Magneto Electro Elastic Modelling and Nonlinear Vibration Analysis of Bi Directional Functionally Graded Beams

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Abstract

In the paper, a novel magneto electro elastic (model of bi-directional (2 D) functionally graded material s (FGM s) beam s is developed for investigating the nonlinear dynamics It is shown that the asymmetric modes induced by the 2D FGM s may significantly affect the nonlinear dynamic responses which is tremendously different from previous studies Taking into account the geometric nonlinearity, the nonlinear equation of motion and associated boundary conditions for the beam s are derived according to the Hamilton's principle The linear frequencies and modes of the beam s are numerically calculated by the generalized differential quadrature method (GDQM) GDQM). The frequency responses of the nonlinear forced vibration are constructed based on the Galerkin technique incorporating with the incremental harmonic balance (I HB) approach. The influences of the material distributions, length thickness ratio, electric voltage, magnetic potential as well as boundary condition on the nonlinear resonant frequency and response amplitude are discussed in details. It is notable that increasing in the axial and thickness FG indexes, negative electric potential and positive magnetic potential can lead to decline the nonlinear resonance frequency and amplitude peak which is usually applied to accurately design the multiferroic composite structures.

Full Text

This preprint is available for download as a PDF.

Figures

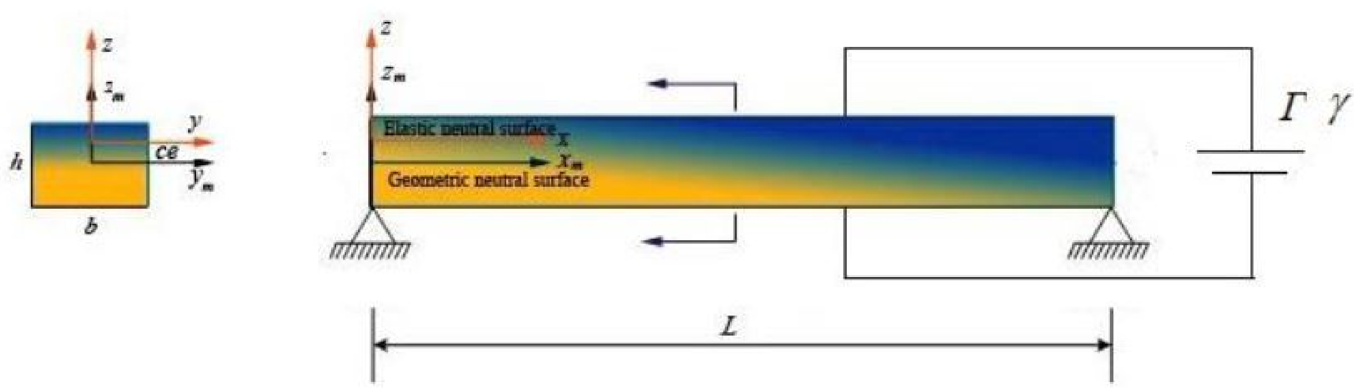


Figure 1

Schematic diagram of a 2D FGMEE beam

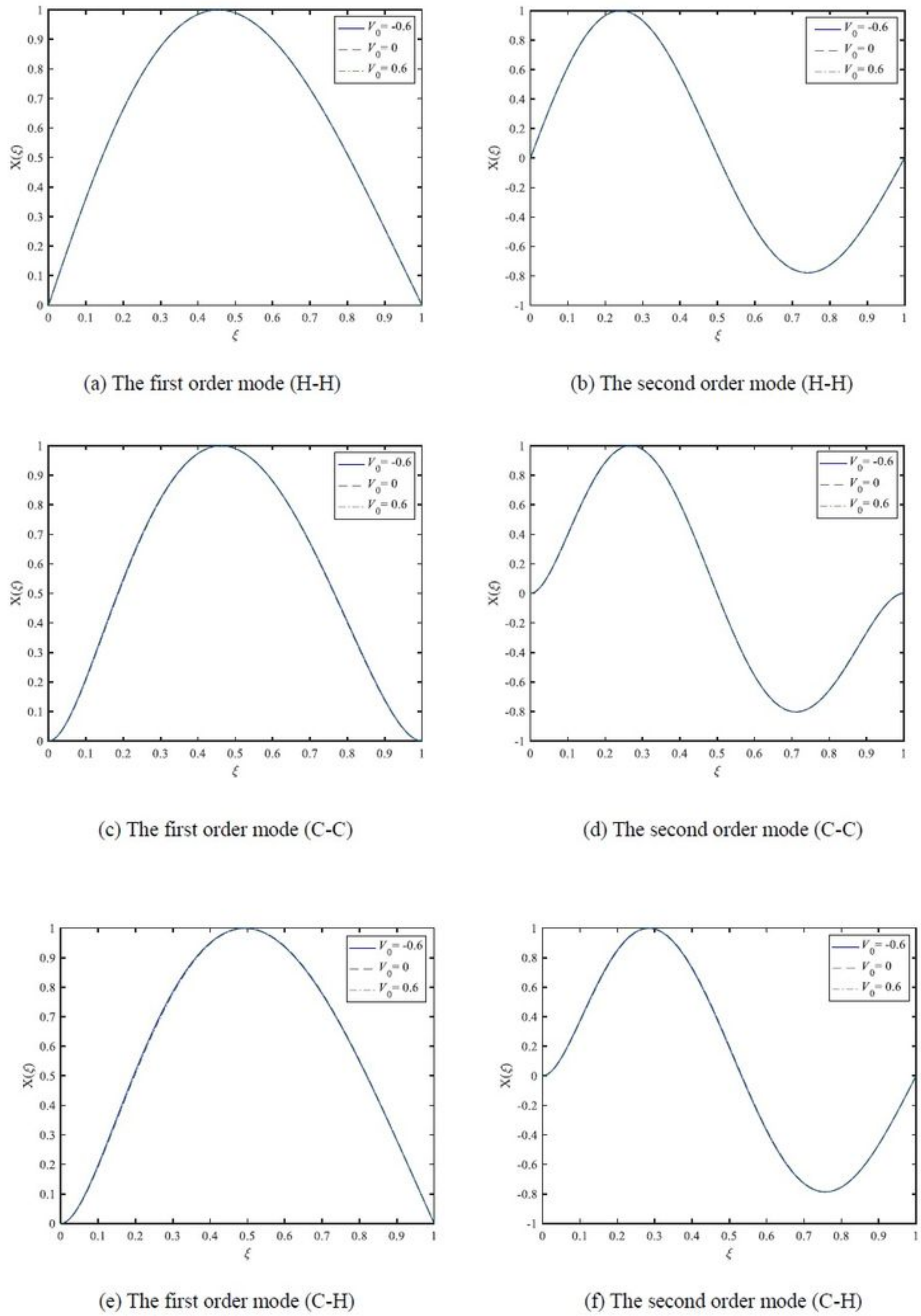


Figure 2

The first two order modes of 2D FGMEE beams against the initial electric potential for different types of boundary condition

