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BACH. OF MECH ENG. (STRUCTURE & MATERIAL) (HONS.)

2015 UTeM

DESIGN AND DEVELOPMENT OF TEST FIXTURES AND TOOLS FOR SHEAR TEST OF FASTENER

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SUPERVISOR DECLARATION

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This thesis is submitted to Faculty of Mechanical Engineering as a requirement to get reward of
Degree of Mechanical Engineering (Structure & Material)

Faculty of Mechanical Engineering
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JUNE 2015

DECLARATION

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

Signature : …….
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Specially dedicated to

my family and beloved companion

ACKNOWLEDGEMENT

I would like to express my special thanks and gratitude to my supervisor, Prof Madya Abd. Salam Bin Md. Tahir for his enormous contribution throughout this project and guided me in the right direction in order to reach the final goals of this final year project (FYP). With his invaluable guidance, I had gained a lot and obtained more understanding about the title. Without all this, I couldn't complete my FYP successfully.

Not forgotten the FKM laboratory Assistant Engineers, Mr Wan Saharizal Bin Wan Harun and Mr MohdFaizal Bin Zailani who are in charge of the Instron's Universal Testing Machine in Phase B, FKM Laboratory Complex, Ayer Keroh. A very big thanks to them for their willingness to explain and give ideas whenever I had questions and problems of using the testing machine. With all those useful information and help offered by them, I managed to complete my FYP report in time.

Last but not least, I would also like to thank all my friends who gave their valuable time, opinion, and suggestion to help me in completing this FYP report. Their kindness and generosity were surely remained to be remembered in helping me to accomplish the final aims of this report.

ABSTRACT

A good understanding regarding fastener behavior and mechanical properties of a fastener is important during designing of a structure to make sure the structure is safe. Fasteners are essential components used in many sectors such as automation, manufacturing, infrastructure, medical and others. Due to this reason, uncountable testing of fastener is published to determine the standard and quality of various fasteners. In this research, design and develop of a shearing test fixture, several considerations such as the specimen properties, the design characteristics of the fixture, and the safety aspects have to be examined and investigated. The main goals of this research are to produce a safe and convenient fixture for single and double shear tests.Study on the requirement of shear joint is important in designing a fixture in order to get an accurate result from the test. In the early stage, decision ofmaterials selection, fabrication process and specimen selection is determined. The shear test results carried out by using the designed test fixture were not compatible with the expected results. Therefore, analysis and inspection of the failure of the fixture is carried out in order to improve the future design.

ABSTRAK

Pemahaman yang baik mengenai perilaku pengikat dan sifat-sifat mekanik pengikat adalah penting dalam mereka bentuk struktur untuk memastikan struktur yang selamat. Pengikat adalah komponen penting yang digunakan dalam sektor-sektor seperti automasi, pembuatan, infrastruktur, perubatan dan lain-lain. Oleh itu, ujian-ujian daripada pengikat diterbitkan untuk menentukan taraf pengikat. Dalam kajian reka bentuk dan penghasilan satu jig ujian ricih, beberapa pertimbangan perlulah diambilkira seperti sifat spesimen, ciri-ciri reka bentuk jig, dan ciri-ciri keselamatan. Matlamat utama kajian ini adalah menghasilkan jig yang selamat dan mudah untuk ujian ricih. Kajian tentang keperluan untuk ujian ricih adalah penting dalam mereka bentuk jig supaya mendapatkan data yang tepat daripada ujian. Pada peringkat awal, keputusan pemilihan bahan, proses pembuatan dan pemilihan specimen telah ditentukan. Keputusan ujian ricih yang dilakukan dengan menggunakan jig yang telah direkabentuk didapati tidak serasi dengan keputusan yang dijangkakan. Oleh itu, analisis dan pemeriksaan kegagalan jig dilaksanakan untuk membuat penambahbaikan untuk reka bentuk masa depan.

