ASPS Conference Proceedings 1: 83-88 (2022)

Proceedings of

12th Structural Engineering Convention - An International Event (SEC 2022)

Available at https://asps-journals.com/index.php/acp

Review on laminated composite plates

D.Dibyajyoti[1,*], B.Alfia [1]

[1]*Department of civil engineering, NIT Raipur, Chhattisgarh, India*

Paper ID - 010258

Abstract

A composite material is a combination of different material which can be assembled to provide required engineering properties like bending, buckling, stiffness etc. It can give better properties than those of individual components. A lamina is the building block of modern composite laminated structures. A lamina is also known as a ply, or a layer. A laminate has several layers of lamina, or *laminae*. Since the early years of engineering, various types of laminated composite materials have been used in various engineering fields, such as in aerospace, military and automotive industries that are subjected to high temperatures. Thermal stress caused due to change in temperature, increase in temperature causes the changes in material properties of a plate which in turn complicates the analysis and design and may affect the structure also. Therefore, the analysis of thermal stress in design of structure is very important. A critical review of available literature for the prediction of the behaviour of laminated composites under thermal conditions is carried out and summarized. This work attempts to review the studies carried out from 2000 on laminated composite plates by representing classification based on Classical laminate plate concept, First order shear deformation theory, Higher order shear deformation theory, Layerwise theory and Thermal stress on laminated plates.

Keywords: composite material, laminate, thermal stress, laminate composite.

1. INTRODUCTION

A lamina is the building block of modern composite laminated structures. A lamina is also known as a ply, or a layer. Each lamina may have in itself more than one types of fibers. These fibers may be oriented in different directions. A laminate has several layers of lamina, or laminae. In laminate each lamina may hold one or more than one type of fiber, they may be acquainted in nonidentical directions. The plates made of laminated composite materials have some superior properties as compared to metal and ceramic materials. Therefore, the need for these materials is increasing nowadays. Now a days the high requirement of composite materials in engineering fields led to the use of laminated composite plates as structural components in various engineering field due to their very good mechanical properties. With the increased use of these laminated plates in engineering fields and in thermal environment the thermal stress analysis of laminated composite plates has arises. A variation in temperature of a body causes a change in its dimension, proportional to the change in temperature and its initial dimensions. The thermal stress can be an important feature which will affect the laminate plate and may be one of the main reasons for the failure of the composite structure, hence development of precise computational models or computational problems for the analysis of thermal stress of laminates has continuously stayed an area of research.

Normally, following are the categories of laminated plate theories:

(a) Equivalent-single layer (ESL) theories, including
   Classical laminate plate theory (CLPT)
   The First-order shear deformation theory (FSDT)
   The Higher-order shear deformation theories (HSDT)

(b) The Layer-wise lamination theory (LLT) and

(c) Zig-Zag theories.

In general, there are two different approaches (1) The single layer theory and (2) The discrete layer theories. The former focuses on the study of single layer structures i.e considering the whole composite as a single layer while the latter considers the layers individually. There are two kinds of theories related to plate deformation: stress-based theories and displacement theories. There are two categories of displacement-based theories: the classical laminated plate theory and the shear deformation plate theories. These theories can be divided into two groups: the global higher-order theory and the local higher-order theory. In this study,

*Corresponding author. Tel: +917894355641; E-mail address: dibyajyoti.dash14@gmail.com

Published online: December 19, 2022
doi:10.38208/acp.v1.477

we will discuss various theories related to the thermal stress behavior of composite materials.

Since the classical plate theory does not take into account the transverse shear effect. This concept is not suitable for the analysis of thick plate. A work on finite element formulation using Mindlin's (1951) first-order shear deformation theory (FSDT) was presented by Reddy and Hsu (Reddy, 1980) [21] for the thermal analysis of laminated composite plates. Reddy (1984) has developed a simple third order shear deformation theory for the study of laminated composite plates. EN, F LIN and L CHEN (Chen, (1991).) [7] presented a literature on thermal buckling behavior of thick laminated plates under non uniform temperature distribution. An analysis of the buckling behavior of composite laminated plates given uniform or nonuniform thermal fields was illustrated using finite element techniques. It had been shown that geometry, modulus ratio, plate aspect ratio, and boundary constraints significantly affect the critical buckling temperature.

