وزارةالتعليم العالي
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جامعة ديالى
كلية الهندسة

السلوك الإنشائي للعتبات الخرسانية المسلحة المركّبة بأستخدام مقاطع حديدية مجوفة ومختلفة الشكل

رسالة
مقدمة إلى قسم الهندسة المدنية في جامعة ديالى كجزء من متطلبات نيل درجة الماجستير في علوم الهندسة المدنية/إنشاءات

من قبل

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كانون الاول 2018 **ربيع الثاني 1440**

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STRUCTURAL BEHAVIOR OF REINFORCED CONCRETE COMPOSITE BEAMS WITH DIFFERENT STEEL TUBE SECTIONS

A THESIS SUBMITTED TO COUNCIL OF COLLEGE OF ENGINEERING, UNIVERSITY OF DIYALA IN PARTIAL FULFILLMENT OF THE REQUIRMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN CIVIL ENGINEERING

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December, 2018 Rabea' Al-thani. 1440

Chapter One

Introduction

1.1 Background

Civil engineering structures have gained much popularity because of their attractive benefits and service.

Countries use them to develop their cities and communities when researchers create scientific thoughts and begin to convert them into constructions like high rise buildings, infrastructures and others steel constructions. Additionally, structural members compose such total buildings as foundations, columns, beams and slabs.

1.2 Composite Beams

The term composite means that more than one material interfere to combine a distinctive unit mass which offers several advantages over a non-composite portion. In this case, using the steel beam and the slab together acts as " Composite Beam " and their action is similar to that of the monolithic T-beam. Concrete is stronger under compression than in tension, and steel is susceptible to buckling in compression (IS 11384-1985)[26].

This member is able to reduce the building overall height and the steel tonnage required, and this consequently resulting reducing cost. (Morris, L.J. and Plum, D. R.,1988)[39].

Figure (1-1) shows composite section in bridge construction.

Figure (1-1) Using Composite Section in Bridge Construction (Guardian Bridge Rapid Construction Company) [21]

1.3 Advantages of Composite Beams

There are several considerable advantages achieved by using the composite action. They can be summarized as follows:

1. efficient use of material.
2. cost reduction.
3. greater stiffness.
4. extra usable space.
5. saving in labor and other construction material.
6. sustainable effort.

Indeed, this type of beams may be appreciated for such building types as commercial, industrial buildings, stores, etc.

Figure (1-2) explains a typical cross section of composite beams.

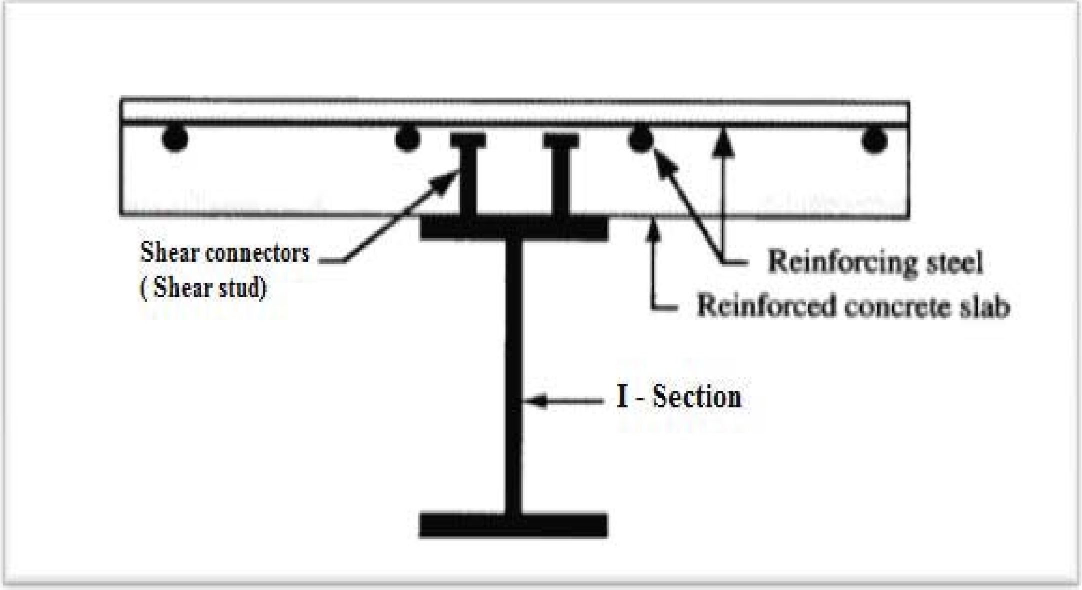

Figure (1-2) Cross Section of Composite Beam (IS 11384, 1985) [26]

Generally the composite beams as structural member have been used extensively in steel-framed construction. Figure (1-3) explains the large space which is one of the composite beams construction advantages.

Figure(1-3) Building Consists of Composite Beams Provide Large Space (New Millennium Building Company) [33]

1.4 Hollow Steel Sections

Hollow steel sections are the most effective and variable forms used in mechanical and constructional applications (Manahel, Sh. Kh. 2017) [29].

