IOP Conf. Series: Materials Science and Engineering **161** (2016) 012059 doi:10.1088/1757-899X/161/1/012059

The Study of Some Cracks on the Panels of a Minibus Body Using Modal Analysis

D Iozsa [1] and D A Micu [2]

[1] Associate Professor, POLITEHNICA University of Bucharest, ROMANIA
[2] Lecturer, POLITEHNICA University of Bucharest, ROMANIA

E-mail: daniel_iozsa@yahoo.com, dan.alexandru.micu85@gmail.com

Abstract. The body vibrations caused by the disturbing forces which acts on this one cause many problems connected, generaly, with the passengers confort (mechanical vibrations, noises) and also connected with the body reliability. The paper presents the study of some craks appeared on the roof panels of the body of a minibus and the study of some attempts to improve the behaviour. The study was made using the modal analysis in two steps. First was studied the behaviour of the hole structure and than was studied only the panel where cracks appear. The analysis of the first four eigenmodes confirmed cause of the cracks. Finally, it was offered an improved solution.

1. Introduction

The study presented in this paper started after the observation of some cracks which are appearing after a fairly short running distance, on the first panel of the roof of a minibus (figure 1). The producer noticed that the cracks appear especially at romanian users [3].

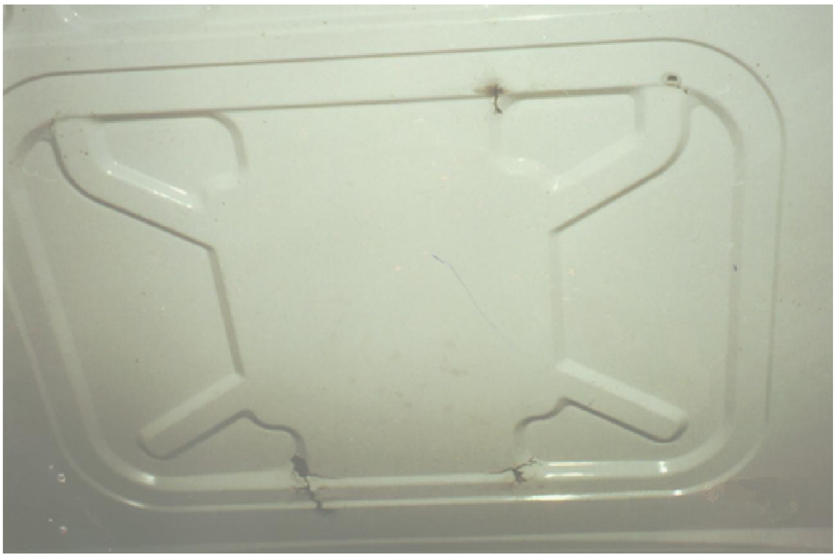

Figure 1. The cracks observed on the roof panel

The main causes could be the frequencies and the amplitude of the vibrations which excite the body structure. Areas of maximum stresses appear in the sensible zones with less rigidity. If the amplitude of the vibration is higher, cracks could be generated in these areas after a relatively small number of cycles.

Modal analysis offers many informations about the vibrational behaviour of a structure. The study of the vibration eigenmodes of the structure gives information about the resonance frequencies, the shape of the structure during vibration and the distribution of stresses for each eigenmodes. It is important to study that eigenmodes of the structure which are excited in the frequencies domain of the disturbing forces and to observe the areas where the structure has less stiffness, with peaks of stresses, areas where could be generated cracks. To perform such analysis is very useful a deformable model of finite elements [1], [2].

2. Modal analysis of the body structure

In the first stage of the analysis were studied the eigenmodes of the whole structure of the body using a simplified model. This model was made by beams and shells finite elements, and the calculus was performed with ADINA, a software specialized in the linear and nonlinear analysis of the structures.

Many of the first modes of the body stucture were excited in the frequencies domain due to running on the road, showing deformations of the roof panels. The first mode was manifested on the first panel, the panel with cracks (figure 2) [3].