2. CLASSICAL LAMINATED PLATE THEORY:

The classical laminate plate theory is primarily built totally upon the belief that the laminate is thin. 'CLPT' is the simplification of 3 dimensions to 2 dimensional problems. In CLPT It is assumed that lines which are straight and normal to the neutral surface before deformation remain straight and normal after deformation. Since CLPT does not include transverse stresses, it can't accurately analyse thick plates. This is especially true for composite plates, which have low shear modulus. Due to its simplicity, CLPT was extended to composite plate analysis besides its limitations. Onur Sayman, Numan B. Bektas ((Bektaş, (2001))) [2] derived the analytical solution for thermoplastic-plastic stress-strain relationship. A mathematical solution is provided which satisfies the thermoelasto-plastic stress/strain relationship and boundary conditions for small plastic deformations of the composite materials with a Tsai-Hill yield criteria. Sayman (2002) ((Sayman, (2002))) [24] determined the residual stresses in thermoplastic laminated symmetrical plates under a linear thermal load by using the elastic-plastic theory. It was observed that symmetric laminates also produce high stresses at or around the boundary of the elastic-plastic region. Specifically, the magnitude of the equivalent stress was found to be large only in the principal material direction of the symmetric cross-ply laminate. Yujun Wen Cemal Basaran [33](Wen, 2005) analyzed the thermal stress of multi-layer microelectronic packaging in an analytical model. They proposes an analytical model for thermal stress analysis of multi-layered thin stacks on a thick substrate under isothermal loading. Based on classical plate theory, an analytical procedure for calculating interfacial shear and peeling stresses in layered structures under thermal gradient is presented in this paper. Comparing analytical, experimental, and finite element analyses shows that no matter how fine a mesh is, it cannot capture even qualitatively how the free edge actually behaves.

While CLPT has limitations, it is still a common approach for predicting the behavior of thin plated structures, especially for quick and simple predictions. It simplifies the simulation process by treating structural plates or shells as thin 2D plates located at mid-thickness instead of 3D thick plates, resulting in a reduction in variables and equations, and time and effort saved during computation. In closed-form solutions, the governing equations are easier to solve and provide a more physical or practical interpretation. This method is still widely used since it is well-known and has served as a foundation for other composite plate analysis methods. Marco Gigliotti, Fre´de´ric Jacquemin, Je´roˆme Molimard, Alain Vautrin (Gigliotti, 2007) [12] they modeled and simulated hygrothermoelastic stresses in composite laminated plates. The hygrothermal fields are established using Fick's law for transient and cyclical environmental conditions, and then the classical laminated plate theory is used to account for these conditions. Unsymmetric samples have been found to be reliable tools for determining the coefficients of thermal and moisture expansion (CTEs and CMEs) of composite laminates. P. Jeyaraj, N. Ganesan, Chandramouli Padmanabhan (Jeyaraj, 2009) [13] investigated that in a temperature environment, vibration and acoustic response of a composite plate with intrinsic material damping. Numerical analyses of the vibration and acoustic response characteristics of a fiber-reinforced composite plate in a temperature environment are presented in this study, which take into account the composite material's inherent material damping property. After determining the critical buckling temperature, free and forced vibration evaluations are performed, with the pre-stress due to the imposed thermal environment taken into account.

3.FIRST ORDER SHEAR DEFORMATION THEORY:

To account for the transverse shear effect in thicker laminated composite plates, several ideas have been offered. Most of these theories are expansions of the shear deformation plate theories published by Reissner and Mindlin. These theories are founded on the premise that the displacement w remains constant throughout the thickness of each layer, whereas the displacements u and v fluctuate linearly. According to this hypothesis, transverse straight lines that were straight before deformation would remain straight after deformation, but they will no longer be normal to the mid-plane.

