

FLEXURAL BEHAVIOR OF REINFORCED CONCRETE BEAM WITH VARIATION OF COATED REINFORCEMENT

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TABLE OF CONTENTS

		Page
SUPER	RVISOR'S DECLARATION	ii
STUDI	ENT'S DECLARATION	iii
ACKN	OWLEDGEMENTS	v
ABSTI	RACT	vi
ABSTI	RAK	vii
TABLI	E OF CONTENTS	viii
LIST (OF TABLES	xii
LIST C	OF FIGURES	xiii
LIST C	DF SYMBOLS	xiv
LIST (DF ABBREVIATIONS	xv
CHAP	TER 1 INTRODUCTION	1
1.1	Introduction	1
1.2	Background of Study	2
1.3	Problem Statement	3
1.4	Research Objectives	4
1.5	Scope of Study	5
1.6	Research Significance	5
1.7	Conclusion	6
СНАР	TER 2 LITERATURE REVIEW	7
2.1	Introduction	7
2.2	Concrete	7
2.3	Reinforced Concrete	8
	2.3.1 Application of Reinforced Concrete	9
2.4	Deterioration of Concrete	10
	2.4.1 Corrosion of Embedded Steel Reinforcement	11
	2.4.2 Sulphate Attack	11

	2.4.3	Freezing and Thawing	12
	2.4.4	Abrasion	1 <u>3</u>
	2.4.5	Alkali-Silica Reactivity	14
2.5	Corrosio	on Mechanism in Concrete	14
	2.5.1	Chloride Attack	15
	2.5.2	Carbonation	15
2.6	Effect o	f Corrosion on Reinforcement	16
	2.6.1	Residual Flexural Strength	16
	2.6.2	Ultimate Load Capacity	16
	2.6.3	Tensile Strength	. 17
	2.6.4	Ductility	18
	2.6.5	Yield Strength	18
	2.6.6	Crack	19
2.7	Method		20
	2.7.1	Corrosion-Inhibiting Admixtures	21
	2.7.2	High Corrosion Resistance Steel Materials	22
	2.7.3	Cathodic Protection	23
	2.7.4	Reinforcement Coating	23
2.8	Epoxy		25
	2.8.1	Moisture Content	25
	2.8.2	Physical Barrier	25
	2.8.3	Bond Strength	26
	2.8.4	Adhesion	26
	2.8.5	Coefficient of Friction	27
	2.8.6	Epoxy Coated Steel Reinforcement Properties	27
2.9	Acrylic	Latex	28
	2.9.1	Flexibility and Impact Test	28
	2.9.2	Corrosion Resistance	29
	2.9.3	Chloride Diffusion	29
	2.9.4	Water Absorption	30
	2.9.5	Thickness and Adhesive Strength	30
2.10	Natural	Rubber Latex	31
	2.10.1	Polymer Modified Asphalt Binder	31

