Journal of Composites and Compounds 7(2025) 1-2

Available Online at www.jourcc.com

Journal homepage: www.JOURCC.com

Journal of Composites and Compounds

Thermal stability of functionally graded graphene platelet reinforced composites

Yaser Kiani [a,b] *

[a] *Faculty of Engineering, Shahrekord University, Shahrekord, Iran*

[b] *Nanotechnology Research Institute, Shahrekord University, Shahrekord, Iran*

COMMENTARY

Abstract

The thermal stability of functionally graded graphene platelet-reinforced composites (FG-GPLRCs) is influenced by the distribution and weight fraction of graphene platelets (GPLs). Different grading patterns, such as FG-X and FG-O, affect the critical buckling temperature, with FG-X providing the highest thermal resistance. The Halpin-Tsai model is commonly used to estimate elasticity modulus, while other properties are evaluated using the rule of mixtures. Studies indicate that a laminated structure with a limited number of layers can effectively mimic a continuously graded composite, making FG-GPLRCs a promising choice for high-temperature applications

ARTICLE INFORMATION

Article History:
Received 27 January 2025
Received in revised form 25 March 2025
Accepted 31 March 2025

Keywords:
Thermal buckling
Graphene platelet
Laminated composite
Critical buckling temperature

As a single atomic layer with 2D nano-structure, graphene was discovered in 2004 [1]. Graphene is a repeated structure which is composed of atoms which are joined together via bundles. Since graphene has shown extraordinary thermal and electrical conductivity, extraordinary mechanical strength and a large surface to mass ratio, it is designated as an excellent candidate for reinforcement of the composites [2-6]. Some of the main features of the graphene are 1TPa elasticity modulus, appropriate conduction capacity even better that copper and silver, and excellent stiffness even better than stainless steel. A novel class of composites was introduced by Yang [7] who joined the concepts of nanocomposites and functionally graded materials (FGMs) together. In this type of composites, a composite laminated media was introduced where each layer may have different amount of graphene platelets (GPLs). Since the weight or volume fraction of GPLs varies between layers a piecewise FGM nanocomposite is introduced. By designating various patterns of weight fraction for layers of the composite, different GPL reinforced composites may be defined where an overview of them is shown in Fig. 1.

Fig. 1. Various configurations of GPLRCs.

In Fig. 1 when a layer is darker, more weight fraction of GPL is resulted. When it comes to evaluate the thermo-mechanical properties of the composite, to evaluate the elasticity modulus, a Halpin-Tsai model is introduced. This model takes into account the elasticity modulus of components, their volume fraction and even the size of reinforcements. It is shown that this model is able to predict the elasticity modulus of composites with reasonable accuracy in comparison to experiments.

It is widely accepted that since strain gradients effects, non-local effects, and incomplete transfer of stress between matrix and GPLs are present, simple rule of mixtures is unable to predict the elasticity modulus of the composite. However, to evaluate the mass density, Poisson's ratio and thermal expansion coefficient simple rule of mixtures is widely accepted.

When it comes to thermal stability of FG-GPLRC structures, research on beam [8], on rectangular plate [9], skew plate [10] and sector plate [11] may be mentioned.

Through investigation of these works it may be concluded that the FG-X pattern of the GPLs results in the maximum critical buckling temperature of FG-GPLRCs while lower critical buckling temperatures are observed in FG-O pattern. In addition, when the impact of weight fraction of GPLs is under investigation, it is seen that its effect on critical buckling temperature of UD pattern is almost negligible. For FG-X pattern higher weight fraction of GPLs results in higher critical buckling temperature. For FG-O pattern, higher weight fraction of GPLs results in lower critical buckling temperature. An analysis on the effect of number of

* Corresponding author: Yaser Kiani, Email: y.kiani@sku.ac.ir
https://doi.org/10.61186/jcc.7.1.7

layers of FG-GPLRC, indicates that a composite laminated beam/plate with only 10 layers may serve as an excellent candidate for the FG beam/plate with continuous change of materials.

Author contributions

Yaser Kiani: Writing—Original Draft Preparation, Writing—Review and Editing.

Funding

No funding was received for this study.

Conflict of interest

Given their role as Section Editor, Yaser Kiani had no involvement in the peer-review of this article and has no access to information regarding its peer-review. Full responsibility for the editorial process for this article was delegated to another journal editor.

Data availability

No data is available.

REFERENCES

[1] K.S. Novoselov, A.K. Geim, S.V. Morozov, D. Jiang, Y. Zhang , S.V. Dubonos, I.V. Grigorieva , A. Firsov, Electric filed effect in atomically thin carbon films, Science 306 (2004) 666-669.
[2] C.D. Reddy, S. Rajendran, K.M. Liew, Equilibrium configuration and continuum elastic properties of finite sized graphene, Nanotechnology 17 (2006) 864-870.
[3] F. Scarpa, S. Adhikari, A.S. Phani, Effective elastic mechanical properties of single layer graphene sheets, Nanotechnology 20 (2009) 065709.
[4] E. Cadelano, P.L. Palla, S. Giordano, L. Colombo, Nonlinear elasticity of monolayer graphene, Physical Review Letters 102 (2009) 235502.
[5] Z. Ni, H. Bu, M. Zou, H. Yi, K. Bi, Y. Chen, Anisotropic mechanical properties of graphene sheets from molecular dynamics, Physica B: Condensed Matter 405 (2010) 1301-1306.
[6] Y.Y. Zhang, C.M. Wang, Y. Cheng, Y. Xiang, Mechanical properties of bilayer graphene sheets coupled by sp3 bonding, Carbon 49 (2011) 4511-4517.
[7] J. Yang, H. Wu, S. Kitipornchai, Buckling and postbuckling of functionally graded multilayer graphene platelet-reinforced composite beams, Composite Structures 161 (2017) 111-118.
[8] A. Haghani, Y. Kiani, Closed Form Expressions for Nonlinear Analysis of FG-GPLRC Beam Under Thermal Loading: Thermal Postbuckling and Nonlinear Bending, International Journal of Structural Stability and Dynamics 24(2) (2024) 2450016.
[7] J. Yang, H. Wu, S. Kitipornchai, Buckling and postbuckling of functionally graded multilayer graphene platelet-reinforced composite beams, Composite Structures 161 (2017) 111-118.
[8] A. Haghani, Y. Kiani, Closed Form Expressions for Nonlinear Analysis of FG-GPLRC Beam Under Thermal Loading: Thermal Postbuckling and Nonlinear Bending, International Journal of Structural Stability and Dynamics 24(2) (2024) 2450016.
[9] Y Kiani, M Mirzaei, Isogeometric thermal postbuckling of FG-GPLRC laminated plates, Steel and Composite Structures 32(6) (2019) 821-832.
[10] Y. Kiani, NURBS-based thermal buckling analysis of graphene platelet reinforced composite laminated skew plates, Journal of Thermal Stresses 43(1) (2020) 91-108.
[11] M Javani, Y Kiani, MR Eslami, Thermal buckling of FG graphene platelet reinforced composite annular sector plates, Thin-walled Structures, 148 (2020) 106589.