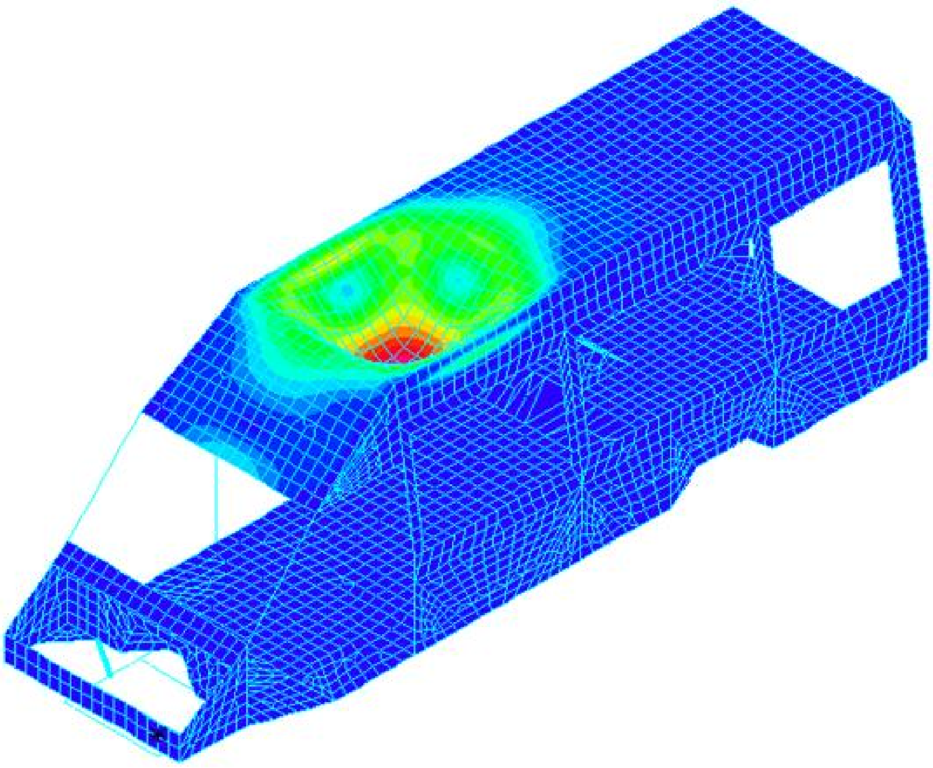

Figure 2. Resonance mode of the first panel of the roof

Vibrations of the first panel of the roof were manifested, also, in other eigenmodes determined by modal analysis. This shows that the body has a low stiffness and a higher vibration sensibility on this first panel of the roof, which can be excited by the vibrations generated by the running of the minibus on the road. In this stage, the panels where modeled like flat panels without ribs.

IOP Conf. Series: Materials Science and Engineering **161** (2016) 012059 doi:10.1088/1757-899X/161/1/012059

In the next step of the study was made a detaliated modeling of the first panel of the roof in order to observe the causes which are determining the appearance of the cracks, in the areas showed in the figure 1. The researching of eigenmodes was performed using the Modal analysis modulus of ANSYS, an well known software in the automotive industry.

The geometry of the panel presented in figure 3 shows that were modeled detailed all the ribs made by stamping on the surface of the panel. The finite elements model was made using only shell elements. It was used a relatively high mesh density, so the level of trust for the results obtained is also great.

