PERFORMANCE OF IBS LIGHTWEIGHT COLD-FORMED STEEL ROOF

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ABSTRACT

Cold-formed steel has been recently brought into Malaysian construction. It is a steelwork technology that has high potential to be developed in Malaysia, that can offers advantages such as fast erection, lightweight, clean and easier construction. This paper reported a series of research studies carried out in UMP for locally produced cold formed steel sections. The research work included study on the member capacities for lipped C-section and Hat-section, a test for roof truss system member. The objective of this study, which base from the code is practice to analyze several C-cross-section and hat section of steel design from cold formed from different material (Zincalume, Galvanized and Truecore) for its strength to sustain axial load. The interest capacities are compression strength, moment capacity and yield strength. All the studies were based on the requirements of British Standard BS 5950 Part 5 1998. The results of the experimental tests on the proposed cold-formed steel section and roof truss system showed good agreement to the requirements of BS5950 Part 5 1998.

ABSTRAK

Penggunaan keluli terbentuk sejuk merupakan satu bahan besi yang baru-baru ini diperkenalkan ke dalam pembinaan di Malaysia. Ia merupakan teknologi keluli yang mempunyai potensi tinggi untuk dibangunkan di Malaysia, yang boleh menawarkan kelebihan seperti pemasangan yang cepat, bahan yang ringan, bersih dan mudah. Kertas kerja ini melaporkan satu siri kajian penyelidikan yang dijalankan di UMP untuk bahagian sejuk keluaran tempatan keluli terbentuk. Kerja penyelidikan termasuk kajian ke atas kapasiti bahan untuk rekabentuk C dan rekabentuk topi, satu ujian bagi bahagian sistem kekuda bumbung. Tujuan kajian ini, yang mana berdasarkan kod rujukan untuk menganalisis rekabentuk C dan rekabentuk topi dari bahan terbentuk sejuk yang bergantung kepada jenis bahan yang berlainan (Zincalume, Galvanized dan Truecore) bagi mengekalkan kekuatan beban paksi. Kapasiti yang dikaji ialah kapaciti kekuatan mampatan, kapasiti momen dan kekuatan alah. Semua keperluan kajian adalah berdasarkan Piawaian British BS Bahagian 5950 5 1998. Keputusan ujian eksperimen rekabentuk keluli terbentuk sejuk yang dicadangkan dan bahagia sistem kekuda bumbung menunjukkan perhubungan yang baik untuk keperluan BS5950 Bahagian 5 1998.

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A_n	-	Net area of a section
A_t	-	Tensile stress area
A_{eff}	-	Effective area
b	-	Flat width of an element
b_{eff}	-	Effective width of a compression element
b_{eu}	-	Effective width of an unstiffened compression element
E	-	Modulus od elasticity of steel
f_c	-	Applied axial compression load
I_x	-	Second moment of area of a cross-section about the x axes
I_y	-	Second moment of area of a cross-section about the y axes
K	-	Buckling coefficient of an element
L	-	Length of a member between support point
L_e	-	Effective length of a member
M_c	-	Moment capacity of a cross-section
p_c	-	Buckling resistance under axial load
P_{cs}	-	Short strut capacity
p_y	-	Design strength of steel
P_t	-	Tensile capacity of a member or connection
p_o	-	Limiting compressive stress in a flat web
r	-	Radius of gyration
Y_s	-	Nominal yield strength of a steel
Z_c	-	Compression modulus of a section in bending

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Industrialised Building Systems (IBS) is defined as the complete assembly construction. A construction system where components are manufactured at factories on or off site transported and then assembled into a structure with minimum work. IBS is the new way forward in the construction industry. The Malaysian government has recently mandated that any government project should comprise of 70% IBS components (Wan Abdul Aziz, 2008). We take pride that we are one of the main IBS system provider in the country. Industrialized Building System (IBS) has been promoted diligently by CIDB, Malaysia since Year 2003. Besides reduced dependency on foreign labour, the simplified construction solutions offer better control of quality, increased productivity and faster completion, less wastage and cleaner environment. Through industrialization of construction, huge amount of work has been shifted to the factory and leaving the construction sites tidier and safer. (Sumadi, 2001)

In addition the use of light gauge construction material has been recently highlighted by Public Works Department Malaysia especially in replacing wood for roof truss system in open buildings. Therefore, cold-formed steel section, which has been proven to be efficient and widely used in developed countries, is a good alternative to traditional timber truss system. Manufacturers have started to develop new industrial-network system to elaborate the process from manufacturing to construction stage while some of them still import existing technology from abroad.

