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A Parametric Study on Free Vibration of Multi-Perforated Rectangular Plates*

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Abstract

This work involves study of the first three natural frequencies of the perforated plates. The effect of the parameters which influence them have been studied. The parameters considered are the shape of perforations, pattern of the perforations, aspect ratio of the plate, dimensions of the plate, ligament efficiency and the mass remnant ratio (MRR). The study is focused on the effect of the most influencing parameter on the free vibrations.

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Keywords: Mass Remnant Ratio (MRR); Ligament Efficiency; Aspect Ratio; Perforated Plates; Natural Frequencies

1. Introduction

Perforated metal plates are used for various applications like agriculture, and other applications involving sieving, noise control, heat exchangers, and pressure vessels and so on. Most of these processes involve the vibration of these plates. It is important to study the variation of the properties of the plates during their use. Warburton [1] in his paper 'The Vibration of Rectangular plates' worked on rectangular plates with all the possible combinations of boundary conditions. The frequency is derived by using the frequency expression for all modes of vibration and this expression is derived from the Rayleigh method. Suhn Choi et al [2] performed finite element

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modal analysis of perforated plates with square and triangular hole patterns. Dawe [3] computed the natural frequencies of vibration of flat plates having arbitrary shape where the plate is considered as assemblage of elements. Lim and Liew [4] performed a free vibration study of perforated plates with rounded corners. Guminiak [5] studied free vibration analysis of Kirchoff plates by using Boundary Element Method (BEM). Cuenca [6] developed a model for predicting the flexural vibrations of thin polygonal plates in the medium and high frequency range. Mali and Singru formulated analytical models for perforated rectangular plates by using different approaches to represent perforations such as Greatest Integer function, Heaviside functions and negative mass approach [6, 7, 8, 9, 10]. They have also given detailed literature related to the perforated plate vibration. This work aims at understanding the variation of the first three natural frequencies with the variation of some specific parameters. The main parameters which have been considered in this work are, the effects of the mass remnant ratio (MRR), the ligament efficiency, the pattern of the holes and the aspect ratio. The plates considered are thin with the boundary condition, all edges clamped. Three perforation patterns have been considered i.e. the Rectangular pattern, the 45^o staggered pattern and the 60^o staggered pattern. The thickness of the plate is maintained at 0.002 m for all the simulations that have been considered.

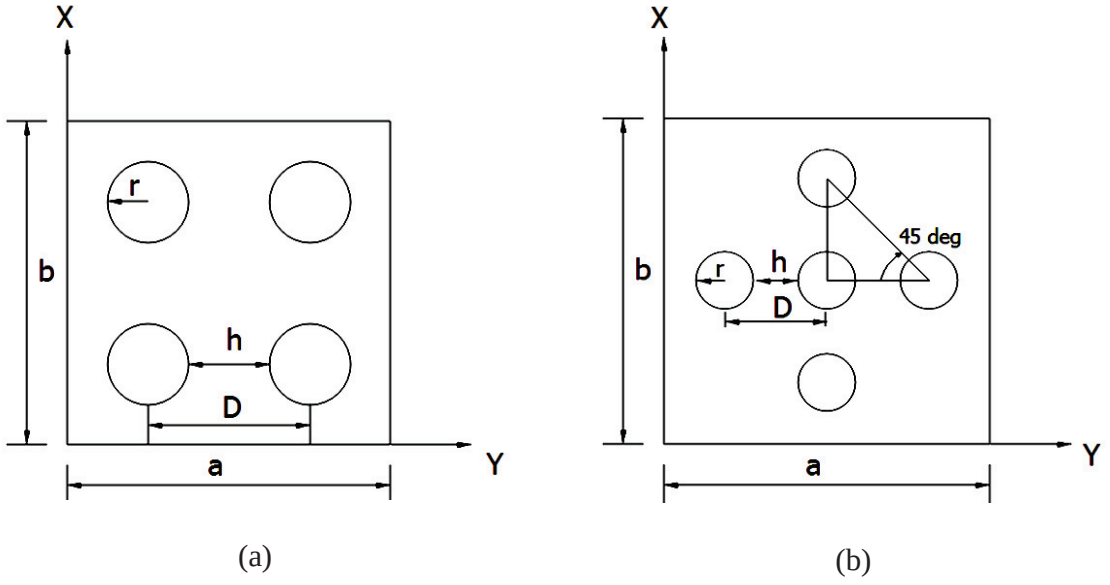

Fig. 1. Description of measures as used for calculation of Ligament efficiency a). Rectangular pattern; b). Triangular pattern

2. Methodology

The Finite Element Analysis has been carried out. The simulations have been conducted using ANSYS 15 APDL, and the element used for this study is Shell63 [1]. The material properties of the mild steel [2] considered are, the density 7850 kg/m^3, the Poisson's ratio 0.3, and the Modulus of elasticity 2.1×10^{11}. The plate has been modelled and the various specimens with different parameter variation have been simulated using ANSYS APDL. Analysis is carried out for the following cases of perforated plate. As the ligament efficiency cannot be kept the same for a plate in the 60^o staggered pattern (as the 60^o constraint does not allow it), this pattern is considered only for the first case.

1. Constant MRR, no constraints on ligament efficiency and mutual comparison of all 3 patterns.
2. Constant MRR, constant ligament efficiency and varying the aspect ratio for the rectangular and 45^o pattern. The 60^o pattern cannot be considered.