

NON-LINEAR ANALYSIS OF BOLTED FLUSH ENDPLATE STEEL BEAM-
TO-COLUMN CONNECTIONS

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DEDICATION

Specially dedicated to my father and mother

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ABSTRACT

In the typical steel building construction, steel connections are playing a crucial part in the construction to connect two different members into a desired length as specified by the architect. In modern building industry, it is a challenge for design engineers to provide simple steel connections to aid the construction sequence as most connections required by modern architecture is often complex. It was a common practice for design engineers to design steel connection to behave within the elastic zone of the stress-strain curve. However, this approach does not utilize the capacity of the steel members as well as component within a steel connection as compared to non-linear analysis. Referring to the design standard available locally, design engineers still lack a simple method, formula, or information provided by the codes to carry out preliminary prediction on the effect of the simple steel connection in the non-linear stage. This paper reports the study of non-linear analysis of bolted flush end plate to steel beam-to-column connection by using finite element analysis. Parametric study was carried out to determine the effect of plate thickness and number of bolt on the structural capacity of the connection. Graphs to aid design engineers to assess the nonlinear behaviour of steel connection without a need for detail calculations are plotted from the analysis results.

ABSTRAK

Sambungan elemen keluli memainkan peranan yang amat penting dalam pembinaan bangunan keluli dengan menghubungkan dua anggota keluli yang berbeza kepada struktur yang ditentukan oleh arkitek. Dalam industri bangunan moden, reka bentuk sambungan elemen keluli merupakan satu cabaran kepada jurutera struktur kerana kebanyakan sambungan yang diperlukan oleh seni bina moden sering kali kompleks. Ini adalah amalan biasa bagi jurutera reka bentuk untuk merancang sambungan keluli untuk berkelakuan dalam zon anjal keluk strain-strain. Walau bagaimanapun, pendekatan ini tidak menggunakan kapasiti ahli keluli serta komponen dalam sambungan keluli berbanding dengan analisis tidak linear. Merujuk kepada standard reka bentuk yang ada di dalam negara, jurutera reka bentuk masih kurang kaedah, formula, atau maklumat yang disediakan oleh kod untuk melaksanakan ramalan awal mengenai kesan sambungan keluli yang mudah dalam peringkat bukan linear. Kajian analisis non-linear plat akhir siram bergolek kepada sambungan balok-ke-lajur dengan menggunakan analisis unsur terhingga. Kajian parametrik dijalankan untuk menentukan kesan ketebalan plat dan bilangan bolt pada kapasiti struktur sambungan. Graf untuk membantu jurutera reka bentuk untuk menilai kelakuan bukan line sambungan besi tanpa memerlukan pengiraan terperinci yang diplotkan dari hasil analisis.

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CHAPTER 1

INTRODUCTION

1.1 Background

Steel connection is the most important component in the construction of steel frame buildings. Connection is required to join two different members to form complete and stable structure, such as between beams and columns. Beam, columns and girders are usually fabricated in fabrication yard and been transported to the construction site by using truck, trailer and etc. The length of the truck or trailer are limited by the relevant authority, in order to ensure the safety of other road users. Once the steel members arrive at the construction site, the contractor will erect and connect the members together according to the details provided by design engineers, In Malaysia, the steel connection shall be designed according to Malaysian Standard-Euro code 3 Part 8.

In order to speed up the duration of the construction, it is vital to provide an easy and simple steel connection detail and most of the design engineer may face difficulties in providing a simpler and better solution for the steel connection installation.

In the conventional steel connection design process, design engineers only assumed the material, steel in this case, to behave in the elastic zone. This assumption is done due to the lack of knowledge of the behaviour of the material in the non-linear zone. This has impact significantly on the cost of the project as the steel member has not been designed up to the material strength. By introducing the

non-linear behaviour of the material, the same steel member is allowed to carry more load compared to elastic analysis. As result, design that considers the non-linear behaviour may results in more economical construction.

Referring to the design standard available locally, design engineers still lack of a simple method, formula, or information provided by the codes to carry out preliminary prediction on the effect of the steel connection in the non-linear stage. Thus, a research is proposed to provide a simple guidance to engineers to carry out preliminary prediction or design of bolted flush-end plate steel beam-to-column connections at non-linear zone.

1.2 Problem Statements

On 30th November 2016, a bridge collapsed at KL Eco City near Mid Valley Megamall has caused death of a construction workers, and suspected to be a failure on the steel connection between the bridge supports and the supporting columns (Fong, 2016). Connection in steel structural construction plays a crucial part as it connect two separate steel members together and transfer all forces, such as, axial force, shear force and bending moment, from one to another. Failure in steel connection may lead to disastrous impact to the construction projects. It will cause damage to newly built structural part and to a serious extend it will cause loss of life to the construction workers.

The incident of bridge collapse as report in (Fong, 2016) has arisen the awareness in the construction industry that the importance of proper design procedure of steel connection must be carried out in order to avoid this incident to happen in the future. Referring to the design standard available locally, design engineers are still not capable and lack of a simple method, formula, or information to carry out the steel connection design.

The most common beam-to-column steel connection in Malaysia steel structure construction is bolted flushed end plate steel type connection. In order to

understand the actual behaviour of this type of connection, a thorough analysis must be performed. In the conventional research study, experimental study was carried out. However, the cost of experimental study is time-consuming and expensive. It is suggested that finite element analysis shall be used to study connection behaviour, as it offers a more accurate results, time-saving and cost-effective solutions, when the number of parametric study is high.

1.3 Aim & Objectives

The aim of this study is to propose an assessment chart for structural design engineers to predict the strength of the bolted flush end plate steel beam-to-column connections at nonlinear stage.

The objectives of research is

- a) To carry parametric study, namely end plate size and bolt sizes.
- b) To generate a design chart/table for use by design engineer without a need to conduct rigorous analysis for their design work.

1.4 Scope of Work

This study will cover two scopes, whereas:-

- a) To model the extended end-plate bolted connection using LUSAS 2014 finite element software
- b) To study the non-linear analysis behaviour of the bolted flush endplate steel beam-to-column connections with various diameter of bolts and various sizes of end plates.

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