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A	Cross section area
A_b	Area of bearing joint
d	Diameter of the fastener
l	Length of bearing joint
N	Safety factor
t	Thickness of the part subjected to the bearing
P	Local force
P_{max}	Maximum load
P_s	Ultimate shear load
P_b	Bearing load
P_{yiekd}	Yield load
σ_s	Shearing stress
σ_b	Bearing stress
σ_d	Design stress
σ_{ut}	Ultimate tensile strength
σ_{us}	Ultimate shear strength
σ_{as}	Allowable shear strength
σ_{yield}	Yield stress

CHAPTER 1

INTRODUCTION

1.1 Background

A fastener is a hardware device that mechanically joints or assembles two or more objects together. Most fastener applications are designed to support or transmit some form of externally applied load. Therefore, the mechanical properties of fastener are very important to identify the limitation to be used. Test methods have been established and published for mechanical properties such as hardness, tensile strength, torsion strength, and corrosion. Conducting all these tests require a specific fixture to hold the fastener.

There is a lot of testing fixture available for different testing machine to conduct various test methods. However, fixture for shearing test of fastener is not popular among the testing field. Designing a fixture that will be mounted and operated by using Instron's Universal Testing Machine (UTM) Model 8802 is the main purpose of this project. By undertaking research and study the specification of fastener standard as the specimen that will be tested with the fixture, suitable dimension and materials of the fixture are determined in order to operate and function correctly.

1.2 Fastener

Mechanical fasteners, such as screws, bolts, pins and rivets, have been used for many years to assemble two components. Nowadays, many types of fastener invented for different applications. Various types of materials are used to made fasteners depending on its physical properties such as corrosion resistance, high strength and high thermal resistance.

There are two conditions of bolt joint depending on the direction of the external loads or forces acting on the joint. Tension or tensile joint happen when the direction of the force applied is parallel to the axes of the bolt. On the other hand, force applied perpendicular to the axes of the bolt, the joint is loaded in shear and called shear joint. The Figure1.1 shows both types of joints.

