DESIGN, FABRICATION AND OPTIMIZATION OF SHEAR TEST RIG (DOUBLE SHEAR TYPE)

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SUPERVISOR'S DECLARATION

We hereby declare that we have checked this project and in our opinion this project is satisfactory in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering .

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Date: 15th November 2008

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Position:
Date:

STUDENT'S DECLARATION

I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged. The thesis has not been accepted for any degree and is not concurently submitted for award of other degree.

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ABSTRACT

Shear stress-strain relationship is an important material property of sheet metals. The property is difficult to measure compared to a more commonly used tensile stress-strain relationship. The objective of this project is to design and fabricate a rig that can be use to measure shear stress-strain relationship and test its workability. The rig has to be mounted in a tensile test machine and utilise the machine capability of measuring load and displacement progression. The data of load versus displacement will have to be converted into shear stress-strain relationship based on an oblique parallelepiped deformation theory.

ABSTRAK

Hubungan antara ricihan tegasan dan ricihan terikan ialah sifat bahan yang sangat penting bagi kepingan besi. Sifat tersebut sukar untuk dikira jika dibandingkan dengan kebiasaan hubungan tegangan antara tegasan dan terikan. Objektif projek ini ialah untuk mereka dan membuat satu alat yang boleh digunakan untuk mengira ricihan tegasan dan ricihan terikan dengan menguji kebolehannya menggunakan mesin uji tegangan. Alat tersebut akan dipasangkan pada mesin uji tegangan dan menggunakan keupayaan mesin tersebut untuk mengira beban dan perubahan jarak bahan uji. Data beban dan perubahan jarak akan ditukarkan kepada hubungan antara ricihan tegasan dan ricihan terikan berasakan kepada teori kecacatan iaitu ‘oblique parallelepiped’.

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LIST OF SYMBOLS

F	Force
γ	Shear strain
τ	Shear stress
L	Height, length
Δx	Distance
ΔL	Horizontal distance
G	Shear Modulus
τ_{ave}	Average shear stress
t, e	Thickness
δ_u	Effective shear displacement
δ_g	Sliding movement under the grips
δ_m	Relative displacement
$\sigma_{\max}$	Maximum shearing stress

LIST OF ABBREVIATIONS

Al	Aluminium
ASTM	American Society for Testing and Materials
mm	Milimeter
rpm	Revolution per minutes

CHAPTER 1

INTRODUCTION

This chapter explain a surface about shear stress-strain and the view of this project. In this chapter, the project background, problem statements, objectives, scopes and thesis outline are included.

1.1 INTRODUCTION

The shear modulus is the elastic modulus used for the deformation which takes place when a force is applied parallel to one face of the object while the opposite face is held fixed by another equal force. [3]

When an object likes a block of height *L* and cross section, *A* experiences a force, *F* parallel to one face, the sheared face will move a distance Δx. The shear stress is defined as the magnitude of the force per unit cross-sectional area of the face being sheared (F/A). The shear strain is defined as Δx /L. [3]

The shear modulus *S* is defined as the ratio of the stress to the strain.

$$S \equiv \frac{ShearStress}{ShearStrain} = \frac{\frac{F}{A}}{\frac{\Delta x}{L}} = \frac{FL}{A\Delta x} \tag{1.1}$$

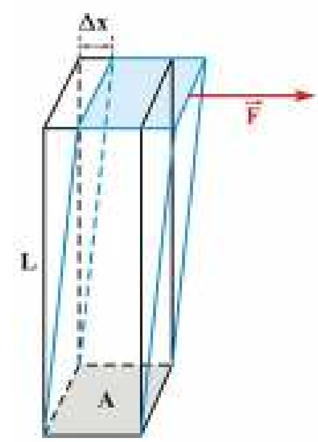

Figure 1.1: Shear stress and shear strain [3]

The bigger the shear modulus the more rigid is the material since for the same change in horizontal distance (strain) need a bigger force (stress). This is why the shear modulus is sometimes called the modulus of rigidity.

To a first approximation there is no change in volume in this deformation. The planes of atoms merely slide sideways over one another. That is why the area *A* (which determines the number of atomic bonds) is important in defining the stress and not just *F*. [3]

Note that in the diagram, since the block is not moving, there is a force *F* to the left on the bottom face which is not shown.

