ABSTRACT

Finite element models with three-dimensional solid elements were generated to investigate the moment-rotation behavior of cold-formed steel connections. The finite element results were compared with the results of the experimental data from the laboratory tests carried out by a previous researcher. The three dimensional materially static non-linear finite element analysis using LUSAS software was perform on cold-formed steel connections which consisted of column-base connection and beam-column sub-frame. For column-base connection thick hot rolled connection element was used as the base plate which is already designed according to the sized wanted in the laboratory test, while for beam-column connection, channel section were connected back to back as simple and effective means to connect beam to column in steel construction. The moment-rotation curves were plotted to determine the moment resistance values of the connection. Then, the finite element curves were compared with the experimental curves to check the accuracy of the analysis results. The finite element curves for both connections resembled closely with the experimental curves. Comparison between the moment resistance values of both test and LUSAS gave good agreement.

ABSTRAK

Model unsur terhingga dengan elemen isipadu dalam bentuk tiga dimensi digunakan untuk mengkaji sifat momen-putaran sambungan keluli terbentuk sejuk. Keputusan kaedah unsur terhingga dibandingkan dengan keputusan daripada ujikaji yang dijalankan oleh penyelidik sebelum ini. Analisis statik unsur terhingga dengan bahan tak lelurus dalam bentuk tiga dimensi statik menggunakan perisian LUSAS telah dilaksanakan terhadap sambungan keluli terbentuk sejuk yang terdiri daripada sambungan asas tiang dan juga terhadap sambungan rasuk tiang sub rangka. Untuk sambugan asas tiang, unsur sambugan keluli tergolek panas telah digunakan sebagai plat asas yang mana telah direka bentuk mengikut saiz yang diperlukan di dalam ujikaji yang dijalankan di makmal. Sementara untuk sambungan rasuk tiang, bahagian saluran telah disambungkan secara membelakangi di antara satu sama lain sebagai satu cara yang mudah dan berkesan untuk penyambungan rasuk ke tiang di dalam pembinaan struktur keluli. Setelah analisis dijalankan, lengkung momen-putaran telah diplot untuk menentukan nilai momen rintangan bagi sambungan keluli terbentuk-sejuk. Kemudian, lengkung unsur terhingga dibandingkan dengan lengkung momen-putaran daripada ujikaji makmal untuk menentukan ketepatan kaedah analisis unsur terhingga. Lengkung yang diperolehi menggunakan kaedah unsur terhingga adalah hampir menyamai lengkung-lengkung ujikaji. Bandingan nilai-nilai momen rintangan yang diperolehi melalui ujikaji dan LUSAS menunjukkan bandingan yang bersesuaian.

CHAPTER I

INTRODUCTION

1.1 Background of Problem

Cold-formed steel are used in construction besides using hot-rolled steel members. Cold-formed steel sections are made of lightweight materials and can be shaped easily to their desired shapes. It is very suitable for building construction owing to their high structural performance and durability. They are widely used as secondary members, such as purlins in roofs, joists of medium span in floors, studs in wall panels, storage racking in warehouse, and hoarding structures in construction sites. Since 1990, there has been a growing trend to used cold-formed steel sections as primary structural members in building construction, such as low to medium rise residential houses and portal frames of modest span.

The most common cold-formed steel sections are lipped C-sections and lipped Z-sections, and the thickness typically ranges from 1.2 to 3.2 mm. Common yield strengths are 280 and 350 N/mm^2. Moreover, there are a whole range of variants of these basic shapes, including sections with single and double lips, and sections with internal stiffeners. Due to the thinness of cold-formed steel sections, local buckling is a predominant consideration in assessing their section capacities. Futhermore, as they are very weak in torsion, torsional flexural buckling in columns and lateral torsional buckling in beams may be critical.

In building construction, cold-formed steel sections are usually bolted to hot-rolled steel plates or sections to form simple and moment connections. However, despite their simplicity, simple connections between cold-formed steel sections have received relatively little attention. So it is important to study and understand the structural behavior of connection between cold-formed members.

The aim of this study is to investigate the moment-rotation behavior of bolted moment connections between cold-formed steel sections. The analyses work were conducted by using the LUSAS Version 13.57 software [1] utilising three-dimensional solid elements which included material non-linearity.

1.2 Problem Statement

It is very important to understand the structural behavior of cold-formed steel connection especially for design and analysis. In design, a connection will be considered as pin or rigid where a pin connection only take the axial force while the rigid connection resists the moment without any rotation. So, in the design of connection, they will be assumed as perfectly pinned or fully rigid but in real situation the connection usually behaves between these two extreme cases which is semi-rigid.

For cold-formed steel sections, the types of connection usually used is simple connection which is only bolted to hot rolled steel plates or sections to form moment connections but it should be noted that most of the design recommendations on connections among cold-formed steel sections concern the load carrying capacities of individual fasteners such as bolts, screws, rivets and spot welds.

It is important to carry out physical tests to establish the use of moment connections between cold-formed steel sections so that efficient moment framing may be designed and built in building construction [2]. But with the introduction and availability

of the computer software nowadays, it will be easier and cheaper to study the behavior of moment connections between cold-formed members than using the lab-test which is time consuming and involve a high cost. So, finite element modeling will be used to model the connection of cold-formed steel section having similar dimensions to the specimens tested in the laboratory.

1.3 Objectives of Study

The objective of this research is to model cold-formed steel connections using the finite element method. The connections modelled consisted of column-base and beam-column sub-frame by using four bolts connection configurations with 2 mm thickness of cold-formed steel. From the results of the analysis, the moment-rotation (M-ϕ) curves of the connection were plotted in order to determine the moment resistance of the connection. Then, the results obtained from the analysis were compared with the results obtained from full scale laboratory tests in order to determine their accuracy.

1.4 Scope of Study

In this research, the connections for column-base and beam-column sub-frame were modelled and analyzed using the finite element analysis software, LUSAS 13.57 [1]. This research was focused on column-base and beam-column sub-frame connections made of cold-formed steel where for the beam-column connection, channel sections were connected back to back as simple and effective means to connect beam to column in steel construction. The dimensions and material properties for the model followed the dimensions of the full scale laboratory test specimens, conducted by Ali [3] whose results were compared with those obtained in the present work.

1.5 Importance of Study

The present study concerns about the analysis and the behavior of column-base and beam-column sub-frame of cold-formed steel connection. Good comparison between the moment-rotation curve, results from the finite element analysis and the results from laboratory test would prove that the finite element method was good and could be used to predict the strength and the moment-rotation curves of the above connections.

CHAPTER I

INTRODUCTION

1.1 Background of Problem

Cold-formed steel are used in construction besides using hot-rolled steel members. Cold-formed steel sections are made of lightweight materials and can be shaped easily to their desired shapes. It is very suitable for building construction owing to their high structural performance and durability. They are widely used as secondary members, such as purlins in roofs, joists of medium span in floors, studs in wall panels, storage racking in warehouse, and hoarding structures in construction sites. Since 1990, there has been a growing trend to used cold-formed steel sections as primary structural members in building construction, such as low to medium rise residential houses and portal frames of modest span.

The most common cold-formed steel sections are lipped C-sections and lipped Z-sections, and the thickness typically ranges from 1.2 to 3.2 mm. Common yield strengths are 280 and 350 N/mm^2. Moreover, there are a whole range of variants of these basic shapes, including sections with single and double lips, and sections with internal stiffeners. Due to the thinness of cold-formed steel sections, local buckling is a predominant consideration in assessing their section capacities. Futhermore, as they are very weak in torsion, torsional flexural buckling in columns and lateral torsional buckling in beams may be critical.

In building construction, cold-formed steel sections are usually bolted to hot-rolled steel plates or sections to form simple and moment connections. However, despite their simplicity, simple connections between cold-formed steel sections have received relatively little attention. So it is important to study and understand the structural behavior of connection between cold-formed members.

The aim of this study is to investigate the moment-rotation behavior of bolted moment connections between cold-formed steel sections. The analyses work were conducted by using the LUSAS Version 13.57 software [1] utilising three-dimensional solid elements which included material non-linearity.

1.2 Problem Statement

It is very important to understand the structural behavior of cold-formed steel connection especially for design and analysis. In design, a connection will be considered as pin or rigid where a pin connection only take the axial force while the rigid connection resists the moment without any rotation. So, in the design of connection, they will be assumed as perfectly pinned or fully rigid but in real situation the connection usually behaves between these two extreme cases which is semi-rigid.

For cold-formed steel sections, the types of connection usually used is simple connection which is only bolted to hot rolled steel plates or sections to form moment connections but it should be noted that most of the design recommendations on connections among cold-formed steel sections concern the load carrying capacities of individual fasteners such as bolts, screws, rivets and spot welds.

It is important to carry out physical tests to establish the use of moment connections between cold-formed steel sections so that efficient moment framing may be designed and built in building construction [2]. But with the introduction and availability

of the computer software nowadays, it will be easier and cheaper to study the behavior of moment connections between cold-formed members than using the lab-test which is time consuming and involve a high cost. So, finite element modeling will be used to model the connection of cold-formed steel section having similar dimensions to the specimens tested in the laboratory.

1.3 Objectives of Study

The objective of this research is to model cold-formed steel connections using the finite element method. The connections modelled consisted of column-base and beam-column sub-frame by using four bolts connection configurations with 2 mm thickness of cold-formed steel. From the results of the analysis, the moment-rotation (M-ϕ) curves of the connection were plotted in order to determine the moment resistance of the connection. Then, the results obtained from the analysis were compared with the results obtained from full scale laboratory tests in order to determine their accuracy.

1.4 Scope of Study

In this research, the connections for column-base and beam-column sub-frame were modelled and analyzed using the finite element analysis software, LUSAS 13.57 [1]. This research was focused on column-base and beam-column sub-frame connections made of cold-formed steel where for the beam-column connection, channel sections were connected back to back as simple and effective means to connect beam to column in steel construction. The dimensions and material properties for the model followed the dimensions of the full scale laboratory test specimens, conducted by Ali [3] whose results were compared with those obtained in the present work.

1.5 Importance of Study

The present study concerns about the analysis and the behavior of column-base and beam-column sub-frame of cold-formed steel connection. Good comparison between the moment-rotation curve, results from the finite element analysis and the results from laboratory test would prove that the finite element method was good and could be used to predict the strength and the moment-rotation curves of the above connections.