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A simulation study on the modal analysis of perforated plates

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ABSTRACT – This paper presents a comprehensive modal analysis study of perforated plates with micro and macro size holes as one of the most important aspects in engineering vibration point of view. The Finite Element Method (FEM) in SolidWorks environment is employed to simulate the phenomena and visually present the results. It is found that the presence of holes apparently shifts the natural frequency gradually towards the lower value. As the holes size increases, the natural frequency is proportionally reduced.

1. INTRODUCTION

Perforated plates, either micro or macro size holes, have been widely used in many engineering application [1]. Besides its unique and attractive looks, the perforated panel can also provide many engineering benefits i.e. considerable structural strength and good acoustical performance. Researches on the micro and macro-perforated panel have also been conducted particularly for their acoustical performances [2–4]. Even so, there has been a lack of comprehensive knowledge on the structural mechanical behaviour especially for micro-perforated plate since the existing studies were only conducted in separate ways and for their own particular purposes. Therefore, this paper presents a comprehensive modal analysis study of perforated plates with micro and macro size holes as one of the most important aspects in the structural engineering point of view. This study is an extensive work of Burgemeister and Hansen whereas only macro-holes were considered in the discussion [5]. The Finite Element Method (FEM) in SolidWorks environment is employed to simulate the study and visually present the results.

2. METHODOLOGY

A simply supported square aluminum plate 15 x 15 cm with 2 mm thickness is made in Solid Works environment as a sample. The plate is varied from solid to perforated with gradual holes size increment. Figure 1 shows the initial design of the solid and perforated plate in Solid Works.

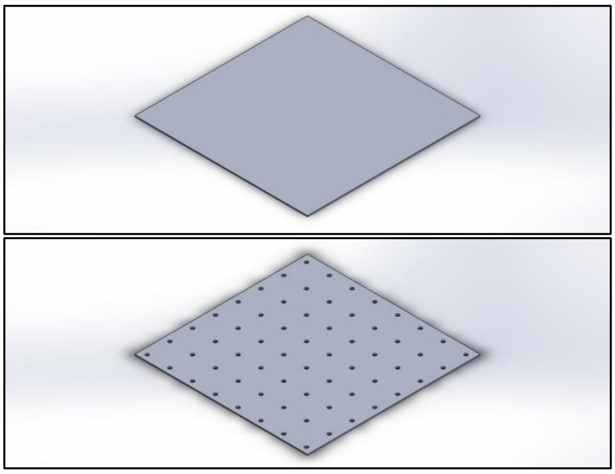

Figure 1 Solid (top) and perforated plates (bottom).

The hole diameter is made to be 0.5 mm to represent micro-holes and 1.5 mm to represent macro-holes. The perforation ratio, however, is kept constant at 0.5% of the plate area. Figure 2 shows the example of finite element models of the perforated plates.

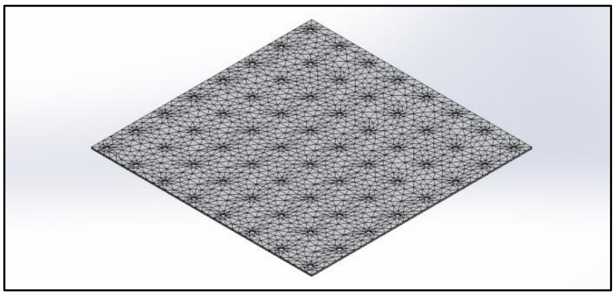

Figure 2 Finite element models of the perforated plate.

3. RESULT AND DISCUSSION

Figure 3 to 7 show the example of FEM result of the perforated plate showing the 1st to the 5th mode shape of both micro and macro-holes. Table 1 shows the frequency value from 1st to 5th mode shape.

It can be seen that the presence of holes gradually shifts the natural frequency to the lower value. For the 1st mode, micro-holes give 9 Hz lower natural frequency than that of solid plate while macro holes shift up to 13 Hz lower. For the 2nd mode and further, the shifting is even higher. Micro-holes shifting is up to 29 Hz while macro-holes is up to 30 Hz. This is happened because the presence of holes apparently affects the mass of the panels. Micro-holes on the plate reduces the panel mass and macro-holes obviously reduces more. At the same time, the stiffness of the panel is reduced accordingly. As the natural frequency significantly depends on those two parameters, the reduction on both will eventually shifts the natural frequency to the lower level.

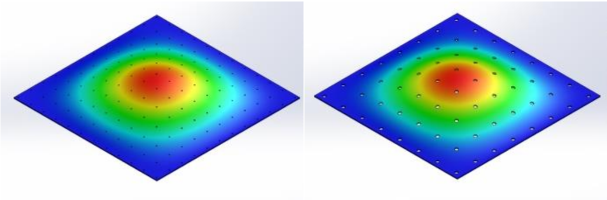

Figure 3 1st mode of the perforated plate.

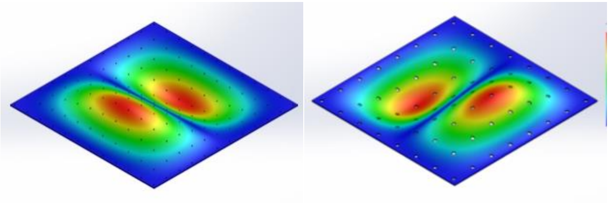

Figure 4 2nd mode of the perforated plate.

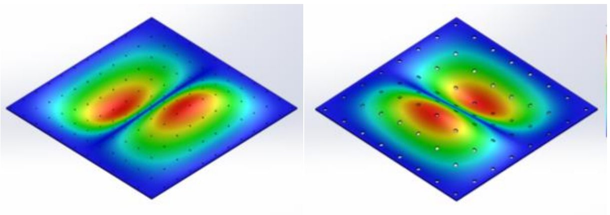

Figure 5 3rd mode of the perforated plate.

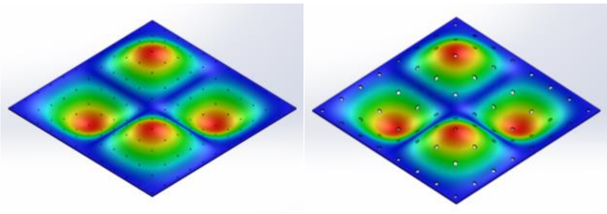

Figure 6 4th mode of the perforated plate.

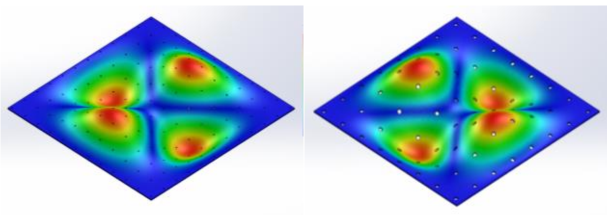

Figure 7 5th mode of the perforated plate.

Table 1 Mode shape frequency (Hertz).

Plate	**1st**	**2nd**	**3rd**	**4th**	**5th**
Solid	404.14	829.63	830.01	1260.6	1489.9
Micro holes (0.5mm)	393.08	801.69	801.87	1182.2	1437.6
Macro holes (1.5mm)	391.49	799.74	800.14	1181.3	1437.7

4. SUMMARY

The natural frequency of perforated panels with micro and macro size holes has been studied in the Solid Work environment. The results have been compared to that of solid plate natural frequency. It is found that the holes give significant effect on the mass and stiffness of the panels which proportionally shifts the natural frequency of perforated panel to the lower value. As the holes size increases, the natural frequency accordingly shifts to the lower value.

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