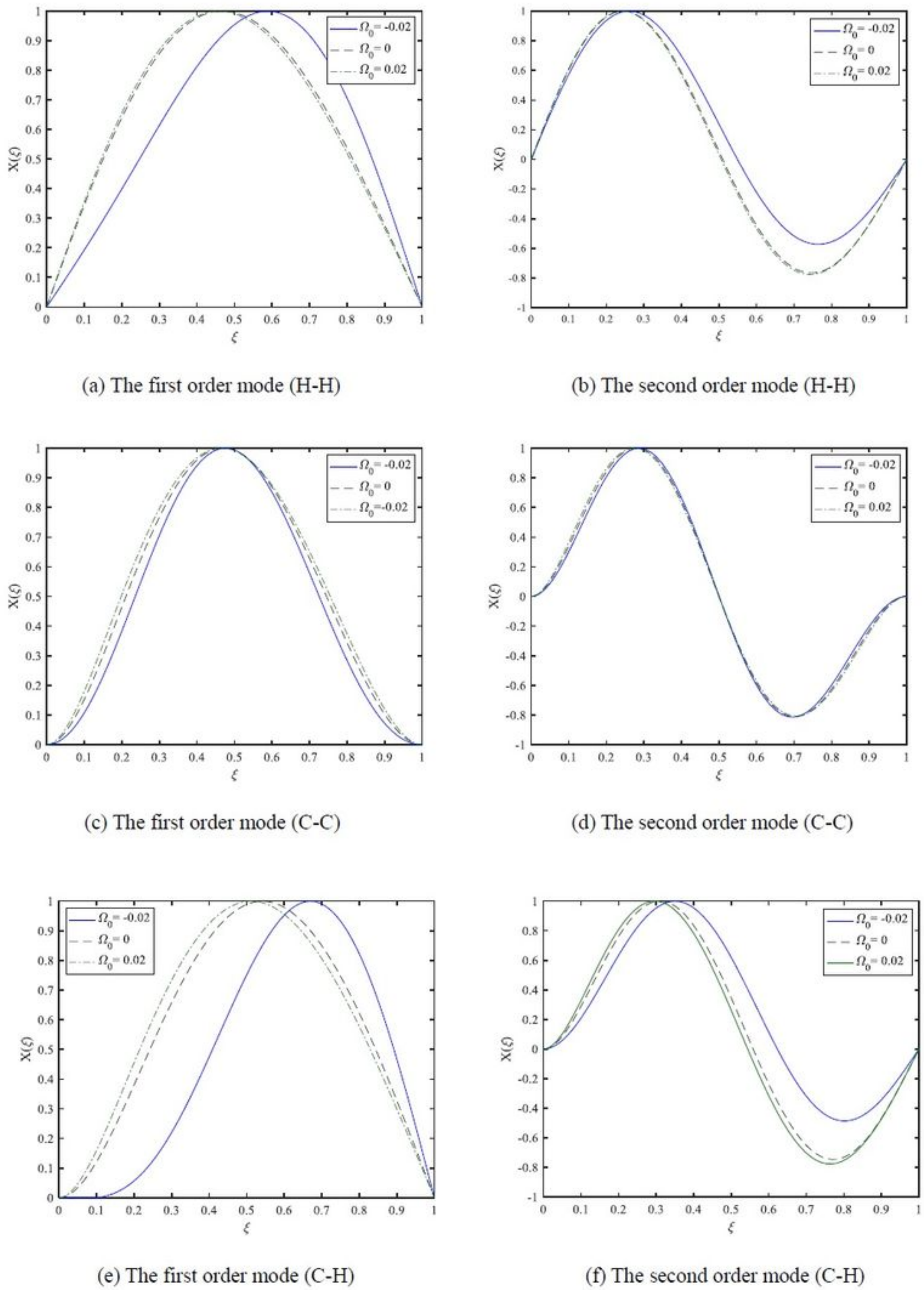
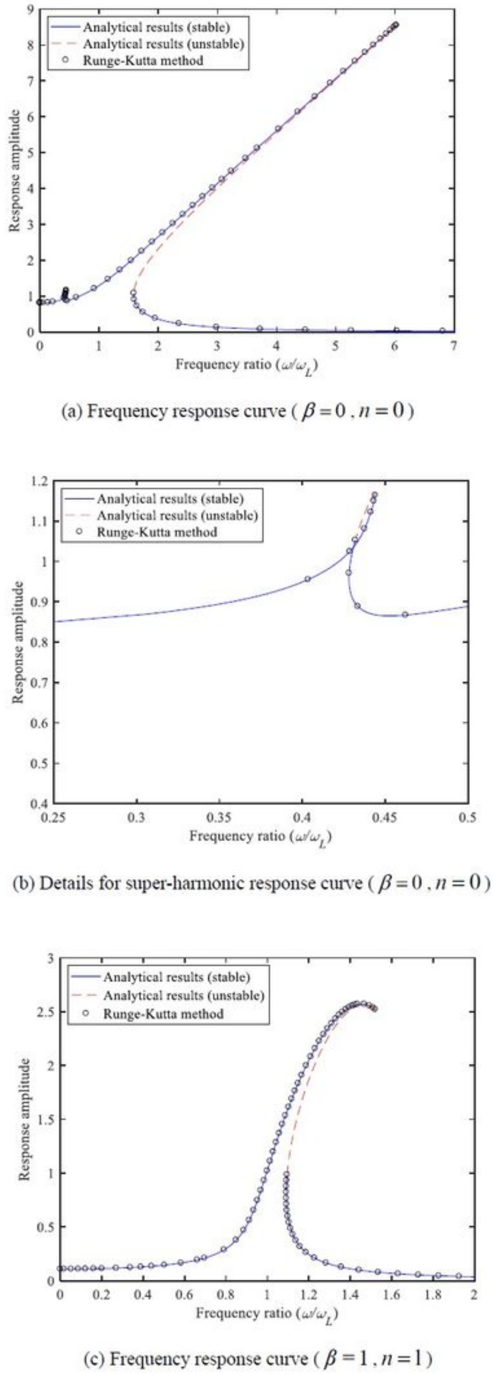


Figure 3

The first two order modes of 2D FGMEE beams against the initial magnetic potential for different types of boundary condition



(a) Frequency response curve ($\beta = 0$, $n = 0$)

(b) Details for super-harmonic response curve ($\beta = 0$, $n = 0$)

(c) Frequency response curve ($\beta = 1$, $n = 1$)

Figure 4

Comparison of frequency-responses of 2D FGMEE H-H beams as determined from analytical and numerical solutions (L h= 20, c= 0.01, P= 0.03)