The need for roof truss system using cold-formed section have shown tremendous increase in demand in Malaysia due to the policy changes that require the use of cold-formed steel sections for roof truss system by Public Works Department for most of the government projects.

In support of the ongoing process of implementation of IBS in the construction industry, the research and development have been identified to focus in the area of open-building, lightweight materials, joints and sealants, services, and IT and robotics (Grubb, 2001). The application of light steel truss design using cold-formed steel is one of the developments of lightweight material. Light steel truss design is generally based on the use of standard C or Z shaped steel sections at Figure 1.2 produced by cold rolling from strip steel. Cold formed sections are generically different from hot rolled steel sections (e.g. Universal Beams and Universal Column), which are used in fabricated steelwork. A research was carried on cold-formed steel Lipped C-section and Hat-section (Tahir, 2005). It aimed to provide a complete design of the proposed Lipped C-section and hat-section just like at Figure 1.3 which is anticipated to be apply.

In addition, cold-formed steel is a steel product that is formed by a steel strip or sheet of uniform thickness, in cold state. The cold-formed steel section, which is regarded as steel strip with uniform profile along its length, is usually used in load bearing application. The use of cold-formed steel section can be found in automobile industry, shipbuilding, rail transport, and construction industry. In building construction, the cold formed steel is utilised in both non-structural and structural members. As non-structural members, the advantages are more on rust resistance and aesthetic purposes.

It is used as non-structural member for wall panelling, doorframes, window frames, and services. As structural members, the usage includes roof sheeting, purlins, truss members, beams, columns, and floor decking in steel concrete composite construction. Figure 1.1 shows a typical model of roof truss system formed with cold-formed steel section. A pointed screw system using a hand drill is normally used for the installation of the connections.

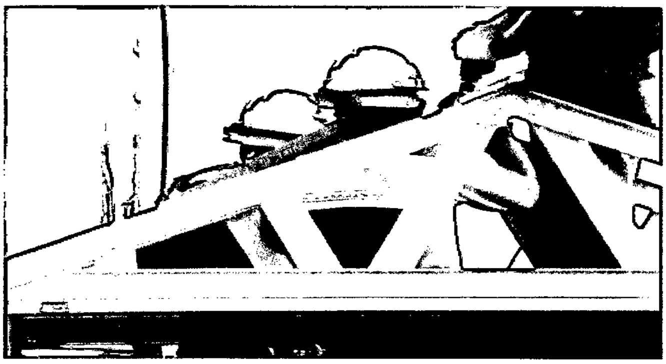

Figure 1.1: Model of Cold-Formed Steel Roof Truss System

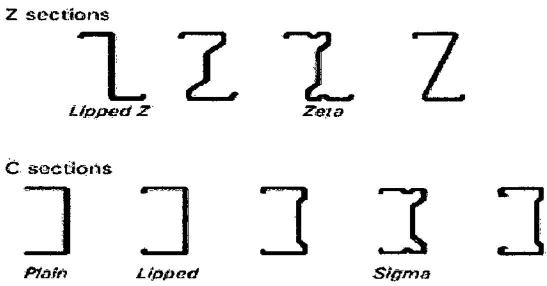

Figure 1.2: Common Shapes for Cold Formed Steel

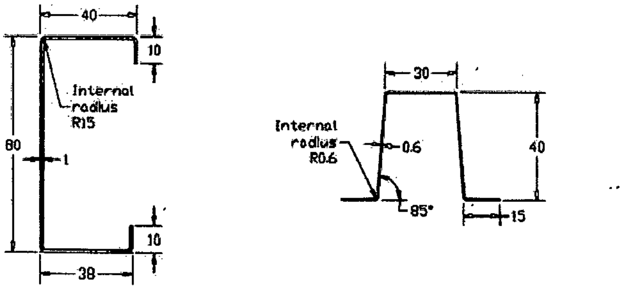

Figure 1.3: Cold formed lipped C-section (Left) & Hat-section (Right)

