A COMPARISON STUDY BETWEEN THEORETICAL, FINITE ELEMENT AND TESTING OF AUXETIC COMPOSITE PLATE USING UNIDIRECTIONAL CARBON FIBRE UFC385/POLYESTER RESIN.

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ABSTRACT

The purpose of this research is to compare the ability of three different methods in producing an auxetic composite plate. An auxetic composite plate is a special plate that has a negative Poisson ratio. This type of plate has a peculiar behavior where the material expand laterally when stretched and contract laterally when compressed. Composite with auxetic behavior present some unique próperties such as increased plane strain fracture resistance and increased shear modulus, impact resistance, indentation resistance, fracture toughness and acoustic response compare to conventional material. Some of the applications of auxetic composites are personal protective clothing or equipment in the form of crash helmet, projectile resistance or bullet proof vest, shock and sound absorbers and vascular implants. Based on the unidirectional tape properties determined from experiments, an analytical model using two-dimensional constitutive equation and Classical Laminate Theory (CLT) has been developed. The composite plate is constructed using UFC385/POLYESTER a carbon fibre unidirectional tape. The method used in the plate construction is the Hand Lay-up method. This research work is divided into two main parts. After the design and development part of the plate is completed, the simulation and testing part of the plate using MSC Nastran and INSTRON Tensile Test Machine respectively is carried out. The model is tested to verify the existence of negative poisson ratio. From the theoretical and experimental result, the existence of auxetic behaviour will be compared and discussed. The unidirectional carbon fibre UFC385/POLYESTER has properties as follows; $E_1 = 1x10^{10}$ Pa, $E_2 = 5.75x10^8$ Pa, $\nu_{12} = 0.3$ and $G_{12} = 1.5x10^8$. The most negative Poisson's ratio can be achieved by theoretical calculation is -0.33 when the angle combination is $[22.5^0, 67.5^0]_S$. Simulation and experimental results are -0.337 and -0.5206 respectively. It is shown that, negative Poisson's ratio as high as -0.5704 can be achieved experimentally. The difference between experimental and theoretical value is believed due to the assumptions used in the formulation of the theory and also human error in constructing the plate (hand lay-up). Further analysis can be carried out using different construction methods such as using vacuum bag or autoclave which is more expensive but will give a better result. Finally, factors that promoting negative Poisson's ratio also is an interesting area to look into in the future.

TABLE OF CONTENTS

CHAPTER I

INTRODUCTION

1.1 Objective

This work will focus on a peculiar behaviour of composite laminate known as auxetic behaviour. The main objective of this work is to design in plane auxetic behaviour of composite material using three different methods; theory, simulation and experimental. The two-dimensional constitutive equation and Classical Laminate Theory (CLT) is utilized in the theoretical part. MSC Nastran is used in the simulation part and finally INSTRON tensile test machine is employed in the experimental part.

The effective Poisson's Ratio of laminate fibre reinforced composite can also be appear to be negative. This material present some unique properties such as increased plane strain fracture resistance and increased shear modulus, indentation resistance, fracture toughness and acoustic response compare to conventional material. This material can be used as vehicle body or car bumper, personal