STRENGTH ANAL OOF TRUSS MEMBERS CONSIST OF HAT CHANNEL AND C-CHANNELWITH DIFFERENT THICKNESS

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ABSTRACT

A roof truss is a very important structure when constructing the roof. It transfers the dead load and the live load from the roof to the nearest structural support such as column. The strength test on the truss member is a very essential procedure as it will determine whether the member type is suitable to sustain the load or not. It can also help in determining the most economical material to be used in the construction hence cutting the construction cost. Laboratory test provides more accurate results because it is tested directly onto the material but it must be done according to the related standard specification. This research's purpose is to determine the maximum tensile strength the available cold-rolled steel channel can afford before it counters failure. This test was carried out by the Universal Testing Machine (20kn~50kN) for the coupon test and 3-point load Bending Testing Machine for the bending test.

ABSTRAK

Kekuda bumbung adalah sesuatu struktur yang sangat penting dalam sesuatu pembinaan. Ia memindahkan beban kenaan dan beban mati dari bumbung kepada struktur penyokong seperti tiang. Ujian kekuatan ke atas anggota kekuda bumbung amatlah penting bagi memastikan ianya sesuai digunakan dalam sesuatu projek pembinaan.Ia juga dapat membantu mengurangkan kos pembinaan dengan menentukan material yang paling ekonomi tetapi sesuai untuk sesuatu projek pembinaan. Ujian analisis makmal menghasilkan keputusan yang lebih tepat bagi sesuatu bahan kerana ia diuji secara terus keatas bahan tersebut.tetapi ia haruslah dijalankan mengikut spesifikasi yang telah ditetapkan dalam standard yang berkaitan. Kajian ini bertujuan untuk mengira kekuatan tegangan maksima bagi setiap profail keluli terbentuk sejuk yang ada. Ujian ini dijalankan menggunakan Universal Testing Machine (kapasiti beban 20kN~50kN) bagi ujian kupon manakala bagi ujian lenturan pula menggunakan 3-point Bending Testing Machine.

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CHAPTER 1

INTRODUCTION

1.1 Background of study

In the old days, timber has been used to build roof trusses but as time goes by, it proves that the usage of timber has many disadvantages. For instance, it is not environmental friendly. We have to cut a lot of trees to produce trusses that made of timber. It also shows that timber can easily be damaged by termites. That's why, nowadays, steel have been used nationwide for the purpose of construction. Steel is essential for the construction either for the reinforcement of concrete or trusses for roof. It is used because of its strong structure, its resistance towards heat, its bending ability and et cetera. It also can stand a lot of pressure and very durable. Steel is also better than timber in terms of moisture and insect resistance and also has a higher strength-to-weight ratio than timber.

As concern, steel's quality is very high and has standard because it is manufactured straight from the factory. Even it is a little bit expensive compared to the timber or concrete; it still saves the overall cost because it saves the structures assembling time. It also needs a very little maintenance and prolong the lifespan of the building.

In steel industries, there are two main types of steel which is the hot rolled steel and the cold-formed steel. The hot rolled steel is very popular for erecting high-rise building while the cold-formed steel has become popular during the last decade. Hot-rolled steel is made from a very high temperature while the cold-formed steel is made within the room temperature. Meanwhile, cold-formed steel trusses are commonly assembled using C-sections and self-drilling screws.

In these modern days, the cold-formed steel has been used more widely compared to the hot-rolled steel. Cold-formed steel have been proven to have meet the requirement strength for structural applications. Furthermore, cold-rolled steel is lighter compared to the hot-rolled steel. Experimental studies indicate the connection made by this type of steel has sufficient strength and stiffness to form the pitched roof portal frame effectively.

Design properties of cold-rolled steel can be found in some part of British Standard 5950 and the proper method to do the test can be read from the American Standard Test Method. Actually, the procedure in making a cold-formed structural shape is to take a flat sheet at room temperature and bend it. It is quite easy because all it may need is juat a single person lifting a sheet onto a press brake. Generally, though, cold-formed members are made by running a coil of sheet steel through a series of rolling stands, each of which makes a small step in bending the sheet to its final form. But the equipment investment is still much less than that of the hot-rolled industry and the end product coming out of the last roller stand can often be lifted by one person.

