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Degree: MASTER OF ENGINEERING (CIVIL - STRUCTURE)
Faculty: FACULTY OF CIVIL ENGINEERING
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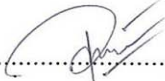
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BONDING BEHAVIOUR BETWEEN CFRP AND STEEL PLATES TO
CONCRETE PRISMS

PETER LING CHUAN CHANG

A project report submitted in 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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To my beloved mother and father

ACKNOWLEDGEMENTS

In preparing this project report, I was in contact with many people, researchers, academicians, and practitioners. They have contributed towards my understanding and thoughts. In particular, I wish to express my sincere appreciation to my main thesis supervisor, Associate Professor Dr. Abdul Rahman Mohd Sam, for encouragement, guidance, critics and friendship. I am also very thankful to my co-supervisors Dr. Shukur Abu Hassan for his guidance, advices and motivation. Without their continued support and interest, this project report would not have been the same as presented here.

I am also indebted to Universiti Teknologi Malaysia (UTM) for funding my Master study. My sincere thanks also go out to anyone who has contributed in a variety ways towards the success of this project. Their views and tips are useful indeed. Unfortunately, it's very difficult to list all of them in this limited space. Thank you so much. I am grateful to all my family members.

ABSTRACT

Attaching external plate to concrete surfaces by adhesive bonding method is a practical solution for upgrading the existing structures. An investigation on the bonding behavior between Carbon Fibre Reinforced Polymer (CFRP) and steel plates to concrete prisms was carried out. Four groups of specimens, namely CFRP Plate-Epoxy-Concrete Prism, Steel Plate-Epoxy-Concrete Prism, CFRP Plate-Epoxy-CFRP Plate specimen and Steel Plate-Epoxy-Steel Plate specimen, were tested by applying direct tensile loads until failure. The bonding performances of CFRP and steel plates were compared. The load and strain relationship along the bonding region were reported. The test results showed that epoxide resin was suitable to be used as structural adhesive because the bond failure was dominant by concrete shearing. CFRP plate is better in term of bonding because of its rough surface and the smooth surface of the steel plate results in slippage when load is applied.

ABSTRAK

Penambahan plat pada permukaan luar konkrit dengan kaedah lekatan merupakan salah satu cara yang praktikal untuk menaik taraf bangunan sedia ada. Satu penyelidikan yang berkaitan dengan ciri-ciri kelekatan plat (Polimer Bertetulang Gentian Karbon) CFRP and keluli pada prisma konkrit telah dijalankan. Empat kumpulan spesimen, iaitu Plat CFRP-Epoksi-Prisma Konkrit, Plat Keluli-Epoksi-Prisma Konkrit, Plat CFRP-Epoksi-Plat CFRP spesimen dan Plat Keluli-Epoksi-Plat Keluli spesimen telah diuji dengan mengaplikasikan beban tegasan tegangan sehingga gagal. Prestasi lekatan di antara plat CFRP and plat keluli telah dibandingkan. Hubungan beban dan terikan sepanjang kawasan lekatan telah dilaporkan. Keputusan ujian menunjukkan bahawa damar epoksi adalah sesuai digunakan sebagai pelekat struktur kerana kegagalan adalah didominasi pada bahagian konkrit. Plat CFRP adalah lebih baik dalam kelakuan lekatan kerana permukaan yang kasar. Permukaan licin pada plat keluli menyebabkan kegelongsoran apabila beban dikenakan.

TABLE OF CONTENTS

CHAPTER	CONTENT	PAGE
	DECLARATION	ii
	DEDICATION	iii
	ACKNOWLEDGEMENT	iv
	ABSTRACT	v
	ABSTRAK	vi
	TABLE OF CONTENTS	vii
	LIST OF TABLES	xii
	LIST OF FIGURES	xiv
	LIST OF APPENDIX	xix
1	INTRODUCTION	
	1.1 Introduction	1
	1.2 Background and statement of problem	2
	1.3 Objective of research	3
	1.4 Scope of research	3
	1.5 The contribution of research	4
2	LITERATURE REVIEW	
	2.1 Introduction	5
	2.2 Adhesive	5
	2.3 Classification of adhesives	7

