PSZ 19:16 (Pind. 1/07)

UNIVERSITI TEKNOLOGI MALAYSIA

DECLARATION OF THESIS / UNDERGRADUATE PROJECT PAPER AND COPYRIGHT

Author's full name : **ANG TING GUAN**

Date of birth : **10 / 02 / 1982**

Title : ***THE INFLUENCE OF THE ANCHORAGE OF INDEPENDENT BENT-UP BAR ON ITS SHEAR CAPACITY***

Academic Session: ***2007/2008***

I declare that this thesis is classified as :

☐	CONFIDENTIAL	(Contains confidential information under the Official Secret Act 1972)*
☐	RESTRICTED	(Contains restricted information as specified by the organization where research was done)*
√	OPEN ACCESS	I agree that my thesis to be published as online open access (full text)

I acknowledged that Universiti Teknologi Malaysia reserves the right as follows:

1. The thesis is the property of Universiti Teknologi Malaysia.
2. The Library of Universiti Teknologi Malaysia has the right to make copies for the purpose of research only.
3. The Library has the right to make copies of the thesis for academic exchange.

Certified by :

SIGNATURE	SIGNATURE OF SUPERVISOR
820210-01-6267	P.M. DR. RAMLI ABDULLAH
(NEW IC NO. /PASSPORT NO.)	NAME OF SUPERVISOR
Date : 8 MAY 2008	Date :

NOTES : * If the thesis is CONFIDENTAL or RESTRICTED, please attach with the letter from the organization with period and reasons for confidentiality or restriction.

"I hereby declare that I have read this thesis and in my opinion to this thesis is sufficient in terms of scope and quality for the award of the Master of Civil Engineering".

Signature	: ……………………………………...
Name of Supervisor	: PM. DR. RAMLI ABDULLAH
Date	: 9 MAY 2008

THE INFLUENCE OF THE ANCHORAGE OF
INDEPENDENT BENT-UP BAR ON ITS
SHEAR CAPACITY

ANG TING GUAN

A project report submitted in partial fulfillment of the
requirement for the award of degree of
Master of Engineering (Civil - Structure)

Faculty of Civil Engineering
Universiti Teknologi Malaysia

APRIL, 2008

"I declare that this thesis entitled "The Influence of the Anchorage of Independent Bent-up Bar on its Shear Capacity" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree."

Signature	:	___________________
Name	:	ANG TING GUAN
Date	:	8 MAY 2008

Dedicated to

To my beloved parents

Thanks for your support

ACKNOWLEDGEMENT

The successfully completion of this project is the result of many people have given me a helping hand. I have learnt a many things other than from text or note from my engineering course. The experience that I gain through this project will become the valuable treasure in my life.

First of all, I wish to express my grateful thanks to my project supervisor, P.M Dr. Ramli Abdullah for his invaluable guidance, suggestions and helpful advices for various types of analysis and comparison processes to be carried out as well as contents improvements. Thanks for his contribution in the progress of doing this project. In addition, deep appreciation to his for spending time in our frequent discussions and questioning and answering which led to the accomplishment of this project.

I also wish to acknowledge those who lend me a hand when I encounter some problem in my project. For example the lecturers that have taught me the knowledge about reinforced concrete and other related. Without their help, I may not finish the project on time. In addition, I also wish to express my great appreciation to my friend, who gives the information and also guidance to accomplish this project.

Finally, I wish to convey my heartful thanks to my parents and wife who have given me constant support and encouragement throughout the dissertation. For the last but not the least, I want to give my gratitude for those people that help me in this project but not stated above, their contributions will not be forgotten.

