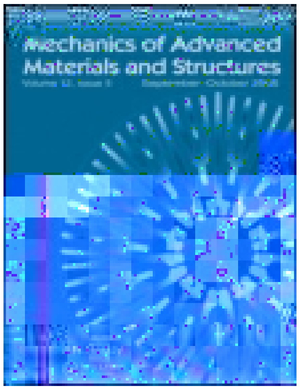

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Buckling of Functionally Graded Cylindrical Shells under Combined Loads

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By using the Rit energy method and nite 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 signi cant 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

he str n energy of th n y mdr she s rox ted to be

$$U = -\iiint_V ($$

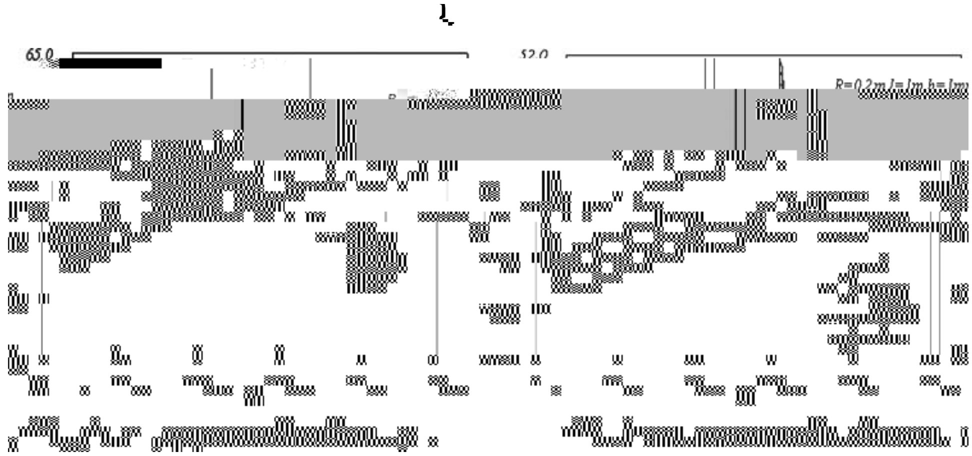
Comparison of the present critical lateral load q_{cr} (×) of homogeneous cylindrical shells

h	Shen [ ]	Present	Difference (%)
	. (,)[a]	. (,)	.
	. (.)	. (,)	.
	. (,)	. (,)	.
	. (,)	. (,)	.
	. (,)	. (,)	.
	. (,)	. (,)	.
	. (,)	. (,)	.
	. (,)	. (,)	.
	. (,)	. (,)	.
	. (,)	. (,)	.
	. (,)	. (,)	.
	. (,)	. (,)	.
	. (,)	. (,)	.
	. (,)	. (,)	.

[a] The numbers in the parentheses denote the buckling mode (m, n)

Comparison of the critical loads ( ) of s with those reproduced from Sofiyev (, $R/h =$, $L/R =$)

	$N =$	$N =$	$N =$	$N =$	$N =$	$N =$	$N =$	
The critical axial load p_{cr}								
Sofiyev [ ]	.	.	.	.	.	.	.	.
Present	.	.	.	.	.	.	.	.
The critical lateral load q_{cr}								
Sofiyev [ ]	.	.	.	.	.	.	.	.
Present	.	.	.	.	.	f	f [(	fj f

