APPROVAL

"I admit that have read this report and in my view this report
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Bachelor of Mechanical Engineering (Structure & Material)"

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ANALYSIS OF THE STRESS-STRAIN BEHAVIOUR OF BEAM FOR DIFFERENT TYPE OF CROSS-SECTION AND MATERIAL

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This report is submitted in partial fulfilment of requirement for Bachelor of Mechanical Engineering (Structure & Material)

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MAY 2009

DECLARATION

"I hereby, declared this thesis entitled 'Analysis of the Stress-strain Behaviour of Beam for Different Type of Cross-section and Material' is the results of my own research except as cited in references"

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Date : 8 MAY 2009

DEDICATION

For my loving parents and family

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ABSTRACT

This thesis discusses the analysis and relationship between stress and strain of beams with different types of materials. In addition an attempt will be make to draw together the various aspects of methods and applications of analysis in order to identify areas of relevance. The selected beams are manufactured by scaling down to laboratory-size specimen. This study also presents an analytical procedure for these beams. It examines the strain and load–deflection characteristics and proceeds to estimate the maximum load carrying capacity by taking into consideration the change of stress that occurs along the beam with the application of strain gauges. The analysis technique is divided into three main parts, which are theoretical, experimental and simulations. The first part is focused on the calculations of beams by using proper beam formulae. The second part is conducting experiment of bending stress for rectangular beam, I-beam and C-beam consisted of aluminium and mild steel. The third part is using Computer Aided Engineering (CAE) to verify the proposed analytical method. With the help of modern simulation tools such as Finite Element Analysis (FEA) this process has significantly been improved and simplified. In this research, the results of all analyze techniques are compared and briefly discussed. The accuracy of each technique can be determined based on analysis conducted and result obtained. The factor that affected the results has been identified and discussed such as type of materials, cross sections, the used of FEA, and errors involved. The relationship of stress and strain can be determined from the finding of this thesis which is stress is directly proportional to strain.

ABSTRAK

Kajian ini membincangkan tentang rekabentuk, analisis dan hubungkait antara tegasan dan terikan rasuk yang diperbuat dari bahan yang berlainan. Rasuk yang dipilih akan dibuat dengan mengecilkan skala berdasarkan saiz untuk ujikaji makmal. Kajian ini membentangkan tentang prosedur analitikal untuk rasuk ini. Ia menyelidik sifat terikan dan pembengkokan yang disebabkan beban dan seterusnya menganggarkan muatan tertinggi disebabkan beban yang dibawa dengan mengambilkira perubahan tegasan yang berlaku ke atas rasuk dengan penggunaan tolok terikan. Teknik analisis terbahagi kepada tiga bahagian utama iaitu berdasarkan teori, uji kaji dan simulasi. Bahagian pertama memfokuskan kepada pengiraan rasuk menggunakan formula rasuk yang sesuai. Bahagian kedua ialah menjalankan eksperimen tegasan membengkok untuk rasuk berkeratan rentas segi empat tepat, rasuk berkeratan rentas I dan rasuk berkeratan rentas C yang terdiri daripada aluminium dan besi lembut. Bahagian ketiga ialah menggunakan kejuruteraan berbantu computer (CAE) untuk mengesahkan cara analitikal yang telah dicadangkan. Dengan bantuan alatan simulasi moden seperti analisis unsur terhingga (FEA), proses ini dapat disahkan. Dalam kajian ini, semua keputusan teknik analisis dibandingkan dan dibincangkan dengan terperinci. Ketepatan setiap teknik dapat ditentukan berdasarkan analisis yg telah dibuat dan keputusan yang telah diperolehi. Perkara yang mempengaruhi keputusan dapat dikenalpasti dan dibincangkan seperti jenis bahan, keratan rentas, penggunaan analisis unsur terhingga dan ralat yang terlibat. Hubungkait antara tegasan dan terikan telah diperolehi daripada hasil kajian iaitu tegasan berkadar terus dengan terikan.