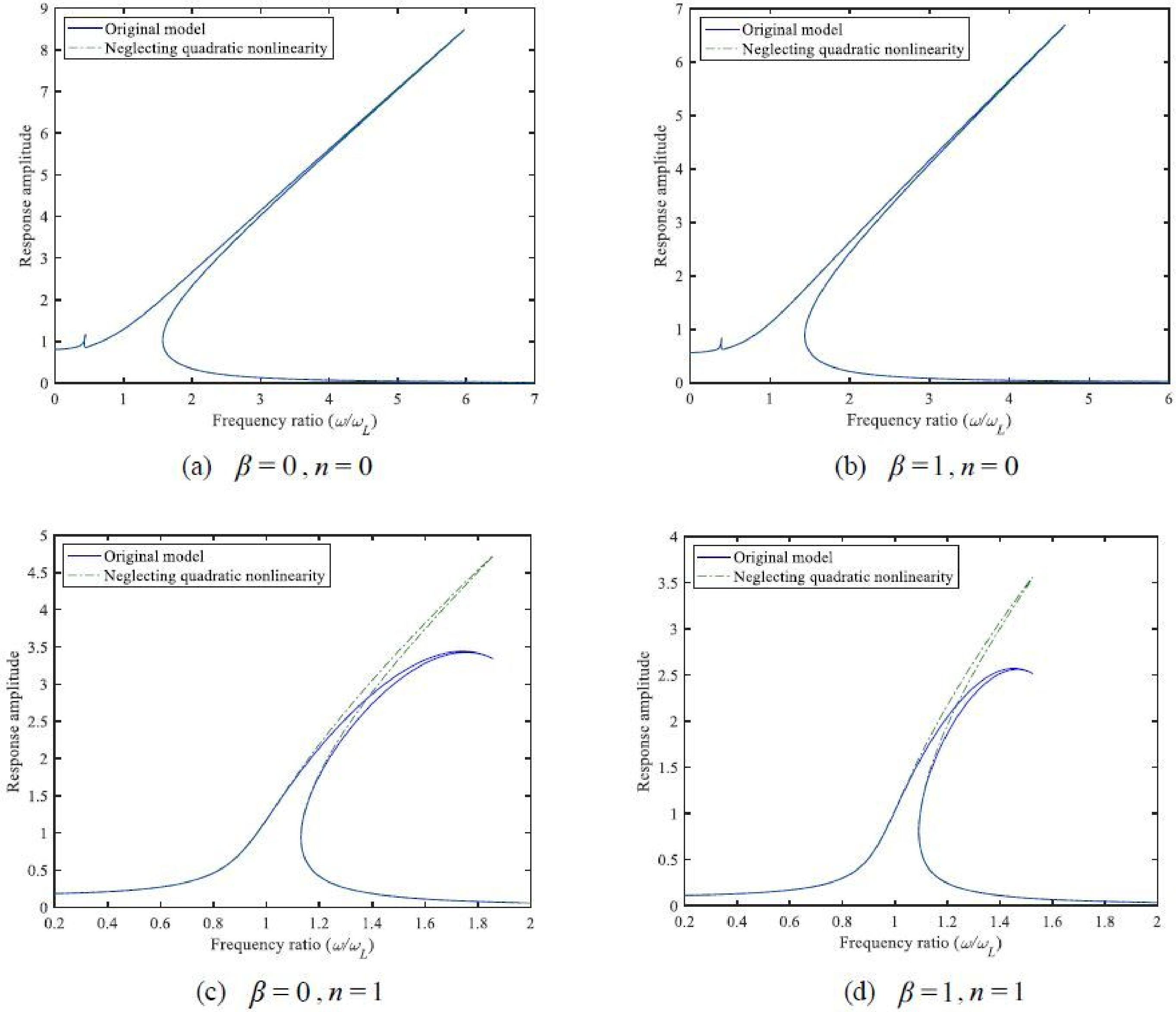


Figure 5

Comparison of frequency responses of 2D FGMEE H-H beams predicted by original model and the model of neglecting quadratic nonlinearity for different values of axial and thickness FG indexes (L h= 20, c= 0.01, P= 0.03)

