FLEXURAL BEHAVIOR OF REINFORCED CONCRETE BEAM WITH VARIATION OF COATED REINFORCEMENT

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LIST OF SYMBOLS

$\emptyset$	Diameter
c/c	Centre to centre
σ	Stress
P	Load
A	Cross sectional area
ε	Strain
ΔL	Change in length
L_o	Original Length
f_{ck}	Compressive strength
f_{cu}	Concrete strength
F_{cc}	Stress in concrete in compression
F_{st}	Stress in steel in tension
f_{yy}	Shaer link strength
f_{yk}	Reinforcement strength
ε_{st}	Steel strain
$\varkappa$	Neutral axis depth
z	Lever arm
$\emptyset_{Bar}$	Diameter of reinforcement of main bar
$\emptyset_{Link}$	Diameter of reinforcement of shear link
n	Modulus of elasticity transformation coefficient for steel to concrete
E	Modulus of elasticity
A_s	Area of reinforcement
I_{cr}	Moment of Inertia of cracked, transformed section
I	Moment of inertia

LIST OF ABBREVIATIONS

ACI	American Concrete Institute
ASTM	American Society for Testing and Materials
BS	British Standard
$Ca(OH)_2$	Calcium hydroxide
Fe_2O_3	Ferric oxide
NaCl	Sodium chloride
H_2SO_4	Sulphuric acid
$Ca(OH)_2$	Carbonic acid
HSLA	High Strength Low Alloyed
EIS	Electrochemical Impedance Spectroscopy
OCP	Open circuit potential test
LPR	Linear polarization resistance test
SiO_2	Silicon dioxide
TiO_2	Titanium dioxide
B_2O_3	Boron trioxide
ZrO_2	Zirconium dioxide
NRL	Natural rubber latex
C	Control beam
E	Beam embedded with epoxy reinforcement
A	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 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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