DEBONDING MECHANISMS OF FIBRE REINFORCED POLYMER STRENGTHENED STEEL MEMBERS

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DECEMBER 2010

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By

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A DISSERTATION

SUBMITTED TO THE SCHOOL OF CIVIL,

ENVIRONMENTAL AND MINING ENGINEERING,

THE UNIVERSITY OF ADELAIDE

FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

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ABBREVIATIONS AND NOMENCLATURES

τ	bond stress
χ	curvature
Δ	global slip
Δ_s	change of slip
δ	slip
ε	strain
δ_1	slip at maximum bond stress
θ_1	theoretical rotation when full plastic capacity is achieved
θ_2	rotation when moment capacity drops below M_p
$(AE)_p$	axial rigidity of FRP
$(AE)_s$	axial rigidity of steel
$(\mathrm{EA})_c$	axial rigidity of the concrete
$(\mathrm{EA})_p$	axial rigidity of the FRP plate
θ_h	plastic rotation
θ_{hm}	plastic rotation at maximum moment
τ_{max}	maximum bond stress
δ_{max}	maximum slip
$\delta_{max,cal}$	calculated maximum slip
$\tau_{max,exp}$	experimental bond stress
$\delta_{max,exp}$	experimental maximum slip
θ_p	elastic rotation
ε_p	FRP strain
ε_s	steel strain
ε_u	steel strain at ultimate rotation
ε_{sh}	strain hardening
θ_u	ultimate rotation
ε_Y	yield strain,
$\mathrm{A_p}$	area of FRP
B	bond force
b	width
b_p	FRP width
CDC	critical diagonal crack
d	depth
d_x	segment length
E_p	Young’s Modulus of FRP
E_s	Young’s Modulus of steel
F	force
FRP	Fibre Reinforced Polymer
f_{sh}	Strain hardening stress
f_y	Yield stress
G_f	fracture energy

h height
IC interfacial crack
J geometry of the interface debonding failure plane
L_{crit} critical bond length
L_p length of embedment
l_p length of full plastic zone
L_{per} perimeter length
l_{pf} length of flange plastic zone
M moment
M_p plastic moment
M_{pf} plastic moment at flange
M_u ultimate moment
P load
PE plate end
P_{IC} debonding load
$P_{IC,exp}$ experimental interfacial crack load
P_L load increment
P_{UL} load decrement
$P_{y.}$ yield load
q uniform distributed load
R rotation capacity
t_p thickness of FRP
t_s Steel thickness
x_i distance to inflection point
x_m distance to plastic moment

ABSTRACT

Applying Fibre Reinforce Polymer (FRP) to steel structures has been proved to be an effective method of strengthening. Experimentally, ageing steel structures such as bridge decks and composite beams which have been strengthened with FRP have shown lifetime extension and enhanced strength. Numerically, different approaches have been carried out to quantify the relationship between FRP and steel members in regard to the observance of the experimental works.

This thesis contributes in term of quantifying the debonding mechanism of FRP strengthened steel members. First, a procedure in the derivation of the bond-slip (τ-σ) relationship is presented by combining the results of the experimental work with a numerical method developed specifically for this purpose. Secondly, the debonding mechanisms of FRP strengthened steel plates due to the yielding of steel is established by experimental and numerical works. Finally, a numerical method was developed to quantify the plate end debonding of a simply supported steel beam.

A total of seventeen pull tests with different types of FRP lengths and adhesives were tested to quantify the (τ-σ) relationship. Another four steel plate tests were carried out to study the debonding mechanism of FRP allowing for the steel to yield. Three different numerical methods were developed to analyse the results obtained experimentally.

STATEMENT OF ORIGINALITY

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution to Ibrisam Akbar, and, to the best of my knowledge and belief, contains no material previously published or written by another person except where due reference has been made in the text.

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ACKNOWLEDGEMENT

In the name of God, Most Gracious, Most Merciful.

The work of research in this thesis was carried out at the University of Adelaide in the Deparment of Civil, Environmental and Mining Engineering under the supervision of Professor Dr. Deric Oehlers, Dr. Ali Mohamed Sadakkathulla and Associate Professor Dr. Abdul Hamid Sheikh.

I am forever thankful to Professor Dr. Deric Oehlers, Dr. Ali Mohamed Sadakkathulla and Associate Professor Dr. Abdul Hamid Sheikh for their excellent guidance, careful supervision and patience throughout this research. They provided me their dedication and contribution which helped me for the completion of this research and publication of the papers. Their commitment in organising the weekly meeting and dedicated supervisions has been cherished with valuable discussions and ideas.

My thank you also goes to the laboratory technicians; especially to Steven Huskinson, David Hale and Ian Cates for their professional advices and dedications throughout the experimental program.

My love to the family; parents Akbar Pura and Isah Parman; wife, Suzilawati Amir Hamzah and children, Iman Ibrisam, Ismail Ibrisam, Sumaiyyah Ibrisam and Isa Ibrisam for their love, encouragement and support throughout the completion of this research. May we all be gathered together in *Jannatul Firdaus*.

Finally, my gratitude to my sponsor and employer, Universiti Teknologi Petronas which provided me their care while completing this work of knowledge.

LIST OF PUBLICATIONS

The following papers were written based on the work presented in this thesis.

1. Ibrisam Akbar, Deric John Oehlers, M.S. Mohamed Ali (2010). "Derivation of the bond-slip characteristics for FRP plated steel members." Journal of Constructional Steel Research, 66(8-9), 1047-1056.

2. Ibrisam Akbar, Deric John Oehlers, M.S. Mohamed Ali (2010). “Partial and Full Interaction Behaviour of FRP Plated Steel Member.” International Conference on Sustainable Building and Infrastucture. Kuala Lumpur.

3. Ibrisam Akbar, Deric John Oehlers, M.S. Mohamed Ali (2010). “Plate end debonding of FRP plated steel member using partial interaction theory.” Journal of the Institution of Engineers Malaysia. Kuala Lumpur. *submitted*