Steel Compost. Struct., *Vol. 44*, *No. 3* (*2022*) *339-355*
https://doi.org/10.12989/scs.2022.44.3.339

Coupled effect of variable Winkler–Pasternak foundations on bending behavior of FG plates exposed to several types of loading

Nabil Himeur[1,2], Belgacem Mamen[3,4b], Soumia Benguediab[5b], Abdelhakim Bouhadra*[3,4], Abderrahmane Menasria[3,4b], Benattou Bouchouicha[1b], Fouad Bourada[3,5b], Mohamed Benguediab[1a] and Abdelouahed Tounsi[3,7,8a]

[1]*Reactive Materials and Systems Laboratory (LMSR)*, *Department of mechanical Engineering*, *University of Sidi Bel Abbes*, *Faculty of Technology*, *Algeria*
[2]*Department of mechanical Engineering*, *University of Abbés Laghrour Khenchela*, *Faculty of Science and Technology*, *Algeria*
[3]*Material and Hydrology Laboratory*, *University of Sidi Bel Abbes*, *Faculty of Technology*, *Algeria*
[4]*Department of Civil Engineering*, *University of Abbès Laghrour Khenchela*, *Faculty of Science and Technology*, *Algeria*
[5]*Department of Civil Engineering and Hydraulic*, *University of Saida*, *Algeria*
[6]*Département des Sciences et de la Technologie*, *université de Tissemsilt*, *BP 38004 Ben Hamouda*, *Algeria*
[7]*YFL (Yonsei Frontier Lab)*, *Yonsei University*, *Seoul*, *Korea*
[8]*Department of Civil and Environmental Engineering*, *King Fahd University of Petroleum & Minerals*, *31261 Dhahran*, *Eastern Province*, *Saudi Arabia*

(Received August 22, *2021*, *Revised June 11*, *2022*, *Accepted July 15*, *2022)*

Abstract. This study attempts to shed light on the coupled impact of types of loading, thickness stretching, and types of variation of Winkler–Pasternak foundations on the flexural behavior of simply- supported FG plates according to the new quasi–3D high order shear deformation theory, including integral terms. A new function sheep is used in the present work. In particular, both Winkler and Pasternak layers are non-uniform and vary along the plate length direction. In addition, the interaction between the loading type and the variation of Winkler–Pasternak foundation parameters is considered and involved in the governing equilibrium equations. Using the virtual displacement principle and Navier's solution technique, the numerical results of non-dimensional stresses and displacements are computed. Finally, the non-dimensional formulas' results are validated with the existing literature, and excellent agreement is detected between the results. More importantly, several complementary parametric studies with the effect of various geometric and material factors are examined. The present analytical model is suitable for investigating the bending of simply-supported FGM plates for special technical engineering applications.

Keywords: FGM plates; Navier's technique; non-uniform Winkler–Pasternak foundations; original quasi–3D theory; several types of load

1. Introduction

The continuous evolution of mechanical properties between the lower and the upper surface of functionally graded structures overcomes the phenomenon of local stress concentrations induced generally by abrupt transitions in constituent materials properties. Moreover, this feature controls the low fracture toughness of ceramics and reduces metals' strength during exposure to severe heat. Importantly, the FG elements still attract many interests from various engineering areas such as aircraft, marine, construction, and mechanical engineering.

The stable behavior of reinforced composites structures has been a topical topic that has attracted many researchers in recent years. In the engineering areas mentioned above, many studies have been devoted recently to evaluating the dynamic behavior of imperfect functionally graded structures, such as Raad *et al*. (2020), Yuan *et al*. (2020), Emad *et al*. (2020), Behrouz *et al*. (2020), Liu *et al*. (2020), Kasra *et al*. (2020), Gafour *et al*. (2020), Si *et al*. (2020) and Ridha *et al*. (2021). The nonlinear buckling under thermo-mechanical loading of imperfect micro-scale beam made of graded graphene reinforced composites has been analyzed by Basima *et al*. (2019). Abdulrazzaq *et al*. (2019) used refined plate theory and a secant function to study the clamped boundaries.

Through Hamilton's energy principle, Boulal *et al*. (2020), and Si Tayeb *et al*. (2020) have studied the stability of carbon nanotube-reinforced composite plates with and without foundation. Haidari *et al*. (2020) present an equilibrium and stability analysis of FG-CNTRC with piezoelectric layers, considering the size effect. Ghannadpour and Mehrparvar (2020) study the nonlinear and post-buckling responses of relatively thick functionally graded plates with oblique elliptical cutouts using a new semi-analytical approach. Asrari *et al*. (2020), based on the classical theory and non-local theory, analyze the geometrically nonlinear buckling of functionally graded. Tabasi *et al*. (2020) present stability and dynamic analysis

*Corresponding author, Ph.D.
E-mail: bouhadrahako@gmail.com
[a]Professor
[b]Ph.D.

http://www.techno-press.com/journals/scs&subpage=8 ISSN: 1229-9367 (Print), 1598-6233 (Online)