Advances in Nano Research, *Vol. 13, No.3 (2022) 297-312*
https://doi.org/10.12989/anr.2022.13.3.297

Application of machine learning and deep neural network for wave propagation in lung cancer cell

Lumin Xing^{*1,2§}, Wenjian Liu^{2§}, Xin Li^{3}, Han Wang^{4}, Zhiming Jiang^{1} and Lingling Wang^{**5}

[1]*The First Affiliated Hospital of Shandong First Medical University & Shandong Provincial Qianfoshan Hospital, Jinan, Shandong, 250014, China*
[2]*City University of Macau, Macau, 999078, China*
[3]*Shandong University of Political Science and Law, Jinan, Shandong, 250014, China*
[4]*Zhuhai Institute of Advanced Technology Chinese Academy of Sciences, Zhuhai, Guangdong, 519000, China*
[5]*Shandong Academy of Chinese Medicine, Jinan, 250014, Shandong, China*

(*Received March 15, 2022, Revised May 1, 2022, Accepted May 6, 2022*)

Abstract. Coughing and breath shortness are common symptoms of nano (small) cell lung cancer. Smoking is main factor in causing such cancers. The cancer cells form on the soft tissues of lung. Deformation behavior and wave vibration of lung affected when cancer cells exist. Therefore, in the current work, phase velocity behavior of the small cell lung cancer as a main part of the body via an exact size-dependent theory is presented. Regarding this problem, displacement fields of small cell lung cancer are obtained using first-order shear deformation theory with five parameters. Besides, the size-dependent small cell lung cancer is modeled via nonlocal stress/strain gradient theory (NSGT). An analytical method is applied for solving the governing equations of the small cell lung cancer structure. The novelty of the current study is the consideration of the five-parameter of displacement for curved panel, and porosity as well as NSGT are employed and solved using the analytical method. For more verification, the outcomes of this reports are compared with the predictions of deep neural network (DNN) with adaptive optimization method. A thorough parametric investigation is conducted on the effect of NSGT parameters, porosity and geometry on the phase velocity behavior of the small cell lung cancer structure.

Keywords: deep neural network; nano cell lung cancer structure; NSGT; Porosity; wave propagation

1. Introduction

Nano (small) cell lung cancer (SCLC) is a prevalent cancer among smoking groups (van Meerbeeck *et al*. 2011, Rudin *et al*. 2021). Indeed, smoking is a high risk factor of SCLC. The cancer cells form on the soft tissue of the lung (He *et al*. 2020, Yan *et al*. 2020, Lv *et al*. 2021, Chen *et al*. 2022b, Jin *et al*. 2022, Zhang *et al*. 2022c). Inhaling and exhaling difficulties are common symptoms of this type of disease which involves mechanical change in shape of the soft tissues and in the case of coughing vibration in the soft tissues are dominant. Since, the mechanisms of deformation in the tissues are dominantly affected by small length scale investigating deformation in the lung tissues are justifiable only using scale-capture deformation theories (Abd Wahab and Adzmi 2017, Bumidin *et al*. 2018, Wang *et al*. 2021, Zhang *et al*. 2022a, b). On the other hand, the lung structure is a porous medium. Therefore, porous elasticity methods should be used in the mechanical investigation of its behavior (Esayas and Kattimani 2021).

Wave propagation in tissue structure in coughing is a challenging problem in investigating small-cell lung cancer (Li *et al*. 2017, Liao *et al*. 2021, Ma *et al*. 2021, Tang *et al*. 2021, Zhang *et al*. 2021a, Zheng *et al*. 2021a). Coughing in some cases causes damage to the lung tissue. The vibration and dynamical force in lung is very similar to mechanical behavior of membranes and panels. Size-dependent stress and strain gradient theories have been utilized in many investigation on nano-scale structure and functionally graded materials (Dai and Safarpour 2021, Forsat *et al*. 2021, Ghamkhar *et al*. 2021, Khadimallah *et al*. 2021a, b, Kumar *et al*. 2021, Madenci 2021, Tlidji *et al*. 2021). Oyarhossein *et al*. (2020a) utilized nonlocal stress-strain gradient theory to examine vibrational behavior of microtubule composites. Hamilton's principle in the context of small deformation of elasticity has been employed in their study. They obtained effects of different laminate orientations and nonlocal parameters on the natural frequency of the structure. Moayedi *et al*. (2021) utilized size-dependent theories to investigate buckling and vibration of cylindrical nanoshell under thermal loading. It was concluded that in length scale in the nonlocal theory had a significant influence on the natural frequencies of the structure. Zhang *et al*. (2020a) developed gradient models for beam structures base on three different beam theories. Small-scale effects were included in the vibrational analysis of beam structures using inertia gradient, strain gradient and surface energy method. Variational principle of Euler-Lagrange was employed to obtain the governing equations. They found that shape modes of the beams were substantially changed with introducing scale effects in the analysis. Vibration of doubly curved functionally graded composite was studied using strain gradient elasticity and

---

∗Corresponding author, Ph.D.,
E-mail: xrl_net@msn.com
∗∗Co-corresponding author, Professor,
E-mail: 870846819@qq.com

§These authors contributed equally to this work

http://www.techno-press.org/?journal=journal=anr&subpage=5
ISSN: 2287-237X (Print), 2287-2388 (Online)

shear defamation theory by Karami and Shahsavari (2020). In their study, different geometries of nano-shell structure has been investigated. It was revealed that resonance in the hyperbolic geometries occurred before other investigated geometries. Sahmani *et al.* (2018) explored the vibration behavior of functionally graded porous materials using nonlocal strain gradient theory. They demonstrated that in doubly curved composite structures made from this material plate deflection and amplitude influenced behavior of the shell structure. Using classical plate theory and nonlocal strain gradient constitutive equations (Habibi *et al.* 2016, 2018a, b, 2019b, d, e Ebrahimi *et al.* 2019a, Esmailpoor Hajilak *et al.* 2019, Pourjabari *et al.* 2019, Safarpour *et al.* 2019a), Ebrahimi and Dabbagh (2020) computed frequencies of a composite plate using analytical solutions. A detailed parameter study was further conducted to observe most important parameters affecting vibration of the plate. Responses of nano-scale rotating circular plate made of FG material were presented by Mahinzare *et al.* (2019) employing nonlocal Eringen formulation, nonlocal and classic strain gradient theory and of plate structure. Effects of different parameters were examined on the vibrational behavior of the plate. There many reports on the using of nonlocal stress and strain gradient theories on the static and dynamic behavior of the structures (Al-shujairi and Mollamahmutoğlu 2018, Karami and Shahsavari 2019, lori *et al.* 2020b, Huang *et al.* 2021a, Zhang *et al.* 2021b).

Porosity in materials cause different responses of bio and structural material under thermal, static and dynamic loadings (Safarpour *et al.* 2018, 2019b, 2020, Habibi *et al.* 2017, 2019a, c, Alipour *et al.* 2020, Ebrahimi *et al.* 2020a, Ghazanfari *et al.* 2020, Chen *et al.* 2022a). In this regard, Lande and Mitzner (2006) modeled air flow in the lung considering the lung materials as viscoelastic material to observe dynamical responses in bith healthy and diseased lungs. Kowalczyk (1993) used nonlinear elasticity and perfect air equations to model solid and gaseous parts of the two-phase solid/air lung. The constitutive equations of the two phase material were developed and matrix form was presented for further finite element analysis. Ramteke and Panda (2021) examined effect of porosity on the free vibration of graded structure. They considered different pattern of porosity distribution. It was revealed that porosity pattern could alter the vibrational behavior significantly. The mechanical properties of porous medium are averaged and a continuum model is used to analyze the static and dynamical behavior of the structures (Massoumi *et al.* 2018). Seyfi *et al.* (2016) compared computational and actual deformation of lung during breathing engaging a poro-elastic model. The lung geometry was constructed using high-resolution images and fluid-solid interaction finite element method employed to find the deformation of the lung. There are several studies on the mechanical behavior of lung during breathing (Fredberg and Stamenovic 1989, Ilegbusi *et al.* 2015, Seyfi Noferest *et al.* 2015). However, small-scale effects in lung have not been properly addressed. Karimiasl *et al.* (2019) employed size-dependent elasticity theories to procure vibration and buckling responses of porous structure with fluid flow. Analytical solutions were presented and the results revealed that fluid flow inside the porous medium substantially alter vibrational behavior of the structure. Gao *et al.* (2020) investigated wave propagation in functionally graded porous medium and considered various porosity patterns in their analysis. They concluded that the wave propagation in porous medium is highly reliant on the porosity distribution.

Marchesseau *et al.* (2010) presented a nonlinear viscoelastic model for porous material with the focus on the human organs. They provide application of the model in surgery of liver. A porohyperviscoelastic model (Zheng *et al.* 2021b) to investigate effect of internal pressure on the shear wave motion in soft tissues similar to liver. Mechanics of soft tissues are investigated in other references to examine wave propagation in the human organs (Sevostianov and Kachanov 2000, Evans *et al.* 2013, MacMinn *et al.* 2016)

For the first time, phase velocity analysis of a small cell lung cancer structure employing first-order shear deformation theory is presented. The current small cell lung cancer structure is modeled using curved panel system with porosity. Besides, the size-dependent small cell lung cancer structure is simulated via NSGT. A detailed analytical procedure is utilized for solving the governing equations of the small cell lung cancer structure. For more verification, the outcomes of the present reports are compared with the predictions of adaptively tuned DNN. A thorough parametric investigation is conducted on the effect of NSGT parameter, porosity level and geometry on the phase velocity response of the small cell lung cancer structure.