1.4 Scope of Study

In this research, the channels that will be tested are lipped-channel, box-up channel and hat-channel. Those three channels will be run through the tension test and bending test. We will study the strength properties of each channel and how much load they can handle until they reach their failure point. This research will be practiced according to the code of practice as prescribe by BS 5950 Part 5: 1987. The tests were also performed to meet the requirements that have been outlined by Public Works Department, Malaysia.

1.5 Significant of Study

Strength analysis on the truss member is very important to avoid structural failure on later days. Structural failure is very hazardous to public and may lead to court cases where the respected party who is responsible for the situation must bear the consequences. The involved company will suffer a great loss and that is all because they neglect to analyze the material meticulously in the first place.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Cold-formed steel is a very important component in construction industry nowadays. Roof truss used to be made by timber. Now, steel has taken its place because it has many advantages compared to timber. It is easy to be mould into any shapes, it has very high yield strength, it has higher tolerance upon heat, it can withstand higher loading compared to the timber. Generally, cold-formed steel was made by galvanized steel plate which will be later used in this experiment. Cold-formed c-channel are usually used as roof truss because of its lightness, high strength and stiffness, ease of prefabrication and mass production, fast and easy erection and installation, and economy in transportation and handling (Yu, 1999).

Conversely, all it takes to make a cold-formed structural shape is to take a flat sheet at room temperature and bend it. This may be as simple as a single person lifting a sheet onto a press brake. Generally, though, cold-formed members are made by running a coil of sheet steel through a series of rolling stands, each of which makes a small step in bending the sheet to its final form. But the equipment investment is still much less than that of the hot-rolled industry and the end product coming out of the last rollerstand can often be lifted by one person. It is easy for a manufacturer of cold-formed steel sections to add a wrinkle here and there to try and get an edge on a competitor. For this reason, there is not much in the way of standardization of parts. Each manufacturer makes the section it thinks will best compete in the marketplace. They may be close but rarely exactly like products by other manufacturers used in similar applications. (Hancock *et. al.*, 2001).

2.2 Cold-formed steel roof truss

2.2.1 Definition

A standard truss is a series of triangles - a stable geometric shape that is difficult to distort under load. Regardless of its overall size and shape, all the chords and webs of a truss form triangles. These triangles combine to distribute the load across each of the other members, resulting in a light structure that is stronger than the sum of the strength of its individual components. However, for all the advantages, proper installation techniques and bracing are critical. Additionally, trusses should not be modified in the field without consulting the truss manufacturer. Cutting a web member, for example will radically alter its strength. They are more expensive compare to timber trusses but they are more durable and reliable. The quality of these trusses are good coz they are manufactured in an controlled environment, their strength is consistent and do not vary as the timber product. Most of the steel trusses are coated with protective layer to prevent rust only and do not need to be chemically treated.

2.2.2 Common Cold-Formed Section Profiles

Typical sections for use in roof and wall systems are Z, Hat or C- (channel) sections, used as purlins and girts, or sometimes beams and columns. There are a lot of type of channel section, as shown in Figure 2.1. To name a few;

a) Hat Channel
b) C- Channel
c) Box-up channel
d) Z- channel

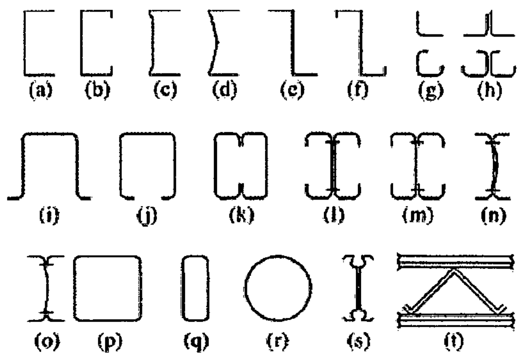

Figure 2.1 Cold-formed steel sections used for structural framing.