1.2 Problem Statement

KUALA LUMPUR: Prefabricated parts will be used in all Government projects in a bid to reduce the dependence on foreign workers, Works Minister Datuk Mohd Zin Mohamed said. He said the move would begin with projects under the Public Works Department, which are worth RM6.9bil. The use of prefabricated parts was part of the Industrial Building System (IBS) which would be adopted for all Government projects. (Wan Abdul Aziz, 2008)

"The Government has ordered all government agencies carrying out development and people's housing projects to use at least 70% IBS content in those projects," he told a press conference at his office after the weekly Cabinet meeting yesterday.

(The Star, 25 Oct 08)

IBS Score about 70 percent. Basically, this system uses prefabricated elements in a construction project. These ranges from precast systems, prefabricated roof structures, steel structures to steel formworks, reusable formworks, permanent formworks to element of vertical repetition, horizontal repetition and lots more. Conventional construction with timber formworks and cast-in-situ system just could not catch up with the speed of IBS. There will be a price to pay for it, but it is certainly good news for clients looking for a speedy construction period.

With Precast suppliers coming into the picture, there will certainly be a lot of alternative proposals to replace cast-in-situ systems. This paper will represent steel truss roof system as the material used as IBS structure. Traditionally, timber is usually used for roof truss as a construction material. However, the use of timber is no longer popular recently due to the increase in cost, not environmental friendly as more trees need to be cut, prone to termite attack, and lesser capacity compared with steel. Cold-formed steel section has been introduced as IBS material together with in this paper for the construction of roof truss system as an alternative to timber truss.

The thin-walled nature of cold-formed steel members requires designers and researchers to explore cross-section stability in great detail. The issue begins with five papers covering experimental and numerical examinations of cold-formed steel members, with a particular emphasis on the distortional buckling limit (Benjamin, 2006).

Thus, this paper will examine and analyze:

i. A suitable requirement of the yielding strength for each cold-formed steel section;
ii. A suitable requirement of full test on the cold-formed steel roof truss member.

1.3 Objective of Study

Consider Cold Formed Steel Trusses as structural innovations that provides prefabricated, engineered steel products for your building. Cold Formed Steel is changing the construction industry. This recyclable product is itself made from up to 30% recycled steel (Rick, 2011) and therefore is green and eligible for lead consumer credits and supply the benefits of steel comparable to wood thus this paper will examine the characteristic of cold form steel roof trusses by:

i. To study a laboratory testing of cross-section of roof truss member as Cold-formed Lipped C-section, and hat-section sections by carried out in accordance with the code of practice. These test results need to be verified with the formula as described in the code depending on the usage of the section in the roof truss system.

ii. To investigate the lipped C-section, and hat-section sections are designed for tension, compression, and bending force in roof truss. Both analytical and experimental approaches will be carrying out in the study.

iii. To determine the effect of thickness parameter and the effect of web embossment on the material to the yield strength, short strut capacity and moment capacity of the material.

1.4 Scope of Study

i. Coupon test for yield strength of C-section and hat section material.

ii. C-sections, for, pure compression test of short strut, and pure bending test;

iii. hat sections for pure bending test;

1.5 Significant of Study

To showed good agreement with the theoretical values. The results need to be applied to the design requirements of the roof truss system. The main application of the tested specimens is to apply to the actual design of roof truss system. Therefore, results of the actual analysis and design of roof truss system of building need to be adopted and compared with the accordance experimental results.

