency of a reinforcement compositionally graded nanostructure", *Wave. Random Complex Med.*, 1-27. https://doi.org/10.1080/17455030.2019.1662968.

He, X., Ding, J., Habibi, M., Safarpour, H. and Safarpour, M. (2021), "Non-polynomial framework for bending responses of the multi-scale hybrid laminated nanocomposite reinforced circular/annular plate", *Thin Wall. Struct.*, **166**, 108019. https://doi.org/10.1016/j.tws.2021.108019.

Heydari, A. and Shariati, M. (2018), "Buckling analysis of tapered BDFGM nano-beam under variable axial compression resting on elastic medium", *Struct. Eng. Mech.*, **66**(6), 737-748. https://doi.org/10.12989/sem.2018.66.6.737.

Hosseini, S.A. and Toghroli, A. (2021), "Effect of mixing Nano-silica and Perlite with pervious concrete for nitrate removal from the contaminated water", *Adv. Concr. Constr.*, **11**(6), 531-544. https://doi.org/10.12989/acc.2021.11.6.531.

Hou, F., Wu, S., Moradi, Z. and Shafiei, N. (2021), "The computational modeling for the static analysis of axially functionally graded micro-cylindrical imperfect beam applying the computer simulation", *Eng. Comput.*, 1-19. https://doi.org/10.1007/s00366-021-01456-x.

Hu, J.W., Zheng, B.Y., Wang, C., Zhao, C.H., Hou, X.L., Pan, Q. and Xu, Z. (2020), "A survey on multi-sensor fusion based obstacle detection for intelligent ground vehicles in off-road environments", *Front. Inform. Technol. Electr. Eng.*, **21**, 675-692. https://doi.org/10.1631/FITEE.1900518.

Huang, Z., Yi, S., Chen, H. and He, X. (2019), "Parameter analysis of damaged region for laminates with matrix defects", *J. Sandw. Struct. Mater.*, 1099636219842290. https://doi.org/10.1177/1099636219842290.

Huang, H., Huang, M., Zhang, W. and Yang, S. (2021a), "Experimental study of predamaged columns strengthened by HPFL and BSP under combined load cases", *Struct. Infrastruct. E.*, **17**(9), 1210-1227. https://doi.org/10.1080/15732479.2020.1801768.

Huang, X., Hao, H., Oslub, K., Habibi, M. and Tounsi, A. (2021b), "Dynamic stability/instability simulation of the rotary size-dependent functionally graded microsystem", *Eng. Comput.*, 1-17. https://doi.org/10.1007/s00366-021-01399-3.

Huang, X., Zhang, Y., Moradi, Z. and Shafiei, N. (2021c), "Computer simulation via a couple of homotopy perturbation methods and the generalized differential quadrature method for nonlinear vibration of functionally graded non-uniform micro-tube", *Eng. Comput.*, 1-18. https://doi.org/10.1007/s00366-021-01395-7.

Huang, X., Zhu, Y., Vafaei, P., Moradi, Z. and Davoudi, M. (2021d), "An iterative simulation algorithm for large oscillation of the applicable 2D-electrical system on a complex nonlinear substrate", *Eng. Comput.*, 1-13. https://doi.org/10.1007/s00366-021-01320-y.

Jang, J.S. (1993), "ANFIS: Adaptive-network-based fuzzy inference system", *IEEE T. Syst. Man Cy.*, **23**(3), 665-685. https://doi.org/10.1109/21.256541.

Jiao, J., Ghoreishi, S.M., Moradi, Z. and Oslub, K. (2021), "Coupled particle swarm optimization method with genetic algorithm for the static–dynamic performance of the magneto-electro-elastic nanosystem", *Eng. Comput.*, 1-15. https://doi.org/10.1007/s00366-021-01391-x.

Katebi, J., Shoaei-parchin, M., Shariati, M., Trung, N.T. and Khorami, M. (2019), "Developed comparative analysis of metaheuristic optimization algorithms for optimal active control of structures", *Eng. Comput.*, 1-20. https://doi.org/10.1007/s00366-019-00780-7.

Khorramian, K., Maleki, S., Shariati, M., Jalali, A. and Tahir, M.M. (2017), "Numerical analysis of tilted angle shear connectors in steel-concrete composite systems", *Steel Compos. Struct.*, **23**(1), 67-85. https://doi.org/10.12989/scs.2017.23.1.067.

Kristiawan, S., Supriyadi, A., Sangadji, S. and Wicaksono, H.B. (2017), "Shear failure of patched reinforced concrete beam without web reinforcements", *Key Eng. Mater.*, **737**, 441-447. https://doi.org/10.1080/15732479.2020.1801768.

Lantsoght, E.O. (2019), "How do steel fibers improve the shear capacity of reinforced concrete beams without stirrups?", *Compos. Part B Eng.*, **175**, 107079. https://doi.org/10.1016/j.compositesb.2019.107079.

Li, D.Y., Toghroli, A., Shariati, M., Sajedi, F., Bui, D.T., Kianmehr, P., Mohamad, E.T. and Khorami, M. (2019a), "Application of polymer, silica-fume and crushed rubber in the production of Pervious concrete", *Smart Struct. Syst.*, **23**(2), 207-214. https://doi.org/10.12989/sss.2019.23.2.207.

Li, T., Xu, M., Zhu, C., Yang, R., Wang, Z. and Guan, Z. (2019b), "A deep learning approach for multi-frame in-loop filter of HEVC", *IEEE T. Image Process.*, **28**(11), 5663-5678. https://doi.org/ 10.1109/TIP.2019.2921877.

