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ANALYSIS OF MECHANICAL PROPERTIES OF INORGANIC ADHESIVE BASED COMPOSITE USING FINITE ELEMENT METHOD

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DECLARATION

"I hereby declare that the work in this report is my own except for summaries and quotations which have been duly acknowledged."

Signature: .....

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For my beloved parent and family for their guidance and love.

Special thanks to my supervisor.

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ABSTRACT

This study is about analysis of mechanical properties of inorganic adhesive based composite using finite element method. There are varieties of ways to joint different part together, but two major methods are mechanical fastening and adhesive bonding. However, adhesive bonding is becoming one of the popular joining methods in industries since it offers different option over mechanical joint such as riveted and welding. Many structural analysis tools exist that have capability to conduct fracture mechanics and crack propagation analysis. In this study, Finite Element Method which simulates crack growth in layered structure is used as a method to do the analysis. Methodology of this study is used software packages Simulia ABAQUS to show the stress distribution in tensile loading. The finite element model is validated with the available result of experimental method with same material properties of SUS 304 as adherend and ARON C as adhesive. The result is shows and divided according to thickness value starting from 0.1mm to 0.7mm. The out-of-plane normal and shear stresses are computed at the interfaces of the adherends and adhesive, and at mid surface of the adhesive to analyzed the stress distribution and predict the mode of failure occurred. Some recommendation for future work or extension of this study is mention significantly in this report.

ABSTRAK

Kajian ini dijalankan untuk menganalisis sifat-sifat mekanikal perekat bukan organik berasaskan komposit menggunakan kaedah 'Finite Element'. Terdapat pelbagai kaedah boleh digunakan untuk menyambungkan bahagian yang berbeza bersama, tetapi dua kaedah utama yang biasa digunakan adalah ikatan mekanikal dan ikatan perekat. Bagaimanapun, ikatan perekat menjadi kaedah paling popular dalam industri kerana ia berbeza daripada ikatan mekanikal seperti rivet dan kimpalan. Terdapat banyak cara untuk menganalisis struktur yang boleh digunakan untuk mengkaji keupayaan mekanik patah dan penyebaran retak. Dalam kajian ini, kaedah 'Finite Element' akan digunakan sebagai kaedah analisis untuk mengkaji pertumbuhan keretakan dalam lapisan struktur. Perisisian Simulia ABAQUS digunakan untuk menunjukkan agihan daya apabila daya tarikan dikenakan. Model ini akan disahkan dengan cara dibandingkan dengan kajian melalui eksperimen yang dilakukan menggunakan sifat bahan perekah dan bahan sambungan yang sama. Hasil kajian akan dibahagikan mengikut ketebalan perekah yang digunapakai iaitu diantara 0.1 mm hingga 0.7 mm. Tegasan pelan dan tegasan terikan dikira pada lapisan antara repekah dan bahan penyambung dan dilapisan tengah perekah dan bahan penyambung. Beberapa cadangan untuk menyambungan kajian ini juga turut dinyatakan dalam laporan ini.

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LIST OF SYMBOL

SYMBOL		DESCRIPTION
v	=	Poisson ratio
σ	=	Stress
ε	=	Strain
E	=	Modulus of Elasticity

LIST OF ABBREVIATION

WORD	DESCRIPTION
ASTM	American Society for Testing and Materials
CAD	Computer Aided Design
CAE	Computer Aided Engineering
DOF	Degree of Freedom
FE	Finite Element
FEA	Finite Element Analysis
FEM	Finite Element Method
UTS	Ultimate Tensile Strength

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CHAPTER I

INTRODUCTION

1.1 BACKGROUND OF STUDY

Recently, with the heavy development of industry in aeronautical, shipbuilding and automobile, there is a lot advancement of technologies has been discovered to joint different part together. There are wide varieties of ways to joint different parts together, but two major methods are mechanical fastening and adhesive bonding. Adhesive bonding becoming one of the popular joining methods since it offers different option over mechanical joint such as riveted and welding. Volkersen (1938) first proposed a simple shear lag model for mechanical joints with many fasteners, and later on, this model was adopted for adhesively bonded lap joints with the assumption that the adherents are in tension and adhesive is in shear only and both stresses are constant across the thickness (Dillard, D. A., 2002).

