International Journal of Research (IJR)
e-ISSN: 2348-6848, p- ISSN: 2348-795X Volume 2, Issue 10, October 2015
Available at http://internationaljournalofresearch.org

Thermal and Damping Analysis on Composite Circular Bar

1. I.Vijayakiran & 2. Perika Vijay

1. ASSISTANT PROFESSOR Bomma Institute of Technology and Science,Allipuram, Khammam, Telengana, INDIA - 507318
2. M.Tech, Bomma Institute of Technology and Science,Allipuram, Khammam, Telengana, INDIA – 507318

ABSTRACT :

Composite materials have interesting properties such as high strength to weight ratio, ease of fabrication, good electrical and thermal properties compared to metals. A laminated composite material consists of several layers of a composite mixture consisting of matrix and fibers. Each layer may have similar or dissimilar material properties with different fiber orientations under varying stacking sequence There are many open issues relating to design of these laminated composites. Design engineer must consider several alternatives such as best stacking sequence, optimum fiber angles in each layer as well as number of layers itself based on criteria such as achieving highest natural frequency or largest buckling loads of such structure. Analysis of such composite materials starts with estimation of resultant material properties User can enter the number of layers and layer orthotropic properties and the back end program calculates the extension, bending and coupling stiffness matrices and further it estimates the overall elastic constants, Poisson ratios and density. The result will be displayed in the front end interface boxes. The obtained constants are validated with an ANSYS model, where the laminate stacking sequence is built and the member is subjected to a uniform strain at free end, while the reaction stress at the fixed end is predicted. The developed interface simplifies the design process to some extent. The dynamic analysis in terms of fundamental natural frequency and critical buckling load is illustrated by using these overall material constants as a later part of analysis.

INTRODUCTION :

Laminated composite materials are extensively used in aerospace, defense, marine, automobile, and many other industries. They are generally lighter and stiffer than other structural materials. A laminated composite material consists of several layers of a composite mixture consisting of matrix and fibers. Each layer may have similar or dissimilar material properties with different fiber orientations under varying stacking sequence. Because, composite materials are produced in many combinations and forms, the design engineer must consider many design alternatives. It is essential to know the dynamic and buckling characteristics of such structures subjected to dynamic loads in complex environmental conditions. For example, when the frequency of the loads matches with one of the resonance frequencies of the structure, large translation/torsion deflections and internal stresses occur, which may lead to failure of structure components. The structural components made of composite materials such as aircraft wings, helicopter blades, vehicle axles and turbine blades can be approximated as laminated composite beams.

Definition of composite

Composites are the combinations of two materials in which one of the materials is in the form of fiber sheets which is called the reinforcing phase and these are embedded in the other materials which are called the matrix phase. A combination of two or more micro-constituents that differ in physical form and chemical composition and which are insoluble in each other can be termed as composites. To take the advantage of the superior properties of both materials without compromising on the weakness of either is the main objective for making composites. Particulate filled polymer composites have become most important because of their wide applications in various fields of science and engineering for technological developments.

Incorporation of inorganic fillers into a matrix does enhance various physical properties of the materials like mechanical strength, elastic modulus and heat transfer coefficient, thermal conductivity etc. In general, the mechanical properties of particulate filled polymer composites depend strongly on size, shape and distribution of filler particles in the polymer matrix .

Polymer composite materials have been found extremely useful for heat dissipation applications like in electronic packaging, in computer chips . Polymer composites filled with metal particles has now become interest for many fields of engineering. Adding fillers to epoxy, plastics changes the behavior of polymers and a significant increase in the effective thermal conductivity of the system has been observed.

By the type of material used for the matrix the composites are mainly classified. The reinforcing material can be either fibrous or non-fibrous (particulates) in nature. The composite materials have advantages over other conventional materials Due to their higher specific properties such as impact, tensile, flexural strengths, stiffness and fatigue characteristics the composite materials have a lot of advantage which enables for structural design applications and in a lot of fields. Epoxy resins are polyether resins containing more than one epoxy group capable of being converted into the thermoset form. In spite of the presence of a volatile solvent these resins on curing do not produce or create any volatile products. Applications for epoxy resins are extensive: adhesives, bonding, construction materials, composites, laminates, coatings, molding, and textile finishing. They have recently found uses in the spacecraft and air industries . Usually Because of their following characteristics epoxy or polyester resin systems are used for encapsulating a variety of electronic components.