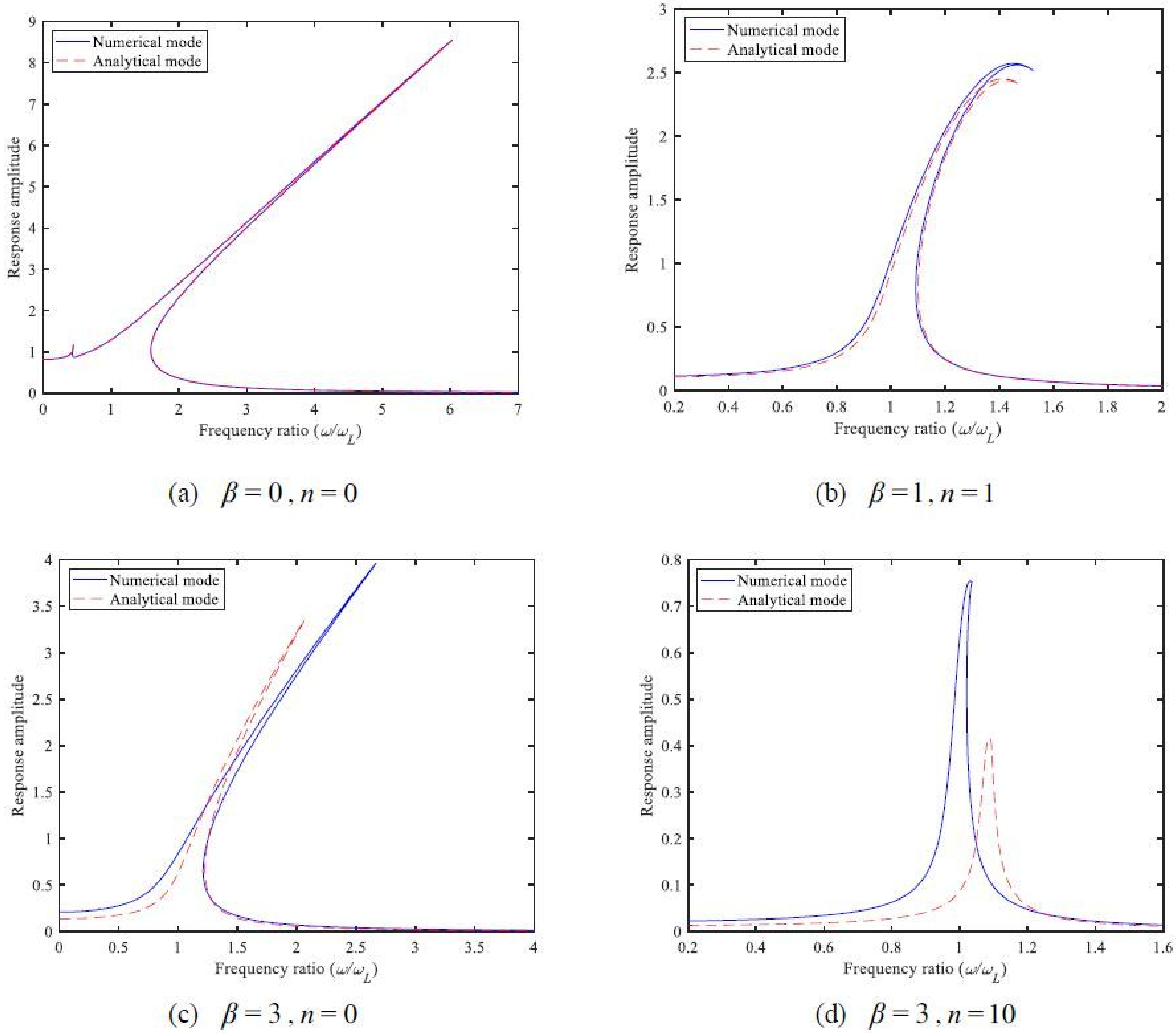


Figure 6

Comparison of frequency responses of 2D FGMEE H-H beams used by analytical mode and those obtained by numerical mode for different values of axial and thickness FG indexes (L h= 20, c= 0.01, P= 0.03)