Li, B.H., Liu, Y., Zhang, A.M., Wang, W.H. and Wan, S. (2020a), "A survey on blocking technology of entity resolution", *J. Comput. Sci. Technol.*, **35**(4), 769-793. https://doi.org/10.1007/s11390-020-0350-4.

Li, J., Tang, F. and Habibi, M. (2020b), "Bi-directional thermal buckling and resonance frequency characteristics of a GNP-reinforced composite nanostructure", *Eng. Comput.*, 1-22. https://doi.org/10.1007/s00366-020-01110-y.

Li, Y., Li, S., Guo, K., Fang, X. and Habibi, M. (2020c), "On the modeling of bending responses of graphene-reinforced higher order annular plate via two-dimensional continuum mechanics approach", *Eng. Comput.*, 1-22. https://doi.org/10.1007/s00366-020-01166-w.

Lisantono, A., Wigroho, H.Y. and Purba, R.A. (2017), "Shear behavior of high-volume fly ash concrete as replacement of portland cement in RC beam", *Procedia Eng.*, **171**, 80-87. https://doi.org/10.1016/j.proeng.2017.01.312.

Liu, Z., Su, S., Xi, D. and Habibi, M. (2020a), "Vibrational responses of a MHC viscoelastic thick annular plate in thermal environment using GDQ method", *Mech. Based Des. Struct.*, 1-26. https://doi.org/10.1080/15397734.2020.1784201.

Liu, Z., Wu, X., Yu, M. and Habibi, M. (2020b), "Large-amplitude dynamical behavior of multilayer graphene platelets reinforced nanocomposite annular plate under thermo-mechanical loadings", *Mech. Based Des. Struct.*, 1-25. https://doi.org/10.1080/15397734.2020.1815544.

Liu, H., Shen, S., Oslub, K., Habibi, M. and Safarpour, H. (2021a), "Amplitude motion and frequency simulation of a composite viscoelastic microsystem within modified couple stress elasticity", *Eng. Comput.*, 1-15. https://doi.org/10.1007/s00366-021-01316-8.

Liu, H., Zhao, Y., Pishbin, M., Habibi, M., Bashir, M. and Issakhov, A. (2021b), "A comprehensive mathematical simulation of the composite size-dependent rotary 3D microsystem via two-dimensional generalized differential quadrature method", *Eng. Comput.*, 1-16. https://doi.org/10.1007/s00366-021-01419-2.

Liu, W., Guo, Z., Wang, C. and Niu, S. (2021c), "Physico-mechanical and microstructure properties of cemented coal Gangue-Fly ash backfill: Effects of curing temperature", *Constr. Build. Mater.*, **299**, 124011. https://doi.org/10.1016/j.conbuildmat.2021.124011.

Liu, Y., Wang, W., He, T., Moradi, Z. and Larco Benítez, M.A. (2021d), "On the modelling of the vibration behaviors via discrete singular convolution method for a high-order sector annular system", *Eng. Comput.*, 1-23. https://doi.org/10.1007/s00366-021-01454-z.

Liu, Z., Wu, S., Jin, S., Liu, Q., Ji, S., Lu, S. and Cheng, L. (2022), "Investigating pose representations and motion contexts modeling for 3D motion prediction", *IEEE T. Pattern Anal.*, 34982672. https://doi.org/10.1109/TPAMI.2021.3139918.

Lori, E.S., Ebrahimi, F., Supeni, E.E.B., Habibi, M. and Safarpour, H. (2020), "The critical voltage of a GPL-reinforced composite microdisk covered with piezoelectric layer", *Eng. Comput.*, 1-20. https://doi.org/10.1007/s00366-020-01004-z.

Lu, Z.H., Li, H., Li, W., Zhao, Y.G. and Dong, W. (2018), "An empirical model for the shear strength of corroded reinforced concrete beam", *Constr. Build. Mater.*, **188**, 1234-1248. https://doi.org/10.1016/j.conbuildmat.2018.08.123.

Lu, N., Wang, H., Wang, K. and Liu, Y. (2021), "Maximum probabilistic and dynamic traffic load effects on short-to-medium span bridges", *Comput. Model. Eng. Sci.*, **127**(1), 345-360. https://doi.org/100000127/00000001/art00006.

Luo, Z.Y., Sinaei, H., Ibrahim, Z., Shariati, M., Jumaat, Z., Wakil, K., Pham, B.T., Mohamad, E.T. and Khorami, M. (2019), "Computational and experimental analysis of beam to column joints reinforced with CFRP plates", *Steel Compos. Struct.*, **30**(3), 271-280. https://doi.org/10.12989/scs.2019.30.3.271.

Luo, Y., Zheng, H., Zhang, H. and Liu, Y. (2021), "Fatigue reliability evaluation of aging prestressed concrete bridge accounting for stochastic traffic loading and resistance degradation", *Adv. Struct. Eng.*, **24**(13), 3021-3029. https://doi.org/10.1177/13694332211017995.

Ma, L., Liu, X. and Moradi, Z. (2021), "On the chaotic behavior of graphene-reinforced annular systems under harmonic excitation", *Eng. Comput.*, 1-25. https://doi.org/10.1007/s00366-020-01210-9.

Ma, X., Quan, W., Dong, Z., Dong, Y. and Si, C. (2022), "Dynamic response analysis of vehicle and asphalt pavement coupled system with the excitation of road surface unevenness", *Appl. Math. Model.*, **104**, 421-438. https://doi.org/10.1016/j.apm.2021.12.005.