		2.10.2 Brass Plated Steel Cords	32
		2.10.3 Medical Gloves	33
	2.11	Conclusion	34
	СНАРТ	ER 3 RESEARCH METHODOLOGY	35
	3.1	Introduction	35
	3.2	Experimental Works	37
	3.3	Testing	38
		3.3.1 Slump Test	39
		3.3.2 Concrete Compression Test	40
		3.3.3 Concrete Flexural Test	41
	,	3.3.4 Tensile Test	42
	3.4	Conclusion	43
	СНАРТ	TER 4 RESULTS AND DISCUSSIONS	44
	СНАРТ	TER 4 RESULTS AND DISCUSSIONS	44
	4.1	Introduction	44
	4.1 4.2	Introduction Compressive Test	44 44
	4.1	Introduction Compressive Test Tensile Test for Reinforcement Y12	44
	4.1 4.2	Introduction Compressive Test	44 44
	4.1 4.2	Introduction Compressive Test Tensile Test for Reinforcement Y12 Stress-Strain Curve of Reinforcement Y 12 in Sulphuric 4.3.1	44 44 46
	4.1 4.2	Introduction Compressive Test Tensile Test for Reinforcement Y12 4.3.1 Stress-Strain Curve of Reinforcement Y 12 in Sulphuric Acid Solution at 30 Days Stress-Strain Curve of Reinforcement Y 12 in Sodium 4.3.2	44 44 46 47
	4.1 4.2	Introduction Compressive Test Tensile Test for Reinforcement Y12 4.3.1 Stress-Strain Curve of Reinforcement Y 12 in Sulphuric Acid Solution at 30 Days 4.3.2 Stress-Strain Curve of Reinforcement Y 12 in Sodium Chloride Solution at 30 Days Stress-Strain Curve of Reinforcement Y 12 in Sulphuric 4.3.3	44 44 46 47 49
	4.1 4.2	Introduction Compressive Test Tensile Test for Reinforcement Y12 4.3.1 Stress-Strain Curve of Reinforcement Y 12 in Sulphuric Acid Solution at 30 Days 4.3.2 Stress-Strain Curve of Reinforcement Y 12 in Sodium Chloride Solution at 30 Days 4.3.3 Stress-Strain Curve of Reinforcement Y 12 in Sulphuric Acid Solution at 60 Days Stress-Strain Curve of Reinforcement Y 12 in Sodium 4.3.4	44 46 47 49 51
·	4.1 4.2 4.3	IntroductionCompressive TestTensile Test for Reinforcement Y12Stress-Strain Curve of Reinforcement Y 12 in SulphuricA.3.1Stress-Strain Curve of Reinforcement Y 12 in SodiumChloride Solution at 30 DaysStress-Strain Curve of Reinforcement Y 12 in SodiumChloride Solution at 30 DaysStress-Strain Curve of Reinforcement Y 12 in SulphuricAcid Solution at 30 DaysStress-Strain Curve of Reinforcement Y 12 in SulphuricAcid Solution at 60 DaysStress-Strain Curve of Reinforcement Y 12 in SulphuricAcid Solution at 60 DaysStress-Strain Curve of Reinforcement Y 12 in SodiumChloride Solution at 60 Days	44 46 47 49 51 53
	4.1 4.2 4.3	IntroductionCompressive TestTensile Test for Reinforcement Y124.3.1Stress-Strain Curve of Reinforcement Y 12 in SulphuricAcid Solution at 30 DaysStress-Strain Curve of Reinforcement Y 12 in SodiumChloride Solution at 30 DaysStress-Strain Curve of Reinforcement Y 12 in SodiumAcid Solution at 30 DaysStress-Strain Curve of Reinforcement Y 12 in SulphuricAcid Solution at 60 DaysStress-Strain Curve of Reinforcement Y 12 in SulphuricAcid Solution at 60 DaysLoad Theory (Based on Eurocode 2)	44 46 47 49 51 53 56
	4.1 4.2 4.3 4.4 4.4	IntroductionCompressive TestTensile Test for Reinforcement Y12Stress-Strain Curve of Reinforcement Y 12 in Sulphuric4.3.1Acid Solution at 30 Days4.3.2Stress-Strain Curve of Reinforcement Y 12 in Sodium Chloride Solution at 30 Days4.3.3Stress-Strain Curve of Reinforcement Y 12 in Sulphuric Acid Solution at 60 Days4.3.4Stress-Strain Curve of Reinforcement Y 12 in Sodium Chloride Solution at 60 Days4.3.4Stress-Strain Curve of Reinforcement Y 12 in Sodium Chloride Solution at 60 DaysLoad Theory (Based on Eurocode '2)Deflection Theory (Based on ACI-318)	44 46 47 49 51 53 56 59

х

4.9	Conclusion	67
CHAP	TER 5 CONCLUSIONS AND RECOMMENDATIONS	68
5.1	Introduction	68
5.2	Conclusions	68
5.3	Recommendations	70
REFEF	RENCES	72
APPEN	NDICES	
Α	Theoretical Load-Deflection data (Based on ACI318)	76
В	Load-Deflection Data (Control Beam)	77
С	Load-Deflection Data (Beam E)	80
D	Load-Deflection Data (Beam A)	83
E	Load-Deflection Data (Beam NL)	85

