THE EFFECT OF PERFORATIONS ON BUILT-UP OPEN SECTION COLD-FORMED STEEL BEAM

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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRACT

This paper presents the study of the effect on built-up open section when receiving load in term of flexural behavior (failure mode) and the ultimate load with the present of web perforations. In steel production, there are two types of structural members which are hot-rolled steel and the other one is cold-formed steel. In detail, cold-formed steel is pressed at significantly cooler temperatures and often even room temperature. Hot-rolled steel is heated above the metal recrystallization temperature (around 1700° F or higher) to make it easier to bend the metal into specific shape. This experiment is involving the beam test on several specimens focuses on built-up open section steel with various position of web-opening on the beam. Each specimen have 1600 mm length and different position of web-perforations. The shape of openings used are circle and the size are keep constant that is 20 mm diameter to ensure the consistency in the result making. The ultimate load strength of the cold-formed steel section and failure modes differs depend on the position of the openings and the number of the opening, where the conclusions are make on the basis of the comparisons between the positions of openings. The value of displacement was measured by using the transducer which placed at the middle point below the beam. The load – displacement graph was plotted after the result is obtained.

ABSTRAK

Kajian ini membentangkan tentang kesan yang berlaku kepada keluli terbentuk sejuk yang telah dicantum apabila menerima beban dan diukur dari segi kelakuan lentur (mod kegagalan) dan beban maksimum yang mampu di ampu oleh keluli tersebut. Dalam pengeluaran keluli, terdapat dua jenis bentuk pemprosesan iaitu dibentuk dalm suhu yang panas dan suhu sejuk. Secara terperinci, keluli yang terbentuk sejuk ditekan pada suhu yang sangat sejuk dan seringkali suhu bilik. Keluli tergelek panas dipanaskan di atas suhu penghabluran semula logam (sekitar 1700 ° F atau lebih tinggi) untuk memudahkan bengkok logam menjadi bentuk tertentu. Eksperimen ini melibatkan ujian pada beberapa spesimen yang memfokuskan pada keluli yang telah dicantumkan dan jenis yang digunakan ialah keluli yang diproses menggunakan suhu sejuk. Setiap spesimen mempunyai panjang 1600 mm dan kedudukan lubang pada specimen adalah berbeza-beza. Bentuk bukaan yang digunakan adalah berbentuk bulat dan saiz lubang adalah berdiameter 20 mm untuk setiap specimen bagi memastikan konsistensi dari segi keputusan. Nilai kekuatan maksimum bahagian keluli terbentuk sejuk dan mod kegagalan adalah berbeza bergantung pada kedudukan lubang dan bilangan lubang tersebut, di mana kesimpulan dibuat berdasarkan perbandingan antara posisi lubang. Nilai anjakan diukur dengan menggunakan transducer yang diletakkan pada titik tengah di bawah specimen ketika eksperimen dijalankan. Keputusan yang telah diambil dari eksperimen kemudian digunakan di plot melalui graf.

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LIST OF ABBREVIATIONS

PCFS	Perforated Cold-Formed Steel
CFS	Cold-Formed Steel
DSM	Direct Strength Method

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Steel is now widely used across various industries and plays a crucial role in construction industry as well as comparable to wood or concrete. In steel production, there are two types of structural members which are hot-rolled steel and the other one is cold-formed steel. In detail, cold-formed steel is pressed at significantly cooler temperatures and often even room temperature. It is a stronger lightweight product than hot-formed steel and has a smoother appearance. The corners and dimensions are more precise, allowing it to be used for more visible, exterior applications. Cold-formed steel is used most commonly in the construction world to fabricate structural shapes and panels. Hot-rolled steel is heated above the metal recrystallization temperature (around 1700° F or higher) to make it easier to bend the metal into specific shape. The section size used for hot-formed steel can be much larger. This process is often used in construction for things like railroad ties, I-beams and other products. Its appearance is more scaly and rounded, and it has less precise corners than cold-formed products.

