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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)

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To my beloved mother and father

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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.

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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.