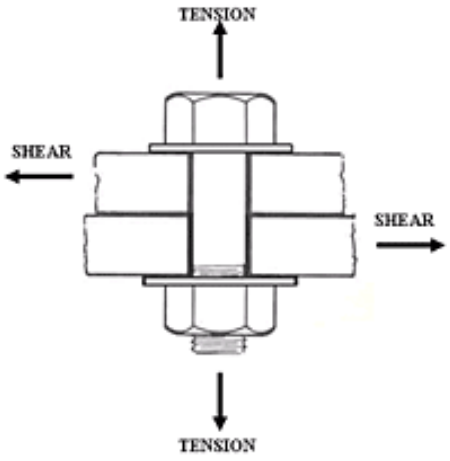


Figure 1.1: Tension and Shear joints in the bolt joint

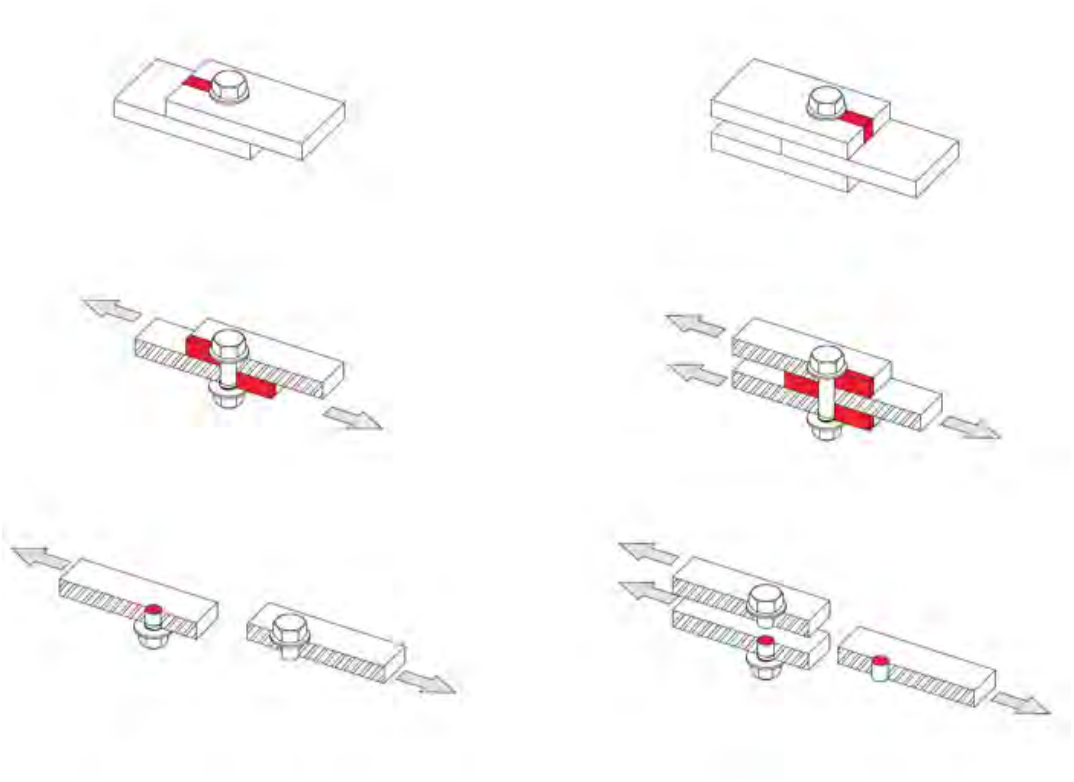
1.2.1 Tensile Joint

In tensile joints, the bolts are tighten up with nut to create a clamping force between the joint members, so that it can prevent the joint members sliding or separating from each other. Therefore, the tensile in the bolt must be great enough to

sustain the clamping force in order to prevent it from self loosening when exposed to vibration, shock, or thermal cycles. Although high tension in the bolt make it less susceptible to fatigue, but sometimes it make more susceptible to stress cracking. In general, we usually want the bolt in a joint loaded in tension to exert as much force on the joint and the joint members can stand.

1.2.2 Shear Joint

In particular, shear is the dominant fasteners design factor in the aircraft and aerospace field, where structural components are thin and very elastic. The main rule of bolt in a shear joint is to hold the joint and prevent it slipping or from tearing apart in the slip direction. There are two general types of shear fasteners namely, rivets and bolts or screws. The conditions of shear joint are shown in Figure 1.2 (single shear and double shear). In single shear condition, the force act in opposite and equally reacted by shear stress on the reaction area. In the double shear condition has two reaction areas. For a bolted joint in shear it is imperative that the gap between material sheets be as close to zero as possible to prevent fasteners bending. (Note that single shear joint can have a small bending moment due to the eccentricity of the opposing forces.)(Barrett, 1998)



(a) (b)

Figure 1.2:In (a) is a condition of single shear. In (b) is a condition of double shear. The line of the primary piece of steel does not align either side of the joint. The greater the force through the connection, the more of the shaded area is needed. The number of bolts will be increased so that the cross sectional area is sufficient to resist the SHEAR loads. (Boake, T. M. 2014)

1.2.3 Fastener Standard

Fastener standard is a document that provides requirements, specifications, guidelines or characteristics that can be used consistently to ensure that materials, products, processes and services are fit for their purpose. There are three similar yet slightly different metric fastener standard systems in use; ISO, US (ASME, ASTM, and SAE), and DIN. (Industrial Fasteners Institute 2012)

1.3 Shear Test

Shearing test is different from tensile and compression testing in that the stress applied causes a shearing or tearing along a plane where it is parallel to the exerted force. Basically, shearing occurs when one surface of a material to move in one direction and the other surface move in the opposite direction so that the material is stressed in a sliding motion. Shear tests differ from tension and compression tests in that the forces applied are parallel to the two contact surface, whereas, in tension and compression they are perpendicular to the contact surfaces.(TestResources, Inc. 2014)

1.3.1 Purpose of Shear Testing

The general purpose of shear testing is to determine the mechanical properties, which is the maximum shear strength of the material that can sustain before failure occurs. This is an important mechanical property of many types of fasteners use in shear joint such as bolts and rivets. For example, when a bolt is used to clamp two components together, it will experience a shear forces if there are forces apply parallel to the component and attempt to slide on each other. If the bolt fails in shear, it may lead to structure failures that could endanger tothewhole structure.