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LIST OF SYMBOLS

A	=	Cross-sectional Area (m^2)
E	=	Modulus of Elasticity or Young Modulus (GPa)
F, P	=	Axial Force (N)
h	=	Height or Thickness (m)
I	=	Moment of Inertia (m^4)
L	=	Length (m)
M	=	Bending Moment (Nm)
R	=	Electrical Resistance (Ω)
V	=	Voltage (V)
X	=	Distance (m)
y	=	Vertical Distance Away from the Neutral Axis (m)
y	=	Deflection (m)
ΔL	=	Change in Length (m)
ΔT	=	Change in Temperature (ºC)
α	=	Linear Dilatation Coefficient
ε	=	Strain (με)
σ	=	Stress (MPa)
ρ	=	Specific Resistance of the Resistance Material (Ω/m)
υ	=	Poisson Ratio

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CHAPTER 1

INTRODUCTION

1.1 Background

Stress-strain analysis of a material is one way to determine many of its physical properties. With the information gained through much analysis, one can predict how a part will react when placed under various working loads.

There are many different types of beam designs and materials to choose from when designing a structure. Engineers can choose from various shapes, sizes, construction materials, and construction techniques. Deciding on the proper beam design for a particular structure can be a complicated process. Structural engineers and builders have many different beam designs and materials to choose from when attempting to create a sound structural design.

Measuring bending stresses is an important part of structural engineering. Measuring bending stresses determines how much load a structure can support before it fails. Building structurally sound projects is the ultimate goal of successful structural engineering.

1.2 Work Method

Work method can be described as a process of subjecting work to systematic, critical examination of existing and proposed ways of doing work, as a mean of developing and applying easier and more effective methods and reducing cost.

The process adopted in this project consists of the following:

i. Select the work to be studied
ii. Research all the relevant information about the work
iii. Examine the facts critically
iv. Develop an improved way of doing things
v. Manufacture new method as standard practice
vi. Technique of analysis used are experimental, theoretical and simulation
vii. Analyze the result from each technique conducted
viii. Compare results from all technique used

1.3 Problem Statement

In many engineering applications, it is of interest to measure the forces that are exerted on bodies. Because all solid materials experience some degree of elastic deformation when subjected to a force or "load," the force can be detected by measuring the amount of deformation. One common technique for such a measurement involves the use of strain gauges attached to a simply supported beam. Strain gauge is a device used for measuring strain or deformation in a body.

The working principle of strain gauge is complicated to understanding since it is involved electrical knowledge. Besides that, there are many explanations about stress and strain behaviour that will bring confusion in understanding. Misunderstanding of stress and strain concept and behaviour can bring to disaster if a person working as a

design or structural engineer. So, it is necessary to create a simple experiment that combining the used of strain gauge to measure the strain as an aid in helping to understand the stress-strain behaviour and strain gauge applications.

1.4 Objectives

The objectives of this paper are:

a) To design an experimental setup for conducting experiment of the stress and strain behaviour analysis of beams
b) To analysis the stress and strain behaviour of beams by using theoretical, experimental and Computer Aided Engineering (CAE) methods
c) To compare the analysis of stress and strain among the results of theory, experimental, and Computer Aided Engineering (CAE) by using Finite Element Analysis (FEA)

1.5 Scope

The scopes of this paper are:

a) Manufacturing of beams by scaling down to laboratory-size specimen according to selection of different type of materials and cross section
b) Analysis of the stress and strain behaviour of beams by using experimental, theoretical and simulation
c) The measurement of strain or deflection by application of strain gauge

1.6 Report Outline

This project will be divided into two parts which is Projek Sarjana Muda (PSM) 1 and PSM 2. PSM 1 contains of three chapters which are introduction, literature review and methodology. Introduction discusses about the definition, objectives, scope and the problems statement related to the project. Literature review will briefly explain in term of method and measurement used to gain the result. Methodology consists of the technique used in obtaining the data. Result and discussion will be explained in PSM 2. Result and discussion mainly explain about the result and how the data is being analyzed after the implementation of work study. The final chapter is conclusion and the objectives that had been determined before will be concluded in this chapter.