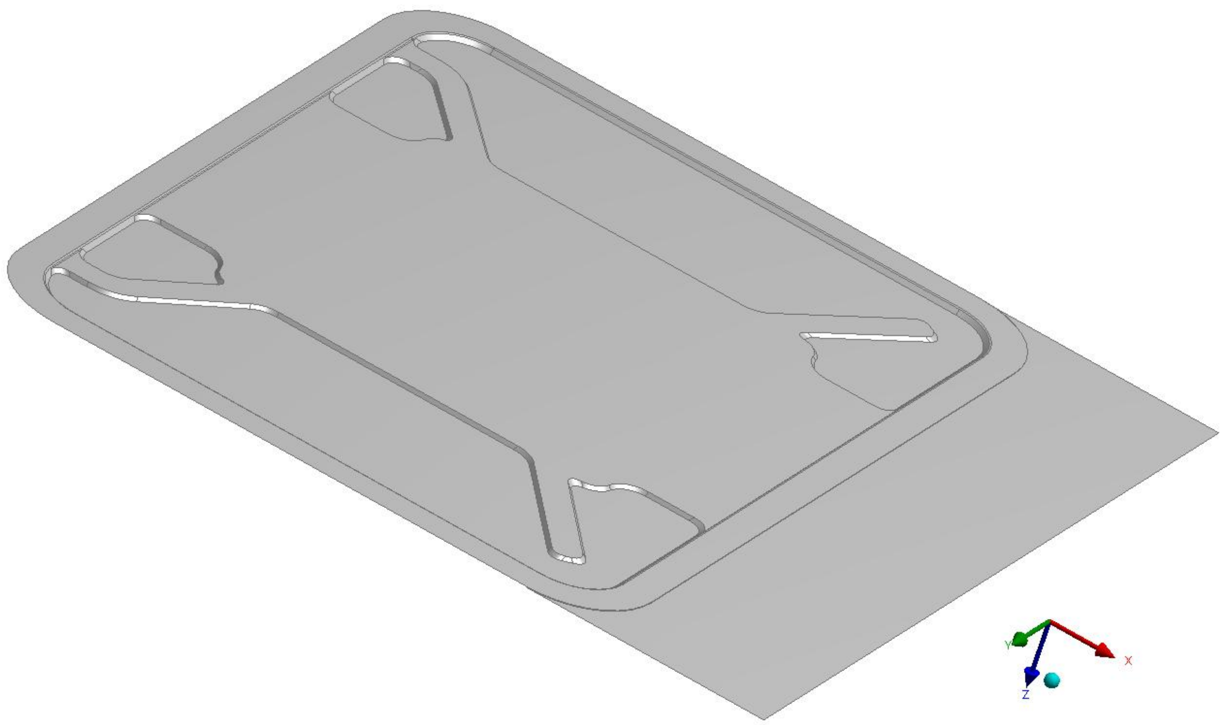

Figure 3. The geometry of the first panel of the roof

The model is fixed on the boundary lines in the same way that the panel is fixed on the beam structure of the minibus body.

The modal analysis of this panel shows that the first three modes are excited at low frequencies which could be caused by rolling on the road or by the operation of some subassemblies (Table 1). The fourth mode is excited at 43.14 Hz.

The displacements of the panel in these four modes are presented in figure 4.

Table 1. Resonance frequency of the first modes

Mode No.	**Frequecy**
Mode 1	14.05 Hz
Mode 2	26.985 Hz
Mode 3	27.976 Hz
Mode 4	43.14 Hz