2. Governing equations

Displacement components in a curves shell structure in the FSDT is regarded as (Wang *et al.* 2018, Karami and Shahsavari 2020):

$$\begin{aligned} u(x,y,h,t) &= u_0(x,y,t) + hu_1(x,y,t) \\ v(x,y,h,t) &= v_0(x,y,t) + hv_1(x,y,t) \\ w(x,y,h,t) &= w_0(x,y,t) \end{aligned} \tag{1a}$$

in which u_0, v_0, and w_0 show, respectively, the mid-plane displacements along the x, y, and z directions. The terms u_1 and v_1 are shear rotations functions. In addition, the non-zero components of normal and shear strains can be obtained as given below (Wang *et al.* 2018, Karami and Shahsavari 2020):

$$\begin{Bmatrix} \varepsilon_{xx} \\ \varepsilon_{yy} \\ \gamma_{\gamma y} \\ \gamma_{\gamma h} \\ \gamma_{yh} \end{Bmatrix} = \begin{bmatrix} \frac{\partial u_0}{\partial x} + z\frac{\partial u_1}{\partial x} + \frac{w_0}{R_\gamma} \\ \frac{\partial v_0}{\partial y} + h\frac{\partial v_1}{\partial y} \\ \frac{\partial u_0}{\partial y} + h\frac{\partial u_1}{\partial y} + \frac{\partial v_0}{\partial x} + z\frac{\partial v_1}{\partial x} \\ u_1 + \frac{\partial w_0}{\partial x} - \frac{1}{R_\gamma}(u_0) \\ v_1 + \frac{\partial w_0}{\partial y} \end{bmatrix} \tag{1b}$$

Material properties are functions of position and well as porosity level in porous materials (Mohammadhassani *et al.* 2013, 2014, Toghroli *et al.* 2014, 2016, Safa *et al.* 2016, 2020b, Sadeghipour Chahnasir *et al.* 2018, Sedghi *et al.* 2018, Katebi *et al.* 2019, Shariati *et al.* 2019b, 2020n, o, p, q, 2021d). The following relations is adopted for the module of elasticity, density and Poisson’s ratio (Sahmani *et al*. 2018):

$$
\begin{aligned}
&E_p = E[1-\alpha_P\beta(z)],\\
&\rho_p = \rho[1-\alpha_m\beta(z)],\\
&\upsilon_p = 0.221\left(1-\frac{\rho_p}{\bar{\rho}}\right)\\
&+\upsilon\left[1+0.342\left(1-\frac{\rho_p}{\bar{\rho}}\right)^2-1.21\left(1-\frac{\rho_p}{\bar{\rho}}\right)\right]
\end{aligned}
\tag{2}
$$

where

$$
\begin{aligned}
&\beta(z)=\begin{cases} cos(\frac{\pi z}{2h}+\frac{\pi}{4})imperfection1\\ cos(\frac{\pi z}{h})imperfection2\end{cases}\\
&\alpha_m=\frac{1.121}{\beta(z)}\left\{1-[1-\alpha_p\beta(z)]^{\frac{1}{2.3}}\right\}
\end{aligned}
\tag{3}
$$

The constants α_m and α_p in Eqs. (2) and (3) are density and porosity factors, respectively. Moreover, E_p, υ_p and ρ_p are isotropic module of elasticity, Poisson's ratio and density of the porous material, respectively. The linear constitutive equations of the porous material can be given as (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*. 2020b, Shariati *et al*. 2020h, k, Shokrgozar *et al*. 2020):

$$
\begin{bmatrix}\sigma_{xx}\\ \sigma_{yy}\\ \sigma_{xy}\\ \sigma_{xh}\\ \sigma_{yh}\end{bmatrix}=\begin{bmatrix}\bar{Q}_{11} & \bar{Q}_{12} & 0 & 0 & 0\\ \hat{\bar{Q}}_{21} & \hat{\bar{Q}}_{22} & 0 & 0 & 0\\ 0 & 0 & \bar{Q}_{44} & 0 & 0\\ 0 & 0 & 0 & \bar{Q}_{55} & 0\\ 0 & 0 & 0 & 0 & \bar{Q}_{66}\end{bmatrix}\begin{bmatrix}\varepsilon_{xx}\\ \varepsilon_{yy}\\ \varepsilon_{xy}\\ \varepsilon_{xh}\\ \varepsilon_{yh}\end{bmatrix}
\tag{4a}
$$

The terms used in Eq. (4a) would be obtained as (Mohammadreza 2012, Aghakhani *et al*. 2015, Toghroli 2015, 2018, 2020, Mohammadhassani *et al*. 2015, Sari *et al*. 2019, Xu *et al*. 2019, Jermsittiparsert *et al*. 2020, Safa *et al*. 2020a, Shariati *et al*. 2014, 2020a, b, c, d, e, f, g, j, i, m, 2021a, b, c,):

$$
\begin{aligned}
&\bar{Q}_{11}=\frac{E_{11}}{1-\nu_{12}\nu_{21}},\bar{Q}_{12}=\frac{\nu_{12}E_{22}}{1-\nu_{12}\nu_{21}},\\
&\bar{Q}_{22}=\frac{E_{22}}{1-\nu_{12}\nu_{21}},\bar{Q}_{44}=G_{12},\bar{Q}_{55}=G_{23},\bar{Q}_{66}=G_{13}.
\end{aligned}
\tag{4b}
$$

Also, the strains relations are (Liu *et al*. 2020b, 2021b, Habibi *et al*. 2021, He *et al*. 2021, Huang *et al*. 2021a, Zhang *et al*. 2021):

2.1 Hamilton's principle and its extended form

Energy equations of the structure are obtained using the well-known Hamilton's principle (Hashemi *et al*. 2019, Al-Furjan *et al*. 2020c, d, e, f, Bai *et al*. 2020, Cheshmeh *et al*. 2020, Li *et al*. 2020a, Lori *et al*. 2020a, Najaafi *et al*. 2020, Shariati *et al*. 2020l, Zhang *et al*. 2020b, Guo *et al*. 2021b, Liu *et al*. 2021a). In the current study, the extended from of this principle is utilized in the following relations:

$$
\int_{t_1}^{t_2}(\delta\Pi_u-\delta\Pi_k)dt=0 \tag{5}
$$

The components of the first strain energy (Adamian *et al*. 2020, Al-Furjan *et al*. 2020a, b, Li *et al*. 2020b, 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) term is calculated using Eq. (1) as given below:

$$
\begin{aligned}
&\delta\Pi_u=\iiint_V\sigma_{ij}\delta\varepsilon_{ij}dV=\\
&=\iint_A\left[\begin{gathered}N_{\gamma\gamma}\left(\frac{\partial\delta u_0}{\partial\gamma}+\frac{\delta w_0}{R_\gamma}\right)+M_{\gamma\gamma}\frac{\partial\delta u_1}{\partial\gamma}\\ +N_{yy}\left(\frac{\partial\delta v_0}{\partial y}\right)+M_{yy}\frac{\partial\delta v_1}{\partial y}\\ +N_{yz}\left(\delta v_1+\frac{\partial\delta w_0}{\partial y}\right)\\ +N_{\gamma z}(\delta u_1+\frac{\partial\delta w_0}{\partial\gamma}-\frac{\delta u_0}{R_\gamma})+M_{\gamma z}(-\frac{\delta u_1}{R_\gamma})\\ +N_{\gamma y}\left(\frac{\partial\delta u_0}{\partial y}+\frac{\partial\delta v_0}{\partial\gamma}\right)+M_{\gamma y}\left(\frac{\partial\delta u_1}{\partial y}+\frac{\partial\delta v_1}{\partial\gamma}\right)\end{gathered}\right]dA
\end{aligned}
\tag{6a}
$$

where

$$
\{N_{ij},M_{ij}\}=\int_z\{\sigma_{ij},z\sigma_{ij}\}\,dz \tag{6b}
$$

In addition, the kinetic energy (Liu *et al*. 2020a, Wang *et al*. 2020, Zhou *et al*. 2020, Dai *et al*. 2021a, Guo *et al*. 2021a, Shao *et al*. 2021, Wu and Habibi 2021) term can be calculated using the following:

$$
\delta\Pi_k=\int_Z\iint_A\rho\left\{\frac{\partial u}{\partial t}\frac{\partial\delta u}{\partial t}+\frac{\partial v}{\partial t}\frac{\partial\delta v}{\partial t}+\frac{\partial w}{\partial t}\frac{\partial\delta w}{\partial t}\right\}dA \tag{7}
$$

As a consequent, substituting Eqs. (8), (7), and (6a) in Eq. (5), equations of motion of the porous doubly-curved shell are achieved as given below for different directions:

$$
\begin{aligned}
&\delta u_0:\frac{\partial N_{\gamma\gamma}}{\partial\gamma}+\frac{\partial N_{\gamma y}}{\partial y}+\frac{N_{\alpha\gamma}}{R_\gamma}=I_0\frac{\partial^2u_0}{\partial t^2}+I_1\frac{\partial^2u_1}{\partial t^2},\\
&\delta v_0:\frac{\partial N_{yy}}{\partial y}+\frac{\partial N_{\gamma y}}{\partial\gamma}=I_0\frac{\partial^2v_0}{\partial t^2}+I_1\frac{\partial^2v_1}{\partial t^2},\\
&\delta w_0:\frac{\partial N_{yz}}{\partial y}+\frac{\partial N_{\gamma z}}{\partial\gamma}-\frac{N_{\gamma\gamma}}{R_\gamma}=I_0\frac{\partial^2w_0}{\partial t^2},\\
&\delta u_1:\frac{\partial M_{\gamma\gamma}}{\partial\gamma}+\frac{\partial M_{\gamma y}}{\partial y}+\frac{M_{\gamma z}}{R_\gamma}-N_{\gamma z}=I_1\frac{\partial^2u_0}{\partial t^2}+I_2\frac{\partial^2u_1}{\partial t^2},\\
&\delta v_1:\frac{\partial M_{yy}}{\partial y}+\frac{\partial M_{\gamma y}}{\partial\gamma}-N_{yz}=I_1\frac{\partial^2v_0}{\partial t^2}+I_2\frac{\partial^2v_1}{\partial t^2}.
\end{aligned}
\tag{8}
$$

where

$$
\{I_i\}=\int_{-\frac{h}{2}}^{\frac{h}{2}}\rho\{z^i\}dz \tag{9}
$$

2.2 Applying size-dependent theory

In the nonlocal strain gradient theory, both nonlocal stresses and strain gradient are consideredin the constitutive equations of the material (Arabnejad Khanouki *et al*. 2010, Mojtaba 2011, Shariati *et al*. 2011a, b, 2019a, c, d, e, 2020r, Sinaei *et al*. 2011, 2012, Mansouri *et al*. 2016, Shahabi *et al*. 2016, Khorramian *et al*. 2017, Nosrati *et al*. 2018, Ziaei-Nia *et al*. 2018, Milovancevic *et al*. 2019, Sajedi and Shariati 2019, Trung *et al*. 2019a, b, Afshar *et al*. 2020, Yazdani *et al*. 2020, Davoodnabi *et al*. 2021). Therefore, the relationship between stress and strain in this theory includes both gradients of stress and strain fields:

$$\boldsymbol{(1-\nabla^2\mu^2)\sigma_{ij}=(1-\nabla^2 l^2)Q_{ij}\varepsilon_{ij}} \tag{10}$$