ABSTRACT

The use of independent bent-up bars as parts of shear reinforcement has been shown to be effective. Laboratory tests revealed that beams provided with a particular amount of such reinforcement in conjunction with nominal links achieved higher shear resistance than beams with the normally adopted vertical design links. In the conventional bent-up bars system, it was required that the length of the horizontal portion of the bars after the bend be at least the anchorage length of the bar. In many cases, this requirement has limited the provision of closely spaced multiple system of bent-up bars. This project presents the results of experimental investigation on five rectangular beams in which the effect of using short anchorage of the independent bent-up bars on the capacity of the beam in carrying shear was studied. The influence of various amounts of bent-up bars was also investigated. All the beams were provided with identical longitudinal reinforcement but with different sets of shear reinforcement. In one beam, the shear reinforcement was in the form of closely spaced vertical links, while the other three beams had nominal links combined with independent bent-up bars of various amount and anchorage lengths. Test results indicate that the anchorage length of the bent-up bars is insignificant to the capability of the bars in carrying shear. It also suggests that the provision of the large amount of the bent-up bars does not produce the corresponding advantage to the beams shear capacity. It may therefore be concluded that independent bent-up bars be used effectively and economically in reinforced concrete beam design to resist shear.

ABSTRAK

Kegunaan bar condong bebas sebagai tetulang ricih adalah berkesan. Ujikaji makmal mendapati rasuk yang dibekalkan dengan sesetengah bilangan tetulang bersama dengan nonimal perangkai untuk mencapai rintangan ricih yang lebih tinggi daripada perangkai pugak yang biasa digunakan. Dalam sistem tradisional bar condong, kepanjangan bahagian bar melintang selepas dibengkokkan mesti sekurang- kurangnya kepanjangan tambatan bar. Dalam banyak situasi, kelayakan ini telah mengehadkan bekalan gandaan sistem yang berjarak rapat bagi bar condong. Kajian ini memaparkan keputusan dari ujikaji makmal yang telah dijalankan ke atas lima rasuk bersegi empat dimana kesannya menggunakan tambatan yang pendek dalam bar condong terhadap keupayaan menanggung ricih telah dikaji. Pengaruh dari pelbagai bilangan bar yang dibengkok juga pun diujikaji. Semua rasuk dibekalkan dengan tetulang bergarisan bujur yang sama tetapi set ricih tetulang yang berlainan. Dalam satu rasuk, ricih tetulang adalah dalam bentuk perangkai pugak yang berjarak dekat, manakala tiga rasuk yang berlainan mempunyai nominal perangkai yang bergabungan dengan bar condong bebas dengan pelbagai bilangan dan panjang tambatan. Keputusan ujikaji menunjukkan kepanjangan tambatan dari bar condong adalah tidak berkesan untuk menanggung ricih. Ujikaji ini juga mencadangkan dengan membekalkan banyak bar condong bebas tidak akan menghasilkan kebaikan yang sama kepada keupayaan ricih rasuk. Oleh yang demikian, bar condong bebas adalah bekesan dan ekomoni untuk digunakan dalam mencorakkan rasuk konkrit bertetulang untuk menahan ricih.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

A	-	Area of cross-section
A_s	-	Area of tension reinforcement
A_{sb}	-	Area of steel in bent-up bars
$A_{s,prov}$	-	Area of tension reinforcement provided
$A_{s, req}$	-	Area of tension reinforcement required
A_{sv}	-	Total cross-sectional area of links at the neutral axis
a_v	-	Shear span
b	-	Width of a section
b_v	-	Breadth of member for shear resistance
c	-	Cover to reinforcement
d	-	Effective depth of the tension reinforcement
f_{cu}	-	Characteristic concrete cube strength at 28 days
fs	-	Service stress in reinforcement
f_{tt}	-	Design tensile stress in concrete at transfer
f_y	-	Characteristic strength of reinforcement
f_{yb}	-	Characteristic strength of inclined bars
f_{yv}	-	Characteristic strength of link reinforcement
L	-	Effective span of a beam
M_{max}	-	Maximum bending moment
s_b	-	Spacing of bent-up bars
s_v	-	Spacing of links
V	-	Shear force at ultimate design load
V_b	-	Design ultimate shear resistance of bent-up bars
V_c	-	Design ultimate shear resistance of a concrete section
v	-	Shear stress

v_b	-	Design shear stress resistance of bent-up bars
v_c	-	Design ultimate shear resistance of a singly reinforcement concrete beam
α	-	Angle between a bent-up bar and axis of a beam
β	-	Bond coefficient
ø	-	Bar diameter
θ	-	Angle