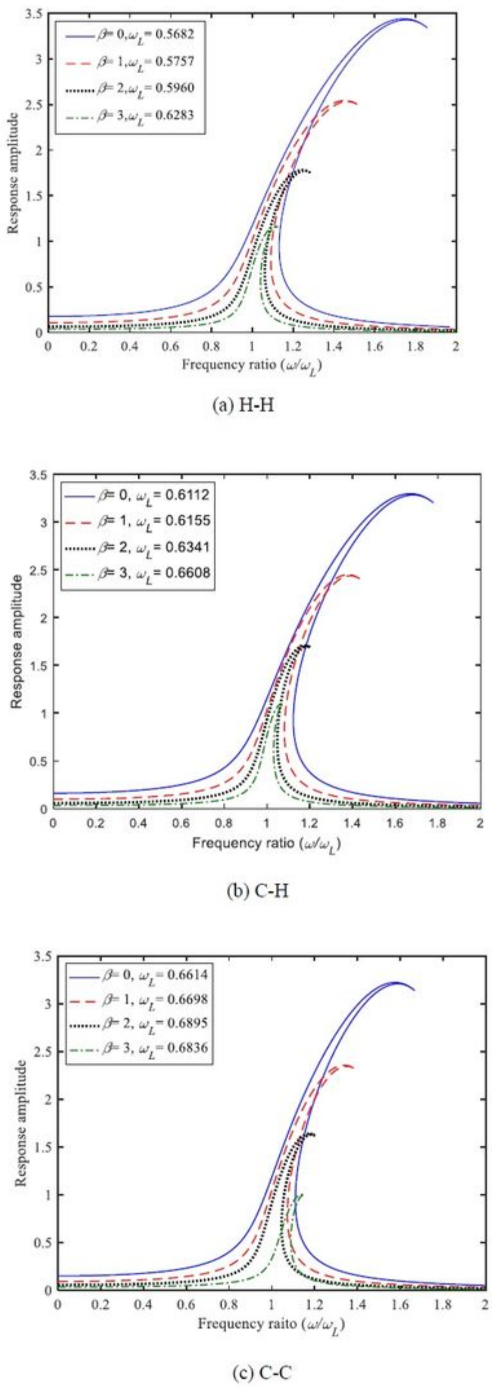


Figure 7

Influence of the axial FG index on frequency responses of 2D FGMEE beams for various boundary conditions (L h= 20, c= 0.01, P= 0.03, n =1)

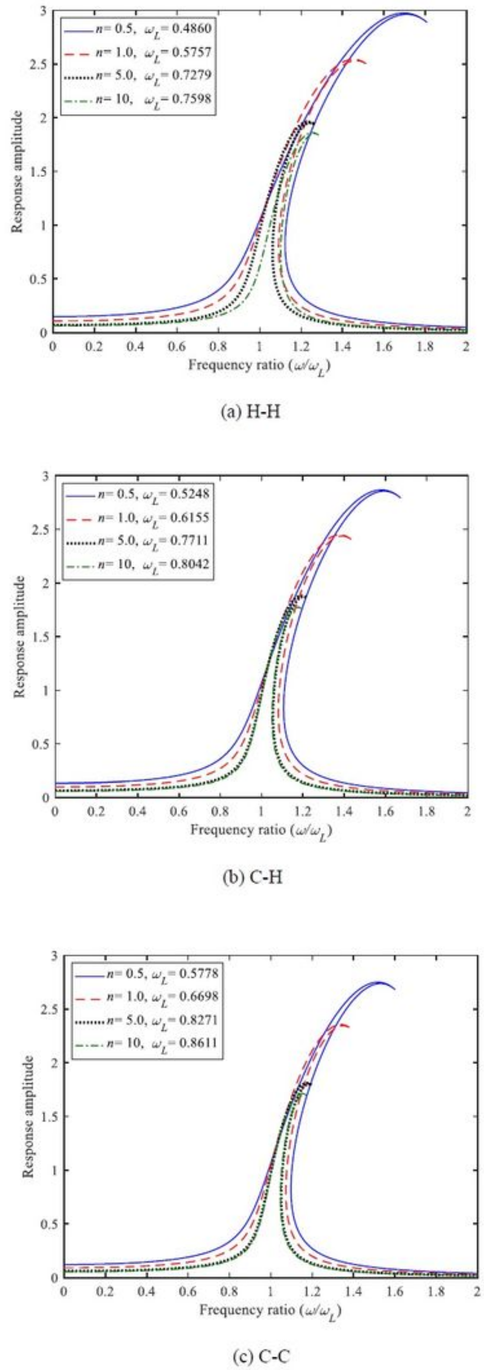


Figure 8

Influence of the thickness FG index on frequency responses of 2D FGMEE beams for various boundary conditions (L h= 20, c= 0.01, P= 0.03, β =1)