1.2 PROJECT BACKGROUND

Shear stress-strain relationship is an important material property of sheet metals. Mechanical properties of sheet metals can be altered by giving a load to the sheet metals. But the property is difficult to measure compared to a more commonly used tensile stress-strain relationship. It is very important aspect to analysis and design the rig or frame relates to the shear stress-strain of sheet metals caused by the loads applied to the rig. The rig has to be mounted in a tensile test machine and utilise the machine capability of measuring load and displacement progression. The data of load versus displacement will have to be converted into shear stress-strain relationship based on an oblique parallelepiped deformation theory. This project will study about the shear modulus of aluminum. By getting the shear stress-strain relationship, it will be then used to determine the modulus of rigidity or shear modulus. The project is succeeding if the shear modulus of the aluminum from the experimental value is same to the theoretical value.

The planar simple shear test has proved to be a very efficient technique to evaluate the mechanical properties of flat samples. Previous studies of this mechanical test can be found in Genevois, Liu and Miyauchi. Briefly, the planar simple shear test device consists of two rigid parts subjected to a parallel movement. [8]

1.3 PROBLEM STATEMENT

Shear modulus is influenced by the shear stress-strain relationship. But plane shear load is difficult to apply on sheet metals. So, it is very important to design a new test rig with established standard.

1.4 PROJECT OBJECTIVES

1.4.1 Design a new shear test rig.

1.4.2 Determine shear modulus of aluminum using shear-stress relationship.

1.5 PROJECT SCOPES

1.5.1 Fabricate the design using mild steel part.

1.5.2 Fit the prototype when mounted to the tensile test machine.

1.5.3 Test with Aluminum 1.5mm width as a benchmark.

1.5.4 Optimisation of the shear test rig

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Tensile tests are performed for several reasons. The results of tensile tests are used in selecting materials for engineering applications. Tensile properties frequently are included in material specifications to ensure quality. Tensile properties often are measure during development of new materials and processes, so that different materials and processes can be compared. Finally, tensile properties often are used to predict the behavior of a material under forms of loading other than uniaxial tension. The strength of a material often is the primary concern. The strength of interest maybe measured in terms of either the stress necessary to cause appreciable plastic deformation or the maximum stress that the material can withstand. [5]

These measures of strength are used, with appropriate caution (in the form of safety factors), in engineering design. Also of interest is the material is ductility, which is a measure of how much it can be deformed before it fractures. Rarely is ductility in corporate directly in design; rather, it is included in material specifications to ensure quality and toughness. Low ductility in a tensile test often is accompanied by low resistance to fracture under other forms of loading. Elastic properties also may be of interest, but special techniques must be used to measure these properties during tensile testing, and more accurate measurements can be made by ultra sonic techniques. [5]

2.2 SHEAR STRESS

In additional to axial (or normal) stress and strain, it is known as shear stress and shear strain. In Figure 2.1 there is a metal rod which is solidly attached to the floor. After a force, F exerted and acting at angle theta with respect to the horizontal on the rod, the component of the force perpendicular to the surface area will produce an axial stress on the rod given by Force perpendicular to an area divided by the area, or:

$$\sigma = F \sin\theta / A \tag{2.1}$$

The shear stress is produced because of the effect of the component of the Force parallel to the area, defined as Force parallel to an area divided by the area, or:

$$\tau = F \cos\theta / A \tag{2.2}$$

where the Greek letter, Tau, is used to represent Shear Stress. The units of both Axial and Shear Stress will normally be lb/in^2 or N/m^2. [7]

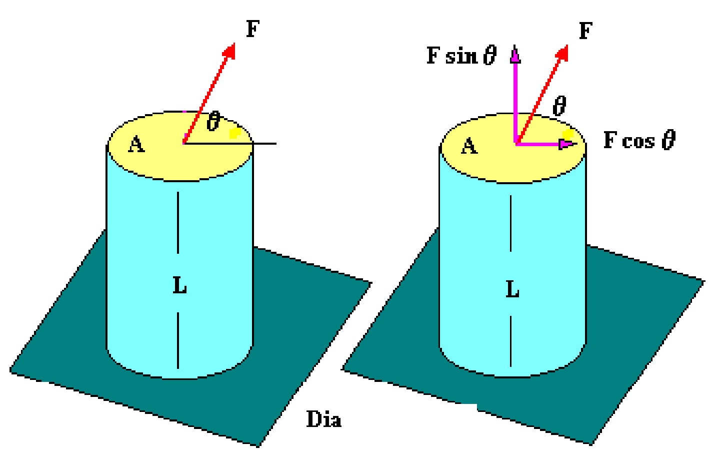

Figure 2.1: Shear stress and shear strain on a rod [7]