t i

xi

xii

LIST OF TABLES

Table N	o. Title	Page
2.1	Tensile strength of 12 mm diameter bars	17
2.2	Mechanical properties of reinforcement	18
2.3	Summary of experimental results of reinforced concrete beam	19
2.4	Type of cracking on beam	20
2.5	Friction test result	27
2.6	Mechanical properties of steel reinforcement	28
2.7	Results of flexibility and impact test	29
2.8	Thickness and adhesive strength of acrylic coating	31
4.1	Result of compressive test for 7 days of curing for control sample	45
4.2	Result of compressive test for 28 days of curing for control sample	45
4.3	Result of tensile test for 30 days (acid solution)	48
4.4	Result of percentage of reduction in area for 30 days (acid solution)	48
4.5	Result of tensile test for 30 days (alkali solution)	50
4.6	Result of percentage of reduction in area for 30 days (alkali solution)	50
4.7	Result of tensile test for 60 days (acid solution)	52
4.8	Result of percentage of reduction in area for 60 days (acid solution)	52
4.9	Result of tensile test for 60 days (alkali solution)	54
4.10	Result of percentage of reduction in area for 60 days (alkali solution)	54
4.11	Result of flexural behaviour of each reinforced concrete beam	63
4.12	First crack, deflection and nature of failure	64
4.13	Ultimate load, deflection and nature of failure	64

LIST OF FIGURES

Figure No	D. Title	Page
3.1	Research flow chart	36
3.2	Concrete mix design computation and summary	38
3.3	Types of slump	39
3.4	Test set up	41
4.1	Coated reinforcement after immersed in acid solution	46
4.2	Coated reinforcement after immersed in alkali solution	46
4.3	Stress-strain for 30 days (acid solution)	47
4.4	Stress-strain for 30 days (alkali solution)	49
4.5	Stress-strain for 60 days (acid solution)	51
4.6	Stress-strain for 60 days (alkali solution)	53
4.7	Control bar failed at breakage point	55
4.8	Epoxy coated bar failed at breakage point	55
4.9	Acrylic latex coated bar failed at breakage point	55
4.10	Natural latex coated bar failed at breakage point	55
4.11	Singly reinforced section with rectangular stress block	56
4.12	Forces of reinforced concrete structure	58
4.13	Load-deflection curve	61
4.14	Crack Pattern of Control beam, C	66
4.15	Crack Pattern of E	66
4.16	Crack Pattern of A	66
4.17	Crack Pattern of NL	66

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LIST OF SYMBOLS

Ø	Diameter
c/c	Centre to centre
σ	Stress
Р	Load
А	Cross sectional area
3	Strain
ΔL	Change in length
Lo	Original Length
\mathbf{f}_{ck}	Compressive strength
\mathbf{f}_{cu}	Concrete strength
F_{cc}	Stress in concrete in compression
F _{st}	Stress in steel in tension
$\mathbf{f}_{\mathbf{y}\mathbf{y}}$	Shaer link strength
$\mathbf{f}_{\mathbf{yk}}$	Reinforcement strength
E _{st}	Steel strain
x	Neutral axis depth
Z	Lever arm
ϕ_{Bar}	Diameter of reinforcement of main bar
$m{ extsf{w}}_{ extsf{Link}}$	Diameter of reinforcement of shear link
n	Modulus of elasticity transformation coefficient for steel to concrete
E	Modulus of elasticity
$\mathbf{A}_{\mathbf{s}}$	Area of reinforcement
I _{cr}	Moment of Inertia of cracked, transformed section

I Moment of inertia

.

LIST OF ABBREVIATIONS

American Concrete Institute ACI American Society for Testing and Materials ASTM **British Standard** BS $Ca(OH)_2$ Calcium hydroxide Ferric oxide Fe₂O₃ Sodium chloride NaCl Sulphuric acid H_2SO_4 Carbonic acid Ca(OH)₂ HSLA High Strength Low Alloyed EIS Electrochemical Impedance Spectroscopy OCP Open circuit potential test LPR Linear polarization resistance test SiO_2 Silicon dioxide TiO₂ Titanium dioxide B_2O_3 Boron trioxide ZrO_2 Zirconium dioxide NRL Natural rubber latex С Control beam E Beam embedded with epoxy reinforcement Α Beam embedded with acrylic latex reinforcement NL Beam embedded with natural latex reinforcement SBR Styrene-butadiene rubber