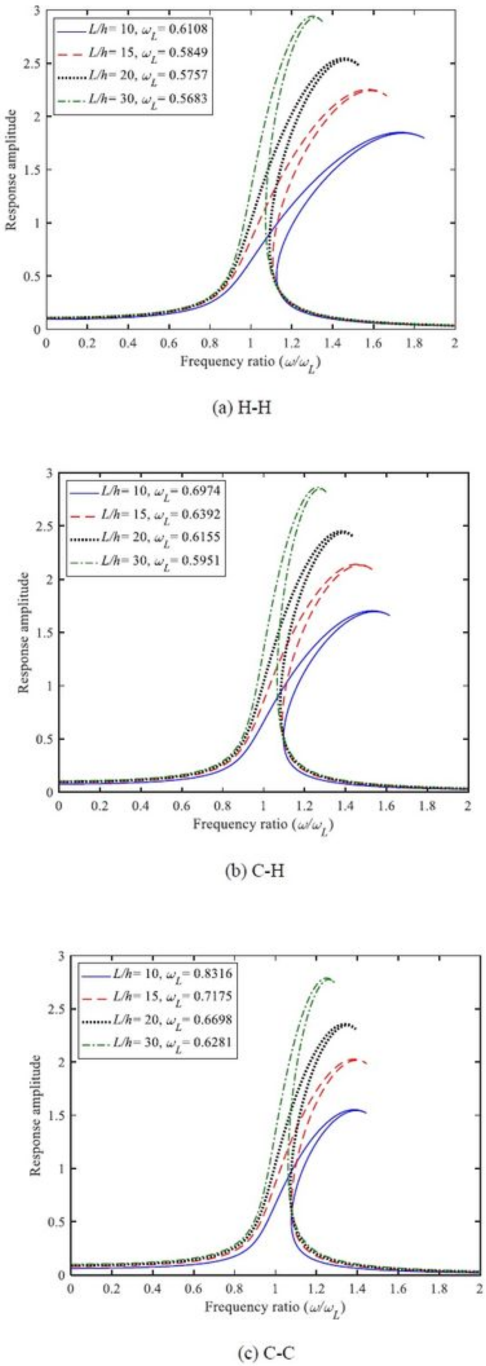
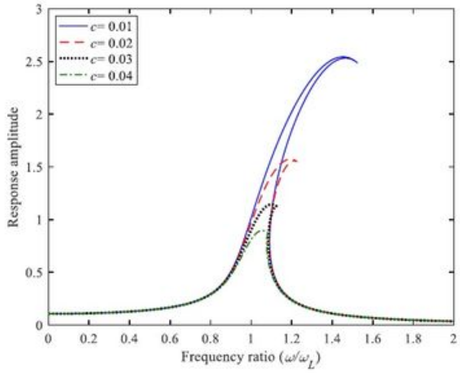
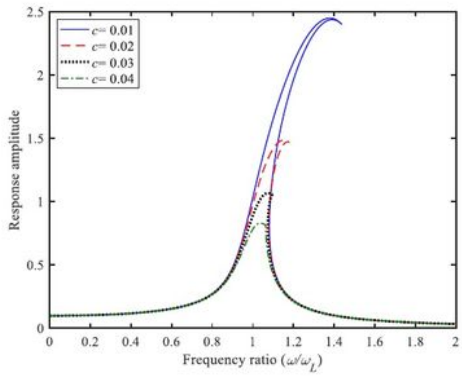


Figure 9

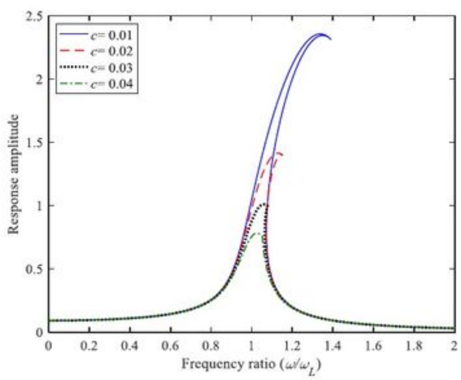
Influence of the length-thickness ratio on frequency responses of 2D FGMEE beams for various boundary conditions (c=0.01, P=0.03, n =1, β =1)