In Eq. (9), ∇^2 represent the Laplacian operator. Substituting Eqs. (10), and (4a) in Eq. (8) the equations of motion for the current small cell lung cancer structure can be obtained as given below:

$$\delta u_0\colon 1-\nabla^2 l^2)\begin{pmatrix} \frac{\partial}{\partial\gamma}\begin{pmatrix} A_{11}\frac{\partial u_0}{\partial\gamma}+B_{11}\frac{\partial u_1}{\partial\gamma} \\ +A_{11}\frac{w_0}{R_\gamma}+A_{12}\frac{\partial v_0}{\partial y}+B_{12}\frac{\partial v_1}{\partial y} \end{pmatrix} \\ +\frac{\partial}{\partial y}\begin{pmatrix} A_{44}\frac{\partial u_0}{\partial y}+B_{44}\frac{\partial u_1}{\partial y} \\ +A_{44}\frac{\partial v_0}{\partial\gamma}+B_{44}\frac{\partial v_1}{\partial\gamma} \end{pmatrix} \\ +\frac{1}{R_\gamma}\begin{pmatrix} A_{55}u_1+A_{55}\frac{\partial w_0}{\partial\gamma} \\ -\frac{1}{R_\gamma}(A_{55}u_0+B_{55}u_1) \end{pmatrix} \end{pmatrix} \\ =(1-\nabla^2\mu^2)\left(I_0\frac{\partial^2 u_0}{\partial t^2}+I_1\frac{\partial^2 u_1}{\partial t^2}\right) \tag{11a}$$

$$\delta v_0\colon(1-\nabla^2 l^2)\begin{pmatrix} \frac{\partial}{\partial y}\begin{pmatrix} A_{21}\frac{\partial u_0}{\partial\gamma}+B_{21}\frac{\partial u_1}{\partial\gamma} \\ +A_{21}\frac{w_0}{R_\gamma}+A_{11}\frac{\partial v_0}{\partial y}+B_{11}\frac{\partial v_1}{\partial y} \end{pmatrix} \\ +\frac{\partial}{\partial\gamma}\begin{pmatrix} A_{44}\frac{\partial u_0}{\partial y}+B_{44}\frac{\partial u_1}{\partial y} \\ +A_{44}\frac{\partial v_0}{\partial\gamma}+B_{44}\frac{\partial v_1}{\partial\gamma} \end{pmatrix} \end{pmatrix} \\ =(1-\nabla^2\mu^2)\left(I_0\frac{\partial^2 v_0}{\partial t^2}+I_1\frac{\partial^2 v_1}{\partial t^2}\right) \tag{11b}$$

$$\delta w_0\colon(1-\nabla^2 l^2)\begin{pmatrix} \frac{\partial}{\partial y}\left(A_{66}v_1+A_{66}\frac{\partial w_0}{\partial y}\right) \\ +\frac{\partial}{\partial\gamma}\begin{pmatrix} A_{55}u_1+A_{55}\frac{\partial w_0}{\partial\gamma} \\ -\frac{1}{R_\gamma}(A_{55}u_0+B_{55}u_1) \end{pmatrix} \\ -\frac{1}{R_\gamma}\begin{pmatrix} A_{11}\frac{\partial u_0}{\partial\gamma}+B_{11}\frac{\partial u_1}{\partial\gamma} \\ +A_{11}\frac{w_0}{R_\gamma}+A_{12}\frac{\partial v_0}{\partial y}+B_{12}\frac{\partial v_1}{\partial y} \end{pmatrix} \end{pmatrix} \\ =(1-\nabla^2\mu^2)\left(I_0\frac{\partial^2 w_0}{\partial t^2}\right) \tag{11c}$$

$$\delta u_1\colon(1-\nabla^2 l^2)\begin{pmatrix} \frac{\partial}{\partial\gamma}\begin{pmatrix} B_{11}\frac{\partial u_0}{\partial\gamma}+C_{11}\frac{\partial u_1}{\partial\gamma} \\ +B_{11}\frac{w_0}{R_\gamma}+B_{12}\frac{\partial v_0}{\partial y}+C_{12}\frac{\partial v_1}{\partial y} \end{pmatrix} \\ +\frac{\partial}{\partial y}\begin{pmatrix} B_{44}\frac{\partial u_0}{\partial y}+C_{44}\frac{\partial u_1}{\partial y} \\ +B_{44}\frac{\partial v_0}{\partial\gamma}+C_{44}\frac{\partial v_1}{\partial\gamma} \end{pmatrix} \\ +\frac{1}{R_\gamma}\begin{pmatrix} B_{55}u_1+B_{55}\frac{\partial w_0}{\partial\gamma} \\ -\frac{1}{R_\gamma}(B_{55}u_0+C_{55}u_1) \end{pmatrix} \\ -\begin{pmatrix} A_{55}u_1+A_{55}\frac{\partial w_0}{\partial\gamma} \\ -\frac{1}{R_\gamma}(A_{55}u_0+B_{55}u_1) \end{pmatrix} \end{pmatrix} \\ =(1-\nabla^2\mu^2)\left(I_1\frac{\partial^2 u_0}{\partial t^2}+I_2\frac{\partial^2 u_1}{\partial t^2}\right) \tag{11d}$$

$$\delta v_1\colon(1-\nabla^2 l^2)\begin{pmatrix} \frac{\partial}{\partial y}\begin{pmatrix} B_{21}\frac{\partial u_0}{\partial\gamma}+C_{21}\frac{\partial u_1}{\partial\gamma} \\ +B_{21}\frac{w_0}{R_\gamma}+B_{11}\frac{\partial v_0}{\partial y}+C_{11}\frac{\partial v_1}{\partial y} \end{pmatrix} \\ +\frac{\partial}{\partial\gamma}\begin{pmatrix} B_{44}\frac{\partial u_0}{\partial y}+C_{44}\frac{\partial u_1}{\partial y} \\ +B_{44}\frac{\partial v_0}{\partial\gamma}+C_{44}\frac{\partial v_1}{\partial\gamma} \end{pmatrix} \\ -\left(A_{66}v_1+A_{66}\frac{\partial w_0}{\partial y}\right) \end{pmatrix} \\ =(1-\nabla^2 l^2)\left(I_1\frac{\partial^2 v_0}{\partial t^2}+I_2\frac{\partial^2 v_1}{\partial t^2}\right) \tag{11e}$$

where

$$\{A_{ij},B_{ij},C_{ij}\}=\{1,z,z^2\}\sigma_{ij}dz \tag{12}$$

3. Solution method

A harmonic field of displacement as complex exponential function is assumed as follows (Ma *et al.* 2022, Zhao *et al.* 2022, Habibi *et al.* 2019d, Hou *et al.* 2021, Huang *et al.* 2021c, d, Jiao *et al.* 2021, Liu *et al.* 2021c, Moradi *et al.* 2021, Xu *et al.* 2021, Dong *et al.* 2022, Luo *et al.* 2022, Yang *et al.* 2022, Yu *et al.* 2022):

$$\begin{Bmatrix} u_0 \\ v_0 \\ w_0 \\ u_1 \\ v_1 \end{Bmatrix}=\begin{Bmatrix} U_0\,exp(m\gamma+ny-\omega t)i \\ V_0\,exp(m\gamma+ny-\omega t)i \\ W_0\,exp(m\gamma+ny-\omega t)i \\ U_1\,exp(m\gamma+ny-\omega t)i \\ V_1\,exp(m\gamma+ny-\omega t)i \end{Bmatrix} \tag{13}$$

in which wave numbers along axial and circumferential directions are represented by m and n, respectively. In addition, ω is the frequency of vibration of the structure. Replacing Eq. (13) into equations of motion without considering damping effects results in:

$$(\omega^2[M]-[K])\{d\}=\{0\} \tag{14}$$

where

$$\{d\}=\{u_0\quad v_0\quad w_0\quad u_1\quad v_1\} \tag{15}$$

Moreover, the phase velocity is considered to have the following:

$$S=\frac{\omega}{n} \tag{16}$$

4. Comparative study using deep learning model

Deep learning and machine learning models have been commonly used in the field of regression. These methods, in general, utilized a set of input data to learn the behavior of the system and later uses the trained model for further predictions. Therefore, having enough data to train the model, these network could be utilize for prediction of behavior of the small cell lung cancer vibrations.

The learning procedure is simple and straight forward. A deep neural network (DNN) initiates its prediction with arbitrary constants for regression functions also known as weight and biases. Then, the outcome of the network compared with the actual outcome provided in data set. If the differences between predicted and actual outputs are not desirable, the network utilized an optimization algorithm to adjust regression constants until the desire values obtained by network. At the end, the network is tested to find out the accuracy of the DNN in predicting unknown problems.

