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"I hereby declared that I have read this thesis and in my opinion this report is sufficient in Terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Structures-Material)"

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EVALUATION OF MECHANICAL PROPERTIES OF INORGANIC BASED COMPOSITIES ADHESIVE BY EXPERIMENTAL METHOD

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This report submitted in accordance with requirement for the Bachelor Degree of Mechanical Engineering (Structure and Material)

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

Signature : ....
Author : Hamzaitul Akmarizal Bin Hamdan
Date : ....

Special for
My beloved mother, father and my siblings

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ABSTRAK

Perekat komposit berunsurkan bukan organik telah menjadi jenis perekat yang penting sekarang. Sambungan perekat amat sensitive terhadap rawatan permukaan, suhu servis , kelembapan dan keadaan persekitatan yang lain. Ia begitu susah untuk menentukan lingkungan tebal yang sesuai yang memenuhi keperluan mekanikal. Dalam pengajian ini, sifat – sifat mekanikal pengikatan perekat akan di nilai dengan menggunakan kaedah eksperimen. Bahan ujikaji di dalam suhu bilik akan di uji dengan kaedah ujian ketegangan. Keluli tahan karat SU 303 dengan 3 ketebalan berbeza akan di bina dan diuji. Kesan sifat-sifat mekanikal, ketebalan perekat dan suhu bahan ujikaji diuji berdasarkan standard ASTM. Mesin Ujikaji Universal (INSTRON Model 5585) akan digunakan sebagai mesin ujikaji utama. Terdapat 12 bahan ujikaji digunakan untuk 4 ketebalan perikat yang berbeza. Untuk bahan ujikaji di mana ketebalan perikat adalah 0.1 mm, 0.3 mm, 0.5 mm dan 0.7 mm, keputusan ujikaji ketegasan adalah 4.2 MPa, 11.2 MPa, 14.4 MPa dan 16.2 MPa. Ini jelas menunjukkan bahawa apabila ketebalan perikat meningkat, kekuatan sambungan juga meningkat. Ini bermaksud perikat yang tebal menghasilkan sambungan yang lebih kuat.

ABSTRACT

Inorganic based composites adhesive become one of the most important adhesive types now. Adhesive joints are very sensitive to surface treatments, service temperature, humidity and other environmental condition. It also hard to determine the suitable range of thickness range that fulfill the mechanical requirement. In this study, the mechanical properties of adhesive bonding will be evaluated by experimental method. Same specimen temperature with different thickness will be tested using tensile testing method. 3 different thickness of adhesive by using stainless steel SU 303 as specimen were manufacture and tested. Effect of material properties, adhesive thickness, and specimen temperature is tested using ASTM standard. Universal Testing Machine (INSTRON Model 5585) will be used as main testing machine. There were 12 specimen used for 4 different adhesive thickness. For specimen which adhesive thickness were 0.1 mm, 0.3 mm, 0.5 mm and 0.7 mm, the tensile stress results were 4.2 MPa, 11.2 MPa, 14.4 MPa and 16.2 MPa. That clearly shows that, when the adhesive thickness increases, strength of the joint will be increase. That means, the thicker adhesive layer, the stronger joining will produce

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Heading to the end of the 2010, the development of composites as adhesive materials become more and more important. An inorganic based composite enters new level and play a bigger role in structure joints. Commonly, the available joining methods can be classified into two types, mechanical and adhesive. Adhesive joints do not require holes and they distribute load over a large area than mechanical joints.

Compare to mechanical joints like fastened, adhesive joints are stronger. Mechanical fastening can only achieve a maximum tensile strength of 50% of the weakest adherend in the joint due to the stress concentrations caused by the fastener holes. In comparison, adhesively bonded joints can achieve in excess of 80% of the tensile strength of the weakest adherend even with a simple single-shear configuration However; adhesive joints are very sensitive to surface treatments, service temperature, humidity and other environmental conditions.

There a long list that can become the factor that can cause the failure of the adhesive bonding. One of the factors is cohesive fracture. Cohesive fracture is obtained if a crack propagates in the bulk polymer which constitutes the adhesive. In this case the surfaces of both adherents after debonding will be covered by fractured adhesive. The crack may propagate in the centre of the layer or near an interface. Others factor is interfacial fracture. Cohesive fracture is obtained if a crack propagates in the bulk polymer which constitutes the adhesive. In this case the surfaces of both adherents after debonding will be covered by fractured adhesive. The crack may propagate in the centre of the layer or near an interface.

1.2 Problem Statement

Adhesive joints are often the weakest link at the structure joints. Adhesive joints are very sensitive to surface treatments, service temperature, humidity and other environmental condition. To overcame and get the full performance from adhesive joints, it requires a specific adhesive joint design, enhancing its performance and reducing its limitations.