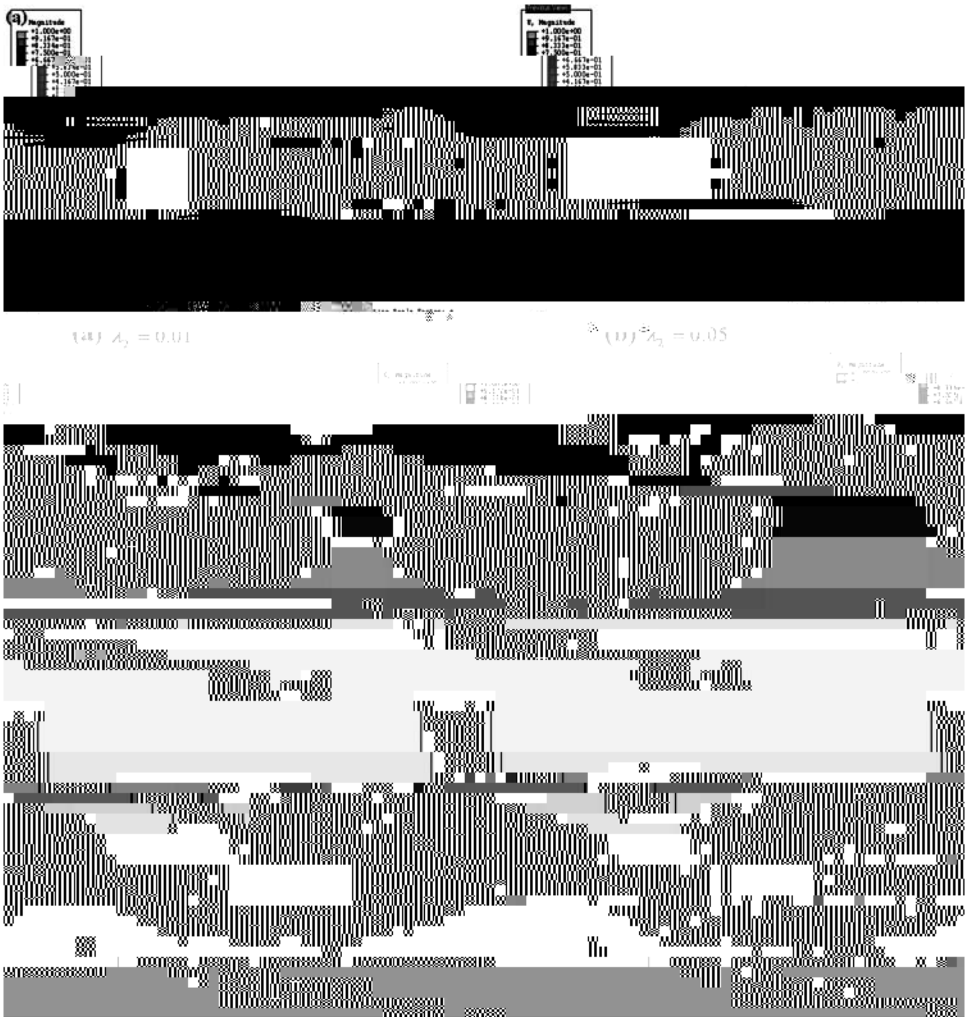


...tion curves of the ... parameters versus the power-law exponent under

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 general 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 elastic analysis by FEM code, were reported by ... [ ] and ... [ ]. They regarded FGMs as multi-layer materials and define



u-k, ng modes of s under $(N = \ , l = \ m, R = \ . \ m, h = \ mm)$

and , gures – show m xed bu-k, ng modes roused by , nter-t on between x and n tors on and

, gure shows ex-e ent greement between theoret - re- su ts nd results t, s re rk b th t, w th the, n-re se of λ , P_{cr} kes s n r y, n r, b d -re ses s, ght y hus, the -ontr but ons of x and n tors on and to bu-k, ng e u te to e -h other nd , gure -nnot be used to determ ne the and om n nt bounds s, n the x nd ter -omb ned and -se owever, one - n determ ne the and om n nt bounds

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

torsion range by λ ranges s the axial half wave number m under axial and torsion loads are used, i.e., $m =$, there is no ... factor to determine the ... boundary from figure

Figure shows excellent agreement between theoretical results and results λ axis, is in the logarithm form. It is remark be that, with the increase of λ, there appears, in order, slow, ..., and then slow increase 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, and ... can be divided into three different regions, i.e., (, ×], (× , ×), and [× , +∞), which corresponds respectively to axial ... axial ... buckling mode, ...