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List of Symbols

x_1, x_2, x_3	Cartesian coordinate system
U_1, U_2, U_3	3D displacements in the global x_1, x_2 and x_3- direction
u_1, u_2, u_3	Mid-plane displacement components in the x_1, x_2 and x_3-direction
β_1, β_2	Rotation of the transverse normal to the mid-plane about x_2 and x_1-direction
$\alpha_{1u}^i, \alpha_{1l}^j, \alpha_{2u}^i, \alpha_{2l}^j$	Auxiliary variables defined at the interfaces of the multi-layered plate structures in the x_1 and x_2-direction
$\{\sigma\}$	Stress vector in the global coordinate system
$\{\varepsilon\}$	Strain vector in the global coordinate system
$[\bar{Q}]$	Transformed reduced stiffness matrix
$\{\bar{\sigma}\}$	Stress vector in the material coordinate axis
$\{\bar{\varepsilon}\}$	Strain vector in the material coordinate axis
$[Q]$	Reduced stiffness matrix
E_{11}, E_{22}	Young's Modulus in the longitudinal and transverse direction to the fiber direction
G_{12}	In-plane shear modulus
G_{13}, G_{23}	Transverse shear modulus
$\{\bar{E}\}$	Electric field vector in the material coordinate axis
$[\epsilon]$	Electric permittivity matrix in the material coordinate axis
$\{\bar{D}\}$	Electric displacement vector in the material coordinate axis
$\{E\}$	Electric field vector in the global coordinate axis
$[\bar{\epsilon}]$	Electric permittivity matrix in the global coordinate axis
$\{D\}$	Electric displacement vector in the global coordinate axis
k_w	Winkler stiffness of the foundation
k_s	Shear stiffness of the foundation

p_1, p_2, q_1, q_2	Mathematical functions of the thickness coordinate
U	Strain energy of the smart laminated composite plate
U_F	Strain energy of the elastic foundation
W	Work potential of the applied loads
K	Kinetic energy of the smart laminated composite plate
N_{11}, N_{12}, N_{22}	In-plane stress resultants
M_{11}, M_{12}, M_{22}	Moment stress resultants
N_{11}^*, N_{12}^*	Higher-Order In-plane stress resultants
M_{22}^*, M_{12}^*	Higher-Order moment stress resultants
Q_1, Q_2	Transverse shear stress resultants
T_1^*, T_2	Higher-Order transverse shear stress resultants
h	Overall thickness of the laminated composite plate
t_p	Thickness of the piezoelectric actuator and sensor
q	Mechanical pressure
$\bar{I}_0, \bar{I}_1, \bar{I}_2, \bar{I}_3,$ $\bar{I}_4, \bar{I}_5, \bar{I}_6, \bar{I}_7, \bar{I}_8$	Inertia components
$[A], [B], [C], [D],$ $[G], [H], [I], [L],$ $[M], [P]$ $[AA], [EE], [FF];$ $[SS], [TT], [UU]$	Rigidity submatrices relating the stress-resultants and derivatives of the primary variables
$\{A\}, \{C\}, \{E\}, \{G\},$ $\{L\}, \{N\}, \{P\}$	Forces generated due to piezoelectric coefficients
V	Electric voltage
NL	Number of layers in the smart laminated plate
Φ	Electric potential
$[\bar{K}]$	Stiffness matrix of the smart composite plate
$\{\Delta\}$	Displacement vector
$\{\bar{F}_M\}$	Mechanical force vector
$\{\bar{F}_E\}$	Electrical force vector

ω	Natural frequency of the plate
$[\bar{M}]$	Mass matrix
$[\overline{N_\iota}]$	Shape function matrix
ξ, η	Natural coordinate system used in finite element
$\{d^e\}$	Nodal coordinates
$\rho^{(s)}, \rho^{(k)}, \rho^{(a)}$	Density of piezoelectric sensor, laminated composite plate and actuator, respectively
$[H]$	Matrix relating the strains and derivatives of the primary variables
$[B]$	Matrix relating the derivatives of the primary variables and the nodal coordinates
$\{V(t)^e\}$	Elemental electric force vector
$\{\dot{d}^e\}$	Elemental velocity force vector
P_e	Penalty function
$[K^{(s)}]$	Elemental stiffness matrix of sensor
$[K]$	Elemental stiffness matrix of laminated plate
$[K^{(a)}]$	Elemental stiffness matrix of actuator
$[K_{ds}]$	Piezoelectric coupling matrix of the sensor
$[K_{da}]$	Piezoelectric coupling matrix of the actuator
$[K_{pe}]$	Elemental penalty stiffness matrix
$[K^{(F)}]$	Elemental stiffness matrix of the foundation
$\{F_M\}$	Elemental force vector
$[M]$	Elemental mass matrix
L	Lagrangian
$\{\bar{\mathbf{F}}_{\boldsymbol{M}}\}$	Global mechanical force vector
$[\bar{\mathbf{M}}]$	Global mass matrix
$[\bar{\mathbf{K}}^{(s)}]$	Global stiffness matrix of the sensor
$[\bar{\mathbf{K}}]$	Global stiffness matrix of the laminated composite plate

$[\bar{\mathbf{K}}^{(a)}]$	Global stiffness matrix of the actuator
$[\bar{\mathbf{K}}^{(F)}]$	Global stiffness matrix of the foundation
$[\bar{\mathbf{K}}^{(pe)}]$	Global stiffness matrix containing the penalty terms
G_c	Constant gain of the amplifier
G	Gain of the amplifier
$[C_R]$	Rayleigh damping matrix
$[\boldsymbol{C_{cnt}}]$	Active damping matrix

Abbreviations

3 D	Three Dimensional
2 D	Two Dimensional
CLPT	Classical Laminated Plate Theory
CPT	Classical Plate Theory
FSDT	First Order Shear Deformation Theory
HSDT	Higher-Order Shear Deformation Theory
FRP	Fiber Reinforced Polymers
FGM	Functionally Graded Material
PZT	Lead Zirconate Titanate
PVDF	Polyvinylidene Fluoride
PFRC	Piezoelectric Fiber-Reinforced Composites
ESL	Equivalent Single Layer
LW	Layerwise
ZZ	Zigzag
PHSDT	Polynomial Higher-Order Shear Deformation Theory
NPHSDT	Non-Polynomial Higher-Order Shear Deformation Theory
ODE	Ordinary Differential Equation
PDE	Partial Differential Equation
FEM	Finite Element Method
SBFEM	Scaled Boundary Finite Element Method
IGA	Isogeometric Analysis
XFEM	Extended Finite Element Method
FDM	Finite Difference Method
DSC	Discrete Singular Convolution
DQM	Differential Quadrature Method

CUF	Carrera Unified Formulation
EE	Equilibrium Equations
EKM	Extended Kantorovich method
SCF	Shear-Correction Factor
RHZZT	Refined Higher-Order Zigzag Theory
RFSDT	Refined First Order Shear Deformation Theory
FN	Fundamental Nucleus
BEM	Boundary Element Method
TZZT	Trigonometric Zigzag Theory
AVC	Active Vibration Control
UDL	Uniformly Distributed Load
SSL	Sinusoidal Load
MM	Material Model
ND	Non-Dimensional Parameter