There have many factors that influence the mechanical properties of the adhesive bonding. The two main factors are the thickness of the adhesive and the specimen/object temperature. The main problem is to find the suitable thickness range that fulfill the mechanical requirements and guarantee for a suitable reliability. The results of this study will has a clear economic impact on the manufacturing processes because if the result of the study show that the less thickness of the adhesive produce the higher bonding strength, it will save adhesive materials cost.

1.3 Objective of Study

The main objective are this study is to make a research about mechanical properties of inorganic based composites adhesive. In this study, the strength of the inorganic based composites will be tested based on the thickness of the adhesive bonding and the specimen temperature. The objective of this study is:

i. To evaluate the mechanical properties of Inorganic Based Composites adhesive at room temperature.
ii. To study the influences of the adhesive thickness to the mechanical properties of the bonding joints.
iii. To used the appropriate experimental method to evaluate the result of the adhesive thickness to the bonding joints

1.4 Scopes of Study

To make this study more specific and details, there were some scopes must be considered as well:

i. Focusing on single lap joint will be tested in experimental method
ii. Using SUS 304 as specimen material
iii. Using inorganic composites adhesive

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction of Adhesive Bonding Strength

The true strength of an adhesive is a material property independent of the geometry, adherend properties and load and is a good starting point for determining an allowable design stress. Allowable stresses in shear and tension are needed to design safe, efficient, adhesively bonded joints and structures. The composite adhesives become very important research now.

Many researchers have studies and investigate this adhesive joint. Jae-Hyun Park, Park Jin-Ho Choi and Jin-Hwe Kweon (Jae, H.P *et al*. 2009) studies the evaluating the strengths of thick aluminum to aluminum joints with different adhesive lengths and thickness. Do Won Seo and Jae Kyoo Lim (Do, W.S *et al*, 2005) investigates tensile, bending and shear strength distributions of adhesive of adhesive-bonded butt joint specimen. They carried an experiment in order to provide the statistical data with strength evaluation methods: tensile, shear and four-point bending tests for thermosetting epoxy resin based adhesive-bonded butt joints. The certification of the probability in the adhesive is evaluated.

Jose M. Arenas, Julian J. Narbon and Cristina Alia (Arenas, J.M *et al*, 2009) investigate optimum adhesive thickness in structural adhesives joints using statistical techniques based on Weilbull distribution. The experiment study consisted of a shear tensile strength test of 20 specimen representative of each thickness of adhesive considered (7 thickness of between 0.2 mm and 0.8 mm) following standard UNE-EN 1465 on the determination of the shear strength of single lap joints adhesively bonded with rigid substrates.

Kim KS, Yoo JS, Yi YM (Kim. K.S *et al*, 2006) studies failure mode and strength of indirectional composite single lap bonded joints with different bonding methods They investigated how best to predict the strength of a single adhesive lap joints. Owens James and Sullivian (James and Sullivian, 2000) analyzed and tested the modulus of an single lap joint composed of composite material and aluminum.

Karl E Hokanson and Avram Bar-Coben (Hokanson and Coben, 1995) studies a shear-based optimization of adhesive thickness for die bonding. Choi JH and Lee (Choi and Lee, 1994) investigate the torque transmission capabilities of the adhesive bonded tubular single lap joint and the double lap joint. Hart-Smith LJ (Smith, 1985) designing to minimize peel stresses in adhesive bonded joints. He proposed a maximum strain failure criterion to predict failure loads for a given adhesive joint.

2.2 Adhesive Strength with Different Thickness and Length

Jae-Hyun Park, Park Jin-Ho Choi and Jin-Hwe Kweon in their studies in 2009 used 8 different lengths and 4 adhesive thicknesses to test and analyze the strengths of single lap joints made of thick aluminum adherends. Aluminum alloy 660-T6 and FM73 M epoxy adhesive film were used. Elastic modulus of adhesive is 4.2 GPa, Poisson‟s ratio is 0.45 and tensile strength is 58.7 MPa. Figure 2.1 show the tensile test specimen and the stress-strain curve of the adhesive.

The surface treatment of the aluminum adherend follows ASTM D 2851 and includes several steps. First, the surface of the aluminum was polished with the 40 mesh sandpaper and corroded using 27% sulfuric acid and 135g/L ferric sulfate for 12 minutes. After the corrosion step, the surfaces were cleaned and dried using water. The assembled adhesive joints were cured by autoclaving at 120°C for 120 minutes. The fillets of the adhesive joints were removed using razor.