Mansouri, I., Safa, M., Ibrahim, Z., Kisi, O., Tahir, M.M., Baharom, S. and Azimi, M. (2016), "Strength prediction of rotary brace damper using MLR and MARS", *Struct. Eng. Mech.*, **60**(3), 471-488. 10.12989/sem.2016.60.3.471.

Mehrabi, P., Shariati, M., Kabirifar, K., Jarrah, M., Rasekh, H., Trung, N.T., Shariati, A. and Jahandari, S. (2021), "Effect of pumice powder and nano-clay on the strength and permeability of fiber-reinforced pervious concrete incorporating recycled concrete aggregate", *Constr. Build. Mater.*, **287**, 122652. https://doi.org/1016/j.conbuildmat.2021.122652.

Milovancevic, M., Marinovic, J.S., Nikolic, J., Kitic, A., Shariati, M., Trung, N.T., Wakil, K. and Khorami, M. (2019), "UML diagrams for dynamical monitoring of rail vehicles", *Physica A*, **531**, 121169. https://doi.org/1016/j.physa.2019.121169.

Moayedi, H., Habibi, M., Safarpour, H., Safarpour, M. and Foong, L. (2019), "Buckling and frequency responses of a graphene nanoplatelet reinforced composite microdisk", *Int. J. Appl. Mech.*, **11**(10), 1950102. https://doi.org/10.1142/S1758825119501023.

Moayedi, H., Aliakbarlou, H., Jebeli, M., Noormohammadiarani, O., Habibi, M., Safarpour, H. and Foong, L. (2020a), "Thermal buckling responses of a graphene reinforced composite micropanel structure", *Int. J. Appl. Mech.*, **12**(1), 2050010. https://doi.org/10.1142/S1758825120500106.

Moayedi, H., Ebrahimi, F., Habibi, M., Safarpour, H. and Foong, L.K. (2020b), "Application of nonlocal strain–stress gradient theory and GDQEM for thermo-vibration responses of a laminated composite nanoshell", *Eng. Comput.*, 1-16. https://doi.org/10.1007/s00366-020-01002-1.

Mohammadhassani, M., Nezamabadi-Pour, H., Suhatril, M. and Shariati, M. (2013a), "Identification of a suitable ANN architecture in predicting strain in tie section of concrete deep beams", *Struct. Eng. Mech.*, **46**(6), 853-868. https://doi.org/10.12989/sem.2013.46.6.853.

Mohammadhassani, M., Suhatril, M., Shariati, M. and Ghanbari, F. (2013b), "Ductility and strength assessment of HSC beams with varying of tensile reinforcement ratios", *Struct. Eng. Mech.*, **48**(6), 833-848. https://doi.org/10.12989/sem.2013.48.6.833.

Mohammadhassani, M., Akib, S., Shariati, M., Suhatril, M. and Khanouki, M.M.A. (2014a), "An experimental study on the failure modes of high strength concrete beams with particular references to variation of the tensile reinforcement ratio", *Eng. Fail. Anal.*, **41**, 73-80. https://doi.org/10.1016/j.engfailanal.2013.08.014.

Mohammadhassani, M., Nezamabadi-pour, H., Suhatril, M. and Shariati, M. (2014b), "An evolutionary fuzzy modelling approach and comparison of different methods for shear strength prediction of high-strength concrete beams without stirrups", *Smart Struct. Syst.*, **14**(5), 785-809. https://doi.org/10.12989/sss.2014.14.5.785.

Mohammadgholiha, M., Shokrgozar, A., Habibi, M. and Safarpour, H. (2019), "Buckling and frequency analysis of the nonlocal strain–stress gradient shell reinforced with graphene nanoplatelets", *J. Vib. Control*, **25**(19-20), 2627-2640. https://doi.org/10.1177/1077546319863251.

Mohammadi, A., Lashini, H., Habibi, M. and Safarpour, H. (2019), "Influence of viscoelastic foundation on dynamic behaviour of the double walled cylindrical inhomogeneous micro shell using MCST and with the aid of GDQM", *J. Solid Mech.*, **11**(2), 440-453. https://doi.org/10.22034/JSM.2019.665264.

Moradi, Z., Davoudi, M., Ebrahimi, F. and Ehyaei, A.F. (2021), "Intelligent wave dispersion control of an inhomogeneous micro-shell using a proportional-derivative smart controller", *Wave. Random Complex Med.*, 1-24. https://doi.org/10.1080/17455030.2021.1926572.

Najaafi, N., Jamali, M., Habibi, M., Sadeghi, S., Jung, D.w. and Nabipour, N. (2020), "Dynamic instability responses of the substructure living biological cells in the cytoplasm environment using stress-strain size-dependent theory", *J. Biomol. Struct. Dyn.*, 1-12. https://doi.org/10.1080/07391102.2020.1751297.

Ning, F., He, G., Sheng, C., He, H., Wang, J., Zhou, R. and Ning, X. (2021), "Yarn on yarn abrasion performance of high modulus polyethylene fiber improved by graphene/polyurethane composites coating", *J. Eng. Fiber Fabrics.*, **16**, 1558925020983563. https://doi.org/1558925020983563.

Nosrati, A., Zandi, Y., Shariati, M., Khademi, K., Aliabad, M.D., Marto, A., Mu'azu, M., Ghanbari, E., Mandizadeh, M.B., Shariati, A. and Khorami, M. (2018), "Portland cement structure and its major oxides and fineness", *Smart Struct. Syst.*, **22**(4), 425-432. https://doi.org/10.12989/sss.2018.22.4.425.