Optimizing of the thermal buckling load of laminated composite plates was studied by U. Topal, Uzman (Topal, 2008) [30]. In this paper the application of the Modified Feasible Direction (MFD) approach to the thermal buckling optimization of laminated plates under uniformly distributed temperature load is examined in this study. The goal is to optimize the critical temperature capacity of laminated plates, with fiber orientation acting as a design variable. The goal was to optimize the critical temperature capacity of laminated plates. The effect of shear deformation and anisotropy on the thermal bending of layered composite plates were examined by J. N. Reddy and Y. S. Hsu. (Reddy J. N., 1980) [22]. The equations governing multilayer anisotropic composite plates subjected to mechanical and thermal loads were formulated using finite element method. The effect of shear deformation was included in the element, which has five degrees of freedom per node (three deflections and two slope functions). The convergence of linear and quadratic elements was demonstrated numerically, and results were reported for cross-ply and angle-ply rectangular plates exposed to sinusoidal and uniform loadings; thermal, mechanical, and combination loadings were all taken into account. The spline finite strip method was used to calculate thermal buckling of shear-deformable composite laminated plates. By D.J. Dawe, Y.S. Ge (Dawe, 2000) [8]. The critical buckling temperatures of rectangular composite laminated plates subjected to a temperature field have been predicted using a spline finite strip capability. The breakthrough was made within the framework of first-order shear deformation plate theory. It allows for solutions to be found for laminates with a variety of layup types, as long as the combination of layup, boundary conditions, and temperature field causes buckling. Using a three-node isoparametric element, the thermal buckling behaviour of shear flexible laminated anisotropic plates was investigated. H.R.H. Kabir Hasan Askar, R.A. Chaudhuri (Kabir, 2003)[14]. The plate element is based on the first-order shear deformation theory and is best suited for medium-thick plates, but it can also handle thin plates with ease. The findings obtained with the current element are compared to those obtained with NASTRAN's QUAD4 element (which only supports symmetric laminates) and ANSYS' SHELL99 element.

M.E. Fares, Y.G. Youssif, and M.A. Hafiz (Fares, 2004) [9] examined structural and control optimization of composite laminated plates for maximal thermal buckling and minimal dynamic response. In a multi objective formulation of the design and control problem for a symmetric cross-ply laminate with simply supported edges, the optimal layer thickness and optimal closed loop control function are determined. The primary goals of this research are to maximize the critical mix of applied edge loads and temperature levels while minimizing the laminate dynamic response. The design and control objectives are formulated using a first-order shear deformation theory that is consistent without the need of a shear correction factor. Tsung-Lin Wu, K.K. Shukla, and Jin H. Huang (Wu, 2007) [34] explored the post-buckling analysis of functionally graded rectangular plates. Using Chebyshev series solution approach, the post-buckling response of a FGM plate is determined directly. Thermal buckling of a hole in a hybrid angle-ply laminated composite plate was investigated by Omer Sinan Sahin (Şahin, 2005) [23]. Thermal buckling analysis of symmetric and antisymmetric laminated hybrid composite plates with a hole subjected to a homogeneous temperature rise is provided in this work for various boundary conditions. In the mathematical formulation, the first-order shear deformation theory is used in conjunction with the variational energy approach. Optimizing the thermal buckling load of laminated composite plates was presented by U. Topal, U. Uzman (Topal U. M., 2008) [30]. Hiroyuki Matsunaga (Matsunaga, 2009) [20] cites a stress analysis of functionally graded plates subjected to thermal and mechanical loadings. For the evaluation of displacements and stresses in functionally graded (FG) plates subjected to thermal and mechanical loadings, a two-dimensional (2D) higher-order deformation theory is proposed. Load optimization of laminated skew plates for thermal buckling was presented by U. Topal, U Uzman (Topal U. a., 2009) [29] The optimization of thermal buckling load of laminated skew plates subjected to evenly distributed temperature load is addressed in this study. The boundary conditions of all of the laminates discussed are assumed to be entirely clamped, although the general boundary conditions can also be studied without trouble. The target function is to maximize the laminated skew plates' critical temperature capacity, and the fibre orientation is a design variable. The mathematical formulation employs first-order shear deformation theory.

4.HIGHER ORDER SHEAR DEFORMATION THEORY:

The higher-order models are based on a nonlinear stress fluctuation through thickness assumption. These theories can depict section warping in a deformed structure. However, several of these models fail to meet the transverse shear stress continuity requirements at the layer interfaces. Although discrete layer theories do not have this issue, because the order of their governing equations is dependent on the number of layers, they are substantially more labor costly and computationally slow when solving such issues.