Understanding of the application of the proposed section can only be done by testing of the roof truss member which being use in IBS material. However, the member has been successfully implemented in the market as roof truss system where the design is based on the strength of the individual sections. The testing of the truss using different types of cold-formed steel section has been published elsewhere.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Cold-formed steel members as shown in Figure 2.1 are broadly used in building construction, bridge construction, storage racks, highway products, drainage facilities, grain bins, transmission towers, car bodies, railway coaches, and many types of equipment (Yu *et al.*, 1991) . These sections are cold-formed from carbon or low alloy steel sheet, strip, plate, or flat bar in cold-rolling machines or by press brake or bending brake operations. The thicknesses of such members usually range from 0.0149 in. (0.378 mm) to about 1/4 in. (6.35 mm) even though steel plates and bars as thick as 1 in. (25.4 mm) can be cold-formed into structural shapes (Yu *et al.*, 1991; Schafer, 2002)

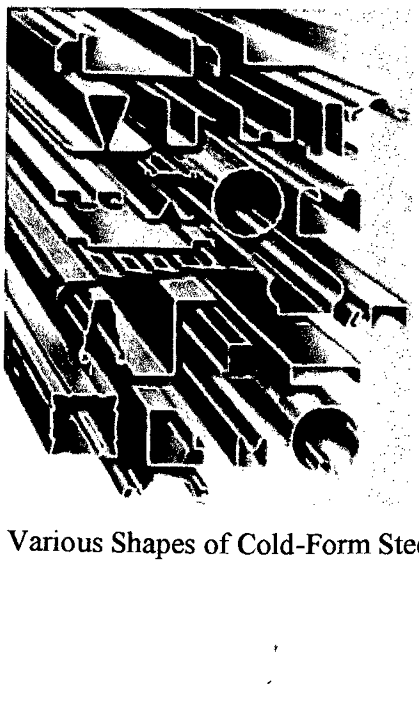

Figure 2.1: Various Shapes of Cold-Form Steel Sections

The use of cold-formed steel members in building construction originated in the 1850s in both the U.S. and Great Britain. Nevertheless, such steel members were not widely used in buildings in the U.S. until the 1940s. At the present time, cold-formed steel members are widely used as building materials worldwide in including in Malaysia.

Compared with other materials such as timber and concrete, cold-formed steel members can offer the following advantages: (1) lightness, (2) high strength and stiffness, (3) ease of prefabrication and mass production, (4) fast and easy erection and installation, (5) economy in transportation and handling, and (6) environmental friendly (Rogan and Lawson, 1998; Trebilcock, 1993). From the structural design point of view, cold-formed steel members can be classified into two major types: (1) individual structural framing members (Figure 2.2) and (2) panels and decks (Figure 2.3).

In view of the fact that the major function of the individual framing members is to carry load, structural strength and stiffness are the main considerations in design. The sections shown in Figure 2.2 can be used as primary framing members in buildings up to four or five stories in height. In tall multi-storey buildings, the main framing is typically of heavy hot-rolled shapes and the secondary elements such as wall studs, joists, decks, or panels may be of cold-formed steel members. In this case, the heavy hot-rolled steel shapes and the cold-formed steel sections supplement each other.

The cold-formed steel sections shown in Figure 2.3 are generally used for roof decks, floor decks, wall panels, and siding material in buildings. Steel decks not only provide structural strength to carry loads, but they also provide a surface on which flooring, roofing, or concrete fill can be applied as shown in Figure 2.4. They can also provide space for electrical conduits. (Nuruddin, 2003)

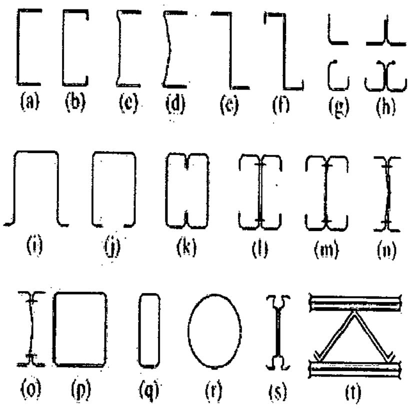

Figure 2.2: Cold-Formed Steel Sections used for Structural Framing. (From Yu, W.W. 1991. Cold Formed Steel Design, John Wiley & Sons, New York.)