In the current study, the inputs of the DNN network is vector $X=\{a/h, l, \mu, R/h, \alpha_p\}^T$ and its output is phase velocity. The optimization method is called ADADELTA (adaptive delta) method in which the mean squared error between predicted values and actual data is minimized (Yegnanarayana 2009):

$$\text{MSE}=\frac{1}{n}\sum_{\text{i}=1}^{n}\left(\text{Y-}\hat{\text{Y}}\right)^2. \qquad (17)$$

4.1 ADADELTA optimization to adjust the DNN parameters

ADADELTA optimization method is a reliable and fast algorithm in the neural network which the learning rate can be adjusted automatically. In addition, this method is not affected by the hyperparameters of the network. On the other hand, both distributed and local factors are involved in this method. The optimization procedure, tuning the weights and biases of the network, at each iteration uses the following returning equations:

$$\begin{aligned}\chi_{t+1} &= \chi_t + \triangle\,\chi_t \\ \triangle\,\chi_t &= -\eta\frac{\partial f(\chi_t)}{\partial \chi_t}\end{aligned} \qquad (18)$$

where the initial learning rate is represented by parameter η. In the next steps the notation G_t wil be used instead of$\frac{\partial f(\chi_t)}{\partial \chi_t}$. The root mean square gradient of the following function should be calculated at each iteration (epoch) to optimally adjust the constants of the DNN network:

$$RMS[G_t]=\sqrt{E[G_t^2]+\varepsilon} \qquad (19)$$

where, ε is a constant. It should be noted that $E[G_t^2]$ represents the expected value of the square of gradient which can be determined using the given relation below:

$$E\left[G_t^2\right]=\rho E\left[G_{t-1}^2\right]+(1-\rho)G_t^2 \qquad (20)$$

where, ρ denotes the decay rate. Utilizing Eq. (19) and Eq. (20), the following equation could be given for updating network parameters:

$$\triangle\chi_t=-\frac{\eta}{RMS\left[G_t\right]}G_t \qquad (21)$$

The ADADELTA optimization is a high performance optimizing procedure as shown by Zeiler (2012) among all other optimization method which gives the minimized error in reduced steps.

Table1 Comparison of the dimensionless natural frequency $(\omega h\sqrt{\frac{\rho}{E}})$ of simply-supported square perfect panel (*a*/*h*=5)

E_1/E_2	Ref. (Noor 1973)	Ref. (Khdeir 1988)	Current study
10	0.32841	0.33095	0.33108
20	0.38241	0.38110	0.38123
30	0.41089	0.41094	0.41099
40	0.43006	0.43155	0.43161

5. Results

Used parameters:

μ/h	Dimensionless nonlocal parameter
l/h	Dimensionless length scale parameter
n	Circumferential wave number
m	Axial wave number
R_Y	Radius curvature
a	Length of the structure
h	Thickness of the structure
α_p	Porosity coefficient

The proposed model for exploring vibration of porous medium is scrutinized to discover the validity of the results. In this regard, dimensionless natural frequency as calculated by the presented model is compared to the previously measured natural frequencies in the literature (Noor 1973, Khdeir 1988). The results are given in 0. As seen, there is a minor difference between the method of the current study and other methods in literature affirming the viability of the model.

The trained deep neural network performance is explained in this section. For this aim, different geometrical condition of the structure is presented in 0 and 0. As can be observed, the mean square error of the training process is very low and in lower MSE, values given by the DNN are approaching the values of numerical study in all geometrical conditions. In 0, effect of the dimensionless length scale parameters l/h is presented for different values of dimensionless nonlocal parameter μ/h. The accuracy of the DNN model is evident in the data in this table with the maximum error 1% for the case of $MSE_{Train}=0.41\times10^{-6}$.

The effect of dimensionless radius of the shell structure is given in 0. Similar accuracy is observed in this table. Therefore, it can be concluded that DNN model is reliable for different geometrical condition taking the value of training mean squared error as low as possible.

The material properties of the current biological structure can be used in Ref. in detail. In this section influence of different geometrical parameters on the natural

Table 2 Prediction on the performance of DNN model toward test data (phase velocity (10^2)) for various zigma and MSN parameters for various dimensionless nonlocal and length scale parameters

l/h=0				
Predicted				
	Fit	$MSE_{Train} = 0.21 \times 10^{-6}$	$MSE_{Train} = 0.31 \times 10^{-6}$	$MSE_{Train} = 0.41 \times 10^{-6}$
μ/h=0	0.4535	0.415698	0.436598	0.452352
μ/h=0.1	0.4236	0.385469	0.405659	0.421236
μ/h=0.2	0.4126	0.354566	0.384569	0.411025
μ/h=0.3	0.3956	0.336598	0.369852	0.391256
μ/h=0.4	0.3899	0.295698	0.356598	0.388805
l/h=0.1				
μ/h=0	0.4605	0.425469	0.445659	0.461235
μ/h=0.1	0.4245	0.395698	0.415236	0.425659
μ/h=0.2	0.4149	0.369856	0.398569	0.415987
μ/h=0.3	0.3921	0.345698	0.378965	0.391569
μ/h=0.4	0.3978	0.305236	0.359856	0.398565
l/h=0.2				
μ/h=0	0.4645	0.429658	0.449659	0.465659
μ/h=0.1	0.4289	0.399569	0.419659	0.429658
μ/h=0.2	0.4163	0.375659	0.400123	0.419658
μ/h=0.3	0.3933	0.350010	0.381089	0.394655
μ/h=0.4	0.3999	0.309856	0.362365	0.400012

Table 3 Prediction on the performance of DNN model toward test data (phase velocity (10^2)) for various zigma and MSN parameters for various *R/h*, and *a/h*

R_γ/h=0.8				
Predicted				
	Fit	$MSE_{Train} = 0.21 \times 10^{-6}$	$MSE_{Train} = 0.31 \times 10^{-6}$	$MSE_{Train} = 0.41 \times 10^{-6}$
μ/h=0	0.4535	0.415698	0.436598	0.452352
μ/h=0.1	0.4236	0.385469	0.405659	0.421236
μ/h=0.2	0.4126	0.354566	0.384569	0.411025
μ/h=0.3	0.3956	0.336598	0.369852	0.391256
μ/h=0.4	0.3899	0.295698	0.356598	0.388805
R_γ/h=0.9				
a/h=0.06	0.4120	0.365469	0.385659	0.418235
a/h=0.08	0.3985	0.356698	0.375236	0.399659
a/h=0.1	0.3790	0.332856	0.359569	0.385987
a/h=0.12	0.3750	0.301698	0.368965	0.381569
a/h=0.14	0.3685	0.300236	0.331856	0.369565
R_γ/h=1				
a/h=0.06	0.4256	0.372658	0.401659	0.428659
a/h=0.08	0.4010	0.365569	0.389659	0.409658
a/h=0.1	0.3985	0.341659	0.365123	0.399658
a/h=0.12	0.3859	0.311010	0.371089	0.388655
a/h=0.14	0.3789	0.310856	0.340365	0.385012

frequency of the structure are presented. In 0, effect of the dimensionless length scale parameter l/h on the natural frequency is given for various values of parameter a/h. Increasing parameter l/h cause slight increase in natural frequency of the shell structure. On the other hand, increasing a/h significantly decreases the natural frequency

Table 4 Effect of geometrical parameters dimensionless $\frac{l}{h}$ and $\frac{a}{h}$ on the natural frequency of the structure

	l/h=0	*l/h=0.1*	*l/h=0.2*	*l/h=0.3*
a/h=0.08	345.659	351.569	353.659	356.985
a/h=0.1	333.659	339.658	342.659	346.658
a/h=0.12	310.659	313.365	316.598	318.266

Table 5 Effect of geometrical parameters dimensionless $\frac{\mu}{h}$ and $\frac{a}{h}$ on the natural frequency of the structure

	l/h=0	*l/h=0.1*	*l/h=0.2*	*l/h=0.3*
a/h=0.08	343.859	341.985	339.569	335.598
a/h=0.1	341.759	339.658	337.585	332.569
a/h=0.12	307.659	306.569	304.658	302.159

Table 6 Impact of curvature of the shell structure on the natural frequency for various values of $\frac{a}{h}$

	l/h=0	*l/h=0.1*	*l/h=0.2*	*l/h=0.3*
a/h=0.08	$R_\gamma/h=0.8$	$R_\gamma/h=0.9$	$R_\gamma/h=1$	$R_\gamma/h=1.1$
a/h=0.1	342.985	343.105	343.569	343.896
a/h=0.12	340.659	341.215	341.856	342.105

for all values of dimensionless length scale parameter. Therefore, increase in length scale parameter is in favor of vibrational behavior of the structure.

In 0, effect of the dimensionless nonlocal parameter μ/h on the natural frequency is given for various values of parameter a/h. Increasing parameter μ/h cause slight decrease in natural frequency of the shell structure. In addition, increasing a/h reduces the natural frequency for all values of dimensionless nonlocal parameter. Therefore, increase in nonlocal parameter cause deterioration in frequency response of the structure.

Radius of curvature also impacts the natural frequency. Increasing the curvature cause insignificant reduction in natural frequency for all values of a/h as given in 0. Thus, curvature of the shell structure is not am important parameter in determining natural frequency of the structure and in design of such structure focus should be on the ratio of a/h, nonlocal and length scale parameters.

Influences of different parameters on the phase velocity are clarified in this section. Phase velocity is a function of nonlocal parameter as shown in Fig. 1. The effect of increasing nonlocal parameter on the phase velocity is highly dependent on the axial wave number m. In low wave numbers increasing nonlocal parameters cause a minor decrease in the phase velocity. For higher values of the axial wave number, the decrease in the phase velocity in significant in which at $m = 400$ phase velocity reduces from $6000m/s$ to $2000m/s$ by increasing dimensionless nonlocal parameter from 0 to 4. Influence of increasing axial wave number is more pronounce at lower nonlocal parameter.

