FINITE ELEMENT SIMULATION OF RECTANGULAR CONCRETE-FILLED STEEL-HOLLOW SECTION BEAM-COLUMN STRUCTURE

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I cordially dedicate this project report to the biggest
treasures of my life, my parents, who gave me their love,
and also for their endless support and encouragement.

To my beloved mother and father

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ABSTRACT

Composite steel–concrete construction is widely used in the construction of modern buildings and bridges, even in regions of high seismic risk. Despite the excellent engineering properties of concrete filled tubs (CFT), they are not as widely used as traditional structural steel and reinforced concrete members. Although much research has been performed on the topic, the amount of information regarding CFTs is significantly less than that available for traditional steel or reinforced concrete members. The aim of this study is to predict the buckling behavior of concrete-filled steel hollow structural section beam-columns with advanced finite element methods, then compare the predictions with experimental results found from literature. It is also optimize findings and represent a finite element model for further studies. In this study the modeling and non-linear analysis of beam-column specimens is perform using ABAQUS finite element software. A total of two different specimens from experimental study were investigated with eccentric loading. The specimens have square section with overall depth of 120 mm and 140 mm respectively. Two different models were established, to investigate bending behavior of rectangular sections with overall depth of 120 mm and 140 mm. The steel tube section thickness for all sections was 3.84 mm. The tests were performed on pin-ended Beam-columns. It is found that the buckling shape and the displacements predicted from ABAQUS are in good agreement to those observed experimentally. ABAQUS non-linear Finite element analysis can be also used to predict the ultimate load of concrete filled steel tube members.

ABSTRAK

Komposit keluli-konkrit telah digunakan secara meluas dalam industri pembinaan moden bangunan dan jambatan walaupun di kawasan berisiko tinggi seperti kawasan seismik. Sungguhpun sifatnya yang baik ditunjukkan oleh tiub diisi konkrit (CFT), ianya tidak digunakan secara meluas seperti mana struktur keluli dan anggota konkrit bertulang biasa. Walaupun agak banyak penyelidikan dilakukan ke atas topik ini , maklumat berkaitan CFT adalah tersangat sedikit berbanding keluli dan anggota konkrit bertetulang biasa. Tujuan kajian ini adalah untuk meramalkan kelakuan lengkukan ke atas rasuk-tiang keluli berongga berisi konkrit menggunakan kaedah unsur terhingga, seterusnya membanding ramalan tersebut dengan hasil ujikaji yang didapati daripada literatur. Kajian ini juga akan mengoptimumkan keputusan dan turut mencadangkan permodelan unsur terhingga bagi kajian seterusnya. Dalam kajian ini, permodelan dan analisis tak linear ke atas spesimen rasuk-tiang dilakukan menggunakan kaedah unsur terhingga ABAQUS. Sebanyak dua spesimen berbeza daripada kajian ujikaji literatur dengan pembebanan sipi telah diambil. Spesimen mempunyai keratan segiempat sama dengan ukurdalam keseluruhan adalah masing-masingnya 120 mm dan 140 mm. Dua model yang berbeza telah dibentuk bagi mengkaji tingkah laku lenturan terhadap keratan segiempat dengan ukurdalam keseluruhan 120 mm dan 140 mm. Ketebalan tiub untuk kesemua keratan adalah 3.84 mm. Analisis ke atas sampel ujian telah dilakukan ke atas rasuk-tiang dengan kedua-dua hujung adalah pin. Bentuk lengkokan ujikaji dan anjakan yang diramalkan daripada perisian ABAQUS didapati memberikan persetujuan yang baik dengan keputusan ujikaji. Analisis tak linear unsur terhingga ABAQUS juga didapati boleh digunakan untuk meramalkan beban muktamad bagi anggota tiub keluli berisi konkrit.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 General

Concrete filled tubes (CFT) are composite structural elements comprised of a rectangular or circular steel tube with concrete infill. CFT, structural members efficiently combine the tensile strength and ductility of steel with the compressive strength of concrete. Lighter and more slender CFT columns can replace traditional steel or reinforced columns with equivalent resistance. The tube provides large buckling and bending capacity by placing the steel at the outer perimeter of the section where the moment of inertia and radius of gyration are greatest. There, the steel can perform most effectively in tension with the minimum amount of material. The concrete core provides compressive strength and flexural stiffness to the section, and it delays and often prevents local buckling of the steel tube. In addition, the steel tube enhances the shear resistance and confines the concrete, increasing the compressive strength and strain capacity of the concrete, and in turn the ductility of the member. Multi-story buildings develop large compressive loads due to the accumulation of gravity loads over the height of the building, and the high axial strength of CFT columns makes them particularly attractive for the lower story columns. Confinement of the concrete infill improves its strength and prevents spalling that might occur in a traditionally reinforced concrete component under cyclic lateral loading such as an earthquake.

In addition to reducing section sizes, CFT members provide economic benefits by reducing costs associated with traditional steel or concrete construction. A CFT column providing resistance equivalent to a steel column replaces a significant portion of the steel weight with concrete. In addition, CFT construction can proceed rapidly, as erection of the tubes and framing elements in a building can precede concrete pouring by several stories. CFT columns reduce time and costs associated with reinforced concrete construction by eliminating the need for formwork and additional reinforcement.

1.2 Statement of problem

Despite the excellent engineering properties of CFTs, they are not as widely used as traditional structural steel and reinforced concrete members. Although much research has been performed on this topic, the amount of information regarding CFTs is significantly less than that available for traditional steel or reinforced concrete members. As a result, the design procedures have been in part based on these traditional systems.

Current design methods for CFT component are limited and the experimental research is not sufficient to establish reliable engineering methods. Specially, although the codes have provisions for using CFT, but they are restrictive and therefore of limited practical value.

1.3 Objectives of study

As mentioned before, different researches have been done to simulate the concrete filled steel hollow structural sections. The objective of this study is to predict the behavior of concrete-filled steel hollow structural section beam columns with a finite element model and compare the predictions with experimental results and optimize findings and represent a finite element model for further studies.

The specific objectives of this study are as follows:

- Develop a finite element model using ABAQUS that can predict the behavior of concrete-filled steel hollow structural section beam columns;
- Investigate the existing specifications for the design of CFT;
- Develop the finite element models of reinforced concrete and steel tube beam-column and compare behavior of them with concrete filled steel hollow section.

1.4 Scope of study

The main purpose of current study is summarizes the literature review on the behavior of concrete-filled tube members, develop an analytical model for CFTs, evaluation of code specifications, and recommendations for design and evaluates the design specifications used to design them.

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