☐ They have a very high moisture resistance

☐ Thermally they are very much stable

☐ They have a very low cost

But unfortunately, they have

☐ A very high value of cœfficient of thermal expansion

☐ A very low value of thermal conductivity

Laminated Composite Structures

A laminate is constructed by stacking a number of laminas in the thickness (z) direction. Each layer is thin and may have different fiber orientation. The fiber orientation, stacking arrangements and material properties influence the response from the laminate. The theory of lamination is same whether the composite structure may be a plate, a beam or a shell. Fig.1.1 shows a laminated plate or panel considered in most of the analysis.

The following assumptions are made in formulations:

(i) The middle plane of the plate is taken as the reference plane.
(ii) The laminated plate consists of arbitrary number of homogeneous, linearly elastic orthotropic layers perfectly bonded to each other.
(iii) The analysis follows linear constitutive relations i.e. obeys generalized Hooke's law for the material.
(iv) The lateral displacements are small compared to plate thickness.
(v) Normal strain in z-direction is neglected.

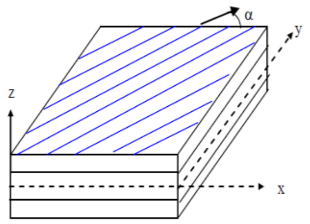
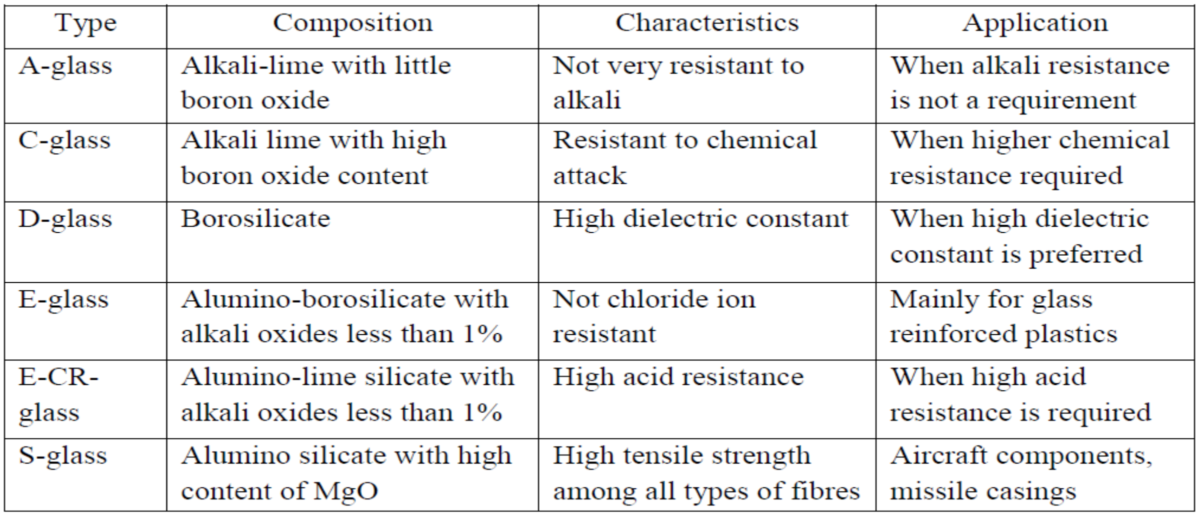


Fig.1.1 Plate

As shown in Fig.1.2, laminated beams are made-up of many plies of orthotropic materials and the principal material axes of a ply may be oriented at an arbitrary angle with respect to the x-axis. In the right-handed Cartesian coordinate system, the x-axis coincides with the beam axis and its origin is on the mid-plane of the beam. The length, breadth and thickness of the beam are represented by L, b and h, respectively.

Table 1.1 Different types of glass fibres [4]



Type	Composition	Characteristics	Application
A-glass	Alkali-lime with little boron oxide	Not very resistant to alkali	When alkali resistance is not a requirement
C-glass	Alkali lime with high boron oxide content	Resistant to chemical attack	When higher chemical resistance required
D-glass	Borosilicate	High dielectric constant	When high dielectric constant is preferred
E-glass	Alumino-borosilicate with alkali oxides less than 1%	Not chloride ion resistant	Mainly for glass reinforced plastics
E-CR-glass	Alumino-lime silicate with alkali oxides less than 1%	High acid resistance	When high acid resistance is required
S-glass	Alumino silicate with high content of MgO	High tensile strength among all types of fibres	Aircraft components, missile casings

In practical engineering applications, laminated shells of revolution may have different geometries based mainly on their curvature characteristics such as cylindrical shells, spherical shells and conical shells. The composite shell of revolution is composed of orthotropic layers of uniform thickness as shown in Fig.1.3. A differential element of a laminated shell shown with orthogonal curvilinear coordinate system located on the middle surface of the shell. The total thickness of the shell is *h*.