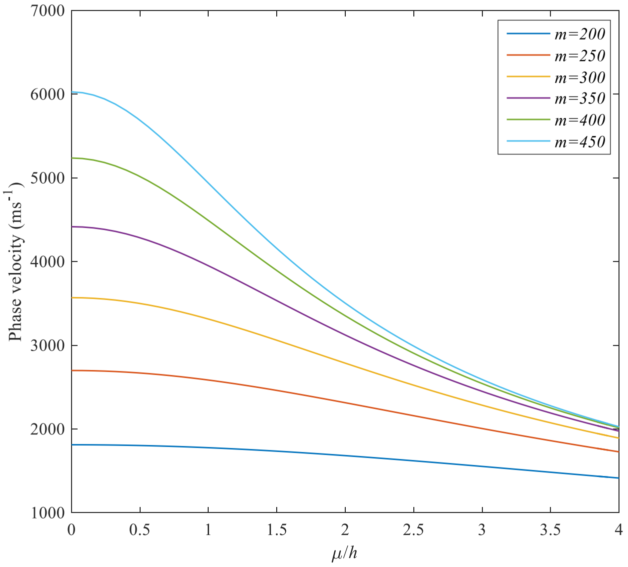

Fig. 1 Phase velocity of the structure for different values of axial wave number m as function of dimensionless nonlocal parameter

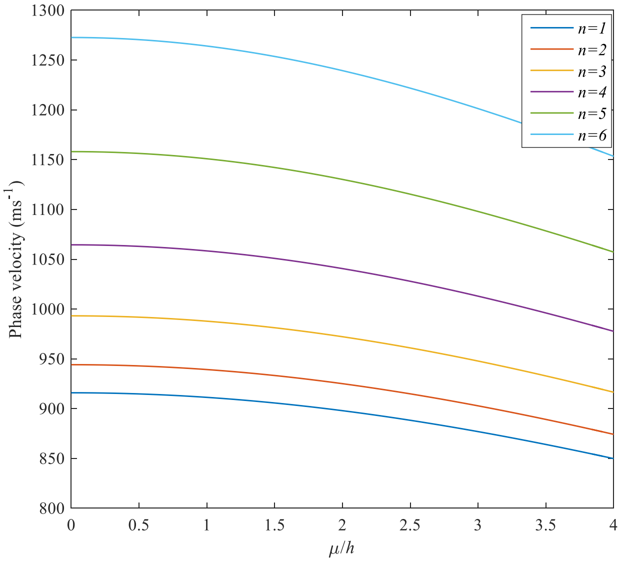

Fig. 2 Phase velocity of the structure for different values of circumferential wave number n as function of dimensionless nonlocal parameter

In Fig. 2, the similar effects is seen effect of increasing nonlocal parameter on the phase velocity is highly dependent on the circumferential wave number n. In all circumferential wave numbers, phase velocity decreases virtually at same ratio with increasing dimensionless nonlocal parameters from 0 to 4. Moreover, increase in wave number results in rise in the phase velocity.

Geometrical parameters in h/a also changes the phase velocity as depicted in Fig. 3. With increase in h/a parameter, phase velocity receive considerable growth from $750m/s$ to $1630m/s$. On the other hand, at higher values of the h/a or when the shell thickness become thinner, the behavior of the phase velocity function changes so that its curve versus nonlocal parameter has more descending gradient than curves associated with lower value of h/a.

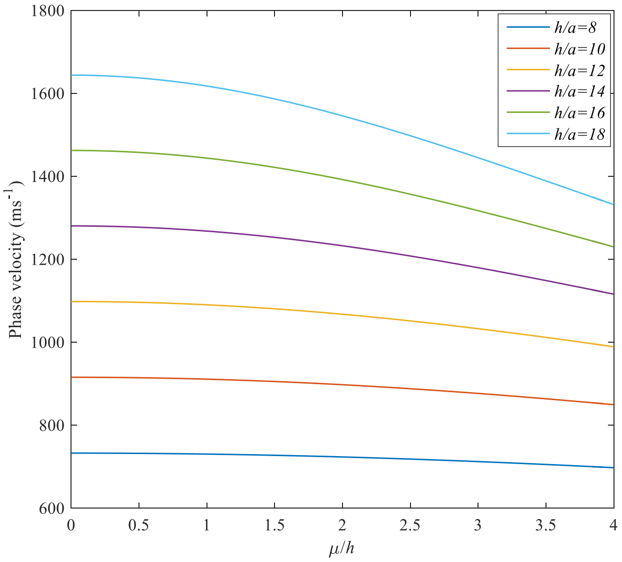

Fig. 3 Phase velocity of the structure for different values of geometrical parameter *h/a* as function of dimensionless nonlocal parameter

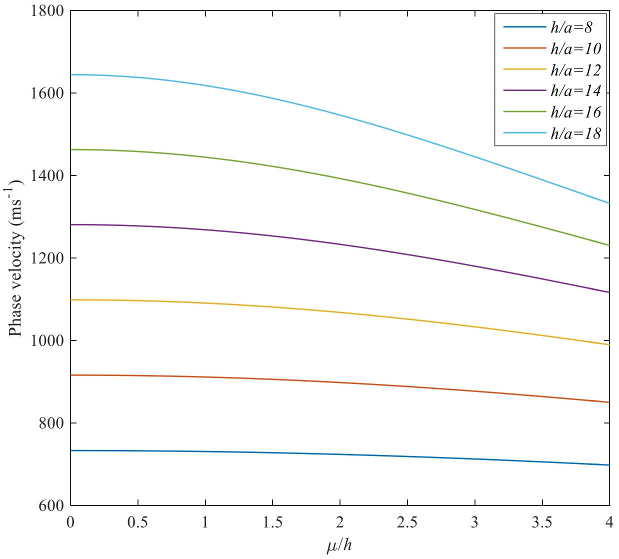

Fig. 4 Phase velocity of the structure for different values of circumferential wave number *n* as function of dimensionless nonlocal parameter

Porosity existence in general increase the phase velocity of the shell structure as depicted in Fig. 5. It is clear from this figure that increase in porosity of the structure does change the behavior of the phase velocity function. However, it increases the phase velocity at a constant rate. It means, independent from the value of nonlocal parameter, increasing porosity adds some specific value to the phase velocity.

Finally, increase in axial and circumferential wave numbers cause considerable rise in the phse velocity. The wave numbers in the axial direction are two order of magnitude greater than circumferential wave number. Thus, at same increase in wave numcers, circumferential wave numbers have greater influence on the phase velocity.

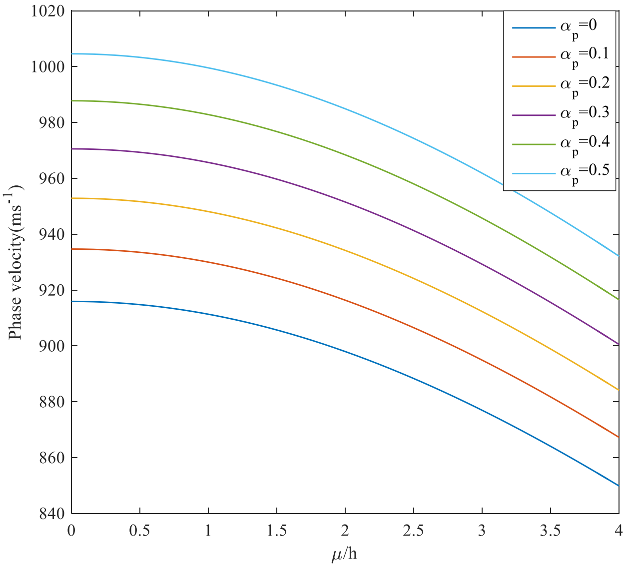

Fig. 5 Phase velocity of the structure for different values of porosity coefficient α_P as function of dimensionless nonlocal parameter

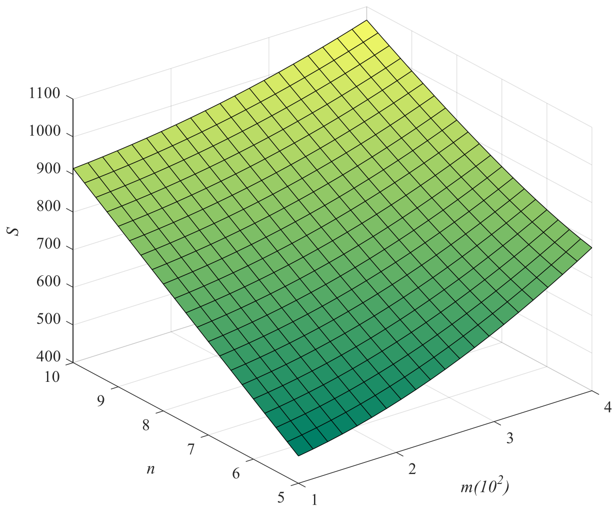

Fig. 6 Phase velocity of the structure for different values of circumferential wave number *n* as function of dimensionless nonlocal parameter

6. Conclusions

This study performed first-order dynamic stability analysis of Small cell lung cancer structure. Governing differential motion equations were solved analytically based on Navier-solution procedure. Besides, the current small cell lung cancer structure is simulated via NSGT. Due to some imperfection of the current small cell lung cancer structure, porosity with 2 patterns was considered. Validation of the approach was carried out by comparing this study results with those published in available literature. For more verification, the outputs of current reports are compared with the results of adaptively tuned deep neural network (DNN). The numerical results revealed that:

- Curvature of the shell structure is not being important parameter in determining natural frequency of the structure.
- Increase in nonlocal parameter cause deterioration in frequency response of the structure.
- Increase in length scale parameter is in favor of vibrational behavior of the structure.
- Phase velocity reduces with increasing nonlocality.
- Independent from the value of nonlocal parameter, increasing porosity adds some specific value to the phase velocity.
- Increase in wave number results in rise in the phase velocity.

Funding

This work was supported d in part by the Academic promotion programme of Shandong First Medical University under Grant 2019LJ005.

References

Abd Wahab, W. and Adzmi, A.N. (2017), “The investigation of cytotoxic effect of Cinnamomum zeylanicum extracts on human breast cancer cell line (MCF7)”, *Sci. Heritage J.*, **1**(2), 23-28.

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.

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/10.1016/j.conbuildmat.2020.120034.

Aghakhani, M., Suhatril, M., Mohammadhassani, M., Daie, M. and Toghroli, A. (2015), “A simple modification of homotopy perturbation method for the solution of Blasius equation in semi-infinite domains”, *Math. Probl. Eng.*, **2015**. https://doi.org/10.1155/2015/671527.