Oyarhossein, M.A., Alizadeh, A.A., Habibi, M., Makkiabadi, M., Daman, M., Safarpour, H. and Jung, D.W. (2020), “Dynamic response of the nonlocal strain-stress gradient in laminated polymer composites microtubes”, *Sci*. *Rep*., **10**(1), 1-19. https://doi.org/10.1038/s41598-020-61855-w.

Pourjabari, A., Hajilak, Z.E., Mohammadi, A., Habibi, M. and Safarpour, H. (2019), “Effect of porosity on free and forced vibration characteristics of the GPL reinforcement composite nanostructures”, *Comput*. *Math*. *Appl*., **77**(10), 2608-2626. https://doi.org/10.1016/j.camwa.2018.12.041.

Ran, W., Liu, S. and Zhang, Z. (2020), “A polling-based dynamic order-picking system considering priority orders”, *Complexity*, **2020**, 4595316. https://doi.org/10.1155/2020/4595316.

Sadeghipour Chahnasir, E., Zandi, Y., Shariati, M., Dehghani, E., Toghroli, A., Mohamed, E.T., Shariati, A., Safa, M., Wakil, K. and Khorami, M. (2018), “Application of support vector machine with firefly algorithm for investigation of the factors affecting the shear strength of angle shear connectors”, *Smart Struct*. *Syst*., **22**(4), 413-424. http://doi.org/10.12989/sss.2018.22.4.413.

Safa, M., Shariati, M., Ibrahim, Z., Toghroli, A., Bin Baharom, S., Nor, N.M. and Petkovic, D. (2016), “Potential of adaptive neuro fuzzy inference system for evaluating the factors affecting steel-concrete composite beam’s shear strength”, *Steel Compos*. *Struct*., **21**(3), 679-688. https://doi.org/10.12989/scs.2016.21.3.679.

Safa, M., Sari, P.A., Shariati, M., Suhatril, M., Trung, N.T., Wakil, K. and Khorami, M. (2020), “Development of neuro-fuzzy and neuro-bee predictive models for prediction of the safety factor of eco-protection slopes”, *Physica A*, **550**, 124046. https://doi.org/12404610.1016/j.physa.2019.124046.

Safarpour, H., Ghanizadeh, S.A. and Habibi, M. (2018), “Wave propagation characteristics of a cylindrical laminated composite nanoshell in thermal environment based on the nonlocal strain gradient theory”, *Eur*. *Phys*. *J*. *Plus*, **133**(12), 532. https://doi.org/10.1140/epjp/i2018-12385-2.

Safarpour, H., Hajilak, Z.E. and Habibi, M. (2019a), “A size-dependent exact theory for thermal buckling, free and forced vibration analysis of temperature dependent FG multilayer GPLRC composite nanostructures restring on elastic foundation”, *Int*. *J*. *Mech*. *Mater*. *Des*., **15**(3), 569-583. https://doi.org/10.1007/s10999-018-9431-8.

Safarpour, H., Pourghader, J. and Habibi, M. (2019b), “Influence of spring-mass systems on frequency behavior and critical voltage of a high-speed rotating cantilever cylindrical three-dimensional shell coupled with piezoelectric actuator”, *J*. *Vib*. *Control*, **25**(9), 1543-1557. https://doi.org/10.1177/1077546319828465.

Safarpour, M., Ebrahimi, F., Habibi, M. and Safarpour, H. (2020), “On the nonlinear dynamics of a multi-scale hybrid nanocomposite disk”, *Eng*. *Comput*., 1-20. https://doi.org/10.1007/s00366-020-00949-5.

Sedghi, Y., Zandi, Y., Shariati, M., Ahmadi, E., Azar, V.M., Toghroli, A., Safa, M., Mohamad, E.T., Khorami, M. and Wakil, K. (2018a), “Application of ANFIS technique on performance of C and L shaped angle shear connectors”, *Smart Struct*. *Syst*., **22**(3), 335-340. https://doi.org/10.12989/sss.2018.22.3.335.

Sedghi, Y., Zandi, Y., Shariati, M., Ahmadi, E., Moghimi Azar, V., Toghroli, A., Safa, M., Tonnizam Mohamad, E., Khorami, M. and Wakil, K. (2018b), “Application of ANFIS technique on performance of C and L shaped angle shear connectors”, *Smart Struct*. *Syst*., **22**(3), 335-340. https://doi.org/10.12989/sss.2018.22.3.335.

Sajedi, F. and Shariati, M. (2019), “Behavior study of NC and HSC RCCs confined by GRP casing and CFRP wrapping”, *Steel Compos*. *Struct*., **30**(5), 417-432. https://doi.org/10.12989/scs.2019.30.5.417.

Shahabi, S.E.M., Sulong, N.H.R., Shariati, M., Mohammadhassani, M. and Shah, S.N.R. (2016), “Numerical analysis of channel connectors under fire and a comparison of performance with different types of shear connectors subjected to fire”, *Steel Compos*. *Struct*., **20**(3), 651-669. https://doi.org/10.12989/scs.2016.20.3.651.

Shao, Y., Zhao, Y., Gao, J. and Habibi, M. (2021), “Energy absorption of the strengthened viscoelastic multi-curved composite panel under friction force”, *Arch*. *Civil Mech*. *Eng*., **21**(4), 1-29. https://doi.org/10.1007/s43452-021-00279-3.