2.3 Forming of Cold-Rolled Steel

Roll forming is a process where a continuous steel strip is feeding through a series of opposing rolls to progressively deform the steel plastically to form the desired shape. Each pair of rolls produces a fixed amount of deformation in a sequence of the type shown in Figure 2.2. In this example, a Z section is formed by first developing the bends to form the lip stiffeners and then producing the bends to form the flanges. A stage is called for each pair of opposing rolls. In general, the number of stages required is depending on the complexity of the cross-sectional shape. In the case of cold-formed rectangular hollow sections, the rolls initially form the section into a circular section and a weld is applied between the opposing edges of the strip before final rolling (called sizing) into a square or rectangle.

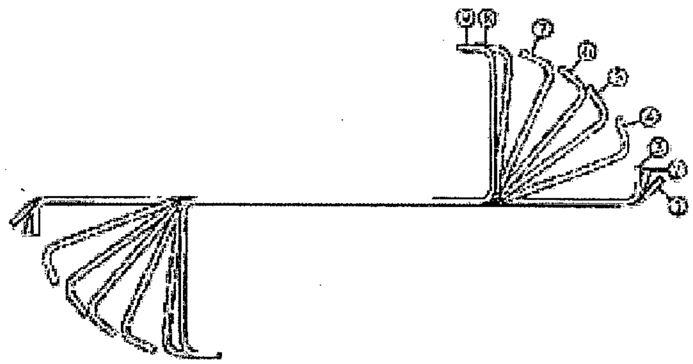

Figure 2.2 Typical roll forming sequences for a Z-section

2.4 Bending Design

For normal ductility steels Section A2.3.1 applies. The ratio of tensile strength to yield stress, Fu/Fy, shall not be less than 1.08 and the total elongation shall not be less than 10 percent for a two-inch gage length (AISI 2007). If these requirements cannot be met other criteria may be satisfied for restricted use in purlins, girts, and curtain wall studs (AISI 2007).For low ductility steels Section A2.3.2 applies. Steels that do not meet the minimum 10 percent elongation requirement may be used for limited applications conforming to several exceptions provided that the steel meet certain requirements. First, the yield stress, Fy, used for determining nominal strength is taken as 75 percent of the specified minimum yield stress or 60 ksi, whichever is less (AISI 2007). Second, the tensile strength, Fu, used for determining nominal strength in connections is taken as 75 percent of the minimum tensile strength or 62 ksi, whichever is less (AISI 2007).

CHAPTER 3

METHODOLOGY

3.1 Introduction

These experiments are carried out to acquire the information of cold-formed steel roof truss with more details. It will analyze the strength of the channel and the maximum load the channel from the truss members can carry before it reaches its failure. To ensure that everything is going as planned, a research flowchart is created as in Figure 3.1 (shown as below). Figure 3.1 shows the workflow of the research from the beginning until the required result is achieved.

