

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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## 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.

## TABLE OF CONTENTS

<b>CHAPTER</b>	<b>TITLE</b>	<b>PAGE</b>
	<b>DECLARATION</b>	ii
	<b>DEDICATION</b>	iii
	<b>ACKNOWLEDGEMENTS</b>	iv
	<b>ABSTRACT</b>	v
	<b>ABSTRAK</b>	vi
	<b>TABLE OF CONTENTS</b>	vii
	<b>LIST OF TABLES</b>	xi
	<b>LIST OF FIGURES</b>	xiii
	<b>LIST OF SYMBOLS</b>	xvi
	<b>LIST OF APPENDICES</b>	xviii
<b>1</b>	<b>INTRODUCTION</b>	<b>1</b>
	1.1 Background Of The Study	1
	1.2 Problem Statement	2
	1.3 Objectives Of The Study	3
	1.4 Scope Of The Study	4
	1.5 Significant Of The Study	5
<b>2</b>	<b>LITERATURE REVIEW</b>	<b>6</b>
	2.1 Introduction	6
	2.2 Structural Behaviour And Analysis	6
	2.2.1 Limit State Design	6
	2.2.1.1 Ultimate Limit State	7
	2.2.1.2 Serviceability Limit State	7
	2.2.2 Characteristic Material Strengths	8

2.2.3	Partial Factors of Safety	9
2.2.3.1	Partial Factor Of Safety For Materials, $\gamma_m$	9
2.2.3.2	Partial Factor Of Safety For Action, $\gamma_f$	10
2.2.4	Actions	11
2.2.4.1	Permanent Actions	11
2.2.4.2	Variable Actions	11
2.2.4.3	Load Combinations And Patterns	12
2.2.5	Stress-Strain Relationships	14
2.2.5.1	Concrete	14
2.2.5.2	Steel	15
2.3	Reinforced Concrete	16
2.3.1	Analysis Of Beam	16
2.3.1.1	Distribution Of Stresses And Strains	16
2.3.2	Bending And Equivalent Rectangular Stress Block	19
2.3.2.1	Rectangular Section	19
2.3.2.2	Flanged Section	21
2.3.3	Shear	23
2.4	Steel	25
2.4.1	Shear Connection	28
2.4.1.1	No Shear Connection	30
2.4.1.2	Full Interaction	31
2.5	Cold-Formed	32
2.5.1	Application Of Cold-Formed Steel	34
2.5.2	Advantages Of Cold-Formed Steel	34
2.6	Composite Structure	36
2.6.1	Effective Cross-Section	36
2.6.2	Resistance To Sagging Moment	37
2.6.2.1	Cross-Section In Class 1 Or 2	37

<b>3</b>	<b>METHODOLOGY</b>	<b>41</b>
3.1	Introduction	41
	3.1.1 Flow Chart Of Methodology	42
3.2	Choices Of Cold-Formed	43
3.3	Model Section	43
3.4	Reinforced Concrete Beam	45
	3.4.1 Material Properties	45
	3.4.1.1 Concrete	45
	3.4.1.2 Reinforcement	45
	3.4.2 Section Dimension	46
3.5	Composite Steel Beam	47
	3.5.1 Material Properties	47
	3.5.1.1 Concrete	47
	3.5.1.2 I-Beam Section Properties	47
	3.5.2 Section Dimension	48
3.6	Composite Cold-Formed Of Protruded Link Beam	49
	3.6.1 Material Properties	49
	3.6.1.1 Concrete	49
	3.6.1.2 Cold-Formed Properties	49
	3.6.2 Model Section Dimension	49
3.7	Parameter Of Design	51
3.8	Assumptions And Limitations	52
<b>4</b>	<b>RESULTS AND DISCUSSIONS</b>	<b>53</b>
4.1	Introduction	53
4.2	Design Calculation	54
	4.2.1 Reinforced Concrete Beam	54
	4.2.2 Composite Steel Beam	56
	4.2.3 Composite Cold-Formed Of Protruded Link Beam	62
4.3	Summary Of Design Calculations	67



4.4	Reinforced Concrete Beam vs Composite Steel Beam	69
4.4.1	Moment Capacity	70
4.4.2	Shear Capacity	70
4.5	Composite Steel Beam vs Composite Cold-Formed Of Protruded Link Beam	71
4.5.1	Moment Capacity	73
4.5.2	Shear Capacity	73
4.6	Conclusion Summary	73
<b>5</b>	<b>CONCLUSIONS AND RECOMMENDATIONS</b>	<b>76</b>
5.1	Conclusions	74
5.2	Recommendations	75
	<b>REFERENCES</b>	<b>76</b>
	<b>APPENDICES</b>	
	Appendix A	78
	Appendix B	83
	Appendix C	94