Thermal buckling behavior of skew fibre-reinforced composite and sandwich plates using shear deformable finite element models was proposed by T. Kant and C.S. Babu (Kant, (2000) ") [16] in a literature. The elastic buckling of skew fiber-reinforced composite and sandwich plates subjected to temperature loads was studied. Thermal buckling solutions were obtained using two shear deformable finite element models, one based on first-order shear deformation theory and the other based on higher order shear deformation theory. For thin and thick laminated composite plates with varying skew degrees, lamination parameters, and boundary conditions, extensive numerical results are presented. For various geometric parameters and skew angles, a few results for skew sandwiches are produced. A.K. Upadhyay, Ramesh Pandey, and K.K. Shukla (Upadhyay, 2010) [32] demonstrated nonlinear flexural response of laminated composite plates under hygro-thermo-mechanical loading. Using fast converging finite double Chebyshev series, analytical solutions to the nonlinear flexural response of a fairly thick laminated composite plate subjected to hygro-thermo-mechanical loading are produced. The flexural response of the laminated composite plate deteriorates significantly as temperature and moisture concentration rise, and this hygrothermal environment becomes increasingly harmful as the working temperature approaches the glass transition point. A. M. Zenkour and N. A. Alghamdi (Zenkour, 2010) [35] investigated the bending of functionally graded sandwich plates under the influence of mechanical and thermal loads. The bending response of Sandwich plates subjected to thermomechanical loads have investigated. The modulus of elasticity, Poisson's ratio, and thermal expansion coefficient of the sandwich plate faces are assumed to vary according to a power law distribution in terms of the volume fractions of the constituents, and the sandwich plate faces are assumed to have isotropic, two-constituent (metal-ceramic) material distribution through the thickness. Wu Zhen and Tian Li (Zhen, 2013) [36] studied a C0-type global–local higher-order theory for laminated composite plates under thermal loading that included transverse normal thermal strain. For the thermal stress analysis of simply supported laminated composite plates subjected to thermal loads, a C0-type global–local higher-order theory with the inclusion of transverse normal thermal strain was proposed in this study. Even in the situation of thick multilayer composite plates, the proposed higher-order theory was acceptable when compared to the conclusions of the three-dimensional theory. S.M. Shiyekar and Tarun Kant (Kant T. &., 2013) [15] investigated a higher-order theory for composite laminates subjected to thermal gradients. For thermal stress analysis of composite laminates, an efficient higher order shear and normal deformation theory with twelve degrees of freedom in the principal displacement field HOSNT12 [1] is proposed. In addition to planner directions, the current theory accounts for the thermal expansion coefficient in the transverse normal direction. Thermal loading is considered across cross-ply laminates with double sinusoidal variation along x and y directions and linear or gradient thermal fields along thickness direction. K. Swaminathan and Reginald Fernandes (Swaminathan, 2013) [28] investigated a higher order computational model for the thermo-elastic analysis of cross-ply laminated composite plates. Based on higher order refined theory, analytical formulations and solutions for stress analysis of simply supported cross-ply laminated composite plates subjected to thermal load are offered. In addition, for the evaluation, another higher order theory and a first-order theory produced by other researchers and already published in the literature are taken into account. The equilibrium equation is derived using the Principle of Minimum Potential Energy (PMPE). Atteshamuddin S. Sayyad, Yuwaraj M. Ghugal, and Bapusaheb A. Mhaske developed a four-variable plate theory for the thermoelastic bending analysis of laminated composite plates (Sayyad, 2015) [25] The thermoelastic bending analysis of laminated composite plates subjected to heat stress linear throughout the thickness is provided in this article utilizing the four variable refined plate theory. Other higher-order theories including first-order shear deformation theory include five unknown variables, whereas this theory has only four. Shear correction factors are not required because the theory is variationally consistent. When a plate is subjected to a thermal load linear across its thickness, numerical results for thermal displacements and stresses are reported. Atteshamuddin Shamshuddin Sayyad, Yuwaraj Marotrao Ghugal, and Bharti Machhindra Shinde (Sayyad A. S., 2016) [26] investigated the thermal stress analysis of laminated composite plates utilizing exponential shear deformation theory. An exponential shear deformation theory was used to analyse the thermal stress of cross-ply laminated composite plates. The theory accounts for transverse shear deformation and eliminates the necessity for a problem-specific shear correction factor. To account for the effect of transverse shear deformation, the theory's in-plane displacements were based on an exponential function in thickness coordinates. The theory takes into account a parabolic fluctuation of transverse shear stress throughout the plate thickness. Moumita Sit, Chaitali Ray, and Dhiraj Biswas (Sit, 2015) [27] researched Thermal Stress Analysis of Laminated Composite Plates Using Third Order Shear Deformation Theory. The third order shear deformation theory was used to analyse the laminated composite plates under thermal load. The surface of the plate is kept at a consistent temperature. An eight node isoparametric plate bending element with seven degrees of freedom per node was used to create the finite element modeling of the plate. Formulating the laminated composite plates with ANSYS 14.0 confirmed the results in terms of deflection and stresses.