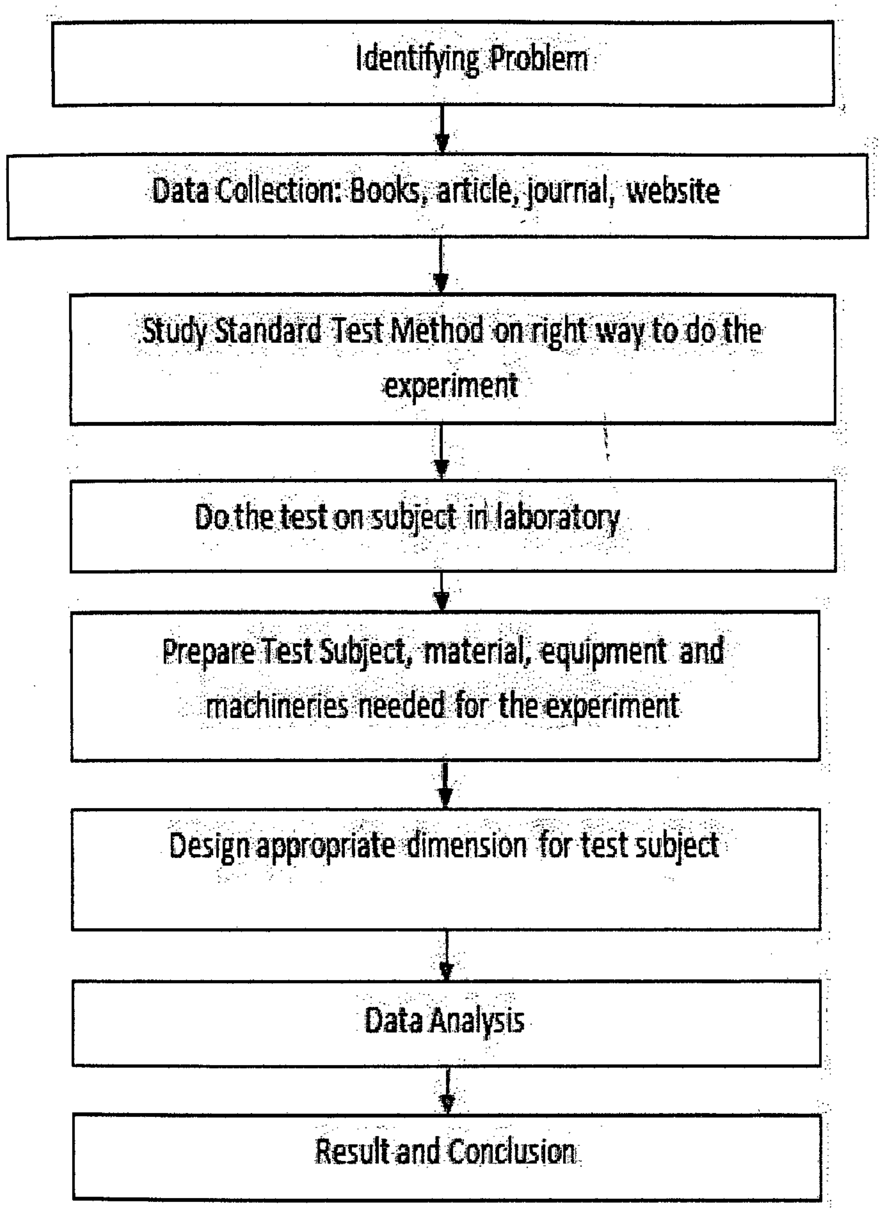

Figure 3.1: Research Flowchart

3.2 Data Collection

There are a lot of methods for data collection. The first part of data collection is via the internet. All data were collected to understand more about the purpose of this project and the right method to do it. Every journal related to the cold-formed steel test is read thoroughly. The right standard test method and design standard for the respective test is identified and searched online. The lack of test information in the internet leads to data collection from books in the library. The American Standard Test Method A370 (ASTM A370) was found in the library and the test method for coupon test and bending test was extracted. All the books that have information about the cold-formed steel were read to understand the properties of the steel.

3.2.1 Literature Review

The literature review is one of the early and main researches to see the general point of view of this research. All the writings regarding the truss and cold formed steel channel is read. The literature review is done to comprehend the research background study and early comprehension of research title. The understanding of the study is very important to obtain all the possible information regarding the study. It also can avoid from picking useless information that out of the scope of the study. These literature reviews explain more about the cold formed steel properties and its abilities. It also explains why cold formed steel has taken the timber and hot rolled steel place. Literature review was extracted from some significant person journals and books. They have done a very thorough research on this type of steel before writing about it.

3.2.2 Data Analysis

Data analysis is the most important part of this research. Any misunderstanding regarding the data can leads to the failure of experiments. Appropriate test method must be acquired before doing the experiment. Failure to do so may affect the equipment used (broke the equipment) or not getting the required data for the study. From previous study, design method for the test was provided by BS5950 Part 5. Study is proceeding by designing the thickness, lip, and height of the channel member. The maximum load for the designed channel is calculated to estimate the maximum load the channel can carry.

3.3 Bending Test

3.3.1 Material

Material used for this experiment is two c-channels with different thickness, one is 0.8 mm while the other one is 1.2 mm. For this test, each member will be applied load on it to find its ductility. According to ASTM A370, the severity of the bend test is primarily a function of the angle of bend. These conditions are varied according to location and orientation of the test specimen and chemical composition, tensile properties, hardness, type and quality of the steel type. Method E 190 and Test Method E290 may be consulted to perform this test. BS 5950 Part 5 limits the length of the member to at least eight times the longest length of the cross-sectional dimension.