2.3 SHEAR STRAIN

Shear strain is produced by the change in the length divided by the original length of the member. Both Axial Strain and Shear Strain are shown in Figure 2.2. The displacement of the rod as indicated in the right drawing in Figure 2.2 produced by shear stress. The edge of the rod is displaced a horizontal distance, ΔL from its initial position. This displacement (or horizontal deformation) divided by the length of the rod L is equal to the shear strain. Examining the small triangle made by ΔL, L and the side of the rod, the shear strain, $\Delta L / L$ is also equal to the tangent of the angle gamma, and since the amount of displacement is quite small the tangent of the angle is approximately equal to the angle itself. Or it can be writing as:

$$\text{Shear Strain} = \Delta L / L = \tan \gamma = \gamma \qquad (2.3)$$

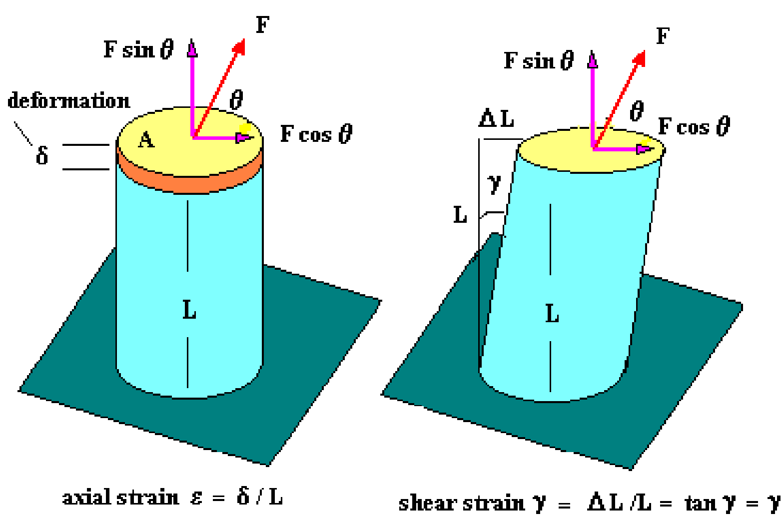

Figure 2.2: The displacement after the shear stress and shear strain [7]

As with axial stress and strain, shear stress and strain are proportional in the elastic region of the material. This relationship may be expressed as, G = Shear

Stress/Shear Strain, where G is a property of the material and is called the Modulus of Rigidity (or at times, the Shear Modulus) and has units of lb/in^2. [7]

If a graph is made of shear stress versus shear strain in Figure 2.3, it will normally exhibit the same characteristics as the graph of axial stress versus axial strain. There is an elastic region in which the stress is directly proportional to the strain. The point at which the elastic region ends is called the elastic limit, or the proportional limit. In actuality, these two points are not quite the same. The elastic limit is the point at which permanent deformation occurs, that is, after the elastic limit, if the force is taken off the sample, it will not return to its original size and shape, permanent deformation has occurred. The proportional limit is the point at which the deformation is no longer directly proportional to the applied force (Hooke's Law no longer holds). Although these two points are slightly different, it will treat as same in this course. There is a plastic region, where a small increase in the shear stress results in a larger increase in shear strain, and finally there is a failure point where the sample fails in shear.

