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Adaptive Vibration Behavior of Circular Sandwich Plates with Graphene-Reinforced MRE Core and Auxetic Metamaterial Skins

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This study investigates the dynamic behavior of a smart circular sandwich plate composed of a graphene platelet-reinforced magnetorheological elastomer (GPLR-MRE) core and graphene origami-enabled auxetic metamaterial (GOEAM) face layers, supported by a novel viscoelastic foundation, as shown in Figure 1.

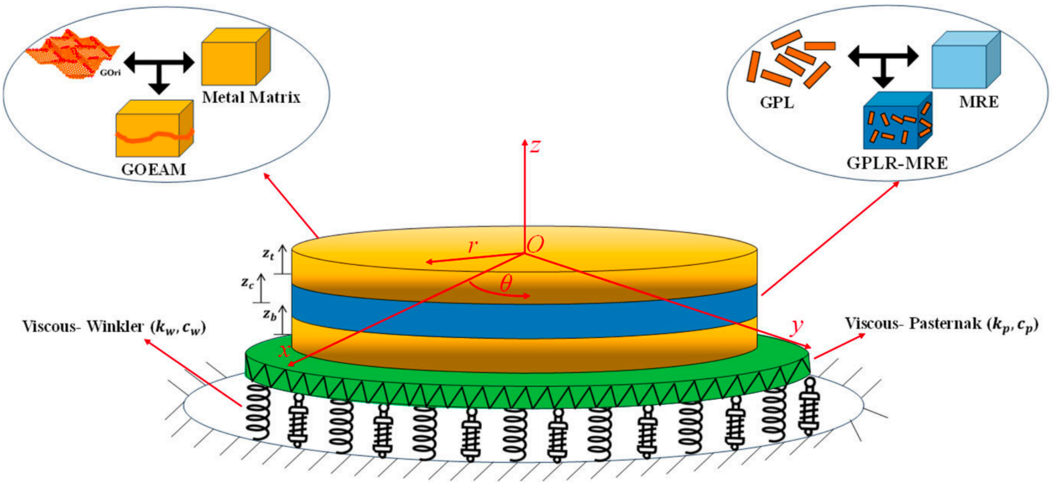

Figure 1: Schematic of the adaptive circular sandwich plate.

The proposed structure combines the adaptive damping capability of magnetorheological elastomers with the enhanced stiffness and auxetic behavior of graphene-based metamaterials, enabling tunable vibration performance under external magnetic fields [1]. The viscoelastic behavior of the MRE core is modeled using the Zener model, with parameters identified via nonlinear least-squares fitting. Effective properties of the GPLR-MRE are obtained using the Halpin–Tsai model and rule of mixtures, while GOEAM face layers are characterized through micromechanical modeling and genetic programming. A viscoelastic Winkler–Pasternak foundation is introduced to capture foundation effects. The governing equations are formulated using HSDT and solved via the FE method. The model is validated with excellent agreement. Results show that increasing magnetic field intensity enhances both natural frequencies and loss factors due to improved stiffness and damping. Increasing graphene content raises stiffness and frequency (up to 25%) but reduces damping. Optimized auxetic patterns (FGV-X and FGH-O) yield the highest stiffness and lowest loss factors.

References

[1] Zhao, S., et al. A functionally graded auxetic metamaterial beam with tunable nonlinear free vibration characteristics via graphene origami. *Thin-Walled Structures.* 2022.

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