

# The study of pre- and post-buckling of FGM box

Leszek Czechowski<sup>1, a)</sup>, Zbigniew Kołakowski<sup>1, b)</sup>

<sup>1</sup> Lodz University of Technology, Department of Strength of Materials

<sup>a)</sup>*leszek.czechowski@p.lodz.pl*

<sup>b)</sup>*zbigniew.kolakowski@p.lodz.pl*

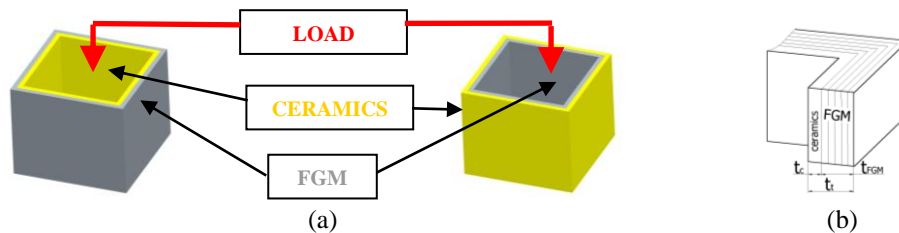
**Abstract.** The work concerns the study of thin-walled box made of functionally graded material (FGM) subjected to compression. The components of box taken into account were the pure alumina and graded material as aluminum-alumina. The problem was solved on the basis of finite element method and asymptotic Koiter's method. It was analyzed both buckling state and post-buckling state with different boundary conditions and different material distributions across the wall of box. In addition, it was considered two conditions: presence of alumina outside or inside of box.

## 1. INTRODUCTION

first concept of functionally graded material (FGM) was presented in 1984 by Niino, researcher from Japan. He and others had dealt with the investigation over FGMs in next years [1-3]. Nowadays, these types of materials are still treated as modern materials that through varying different properties throughout thickness that can endure loads in hard conditions especially under high temperature environment. The gradual changes in volume fraction of the components and non-homogenous structure allow obtaining continuous graded macroscopic properties. At present it can be distinguished different techniques of producing FGMs: gas based method, liquid phase processes or solid phases processes [1]. Looking through the literature, one can find many papers devoted to analysis of structures built of FGMs [4-8]. Authors of mentioned papers studied the behavior of FGMs structures under thermal and/or mechanical loads taking into account the perfect distribution material across the wall at most with use of mathematical formula.

## 2. THE OBJECT OF STUDY

The object of investigation was the square Ceramics-FGM box subjected to compression load (Fig. 1a). The length and total thickness of wall amounted to 200 mm and 2 mm ( $t_t$ ), respectively. The whole thickness of wall of box was composed with FGM ( $Al-Al_2O_3$ ) and pure ceramics (Fig. 1b). To solve the problem, two methods were applied: analytical-numerical [9] on asymptotic Koiter's approach and numerical on the basis of finite element method. It was examined pre- and post-buckling state of box with different boundary conditions (SSSS, SCCS, where S and C represent simply supported edge and clamped edge, respectively) and different relative thickness of ceramics.



**FIGURE 1.** Object of study (a) and denotation of thicknesses (b)

**TABLE 1.** Properties of considered materials

Material	Aluminum	Alumina
Young Modulus [GPa]	72	393
Poisson's ratio [-]	0.33	0.25

### 3. THE RESULTS OF CALCULATIONS

This section contains the results of critical forces obtained in both methods (Table 2). The calculated forces refer to the wall of square box with 11 layers of FGM where thickness of ceramics from 0.2 mm to 1 mm, and thickness of FGM from 1.8 mm to 1 mm. The discrepancy in forces in first considered variant don't exceed 9.2%, but in many cases differs maximally by 1.5% .

**TABLE 2.** Critical forces for some of considered cases (ceramics was inside of square box).

No	$t_t$ [mm]	$t_c$ [mm]	$t_{FGM}$ [mm]	FEM [kN]	ANM [kN]
1	2	0.2	1.8	115.490	106.608
2	2	0.4	1.6	119.943	118.192
3	2	0.6	1.4	124.573	123.280
4	2	0.8	1.2	130.078	130.144
5	2	1	1	137.340	137.444

### 4. SUMMARY

.The calculations was carried out to assess pre- and post-buckling state of square box using two methods. Critical forces for simply supported box were sorted out in Table 2. The more complicated calculation concerned the analysis of box in post-buckling state with regard to different parameters. The collected results of calculations were presented and discussed.

### 5. ACKNOWLEDGMENTS

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