In building construction, cold-formed steel products can be classified into three categories which are members, panels, and prefabricated assemblies. Typical cold-formed steel members such as studs, track, purlins, girts and angles are mainly used for carrying loads. Purlins are structural elements that serve to link roof sheeting to trusses, thus transferring the loads applied on the sheeting to the trusses (or the main structure). The same elements are called girts when they support the lateral sheeting and transmit the loads to the columns (Schafer, 2008). Panels and decks constitute useful surfaces such as floors, roofs and walls, in addition to resisting in-plane and out-of-plane surface loads. Prefabricated cold-formed steel assemblies include roof trusses, panelised walls or floors, and other prefabricated structural assemblies. There are varieties of cold-formed shapes

available as structural members, which include open sections, closed sections, and built-up sections. C-section, Z-section, double channel I-sections, hat, and angle sections are open sections while box sections and pipes are closed sections.

The built-up members are formed by connecting two or more cold-formed steel members together, such as an I-section member built up by connecting two channel sections back-to-back. These structural shapes can be used in buildings as eave struts, purlins, girts, studs, headers, floor joists, braces, and other building components (Steel, 2010). Various shapes are also available for wall, floor, and roof diaphragms and coverings. Cold- formed steel sections are commonly used for floor joists and other structural members. In cold-formed steel structural members, perforation or holes are sometimes provided in webs or flanges of beams and columns to accommodate plumbing, for duct work, piping, to let electrical facilities pass through and for other purposes (Ave, 2008). The most common shape of holes is circular, although various shapes can be used for web opening in floor.

Figure 1.1 Shape of cold-formed steel

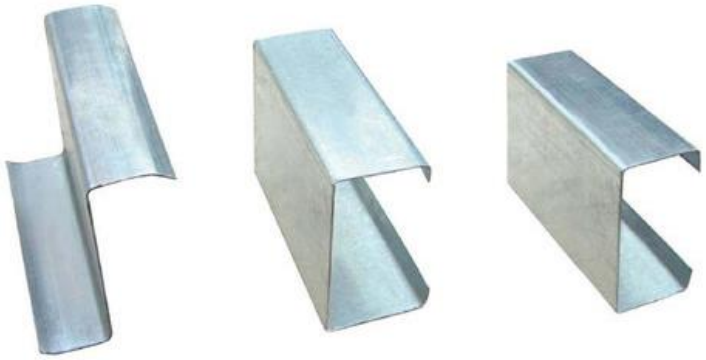

Figure 1.2 Example of cold-formed steel

Compared with other materials such as timber and concrete, cold-formed steel possesses a significant market share because of its advantages or qualities over other construction materials. The cost of cold-formed steel is economical compared to hot-formed steel. This is because of its lightness. But the thinness of its section also is the reason of limiting advantage of cold-formed steel that makes it susceptible to local, distortional and flexural torsional buckling (Youns, Hassaneen, Badr, & Salem, 2016). Its physical properties allow it to be used in a wide range of environments. Even though this type of steel is cheaper, but it has high strength and stiffness. Due to its strength and ductility, many construction project prefer to use this material as it is ideal for construction in regions subject to high winds or earthquakes. Besides, the use of this material can ease the installation process and save time. Plus, it is non-shrinking, non-creeping at ambient temperatures, non-combustibility, termite-proof and rot proof. The combination of the above-mentioned advantages can give a huge impact on the cost saving in a construction project.

1.2 Problem Statement

The uses of cold-formed steel beam already being develop in construction works. Many sections of this type of steel can be used. For example, whether using the individual section or built-up open section without web perforation and by using built-up open section but with web perforation. However, the performance or strength of the beam both without web perforation and with web perforation is differ. Besides, beam that has different length of spacing between the webs perforations will give different result in term of flexural behaviours, failure modes and strength when receiving loads.

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