3.3.2 Test Setup

The compression flange should be supported at a distance not greater than 20 times the least radius of gyration of the specimen. Two point loads should be applied to the member in such a way that the formation of bending moment is quite close to the uniform bending moment developed from uniform load. Local buckling may be restrained at the points of applied load to ensure that failure occurs within the central portion of the span. Both C-section and hat section, with three specimens of each were tested until failure. Figure 3.2 show the machine used for the flexural bending test while Figure 3.3 shows a close up view of a channel after it has been set up to the machine.

Figure 3.2 Universal Testing Machine for the Flexural Bending Test

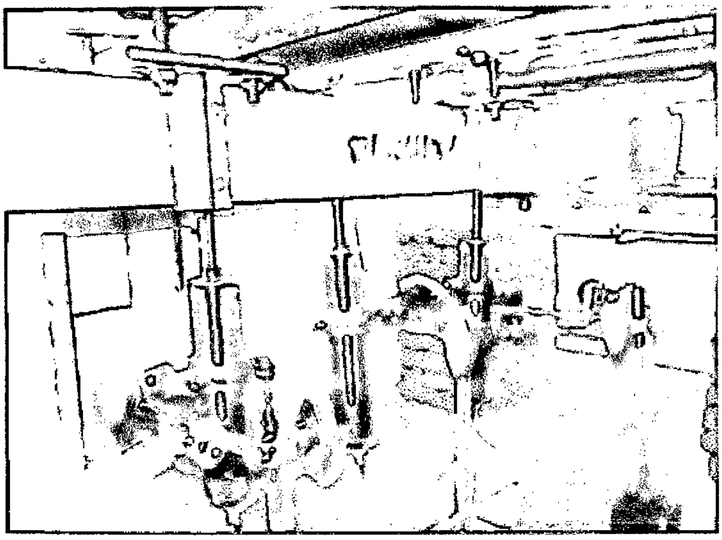

Figure 3.3 Set-up of C-Channel into the Testing Machine

3.4 Coupon Test

3.4.1 Material

Materials used for this experiment are plates with different thickness; one is 0.42 mm, 0.46 mm, 0.8 mm and the other one is 1.2 mm. It also varies in coating

(Galvanized, Truecore and Zinclum). The Standard Test Method, ASTM A370 stated that full section specimens shall be tested in 8 in. (200mm) gage unless specified otherwise. The specimen used will be the sheet type specimen. For the sheet type the thickness is ranged from 0.13 mm to 19 mm.

3.4.2 Test Setup

ASTM A370 stated that for the sheet type, the reduced section in width shall not exceed 0.10 mm and the width shall not be 0.4 larger than width at the center. The capacities of cold-formed C-sections and hat section were estimated using the method provided in BS5950 Part 5. Coupon tests were carried out to determine the yield strength of the. It is important to determine the value of the yield strength because this value is then applied into the capacities calculation of the tested sections. The characteristic tensile strength of specimen is achieved by dividing the maximum applied force by the cross sectional area of the failure part. The design yield strength was adopted at around 85% of the characteristic yield strength as in accordance with BS 5940 part 5. Figure 3.3 was extracted from the American Standard Test Method (ASTM A370) which shows the proper method to do the experiment. The figure also explained on how to install the specimen and what step should be taken if the experiment failed.