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 General

Reinforcement concrete beam is concrete in which reinforcement bars have been incorporated to strengthen a material. The shear reinforcement must be provided when the value of actual shear stress exceeds the permissible shear stress of the concrete used. Shear reinforcement is used to prevent failure in shear; this increases the ductility of the beam and considerably reduces the chances of a sudden failure. Furthermore, the anchorage is the embedment of a bar in concrete so that it can carry load through bond between the steel and concrete.

Generally, an inclined bar is one that is employed to resist tension in the bottom of the beam near mid- span and is then bent up at 45^{o} into the top of the member, where it may provide resistance over the support. In such a case, the force in the horizontal parts of the bar must balance the horizontal components of the force in the inclined part and the complementary compressive resistance.

Any form of effectively anchored reinforcement that intersects these diagonal cracks will be able to resist the stress to a certain extent[3]. In practice, shear reinforcement is provided whether in the form of vertical links, inclined links or combination system of links and bent-up bars. Bent- up bars is normally used to carry heavy shear forces.

Vertical links are simple in fabricating and installing, therefore it is most common used as shear reinforcement in building construction. Links are arranged closely or sometimes double or more shear links are used to resist high shear stress. Congestion near the support of reinforced concrete beam due to the presence of the closely spaced links can increase the cost and time required in fixing the reinforcement.

The use of bent- up bars along with vertical links had been practical before, where all the tensile reinforcement is not required to resist bending moment; some of the bar was bent- up in the region of high shear to form the inclined legs of shear reinforcement. However, inclined bars are seldom used in present- day practice. This is because the cost of bending is not insignificant. They are also difficult to manipulate and fix compare with straight bars, especially in congested situations. In beams with small number of bars provided, the bent- up system is not suitable due to insufficient amount of reinforcement would be left to continue to the support as required by the code of practice.

However, where large concentrated loads must be supported, their use should be considered in order to avoid the congestion that can arise when the multiple- link systems, that would otherwise be necessary, are employed. Inclined bars used as shearing reinforcement must be checked for anchorage and bearing.

In this project, total of five reinforced concrete beams which were contained different types of shear reinforcement and anchorage length were designed and used in the laboratory testing. All the beams were designed to fail in shear. Thus the tension reinforcement and concrete properties recommended need to be considered and calculated to give a sufficient of bending moment resistance. Furthermore, same grade of concrete and the size are applied to the entire beam. All the beams will be tested and the result will be compared.

1.2 Objective of the Studies

The main objectives of this study are:

a) To study the effectiveness of independent inclined bars as shear reinforcement in rectangular beams.

b) To investigate the anchorage length of the independent bent up bar on its capacity in carrying shear.

c) To study the influence of the amount of the independent bent up bar on its capacity in resisting shear.

1.3 Scope of Works

This study was based on the experimental investigation carried out within the scope as below:

(a) Five reinforced concrete beams which are contained different types of shear reinforcement and anchorage length were designed and used in the laboratory testing.

(b) Grade C30 concrete are applied the entire beam and the size of the beam were 200mm width x 250mm height x 2300mm length

(c) Each of the beams was provided with 3T16 as tension reinforcement and 2T10 as top of reinforcement and the variable of vertical links and inclined bars as shear reinforcement system.

(d) All specimens were tested to failure with two point loads near the support.

.

(e) The inclination of the independent bent-up bar was 45 degree from the longitudinal axis and provided within 500mm from support beam.