INFLUENCE OF DAMPING EFFECT ON THE DYNAMIC RESPONSE OF THE PLATE

Ł. BORKOWSKI
Department of Strength of Materials, Lodz University of Technology
Stefanowskiego 1/15, 90-924 Łódź, Poland

1. STUDIED PLATES

A square isotropic plate with dimensions $b = l = 100$ mm, $h = 1$ mm and material constants $E = 200$ GPa, $v = 0.3$ was analyzed (Fig. 1). The analyzed plate was supported on the all edges. The plate has been loaded with a dynamic compressive load.

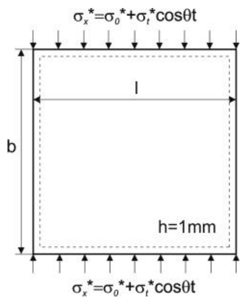

Fig. 1. Studied plate

The test plate with damping can be described by using the dimensionless equation:

$$\ddot{x} + c\dot{x} + a(1 - k\cos\psi\tau)x + bx^3 = 0 \qquad (1)$$

where: $c = 2h/\omega_0$ - the dimensionless damping ratio, $h = 0.02$ [1], $a = 1 - (\sigma_0^* / \sigma_{cr}^*)$, $b = 1 - (\eta / \omega_0^2)$, $k = (\sigma_t^* / \sigma_{cr}^*)/(1 - \sigma_0^* / \sigma_{cr}^*)$, σ_0^* - medium stress, σ_t^* - stress amplitude, σ_{cr}^* = 72.3MPa - critical stress, η = 0.23rad/s^2 - the value of parameter for the plate joint supported on the all edges, ω_0 - natural frequency, τ - dimensionless time. For the plate without damping the parameter $c = 0$.

For the purpose of the further numerical analysis, the equation (1) was described by two first-order differential equations:

$$\begin{aligned} \dot{x}_1 &= x_2 \\ \dot{x}_2 &= -cx_2 - a(1 - k\cos\psi\tau)x_1 - bx_1^3 \end{aligned} \qquad (2)$$

2. NUMERICAL ANALYSIS OF THE STUDY PLATES AND CONCLUSIONS

After the tests, it can be concluded that the impact of damping causes the changes of instability areas for the studied structure. In addition, the introduction of damping to the system results in a significant difference in the occurrence of areas in which the solution is chaotic. In both analyzed cases (for the plate without and with damping), the loss of dynamic stability was associated with a significant increase of the displacement x_1 and velocity x_2 values in comparison to the dynamic stability areas. Using the FFT analysis, the loss of dynamic stability results in the inability to precisely specify the dominant frequencies in the spectral signal (what is possible in the areas of dynamic stability) and a significant increase in their amplitude was found. Implementing the criterion of the largest Lyapunov exponents, it is possible to clearly present significant differences between the areas with a chaotic solution for the plate without and with damping effect.

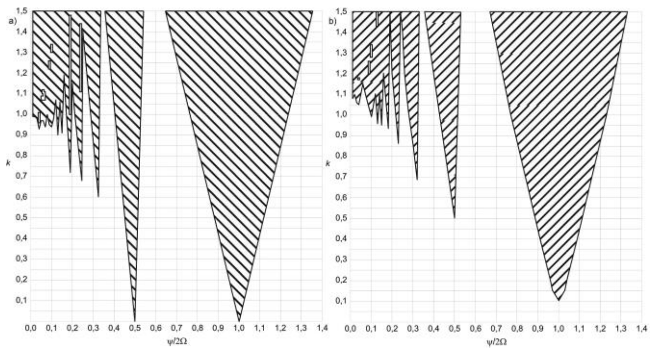

Fig. 2. The graphs of dynamic stability and instability areas
for the study plate without (a) and with (b) damping effect

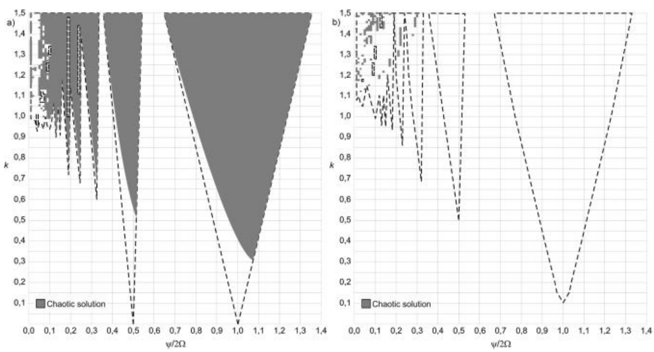

Fig. 3. The graphs of areas representing the chaotic solution
for the plate without (a) and with (b) damping effect

REFERENCES

[1] Kolakowski Z., Teter A., Influence of Inherent Material Damping on the Dynamic Buckling of Composite Columns with Open Cross-Sections, Mechanics and Mechanical Engineering, 17(1), 59-69, 2013.