The benefits of using hollow steel sections are following :

1- Providing new types of sections that acquire structural requirements to give adequate strength and stiffness.
2- Replacing the I-section steel in composite beams by hollow steel section. This gives a new advantage for composite beams have been able to pass the working service such as cables.
3- Using the hollow steel section in constructional applications provides buildings with an appreciated ratio of strength value to weight value.
4- Increasing the strength to weight ratio as mentioned above leads to reducing the use of materials and allowing for greater span buildings. This enhances the structural efficiency and reduces cost (Amit Pashan, A. 2006) [38].
5- These sections make the steel beams resist desirable failure either by lateral buckling or lateral torsional buckling, and this gives a member having a good strength capacity.
6- Hollow steel sections provide faster construction for maximum utilisation.
7- Hollow steel sections are easy to repair, modify and maintain structures.
8- This type of sections reduces the depth of beams. It generally reduces the height of storeys and consequently diminishes the cost of cladding in a building, and lowers the cost of embankment (IS 11384-1985) [26].
9- In construction, hollow sections create lightweight and visually attractive structures that benefit communities and environments (Tata steel company) [46].

1.5 Problems of Study

Some of unfavourable aspects in the structural behaviour of I-sections lead us to suggest these new sections and investigate their structural and service behaviour.

New hollow steel sections are proposed instead of the traditional I-sections which study the possibility of these sections to provide some extra services, in addition to the structural basic function.

1.6 Research Objectives

1. Structural Objectives: The investigation of composite beams with different steel tubes shapes sections (Square, Rectangular and Hexagonal) will be established by carrying out the results of the ultimate load capacity, failure mode, load-deflection behaviour, deflection profiles, end slip, crack pattern, concrete compressive strain, strain profiles, steel strain and plastic moment capacity.
2. Servant Benefits: The provision of varies shapes for hollow steel section in buildings allows using them as service instruments. Hollow steel sections can be used as electrical pipes, sewerage, and transports soft materials like oil products, water in addition to saving the requirements of design and construction.

1.7 Methodology

The experimental program of this study consists of preparing and testing twelve specimens of composite beams with three hollow steel section shapes before and after the failure stage by using different types of shear connectors.

The experimental results are analysed and discussed. Besides the comparative discussion include comparing the results of the specimens that have been tested in the experimental work with the results of different international standard codes concerning same action.

1.8 Parameters

The current study depends on three parameters. These are the **shape of steel tubes** (**Square, Rectangular** and **Hexagonal**) and the **types of shear connectors** (**Stud, Angle** and **Perfobond**) as well as the **thickness of steel tubes** (**2** mm) and (**3** mm), which this work uses them for estimating the structural behaviour of composite beams.

1.9 Layout of the Thesis

The present study contains six chapters as delineated below:

Chapter 1: highlights a general introduction of the civil engineering structures, composite beams and their advantages, problem of study, research objectives, methodology and layout of the thesis.

Chapter 2: presents an overview of some previous studies and researches which shed light on the uses of steel tube sections and the behaviour of composite beams.

Chapter 3: comprise the methodology of experimental groups, including specimen tests.

It also presents the plan of study that is used for the completion of the tests and sizes of the specimens as well as the devices.

Chapter 4: provides the results that have been extracted from the experimental program and discusses these results.

Chapter 5: shows theoretical comparisons between the experimental ultimate loads and specified loads that are calculated according to different international codes. As well as presents suggested formula to predict the moment capacity of composite beams with specified three steel tube sections.

Chapter 6: deals with the conclusions that have been reached through the study, as well as it offers a set of suggested recommendations for future studies.

Abstract

The current study aims to investigate the structural behaviour of reinforced concrete composite beams with different steel tube sections. The experimental work of this study includes a series of bending tests in order to examine and determine the effect of the steel tube section, the type of connector and the thickness of steel section on the structural behavior of the composite beams. The loading type is simply supported by two points load. Twelve composite beam specimens are performed and tested up to the failure stage with the shape of steel section type (hexagonal, square and rectangular), type of shear connector (headed stud, angle and perfobond) and thickness of steel tube (2 mm) and (3 mm). Also nine push out test specimens are performed and tested up to failure stage to estimate the relationship between the load and slip.

The experimental results show that composite beams with rectangular steel sections afford more ultimate strength than the hexagonal section by about (40-43)%. The composite beams with the square steel section give greater ultimate flexural resistance than the hexagonal section by about (35-38)%. Despite of these results in ultimate strength between the three steel tube sections, the composite beams with the hexagonal steel section precede good strength when compared with the least steel section area, i.e. it is less than rectangular and square steel area by about (41, 11)% respectively. Results also show that the best type for shear connection is perfobond, which improves the ultimate strength by about (9.74, 7, 6.25%) for square, hexagonal and rectangular steel section respectively more than the stud, while angle connector improves ultimate strength by about (2.5, 0.88, 0.65%) for rectangular, hexagonal and square steel sections respectively as

compared with the ultimate strength of composite beams having stud connectors.

The results revealed that increasing the thickness of the section from (2 mm) to (3mm) improves the structural strength capacity of hexagonal and square steel section shapes by (32%) as compared specimen of (2 mm) where the increase in the strength capacity of rectangular steel section, i.e. (34%), simultaneously leads to increase the specimen ductility significantly by (193, 85, 70 %) for rectangular, square and hexagonal shapes respectively.

In addition to the experimental work, a comparative study has also been conducted for these twelve specimens by using the international standard codes (British standard, European code and Indian standard) to evaluate the convergence of the experimental results. Comparisons of this analysis show a good agreement with the experimental results. It has also been suggested a new formula for calculating the plastic moment of these three types of steel tube section shapes.