DESIGN BEHAVIOUR OF COLD-FORMED STEEL ENCASED COMPOSITE BEAM WITH PROTRUDED LINK

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Mother : Tebian Binti Bahak

Sister : Dalilawati Binti Buhari

Sister : Zariana Binti Buhari

Brother : Muhammad Hafizul Bin Buhari

~ All of Me Loves All of You ~

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" In the Name of Allah, The Most Beneficent, The Most Merciful "

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ABSTRACT

Composite action of a structural member can be obtained with the combination of concrete and steel. This composite action is achieved through the use of a shear connector. The shear connector resists the horizontal shear by producing vertical interlocking between the concrete slab and steel beam, as a single composite unit. Typical composite beam is consist of I-beam in combination with concrete slab by the aid of a shear connector called stud. However, this study intends to investigate the design behaviour of a link protruded into the concrete slab to act as the shear connector. The moment and shear capacities of the composite cold-formed encased steel beam with protruded link are obtained and compared with the conventional reinforced concrete beam and composite steel beam. A calculation with several different parameters were compared to determine the influence of the parameter that affected the resistance of the moment and shear capacities of the beam. Design calculation for the reinforced concrete beam is carried out using EN1992 (EC2) while the design calculation for the composite steel beam and composite cold-formed encased steel beam with protruded link are carried out using EN1993 (EC3) and EN1994 (EC4) respectively. It has been found that composite cold-formed encased steel beam with protruded link can increase the value of moment and shear capacities compared to the reinforced concrete beam and composite steel beam. In conclusion, this study shows that the effect of the protruded link can enhance the moment and shear capacities of the composite cold-formed encased steel beam.

ABSTRAK

Tindakan rencam anggota struktur boleh diperoleh dengan gabungan konkrit dan keluli. Tindakan komposit ini dicapai melalui penggunaan penyambung ricih. Penyambung ricih menanggung ricih mendatar dan menghasilkan saling tindak secara menegak di antara papak konkrit dan rasuk keluli, sebagai unit rencam tunggal. Rasuk rencam yang tipikal terdiri daripada rasuk-I dalam kombinasi papak konkrit dengan bantuan penyambung ricih yang disebut stud. Walau bagaimanapun, kajian ini bertujuan untuk mengkaji tingkah laku reka bentuk perangkai yang menonjol (*protruded link*) ke dalam papak konkrit yang bertindak sebagai penyambung ricih. Daya rintangan bagi momen dan ricih bagi rasuk rencam dilitupi keluli terbentuk sejuk dengan perangkai yang menonjol yang diperolehi dan dibandingkan dengan rasuk konkrit bertetulang konvensional dan rasuk keluli rencam. Pengiraan dengan beberapa parameter yang berbeza telah dibandingkan untuk menentukan pengaruh parameter yang mempengaruhi rintangan kapasiti momen dan ricih dari rasuk tersebut. Pengiraan reka bentuk untuk rasuk konkrit bertetulang dijalankan menggunakan EN1992 (EC2) manakala pengiraan reka bentuk bagi rasuk keluli komposit dan rasuk rencam dilitupi keluli terbentuk sejuk dengan perangkai yang menonjol masing-masing dijalankan menggunakan EN1993 (EC3) dan EN1994 (EC4). Adalah didapati bahawa rasuk rencam dilitupi keluli terbentuk sejuk dengan perangkai yang menonjol boleh meningkatkan nilai kapasiti momen dan ricih berbanding rasuk konkrit bertetulang dan rasuk keluli rencam. Kesimpulannya, kajian ini menunjukkan bahawa kesan perangkai yang menonjol dapat meningkatkan daya rintangan momen dan ricih dari rasuk rencam dilitupi keluli terbentuk sejuk dengan perangkai yang menonjol.

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LIST OF SYMBOLS AND ABBREVIATIONS

Eurocode 2	-	European standard for concrete structures
Eurocode 3	-	European standard for steel structures
Eurocode 4	-	European standard for composite steel and concrete structures
ULS	-	Ultimate limit state
SLS	-	Serviceability limit state
f_{ck}	-	Characteristic Compressive Strength of Steel Fibre Reinforced Concrete Strength
d	-	Effective Depth
b_f	-	Width of the Flanges
b_{eff}	-	Effective width of concrete flange
b	-	Breadth or width
h_f	-	Height of Flanges
h	-	Overall depth of section
c	-	Nominal cover
L	-	Length
γ_m	-	Partial Factor Of Safety For Materials
γ_f	-	Partial Factor Of Safety For Action
G_k	-	Permanent actions
$Q_{k,1}$	-	Leading variable action
$Q_{k,2}$	-	Accompanying variable actions
Q_k	-	Variable action
ε	-	Strain
α	-	Stress
$I_{y\text{-}y}$	-	Second moment of area for axis y-y
$W_{el,y\text{-}y}$	-	Elastic Modulus for axis y-y
$W_{pl,y\text{-}y}$	-	Plastic Modulus for axis y-y
A	-	Area of section
t_w	-	Web thickness

t_f	-	Flange thickness
r	-	Root radius
h_{cs}	-	Depth of cold-formed section
r_1	-	Outside radius
r_2	-	Inside radius
Ø	-	Diameter
h_{sc}	-	Overal nominal height of stud
η	-	degree of shear connection
h_p	-	Overall depth of the profiled steel sheeting
f_u	-	ultimate tensile strength
n_r	-	number of studs per rib
M_{Rd}	-	Moment resistance of the section
V_{Rd}	-	Shear resistance of the section

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CHAPTER 1

INTRODUCTION

1.1 Background Of The Study

In structural steel usage, there are two types of commonly used steel: hot-rolled steel and cold-formed steel. Hot-rolled steel component are formed at elevated temperatures and cold-formed steel component are formed at room temperatures.

