Ain Shams University
Faculty of Engineering
Structural Engineering Department

Effect of Elevated Temperature on RC Pre-Cracked Beams Repaired and Strengthened Using Jackets of Glass Fiber Reinforced Cementitious Materials

By

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A Thesis

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(Structural Engineering)

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To my parents,
Husband, Son and sister

AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING

APPROVAL SHEET

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Thesis Title : Effect of Elevated Temperature on RC Pre- Cracked Beams Repaired and Strengthened Using Jackets of Glass Fiber Reinforced Cementitious Materials

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STATEMENT

This thesis is submitted to the Faculty of Engineering, Ain Shams University, as a partial fulfillment for the degree of Doctor of Philosophy in Civil Engineering (Structural Engineering).

The work included in this thesis was carried out by the author, and no part of it has been submitted for a degree or a qualification at any other scientific entity.

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Abstract of the Ph.D. Thesis Submitted by
Eng. Yasmin Hefni Abd El-Aziz

ABSTRACT

Due to various causes of deterioration during the service life of concrete structures, retrofitting is a major need aimed to improve their future performance. Jacketing has been considered as one of the most widely used methods of rehabilitation of deteriorated beams.

Fire attack is one of the important causes which may lead to serious symptoms of distress and in many cases to total collapse of the structure. Selecting cementitious materials of lower thermal conductivity for repair and strengthening of RC structural members will increase the thermal isolation of the reinforcement and thus improves the fire resistance of structures. Besides, using environmentally friendly cementitious materials as partial replacement of cement in concrete jackets will reduce concrete cost and environmental pollution as well as conserve natural resources.

The main objective of this research is to investigate experimentally and numerically the behavior of flexural cracked RC beams strengthened using jackets of activated high volume fly ash concrete with added glass fibers at normal temperature and after exposure to elevated temperatures.

The experimental investigation comprises two phases: Phase one was designed to select the desirable repair and strengthening material by investigating the effect of fly ash replacement ratio and glass fiber addition ratio on concrete strength at ambient temperature and after exposure to elevated temperatures. Besides, four methods of chemical activation were applied to overcome the low early strength of fly ash concrete and enhance its reactivity.

Phase two included testing of 18 reinforced concrete beams strengthened using jackets of the selected repair and strengthening material based on phase I results and loaded in four point loading test. The parameters of the study included level of damage induced before jacketing, effect of reinforcing the jackets, and effect of exposure to elevated temperatures according to ASTME119 fire rating curve.

The beams were of dimensions 100x200x2250 mm and main reinforcement of 2T12 mm. The jackets were three sided with thickness 50 mm. Measurements and observations included the cracking load, crack propagation, deflection, ultimate flexural capacity, beam ductility, and failure mode.

The results of the experimental investigation showed the efficiency of using concrete containing activated high volume fly ash (40%) and glass fiber (0.7 %) as an economic, environmentally friendly, and fire resistant repair and strengthening material. Besides, the results revealed its efficiency as an isolation material for concrete structures due to its lower thermal conductivity which helps in protecting the inner part and reinforcement of RC elements upon exposure to elevated temperatures.

Three-dimensional nonlinear finite element model has been developed using ANSYS software suitable for analyzing RC beams repaired and strengthened using jackets of activated fly ash and glass fibers and loaded with four point loading arrangement. The data used for the numerical analysis includes beam dimensions, reinforcement, materials properties at normal temperature and after exposure to elevated temperatures, and loading scheme. The parameters of the study included level of damage induced before jacketing, effect of exposure to fire and effect of reinforcing the jackets. The data obtained from the experimental investigation was used to verify the accuracy of the presented finite element model**.** The numerical analysis showed good agreement when compared with the experimental results.

Finite element thermal analysis was conducted using ANSYS software taking into considerations the thermal properties of different concrete types; density, thermal conductivity and specific heat. Multiple regressions analysis of temperature data attained from the thermal analysis was performed to present simple equations for predicting temperature distribution through normal weight and low weight concrete beam sections when exposed to elevated temperature according to ASTME119 fire rating curve.

In addition, this research offered mathematical equation to evaluate the equivalent thickness of concrete layer that give the same thermal resistance of different fire protection materials.

KEYWORDS

Fly Ash, Glass fibers, Repair, Ansys, Beams, Elevated Temperature, Thermal analysis, Concrete, Fire

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