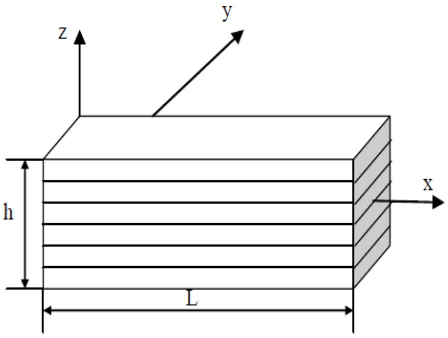


Fig.1.2 Beams

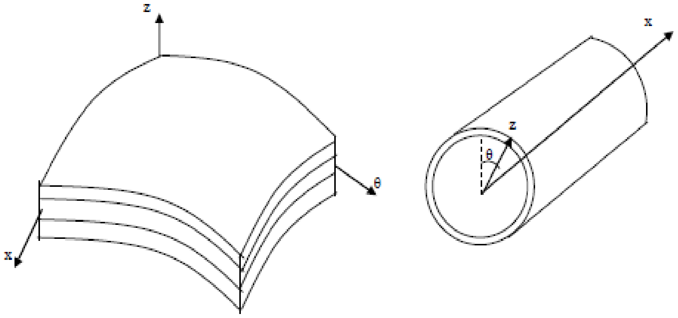


Fig.1.3 Shell (cylindrical)

Review

This section brief-outs the various earlier works done in the area of laminated composite material. These are grouped under four broad headings. More recently, Hajianmaleki presented a review of analysis of laminated composite structures used in recent decades.

Laminated Beams

Many authors analyzed the laminated beam structures. Yildirim [2] used stiffness method for the solution of the purely in-plane free vibration problem of symmetric cross-ply laminated beams. The rotary inertia, axial and transverse shear deformation effects are considered in the mathematical model by the first-order shear deformation theory. A total of six degrees of freedom, four displacements and two rotations are defined for an element. The exact in-plane element stiffness matrix of 6×6 is obtained based on the transfer matrix method. The element inertia matrix consists of the concentrated masses. The sub-space iteration and Jacobi‟s methods are employed in the solution of the large-scale general eigenvalue problem. Jun *et al*. [3] introduced a dynamic finite element method for free vibration analysis of generally laminated composite beams on the basis of first-order shear deformation theory. The influences of Poisson effect, couplings among extensional, bending and torsional deformations, shear deformation and rotary inertia are incorporated in the formulation.

The dynamic stiffness matrix is formulated based on the exact solutions of the differential equations of motion governing the free vibration of generally laminated composite beam. Gurban and Gupta [4] analyzed the natural frequencies of composite tubular shafts using equivalent modulus beam theory (EMBT) with shear deformation, rotary inertia and gyroscopic effects has been modified and used for the analysis. The modifications take into account effects of stacking sequence and different coupling mechanisms present in composite materials. Results obtained have been compared with that available in the literature using different modeling. The close agreement in the results obtained clearly show that, in spite of its simplicity, modified EMBT can be used effectively for rotor-dynamic analysis of tubular composite shafts. Yegao *et al*.[5] presented a general formulation for free and transient vibration analysis of composite laminated beams with arbitrary lay ups and any boundary conditions. A modified variational principle combined with a multi-segment partitioning technique is employed to derive the formulation based on a general higher order shear defomation theory. The material coupling for bending-stretching, bending-twist, and stretching twist as well as the poison‟s effect are taken into account.

Shell Structures

Qu et al. [6] introduced a variational formulation for predicting the free, steady-state and transient vibrations of composite laminated shells of revolution subjected to various combinations of classical and non-classical boundary conditions. A modified variational principle in conjunction with a multi-segment partitioning technique was employed to derive the formulation based on the first-order shear deformation theory. Xiang *et al*.[7] studied a simple yet accurate solution procedure based on the Haar wavelet discretization method (HWDM) is applied to the free vibration analysis of composite laminated cylindrical shells subjected to various boundary conditions. The Reissner–Naghdi‟s shell theory is adopted to formulate the theoretical model. The initial partial differential equations (PDE) are first converted into system of ordinal differential equations by the separation of variables. Then the discretizations of governing equations and corresponding boundary conditions are implemented by means of the HWDM, which leads to a standard linear eigenvalue problem.