5. MIXED THEORY:

Y. M. GHUGAL AND R. P. SHIMPI (Ghugal, 2001) [11] presented A Review of Refined Shear Deformation Theories for Isotropic and Anisotropic Laminated Beams. For isotropic and anisotropic laminated beams, a review of displacement and stress-based revised theories is offered. The pros and drawbacks of various equivalent single layer and layerwise theories for laminated beams are explored. Erasmo Carrera (Carrera, 2003) [5] conducted a historical assessment of Zig-Zag theories for multi-layered plates and shells. The so-called Zig-Zag theories, which describe a piecewise continuous displacement field in the plate thickness direction and ensure interlaminar continuity of transverse stresses at each layer interface, have received the most attention. The focus has been on plate and shell theories based on the so-called method of hypotheses or axiomatic approach, in which assumptions for displacements and/or transverse stresses are introduced. S. Kapuria and G.G.S. Achary (Kapuria, 2004) [17] suggested an efficient higher order zigzag theory for laminated plates subjected to thermal loading. For laminated plates under thermal loading, a novel efficient higher order zigzag theory is provided. The uniform throughout the thickness approximation for deflection is replaced with a layerwise variable approximation for deflection that explicitly accounts for the transverse thermal strain in the third order zigzag model. By satisfying the exact constraints of zero transverse shear stresses at the top and bottom, as well as their continuity at the layer interfaces, the displacement field may be described in terms of the heat field and only five primary displacement variables. The exact three-dimensional thermo-elasticity solutions for two kinds of thermal loads are compared to Navier solutions for simply-supported rectangular test plate devised for this study, composite and sandwich plates, and establishes that this efficient zigzag theory is generally more accurate than the existing zigzag theory. M. Blanc and M. Touratier (Blanc, 2007) [4] developed an effective and simple revised model for temperature analysis in thin laminated composites. Interlaminar hygrothermal stresses in laminated plates were explored by Arash Bahrami and Asghar Nosier (Bahrami, 2007) [1]. The local deformation parameters of various displacement fields are then determined using Reddy's layerwise theory. In order to confirm the efficiency and accuracy of the layerwise theory in forecasting the interlaminar normal and shear stress distributions, an elasticity solution is also created. Finally, numerical results for edge-effect problems in a variety of cross-ply, symmetric, and antisymmetric angle-ply laminates subjected to uniform hygrothermal loads are presented. All of the results point to high interlaminar normal and shear stress gradients near the laminate borders. A. Benkhedda, A. Tounsi, and E.A. Adda bedia (Benkhedda, 2008) [3] examined the effect of temperature and humidity on transient hygrothermal stresses during moisture desorption in laminated composite plates. For finite element analysis of extremely shear-deformable laminated anisotropic shells, Reaz A. Chaudhuri (Chaudhuri, 2008) [6] devised a nonlinear zigzag theory. A previously unavailable extremely accurate nonlinear finite element method (FEM)-based analysis tool for the prediction of massive deformation response of arbitrarily laminated highly shear-flexible general shells of arbitrary geometry is described. Layerwise theories for composite laminates and structures were presented by K.M. Liew, Z.Z. Pan, and L.W. Zhang (Liew, 2019) [19] Developing, numerically implementing, and applying. The major goal of this review was to provide the most recent developments in layerwise theories, as well as their numerical implementation and application in composite laminated structure analysis. Dinghe Li (Li, 2020) [18] provided a review on Layerwise Theories of Laminated Composite Structures and Their Applications. This study provides an overview of laminated composite structures and associated LWTs, as well as their applications. In general, there are two primary strategies for establishing a LWT based on the thickness direction creation of displacement fields. The laminated composite structures are described as an assemblage of individual layers in the first scheme. In the second technique, 1D interpolation functions are used to generate displacement and/or stress fields in the thickness direction, while 2D finite elements are used to discretize displacement and/or stress fields in the plane. Nikhil Garg, Karkhanis Rahul Sanjay, Rosalin Sahoo, P. R. Maiti, and B. N. Singh (Garg, 2020) [10] presented an assessment of the Inverse Hyperbolic Zigzag Theory for Hygro-Thermomechanical Analysis of Laminated Composite and Sandwich Plates. Using the recently established inverse hyperbolic zigzag theory, the hygro-thermomechanical reaction on the static properties of symmetric and antisymmetric laminated composite and sandwich plates is determined in this study (IHZZT). It meets the requirements for interlaminar stress continuity at the layer interfaces, as well as zero transverse shear stresses on the top and bottom surfaces of the plates. The theory comprises seven layer-independent unknown field variables. The obtained results in terms of deflections and stresses are compared to the exact results and results accessible in the literature.