1.7 Planning and Execution

Table 1.1: Gantt chart of PSM 1 research

	JULY				AUGUST				SEPTEMBER				OCT	
RESEARCH ACTIVITY/TIME	W 1	W 2	W 3	W 4	W 5	W 6	W 7	W 8	W 9	W 10	W 11	W 12	W 13	W 14
1.Literature Review														
2.Research Methodology														
-Research Overview														
-Research Design/Design of Experiment:														
i. Prepare standard of procedure of Bending Stress														
ii. Selection types of beam														
iv. Selection of material														
3.Report Writing for PSM 1														
4.Preparation for PSM Seminar 1														
5.Submission of report and log book														

Table 1.2: Gantt chart of PSM 2 research

	DECEMBER				JANUARY				FEBRUARY				MARCH				APRIL			
RESEARCH ACTIVITY/TIME	W 1	W 2	W 3	W 4	W 1	W 2	W 3	W 4	W 1	W 2	W 3	W 4	W 1	W 2	W 3	W 4	W 1	W 2	W 3	W 4
1.Manufacture of beams																				
2.Conducting Experiment																				
-Apparatus Setup																				
-Collecting Data																				
3.Prepare Theoretical Calculation																				
4. Simulation by using Finite Element Analysis (FEA)																				
5. Analysis Data and Discussion																				
6.Report Writing for PSM 2																				
7. Submission of report and log book																				
8. Preparation for PSM Seminar 2																				

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Stress and strain are important aspects of mechanical engineering, especially in structural design. This chapter is discussing on stress and strain, their relationship, and how to measure them.

2.2 Stress and strain

Stress and strain are related terms defining the intensity of internal reactive forces in a deformed body and associated unit changes of dimension, shape, or volume caused by externally applied forces. Stress is a measure of the internal reaction between elementary particles of a material in resisting separation, compaction, or sliding that tend to be induced by external forces. Total internal resisting forces are resultants of continuously distributed normal and parallel forces that are of varying magnitude and direction and are acting on elementary areas throughout the material. These forces may be distributed uniformly or nonuniformly. Stresses are identified as tensile, compressive, or shearing, according to the straining action (Sci-Tech Encyclopedia, 200**5**).

Strain is a measure of deformation such as linear strain, the change of length per unit of linear dimensions; shear strain, the angular rotation in radians of an element undergoing change of shape by shearing forces; or volumetric strain, the change of volume per unit of volume. The strains associated with stress are characteristic of the material. Strains completely recoverable on removal of stress are called elastic strains. Above a critical stress, both elastic and plastic strains exist, and that part remaining after unloading represents plastic deformation called inelastic strain. Inelastic strain reflects internal changes in the crystalline structure of the metal. Increase of resistance to continued plastic deformation due to more favourable rearrangement of the atomic structure is strain hardening (Sci-Tech Encyclopedia, 2005).

2.2.1 Stress and Strain Relationship

The stress-strain curve characterizes the behaviour of the material tested. It is most often plotted using engineering stress and strain measures, because the reference length and cross-sectional area are easily measured. Stress-strain curves generated from tensile test results help engineers gain insight into the constitutive relationship between stress and strain for a particular material (Shodor, 2003).

A stress-strain diagram is a graphical representation of simultaneous values of stress and strain observed in tests and indicates material properties associated with both elastic and inelastic behaviour (see Figure 2.1). It indicates significant values of stress-accompanying changes produced in the internal structure (Sci-Tech Encyclopedia, 2005).

In addition to providing quantitative information that is useful for the constitutive relationship, the stress-strain curve can also be used to qualitatively describe and classify the material. Typical regions that can be observed in a stress-strain curve are: