Faculty of Engineering

TESTING OF RIVETED COLD-FORMED STEEL CONNECTIONS IN BEARING

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This project report attached hereto, entitled **"Testing of Riveted Cold-Formed Steel Connections in Bearing"** is prepared and submitted by Mohamad Redza Bin Ali Madan in partial fulfillment of the requirement of Bachelor's Degree with Honours in Civil Engineering is hereby accepted.

22/3/2004

(Miss Adeline Ng Ling Ying)
Project Supervisor

Date

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2004

To my beloved parents and family members,

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ABSTRACT

The use of riveted cold-formed steel connections in the Malaysian construction industry is still low. This research provides technical information on rivet connections. The topic of interest is on the mode of failure, stronger arrangement and maximum load capacity of the rivet connections. Single shear laboratory tests are conducted for five different arrangements in order to obtain the desired information. The governing design factor for the connections is plate bearing. The better arrangement for double rivet connections is when the rivets are arranged perpendicular to the line of force. For triple rivet connections, the better arrangement is when two rivets are placed at the front row of the rivet connections. The maximum load that the connections can sustain is 3.10 kN, 5.23 kN and 7.57 kN for single, double and triple rivet connections respectively.

ABSTRAK

Penggunaan paku sumbat dari jenis keluli gelek sejuk di dalam industri pembinaan di Malaysia adalah masih rendah. Penyelidikan ini menyediakan maklumat teknikal untuk sambungan paku sumbat. Topik-topik yang menjadi tumpuan ialah mod kegagalan, susunatur yang lebih kuat dan kapasiti beban maksima untuk sambungan paku sumbat. Ujian makmal ricih tunggal dilakukan untuk lima susunatur yang berbeza bagi memperolehi maklumat-maklumat yang dikehendaki. Mod kegagalan yang mempengaruhi rekabentuk sambungan ialah galas plat. Susunatur yang lebih baik untuk sambungan berkembar dua ialah apabila paku sumbat di susun berserenjang dengan garisan beban. Untuk sambungan berkembar tiga, susunatur yang lebih baik ialah apabila dua paku sumbat diletakkan di barisan hadapan pada sambungan paku sumbat berkenaan. Beban maksima yang dapat ditampung oleh sambungan ialah 3.10 kN, 5.23 kN dan 7.57 kN masing-masing untuk sambungan tunggal, berkembar dua dan berkembar tiga.

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A_n	Net area of the connected part
d_f	Nominal rivet diameter
f_{u1}	Tensile strength of the sheet in contact with the rivet head
f_{u2}	Tensile strength of the sheet not in contact with the rivet head
g	The gauge
N_t	Nominal section capacity of the member in tension
N_t^*	Design tensile force on the net section of the connected part
r_f	Ratio of the force transmitted by the rivet or rivets at the section considered, divided by the tensile force in the member at that section
s_f	Spacing of rivets perpendicular to the line of the force
s_p	Staggered pitch
t	Thickness of the holed material
t_1	Thickness of the sheet in contact with the rivet head
t_2	Thickness of the sheet not in contact with the rivet head
V_b	Nominal bearing capacity of the connected part
V_b^*	Design bearing force on a rivet
Φ_1	Capacity [strength reduction] factor of blind rivet subject to tension in the connected part
Φ_2	Capacity [strength reduction] factor of a blind rivet subject to tilting and hole bearing

CHAPTER ONE

INTRODUCTION

1.1 Background

The use of cold-formed steel members in building construction began in the 1850s in both the United States and Great Britain. However, such steel members were not widely used in buildings in the United States until 1940s. Currently, cold-formed steel members are widely used as construction materials worldwide (Gaylords 1990).

Steel structures are made up of members formed from rolled plates and shapes that are connected together with welds or fasteners such as bolts or rivets. Welds fuse the members together, while bolts and rivets form mechanical connections between the members. Connection is very important such that no matter how strong the steel members are, the structure will fail if the connection fails. Cold-formed steel sections, which are made up of thin steel sheets are vulnerable at the joints especially in bearing.

Since fabrication and erection costs are a significant proportion of the overall cost of a steel framework, the specification and detailing of connections are also an important element in the design process (McKenzie 1998). Since the cost of a fabricated structure is governed to a large degree by the joint efficiency, the choice of the material and the method of production are always important (Blake 1985).

Riveting is among the oldest methods of joining materials, dating back as far as the use of metals in construction practice. Rivets were the most popular fasteners during the first half of the nineteenth century, but their use has declined steadily since the introduction of the high-strength bolts. At present, they are rarely used in either field or shop connections; either high-strength bolts or welds are used almost exclusively in new work (Kulak, Fisher, Struik 2001). Further competition comes from the welding technology, which can produce reliable joints even under rough field conditions (Blake 1985).

However, for cold-formed steelwork, it is found that rivet joints has its advantages in terms of speed and efficiency. Usually, the failure of a cold-formed steel connection is governed by the steel plates. High strength bolts or welds are not really required. Furthermore, welding will affect the surface of galvanized cold-formed steel. This location is very vulnerable and corrosion usually is initiated here.

Rivets performed admirably in the past and still have unique applications. The famous Eiffel Tower, now close to 100 years old, is a monument to structural integrity and reliability of a riveted joint. For instance, 15 000 steel members of the tower are still held in place by 2 500 000 rivets (Blake 1985).

1.2 Problem Statement

The use of cold-formed steel is relatively new in Malaysia. The problem faced by the Malaysian construction industry now is to widespread the use of cold-formed steel. Although efforts have been taken to promote its usage, the industry still finds it difficult to accept. This is because they are afraid and unwilling to try something new. They are in a comfort zone to risk a new construction method.

There is also lack of confidence in the use of cold-formed steel since it is very light and thin compared to timber and concrete. Some people believe that members made of cold-formed steel are not strong since they are easily twisted as a single member. This perception rises mainly because the mind set that bigger members are stronger and thus better. But the strength of cold-formed steel members will increase when the members are connected together.

Besides that, the lack of technical information also causes the low acceptability of cold-formed steel. Therefore, more researches should be carried out in this area to promote the use of cold-formed steel.

There are not many manufacturers of this product. Ributek (M) Sdn. Bhd. and Sinlygwan Industries Supply Sdn. Bhd. are among the main manufacturers in Malaysia. Currently, cold-formed steels are mainly used for roof truss and lightweight portal frame buildings.

1.3 Aim and Objectives

The aim of this research is to study the capacity of rivet joints in term of bearing. The objectives of this research are:

(i) To recognize the mode of failure of riveted cold-formed steel connections.

(ii) To determine the better arrangement of rivet for cold-formed steel connections to form the strongest connection.

(iii) To determine the maximum load that the connections can sustain.

1.4 Scope of Study

This research will concentrate on:

(i) Rivet connections only.

(ii) The connections of cold-formed steel sections only.

(iii) Single shear tests.

(iv) Plate with thickness of 0.55 mm and width of 50 mm.

(v) Rivet under axial tensile load.

(vi) Testing for single, double and triple rivet connections with different arrangements.

(vii) Design of rivet connections complying with Australian/New Zealand Standards.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The use of cold-formed steel members has started since 1850s but the use in Malaysia is still new. At present, it is only used in certain types of steel members. This happens mainly because lack of technical information's available on cold-formed steel and the unwillingness to risk something new for the construction industry.

Besides actively promoting the use of cold-formed steel and rivet connections, it is also important to carry out more researchers in order to gain better understanding and confidence from the construction industry. It is also essential to know the different types of steel and connections available and to distinguish their advantages and disadvantages. For building construction, there are primarily two types of structural steel, which are hot-rolled steel sections and cold-formed steel sections.

There are mainly three types of steel connections that are used for cold-formed steel. They are weld, bolt and rivet connections. For the purpose of this research, the specimens used for the laboratory tests are designed according to the Australian/New Zealand Standards.