1.3.2 Types of Shear Tests

There are two general types of shear tests.

1) The sample is setup in a modified three point flexure or four point bend fixture.

   The purpose of this test is to load the sample so that it experiences double shear or so that the sample has two locations where the forces are applied.

Each end of the sample is anchored and the force is applied over the middle of the sample in an attempt to remove the midsection so that both ends are left behind.

2) The sample is tapered ends that are each placed into grip fixtures that have been offset from the vertical axis of the sample. The sample is then pulled so that the opposite faces are pulled in opposing directions.

1.4 Design of bolted joints

There is no multipurpose fastener which acquired all requirements for every environment. The design of bolted joints involves in consideration on its strength, temperature, corrosion, vibration, fatigue and etc. Bickford (1998) states that every industry has characteristics or typical joint configuration and needs, and it would be impossible to detail each in a single text. However, some generalities must apply to most joints, whatever their specific application. And we can review design procedures which have been accepted and used by many.

According to Bickford (1998), as a joint designer, some factors must be considered such as the assembly and in-service uncertainties when designing a joint which will be loaded in tension or shear. Selection of bolt and joint sizes, shapes, and materials are important to guarantee enough clamping force to prevent bolt self loosening or fatigue, and to prevent joint slip, separation, or leakage, when clamping forces are at a minimum and those hard-to-predict service loads are at a maximum. In addition, selection bolts which are able to support a combination of maximum assembly stress plus the maximum increase in stress caused by such service conditions as applied load and differential thermal expansion.

As an example, a joint is loaded in pure shear will only depend for shear strength of the bolts and bearing strength at joint members. Determination only done for the relevant strength that involve in the system.Cyclic load, torsion load and bending moment must not subject on the system where it might cause problem to the bolt joint.

1.5 Objective

To design special tool and fixtures for the Instron's UTM 8802 to conduct single and double shear tests for various type of fasteners available in the local market/industry.

1.6 Problem Statement

In order to conduct a shearing test of fasteners under single and double shear conditions, it is necessary to have a suitable testing machine with appropriate fixtures to hold the specimen. To design a fixture under the specified conditions, it is first necessary to consider the properties of the specimens (fasteners) and the types of testing machine to be used. However, there are various types, strength, grades, and size of fasteners available in the local market. Therefore study and research about the properties of fasteners are very important in selection of specimens to be tested. The next consideration is the design and materials of the fixture where the safety factor of the fixture must be determined so that the testing is conducted in the range of the limitation to avoid failure.

1.7 Scope

1) Conduct preliminary study and survey of the research area/field of study:-
   - Shear test according to various standards.
2) Identify available fasteners in local market to be tested under single and double shear conditions.
3) Proposed design of tool and fixture and also test the fasteners to determine its shear strength under single and double shear conditions with UTM 8802.

CHAPTER 2

LITERATURE REVIEW

2.1 Fasteners in Market

Every type of fasteners have different characteristic in materials that suitable for different environment. This is a difficult task for selecting the suitable fastener material from various standard published by considering the strength, temperature, corrosion, vibration, fatigue and many other variables. However, with the published standard of the fastener, it provides more information to help in evaluation on the fastener.

Fasteners are made from many types of materials, but most common types are carbon steel, alloy steel, or stainless steel. Stainless steel includes both iron and nickel-based chromium alloy. For titanium and aluminum bolts, they have theirs' own limits usage primarily use in the aerospace industries.

2.1.1 Carbon Steel

Carbon steel is the most common and cheapest bolt material where it can be found in every hard ware stores. Among carbon steel, zinc plated bolts is most common which the ultimate strength of this material is 380 MPa (33ksi). Carbon steel is classified by grade (US) or classes (Metric) by the properties of the material such as the ultimate tensile strength of the fastener. Tables 2.1 and 2.2 show the marking and the specification of the fasteners.