## LIST OF TABLES

TABLE NO.	TITLE	PAGE
2.1	Partial factors of safety applied to materials ( $\gamma_m$ ) (Bill Mosley, John Bungey and Ray Hulse, 2012)	9
2.2	Partial safety factors at the ultimate limit state (Bill Mosley, John Bungey and Ray Hulse, 2012)	10
2.3	Partial safety factors at the serviceability limit state (Bill Mosley, John Bungey and Ray Hulse, 2012)	11
2.4	List of parameter	17
3.1	Dimension for reinforced concrete beam	46
3.2	Section properties for composite steel beam	47
3.3	Dimension for composite steel beam	48
3.4	Section properties for cold-formed structure	49
3.5	Dimension for cold-formed protruded link beam	50
3.6	Parameter for reinforced concrete beam	51
3.7	Parameter for composite steel beam	51
3.8	Parameter for composite cold-formed of protruded link beam	51
4.1	Profiled steel sheeting and connectors dimensions and properties	56
4.2	Result moment capacity and shear capacity for reinforced concrete beam	67
4.3	Result moment capacity and shear capacity for composite steel beam	68

4.4	Result moment capacity and shear capacity for composite cold-formed of protruded link beam	68
4.5	Percentages different of moment capacity and shear capacity between reinforced concrete and composite steel beam	69
4.6	Percentages different of moment capacity and shear capacity between composite steel beam and composite cold-formed of protruded link beam	71

## LIST OF FIGURES

FIGURE NO.	TITLE	PAGE
1.1	Hot-rolled steel section (www.frbiz.com)	1
1.2	Cold-Formed steel section (Wei-Wen Yu and Roger A LaBoube, 2010)	2
2.1	Normal frequency distribution strengths (Bill Mosley, John Bungey and Ray Hulse, 2012)	8
2.2	Load arrangements (Mohamad Salleh Yassin, 2012)	13
2.3	Stress-Strain Curve (Bill Mosley, John Bungey and Ray Hulse, 2012)	14
2.4	Stress-Strain curve (Bill Mosley, John Bungey and Ray Hulse, 2012)	15
2.5	Longitudinal section, cross-section, strain and stress diagram (Mohamad Salleh Yassin, 2012)	17
2.6	Rectangular section - Singly reinforced section (Mohamad Salleh Yassin, 2012)	19
2.7	Rectangular section - Doubly reinforced section (Mohamad Salleh Yassin, 2012)	20
2.8	Flange section – neutral axis in flange with singly reinforced section (Mohamad Salleh Yassin, 2012)	22
2.9	Flange section – neutral axis in web with singly reinforced section (Mohamad Salleh Yassin, 2012)	22
2.10	Flange section – neutral axis in web with doubly reinforced section (Mohamad Salleh Yassin, 2012)	23
2.11	Principal stresses in a beam (Bill Mosley, John Bungey and Ray Hulse, 2012)	23

2.12	Truss model for the variable strut inclination method (Bill Mosley, John Bungey and Ray Hulse, 2012)	24
2.13	Transmission of forces by structural members (NS Trahair, MA Bradford, DA Nethercot, L Gardner, 2007)	24
2.14	Idealised stress-strain relationship for structural steel (NS Trahair, MA Bradford, DA Nethercot, L Gardner, 2007)	26
2.15	Types of steel beam (Sources: RP Johnson, 2004)	27
2.16	Early form of shear connector (RP Johnson, 2004)	29
2.17	Headed shear stud (RP Johnson, 2004)	29
2.18	Effect of shear connection on bending and shear stresses (RP Johnson, 2004)	30
2.19	Deflected shape (RP Johnson, 2004)	31
2.20	Various types of cold-formed section (Wei-Wen Yu and Roger A LaBoube, 2010)	33
2.21	Resistance to sagging moment of composite section in Class 1 or 2 (RP Johnson, 2004)	38
3.1	Flow chart of methodology	42
3.2	C-Channel section (Continental Steel Pte Ltd)	43
3.3	Cutted C-channel section	44
3.4	Section of protruded link into slab	44
3.5	Section dimension for reinforced concrete beam	46
3.6	Section dimension for composite steel beam	48
3.7	Section dimension for composite cold-formed protruded link beam	50
4.1	Stress block for reinforced concrete	54
4.2	Cross section of profiled steel sheeting (Laurent Narboux, 2006)	57
4.3	Stress block for composite steel beam	60
4.4	Stress block for composite cold-formed of protruded link beam	66
4.5	Moment capacity vs $\phi_{\text{bar}}$	69
4.6	Shear capacity vs $\phi_{\text{bar}}$	70

4.7	Moment capacity vs $\phi_{\text{link}} / \phi_{\text{bar}}$	72
4.8	Shear capacity vs $\phi_{\text{link}} / \phi_{\text{bar}}$	72