Shariat, M., Shariati, M., Madadi, A. and Wakil, K. (2018), “Computational Lagrangian multiplier method by using for optimization and sensitivity analysis of rectangular reinforced concrete beams”, *Steel Compos*. *Struct*., **29**(2), 243-256. https://doi.org/10.12989/scs.2018.29.2.243.

Shariati, M. (2008), *Assessment Building Using None-destructive Test Techniques (ultra Sonic Pulse Velocity and Schmidt Rebound Hammer)*, Universiti Putra Malaysia. https://doi.org/10.1016/j.tws.2020.106840.

Shariati, M., Ramli-Sulong, N.H., Arabnejad, K.H.M.M., Shafigh, P. and Sinaei, H. (2011a), “Assessing the strength of reinforced concrete structures through Ultrasonic Pulse Velocity and Schmidt Rebound Hammer tests”, *Sci*. *Res*. *Essays*, **6**(1), 213-220. https://doi.org/10.5897/SRE10.879.

Shariati, M., Ramli Sulong, N.H., Arabnejad Khanouki, M.M. and Shariati, A. (2011b), “Experimental and numerical investigations of channel shear connectors in high strength concrete”, *Proceedings of the 2011 World Congress on Advances in Structural Engineering and Mechanics (ASEM’11+)*, Seoul, Korea, September. https://doi.org/10.1016/j.enganabound.2022.04.016.

Shariati, M., Ramli Sulong, N.H., Sinaei, H., Arabnejad Khanouki, M.M. and Shafigh, P. (2011c), “Behavior of channel shear connectors in normal and light weight aggregate concrete (experimental and analytical study)”, *Adv*. *Mater*. *Res*., **168**, 2303-2307. https://doi.org/10.4028/www.scientific.net/AMR.168-170.2303.

Shariati, M., Faegh, S.S., Mehrabi, P., Bahavarnia, S., Zandi, Y., Masoom, D.R., Toghroli, A., Trung, N.T. and Salih, M.N.A. (2019a), “Numerical study on the structural performance of corrugated low yield point steel plate shear walls with circular openings”, *Steel Compos*. *Struct*., **33**(4), 569-581. https://doi.org/10.12989/scs.2019.33.4.569.

Shariati, M., Heyrati, A., Zandi, Y., Laka, H., Toghroli, A., Kianmehr, P., Safa, M., Salih, M.N.A. and Poi-Ngian, S. (2019b), “Application of waste tire rubber aggregate in porous concrete”, *Smart Struct*. *Syst*., **24**(4), 553-566. https://doi.org/10.12989/sss.2019.24.4.553.

Shariati, M., Mafipour, M.S., Mehrabi, P., Bahadori, A., Zandi, Y., Salih, M.N.A., Nguyen, H., Dou, J., Song, X. and Poi-Ngian, S. (2019c), “Application of a Hybrid Artificial Neural Network-Particle Swarm Optimization (ANN-PSO) model in behavior prediction of channel shear connectors embedded in normal and high-strength concrete”, *Appl*. *Sci*., **9**(24), 5534. https://doi.org/553410.3390/app9245534.

Shariati, M., Mafipour, M.S., Mehrabi, P., Zandi, Y., Dehghani, D., Bahadori, A., Shariati, A., Trung, N.T., Salih, M.N.A. and Poi-Ngian, S. (2019d), “Application of Extreme Learning Machine (ELM) and Genetic Programming (GP) to design steel-concrete composite floor systems at elevated temperatures”, *Steel Compos*. *Struct*., **33**(3), 319-332. https://doi.org/10.12989/scs.2019.33.3.319.

Shariati, M., Rafie, S., Zandi, Y., Fooladvand, R., Gharehaghaj, B., Mehrabi, P., Shariat, A., Trung, N.T., Salih, M.N.A. and Poi-Ngian, S. (2019e), “Experimental investigation on the effect of cementitious materials on fresh and mechanical properties of self-consolidating concrete”, *Adv*. *Concr*. *Constr*., **8**(3), 225-237. https://doi.org/10.12989/acc.2019.8.3.225.

Shariati, M., Trung, N.T., Wakil, K., Mehrabi, P., Safa, M. and Khorami, M. (2019f), "Moment-rotation estimation of steel rack connection using extreme learning machine", *Steel Compos. Struct.*, **31**(5), 427-435. https://doi.org/10.12989/scs.2019.31.5.427.

Shariati, A., Habibi, M., Tounsi, A., Safarpour, H. and Safa, M. (2020a), "Application of exact continuum size-dependent theory for stability and frequency analysis of a curved cantilevered microtubule by considering viscoelastic properties", *Eng. Comput.*, 1-20. https://doi.org/10.1007/s00366-020-01024-9.

Shariati, A., Mohammad-Sedighi, H., Żur, K.K., Habibi, M. and Safa, M. (2020b), "On the vibrations and stability of moving viscoelastic axially functionally graded nanobeams", *Materials*, **13**(7), 1707. https://doi.org/10.3390/ma13071707.

Shariati, A., Mohammad-Sedighi, H., Żur, K.K., Habibi, M. and Safa, M. (2020c), "Stability and dynamics of viscoelastic moving rayleigh beams with an asymmetrical distribution of material parameters", *Symmetry*, **12**(4), 586. https://doi.org/10.3390/sym12040586.

