Ain Shams University
Faculty of Engineering
Structural Engineering Department

BEHAVIOR OF TWO WAY RC SLABES STRENGTHENED WITH HYBRID FRP LAMINATES

By
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B.Sc. 2004, Structural Division
Civil Engineering Department
Ain Shams University

Thesis
Submitted in partial fulfillment of the
requirements of the degree of
MASTER OF SCIENCE
in
Civil Engineering (Structural)

Supervised by

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Cairo – 2010

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STATEMENT

This thesis is submitted to Ain Shams University, Cairo, Egypt, in partial fulfillment of the requirements for the degree of Master of Science in Civil Engineering (Structural).

The work included in this thesis was carried out by the author at reinforced concrete lab of the Housing and Building National Research center.

No part of this thesis has been submitted for a degree or qualification at any other university or institute.

Date : / / 2010

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ABSTRACT

In the last two decades, the use of advanced composite materials such as fiber reinforced polymers, (FRP), in strengthening reinforced concrete, (RC), structural elements have been increasing. Researches, design guidelines, and codes concluded that externally bonded FRP could increase capacity of RC elements efficiently. However, the linear stress-strain characteristics of FRP up to failure and lack of yield plateau have a negative impact on the overall ductility of the strengthened RC elements. Strengthening of two-way slabs with FRP in the two directions represents a challenge due to the anticipated reduction in the strength and ductility at onset of failure of FRP in one direction. Not only the linear characteristics of FRP will reduce the slab ductility but also the released energy caused by rupture or bond failure of FRP in one direction, which will affect the bond between the concrete and FRP in the other direction. Use of two types of FRP laminates, which consists of a combination of either carbon and glass fibers or glass and aramid fibers change the behavior of the material to a non-linear behavior (Blarabi et.al.1999) and (Hosny et.al.2005). This thesis aims to study the performance of reinforced concrete two-way slabs strengthened by FRP laminates in two directions.

The experimental program consists of a total of eight RC two-way slabs with overall dimensions equal to 1500 x 1500 x 70-mm with clear spans equal to 1400 x 1400-mm. The slabs were tested under distributed loading up to failure in order to examine its flexural behaviour. Different fiber types, orientation and different percentages of CFRP and GFRP were attached on the slabs to predict the best strengthening scheme. An

analytical model based on the stress-strain characteristics of concrete, steel and FRP was adopted and a good agreement was obtained with experimental results.

Keywords: CFRP, Composite material, GFRP, HFRP, Hybrid, Reinforced Concrete Strengthening and Two Way Slab.

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