Al-Furjan, M., Dehini, R., Khorami, M., Habibi, M. and won Jung, D. (2020a), “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. (2020b), “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. (2020c), “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., won Jung, D. and Safarpour, H. (2020d), “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., Moghadam, S.A., Dehini, R., Shan, L., Habibi, M. and Safarpour, H. (2020e), “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., Oyarhossein, M.A., Habibi, M., Safarpour, H. and Jung, D.W. (2020f), “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-shujairi, M. and Mollamahmutoğlu, Ç. (2018), “Buckling and free vibration analysis of functionally graded sandwich micro-beams resting on elastic foundation by using nonlocal strain gradient theory in conjunction with higher order shear theories under thermal effect”, *Compos. Part B Eng.*, **154**, 292-312. https://doi.org/10.1016/j.compositesb.2018.08.103.

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.

Arabnejad Khanouki, M.M., Ramli Sulong, N.H. and Shariati, M. (2010), “Behavior of through beam connections composed of CFSST columns and steel beams by finite element studying”, *Adv. Mater. Res.*, **168-170**, 2329-2333. https://doi.org/10.4028/www.scientific.net/AMR.168-170.2329.

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.

Bumidin, M.S., Johari, F.A., Risan, N.F. and Nasir, M.H.M. (2018), “The effect of aqueous extracts of nigella sativa on breast cancer cell line Mcf-7: An in vitro study”, *Sci. Heritage J.*, **2**(1), 13-17. https://doi.org/10.26480/gws.01.2018.13.17.

Chen, F., Chen, J., Duan, R., Habibi, M. and Khadimallah, M.A. (2022a), “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.

Chen, J., Zou, Q. and Li, J. (2022b), “DeepM6ASeq-EL: prediction of human N6-methyladenosine (m6A) Sites with LSTM and ensemble learning”, *Front. Comput. Sci.*, **16**(2), 1-7. https://doi.org/10.1007/s11704-020-0180-0.

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/10.1080/15397734.2020.1744005

Dai, H. and Safarpour, H. (2021), “Frequency and thermal buckling information of laminated composite doubly curved open nanoshell”, *Adv. Nano Res.*, **10**(1), 1-14. https://doi.org/10.12989/anr.2021.10.1.001.

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. 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.

Davoodnabi, S.M., Mirhosseini, S.M. and Shariati, M. (2021), “Analyzing shear strength of steel-concrete composite beam with angle connectors at elevated temperature using finite element method”, *Steel Compos. Struct.*, **40**(6), 853-868. https://doi.org/10.12989/scs.2021.40.6.853.

Dong, Y., Gao, Y., Zhu, Q., Moradi, Z. and Safa, M. (2022), “TE-

GDQE implementation to investigate the vibration of FG composite conical shells considering a frequency controller solid ring", *Eng. Anal. Bound. Elem.*, **138**, 95-107. https://doi.org/10.1016/j.enganabound.2022.01.017.

Ebrahimi, F. and Dabbagh, A. (2020), "Viscoelastic wave propagation analysis of axially motivated double-layered graphene sheets via nonlocal strain gradient theory", *Wave. Random Complex Med.*, **30**(1), 157-176. https://doi.org/10.1080/17455030.2018.1490505.

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., 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., 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., 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.

Esayas, L.S. and Kattimani, S. (2021), "Effect of porosity on active damping of geometrically nonlinear vibrations of a functionally graded magneto-electro-elastic plate", *Defence Technol.*, **18**(6), 891-906. https://doi.org/10.1016/j.dt.2021.04.016.

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/10.1080/15397734.2019.1566743.

Evans, D.W., Moran, E.C., Baptista, P.M., Soker, S. and Sparks, J.L. (2013), "Scale-dependent mechanical properties of native and decellularized liver tissue", *Biomech. Model. Mechanobiol.*, **12**(3), 569-580. https://doi/10.1007/s10237-012-0426-3.

Forsat, M., Musharavati, F., Eltai, E., Zain, A.M., Mobayen, S. and Mohamed, A.M. (2021), "Vibration characteristics of microplates with GNPs-reinforced epoxy core bonded to piezoelectric-reinforced CNTs patches", *Adv. Nano Res.*, **11**(2), 115-140. https://doi.org/10.12989/anr.2021.11.2.115.

Fredberg, J.J. and Stamenovic, D. (1989), "On the imperfect elasticity of lung tissue", *J. Appl. Physiol.*, **67**(6), 2408-2419. https://doi/10.1152/jappl.1989.67.6.2408.

Gao, W., Qin, Z. and Chu, F. (2020), "Wave propagation in functionally graded porous plates reinforced with graphene platelets", *Aerosp. Sci. Technol.*, **102**, 105860. https://doi.org/10.1016/j.ast.2020.105860.

Ghamkhar, M., Khadimallah, M.A., Iqbal, M.Z., Hussain, M., Yahya, A., Khedher, K.M., Naeem, M.N. and Tounsi, A. (2021), "Performance of FGM bilayered cylindrical shell placed on cantilever edge", *Adv. Nano Res.*, **11**(4), 339-345. https://doi.org/10.12989/anr.2021.11.4.339.

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., 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.

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/10.22060/MEJ.2016.664.

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., 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.

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.

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. Pr.*, **31**, 310-323.

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., 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., 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.

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, S., Guo, F. and Zou, Q. (2020), "MRMD2. 0: a python tool for machine learning with feature ranking and reduction", *Curr. Bioinform.*, **15**(10), 1213-1221. https://doi.org/10.2174/1574893615999200503030350.

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.

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.

Huang, X., Hao, H., Oslub, K., Habibi, M. and Tounsi, A. (2021a), "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., 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.*, **38**(4), 3137-3149. https://doi.org/10.1007/s00366-021-01320-y.

Ilegbusi, O., Seyfi, B., Neylon, J. and Santhanam, A.P. (2015), "Analytic intermodel consistent modeling of volumetric human lung dynamics", *J. Biomech. Eng.*, **137**(10). https://doi.org/10.1115/1.4031349.

Jermsittiparsert, K., Ghabussi, A., Forooghi, A., Shavalipour, A., Habibi, M., won Jung, D. and Safa, M. (2020), "Critical voltage, thermal buckling and frequency characteristics of a thermally affected GPL reinforced composite microdisk covered with piezoelectric actuator", *Mech. Based Des. Struct.*, 1-23. https://doi.org/10.1080/15397734.2020.1748052.

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.*, **38**(3), 2499-2513. https://doi.org/10.1007/s00366-021-01391-x.

Jin, K., Yan, Y., Chen, M., Wang, J., Pan, X., Liu, X., Liu, M., Lou, L., Wang, Y. and Ye, J. (2022), "Multimodal deep learning with feature level fusion for identification of choroidal neovascularization activity in age-related macular degeneration", *Acta Ophthalmologica*. **100**(2), e512-e520. https://doi.org/10.1111/aos.14928.

Karami, B. and Shahsavari, D. (2019), "Nonlocal strain gradient model for thermal stability of FG nanoplates integrated with piezoelectric layers", *Smart Struct. Syst.*, **23**(3), 215-225. https://doi.org/10.12989/SSS.2019.23.3.215.

Karami, B. and Shahsavari, D. (2020), "On the forced resonant vibration analysis of functionally graded polymer composite doubly-curved nanoshells reinforced with graphene-nanoplatelets", *Comput. Meth. Appl. Mech. Eng.*, **359**, 112767. https://doi.org/10.1016/j.cma.2019.112767.

Karimiasl, M., Ebrahimi, F. and Mahesh, V. (2019), "Nonlinear forced vibration of smart multiscale sandwich composite doubly curved porous shell", *Thin Wall. Struct.*, **143**, 106152. https://doi.org/10.1016/j.tws.2019.04.044.

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.

Khadimallah, M.A., Hussain, M., Naeem, M.N., Taj, M. and Tounsi, A. (2021a), "Monitoring and control of multiple fraction laws with ring based composite structure", *Adv. Nano Res.*, **10**(2), 129-138. https://doi.org/10.12989/anr.2021.10.2.129.

Khadimallah, M.A., Hussain, M., Taj, M., Ayed, H. and Tounsi, A. (2021b), "Parametric vibration analysis of single-walled carbon nanotubes based on Sanders shell theory", *Adv. Nano Res.*, **10**(2), 165-174. https://doi.org/10.12989/anr.2021.10.2.165.

Khdeir, A. (1988), "Free vibration and buckling of symmetric cross-ply laminated plates by an exact method", *J. Sound Vib.*, **126**(3), 447-461.

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 and Compos. Struct.*, **23**(1), 67-85. https://doi.org/10.12989/scs.2017.23.1.067.

Kowalczyk, P. (1993), "Mechanical model of lung parenchyma as a two-phase porous medium", *Transp. Porous Med.*, **11**(3), 281-295. https://doi.org/10.1007/BF00614816.

Kumar, Y., Gupta, A. and Tounsi, A. (2021), "Size-dependent vibration response of porous graded nanostructure with FEM and nonlocal continuum model", *Adv. Nano Res.*, **11**(1), 1-17. https://doi.org/10.12989/anr.2021.11.1.001.

Lande, B. and Mitzner, W. (2006), "Analysis of lung parenchyma as a parametric porous medium", *J. Appl. Physiol.*, **101**(3), 926-933. https://doi.org/10.1152/japplphysiol.01548.2005.

Li, J., Tang, F. and Habibi, M. (2020a), "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, J., Xu, K., Chaudhuri, S., Yumer, E., Zhang, H. and Guibas, L. (2017), "Grass: Generative recursive autoencoders for shape structures", *ACM Transact. Graphics*, **36**(4), 1-14. https://doi.org/10.1145/3072959.3073637.

Li, Y., Li, S., Guo, K., Fang, X. and Habibi, M. (2020b), "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.

Liao, L., Du, L. and Guo, Y. (2021), "Semi-supervised SAR Target detection based on an improved faster R-CNN", *Remote Sens.*, **14**(1), 143. https://doi.org/10.3390/rs14010143.

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, Y., Wang, W., He, T., Moradi, Z. and Larco Benítez, M.A.

