THE USE OF HORIZONTAL AND INCLINED BARS AS SHEAR REINFORCEMENT

NOOR AZLINA BT ABDUL HAMID

UNIVERSITI TEKNOLOGI MALAYSIA

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THE USE OF HORIZONTAL AND INCLINED BARS AS SHEAR REINFORCEMENT

NOOR AZLINA BT ABDUL HAMID

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

FACULTY OF CIVIL ENGINEERING
UNIVERSITI TEKNOLOGI MALAYSIA

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I declare that this thesis entitled " *The use of horizontal and inclined bars as shear reinforcement* " 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.

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To mama and papa,

Thanks for your support

My dream has come true just because of you

To my beloved husband,

Thanks for your understanding and support

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ABSTRACT

Shear failure in beams are caused by diagonal cracks near the support. Any form of effectively anchored reinforcement that intersects these cracks will be able to resist the shear stress to a certain extent. This project presents the results of an experimental investigation on six reinforced concrete beams in which their structural behaviour in shear were studied. All the beams were cast with the same grade of concrete, and provided with identical amount of main reinforcement. In order to investigate the contribution of the additional horizontal and independent bent-up bars to the shear carrying capacity of the beam, two specimens each were provided with horizontal longitudinal bars and bent-up bars in the high shear region. Two different quantities of additional bars in each of these cases were adopted. The fifth specimen was provided with sufficient amount of shear reinforcement in terms of vertical links, while the other one was cast without any shear reinforcement to serve as control specimens. The performances of the beams in resisting shear in the form of deflection, cracking, strain in the shear reinforcement and ultimate load were investigated. The results show that the shear capacities of the beams with additional horizontal and independent bent-up bars larger than 1.2% of their cross-sectional area are higher than that of the conventionally designed beam with vertical links. It may therefore be suggested that these types of shear reinforcement be used to ease the congestion of links near the supports.

ABSTRAK

Kegagalan ricih dalam rasuk adalah disebabkan oleh keretakan condong yang berlaku berdekatan dengan penyokong. Sebarang bentuk tetulang tambatan yang melintasi keretakan ini berkeupayaan untuk menghalang ricih pada suatu takat yang tertentu. Kajian ini memaparkan keputusan dari ujikaji makmal yang telah dijalankan ke atas enam rasuk konkrit bertetulang dimana kelakunannya terhadap ricih telah dikaji. Semua sampel rasuk dibina dengan kekuatan gred konkrit yang sama, dan menggunakan bilangan dan jenis tetulang utama yang sama. Bagi mengkaji sumbangan atau kesan bar ufuk tambahan dan bar yang dibengkok terhadap keupayaan menanggung ricih, dua sampel rasuk dimana setiap satunya disediakan bar ufuk tambahan dan bar yang dibengkok pada satah kegagalan ricih maksimum. Dua perbezaan kuantiti untuk setiap jenis tetulang tambahan disediakan. Spesimen yang kelima disediakan dengan bilangan tetulang ricih yang mencukupi dalam bentuk perangkai pugak, manakala satu lagi rasuk dibina tanpa menggunakan sebarang tetulang ricih dan bertindak sebagai rasuk kawalan. Kelakunan rasuk dalam menghalang ricih dikaji berdasarkan kepada nilai pesongan, keretakan, keterikan dan beban muktamad. Keputusan ujikaji menunjukkan bahawa rasuk yang menggunakan bar ufuk tambahan dan bar yang dibengkokkan sebagai tetulang ricih lebih daripada 1.2% daripada keratan rentas rasuk boleh menanggung keupayaan ricih lebih daripada rasuk yang menggunakan perangkai pugak. Oleh yang demikian, tetulang ricih jenis ini dicadangkan bagi memudahkan kerja-kerja pemasangan perangkai ricih yang disusun rapat berhampiran dengan penyokong rasuk.

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LIST OF SYMBOLS

A	-	Area of a 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 tension reinforcement
f_{cu}	-	Characteristic concrete cube strength at 28 days
f_s	-	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 stress resistance of a singly reinforced concrete beam
α	-	Angle between a bent-up bar and the axis of a beam
β	-	Bond coefficient
θ	-	Angle
ϕ	-	Bar diameter

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CHAPTER 1

INTRODUCTION

Reinforced concrete (RC) beams are the important structural elements that transmit the loads from slabs, walls, imposed loads etc. to columns. A beam must have an adequate safety margin against bending and shear stresses, so that it will perform effectively during its service life.

At the ultimate limit state, the combined effects of bending and shear may exceed the resistance capacity of the beam and causes tensile crack. Since the strength of concrete in tension is considerably lower than its strength in compression, design for shear is of major importance in concrete structures. However, shear failure is difficult to predict accurately. In spite of many decades of experimental research, it is not fully understood.

The behaviour of reinforced concrete beams at failure in shear is distinctly different from their behaviour in flexure, which may be more dangerous than flexure failure. They fail abruptly without sufficient advanced warning[1] and the diagonal cracks that develop are considerably wider than the flexural cracks.