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Concrete is relatively weak in tension but strong in compression so that it is a common practice to embedded steel reinforcement in concrete structure as steel reinforcement can resists tensile loads to improve the mechanical properties of concrete. Thus, the combination of concrete and reinforcement common practice and mainly used of reinforced prestressed concrete in the construction of structures and infrastructures from the beginning of the twentieth century. The component of reinforced concrete consist cement, aggregates, water, sand, mineral additions, and steel reinforcement.

Reinforced concrete (RC) could be presumed as a durable construction material with nearly maintenance-free under normal conditions and designed to meet the requirement relating durability, safety, aesthetics, and serviceability Besides that, the life span of reinforced concrete structures is predicted to have a life of more than hundred years. However, some of reinforced concrete structures have deteriorated excessively within 10 years due to aggressive environmental conditions. This led to several researches investigate and evaluate coating methods to prevent corrosion on the steel reinforcement.

However, coating reinforcement also may help effect toward the beam behaviour itself. Therefore, this chapter will discuss the background of study, problem statements, objectives, scopes and research significance. It will focus on the topics of flexural behaviour of reinforced concrete beam with variation of coated reinforcement.

1.2 BACKGROUND OF STUDY

Reinforcement corrosion has been identified as the dominant reasons for deterioration of reinforced concrete structures especially for those exposed to an oceanic environment, leading to premature failures prior the attainment of their design life. The corrosion reaction occurs due to chloride diffusion, presence of oxygen and water and carbonation to the embedded steel reinforcing bars in concrete. As stated by Rodriguez et al. (1997), more than 100 billion dollars are spent on the maintenance and repair of premature degradation of reinforced concrete structures due to corrosion deterioration of steel reinforcement on every year. In Canada, the cost of repairing the corrosion deterioration of reinforced concrete structures is about \$74 billion (Pei,2015).

As reported by (Selvaraj, Selvaraj, & Iyer, 2009), deterioration of concrete structures is a major issue due to corrosion of steel reinforcement and such a situation can be precluded to some extent by

- i. Using addition of inhibitive admixtures
- ii. Applying a exterior protective coating on the surface of concrete
- iii. Increasing the cover thickness
- iv. Implementing cathodic protection
- v. Coating the steel reinforcement embedded in concrete

From the perspective of economic and technical statement, coating on the steel reinforcement is most feasible, effective barrier as corrosion protective and cost-saving benefit among the corrosion protection methods (Selvaraj, Selvaraj, & Iyer, 2009). Coating materials for steel reinforcement are available over the world such as epoxy coatings, acrylic latex coatings, vinyl, polymer cement inhibitor coating, chlorinated rubber and polyurethane coatings. There are several experimental testing methods to evaluate the performance of coatings used for mitigation the corrosion of steel reinforcement in reinforced concrete structure such as surface characterization, pull out test, visual inspection, and electrochemical measurement.

This paper research discusses the flexural behaviour of reinforced concrete beam with variation of coated reinforcement such as epoxy coatings, acrylic coatings and natural latex coatings. It has been widely reported that epoxy-coated have been applied in steel reinforcement's surface to prevent corrosion of steel reinforcement on reinforced concrete structures since the 1970's.

One of the main obstacles encountered in the application of epoxy coated reinforcement is cracking of the coating at bar bends and damage during transportation and handling process (David G.Manning, 1996). The utilization of acrylic and natural latex used as polymer reinforcement coating have been devised to strengthen the reinforcing steel by mitigate the corrosion of reinforcing steel in concrete. The application of natural latex to steel reinforcement create a physical barriers to protect the steel reinforcement embedded in the concrete, as well as its safety, cheapness and hygienic properties due to freedom of organic solvent (Wang et al., 1998).

1.3 PROBLEM STATEMENT

Reinforced concrete is one of the principal building materials in which concrete behaves as a brittle material with low tensile strength and durability and generally embedded steel reinforcement in concrete to improve its mechanical properties. The widespread use of reinforced and prestressed concrete became common practice in the construction of structures from the beginning of the twentieth century.

Besides that, fiber reinforced polymer bars have been invested as an alternative used in construction industry instead of using steel reinforced bars. Nevertheless, application of fibre reinforced bars has limited success within construction industry due to the high capital cost and the requisite to change design methodologies (Pei, 2015). Therefore, steel reinforcement continues to be most widely produced reinforcing material for concrete structures.

ABSTRACT

Reinforced concrete structure is mainly used in the construction of structures and infrastructures from the beginning of the twentieth century. However, some of reinforced concrete structures have deteriorated excessively within 10 years due to aggressive environmental conditions. Application of coating materials as corrosion resistance have been applied to reduce the corrosion issues throughout the worldwide, thus this study was focus on the effect of variation coated reinforcement on the flexural behaviour of reinforced concrete beam. This study investigates the flexural behaviour of reinforced concrete beam embedded with three different types of coated reinforcement that was epoxy, acrylic latex and natural latex. Generally, the study indicated that epoxy and acrylic latex coated reinforcement did not affect the flexural strength of reinforced concrete beam as they have achieved flexural strength comparable to control beam. However, natural latex coated reinforcement was not suitable as new corrosion resistance material as it will affect the flexural strength of the sample by affecting the bonding strength between reinforcement and concrete. Besides that, the result of the study delineated that reinforced concrete beam embedded with epoxy and acrylic latex coated reinforcement has enhanced the load carrying capacity by 28.78 % and 12.33 % respectively, however reinforced concrete beam embedded with natural latex coated reinforcement has reduced the flexural strength by 8.41 % compared to control beam. This can be concluded that reinforced concrete beam embedded with epoxy coated and acrylic latex reinforcement can performed as effective corrosion materials without affecting the bonding strength between reinforcement and concrete.

ABSTRAK

Struktur konkrit bertetulang digunakan terutamanya dalam pembinaan struktur dan infrastruktur dari awal abad kedua puluh. Walau bagaimanapun, sebahagian daripada struktur konkrit bertetulang telah mengalami kemerosotan dalam tempoh 10 tahun dipengaruhi oleh keadaan persekitaran yang agresif. Penggunaan bahan-bahan salutan rintangan hakisan telah digunakan untuk mengurangkan masalah ini. Sehubungan dengan ini, kajian ini adalah memberi tumpuan kepada kesan pengubahan tetulang bersalut pada kelakuan lenturan rasuk konkrit bertetulang. Kajian ini menyelidik kelakuan lenturan rasuk konkrit bertetulang tertanam dengan tiga jenis tetulang bersalut iaitu epoksi, getah akrilik dan getah asli-Matlamat kajian ini adalah untuk menilai kesan pengubahan tetulang bersalut pada kapasiti lenturan rasuk konkrit bertetulang. Secara umumnya, kajian ini menunjukkan bahawa epoksi dan akrilik lateks bersalut tetulang tidak menjejaskan kekuatan lenturan rasuk konkrit bertetulang kerana mereka telah mencapai kekuatan lenturan yang setara dengan rasuk kawalan. Walau bagaimanapun, tetulang getah asli bersalut tidak sesuai digunakan sebagai salah satu pengganti bahan menahan hakisan kerana ia akan memberi kesan kepada kekuatan lenturan sampel dengan mempengaruhi kekuatan ikatan antara tetulang dan konkrit. Selain itu, hasil kajian ini bertetulang rasuk konkrit yang disaluti dengan epoksi dan akrilik lateks tetulang telah meningkatkan keupayaan sebanyak 28.78% dan 12.33%. Namun, bertetulang rasuk konkrit yang disaluti dengan tetulang getah asli telah mengurangkan kekuatan lenturan sebanyak 8.41% berbanding dengan rasuk kawalan. Ini dapat disimpulkan bahawa rasuk konkrit bertetulang yang bersalut dengan epoksi dan akrilik lateks tetulang boleh dilakukan sebagai bahan hakisan yang berkesan tanpa menjejaskan kekuatan ikatan antara tetulang dan konkrit.

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