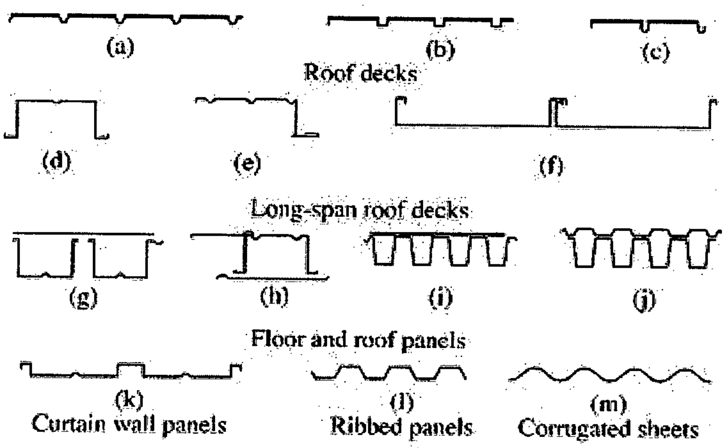

Figure 2.3: Decks, Panels, and Corrugated Sheets. (From Pham, Mills, and Zhuge , 2001"Experimental Capacity Assessment of Cold-Formed Boxed Stud and C Stud Wall Systems used in Australian Residential Construction.")

The cells of cellular panels can also be used as ducts for heating and air conditioning. For composite slabs, steel decks are used not only as formwork during construction, but also as reinforcement of the composite system after the concrete harden. In addition, load-carrying panels and decks not only withstand loads normal to their surface(Grubb and Lawson,1997), but they can also act as shear diaphragms to resist forces in their own planes if they are adequately interconnected to each other and to supporting members.

During recent years, cold-formed steel sections have stayed widely used in residential construction and pre-engineered metal structures for industrial, commercial, and agricultural applications. Metal building systems are also used for community facilities such as recreation buildings, schools, and mosque.

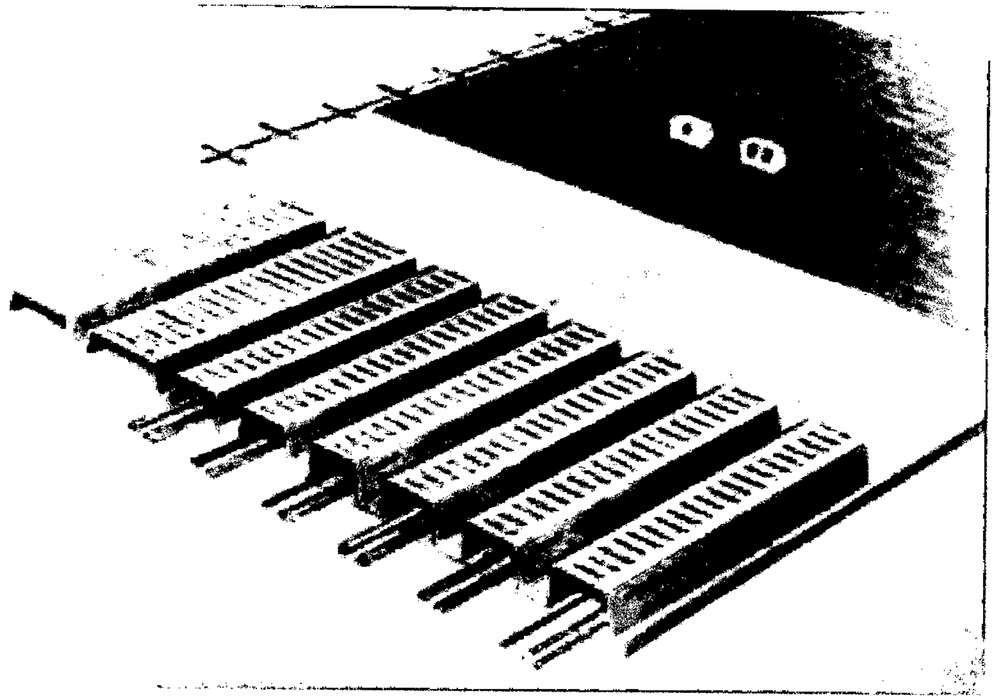

Figure 2.4: Cellular Floor Decks. (From Benjamin W. Schafer, 2006 ASCE Guest Editor, "JOURNAL OF STRUCTURAL ENGINEERING")