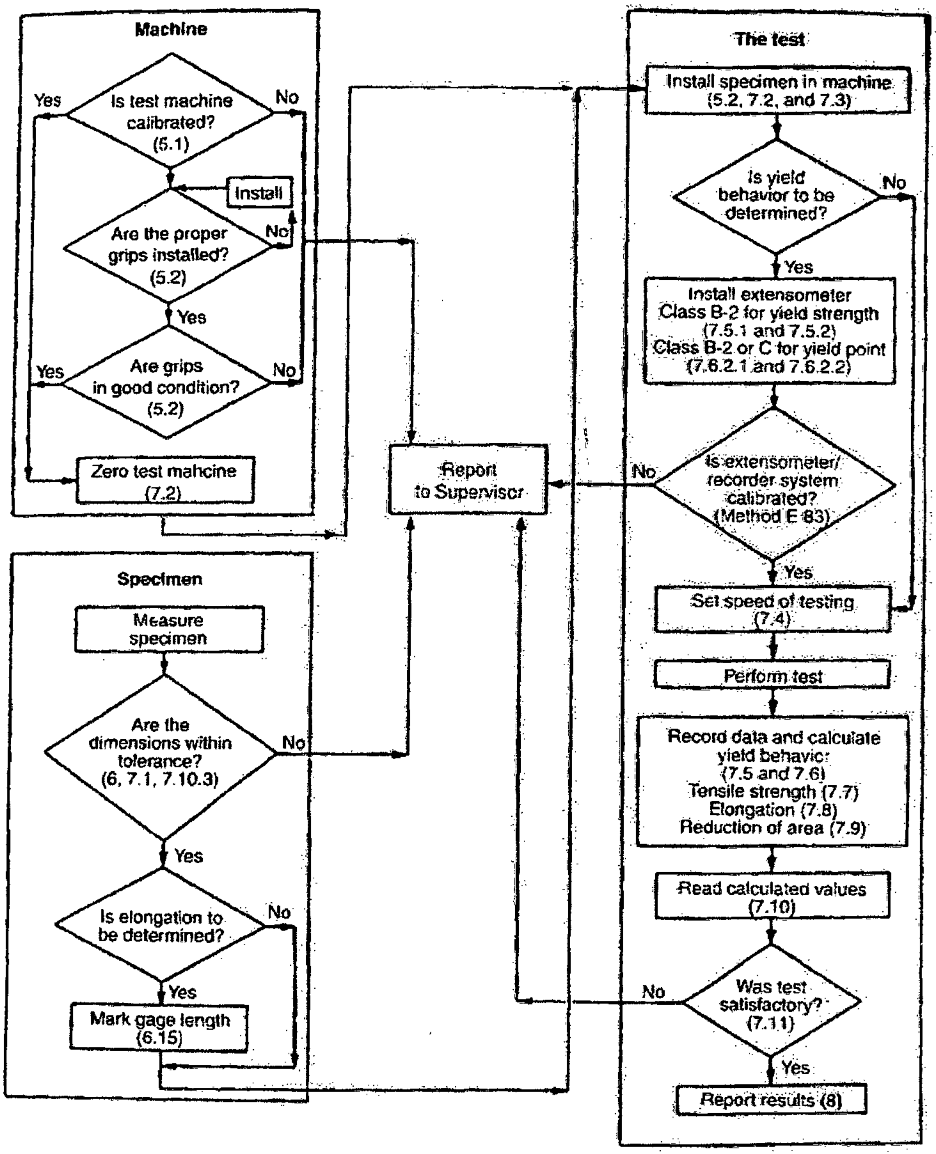

Figure 3.3 A Standard Test Flowchart from American Standard test Method

The Figure 3.4 below shows the serrated wedge that is used in the testing of the coupon. It provides more grip to the coupon plate as the load is applied. The serrated wedge is used because the some of the plate's surface is very smooth which can lead to data error. Meanwhile, Figure 3.5 shows a student doing the test setup by installing the coupon plate into the machine. A ready to be tested coupon plate is shown in the Figure 3.6 where the coupon specimen had been fully setup and ready to undergo the test. The machine used is the Universal Testing Machine that has the load capacity between 20 kN to 50 kN.

