Accepted Manuscript

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PII: S0263-8223(18)31109-7
DOI: https://doi.org/10.1016/j.compstruct.2018.07.041
Reference: COST 9959

To appear in: *Composite Structures*

Received Date: 22 March 2018
Revised Date: 6 June 2018
Accepted Date: 16 July 2018

Please cite this article as: Viet, N.V., Zaki, W., Umer, R., Analytical Model of Functionally Graded Material/Shape Memory Alloy Composite Cantilever Beam under Bending, *Composite Structures* (2018), doi: https://doi.org/10.1016/j.compstruct.2018.07.041

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Analytical Model of Functionally Graded Material/Shape Memory Alloy Composite Cantilever Beam under Bending

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Abstract

A new analytical model for a functionally graded material(FGM)/shape memory alloy (SMA) laminated composite cantilever beam subjected to a concentrated tip load is developed. The novelty of this work lays in the analytical modelling of moment-curvature and shear force-shear strain relations, which are derived based on ZM model and Timoshenko's theory for all stages during loading and unloading. A high-accuracy numerical solution and a three-dimensional finite element analysis (3D FEA) for the composite beam are carried out to validate the analytical solution. The results show very good agreement in each case. The influence of gradient direction, gradient index, temperature, and relative thickness ratio of SMA to functionally graded layer on superelasticity of carbon nanotube (CNT)-epoxy-based-FGM/SMA composite beam is also examined. The results show that the superelasticity of CNT-epoxy FGM/SMA composites increased with an increase in gradient index and decreased with an increase in thickness ratio. The temperature variations induced less effect on the superelasticity of FGM/SMA composites. Furthermore the composite beam with FGM layers having the Young's modulus graded increasingly in the inward direction exhibits a better superelastic property in comparison with that with FGM layers having the Young's modulus graded increasingly along the outward direction.

Keywords: Functionally graded material; shape memory alloy; bending; analytical model.

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