Many studies on the usage of cold-formed steel have been done to replace the conventional mold components in the construction. This is because the structure is very lightweight, inexpensive and can accelerate the construction period. In addition, the cold-formed steel section also has some other advantages such as enhancement of the tensile properties after cold-forming, lower weight (higher strength to weight ratio) and simpler installation.

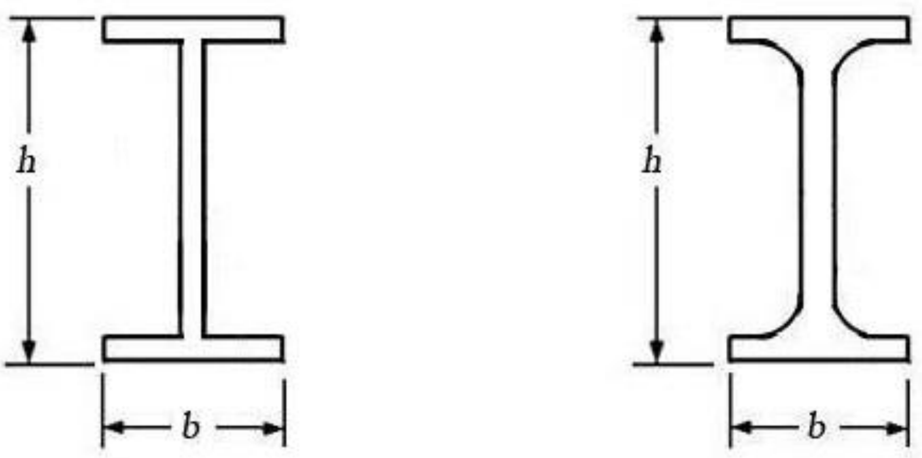

Figure 1.1: Hot-rolled steel section (Sources: www.frbiz.com)

Figure 1.2: Cold-Formed steel section (Sources: Wei-Wen Yu and Roger A LaBoube, 2010)

1.2 Problem Statement

Composite action can be obtained with the combination of concrete and steel. Shear connectors can resist the horizontal shear and produce vertical interlocking between the concrete slab and steel beam and react as a composite action as a single unit. Usually composite beam is need of I-beam combine with concrete with the aid of the stud.

Cold-formed steel has been use in the construction as a secondary structures because their section usually slender and not doubly symmetric. This has led others study to focus on composite of structures.

This study will emphasize the reliability of the cold-formed as a main structure with some modification to their section properties. Other structure such as reinforced concrete beam and composite steel beam will also evaluate as a benchmark to the cold-formed structure. The basic of the design is to investigate the design behaviour of the link protruded into the concrete slab.

1.3 Objective Of The Study

Based on the identified problems discussed, the overall objective of this research is to determine the behavior of protruded link of composite cold-formed steel beam and to predict whether the research can be uses for the building structures.

The main objectives of this study are:

1) To determine the resistance of the propose beam using a typical flange T-section of a reinforced concrete beam.

2) To determine the resistance of the propose beam using a typical flange T-section of a composite steel beam.

3) To determine of the moment and shear resistance of the proposed beam.

4) To determine of the influence other parameters on the moment and shear resistance.

5) To determine the effect of link made protruded into the slab to form the composite action.

1.4 Scope Of The Study

This study are focusing on analytical evaluation of the composite reaction using cold-formed steel structure and compared with hot-rolled steel structure and reinforced concrete structure as a reference model. The dimension and sizes of the material obtained from the catalogue that available in the market.

The overall calculation involved can be listed as follows:

1. Using simply supported reinforced concrete beam and obtained moment capacity and shear force capacity.
2. Using simply supported composite beam with similar dimension of the structure and obtained moment capacity and shear force capacity.
3. Using simply supported composite cold-formed of protruded link beam with similar dimension of the structure and obtained moment capacity and shear force capacity.

The design calculation will be adapted from the references as below:

1. Eurocodes 0: Basis of structural design, BS EN1990:2002 +A1:2005
2. Eurocodes 1: Actions on structures, BS EN1991-1-1:2002: General actions – Densities, self-weight, imposed loads for buildings
3. Eurocode 2: Design of concrete structures, BS EN1992-1-1: General rules and rules for buildings
4. Eurocode 3: Design of steel structures, BS EN1993-1-1: General rules and rules for buildings
5. Eurocode 3: Design of steel structures, BS EN1993-1-3: General rules – supplementary rules for cold-formed members and sheeting
6. Eurocode 4: Design of composite steel and concrete structures, BS EN1994-1-1: General rules and rules for buildings

1.5 Significant Of The Study

Composite beams are extensively used in construction industry due to their efficiency in strength, stiffness and saving materials (Nie, et al., 2006; Tahir, et al., 2009). Shear connector can resist the horizontal shear but its impossible to use any shear connector combine with cold-formed steel structure. Thus, alternative way need to be developed. In general, this study attempts to propose a new type of beam using cold-formed steel structure and protruded link as part of the composite behaviour.

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