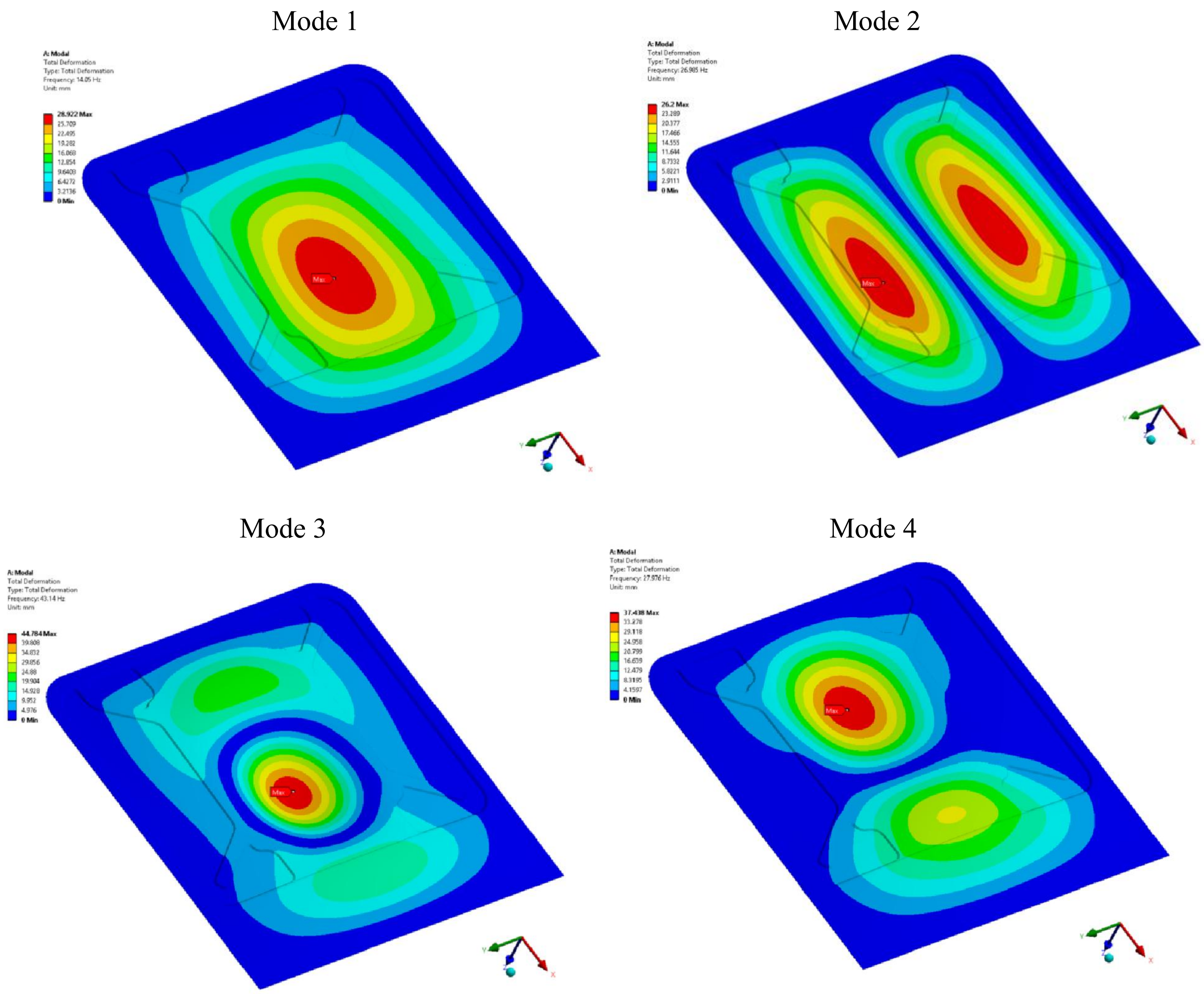

Figure 4. The displacement of the panel in the first four modes

Typicaly for a rectangular plate, the first and the second mode have one, respectively two peaks of amplitude [4]. The third mode is a single peak mode of the central zone of the panel and the fourth mode is a two peaks mode. The shapes of the last two modes are influenced by the shape of the ribs stamped on the panel.

The study of the equivalent stresses in the first three eigenmodes highlights that peaks of maximum stresses are developed in the same places where the cracks appear (figure 5). It was observed that the position of these peaks of stress is influenced by the shape of the ribs stamped on the panel. These peaks are placed in the blend area beetwen the central ribs and the edge rib.

The fourth eigenmode with a higher frequencie, has a peak of maximum stress in a different place.