Plates : Sahoo and Singh [8] proposed a new trigonometric zigzag theory for the static analysis of laminated composite and sandwich plates. This theory considers shear strain shape function assuming the non-linear distribution of in-plane displacement across the thickness. It satisfies the shear-stress-free boundary conditions at top and bottom surfaces of the plate as well as the continuity of transverse shear stress at the layer interfaces obviating the need of an artificial shear correction factor. Rarani *et al*. [9] used analytical and finite element methods for prediction of buckling behavior, including critical buckling load and modes of failure of thin laminated composites with different stacking sequences. A semi-analytical Rayleigh–Ritz approach is first developed to calculate the critical buckling loads of square composite laminates with SFSF (S: simply-support, F: free) boundary conditions. Then, these laminates are simulated under axially compression loading using the commercial finite element software, ABAQUS. Critical buckling loads and failure modes are predicted by both eigenvalue linear and nonlinear analysis.

Alnefaie [10] developed a 3D-FE model of delaminated fiber reinforced composite plates to analyse their dynamics. Natural frequencies and modal displacements are calculated for various case studies for different dimensions and delamination characteristics. Numerical results showed a good agreement with available experimental data. A new proposed model shows enhancement of the accuracy of the results. Sino *et al*. [11] worked on the dynamic instability of an internally damped rotating composite shaft. A homogenized finite element beam model, which takes into account internal damping, is introduced and then used to evaluate natural frequencies and instability thresholds. The influence of laminate parameters: stacking sequences, fiber orientation, transversal shear effect on natural frequencies and instability thresholds of the shaft are studied. The results are compared to those obtained by using equivalent modulus beam theory (EMBT), modified EMBT and layer wise beam theory (LBT).

Conclusion

Composite materials have interesting properties such as high strength to weight ratio, ease of fabrication, good electrical and thermal properties compared to metals. A laminated composite material consists of several layers of a composite mixture consisting of matrix and fibers. Each layer may have similar or dissimilar material properties with different fiber orientations under varying stacking sequence

By above comparison we conclude that composite bar have good thermal properties as well as damping analysis. While comparing damping analysis composite bar have very low deformation factor at same factor of ordinary bar which have large deformation factor

In thermal factors composite bar has good factors when compared to ordinary bar.

Reference

[1] M. Hajianmaleki and M. S. Qatu**,** ‘Vibrations of straight and curved composite beams: A review‟, Composite Structures, Vol. 100, pp 218-232,2013**.**

[2] V.Yildirim, „Effect of the longitudinal to transverse moduli ratio on the in-plane natural frequencies of symmetric cross-ply laminated beams by the stiffness method‟, Composite structures, vol.50, pp.319-326, 2000.

[3] L. Jun, H.Hongxing and S.Rongying, „Dynamic finite element method for generally laminated composite beams‟, Int. J.Mechanical Sciences, vol.50, pp.466-480, 2008.

[4] H.B.H.Gubran and K.Gupta, „The effect of stacking sequence and coupling mechanisms on the natural frequencies of composite shafts‟, J.Sound and Vibration, vol.282, pp.231-248, 2005.

[5] Yegao Qu, Xinhua Long, Hongguang Li, Guang Meng, „A variational formulation for dynamic analysis of composite laminated beams on a general higher-order shear deformation theory‟, Composite Structures, Vol. 102 ,175–192, 2013.

[6] Y.Qu, X. Long, S.Wu and G.Meng, „A unified formulation for vibration analysis of composite laminated shells of revolution including shear deformation

and rotary inertia‟, Composite structures, vol.98, pp.169-191, 2013.

[7] Xiang Xie, Guoyong Jin, Yuquan Yan, S.X. Shi, Zhigang Liu, „Free vibration analysis of composite laminated cylindrical shells using the Haar wavelet method‟, Composite Structures, vol. 109, pp 167-199,2014.

[8] R.Sahoo and B.N. Singh, „A new trigonometric zigzag theory for static analysis of laminated composite and sandwich plates‟, Aerospace science and technology, vol.35, pp.15-28, 2014.