(a) H-H



(b) C-H



(c) C-C

Figure 10

Influence of the damping coefficient on frequency responses of 2D FGMEE beams for various boundary conditions (L h= 20, P= 0.03, n =1, β =1)

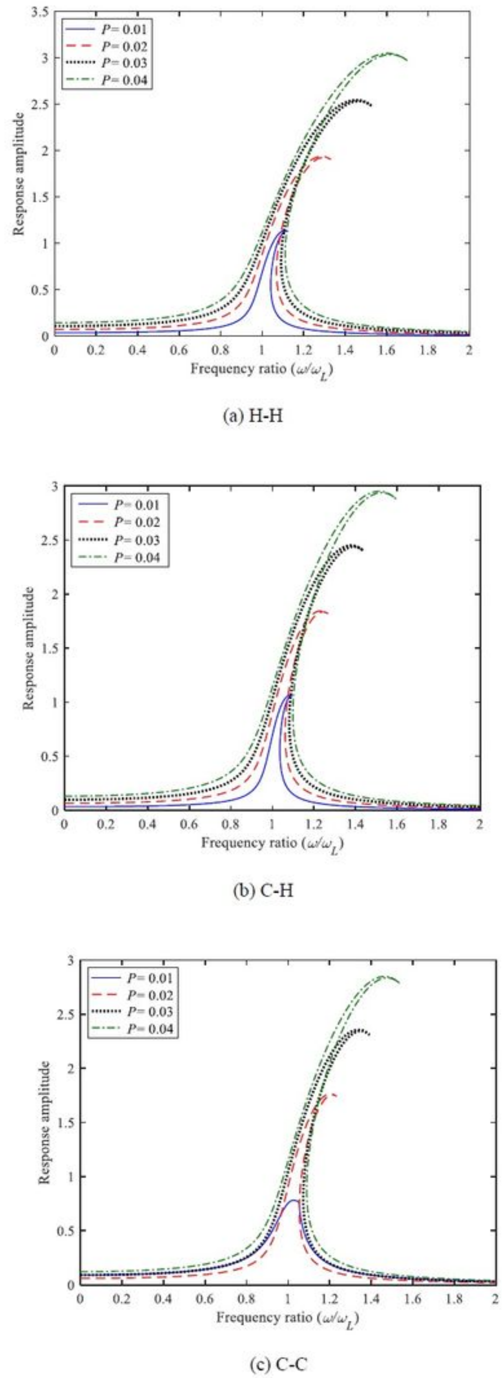
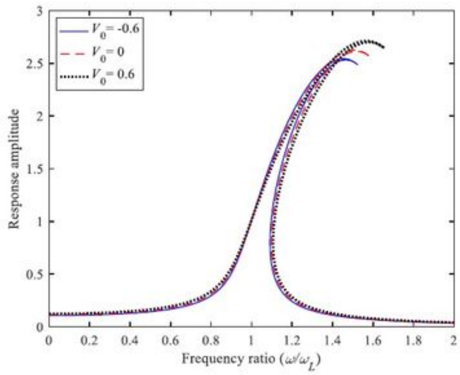
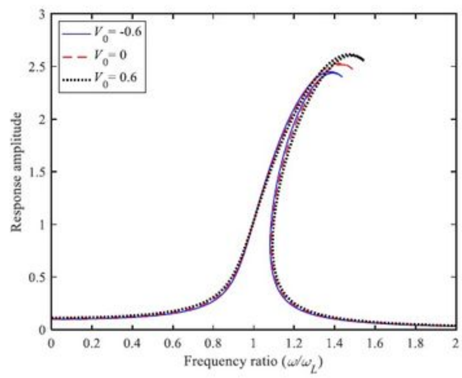


