



AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
Structural Engineering

Restoration of Bond Strength for Fire-Damaged RC Elements

A Thesis submitted in partial fulfilment of the requirements
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Master of Science in Civil Engineering
(Structural Engineering)

by

Nesma Abd EL-Hameed Mohammed Ghazaly

Bachelor of Science in Civil Engineering
(Structural Engineering)

The Higher Institute of Engineering, El Shorouk Academy, 2013

Supervised By

Prof. Dr. Omar Aly Elnawawy
Professor of Reinforced Concrete Structures
Structural Engineering Department
Faculty of Engineering-Ain Shams University

Dr. Ahmed Rashad Mohamed

Assistant Professor
Structural Engineering Dept.
Faculty of Engineering
Ain Shams University

Dr. Mohamed Kohail Mohamed

Assistant Professor
Structural Engineering Dept.
Faculty of Engineering
Ain Shams University

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AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING

Thesis : Master of Science in Civil Engineering (Structural)
Researcher Name : Nesma Abdel Hameed Mohammed Ghazaly
Thesis Title : Restoration of Bond Strength for Fire Damaged RC
Elements

Examiners Committee

Signature

Prof. Dr. Gouda Mohamed Ghanem

Professor of Properties and Testing of Materials

Faculty of Engineering - Helwan University

Dean of the Higher Institute of Engineering El Shorouk Academy

.....

Prof. Dr. Ayman Hussein Khalil

Professor of Reinforced concrete structures

Structural Engineering Department

Faculty of Engineering - Ain Shams University

.....

Prof. Dr. Omar Aly Elnawawy

Professor of Reinforced concrete structures

Structural Engineering Department

Faculty of Engineering - Ain Shams University (Supervisor)

.....



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Supervision Committee

Signature

Prof. Dr. Omar Aly Elnawawy

.....

Professor of Reinforced concrete structures
Structural Engineering Department
Faculty of Engineering - Ain Shams University

Dr. Ahmed Rashad Mohamed

.....

Assistant Professor
Structural Engineering Department
Faculty of Engineering - Ain Shams University

Dr. Mohamed Kohail M. Fayez

.....

Assistant Professor
Structural Engineering Department
Faculty of Engineering - Ain Shams University

Statement

This thesis is submitted as a partial fulfillment of Master of Science in Civil Engineering (Structural Engineering), Faculty of Engineering, Ain shams University. The author carried out the work included in this thesis, and no part of it has been submitted for a degree or a qualification at any other scientific entity.

.

Student name

Nesma Ghazaly

Signature

.....

Date:

Researcher Data

Name	: Nesma Abdel Hameed Ghazaly
Date of birth	: 05 December 1991
Place of birth	: Cairo, Egypt
Last academic degree	: Bachelor of Science
Field of specialization	: Structural Engineering
University issued the degree	: El Shorouk Academy
Date of issued degree	: June 2013
Current job	: Structural Designer Engineer.

ABSTRACT

Reinforced concrete structures are vulnerable to high temperature conditions such as those during exposure to fire. The exposure of reinforced concrete (RC) structural elements to high temperature leads to loss in the mechanical properties of concrete and most importantly loss of bond between concrete and steel rebars. Recovering the structural integrity of heat-damaged RC elements requires extensive repair and rehabilitation works.

This thesis contains details of an experimental and analytical study conducted to evaluate the residual bond strength between concrete and steel rebars after subjected to elevated temperature and to investigate the effective repairing materials and techniques in restoring bond strength for heat –damaged concrete elements. The beam-end specimens were tested in three conditions, in ambient temperature, after subjected to elevated temperature of 800 °C, or after subjected to 600 °C. Steel fiber reinforced concrete and concrete were used as the repairing materials. Shallow and deep repair techniques were used as repairing techniques. The tested rebar was embedded in two concrete covers 30 and 50 mm. The embedded lengths 5Ø and 8Ø were conducted in this study.

The experimental results showed that the residual bond strength for the heated specimens was almost 26% and 32% at 800°C and 600°C respectively, of the original ultimate bond strength with significant increase in slip corresponding to the ultimate bond stress, especially when exposed to 800°C. The residual, restored and original bond strengths decreased with the increase of the bonded length from 5Ø to 8Ø. Although, they increased with the increase of the concrete cover. Considering the repair of heat- damaged specimens, the deep and shallow repair techniques using concrete restored almost 87% and 84% respectively, of the ultimate

bond strength. However, the restored bond strength almost 94% and 90% respectively, of the original ultimate bond strength for specimens repaired using steel fiber reinforced concrete. There is no difference in the restored bond strength for both repairing techniques for specimens exposed to ambient temperature. The effective repairing material used in this study, the steel fiber reinforced concrete (SF), it restored 96% and 91% of the original bond strength of specimens with 50 mm concrete cover.

To predict the bond stress – slip behavior for all specimens simple relationships are proposed based on experimental data and different parameters studied. The modified model for bond stress – slip curve, has been proposed by different researchers is suitable for reproduction of the ascending branch of the bond – slip curve. Key analytical results showed that the proposed equations give a good prediction of the bond strength for different specimens. Also, a good agreement between the modified proposed analytical model for bond stress- slip curve and the experimental data can be observed.

Keywords: Bond strength; Elevated temperature; Steel fiber; Deep repair; Bonded length; Heat damaged; Restoration.

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