Shariati, M., Mafipour, M.S., Ghahremani, B., Azarhomayun, F., Ahmadi, M., Trung, N.T. and Shariati, A. (2020d), "A novel hybrid extreme learning machine-grey wolf optimizer (ELM-GWO) model to predict compressive strength of concrete with partial replacements for cement", *Eng. Comput.*, 1-23. https://doi.org/10.1007/s00366-020-01081-0.

Shariati, M., Mafipour, M.S., Haido, J.H., Yousif, S.T., Toghroli, A., Trung, N.T. and Shariati, A. (2020e), "Identification of the most influencing parameters on the properties of corroded concrete beams using an Adaptive Neuro-Fuzzy Inference System (ANFIS)", *Steel Compos. Struct.*, **34**(1), 155-170. https://doi.org/10.12989/scs.2020.34.1.155.

Shariati, M., Mafipour, M.S., Mehrabi, P., Ahmadi, M., Wakil, K., Trung, N.T. and Toghroli, A. (2020f), "Prediction of concrete strength in presence of furnace slag and fly ash using Hybrid ANN-GA (Artificial Neural Network-Genetic Algorithm)", *Smart Struct. Syst.*, **25**(2), 183-195. https://doi.org/10.12989/sss.2020.25.2.183.

Shariati, M., Mafipour, M.S., Mehrabi, P., Shariati, A., Toghroli, A., Trung, N.T. and Salih, M.N. (2020g), "A novel approach to predict shear strength of tilted angle connectors using artificial intelligence techniques", *Eng. Comput.*, 1-21. https://doi.org/10.1007/s00366-019-00930-x.

Shariati, M., Davoodnabi, S.M., Toghroli, A., Kong, Z.Y. and Shariati, A. (2021), "Hybridization of metaheuristic algorithms with adaptive neuro-fuzzy inference system to predict load-slip behavior of angle shear connectors at elevated temperatures", *Compos. Struct.*, **278**, 114524. https://doi.org/11452410.1016/j.compstruct.2021.114524.

Shi, T., Lan, Y., Hu, Z., Wang, H., Xu, J. and Zheng, B. (2022), "Tensile and fracture properties of silicon carbide whisker-modified cement-based materials", *Int. J. Concr. Struct. Mater.*, **16**(1), 1-13. https://doi.org/10.1186/s40069-021-00495-4.

Shioya, T. and Kawasaki, H. (1985), "Size effect on shear strength of reinforced concrete beam", *Finite Elem. Anal. Reinf. Concr. Struct.*, 255-264. https://doi.org/10.5897/SRE10.879.

Shokrgozar, A., Safarpour, H. and Habibi, M. (2020), "Influence of system parameters on buckling and frequency analysis of a spinning cantilever cylindrical 3D shell coupled with piezoelectric actuator", *Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science*, **234**(2), 512-529. https://doi.org/10.12989/scs.2020.34.1.155.

Sinaei, H., Jumaat, M.Z. and Shariati, M. (2011), "Numerical investigation on exterior reinforced concrete Beam-Column joint strengthened by composite fiber reinforced polymer (CFRP)", *Int. J. Phys. Sci.*, **6**(28), 6572-6579. https://doi.org/10.5897/IJPS11.1225.

Singh, V., Gu, N. and Wang, X. (2011), "A theoretical framework of a BIM-based multi-disciplinary collaboration platform", *Automat. Constr.*, **20**(2), 134-144. https://doi.org/10.1016/j.autcon.2010.09.011.

Sun, L., Su, Z., Xia, Y., Zhang, C. and Li, C. (2019), "Superwide-range fiber bragg grating displacement sensor based on an eccentric gear: Principles and experiments", *J. Aerosp. Eng.*, **32**(1), 04018129. https://doi.org/1943-5525.0000960.

Toghroli, A., Mohammadhassani, M., Suhatril, M., Shariati, M. and Ibrahim, Z. (2014), "Prediction of shear capacity of channel shear connectors using the ANFIS model", *Steel Compos. Struct.*, **17**(5), 623-639. http://doi.org/10.12989/scs.2014.17.5.623.

Toghroli, A., Suhatril, M., Ibrahim, Z., Safa, M., Shariati, M. and Shamshirband, S. (2016), "Potential of soft computing approach for evaluating the factors affecting the capacity of steel–concrete composite beam", *J. Intell. Manuf.*, **29**(8), 1793-1801. https://doi.org/10.1007/s10845-016-1217-y.

Toghroli, A., Shariati, M., Karim, M.R. and Ibrahim, Z. (2017), "Investigation on composite polymer and silica fume–rubber aggregate pervious concrete", *Fifth International Conference on Advances in Civil, Structural and Mechanical Engineering - CSM 2017*, Zurich, Switzerland, September. https://doi.org/10.1186/s40069-021-00495-4.

Toghroli, A., Shariati, M., Sajedi, F., Ibrahim, Z., Koting, S., Mohamad, E.T. and Khorami, M. (2018), "A review on pavement porous concrete using recycled waste materials", *Smart Struct. Syst.*, **22**(4), 433-440. https://doi.org/10.12989/sss.2018.22.4.433.

Toghroli, A., Mehrabi, P., Shariati, M., Trung, N.T., Jahandari, S. and Rasekh, H. (2020), "Evaluating the use of recycled concrete aggregate and pozzolanic additives in fiber-reinforced pervious concrete with industrial and recycled fibers", *Constr. Build. Mater.*, **252**, 118997. https://doi.org/11899710.1016/j.conbuildmat.2020.118997.

