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CHAPTER 1

INTRODUCTION

1.1 Introduction

Steel is a man-made metal containing 95 percents or more iron while the remaining constituents are small amounts of elements derived from the raw materials used in the making of the steel, as well as other elements added to improve certain characteristics or properties of the product. Steel structure consists of one or more elements arranged in certain form in order to resist the subjected forces with no excessive deformation.

Steel construction holds substantial advantages over conventional reinforced concrete. These advantages are due to the combination of several factors such as high strength, flexibility, uniformity, durability and economy [1]. The high strength characteristics per unit weight of steel enable this material to sustain large magnitude of applied loads besides having relatively small selfweight. This fact is of great importance for long span bridges, high rise buildings and perhaps for structures that have poor foundation condition.

Unlike concrete, steel is able to be customized to suit the design and construction requirements, regardless the size of the structure to be constructed. Due to its flexibility in fabrication, the section geometry, quality and other properties can be controlled uniformly and accurately. Meanwhile, the durability of steel makes it a popular structural element in the sense that it can withstand chemical and environmental attacks. However, periodically maintenance should be taken into account due to the susceptibility of steel to corrosion when freely exposed to air and water.

The steel is also ductile in which it is able to withstand extensive deformation without sudden failure under high tensile stresses. The large deflection might occur when overloaded, gives visible evidence of impending failure. Even though the high cost of steel is often being argued, the speed of erection and elimination of falsework might provide a large reduction in overall cost of construction. In addition, the steel is also recommended due to the after-demolished value where the scrap is still valuable although not reusable in its existing form.

Steel structures consist of various kinds of components being designed for various intended functions and purposes. For example, steel columns are basically function as compression members while steel beams and trusses are being subjected to both tension and compression. Those elements must be able to provide sufficient strength to sustain subjected forces appropriately in order to avoid failure and fulfill the intended purposes. The same thing goes to the connections between members, which are the most critical parts of steel structures. Most of structures failures are caused by inadequate and poorly designed connections.

Conventional analysis and design of steel frames are usually carried out under the assumption that the beam-to-column connections are either fully rigid or ideally pinned in which moments and vertical shear forces are transmitted from beam to the column and allow little or no rotation for the former, while no moment transfer is designed for the latter.

Another type of joint system is called semi-rigid connection in which its behaviour exhibits a condition between simple and fully rigid connections. This kind of connection is designed in such a way that a certain percentage of negative moments at the ends of beams might be transferred to the column. However, the complexity and lack of available readily data renders this method impractical at the present time. Meanwhile, many researchers have come out with a variety of studies on semi-rigid connections. Laboratory testing and simulation by means of computer programmes had been carried out extensively. Several studies were done purposely to obtain the values of the moment of resistance, M_R for the various considered types of connection.

Expensive laboratory work and testing were widely conducted to determine the values of M_R for many types of connection system besides observing their behaviour at failure. This experimental method is not only costly but they are also difficult to perform. A possible alternative method is to model a connection by using Finite Element (FE) computer software. Due to the developments in the field of finite element analysis and computer technology, this approach is not only made possible, but also more economical with less time consuming and various types of joint systems can be modelled easily.

1.2 Problem Statement

The most widely used method of studying the behaviour of semi-rigid connections is of course by fabricating full-scale connections and test these to destruction. Unfortunately, this is time consuming, expensive to undertake and has the disadvantage of only recording strain readings at pre-defined gauge locations on the test connection. A possible alternative is to carry out non-linear FE analysis. However, the accuracy of the results from finite element analysis should be validated

by means of comparison with the results obtained from full-scale laboratory test conducted in parallel or from a previous research.

1.3 Research Objectives

The foremost objective of this research is to model a semi-rigid bolted extended endplate connection and analyse the model with the non-linear FE method using LUSAS. From the results of analysis, the moment-rotation $(M-\theta)$ curve of the connection can be plotted for the purpose of determining the value of M_R besides observing the mode of failure. Finally, the accuracy of the findings is verified by comparing them to the relevant results of laboratory test. In addition, the model was also modified to investigate the effect of the length of flat portion of corrugated web of the beam on the values of M_R.

1.4 Scope of Research

In this study, the semi-rigid beam-to-column connections were modelled and analysed with the aid of FE analysis software, namely LUSAS. This study focused on bolted extended endplate in which this type of connection was adopted to joint the Trapezoid Web Profiled (TWP) *I*-section beams to the UC section columns. All dimensions except the modified corrugated web used in the models resemble the actual dimensions being used in the laboratory test conducted by Tahir *et al*. [2].