Adhesive bonding of structures has significant advantages over conventional fastening systems. Bonded joints are considerably more fatigue resistant than mechanically fastening structures because of the absence of stress concentrations that occur at fasteners. Joints may be lighter due to the absence of fastener hardware. A major advantage of adhesive bonds is that adhesive bonds may be designed and made in such a way that they can be stronger than the ultimate strength of many metals in common use for aircraft construction.

Historically, adhesives have been used since ancient times. The first adhesives were probably made from boiled-down animal products such as hides or bones. An organic adhesive, which is carbon-based have also been derived from plant products for use with paper products. While many of these organic glues have proven effective in the adhesion of furniture and other indoor products, they have not been effective in outdoor use where they are exposed to harsher environmental conditions. Although inorganic adhesives, which are based on materials not containing carbon, such as the sodium silicates (water glasses) for bonding paper board, are sold commercially, most adhesives in common use are made of synthetic, organic materials. By far, the most widely used adhesives today are synthetic, polymer-based adhesives.

Many structural analysis tools exist that have capability to conduct fracture mechanics and crack propagation analysis. In this study, Finite Element Method which simulates crack growth in layered structure is used as a method to do the analysis. The technique is based on the approximate solution to any complex engineering problem can be reached by subdividing the problem into smaller manageable elements. In addition, it is not only used for analyzing classical static structural problem, but also for such diverse areas as mass transport, heat transfer, dynamics, stability and radiation problems.

1.2 PROBLEM STATEMENT

Adhesive bonding of structures has significant advantages over conventional fastening systems. Bonded joints are considerably more fatigue resistant than mechanically fastened structures because of the absence of stress concentrations that occur at fasteners while bonded joint distributes the stress uniformly.

The stresses induced at the interfaces of the adherend and adhesive, and in adhesive layer play an important role in the design of the adhesively bonded joint. It is important these stresses and strength properties of adhesive are required to analyze. To lead an answer for this problem, stress distribution of single lap joint with adhesive bonding in tensile loading is determine by simulating the stress distribution using finite element (FE) at elevated thickness.

1.3 OBJECTIVES OF STUDY

The main objectives for the study of mechanical properties of inorganic adhesive based composite using finite element method (FEM) are stated as follow:

i. To study the importance adhesive bonding joint method used in industry.

ii. To determine the effect of adhesive bonded layer thickness in tensile loading.

iii. To analyze stress distribution using appropriate analytical software.

iv. To validate the result with the experimental method.

1.4 SCOPES OF STUDY

The analysis is conducted with two rectangular bar specimen in single lap joint with adhesive bonding joining method in tensile loading. To achieve the above objectives, the scopes need to be considered as follow:

i. Geometry model of 2-Dimensional (2D) FE is created, which is single lap joint of two rectangular bars with elevated thickness of adhesive bonded layer.

ii. Mechanical properties for rectangular bar and adhesive used are Stainless Steel 304 and Aron Ceramic C, respectively.

iii. Analysis on the FE model is performed to simulate the stress distribution between interface of adherent and adhesive and adhesive layer.

iv. Simulia ABAQUS package software is used as a tool of FE analysis.

1.5 THESIS ORGANIZATION

Chapter 1 consists of the introduction of this research which is the background, problem statement and scope of study. It also states the objectives as well as the scopes of the study and organization of thesis.

Chapter 2 consists of the numerous aspects about the study. It is discussing about the result from previous study from journal related to this study and is summarized. Besides, it is include the definition of adhesive, general function of adhesive, mode of failure more focus in single lap joint, testing method of adhesive, the stress distribution in adhesive joining method include the comparison with other mechanical joint and lastly, explanation and exploration in FEA.

Chapter 3 is basically explaining the method and procedures that used in this study. This chapter also includes the study of application of software, FEM and the guide for this study based on the flow chart created before. Methodology is a process where a work is done from an idea. This is possible with proper planning, research and analysis to collect data for the study.

Chapter 4 consists of the result carried out from FEA via Abaqus which were discussed in Chapter 3, is presented in this chapter. The model developed based on rectangular bar specimen adhesively bonding in tensile loading with fixed at one end is analyzed it stress distribution.

