CHAPTER 1

INTRODUCTION

The plates with cutouts are used in several engineering structures such as ships, aircrafts and other mechanical structures. The cutouts are made for diverse reasons such as venting, visual control and accessibility to interior parts of the machine. The prediction of modal behavior of such holed plates is of great interest to avoid undesirable strong coupling between structures or between a structure and a fluid. The panel board of an aircraft is a plate structure housing various precision instruments. Hence, the dynamic behavior of this aircraft instruments panel board significantly affects the life and the performance of the precision instruments fitted on to it. The base excitation set in by the running of the aircraft engine, atmospheric turbulence, gust etc. has significant effect on the vibration of the panel board. The prediction of model behavior of such holed plates is of great interest to avoid undesirable damage to the instruments.

Conventionally aircraft panel boards are made of aluminium alloys due to its lightweight and ductility. The thickness of the board is the only parameter that controls the natural frequencies of the board as the dimensions of the panel board, size and shape of the cutouts, weights of the instruments and the positions of these instruments in the panel board are practically unalterable.

Panel boards made of composite laminates can replace these aluminium alloy panel boards, since the fiber-reinforced plastics possess higher
strength to weight ratio and higher stiffness to weight ratio compared to aluminium alloys.

Using the directional properties of the fibers and arranging different layers of the laminate, the composite panel boards can be suitably designed to avoid the occurrence of resonance at low frequency ranges, which will cause higher amplitudes of vibration, and hence reduce the damage and increase the life of the precision instruments.

The parameters, which control the natural frequencies of the composite panel boards are, their thickness and the number of layers in the laminate, their arrangement, the orientation of the fibers and the volume fraction of the fibers. The information available in the literature is limited to some specific shapes of composite plates and with few cutouts of regular shapes. No closed form solutions are available for the dynamic characteristics of complex shapes such as the panel board with specific boundary conditions and specified numbers, shapes and sizes of the cutouts. Hence it is worthwhile to undertake selected numerical studies to get more insight into this application area.

This investigation presents the results of experimental and numerical studies on the free vibration characteristics of a typical aircraft instruments panel board made of E-glass/Poly vinyl ester composite. Seventeen typical aircraft panel boards with different layer arrangements and fiber orientations are made and their physical and elastic properties are experimentally determined. The first three natural frequencies are also experimentally determined. The numerical frequency analyses are performed on the finite element models for these seventeen boards, using finite element analysis package Cosmos/M software. Experimentally obtained material and elastic properties are used in these numerical studies and the first three natural frequencies of the layered
composite panel boards are determined. These results are compared with the experimental results for verification and validation of the finite element model, the material and elastic properties and the numerical tool.

Further numerical analyses are carried out on the composite panel boards to study the variations of the natural frequencies for symmetric and antisymmetric layer arrangements using uni-directional and bi-directional fibers with different fiber orientations and thicknesses. The results obtained are presented and discussed.