2.3.1	Adhesive which harden by cooling / Thermoplastic adhesive	7
2.3.1.1	Ethylene vinyl acetate (EVA) hot melts	10
2.3.1.2	Polyamide hot melts	10
2.3.2	Adhesives which harden by chemical reaction / Thermoset adhesive	11
2.3.2.1	Epoxides	12
2.4	Adhesive Factors Affecting Durability	12
2.4.1	Modulus of elasticity	12
2.4.2	Interfacial imperfections	13
2.4.3	Heat curing	14
2.4.4	Pressure	14
2.4.5	Adhesive thickness	15
2.5	Advantages and disadvantages of externally steel plate system in shear strengthening	15
2.5.1	Adhesive bonding	16
2.5.1.1	Advantages of adhesive bonding	16
2.5.1.2	Disadvantages of adhesive bonding	17
2.5.2	Bolted construction	17
2.5.2.1	Advantages of bolted construction	18
2.5.2.2	Disadvantages of bolted construction	18
2.6	Debonding and cracking failure	19
2.7	Comparison between FRP and steel bonding	21
2.8	Exposure	21
2.9	Direct tensile test	23
2.10	Surface treatment and bonding properties	26
2.11	Development of design rules for adhesive bonding plates	27
2.12	Flexural peeling	29
2.13	Shear peeling	30

	2.14 Axial peeling	30
	2.15 Advantages of FRP compared to traditional materials	32
	2.16 Perspectives for the application of FRP in construction	33
	2.17 Concluding remarks	34
3	METHODOLOGY	
	3.1 Introduction	35
	3.2 Sieve analysis	35
	3.3 Slump test	36
	3.4 Design of concrete prisms	37
	3.5 Concrete formworks	39
	3.6 Concrete casting and curing	39
	3.7 Concrete surface preparation	40
	3.8 Adhesive for bonding	41
	3.9 Dimension of plates	44
	3.10 CFRP plate and steel plate preparation	47
	3.11 CFRP / Steel plate-concrete prism bonding	51
	3.12 Expected data / result	52
	3.13 Measurement and instrumentation	52
	3.14 Experimentation set-up for concrete prisms	55
	3.15 Experimentation set-up for thermoplastic	56
	3.16 Determination of bond stress characteristics	57
4	RESULTS AND ANALYSIS	
	4.1 Introduction	59
	4.2 Sieve analysis	59
	4.3 Slump test	61
	4.4 Cube test	61
	4.5 Experiment result and discussion	62
	4.5.1 Result and discussion for CFRP plate-epoxy-concrete specimens	63
	4.5.1.1 Strain for CFRP plate-epoxy-	

	concrete prism 1	64
4.5.1.2	Strain for CFRP plate-epoxy- concrete prism 2	66
4.5.1.3	Comparisons between CFRP plate-epoxy-concrete specimens	69
4.5.1.4	Failure mode for CFRP plate- epoxy-concrete specimens	73
4.5.2	Steel plate-epoxy-Concrete specimens	76
4.5.2.1	Strain for steel plate-epoxy- concrete prism 1 (w/o end tab)	78
4.5.2.2	Strain for steel plate-epoxy- concrete prism 2 (with end tab)	80
4.5.2.3	Comparisons between steel plate- epoxy-concrete specimens	82
4.5.3	CFRP plate-epoxy-CFRP plate specimens	86
4.5.3.1	Failure mode for CFRP plate- epoxy-CFRP plate 1	87
4.5.3.2	Failure mode for CFRP plate- epoxy-CFRP plate 2	88
4.5.4	Steel plate-epoxy-steel plate specimens	90
4.5.4.1	Failure mode for steel plate- epoxy-steel plate specimen	92
4.5.5	Steel plates tensile tests	94
4.5.6	Result comparisons	98
4.5.6.1	CFRP and steel plates to concrete specimens	98
4.5.6.2	CFRP and steel plates to plates specimens	99
4.6	Thermoplastic- Low linear density polyethylene testing	100

5

CONCLUSION AND SUGGESTION

5.1	Conclusion	104
-----	------------	-----

5.2 Suggestion	105
REFERENCE	106
APPENDIX	109

LIST OF TABLES

NO.	TITLE	PAGE
3.1	Materials and descriptions	38
3.2	DoE mix design summary	38
3.3	Technical and physical data of Sikadur 330 thixotropic epoxy	42
3.4	Strain gauge technical data for composite	53
3.5	Strain gauge technical data for steel	53
4.1	Sieve Analysis of aggregate	60
4.2	Compressive strength of concrete cubes	61
4.3	Relationship between time, extension and load of CFRP plates-Epoxy-Concrete specimens	63
4.4	Strain gauges readings for CFRP plate-Epoxy- Concrete specimens 1	65
4.5	Strain gauges readings for CFRP plate-Epoxy- Concrete specimen 2	68
4.6	Average strain reading of CFRP plate-Epoxy- Concrete specimens	71
4.7	Average load force of CFRP plate-Epoxy- Concrete specimens	71
4.8	Average bond stress of CFRP plate-Epoxy- Concrete specimens	72
4.9	Relationship between time, extension and load of Steel plates-Epoxy-Concrete specimens	77