(2021c), "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., 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.

Lori, E.S., Ebrahimi, F., Supeni, E.E.B., Habibi, M. and Safarpour, H. (2020a), "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.

lori, E.S., 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.

Luo, J., Song, J., Moradi, Z., Safa, M. and Khadimallah, M.A. (2022), "Effect of simultaneous compressive and inertia loads on the bifurcation stability of shear deformable functionally graded annular fabrications reinforced with graphenes", *Eur*. *J*. *Mech*. *A Solids*, 104581. https://doi.org/10.1016/j.euromechsol.2022.104581.

Lv, Z., Chen, D., Feng, H., Zhu, H. and Lv, H. (2021), "Digital twins in unmanned aerial vehicles for rapid medical resource delivery in epidemics", *IEEE Transact*. *Intell*. *Transp*. *Syst*., 1-19. https://doi.org/10.1109/TITS.2021.3113787.

Ma, L., Liu, X. and Moradi, Z. "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, Z., Zheng, W., Chen, X. and Yin, L. (2021), "Joint embedding VQA model based on dynamic word vector", *Peer J Comput*. *Sci*., **7**, e353. https://doi.org/10.7717/peerj-cs.353.

MacMinn, C.W., Dufresne, E.R. and Wettlaufer, J.S. (2016), "Large deformations of a soft porous material", *Phys*. *Rev*. *Appl*., **5**(4), 044020. https://doi.org/10.1103/PhysRevApplied.5.044020.

Madenci, E. (2021), "Free vibration analysis of carbon nanotube RC nanobeams with variational approaches", *Adv*. *Nano Res*., **11**(2), 157-171. https://doi.org/10.12989/anr.2021.11.2.157.

Mahinzare, M., Jannat Alipour, M., Sadatsakkak, S.A. and Ghadiri, M. (2019), "A nonlocal strain gradient theory for dynamic modeling of a rotary thermo piezo electrically actuated nano FG circular plate", *Mech*. *Syst*. *Signal Pr*., **115**, 323-337. https://doi.org/10.1016/j.ymssp.2018.05.043.

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. https://doi.org/10.12989/sem.2016.60.3.471.

Marchesseau, S., Heimann, T., Chatelin, S., Willinger, R. and Delingette, H. (2010), "Fast porous visco-hyperelastic soft tissue model for surgery simulation: Application to liver surgery", *Prog*. *Biophys*. *Mole*. *Biol*., **103**(2), 185-196. https://doi.org/10.1016/j.pbiomolbio.2010.09.005.

Massoumi, F., Taheri, M., Mohammadi, A. and Amelirad, O. (2018), "Evaluation of the effect of buccolingual and apicocoronal positions of dental implants on stress and strain in alveolar bone by finite element analysis", *J*. *Dent*., **15**(1), 10.

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/10.1016/j.physa.2019.121169.

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.

Moayedi, H., Ebrahimi, F., Habibi, M., Safarpour, H. and Foong, L.K. (2021), "Application of nonlocal strain–stress gradient theory and GDQEM for thermo-vibration responses of a laminated composite nanoshell", *Eng*. *Comput*., **37**(4), 3359-3374. https://doi.org/10.1007/s00366-020-01002-1.

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.

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.

Mohammadhassani, M., Nezamabadi-Pour, H., Suhatril, M. and Shariati, M. (2013), "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., Nezamabadi-pour, H., Suhatril, M. and Shariati, M. (2014), "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.

Mohammadhassani, M., Saleh, A.M.D., Suhatril, M. and Safa, M. (2015), "Fuzzy modelling approach for shear strength prediction of RC deep beams", *Smart Struct*. *Syst*., **16**(3), 497-519. https://doi.org/10.12989/sss.2015.16.3.497.

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.

Mohammadreza, H. (2012), "Application of Schmidt rebound hammer and ultrasonic pulse velocity techniques for structural health monitoring", *Sci*. *Res*. *Essays*, **7**(21), 1997-2001. https://doi.org/10.5897/sre11.1387.

Mojtaba, D. (2011), "A new finite element investigation on pre-bent steel strips as damper for vibration control", *International J*. *Phys*. *Sci*., **6**(36), 8044-8050. https://doi.org/10.5897/ijps11.1585.

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.

Noor, A.K. (1973), "Free vibrations of multilayered composite plates", *AIAA J.*, **11**(7), 1038-1039.

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. (2020a), "Dynamic response of the nonlocal strain-stress gradient in laminated polymer composites microtubes", *Sci. Rep.*, **10**(1), 5616. https://doi.org/10.1038/s41598-020-61855-w.

Oyarhossein, M.A., Alizadeh, A.a., Habibi, M., Makkiabadi, M., Daman, M., Safarpour, H. and Jung, D.W. (2020b), "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.

Ramteke, P.M. and Panda, S.K. (2021), "free vibrational behaviour of multi-directional porous functionally graded structures", *Arab. J. Sci. Eng.*, **46**(8), 7741-7756. https://doi.org/10.1007/s13369-021-05461-6.

Rudin, C.M., Brambilla, E., Faivre-Finn, C. and Sage, J. (2021), "Small-cell lung cancer", *Nature Rev. Disease Primers*, **7**(1), 3. https://doi.org/10.1038/s41572-020-00235-0.

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., Ahmadi, M., Mehrmashadi, J., Petkovic, D., Mohammadhassani, M., Zandi, Y. and Sedghi, Y. (2020a), "Selection of the most influential parameters on vectorial crystal growth of highly oriented vertically aligned carbon nanotubes by adaptive neuro-fuzzy technique", *Int. J. Hydromechatron.*, **3**(3), 238-251.

Safa, M., Sari, P.A., Shariati, M., Suhatril, M., Trung, N.T., Wakil, K. and Khorami, M. (2020b), "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/10.1016/j.physa.2019.124046.

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.

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.

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.

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.

Sahmani, S., Aghdam, M.M. and Rabczuk, T. (2018), "Nonlocal strain gradient plate model for nonlinear large-amplitude vibrations of functionally graded porous micro/nano-plates reinforced with GPLs", *Compos. Struct.*, **198**, 51-62. https://doi.org/10.1016/j.compstruct.2018.05.031.

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.

Sari, P.A., Suhatril, M., Osman, N., Mu'azu, M.A., Dehghani, H., Sedghi, Y., Safa, M., Hasanipanah, M., Wakil, K. and Khorami, M. (2019), "An intelligent based-model role to simulate the factor of safe slope by support vector regression", *Eng. Comput.*, **35**(4), 1521-1531. https://doi.org/10.1007/s00366-018-0677-4.

Sedghi, Y., Zandi, Y., Shariati, M., Ahmadi, E., Azar, V.M., Toghroli, A., Safa, M., Mohamad, E.T., Khorami, M. and Wakil, K. (2018), "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.

Sevostianov, I. and Kachanov, M. (2000), "Impact of the porous microstructure on the overall elastic properties of the osteonal cortical bone", *J. Biomech.*, **33**(7), 881-888. https://doi.org/10.1016/S0021-9290(00)00031-2.

Seyfi, B., Santhanam, A.P. and Ilegbusi, O.J. (2016), "A biomechanical model of human lung deformation utilizing patient-specific elastic property", *J. Cancer Therapy*, **7**(6), 14. https://doi.org/10.4236/jct.2016.76043.

Seyfi Noferest, B., Santhanam, A.P. and Ilegbusi, O.J. (2015). "Effect of gravity on human lung deformation", *ASME 2015 International Mechanical Engineering Congress and Exposition*.

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.

Shariati, A. (2014), *Behaviour of C-shaped Angle Shear Connectors in High Strength Concrete*, Jabatan Kejuruteraan Awam, Fakulti Kejuruteraan, Universiti Malaya, Kuala Lumpur, Malaysia.

Shariati, A., Barati, M.R., Ebrahimi, F., Singhal, A. and Toghroli, A. (2020a), "Investigating vibrational behavior of graphene sheets under linearly varying in-plane bending load based on the nonlocal strain gradient theory", *Adv. Nano Res.*, **8**(4), 265-276. https://doi.org/10.12989/anr.2020.8.4.265.

Shariati, A., Barati, M.R., Ebrahimi, F. and Toghroli, A. (2020b), "Investigation of microstructure and surface effects on vibrational characteristics of nanobeams based on nonlocal couple stress theory", *Adv. Nano Res.*, **8**(3), 191-202. https://doi.org/10.12989/anr.2020.8.3.191.

Shariati, A., Bayrami, S.S., Ebrahimi, F. and Toghroli, A. (2020c), "Wave propagation analysis of electro-rheological fluid-filled sandwich composite beam", *Mech. Based Des. Struct.*, 1-10. https://doi.org/10.1080/15397734.2020.1745646.

Shariati, A., Ebrahimi, F., Hosseini, S.H.S., Toghroli, A. and Bayrami, S.S. (2020d), "On the nonlinear dynamics of viscoelastic graphene sheets conveying nanoflow: Parametric excitation analysis", *Mech. Based Des. Struct.*, 1-18.

https://doi.org/10.1080/15397734.2020.1728544.

Shariati, A., Ebrahimi, F., Karimiasl, M., Selvamani, R. and Toghroli, A. (2020e), "On bending characteristics of smart magneto-electro-piezoelectric nanobeams system", *Adv. Nano Res.*, **9**(3), 183-191. https://doi.org/10.12989/anr.2020.9.3.183.

Shariati, A., Ebrahimi, F., Karimiasl, M., Vinyas, M. and Toghroli, A. (2020f), "On transient hygrothermal vibration of embedded viscoelastic flexoelectric/piezoelectric nanobeams under magnetic loading", *Adv. Nano Res.*, **8**(1), 49-58. https://doi.org/10.12989/anr.2020.8.1.049.

Shariati, A., Ghabussi, A., Habibi, M., Safarpour, H., Safarpour, M., Tounsi, A. and Safa, M. (2020g), "Extremely large oscillation and nonlinear frequency of a multi-scale hybrid disk resting on nonlinear elastic foundation", *Thin Wall. Struct.*, **154**, 106840. https://doi.org/10.1016/j.tws.2020.106840.