Trung, N.T., Alemi, N., Haido, J.H., Shariati, M., Baradaran, S. and Yousif, S.T. (2019a), "Reduction of cement consumption by producing smart green concretes with natural zeolites", *Smart Struct. Syst.*, **24**(3), 415-425. https://doi.org/10.12989/sss.2019.24.3.415.

Trung, N.T., Shahgoli, A.F., Zandi, Y., Shariati, M., Wakil, K., Safa, M. and Khorami, M. (2019b), "Moment-rotation prediction of precast beam-to-column connections using extreme learning machine", *Struct. Eng. Mech.*, **70**(5), 639-647. https://doi.org/10.12989/sem.2019.70.5.639.

Wang, Y., Yuan, Y., Wang, Q., Liu, C., Zhi, Q. and Cao, J. (2020a), "Changes in air quality related to the control of coronavirus in China: Implications for traffic and industrial emissions", *Sci. Total Environ.*, 139133. https://doi.org/10.1016/j.scitotenv.2020.139133.

Wang, Z., Yu, S., Xiao, Z. and Habibi, M. (2020b), "Frequency and buckling responses of a high-speed rotating fiber metal laminated cantilevered microdisk", *Mech. Adv. Mater. Struct.*, 1-14. https://doi.org/10.1080/15376494.2020.1824284.

Wu, J. and Habibi, M. (2021), "Dynamic simulation of the ultra-fast-rotating sandwich cantilever disk via finite element and semi-numerical methods", *Eng. Comput.*, 1-17. https://doi.org/10.1007/s00366-021-01396-6.

Wu, T., Xiong, L., Cheng, J. and Xie, X. (2020), "New results on stabilization analysis for fuzzy semi-Markov jump chaotic systems with state quantized sampled-data controller", *Inform. Sci.*, **521**, 231-250. https://doi.org/10.1016/j.scitotenv.2020.139133.

Xiao, X., Bu, G., Ou, Z. and Li, Z. (2022), "Nonlinear in-plane instability of the confined FGP arches with nanocomposites reinforcement under radially-directed uniform pressure", *Eng. Struct.*, **252**, 113670.

https://doi.org/10.1016/j.engstruct.2021.113670

Xie, Q., Sinaei, H., Shariati, M., Khorami, M., Mohamad, E.T. and Bui, D.T. (2019), “An experimental study on the effect of CFRP on behavior of reinforce concrete beam column connections”, *Steel Compos. Struct.*, **30**(5), 433-441. https://doi.org/10.12989/scs.2019.30.5.433.

Xu, M., Li, T., Wang, Z., Deng, X., Yang, R. and Guan, Z. (2018), “Reducing complexity of HEVC: A deep learning approach”, *IEEE T. Image Process.*, **27**(10), 5044-5059. https://doi.org/10.1109/TIP.2018.2847035.

Xu, H., Wang, X.Y., Liu, C.N., Chen, J.N. and Zhang, C. (2021a), “A 3D root system morphological and mechanical model based on L-Systems and its application to estimate the shear strength of root-soil composites”, *Soil Tillage Res.*, **212**, 105074. https://doi.org/10.1016/j.still.2021.105074.

Xu, W., Pan, G., Moradi, Z. and Shafiei, N. (2021b), “Nonlinear forced vibration analysis of functionally graded non-uniform cylindrical microbeams applying the semi-analytical solution”, *Compos. Struct.*, 114395. https://doi.org/10.1016/j.compstruct.2021.114395.

Yang, Y., Yao, J., Wang, C., Gao, Y., Zhang, Q., An, S. and Song, W. (2015), “New pore space characterization method of shale matrix formation by considering organic and inorganic pores”, *J. Nat. Gas Sci. Eng.*, **27**, 496-503. https://doi.org/10.1016/j.jngse.2015.08.017.

Yazdani, M., Kabirifar, K., Frimpong, B.E., Shariati, M., Mirmozaffari, M. and Boskabadi, A. (2020), “Improving construction and demolition waste collection service in an urban area using a simheuristic approach: A case study in Sydney, Australia”, *J. Clean. Prod.*, **280**, 124138. https://doi.org/10.1016/j.jclepro.2020.124138.

Yin, X. and Zuo, D. (2020), “Fault early warning method of marine transport freighter based on fuzzy comprehensive evaluation”, *J. Coastal Res.*, **103**(SI), 709-713. https://doi.org/10.2112/SI103-145.1.

Yoo, D.Y. and Yang, J.M. (2018), “Effects of stirrup, steel fiber, and beam size on shear behavior of high-strength concrete beams”, *Cement Concrete Compos.*, **87**, 137-148. https://doi.org/10.1016/j.cemconcomp.2017.12.010.

Yu, X., Maalla, A. and Moradi, Z. (2022), “Electroelastic high-order computational continuum strategy for critical voltage and frequency of piezoelectric NEMS via modified multi-physical couple stress theory”, *Mech. Syst. Signal Pr.*, **165**, 108373. https://doi.org/10.1016/j.ymssp.2021.108373.

Zare, R., Najaafi, N., Habibi, M., Ebrahimi, F. and Safarpour, H. (2020), “Influence of imperfection on the smart control frequency characteristics of a cylindrical sensor-actuator GPLRC cylindrical shell using a proportional-derivative smart controller”, *Smart Struct. Syst.*, **26**(4), 469-480. https://doi.org/10.12989/sss.2020.26.4.469.

Zhang, T., Visintin, P. and Oehlers, D.J. (2016), “Shear strength of RC beams with steel stirrups”, *J. Struct. Eng.*, **142**(2), 04015135. https://doi.org/10.1061/(ASCE)ST.1943-541X.0001404.

