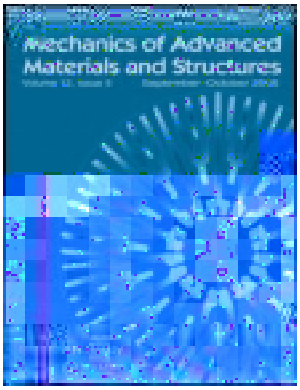

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Buckling of Functionally Graded Cylindrical Shells under Combined Loads

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Buckling of Functionally Graded Cylindrical Shells under Combined Loads

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By using the Ritz energy method and finite element method, buckling behaviors of combined-loaded functionally graded cylindrical shells are investigated. The combined loads are composed of axial, lateral, and torsional loads. Results show that the contribution of lateral pressure to buckling is more significant than that of axial compression or torsion and the contributions of axial compression and torsion are almost the same. Also, a practical method is proposed in this article to determine the load-dominant bound

[illegible]

The strain energy of a thin cylindrical shell is approximated to be

$$U = -\iiint_V ($$

fi t on of the resent r t ter d q_{cr} (×) of homogeneous y dr shel s

h	hen [ ]	resent	fferen e (%)
	. (,)[a]	. (,)	.
	. (.)	. (,)	.
	. (,)	. (,)	.
	. (,)	. (,)	.
	. (,)	. (,)	.
	. (,)	. (,)	.
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	. (,)	. (,)	.
	. (,)	. (,)	.

[a] he numbers n the renthesesdenote the bu k ng mode (m, n)

om r son of the r t ds (n) of s w th those re rodu ed from ofiye (, $R/h =$, $L/R =$)

	$N =$	$N =$	$N =$	$N =$	$N =$	$N =$	$N =$	
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ofiye [ ]	.	.	.	.	.	.	.	.
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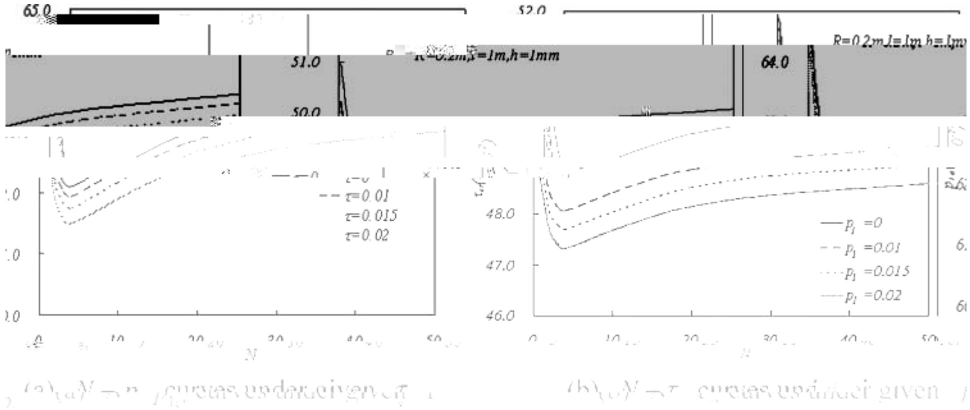


