1. INTRODUCTION

1.1. Background

Vibration is often to be the cause of so many failures in structure, whether it is static structures such as bridge and building or even mechanical structures such as aircraft and other transportation modes. The most famous case is the Tacoma Bridge Incident in 1940[1], which to many refer it as the most dramatic failure in structural engineering. In the said case, it is clear that flow-induced oscillations caused severe damage to its structure.

Flow-induced oscillation is often experienced by an aircraft, due to its operating at a high velocity. This flow-induced oscillation is often referred to as a flutter phenomenon. Theodore von Kármán, the one who first study flutter, said in [2], “Some fear flutter because they do not understand it, and some fear it because they do”. Flutter is a phenomenon of resonance that is caused by an aerodynamic force acting as an excitation force to the system and changes over time[3]. This phenomenon is classified as a forced vibration and if it left unchecked can cause major damage to aircraft main component such as wings.

There are already several cases of failures caused by flutter on aircraft. Such as in 1919, where a Verona Caproni Ca.48 experienced flutter on its wings and caused it to collapse completely[4]. This accident resulted in 15 fatalities and dozens wounded, at the time this is the worst accident that ever happened and currently placed on the 45th of the all-time list according to the aviation-safety.net website. On September 6th, 1952, a prototype model of de Havilland DH.110 experienced flutter during an acrobatic air display during the Farnborough Airshow[5]. This accident caused the aircraft to be damaged beyond repair and cost its pilot, John Derry, his life.

Due to this fact, many researchers have already conducted a study on this subject. Some tried to prevent it and some tried to control it for other use. Various methods have been done using computing software, simulation analysis software, or even actual simulation with scale model using a wind tunnel. Such as M. Yamagishi in his work “Displacement Acquisition of a Flattering Plate by using Image Processing”[6], who tried to use flow-induced vibration’s kinetic energy as a power source for a generator. On the other hand, J. Njuguna which in his work "Flutter prediction, suppression and control in aircraft composite wings as a design prerequisite" [7] tried to predict and suppress the occurrence of flutter by using a theoretical, computational and experimental calculation. This study also stated that the emergence of flutter compromises not only the long term durability of wing structure but also the operational safety, flight performance, and energy efficiency of the aircraft. There is also Luca Pigolotti that tried to find the post-critical response of a wing model by using a wind tunnel, this is stated in his 2017 work "Wind-tunnel tests on the post-critical response of classical-flutter-based generators"[8].

In this study, an aircraft wing will be modeled as a cantilever beam. There will be 2 points to analyze from this beam, the first one is its natural frequency and the second one is its mode shape. By identifying both of these aspects, when and how the beam will resonates can be predicted. To predict it accurately, the beam will be divided into several elements (10, 30, and 90 elements) with each element have 4 DOF. Essentially this study uses the finite element method to find the two aspects stated before. To validate this method, the results will be compared to the Euler-Bernoulli Beam theory[9] which was used by Ahmed Zai in his study.

1.2. Problem Formulation

As mention before, that flutter can inflict a significant amount of damage to the aircraft, especially the wings. If the excitation force has a frequency that equals the natural frequency of the structure, resonance is bound to happen. What happens after resonance is an uncontrollable vibration that causes the system to collapse. Based on those explanations, the analysis of how the flutter phenomenon affects the wing of an aircraft needs to be conducted.

1.3. Objectives

The objectives of this study are:

1. To calculate the natural frequency of the system.
2. To obtain the mode shape of the system.

1.4. Benefit

By obtaining the natural frequency of the system, the frequency in which the system resonates can be predicted. Therefore, the flutter frequency can be predicted.

1.5. Problem Scope

This study's problem scope covers as follow:

1. The model is scaled to accommodate the experimental apparatus.
2. The material used to make the test model is Polylactide Acid (PLA).
3. The type of airfoil used is b737a-il.

1.6. Report Outline

This study consisted of five parts. The first part is the introduction which covered the background, problem formulation, objectives, outcomes, problem scope, and the outline of this study. The second part is the literature review which explained the basic theories that support this study. Then, in the third part, the methodology, the research stages, the research design, and the research procedures of this study will be described. Furthermore, in the fourth part, the result of the said method will be analyzed and compared to other studies and the literature review. Finally, in the last part, the fifth part, the conclusions of this study will be stated and explained.