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Numerical and experimental study on free vibration of 3D-printed polymeric functionally graded plates

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Abstract

The paper presents the free vibration analysis of simply supported 3D printed polymeric functionally graded (FG) plates with variation of material stiffness and density along their length. The analytical formulation based on Higher- Order Shear Deformation Theory (HSDT) accounts for both the shear deformation and thickness stretching effect by a sinusoidal variation of the displacement field across the thickness. The problem is then modelled using the finite element (FE) method. The FE solutions are obtained using linear hexahedral solid elements with spatially graded property distribution at different Gauss points, which is implemented by a subroutine (USDFLD) in the ABAQUS FE software. In order to validate the proposed graded FE solutions, experimental tests using Portable Digital Vibrometer (PDV) performed to capture the first natural frequency of designed and manufactured 3D printed polymeric FG plates. It can be concluded that the presented analytical formulation is not only accurate, but also provides for simple prediction of the free vibration of FG plates. Also, the good agreement found between the numerical models and experimental results demonstrates the effectiveness of graded solid elements in the modelling of FG plate vibration.

Keywords: Functionally graded materials; natural frequency; USDFLD; Portable Digital Vibrometer.