CHAPTER I
INTRODUCTION

1.1 Background

Engineering structures such as unmanned aerial vehicles (UAVs), cars, and ships frequently experience dynamic loads in the form of vibrations or shocks. Repeated vibrations can cause material fatigue and shorten the structure's lifespan. One of the main causes of damage to UAV structures is excessive vibration during landing, especially if the materials used have low vibration damping capacity. Therefore, materials are needed that are not only lightweight and strong but also able to dampen vibrations effectively.

One solution to mitigate the effects of excessive vibrations is to shift the structure's natural frequency, either by increasing or decreasing its stiffness. However, in practice, stiffness values cannot always be flexibly adjusted, necessitating the selection of materials that better dampen vibrations.

One material that can be an option is composite. Composite materials are materials consisting of a mixture or combination of two or more different components with different properties[1]. This material is known for its lightweight nature and ability to be tailored to specific application requirements. However, some composites are also more susceptible to vibration and vary in strength depending on the resin and fiber used. Therefore, it's important to find the optimal composite combination: high strength, good vibration damping, and light weight.

One previous study focused on varying the position and length of spars in UAV structures to increase the natural frequency, thereby avoiding resonance[2]. However, this study did not explore material variation as a factor in increasing the natural frequency. Another study used coconut fiber with different fiber orientations (0°, 45°, and 90°) in a cantilever beam to evaluate the effect of fiber direction on mechanical properties and vibration characteristics[3]. The results of both studies indicate that both material selection and geometric configuration have a significant influence on the dynamic performance of a structure.

Based on this, this research focuses on selecting the optimal combination of composite materials for structures subjected to dynamic loads and vibration. Four combinations of resin and fiber were tested to determine the most ideal material in terms of strength, vibration damping capacity, and weight.

This study will test four resin-fiber based combinations: a combination of epoxy resin with carbon fiber, a combination of polyester resin (70%) and vinyl ester (30%) with carbon fiber, a combination of epoxy resin with fiberglass, and a combination of polyester resin (70%) and vinyl ester (30%) with fiberglass. These combinations are ideal for structures that need to withstand moderate to high loads and long-term resistance to dynamic loads[4].

Numerical and experimental testing were conducted based on ASTM E-756 standard with cantilever beam specimens that represent actual working conditions on UAV structures. The testing began with cantilever beam simulation using MSC Nastran and MSC Patran software to see the stiffness of the variations used. Then the simulation results with the highest stiffness were proven by experimental testing to see the actual vibration response produced. Experimental testing was carried out using the bump test method using an impact hammer to test the modal on the structure. Analysis of experimental data results must pay attention to the coherent function value so that it is not greater than 0.8 on the computer display so that the test response data is free from noise (interference). In addition, static testing is also carried out to obtain the tensile strength value of the structure using Universal Testing Machines with ASTM D-790 standards.

1.2 Problem Formulation

The research problem formulation is to determine which composite material can provide high strength, best vibration damping, and has a light weight. This study also compares four composite material combinations using vibration test results to find the most suitable material for structural applications that frequently experience dynamic loads.

1.3 Aim

The purpose of this final project research is to find the optimal combination of composite materials with a light weight, but still have high mechanical strength. In addition, this research is also aimed at increase the damping ratio of each composite material variation in reducing vibration response so that a composite material can be obtained that is not only strong and light, but also has high damping capabilities against dynamic excitation.

1.3 Benefits

The benefits of this final project are expected to benefit industries requiring composite materials with high strength and vibration resistance. Furthermore, the results of this research can serve as a reference for future composite development and contribute to a deeper understanding of the dynamic response of composite materials in structural applications.

1.4 Problem Scope

The limitations of problems in this final project are:

1. The specimens used in the vibration test used the ASTM E-756 standard, and the tensile test used the ASTM D-790 standard.
2. The vibration analysis on the MSC Nastran Patran was performed linearly.
3. The grain direction in the vibration and tensile test specimens was 0°.
4. The modulus of elasticity (E) input into the MSC Nastran Patran corresponded only to the tensile test orientation.
5. The test was conducted using an impact hammer based on a ground test in a confined space.
6. The test was conducted using Universal Testing Machines.

1.5 Report Outline

This final project proposal consists of five chapters. The first chapter, the introduction, contains the background explaining the rationale for this research, the problem formulation, the objectives to be achieved, the benefits of the research, and the report writing system. The second chapter then discusses various relevant literature and theoretical foundations that support the research. The third chapter, explains the research methodology, including a description of the tools used, the research implementation process, and the detailed steps in conducting the research. The fourth chapter discuss about the results and the analisys of the topic. The final chpater, fifth chapter discuss about the conclusion and the suggestment.