Shariati, A., Habibi, M., Tounsi, A., Safarpour, H. and Safa, M. (2020h), "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., Habibi, M., Tounsi, A., Safarpour, H. and Safa, M. (2021a), "Application of exact continuum size-dependent theory for stability and frequency analysis of a curved cantilevered microtubule by considering viscoelastic properties", *Eng. Comput.*, **37**(4), 3629-3648. https://doi.org/10.1007/s00366-020-01024-9.

Shariati, A., Hosseini, S.H.S., Bayrami, S.S., Ebrahimi, F. and Toghroli, A. (2021b), "Effect of residual surface stress on parametrically excited nonlinear dynamics and instability of viscoelastic piezoelectric nanoelectromechanical resonators", *Eng. Comput.*, **37**(3), 1835-1850. https://doi.org/10.1007/s00366-019-00916-9.

Shariati, A., Hosseini, S.H.S., Ebrahimi, F. and Toghroli, A. (2021c), "Nonlinear dynamics and vibration of reinforced piezoelectric scale-dependent plates as a class of nonlinear Mathieu–Hill systems: parametric excitation analysis", *Eng. Comput.*, **37**(3), 2285-2301. https://doi.org/10.1007/s00366-020-00942-y.

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

Shariati, A., Jung, D.W., Mohammad-Sedighi, H., Zur, K.K., Habibi, M. and Safa, M. (2020j), "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, A., Mohammad-Sedighi, H., Żur, K.K., Habibi, M. and Safa, M. (2020k), "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. (2020l), "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, A., Qaderi, S., Ebrahimi, F. and Toghroli, A. (2020m), "On buckling characteristics of polymer composite plates reinforced with graphene platelets", *Eng. Comput.*, 1-12. https://doi.org/10.1007/s00366-020-00992-2.

Shariati, M., Davoodnabi, S.M., Toghroli, A., Kong, Z.Y. and Shariati, A. (2021d), "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/10.1016/j.compstruct.2021.114524.

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., Mafipour, M.S., Ghahremani, B., Azarhomayun, F., Ahmadi, M., Trung, N.T. and Shariati, A. (2020n), "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. (2020o), "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. (2020p), "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., Bahadori, A., Zandi, Y., Salih, M.N.A., Nguyen, H., Dou, J., Song, X. and Poi-Ngian, S. (2019b), "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/10.3390/app9245534.

Shariati, M., Mafipour, M.S., Mehrabi, P., Shariati, A., Toghroli, A., Trung, N.T. and Salih, M.N. (2020q), "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., Mafipour, M.S., Mehrabi, P., Zandi, Y., Dehghani, D., Bahadori, A., Shariati, A., Trung, N.T., Salih, M.N.A. and Poi-Ngian, S. (2019c), "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., Naghipour, M., Yousofizinsaz, G., Toghroli, A. and Tabarestani, N.P. (2020r), "Numerical study on the axial compressive behavior of built-up CFT columns considering different welding lines", *Steel Compos. Struct.*, **34**(3), 377-391. https://doi.org/10.12989/scs.2020.34.3.377.

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. (2019d), "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., 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+)*.

Shariati, M., Trung, N.T., Wakil, K., Mehrabi, P., Safa, M. and Khorami, M. (2019e), “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.

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/10.1177/0954406219883312.

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.

Sinaei, H., Shariati, M., Abna, A.H., Aghaei, M. and Shariati, A. (2012), “Evaluation of reinforced concrete beam behaviour using finite element analysis by ABAQUS”, *Sci*. *Res*. *Essays*, **7**(21), 2002-2009. https://doi.org/10.5897/SRE11.1393.

Tang, Y., Liu, S., Deng, Y., Zhang, Y., Yin, L. and Zheng, W. (2021), “An improved method for soft tissue modeling”, *Biomed*. *Signal Pr*. *Control*, **65**, 102367. https://doi.org/10.1016/j.bspc.2020.102367.

Tlidji, Y., Benferhat, R., Trinh, L.C., Tahar, H.D. and Abdelouahed, T. (2021), “New state-space approach to dynamic analysis of porous FG beam under different boundary conditions”, *Adv*. *Nano Res*., **11**(4), 347-359. https://doi.org/10.12989/anr.2021.11.4.347.

Toghroli, A. (2015), *Applications of the ANFIS and LR models in the prediction of shear connection in composite beams*, Jabatan Kejuruteraan Awam, Fakulti Kejuruteraan, Universiti Malaya, Kuala Lumpur, Malaysia.

Toghroli, A., Darvishmoghaddam, E., Zandi, Y., Parvan, M., Safa, M., Abdullahi, M.M., Heydari, A., Wakil, K., Gebreel, S.A.M. and Khorami, M. (2018), “Evaluation of the parameters affecting the Schmidt rebound hammer reading using ANFIS method”, *Compu*. *Concr*., **21**(5), 525-530. https://doi.org/10.12989/cac.2018.21.5.525.

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., Nasirianfar, M.S., Shariati, A., Khorami, M., Paknahad, M., Ahmadi, M., Gharehaghaj, B. and Zandi, Y. (2020), “Analysis of extended end plate connection equipped with SMA bolts using component method”, *Steel Compos*. *Struct*., **36**(2), 213-228. https://doi.org/10.12989/scs.2020.36.2.213.

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.

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.

van Meerbeeck, J.P., Fennell, D.A. and De Ruysscher, D.K.M. (2011), “Small-cell lung cancer”, *The Lance*, **378**(9804), 1741-1755. https://doi.org/10.1016/S0140-6736(11)60165-7.

Wang, A., Chen, H., Hao, Y. and Zhang, W. (2018), “Vibration and bending behavior of functionally graded nanocomposite doubly-curved shallow shells reinforced by graphene nanoplatelets”, *Results Phys*., **9**, 550-559. https://doi.org/10.1016/j.rinp.2018.02.062.

Wang, Y., Zou, R., Liu, F., Zhang, L. and Liu, Q. (2021), “A review of wind speed and wind power forecasting with deep neural networks”, *Appl*. *Energy*, **304**, 117766. https://doi.org/10.1016/j.apenergy.2021.117766.

Wang, Z., Yu, S., Xiao, Z. and Habibi, M. (2020), “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.

Xu, C.H., Zhang, X.L., Haido, J.H., Mehrabi, P., Shariati, A., Mohamad, E.T., Nguyen, H. and Wakil, K. (2019), “Using genetic algorithms method for the paramount design of reinforced concrete structures”, *Struct*. *Eng*. *Mech*., **71**(5), 503-513. https://doi.org/10.12989/sem.2019.71.5.503.

Xu, W., Pan, G., Moradi, Z. and Shafiei, N. (2021), “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.

Yan, J., Yao, Y., Yan, S., Gao, R., Lu, W. and He, W. (2020), “Chiral protein supraparticles for tumor suppression and synergistic immunotherapy: an enabling strategy for bioactive supramolecular chirality construction”, *Nano Lett*., **20**(8), 5844-5852. https://doi.org/10.1021/acs.nanolett.0c01757.

Yang, N., Moradi, Z., Khadimallah, M.A. and Arvin, H. (2022), “Application of the Chebyshev–Ritz route in determination of the dynamic instability region boundary for rotating nanocomposite beams reinforced with graphene platelet subjected to a temperature increment”, *Eng*. *Anal*. *Bound*. *Elem*., **139**, 169-179. https://doi.org/10.1016/j.enganabound.2022.03.013.

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.

Yegnanarayana, B. (2009), *Artificial Neural Networks*, PHI Learning Pvt. Ltd.

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.

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.

Zeiler, M.D. (2012), “Adadelta: an adaptive learning rate method”, *arXiv preprint arXiv:1212.5701*.

Zhang, B., Li, H., Kong, L., Shen, H. and Zhang, X. (2020a), “Coupling effects of surface energy, strain gradient, and inertia gradient on the vibration behavior of small-scale beams”, *Int*. *J*. *Mech*. *Sci*., **184** 105834. https://doi.org/10.1016/j.ijmecsci.2020.105834.

Zhang, M., Chen, Y. and Lin, J. (2021a), “A privacy-preserving optimization of neighborhood-based recommendation for medical-aided diagnosis and treatment", *IEEE Internet Things J*., **8**(13), 10830-10842. https://doi.org/10.1109/JIOT.2021.3051060.

Zhang, T., Liang, H., Wang, Z., Qiu, C., Peng, Y.B., Zhu, X., Li, J., Ge, X., Xu, J. and Huang, X. (2022a), "Piezoelectric ultrasound energy–harvesting device for deep brain stimulation and analgesia applications", *Sci. Adv*., **8**(15), eabk0159. https://doi.org/10.1126/sciadv.abk0159.

Zhang, T., Wang, Z., Liang, H., Wu, Z., Li, J., Ou-Yang, J., Yang, X., Peng, Y.B. and Zhu, B. (2022b), "Transcranial focused ultrasound stimulation of periaqueductal gray for analgesia", *IEEE T. Biomed. Eng*., 3155-3162. https://doi.org/10.1109/TBME.2022.3162073.

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, 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, Z., Ma, P., Ahmed, R., Wang, J., Akin, D., Soto, F., Liu, B.F., Li, P. and Demirci, U. (2022c), "Advanced point-of-care testing technologies for human acute respiratory virus detection", *Adv. Mater*., **34**(1), 2103646. https://doi.org/10.1002/adma.202103646.

Zhao, Y., Moradi, Z., Davoudi, M. and Zhuang, J. (2022), "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.

Zheng, W., Liu, X. and Yin, L. (2021a), "Research on image classification method based on improved multi-scale relational network", *Peer J Comput. Sci*., **7**, e613. https://doi.org/10.7717/peerj-cs.613.

Zheng, Y., Jiang, Y. and Cao, Y. (2021b), "A porohyperviscoelastic model for the shear wave elastography of the liver", *J. Mech. Phys. Solids*, **150**, 104339. https://doi.org/10.1016/j.jmps.2021.104339.

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.

JL