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Sy-Ngoc Nguyen, Jaehun Lee, Maenghyo Cho

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Viscoelastic Behavior of Naghdi Shell Model Based on Efficient Higher-Order Zig-Zag Theory

Sy-Ngoc Nguyen[1], Jaehun Lee[2] and Maenghyo Cho[1*]
[1]Department of Mechanical and Aerospace Engineering, Seoul National University, Seoul, 151-742, Korea
[2]Division of Mechanical Engineering, Kyungnam University, Gyeongsangnam-do, 631-701, Korea,

Abstract

This paper proposes a method based on efficient higher-order zig-zag theory to analyze the viscoelastic response of doubly-curved laminated shell structures. In the general curvilinear coordinates, displacement fields are obtained by imposing a varying cubic displacement field on a varying linear zig-zag field. Then, the transverse shear stress-free condition at the top and bottom surfaces and the continuity condition at the interfaces are employed to reduce the number of unknown variables. The Laplace transformation is then used to simplify the integral-formed constitutive equation for viscoelastic material in the real time domain into a linear system equation in the Laplace domain so that all computations can be carried out in the Laplace domain. Therefore, the equilibrium equation for general viscoelastic Naghdi shell model can be obtained by converting the virtual work principle into the Laplace domain. Finally, solutions for the long-term viscoelastic properties in the real-time domain are obtained by using numerical inverse Laplace techniques. To simplify the formulation and conveniently evaluate the method proposed in the present study and to compare its outcomes with those of an elastic laminated composite shell, several numerical examples for a cylindrical shallow shell model are investigated.

Keywords: Composite laminates, Zig-zag shell theory, Viscoelasticity, Laplace transformation.

[*] Corresponding author. Tel.: +82-02-880-1693;
Email address: mhcho@snu.ac.kr (Maenghyo Cho)