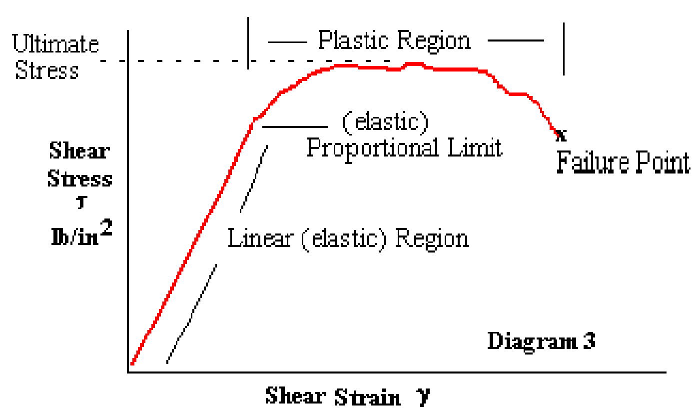

Figure 2.3: Shear stress-strain curve [7]

To summarize the shear stress/ strain/ Hooke's Law relationships up to this point: [7]

$$\text{Shear Stress: } \tau = \left(F_{parallel}\right)/A \quad (\text{Ib/in}^2\text{, or N/m}^2) \tag{2.4}$$

$$\text{Shear Strain: } \gamma = \Delta L / L = \tan\gamma = \gamma \tag{2.5}$$

$$\text{Hooke's Law: } G = \tau / \gamma \ \ (\text{Ib/in}^2\text{, or N/m}^2) \tag{2.6}$$

A materials shear modulus is the coefficient of elasticity for a shearing force. It is defined as “the ratio of shear stress to the displacement per unit sample length”. [6]

2.4 CURRENT DESIGN

2.4.1 Simple Shear Device

The first equipment referred in the literature was that developed by Miyauchi. The specimen has two symmetrically sheared zones and is acted on an axial load. By turning over the device Bauschinger tests can be carried out. The main advantage of this arrangement is that the shear forces to which is subjected the central grip of the device are equilibrating each other. Therefore, the slides are less loaded and the friction forces decrease, thus allowing a better estimate of the shearing forces. A second version of the simple shear device was proposed by G’Sell for polymers and subsequently adapted for metallic materials by Rauch and G’Sell. An improved version of this device was developed by Genevois (Figure.2.4), where the rotation of the specimen under the action of the shearing forces is impeded by a very stiff frame. The specimens easy to prepare because have a simple rectangular shape. [8] To avoid any eventual hardening due to drilling, they can be eventually cut out by electro-erosion in order. The specimen is firmly clamped by the fixed and moving grips of the shearing device (Figure.2.5). The shear test is not sensitive to small shape imperfections of the sample, with the possible exception of thickness variations related to the rolling process. [8]

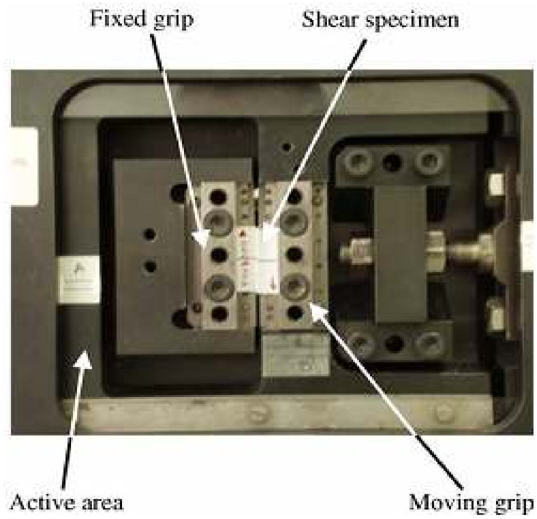

Figure 2.4: Simple shear device [8]

In order to impose the condition h=constant the moving grips of the device presented in Figure 2.4 can also move laterally (along the y-axis in Figure 2.5). In the former case, a supplementary load cell and/ or a motorization can be added in order to super impose a controlled lateral tension or compression on the shear deformation.

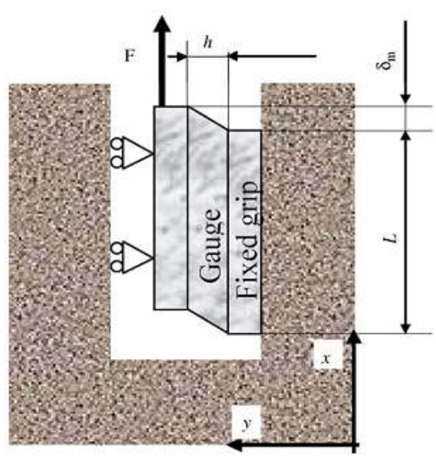

Figure 2.5: Schematic representation of a simple shear test along the x-axis. L and h are respectively, the current length and thickness of the gauge area and δ_m is the relative displacement of two grips. [8]