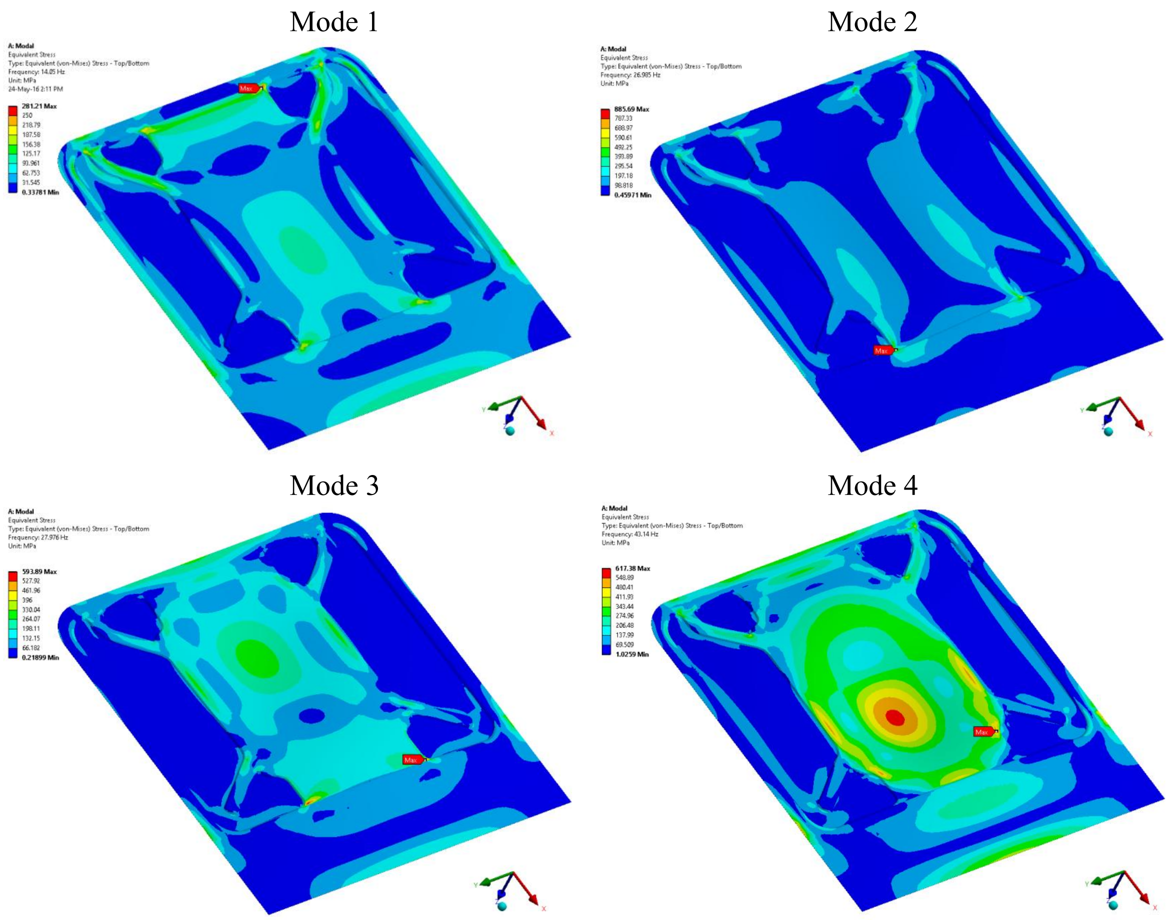

Figure 5. The equivalent stresses in the first four modes

One solution for this problem could be modifying the shape of the stamped ribs in order to increase the rigidity of the panel. So, there were studied some different shapes of the stamped ribs and better results were obtained with a X-shape ribs (figure 6).

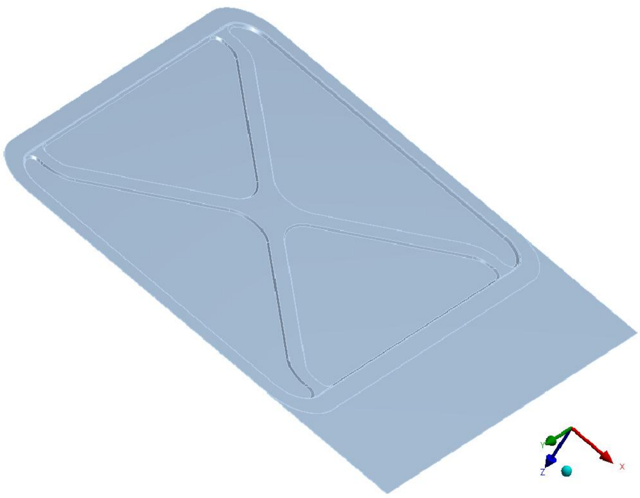

Figure 6. Proposed model with X-shape ribs

The modal anlysis of this model showed that the first mode is also a single peak of amplitude, excited at a higher frequency of 46.16 Hz, which is not caused by the running of the vehicle on the road. The second mode is a two peaks mode and is excited at 76.51 Hz. The position of the peaks was influenced by the X-shape ribs. The first and the second modes are presented in figure 7.

The proposed panel is harder with 23 mg but will have a better rigidity.

