

APPROVAL

“I admit that have read this report and in my view this report was satisfy from the aspect of scope and quality to be awarded for 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
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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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All the praises and thanks to Allah S.W.T for His Love, and I wanted to extend my gratitude to my family, especially my parents who always stand by my side, all lecturers especially my supervisor Mr.Md. Fahmi Bin Samad@Mahmood and my second supervisor Mr. Wan Mohd. Farid Bin Wan Mohamad who's constantly guiding and giving me information about PSM, and also to all my friends.

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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 made 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.

TABLE OF CONTENT

CHAPTER	TITLE	PAGE
	DECLARATION	ii
	DEDICATION	iii
	ACKNOWLEDGEMENT	iv
	ABSTRACT	v
	ABSTRAK	vi
	TABLE OF CONTENT	ix
	LIST OF TABLES	xi
	LIST OF FIGURES	xiii
	LIST OF SYMBOLS	xvi
	LIST OF APPENDICES	xvii
CHAPTER 1	INTRODUCTION	1
	1.1 Background	1
	1.2 Work Method	2
	1.3 Problem Statement	2
	1.4 Objectives	3
	1.5 Scope	3
	1.6 Report Outline	4
	1.7 Planning and Execution	5
CHAPTER 2	LITERATURE REVIEW	7
	2.1 Introduction	7
	2.2 Stress and strain	7
	2.2.1 Stress and Strain Relationship	8
	2.3 Strain Gauges	10
	2.3.1 Principle of Operation	10
	2.3.2 Strain Gauges Materials	14
	2.3.3 Specification Data for Commercial Strain Gauges	14
	2.3.4 Measurement schemes	16
	2.3.5 Applications of Strain Gauge	18
	2.3.5.1 Experimental stress analysis	19
	2.3.5.2 Sensors for machines, automotive, research etc	21
	2.4 Computer-aided engineering (CAE)	22
	2.5 Beam	24
	2.5.1 Beam Structural	24
	2.5.2 Beam Materials	25
	2.5.3 Stresses in Beams	28

CHAPTER 3	METHODOLOGY	32
3.1	Introduction	32
3.2	Selection and Manufacturing of beam	33
3.2.1	Cross-sections of Beam	33
3.2.1.1	Rectangular Cross-section	34
3.2.1.2	I Cross-section	34
3.2.1.3	C Cross-section	35
3.2.2	Type of Material Used	36
3.3	Methods of Analysis	36
3.3.1	Theoretical	36
3.4	Experiment	38
3.4.1	Equipment	39
3.4.2	Specimen	40
3.4.4	Installation of strain gauge	41
3.4.5	Experiment Procedures	45
3.4.6	Formula for Experimental Data Analysis	45
3.5	Computer Aided Engineering (CAE)	46
3.5.1	Finite Element Analysis (FEA) Procedure	46
3.5.2	Parameters in Finite Element Analysis (FEA)	47
3.6	Percentage of Error for Experimental and FEA	47
CHAPTER 4	RESULTS AND ANALYSIS	48
4.1	Experimental Data of Bending Stress Experiment	48
4.2	Experimental Data Analysis	51
4.3	Simulation Based on Finite Element Analysis (FEA)	55
4.4	Comparison of Result for Different Method Used	62
4.4.1	Maximum Stress	62
4.4.2	Deflection	63
CHAPTER 5	DISCUSSIONS	65
5.1	Introduction	65
5.2	Material of Beams	65
5.3	Cross-section of Beams	68
5.4	Finite Element Analysis	71
5.5	Factor of Error	73
CHAPTER 6	CONCLUSION AND RECOMMENDATIONS	76
6.1	Conclusion	76
6.2	Recommendations	77
	REFERENCES	78
	APPENDICES	80

LIST OF TABLES

NO.	TITLE	PAGE
1.1	Gantt chart of PSM 1 research	5
1.2	Gantt chart of PSM 2 research	6
3.1	Standard size	34
3.2	New dimensions of I-Beam	35
3.3	Dimension of Specimens for Rectangular Beam	40
3.4	Dimension of Specimen for I-beam	41
3.5	Dimension of Specimen for C-beam	41
4.1	Data of Load and Strain from Data Logger and Strain Gauges for Mild Steel Rectangular Beam	48
4.2	Data of Load and Strain from Data Logger and Strain Gauges for Aluminum Rectangular Beam	49
4.3	Data of Load and Strain from Data Logger and Strain Gauges for Mild Steel I-Beam	49
4.4	Data of Load and Strain from Data Logger and Strain Gauges for Aluminum I-Beam	49
4.5	Data of Load and Strain from Data Logger And Strain Gauges for Mild Steel C-Beam	50
4.6	Data of Load and Strain from Data Logger and Strain Gauges for Aluminum C-Beam	50
4.7	The Higher Value of Strain for Each Beam and Material at 6.0kN	51
4.8	Comparison between Experimental and Theoretical Results, when Load Maximum Applied for Mild Steel Rectangular Beam	52

