THERMOMECHANICAL ELASTIC BUCKLING OF FUNCTIONALLY GRADED MATERIALS PLATE WITH RANDOM MATERIAL PROPERTIES

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Summary. This paper presents the stochastic thermomechanical buckling response of functionally graded materials (FGM) plate with random material properties subjected to uniform and non-uniform temperature change with temperature dependent and independent material properties. Material properties such as material properties of each constituent's material are taken as independent random input variables. The basic formulation is based on higher order shear deformation theory using modified C⁰ continuity. A finite element method in conjunction with first order perturbation technique is employed to compute the second order statistics of the mechanical and thermal buckling of the FGM plates. The results have been compared with those in literatures and independent Monte Carlo Simulation.

1 INTRODUCTION

Functionally graded material (FGMs) are advanced high-performance and heat resistant materials which are able to withstand the ultra-high temperatures and extremely large temperature gradients present in space-crafts and nuclear plants. They are now being regarded as one of the most promising material for future intelligent composites in many engineering sectors.

Buckling and post-buckling characteristics are one of the major design criteria for plates/panels for their optimal usage. Hence, it is, therefore important to study the buckling and post-buckling characteristics of FGM plates under mechanical, thermal loading and thermomechanical loading for accurate and reliable design. The buckling of rectangular plates has been the subject of study for many investigators. Javaheri and Eslami [1] obtained the buckling of the FGM plates for uniform inplane compressive loading and thermal loading using variational approach, based on classical plate theory. Yang et al. [2] evaluated second order statistics of the elastic buckling of functionally graded rectangular plates using stochastic finite element method based on semianalytical approach.
Keeping all these in mind, the present investigation aims at predicting the statistics of buckling response of the FGM plates with random material properties in thermal environments based on macromechanical model.

II. RESULTS AND DISCUSSION

The material properties used for computation are taken from Ref. [3]

A nine noded Lagrange isoparamatric element with 63 DOFs per element for the present HSDT model has been used for discretizing the FGM and (5 × 5) mesh has been used throughout the study. Typical results are presented for functionally graded square plate made of ceramic and metal of the different compositions with their volume fractions index following the power law distribution through the plate thickness. The basic random variables such as E_c, E_m, v_c, and v_m, are sequenced and defined as

\[ b_1 = E_c, \quad b_2 = E_m, \quad b_3 = v_c, \quad b_4 = v_m \]

where, \( E_c, E_m, v_c, \) and \( v_m \) are material properties and fraction index of ceramic and metal respectively. The dimensionless mean buckling load of the FGM plate subjected to mechanical (\( \lambda_{cr} \)) and thermal (\( \lambda_{th} \)) loadings and foundation parameters are defined as respectively [3,4],

\[ \lambda_{cr} = \frac{(N^p_{cr}) b}{E_c h^3} \quad \text{and} \quad \lambda_{th} = \lambda_c(\Delta T) a \times 10^3; \quad k_1 = K_c a^4 / D_1; \quad k_2 = K_m a^4 / D_11 \]

where, \( D_1 = E_c h^3/12(1-V_c) \), and \( (N^p_{cr}) \) is dimensionless buckling load of the FGM plate.

Table 1 shows the validation of present approach using FEM based on HSDT with the available results using analytical approach by Wu et al. [3].

REFERENCES


Table 1 Effect for thickness ratio, volume fraction index on dimensionless mechanical buckling loads of square FGMs plates.