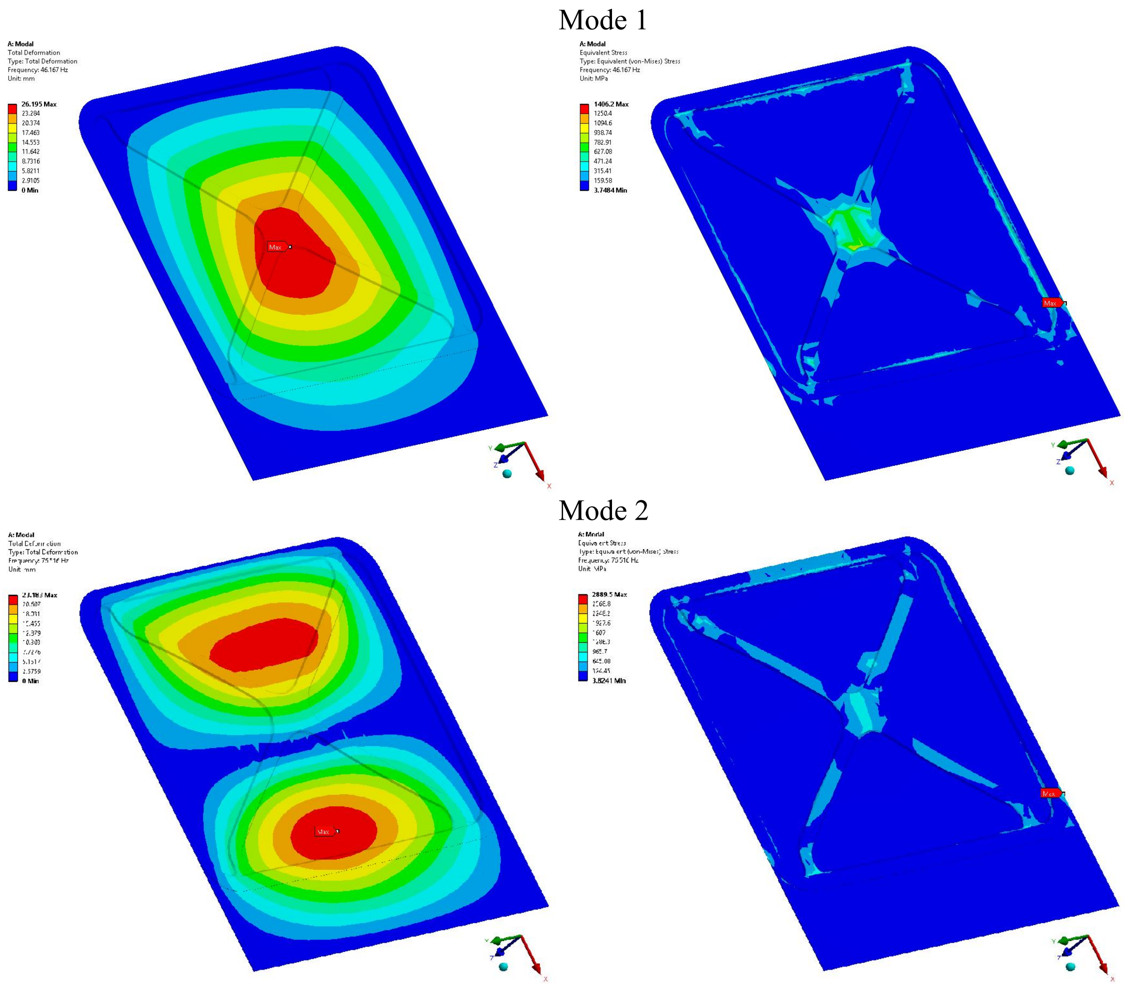

Figure 7. The mode shape and the equivalent stresses in the first two modes of the proposed model

3. Conclusions

The producer of the minibus observed that these craks are appearing only at minibuses of users from Romania, which indicates the well known problems of roads from this country. The vibrational loads which act on the minibus is much higher, favoring the appearance of cracks. The body of these minibuses have a raised roof which is less rigid and more sensitive to the vibrations.

The cracks are caused by the reduced rigidity of the structure in the area of the first panel of the roof. The shape of the stamped sheet metal, the ribs and the blends of the surfaces do not stiffen enough this panel.

References

[1] Zhi-Fang Fu, Jimin He, Modal Analysis, Butterworth-Heinemann, 2001
[2] Zaveri K, Modal Analysis of Large Structures, Brüel&Kjær, 1985
[3] Iozsa D et al, Study of the Dynamic Behaviour of the Car Body using Modal Analysis, ESFA 2003 Conference, Bucharest, 2003
[4] Jiu Hui Wu, A.Q. Liu, H.L.Chen, Exact Solutions for Free-Vibration Analysis of Rectangular Plates Using Bessel Function, Journal of Applied Mechanics, Vol.74, November 2007