4.10	Strain gauges readings for Steel plate-Epoxy- Concrete specimens 1	79
4.11	Strain gauges readings for Steel plate-Epoxy- Concrete specimens 2	81
4.12	Average strain reading of Steel plate-Epoxy- Concrete specimens	83
4.13	Average load force of Steel plate-Epoxy- Concrete specimens	84
4.14	Average bond stress of CFRP plate-Epoxy- Concrete specimens	84
4.15	Relationship between time, extension and load of CFRP Plate-Epoxy-CFRP Plate Specimen 1	86
4.16	Relationship between time, extension and load of Steel Plate-Epoxy-Steel Plate Specimen	92
4.17	Specification of steel plate 1	95
4.18	Specification of steel plate 2	96
4.19	Polyethylene's condition at various temperatures	101

LIST OF FIGURES

NO.	TITLE	PAGE
2.1	Schematic representation of mechanical “hooking”	6
2.2	Low area of interfacial contact resulting from high viscosity of fluid	13
2.3	Lack of voids and high area of interfacial contact resulting from low viscosity fluid	13
2.4	Critical diagonal crack (CDC)	20
2.5	Debonding failure (CDC)	20
2.6	Test rig	22
2.7	Different potential failure mode	23
2.8	Steel to concrete adhesive bond modeling	24
2.9	Specimen configuration and test setup for double-lap pull out test	25
2.10	Premature debonding of an angle section	28
2.11	Premature debonding of a tension face plate	28
2.12	Premature debonding of a compression face plate	28
2.13	Flexural peeling mechanisms	29
2.14	Shear peeling mechanism	30
2.15	Axial peeling mechanisms	31
2.16	Axial peeling of RC beam with FRP tension face plate	31
3.1	Sieving apparatus	36
3.2 (a)	Slump test	37
3.2 (b)	Measuring of slump	37

3.3	Formwork for concrete prisms	39
3.4 (a)	Casting of concrete and cubes	40
3.4 (b)	Concrete specimens	40
3.5 (a)	Concrete surface to be hacked	41
3.5 (b)	Installation of end plate with G-clamp	41
3.5 (c)	Hacking of concrete surface using air tool hammer	41
3.5 (d)	Readily hack concrete prisms	41
3.6	Sikadur 30 thixotropic epoxy	42
3.7 (a)	Development of compressive strength of Sikadur 30	43
3.7 (b)	Development of tensile strength of Sikadur 30	43
3.7 (c)	Development of tensile slant shear strength of Sikadur 30	43
3.8 (a)	Steel end tab dimension	44
3.8 (b)	CFRP plate dimension (Plate to concrete bonding)	44
3.8 (c)	Steel plate dimension (Plate-concrete bonding)	45
3.8 (d)	Steel plate dimension	45
3.8 (e)	Overlapping length for bonding for steel plate	45
3.8 (f)	CFRP plate to CFRP plate bonding dimension	46
3.8 (g)	Application of Sikadur 30 to CFRP plate	46
3.8 (h)	CFRP plates readily bonded at bonding length of 60mm	46
3.8 (i)	Bonding section of steel plates	46
3.8 (j)	Steel plates completely bonded with Sikadur 30	46
3.9 (a)	Aligning the CFRP plate to the cutting edge	47
3.9 (b)	Readily cut CFRP plates	47
3.9 (c)	Peeling and cutting of the protective layer	48
3.9 (d)	A deeper peeling and cutting of the protective layer	48
3.9 (e)	Scraping of solid dirt on mould	49
3.9 (f)	Cleansing of oily stain using acetone	49
3.9 (g)	Polishing of mould using mold release wax	49
3.9 (h)	Cleaning of bonding surface using acetone	49
3.9 (i)	Mixing of Sikadur 30 thixotropic epoxy	49
3.9 (j)	Epoxy application on the plates	49
3.9 (k)	External load applied to the mold using solid block	50
3.9 (l)	Completely bonded CFRP plate with end tab plate	50
3.9 (m)	Drilling of hole for CFRP plate	50