2.2 Cold-Formed Steel

Cold-formed steel structural members are sections commonly manufactured from steel plate, sheet or strip material. The manufacturing process involves forming the material by either press-braking or cold roll forming to achieve the desired shape (Chen 1999).

Press braking is often used for production of small quantity of simple shapes. Cold roll forming is the most widely used method for production of roof, floor and wall panels. It is also used for the production of structural components such as Cees, Zees, and hat sections. Sections can usually be made from sheet up to 60 inches (1.5 m) wide and from coils more than 3,000 feet (1,000 m) long (Chen 1999).

During cold roll forming, sheet stock is fed longitudinally through a series of rolls, each of which works the sheet progressively until it reaches the desired shape. A simple section may require as few as six pairs of roll, but a complex shape can require as many as 24 to 30. The thickness of material that can be formed generally ranges between 0.004 inches (0.10 mm) up to 0.312 inches (0.79 mm), although heavy-duty cold forming mills can handle steel up to ¾ of an inch (19 mm) thick (Chen 1999).

Cold-formed steel structural members are classified by two major categories: framing members and panels and decks. Framing members dimensions frequently result in plane elements having large flat-width to thickness ratios. Such slender elements are commonly stiffened with edge stiffeners or intermediate stiffeners to forestall premature local buckling (Gaylords 1990).

Panel and deck sections are load-resisting shapes that also provide a usable surface. Panels and decks must satisfy a variety of functional requirements of which optimum strength in only one. Other requirements are the coverage provided by a given flat width of sheet, i.e., the flat-width to thickness ratio and the ability to function for floor electrification and telecommunication conduits. An optimum design must therefore serve multifunctional requirements (Gaylords 1990).

The use of cold-formed steel in the current Malaysian construction industry is still new. There are several applications in which the use is starting to gain confidence. Multi-truss made of cold-formed steel has been an alternative to timber truss. This is mainly because multi-truss has several advantages such as absolute freedom in design, need for lightweight and durable truss system, cost effective and ideal for complicated shapes (Multi Resources 2003).

Cold-formed steel sections also perform excellently in light-weight portal frame buildings. Typical applications of lightweight portal frame include factories, warehouses, sheds, farm buildings, chicken sheds, car and motorcycle parking, showrooms, site offices, low-cost houses, schools, clinics, roof-top extensions and markets. Building can be supplied with a clear span of up to 30 metres and larger buildings can be supplied with internal columns included. The system is so flexible that it is easy to provide overhangs, canopies, leas-tos, roof monitors, ventilators, translucent sheet, insulation, louvers, roller, sliding or personnel doors and windows (BHP 2002).

2.2.1 Comparison between Cold-Formed Sections and Hot-Rolled Sections

The most obvious difference between cold-formed steel sections and hot-rolled steel sections is that hot-rolled steel sections are formed at elevated temperatures while the cold-formed steel sections are formed at room temperature. Besides that, cold-formed steel and hot-rolled steel also differ in its thickness and shapes. Since cold-formed steel members are formed at room temperature, its material becomes harder and stronger. Its lightweight also makes it easier and more economical to mass-produce, transport and install (Chen 1999).

Another significant difference between cold-formed steel and hot-rolled steel is in its design. For designing with hot-rolled structural shapes; one is primarily concerned about two types of instability: column buckling and lateral buckling of unbraced beams. The dimensions of hot-rolled shapes are such that local buckling of individual constituent elements generally will not occur before yielding (Chen 1999).

This is not the case with cold-formed members. Here local buckling must also be considered because, in most cases, the material used is thin relative to its width. This means that the individual flat, or plate, elements of the section often have width to thickness ratios that will permit buckling at stresses well below the yield point (Chen 1999).

2.3 Types of Steel Connections

There are mainly three types of steel connections used to connect steel members. They are weld, bolt and rivet connections.

2.3.1 Weld Connections

Weld connections fuse members together. Welding is done by joining two pieces of metal by creating a strong metallurgical bond between them by heat or pressure or both. The most common welding process is the electric arc welding. There are basically two types of welds, which are fillet weld and groove weld (Morrow 1987).