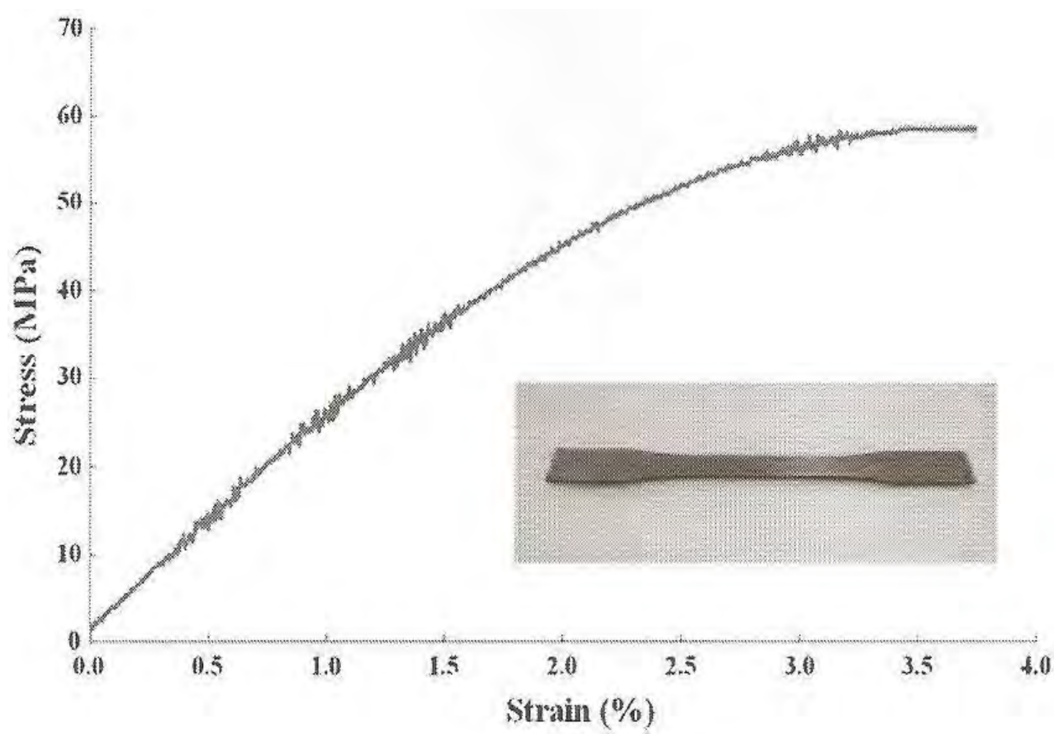

Figure 2.1 Tensile test specimen and stress strain curve.

(Source: Jae, H.P *et al*. 2009)

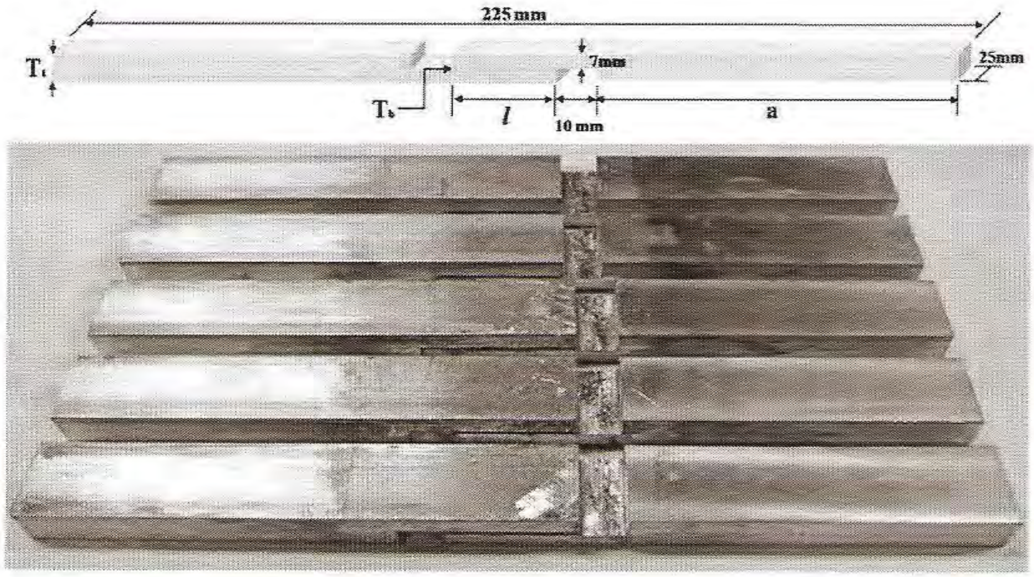

Figure 2.2: Manufactured adhesive joint specimen

(Source: Jae, H.P *et al*. 2009)

Universal Testing Machine Instron 5582 with crosshead speed fixed at 1 mm/min. Five specimens were tested for each case to obtain an average failure load. A drop in load was used to detect a failure. From experiment result, they note that the adhesive would adhere to both aluminum surfaces and that a cohesive failure would subsequently occur. Figure 2.4 show the experimental failure loads of the adhesive joints with the adhesive length of (a) l = 25mm and (b) l = 30mm.