3.9 (n)	CFRP plate readily drilled	50
3.10 (a)	Surface cleaning	51
3.10 (b)	Plate to concrete bonding	51
3.10 (c)	Excessive epoxy at the edge	51
3.10 (d)	Imposed load for proper bonding	51
3.11	Instrumentation of strain gauges onto concrete prism	54
3.12 (a)	Roughening and marking of plates	55
3.12 (b)	Installation of strain gauges and gauge terminals	55
3.12 (c)	Specimens in complete condition	55
3.12 (d)	Strain gauges tested for resistivity	55
3.13 (a)	Test rig for direct tensile load on CFRP plate-Epoxy- Concrete prism	56
3.13 (b)	Test rig for direct tensile load on Steel plate-Epoxy- Concrete prism	56
3.13 (c)	Test rig for direct tensile load on CFRP plate-Epoxy- CFRP plate	56
3.13 (d)	Test rig for direct tensile load on Steel plate-Epoxy- Steel plate	56
3.14	Elementary force analysis	57
4.1	Particle size versus percentage passing	60
4.2	Compressive strength comparisons between different batches of concrete cubes	62
4.3 (a)	CFRP Plate-Epoxy-Concrete sample 1 (Before testing)	64
4.3 (b)	CFRP Plate-Epoxy-Concrete sample 1 (After testing)	64
4.4	Load vs. strain for carbon prism 1	65
4.5	Strain reading at 55 kN for CFRP plate-Epoxy-Concrete sample 1	66
4.6 (a)	CFRP Plate-Epoxy-Concrete sample 2 (Before testing)	67
4.6 (b)	CFRP Plate-Epoxy-Concrete sample 2 (After testing)	67
4.7	Load vs. strain for carbon prism 2	68
4.8	Strain reading at 55 kN for CFRP plate-Epoxy-Concrete sample 2	69
4.9	Load vs. strain comparison for CFRP Plate-Epoxy- Concrete Specimens	70

4.10	Local bond stresses vs. bond length of CFRP-Concrete Prism in simplified mode	72
4.11	Local bond stresses vs. bond length of CFRP-Concrete Prism in actual mode	73
4.12 (a)	Failure at side A	74
4.12 (b)	View from side A	75
4.12 (c)	View from the front of sample 1	75
4.12 (d)	View from the back of the testing apparatus for sample 1	75
4.12 (e)	Concrete shearing surface for sample 1	76
4.12 (f)	CFRP condition at failure for sample 1	76
4.13 (a)	Failure at side B	74
4.13 (b)	View from side B	75
4.13 (c)	View from the front of sample 2	75
4.13 (d)	View from the back of the testing apparatus for sample 2	75
4.13 (e)	Concrete shearing surface for sample 2	76
4.13 (f)	CFRP condition at failure for sample 2	76
4.14 (a)	Steel Plate-Epoxy-Concrete sample 2 (w/o end tab)	78
4.14 (b)	Steel Plate-Epoxy-Concrete sample 2 (welded end tab)	78
4.15	Load vs. strain (Steel prism w/o end tab)	79
4.16	Strain reading at 80 kN for Steel plate-Epoxy-Concrete sample 1	80
4.17	Load vs. strain (Steel prism-welded end tab)	81
4.18	Strain reading at 80 kN for Steel plate-Epoxy-Concrete sample 2	82
4.19	Load vs. strain comparison for Steel Plate-Epoxy-Concrete Specimens	83
4.20	Local bond stresses vs. bond length of Steel-Concrete Prism in simplified mode	85
4.21	Local bond stresses vs. bond length of Steel-Concrete Prism in actual mode	85
4.22	Test set-up for CFRP Plate-Epoxy-CFRP Plate Specimen 1	87
4.23 (a)	CFRP plate 1 final position after test	88
4.23 (b)	Closer view of CFRP plate 1 failure portion	88
4.23 (c)	Failure texture of CFRP plate 1	88

4.24	Test set-up for CFRP Plate-Epoxy-CFRP Plate Specimen 2	89
4.25 (a)	CFRP plate 2 final position after test	90
4.25 (b)	Failure texture of CFRP plate 2	90
4.26	Steel Plate-Epoxy-Steel Plate Specimens 1	91
4.27 (a)	Yielded and bent end	91
4.27 (b)	Elongated connection hole	91
4.28 (a)	Steel Plate-Epoxy-Steel Plate Specimens 2	92
4.28 (b)	End tab bonded with epoxy	92
4.29	Test set-up for Steel Plate-Epoxy-Steel Plate specimen	93
4.30 (a)	Steel plate final position view from side A (front)	93
4.30 (b)	Steel plate final position view from side B (back)	93
4.31	Tensile test set-up for steel plate	94
4.32	Stress vs. strain relationship for steel plate specimen 1	95
4.33 (a)	Steel plate 1 final position view from Side A	96
4.33 (b)	Steel plate 1 final position view from Side B	96
4.34	Stress vs. strain relationship for steel plate specimen 2	97
4.35 (a)	Steel plate 2 final position view from Side A	97
4.35 (b)	Steel plate 2 final position view from Side B	97
4.36	Failure mode of steel plates	98
4.37	Load vs. strain comparison for between CFRP-Concrete and Steel-Concrete Prisms	99
4.38	Load vs. time comparison between plate to plate bonding of CFRP and steel specimens	100
4.39	Polyethylene in pellet form	101
4.40 (a)	Soften and sticky form of polyethylene	102
4.40 (b)	Polyethylene with 30% to 40 % in melted form	102
4.40 (c)	Polyethylene with 85% in melted form	102
4.40 (d)	Polyethylene with 100% in melted form	102
4.40 (e)	Polyethylene in at room temperature	102
4.41 (a)	Burned polyethylene in liquid form	103
4.41 (b)	Burned polyethylene in solid form	103