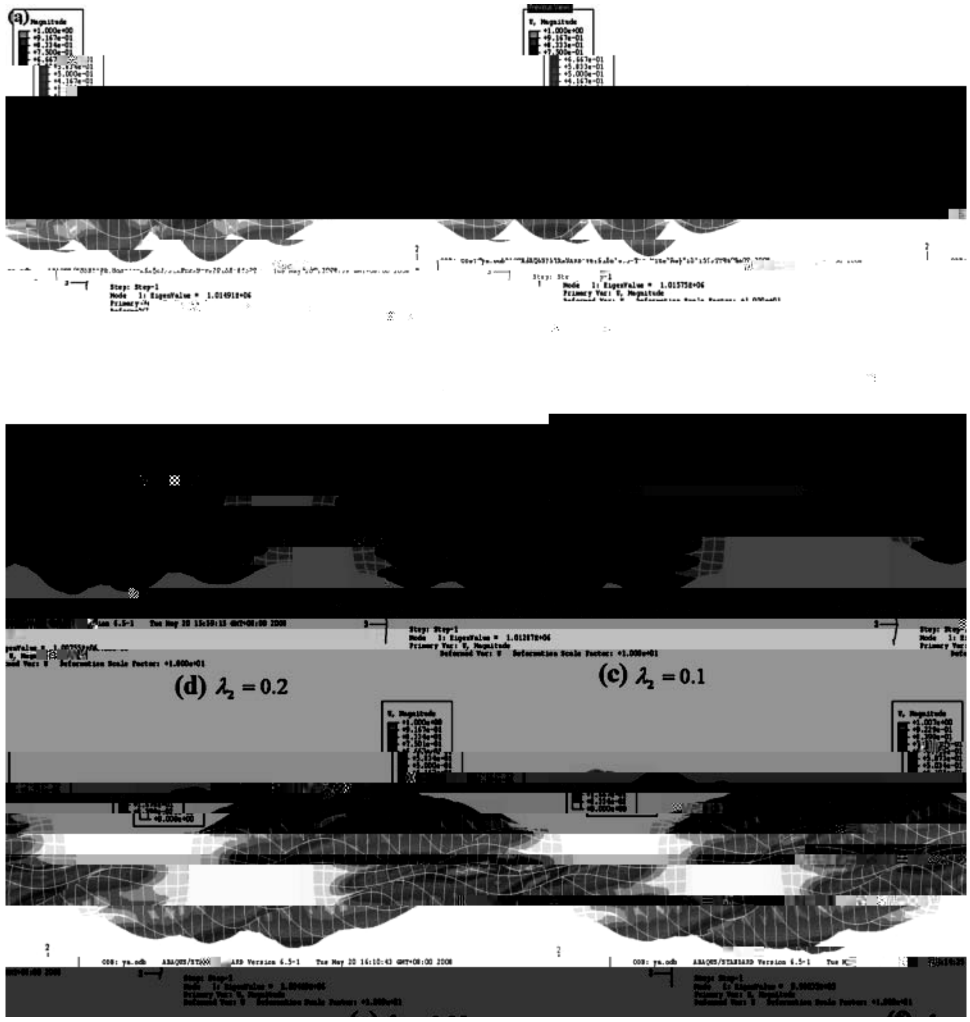
(a) [illegible] curves under given [illegible]   (b) [illegible] curves under given [illegible]

Variation curves of the critical parameters versus the power law exponent under

and decreases slightly with the increase of τ, and τ_{cr} decreases markedly with the increase of p

5. FEM RESULTS

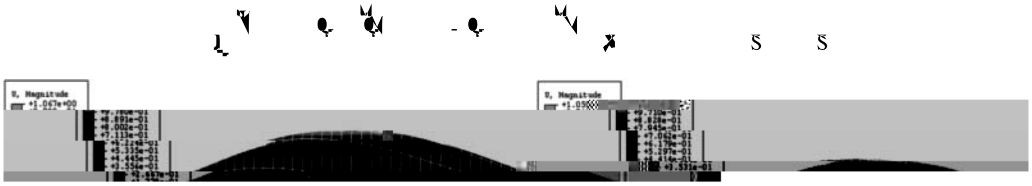
FEM is one of the most effective methods to solve complicated engineering problems. It is also effective in solving the eigenvalue problems of buckling. However, due to absence of ready material option in the existing FEM codes, it is difficult in simulating FGMs' material properties, which vary smoothly through the thickness. For this reason, there is still no precise modeling of FGMs by the FEM code in the literature. Some studies, with regard to three-dimensional stability analysis by [illegible] code, were reported by [illegible] et al. [ ] and [illegible] [ ]. They regarded FGMs as multi-layer materials and define



Buckling modes of s under $(N = \ , l = \ m, R = \ . \ m, h = \ mm)$

load. Figures – show mixed buckling modes aroused by interaction between axial load and torsion load.

Figure shows excellent agreement between theoretical results and FEM results. It is remarkable that, with the increase of λ, P_{cr} keeps similarly, [illegible] decreases slightly. Thus, the contributions of axial load and torsion load to buckling [illegible] to each other and figure can not be used to determine the load domain bounds in the axial and torsion combined load case. However, one can determine the load domain bounds



Buckling modes of s under $(N = \ , l = \ m, R = \ .\ m, h = \ mm)$

torsion changes gradually. As the axial half wave number m under axial and torsion loads are equal, i.e., $m =$, there is no chance to determine the dominant bounds from Figure

Figure shows excellent agreement between theoretical results and results. λ-axis is in the logarithm form. It is remarkable that, with the increase of λ, there appears, in order, a slow, rapid, and then re-slow decrease of P_{cr}. This shows that buckling of the structure is more sensitive to axial load than to torsion load, and the value of λ, accordingly, is divided into three different regions, i.e., $(\ , \ \times \ ]$, $(\ \times \ , \ \times \ )$, and $[\ \times \ , +\infty)$, which corresponds respectively to a classical axially-loaded buckling mode, a