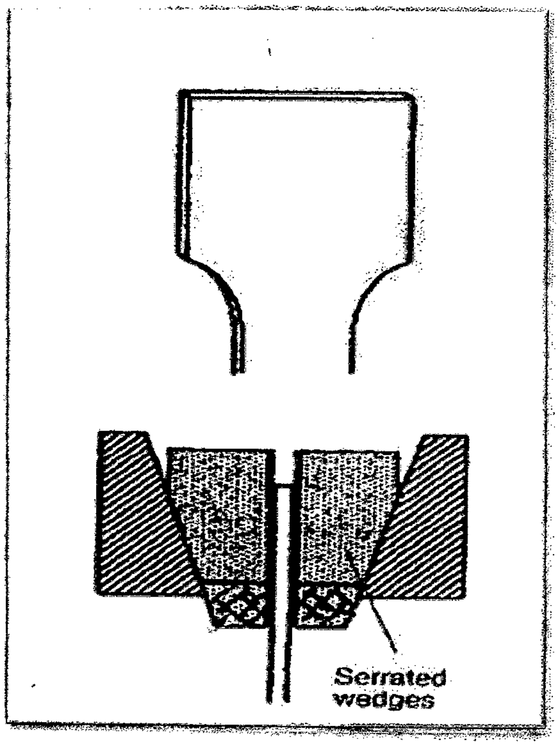

Figure 3.4 Coupon Test Specimen is gripped with serrated wedges

Figure 3.5 A Student Is Installing the Coupon Specimen into the Test Machine

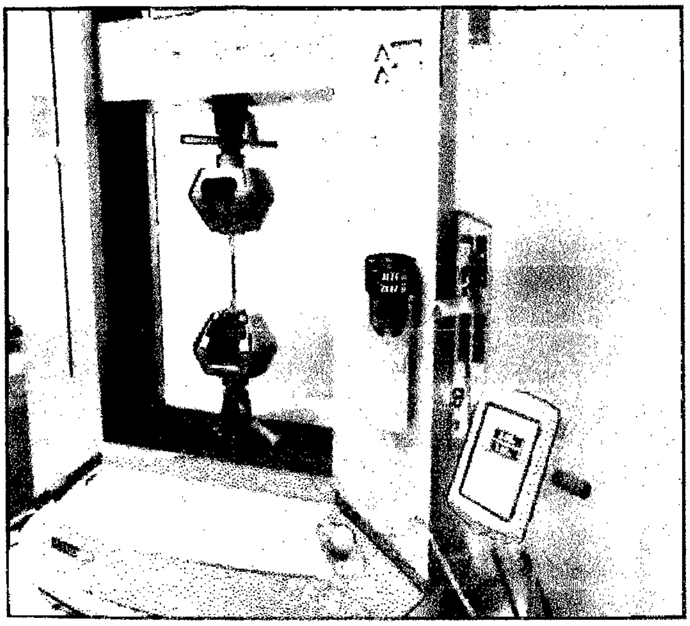

Figure 3.6 Universal Testing Machine

CHAPTER 4

RESULT AND ANALYSIS

4.1 Introduction

This chapter will elaborate about the results regarding the analysis of the roof truss members. The result was obtained from the laboratory test that was carried out on variety type of channels. The machine used is the Universal Testing Machine with the loading capacity of 20 kN to 50 kN. All the required data is recorded using the appropriate table.

4.1.1 Coupon Test

The experiment is done in accordance of American Standard Test Method A370 (ASTM). The coupon specimen is cut out from the existing channel according to the ASTM standard. Before cutting the plate, all safety clothing such as boots, the jacket and the helmet is taken into account. The loading rate applied on the coupon specimen is 1mm/min and will be applied until the coupon steel plate reaches its failure. Before carry out the experiment, the width and the gage length is written on the prepared table. Subsequent table 4.1 shows the coupon test result for the channels.

Table 4.1 Coupon Test Analysis Result

Type	Thickness (mm)	Width (mm)	Elongation (mm)	UltimateTensile Strength(P_{max}/A) (N/mm^2)	Ave. Ultimate Tensile Strength (N/mm^2)
Trucore	0.48	13.0	3	671.3	683.7
Trucore	0.48	13.0	4	696.0	
Galvanised	0.48	14.0	2	540.3	544.5
Galvanised	0.48	16.0	2	548.7	
Galvanised	0.80	12.5	2	525.2	548.6
Galvanised	0.80	14.0	2	572.1	
Trucore	0.80	12.5	1	676.3	681.3
Trucore	0.80	13.0	1	686.4	
Trucore	1.00	13.0	1	603.2	596.4
Trucore	1.00	12.0	1	589.6	
Zinclum	0.80	13.0	3	383.1	416.0
Zinclum	0.80	13.0	4	449.0	
Zinclum	0.42	13.0	1	480.0	475.8
Zinclum	0.42	15.0	2	471.6	