Zhang, X., Wang, Y., Chen, X., Su, C.Y., Li, Z., Wang, C. and Peng, Y. (2018), “Decentralized adaptive neural approximated inverse control for a class of large-scale nonlinear hysteretic systems with time delays”, *IEEE T. Syst. Man Cy.*, **49**(12), 2424-2437. https://doi.org/10.1109/TSMC.2018.2827101.

Zhang, C. and Wang, H. (2019), “Robustness of the active rotary inertia driver system for structural swing vibration control subjected to multi-type hazard excitations”, *Appl. Sci.*, **9**(20), 4391. https://doi.org/10.3390/app9204391.

Zhang, B., Ji, D., Fang, D., Liang, S., Fan, Y. and Chen, X. (2019a), “A novel 220-GHz GaN diode on-chip tripler with high driven power”, *IEEE Electr. Device L.*, **40**(5), 780-783. https://doi.org/10.1109/LED.2019.2903430.

Zhang, H., Qiu, Z., Cao, J., Abdel-Aty, M. and Xiong, L. (2019b), “Event-triggered synchronization for neutral-type semi-markovian neural networks with partial mode-dependent time-varying delays”, *IEEE T. Neur. Networ.*, **31**(11), 4437-4450. https://doi.org/10.1109/TNNLS.2019.2955287.

Zhang, B., Niu, Z., Wang, J., Ji, D., Zhou, T., Liu, Y., Feng, Y., Hu, Y., Zhang, J. and Fan, Y. (2020a), “Four-hundred gigahertz broadband multi-branch waveguide coupler”, *IET Microwaves Antennas Propagation*, **14**(11), 1175-1179. https://doi.org/10.1016/j.jclepro.2020.124138.

Zhang, X., Shamsodin, M., Wang, H., NoormohammadiArani, O., Khan, A.M., Habibi, M. and Al-Furjan, M. (2020b), “Dynamic information of the time-dependent tobullian biomolecular structure using a high-accuracy size-dependent theory”, *J. Biomol. Struct. Dyn.*, 1-16. https://doi.org/10.1080/07391102.2020.1760939.

Zhang, Z., Liu, M., Zhou, M. and Chen, J. (2020c), “Dynamic reliability analysis of nonlinear structures using a Duffing-system-based equivalent nonlinear system method”, *Int. J. Approx. Reason.*, **126**, 84-97. https://doi.org/10.1016/j.ijar.2020.08.006.

Zhang, Z., Luo, C. and Zhao, Z. (2020d), “Application of probabilistic method in maximum tsunami height prediction considering stochastic seabed topography”, *Nat. Hazards*, **104**(3), 2511-2530. https://doi.org/10.1007/s11069-020-04283-3.

Zhang, H., Liu, Y. and Deng, Y. (2021a), “Temperature gradient modeling of a steel box-girder suspension bridge using Copulas probabilistic method and field monitoring”, *Adv. Struct. Eng.*, **24**(5), 947-961. https://doi.org/10.1177/1369433220971779.

Zhang, Y., Wang, Z., Tazeddinova, D., Ebrahimi, F., Habibi, M. and Safarpour, H. (2021b), “Enhancing active vibration control performances in a smart rotary sandwich thick nanostructure conveying viscous fluid flow by a PD controller”, *Wave. Random Complex Med.*, 1-24. https://doi.org/10.1080/17455030.2021.1948627.

Zhang, W. and Tang, Z. (2021), “Numerical modeling of response of CFRP–Concrete interfaces subjected to fatigue loading”, *J. Compos. Constr.*, **25**(5), 04021043. https://doi.org/10.1061/%28ASCE%29CC.1943-5614.0001154.

Zhang, C. and Abedini, M. (2022), “Development of PI model for FRP composite retrofitted RC columns subjected to high strain rate loads using LBE function”, *Eng. Struct.*, **252**, 113580. https://doi.org/10.1016/j.engstruct.2021.113580.

Zhao, J., Liu, J., Jiang, J. and Gao, F. (2020), “Efficient deployment with geometric analysis for mmWave UAV communications”, *IEEE Wirel. Commun.*, **9**(7), 1115-1119. https://doi.org/10.1109/LWC.2020.2982637.

Zhao, R., Zhang, L., Guo, B., Chen, Y., Fan, G., Jin, Z., Guan, X. and Zhu, J. (2021a), “Unveiling substitution preference of chromium ions in sulphoaluminate cement clinker phases”, *Compos. Part B Eng.*, **222**, 109092. https://doi.org/10.1016/j.compositesb.2021.109092.

Zhao, Y., Moradi, Z., Davoudi, M. and Zhuang, J. (2021b), “Bending and stress responses of the hybrid axisymmetric system via state-space method and 3D-elasticity theory”, *Eng. Comput.*, 1-23. https://doi.org/10.1007/s00366-020-01242-1.

Zhou, C., Zhao, Y., Zhang, J., Fang, Y. and Habibi, M. (2020), “Vibrational characteristics of multi-phase nanocomposite reinforced circular/annular system”, *Adv. Nano Res.*, **9**(4), 295-307. https://doi.org/10.12989/anr.2020.9.4.295.

Ziaei-Nia, A., Shariati, M. and Salehabadi, E. (2018), “Dynamic mix design optimization of high-performance concrete”, *Steel Compos. Struct.*, **29**(1), 67-75. https://doi.org/10.12989/scs.2018.29.1.067.

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