4.9	Comparison between Experimental and Theoretical Results, when Load Maximum Applied for Aluminum Rectangular Beam	52
4.10	Comparison between Experimental and Theoretical Results, when Load Maximum Applied for Mild Steel I-Beam	53
4.11	Comparison between Experimental and Theoretical Results, when Load Maximum Applied for Aluminum I-Beam	53
4.12	Comparison between Experimental and Theoretical Results, when Load Maximum Applied for Mild Steel C-Beam	53
4.13	Comparison between Experimental and Theoretical Results, When Load Maximum Applied for Aluminum C-Beam	54
4.14	Result of Maximum Stress and Deflection from CAE Analysis	61
4.15	Comparison of Maximum Stresses Value for Different Method	62
4.16	Percentage Error of Maximum Stresses for Experimental and FEA	63
4.17	Comparison of Maximum Deflection between Theoretical, Experimental and FEA	63
4.18	Percentage Error of Maximum Deflection for Experimental And FEA	64

LIST OF FIGURES

NO.	TITLE	PAGE
1.1	Methodology Sequence Process	
2.1	Various Regions and Points on the Stress-Strain Curve	9
2.2	Stress- strain Curve	10
2.3	Example of Poisson's Ratio in Bar	11
2.4	Metallic Wire	12
2.5	Deformation Of Metallic Wire	13
2.6	Modern Strain Gages	14
2.7	Sensitivity Direction	15
2.8	Wheatstone Bridge	16
2.9	Quarter Bridge	17
2.10	Half Bridge	17
2.11	Quarter Bridge With Temperature Compensation	18
2.12	Full Bridge	18
2.13	Bending And Deflection Of Bar	19
2.14	Compression And Traction (Tension) Bar	19
2.15	Bonded Strain Gauge (Source: http://www.sensorland.com)	21
2.16	Structural Elements (Source: Megson, 2005)	25
2.17	Examples Of Cold-Formed Sections (Source: Megson, 2005)	26
2.18	A Simply Supported Beam Subjected to Three Points Loading	29
3.1	Methodology Sequence Process	32
3.2	Dimension of Rectangular Beam	34
3.3	Characteristics Of I-Beam	34

3.4	C-beam Dimension	35
3.5	Strain Gauge Position	37
3.6	Data Logger Works	40
3.7	Sand With Abrasive Paper	42
3.8	Cleaning With Industrial Tissue Paper Or Cloth Soaking In Chemical Solvent	42
3.9	Applying Bonding Adhesive	42
3.10	Curing And Pressing	43
3.11	Raising The Gauge Leads	43
3.12	Bonding connecting terminals	43
3.13	Soldering with a little slack in the gauge leads	44
3.14	Extension lead wire is soldering to the terminal wires	44
4.1	Result of Finite Element Analysis from Full View for Mild Steel Rectangular Beam	55
4.2	Side View of Finite Element Analysis for Mild Steel Rectangular Beam	55
4.3	Result of Finite Element Analysis from Full View for Aluminum Rectangular Beam	56
4.4	Side View of Finite Element Analysis for Aluminum Rectangular Beam	56
4.5	Result of Finite Element Analysis from Full View for Mild Steel I-Beam	57
4.6	Side View of Finite Element Analysis for Mild Steel I-Beam	57
4.7	Result of Finite Element Analysis from Full View for Aluminum I-Beam	58
4.8	Side View of Finite Element Analysis for Aluminum I-Beam	58
4.9	Result of Finite Element Analysis from Full View for Mild Steel C-Beam	59
4.10	Side View of Finite Element Analysis for Mild Steel C-Beam	59

4.11	Result of Finite Element Analysis from Full View for Aluminum C-Beam	60
4.12	Side View of Finite Element Analysis for Aluminum C-Beam	60
5.1	Graph of Experimental Stress versus Strain for I-beam	66
5.2	Graph of Strain versus Strain Gauge for Rectangular Beam	67
5.3	Graph of Theoretical Stress versus Strain Gauge	68
5.4	Moment of Inertia for Different Types of Beam Chart	69
5.5	Theoretical Maximum Stress for Different Types of Beam	69
5.6	Chart of Comparison Percentage of Error between Experimental and FEA for Mild steel	71
5.7	Suggestion of Altered "Head"	75

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 ($^{\circ}C$)
α	=	Linear Dilatation Coefficient
ϵ	=	Strain ($\mu\epsilon$)
σ	=	Stress (MPa)
ρ	=	Specific Resistance of the Resistance Material (Ω/m)
ν	=	Poisson Ratio

LIST OF APPENDICES

NO.	TITLE	PAGE
A	Summary Of The Various Types Of Strain And Strain Gauges (Source: National Instruments, 2006)	80
B	Strain Gauge Coding System (Source: Tokyo Sokki Kenkyujo,2008)	81
C	Stress/Strain Formulae (Source: RoyMech, 2008)	82
D	Types of Beam Support (Source: RoyMech, 2008)	83
E	Bending Stress Experiment Apparatus	85
F	Specimen And Apparatus Setup	86
G	Technical Data And Specification Of Apparatus	89
H	The Calculation of Moment of Inertia, I for Beams	91
I	Calculations of Maximum Stress for Beams	93
J	Calculation of Theoretical Deflection	103

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

RESEARCH ACTIVITY/TIME	JULY				AUGUST				SEPTEMBER				OCT	
	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, 2005).

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: