PREDICTING THE BEHAVIOUR OF EXTENDED END PLATE CONNECTIONS USING STRAIN GAUGES

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A project report submitted in partial fulfillment of the
requirement for the award of the degree of
Master of Engineering (Civil-Structure)

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DEDICATION

For my beloved

Late Dad (Mohd Mahir Ahmad) - even though you are not here to see me made it to the university but your spirit and determination are always with me

Mom (Hasnah Daud) - thanks for your support, understanding and concern. I will always love you

Brothers and Sisters- thanks for your support and attentions to me

Supervisor, Dr Arizu bin Sulaiman- thank you for giving me the oppurtunity to do the research under your supervision and for the priceless knowledge you gave me

Friends- thanks for all your helps and brilliant ideas

Even thousand words could not express my gratitude

ACKNOWLEDGEMENT

First and foremost, I would like to praise to Allah SWT for giving me the strength and energy to finish up this project report. I would also like to express my gratitude to my supervisor, Dr. Arizu bin Sulaiman for his motivation, words of wisdom, advices and guidance to me throughout the whole two semesters.

My friends that supported me in my research work. I want to thank them for all their help, support, interest and valuable hints. I cannot end without thanking my family, on whose constant encouragement and love I have relied throughout my time. They have always supported and encouraged me to do my best in all matters of life.

ABSTRACT

Most structures especially the conventional steel buildings are usually opting the simple (pinned) design and rigid (continuous) design methods. However, the actual behaviour is known to fall between these two extreme categories. The use of partial strength or semi-rigid connections has been encouraged by codes and studies on the matter known as semi-continuous construction has proven substantial savings in steel weight of the overall construction. In continuation to the experimental works on partial strength connections using trapezoid web profiled (TWP) steel sections that have been conducted in 2006, this study has analysed the strain gauge data of extended end plate connections, manipulated the strain values in predicting the behaviour of the extended endplate connection from isolated tests in terms of the capacity and obtained the related deformation of the connections. The focus is on the behaviour of partial strength beam-to-column connections utilising several TWP sections as beams, conventional hot-rolled H-sections (UC) as columns and extended end plate connections. As a result, moment-rotation curve was obtained for every specimen in order to predict the capacity and behaviour of beam-to-column connections in terms of the strength, stiffness and rotational capacity. The predicted values were then compared to the exact values obtained experimentally using the inclinometers. A good agreement is noticed between the predicted values and the exact values. This shows that the strain gauges can be used as the alternative data collecting devices in predicting the behaviour of extended end plate connections.

ABSTRAK

Kebanyakan struktur, terutamanya bangunan keluli konvensional sering menggunakan kaedah rekabentuk mudah (pin) atau selanjar (tegar). Walau bagaimanapun, sifat sebenar diketahui berada di antara dua kategori ekstrim tersebut. Kegunaan sambungan jenis kekuatan separa atau separa tegar adalah digalakkan oleh kod dan kajian ke atas pembinaan separa selanjar juga telah membuktikan penjimatan dalam berat keluli yang digunakan untuk keseluruhan pembinaan. Sebagai sambungan kepada eksperimen di makmal ke atas rasuk keluli dengan sambungan kekuatan separa menggunakan seksyen keluli web berprofil trapezoid yang telah dijalankan pada tahun 2006, kajian ini telah menganalisis data tolok terikan plat hujung memanjang, memanipulasi nilai-nilai terikan dalam menjangkakan sifat-sifat sambungan plat hujung memanjang dari ujikaji terpencil yang dijalankan dari segi keupayaan dan memperoleh ubah bentuk berkaitan untuk sambungan tersebut. Kajian ini juga lebih fokus untuk melihat sifat sambungan kekuatan separa rasuk ke tiang yang menggunakan beberapa seksyen web berprofil trapezoid sebagai rasuk dan seksyen keluli H tergelek panas (UC) sebagai tiang dan sambungan plat hujung memanjang. Lengkungan momen-putaran diplotkan untuk kesemua spesimen untuk mendapatkan keupayaan dan sifat sambungan rasuk ke tiang dari segi kekuatan, kekukuhan dan keupayaan putaran. Nilai-nilai jangkaan kemudian dibandingkan dengan nilai-nilai yang diperoleh dari eksperimen yang menggunakan *inclinometer*.

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CHAPTER I

INTRODUCTION

1.1 Overview

Most structures especially the conventional steel buildings are opting the simple (pinned) design and rigid (continuous) design methods. However, the actual behaviour is known to fall between these two extreme categories (Shi, *et al.*, 2007). The use of partial strength or semi-rigid connections has been encouraged by codes. Partial strength connection is the term used for connection in the design of semi-continuous construction for multi-storey steel frames by Eurocode 3. From studies by Md. Tahir (1995), it is proven that substantial savings in steel weight of the overall construction can be achieved by using semi-continuous construction although the fabrication of partial strength connection may be marginally more expensive since some degree of rigidity has to be provided. The use of partial strength will also reduce the deflection of the beam as suggested by the Steel Construction Institute. The study and use of end-plates in moment resisting frames for beam-to-beam splices and beam-to-column connections dates back to the early 1960's (Ryan, 1999). Two types of partial strength connections that are commonly used are the flush endplate connection and extended endplate connection where both of the connection depends on the bolt location. Bolted end-plate connections are widely used in constructional steel design because they allow a great variety of structural solutions,

ranging from quasi-pinned connections to rigid connections, by properly modifying the connection structural detail (Faella, *et al.*,2000). Moreover, connection plays an important part in transmitting required action/force between the individual members.

1.2 Statement of Problem

Although the semirigidity concept was introduced many years ago, steel structures are usually designed by assuming that beam-to-column joints are either pinned or rigid (Faella, *et al.*, 2000). These assumptions allow a great simplification in structural analysis and design, but unfortunately the true behavior of the joints being neglected. The economic and structural benefits of semirigid joints are well known. However, they are rarely used by designers because most semirigid connections have highly nonlinear behavior, that makes the analysis and design frames using it are difficult and complicated. In fact, the design problem becomes more difficult as soon as the true rotational behavior of beam-to-column joints is accounted for the design problem requires many attempts to achieve a safe and economical solution (Faella, *et al.*, 2000).

EC3 allows the design of semi-continuous construction provided that the moment resistance of the connection can be quantified and a ductile behavior can be ensured. Therefore, it is important to identify the moment capacity of the connection, moment resistance, the behavior of the connection in terms of strength, stiffness and rotational capacity and the failure mode. In case of this study, is by analyzing the strain gauge data obtained from experimental test.

1.3 Objectives of Study

There are several objectives that are outlined for this study. They are as the followings:

(i) To analyse the strain gauge data of extended end plate connections

(ii) To manipulate the strain values in predicting the behaviour of the extended endplate connections from isolated tests in terms of the capacity

(iii) To obtain the related deformation of the connections

1.4 Scope of Study

This study focuses on predicting the behaviour of partial strength connections which is extended endplate in connecting TWP beams to conventional hot-rolled Universal columns. The data from strain gauge were obtained from experimental as reported by Md.Tahir, *et al.* (2006). The TWP steel section used is a built up section where the flange is designed using S355 steel section and the web is designed using S275 steel section while the column is a Universal Columns. The analyses of the data are compared with the experimental values and finite element analysis.

1.5 Limitation of Study

There are some limitations in this study that should be taken into account which are:

(i) the results from this study are utilizing only the readings from strain gauge considering if data from other devices are not available

(ii) the results from the experimental works which are taken from readings of inclinometer are referred as the exact values due to its direct measurements of rotation values and compared with the results from readings of strain gauge

(iii) the result from this study can be used but the percentage of different must be taken into consideration