Figure 11

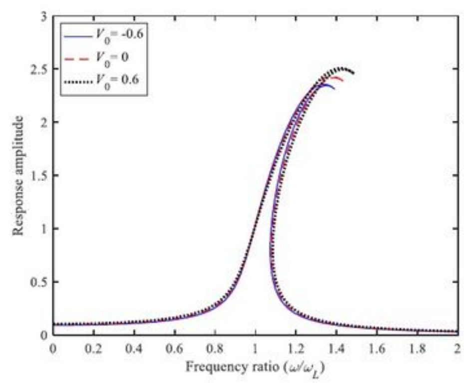
Influence of the forcing amplitude on frequency responses of 2D FGMEE nbeams for various boundary conditions (L h= 20, c= 0.01, n =1, β =



(a) H-H



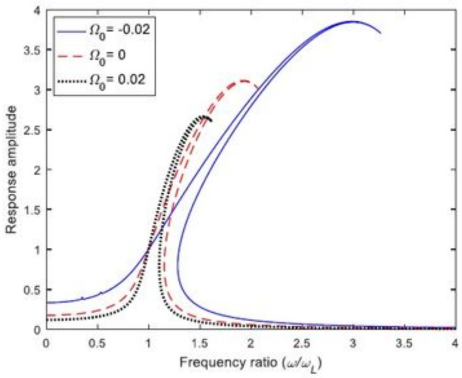
(b) C-H



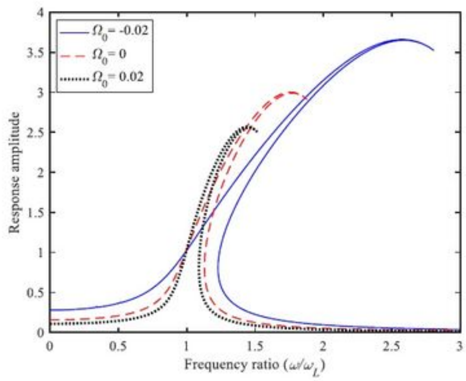
(c) C-C

Figure 12

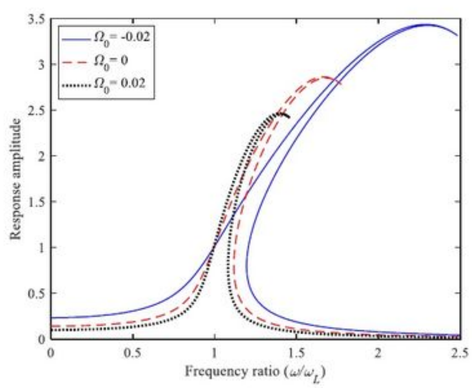
Influence of the initial electric potential on frequency responses of 2D FGMEE beams for various boundary conditions (L h= 20, c= 0.01, P = 0.03, n =1, β =1)



(a) H-H



(b) C-H



(c) C-C

Figure 13

Influence of the initial magnetic potential on frequency responses of 2D FGMEE beams for various boundary conditions (L h= 20, c= 0.01, P = 0.03, n =1, β =1)