## 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
$\gamma_m$	-	Partial Factor Of Safety For Materials
$\gamma_f$	-	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
$\varepsilon$	-	Strain
$\alpha$	-	Stress
$I_{y-y}$	-	Second moment of area for axis y-y
$W_{el,y-y}$	-	Elastic Modulus for axis y-y
$W_{pl,y-y}$	-	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
$\emptyset$	-	Diameter
$h_{sc}$	-	Overall nominal height of stud
$\eta$	-	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



**LIST OF APPENDICES**

<b>APPENDIX</b>	<b>TITLE</b>	<b>PAGE</b>
A	Design Calculation For Reinforced Concrete Beam	78
B	Design Calculation For Composite Steel Beam	83
C	Design Calculation For Composite Cold-Formed Of Protruded Link Beam	94

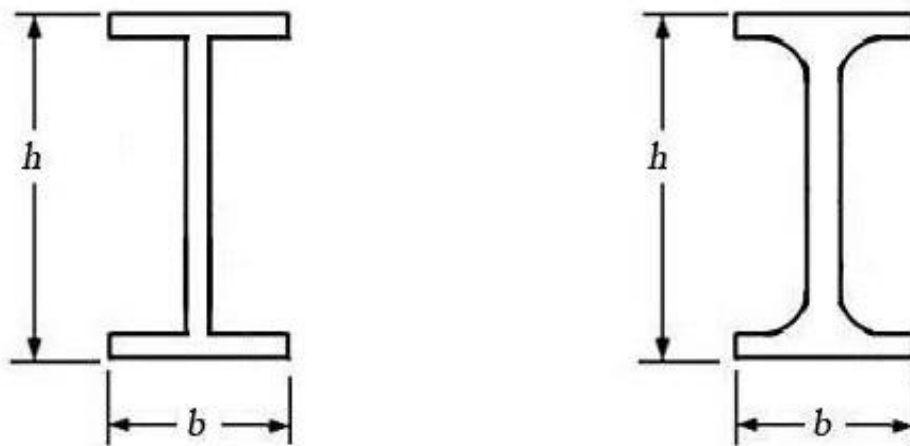
## CHAPTER 1

### INTRODUCTION

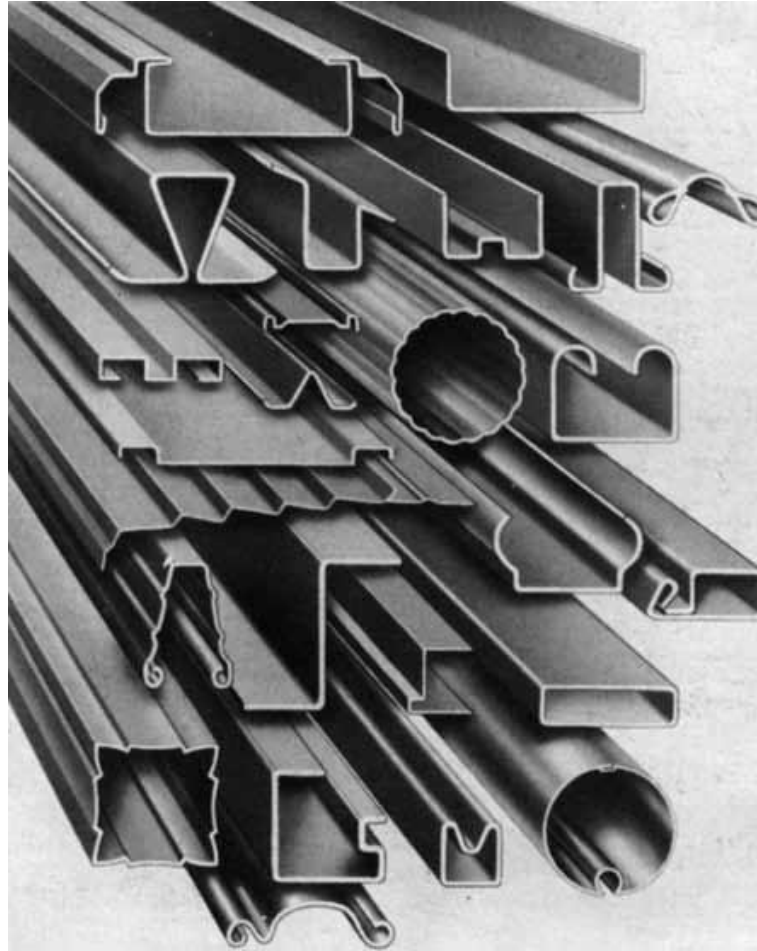
#### 1.1 Background Of The Study

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](http://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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