Chapter 5 consists of the discussion for the results of FEA from the single lap joint are discussed. Tables and figures were used to make the data presented easy to understand. The discussion is focused on stress distribution and the mode of failure occurs is predicting based on the research in literature review and it is validate with the result from experimental method.

Chapter 6 concludes the result and discussion of this study. The first section summarizes all the alternatives that have been mentioned previously. Meanwhile, some recommendations are included in the second section of this chapter.

CHAPTER II

LITERATURE REVIEW

This literature review explores the dominant themes includes previous study and research of published materials like journals, thesis, case study, technical document, and online library. Generally, the purpose of a review is to analyze critical segment of a published body of knowledge through summary, classification and comparison of prior research studies, reviews of literature, and theoretical articles.

This chapter will describe the topics which are related to this study consists of definition of adhesive, general function of adhesive, mode of failure specifically focusing in single lap joint, testing method of adhesive, the stress distribution in adhesive joining method include the comparison with other mechanical joint and lastly, explanation and exploration in finite element analysis (FEA).

2.1 DEFINITION OF ADHESIVE

An adhesive is a material that is applied to the surfaces of any particle to join them permanently by an adhesive bonding process. It is a substance that capable of forming bonds to each of the two parts which is the final object consists of two parts that are bonded together into one part. A feature of adhesives is the relatively small quantities that are required compared to the weight of the final parts.

Adhesion is used to describe the common state where two bodies are stuck together is relatively straightforward (R.J. Good, 1981). The following definition by Simon Wu (1982), Adhesion refers to the state in which two dissimilar bodies are held together by intimate interfacial contact such that mechanical force or work can be transferred across the interface. The interfacial forces holding the two phases together may arise from the Van Der Waals forces, chemical bonding, or electrostatic attraction. Mechanical strength of the system is determined not only by the interfacial forces, but also by the mechanical properties of the interfacial zone and the two bulk phases.

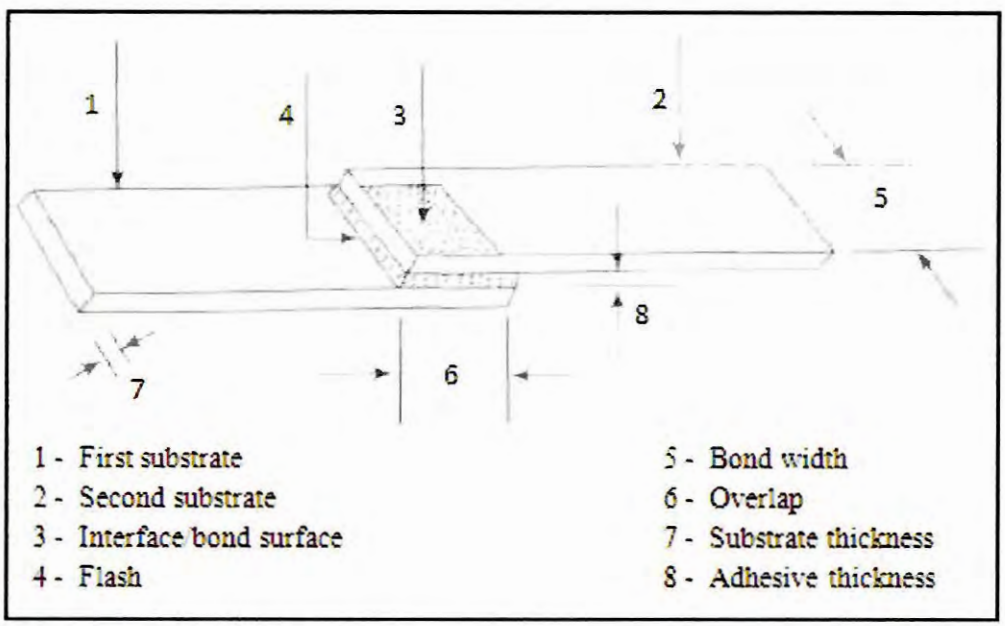

Figure 2.1: Schematic of an adhesive joint

(Source: Packham, D. E., 2005).