6. CONCLUSION:

We can deduce from the preceding theories that each has its own set of limitations in various areas. Aside from the classical laminate plate theory, all theories for "thermal stress inspection of laminated plates" can provide some reasonable results. As now a days laminated composite plates have been used in various engineering fields so they are exposed to environment because of which they are subjected to high temperatures. Due to this buckling may occur in the composite structures. So, the analysis of thermal buckling for the composite structures is very much important and as there are extensive results available using equivalent single layer theories need for analysis using layerwise and zig-zag theories is required.

Disclosures

Free Access to this article is sponsored by SARL ALPHA CRISTO INDUSTRIAL.

REFERENCES

1. Bahrami, A. &. (2007). Interlaminar hygrothermal stresses in laminated plates. *International Journal of Solids and Structures, 44(25-26),*, 8119-8142.

2. Bektaş, N. B. ((2001)). Elasto-plastic stress analysis in simply supported thermoplastic laminated plates under thermal loads. *Composites Science and Technology,* 1695-1701.

3. Benkhedda, A. &. (2008). Effect of temperature and humidity on transient hygrothermal stresses during moisture desorption in laminated composite plates. . *Composite Structures, 82(4),* , 629-635.

4. Blanc, M. &. (2007). An efficient and simple refined model for temperature analysis in thin laminated composites. . Composite.

5. Carrera, E. (. (2003). Historical review of zig-zag theories for multilayered plates and shells. . Appl. Mech. Rev., 56(3), , 287-308.

6. Chaudhuri, R. A. (2008). A nonlinear zigzag theory for finite element analysis of highly shear-deformable laminated anisotropic shells. . Composite Structures, 85(4),, 350-359.

7. Chen, W. J. ((1991).). Thermal buckling behavior of thick composite laminated plates under nonuniform temperature distribution. . Computers & structures, 637-645.

8. Dawe, D. J. (2000). Thermal buckling of shear-deformable composite laminated plates by the spline finite strip method." . Computer Methods in Applied Mechanics and Engineering , 185.2-4 : 347-366.

9. Fares, M. E. (2004). Structural and control optimization for maximum thermal buckling and minimum dynamic response of composite laminated plates." . International Journal of Solids and Structures 41.3-4: , 1005-1019.

10.Garg, N. R. (2020). Assessment of Inverse Hyperbolic Zigzag Theory for Hygro-Thermomechanical Analysis of Laminated Composite and Sandwich Plates. . Journal of Aerospace Engineering, 33(5), , 04020060.

11. Ghugal, Y. M. (2001). A review of refined shear deformation theories for isotropic and anisotropic laminated beams. . Journal of reinforced plastics and composites, 20(3),, 255-272.

12. Gigliotti, M. J. (2007). Transient and cyclical hygrothermoelastic stress in laminated composite plates: Modelling and experimental assessment. Mechanics of materials, 729-745.

13. Jeyaraj, P. G. (2009). Vibration and acoustic response of a composite plate with inherent material damping in a thermal environment. . Journal of Sound and Vibration, 320(1-2), 322-338.

14. Kabir, H. R. (2003). Thermal buckling response of shear flexible laminated anisotropic plates using a three-node isoparametric element.". Composite structures 59, , no. 2: 173-187.

