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FREE VIBRATIONS OF ISO- AND ORTHOTROPIC PLATES CONSIDERING PLATE VARIABLE THICKNESS AND INTERACTION WITH WATER

Agnieszka LENARTOWICZ[1], Michał GUMINIAK[2]

[1]*Doctoral School of Poznan University of Technology, Piotrowo 3 street 60-965 Poznan*
e-mail: agnieszka.z.lenartowicz@doctorate.put.poznan.pl

[2]*Institute of Structural Analysis of Poznan University of Technology, Piotrowo 5 street 60-965 Poznan*
e-mail: michal.guminiak@put.poznan.pl

ABSTRACT

The subject of free vibrations of thin plates having constant or linearly variable thickness is discussed in the paper. The Finite Element Method (FEM) and the Finite Difference Method (FDM) are the main numerical methods used to determine natural frequencies of structural plates in vacuum or in an aqueous environment.

The article begins with a brief introduction where reference is made to known publications dealing with the subject of structural dynamics e.g. Jones and Moore [1], Sygulski [2], Nerantzaki and Katsikadelis [3] or Guminiak [4]. In these scientific papers research on thin plates, including the influence of an external medium, are conducted using such numerical methods as e.g. the Boundary Element Method (BEM) or the Analog Equation Method (AEM). In the next part of the article, the theoretical description of natural vibration of plates is included. Firstly, the FEM is taken into account. In this case, the constant thickness of plate is assumed, but its material may have variable properties in different directions. A rectangular four-node finite elements are analyzed and their displacement field is determined based on [5]. The plate stiffness matrix and mass matrix, occurring in the eigenvalue problem of the structure's natural vibrations, are derived numerically using author's approximate methods of calculating integrals. After considering the FEM, the authors pass on the FDM to describe free vibrations of isotropic plates with variable thickness. For this method, the differential equation of plate deformation is approximated by replacing derivatives by so-called central differences. This procedure allows to obtain the generalized eigenvalue problem where the plate mass matrix is assumed to be diagonal. Last theoretical chapter of the article introduces the subject of plates immersed in fluid with the application of the BEM. The presence of the liquid medium is taken into account by determining the fluid mass matrix and adding it to the plate mass matrix.

At the end of the article, numerical examples of determining the natural frequencies of plates are presented. Iso- and orthotropic plates of constant and variable thickness are considered and all previously described numerical methods are used. The tests allow to obtain insight into the influence of the external medium as well as the geometry and material of the plate on its natural frequency.

REFERENCES

[1] W.P. Jones, J.A. Moore, *Simplified aerodynamic theory of oscillating thin surfaces in subsonic flow*, J. Am. Inst. Aeronaut. Assoc. 11, 9 (1973) 1305 – 1307.

[2] R. Sygulski, *Dynamic analysis of open membrane structures interacting with air*, Int. J. Num. Meth. Engng. 37 (1994) 1807 – 1823.

[3] M.S. Nerantzaki, J.T. Katsikadelis, *An Analog Equation Solution to dynamic analysis of plates with variable thickness*, Engng. Analysis Bound. Elem. 17, 2 (1996) 145 – 152.

[4] M. Guminiak, The Boundary Element Method in plate analysis, Poznan University of Technology Publishing House, Poznań 2016 (in Polish).

[5] M. Kuczma, Foundations of structural mechanics with shape memory. Numerical modeling, University of Zielona Góra Publishing House, Zielona Góra, 2010 (in Polish).