As shown in Figure 2.3 , the failure loads of the adhesive joints increased with the increasing adhesive length but the adhesive strengths decreased if the adhesive length was over 15 mm The failure loads and strength of these joint were found to be constant with the adhesive length of 25mm. In addition, the failure loads of the adhesive loads of the adhesive joints for which the adhesive thickness was greater than 0.3 mm increased when the adhesive length reached 30mm.

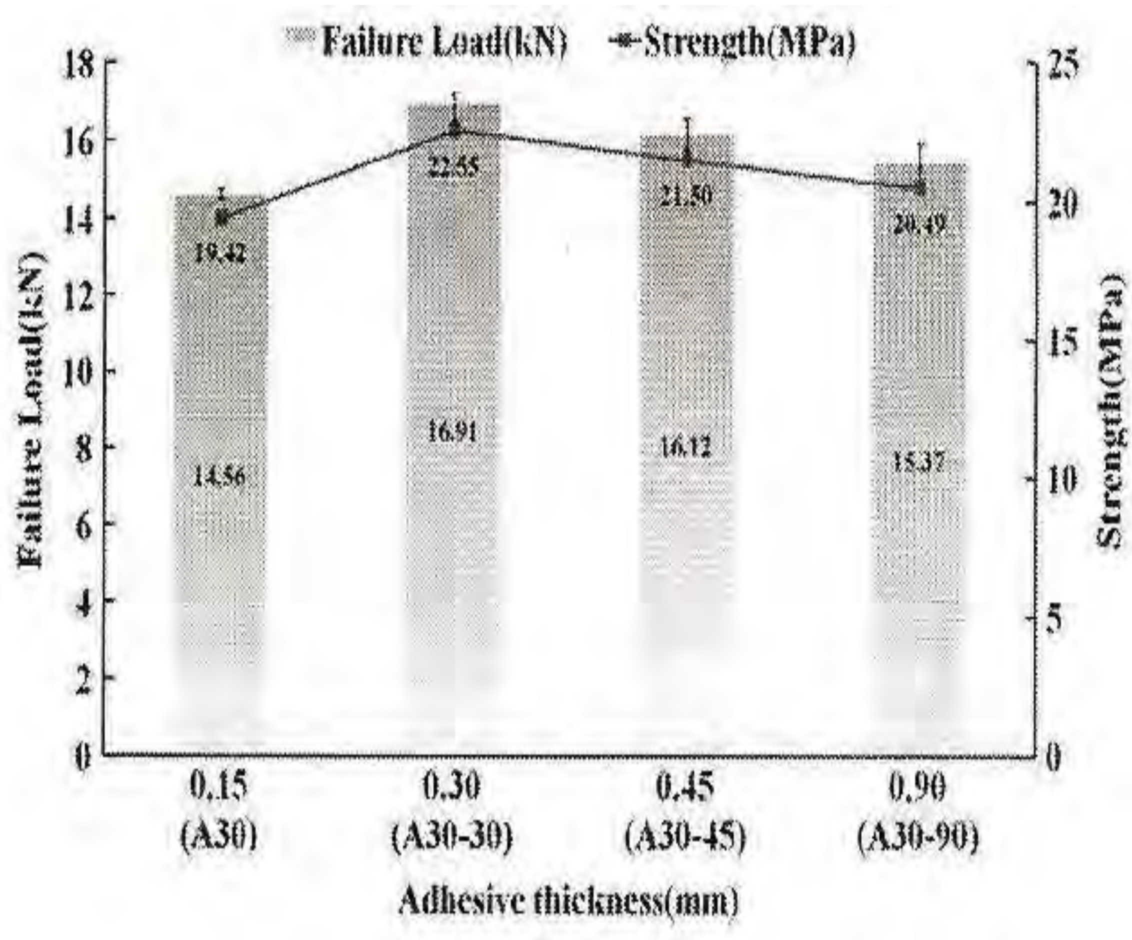

Figure 2.3: Experimental failure load of adhesive joints of different adhesive thickness

(Source: Jae, H.P *et al*. 2009)