LIST OF APPENDIX

NO.	TITLE	PAGE
A	Technical data sheets of Polyethylene	109

CHAPTER 1

INTRODUCTION

1.1 Introduction

Repair and rehabilitation of existing structures has become the construction industry major growth area. Increasing structural load capacity and seismic retrofit of concrete components in earthquake regions is now a substantial part of rehabilitation market [1]. Moreover, transportation infrastructure need to be strengthened to extend the service life and to accommodate the increasing load demand, which is very much higher than that it was first constructed [2-4].

Direct replacement using new structural elements is not practical, thus making repair and rehabilitation a necessity. Among various strengthening and rehabilitation methods developed, externally bonded fiber-reinforced polymer (FRP) materials is an attractive alternatives due to its ease and speed of installation [5]. The main advantages of FRP include excellent strength/self-weight ratio, high durability, corrosion and chemical resistance, lightweight materials, ease of installation, speed of construction and tremendous design flexibility [6].

In most cases, repair and rehabilitation methods involve the use of steel or FRP plates. Plates are usually bonded or bolted to the sides of the beams or tension

faces. However, these plating techniques did cause some unwanted fracture. For composite bolted plated beams, the fracture of bolt shear connectors due to excessive slippage, buckling of plates, splitting and flexural failure are commonly found. On the other hand, the adhesive bonding plates normally result in flexural peeling, shear peeling and axial peeling [7].

This paper study on the bonding performance of epoxy resin adhesives in a CFRP-concrete, steel-concrete, CFRP-CFRP and steel-steel plates system.

1.2 Problem Statement

A large proportion of the adhesives used in the construction industry are associated with essentially non-structural application. Nevertheless, there is a minority of applications in which adhesives, particularly epoxies, are used in a truly structural sense [8].

Although the technology of strengthening reinforced concrete (RC) and prestressed concrete (PC) members with externally bonded steel plates were widely used, the main problem is the corrosion. Therefore, FRP plate bonding method had been introduced. Perhaps the most relevant property of Carbon Fibre Reinforced Polymer (CFRP) composites for construction use is their resistance to corrosion that allows having them installed on the concrete surface. This technique, known as manual lay-up, may be used to increase the shear and flexural capacity of beams [9].

Therefore, this study was carried out to determine the bonding behavior between steel plate and CFRP plates to concrete.

1.3 Objective of Research

The objectives of this study are:

- i. To study the local bond stress characteristics between CFRP and steel plates to concrete prisms using epoxy resin through direct tensile test.
- ii. To compare the local bond stress distribution between CFRP and steel plates to concrete prisms.
- iii. To determine the mode of failure for concrete prisms bonded with CFRP and steel plates.

1.4 Scope of Research

The main purpose of this research is to determine the bonding behavior between CFRP and steel plates to concrete. Sikadur 330® thermoset adhesive had been used. Concrete prisms with Grade 40 and size of 300x100x100 mm were cast. CFRP and steel plates were bonded to concrete prisms and tested to failure under direct tensile load. The ultimate load, local bond stress distribution and mode of failure were recorded.

Meanwhile, plate to plate bonding for CFRP and steel plates were also tested to failure under direct tensile load. Ultimate loads and mode of failure were recorded.

1.5 The Contribution of the Research

At the end of the research, the bonding behavior between CFRP Plate-Epoxy-Concrete prism, Steel Plate-Epoxy-Concrete prism, CFRP Plate-Epoxy-CFRP plate specimen and Steel Plate-Epoxy-Steel plate specimen were obtained and compared. Data gathered from this study can be used in understanding the behaviour of FRP-concrete bonded system under direct tensile load.