15. Kant, T. &. (2013). "An assessment of a higher order theory for composite laminates subjected to thermal gradient." . Composite Structures 96: , 698-707.

16. Kant, T. A. ((2000) "). Thermal buckling analysis of skew fibre reinforced composite and sandwich plates using shear deformable finite element models." . Composite Structures 49.1: ., 77-85.

17. Kapuria, S. &. (2004). An efficient higher order zigzag theory for laminated plates subjected to thermal loading. . International Journal of Solids and Structures, 41(16-17), ., 4661-4684.

18. Li, D. (2020). Layerwise theories of laminated composite structures and their applications: A review. Archives of Computational Methods in Engineering, , 1-24.

19. Liew, K. M. (2019). An overview of layerwise theories for composite laminates and structures: Development, numerical implementation and application. . Composite Structures, 216, , 240-259.

20. Matsunaga, H. (2009). "Stress analysis of functionally graded plates subjected to thermal and mechanical loadings." . Composite Structures 87, no. 4: ., 344-357.

21. Reddy, J. N. (1980). Effects of shear deformation and anisotropy on the thermal bending of layered composite plates. Journal of Thermal Stresses,, 475-493.

22. Reddy, J. N. (1980). Effects of shear deformation and anisotropy on the thermal bending of layered composite plates. ,. *Journal of Thermal Strsses*, 3(4), 475-493.

23. Şahin, Ö. S. (2005). Thermal buckling of hybrid angle-ply laminated composite plates with a hole. *Composites science and technology 65.11-12:* , 1780-1790.

24. Sayman, O. ,. ((2002)). Elastic-plastic and residual stresses in symmetric thermoplastic laminated plates under a linear thermal loading. . *composites science and technology*, 1231-1238.

25. Sayyad, A. S. (2015). "A four-variable plate theory for thermoelastic bending analysis of laminated composite plates." . *Journal of Thermal Stresses 38.8:* , 904-925.

26. Sayyad, A. S. (2016). Thermal stress analysis of laminated composite plates using exponential shear deformation theory. *International Journal of Automotive Composites, 2(1),* , 23-40.

27. Sit, M. C. (2015). "Thermal Stress exposition of Laminated Composite Plates Using Third Order Shear Deformation Theory." . *Advances in Structural Engineering. Springer, New Delhi,.*, 149-156.

28. Swaminathan, K. &. (2013). Higher order computational model for the thermoelastic analysis of cross-ply laminated composite plates. . *International Journal of Scientific & Engineering Research, 4(5),* , 119-122.

29. Topal, U. a. (2009). "Thermal buckling load optimization of laminated skew plates. *Materials & Design 30.7: .*, 2569-2575.

30. Topal, U. M. (2008). Thermal buckling load optimization of laminated composite plates. *Thin-Walled Structures*, 46(6), 667-675.

31. Topal, U. M. (2008). Thermal buckling load optimization of laminated composite plates. *Thin-Walled Structures, 46(6),*, 667-675.

32. Upadhyay, A. K. (2010). Nonlinear flexural response of laminated composite plates under hygro-thermo-mechanical loading.". *Communications in Nonlinear Science and Numerical Simulation 15.9:* , 2634-2650.

33. Wen, Y. &. (2005). An analytical model for thermal stress analysis of multi-layered microelectronic packaging. *Conference on High Density Microsystem Design and Packaging and Component Failure Analysis* (pp. (pp. 1-9)). IEEE.

33 (b). Wen, Y. &. (2005). An analytical model for thermal stress analysis of multi-layered microelectronic packaging. *Conference on High Density Microsystem Design and Packaging and Component Failure Analysis* (pp. (pp. 1-9)). IEEE

34. Wu, T.-L. K. (2007). Post-buckling analysis of functionally graded rectangular plate. *Composite structures 81.1:* , 1-10.

35. Zenkour, A. M. (2010). Bending analysis of functionally graded sandwich plates under the effect of mechanical and thermal loads. . *Mechanics of Advanced Materials and Structures, 17(6),*, 419-432.

36. Zhen, W. a. (2013). "C0-type global–local higher-order theory including transverse normal thermal strain for laminated composite plates under thermal loading." . *Composite Structures 101:* , 157-167.