شبكة المعلومات الجامعية

التوثيق الإلكتروني والميكروفيلم

بسم الله الرحمن الرحيم

HANAA ALY

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جامعة عين شمس

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HANAA ALY

Ain Shams University
Faculty of Engineering
Structural Engineering Department

Structural Performance of RC Beams Strengthened Using Prestressed Basalt FRP Bars

A Thesis submitted in partial fulfillment of the requirements for the degree of
Doctor of Philosophy in Civil Engineering
Structural Engineering Department
by

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Master of Science in Civil Engineering
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STATEMENT

This thesis is submitted as partial fulfillment of the Requirements for the degree of Doctor of Philosophy in Civil Engineering, Faculty of Engineering, Ain Shams University.

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

The candidate confirms that the work submitted is his own and that appropriate credit has been given where reference has been made to the work of others.

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ABSTRACT

Strengthening of existing concrete structures using FRP composites had spread worldwide due to the advantages offered by these composites in comparison with other traditional materials. Basalt fiber reinforced polymer (BFRP) is a newly developed material in this field that is expected to compete strongly among other types of FRP composites. This research aimed at studying the flexural behavior of RC beams strengthened with different techniques using BFRP bars to assess its efficiency for strengthening of RC beams in order to be introduced as alternative to other types of FRP bars. Moreover, this study investigates a new type of strengthening technique named prestressed near surface mounted (PNSM) technique, which is expected to offer lots of advantages owing to combining the two well-known "external prestressing" and "NSM" techniques. However, one of the main properties that affects the use of fiber reinforced polymer (FRP) composites in prestressing application is its long-term creep behavior. Accordingly, investigating the creep behavior of BFRP bars was set as one of the main objectives of this research.

In this study, the long-term creep behavior of basalt fiber reinforced polymer (BFRP) bars was investigated. The initial stress level and the fiber content presented in different diameters are the variables considered in this Phase. Firstly, the creep rupture stress, the creep strain, and the residual properties of BFRP were experimentally studied. Additionally, the ratio of creep rupture stress after million-hour (114 years) to the initial ultimate strength of BFRP bars was extrapolated based on statistical analysis of the experimental results to be 62.3% and 57.7% for 6 and 10 mm diameters of BFRP bars, respectively. The test results showed that the creep rupture stress of BFRP bars under different sustained stresses have linear

relationship with logarithm of time similar to other types of FRP bars. Additionally, the creep behavior of BFRP bars follows the three stages of creep strain similar to other glass and aramid FRP bars. Furthermore, based on the test results, the fiber content had proved to have a significant effect on the long-term creep behavior of BFRP bars, since the 6 mm diameter of higher fiber content exhibit lower creep strain and higher extrapolated creep rupture stress than 10 mm diameter. Finally, BFRP bars are recommended to be used in prestressing application as it showed a similar extrapolated creep rupture stress after 50 years comparable to aramid FRP which is accepted by the ACI440.4R-04 committee to be used in the prestressing applications.

On the other hand, this study aimed at investigating the structural performance of RC beams strengthened with different techniques using BFRP bars. The variables considered in this phase are the strengthening effect (unstrengthened and strengthened), the type of the FRP bars (BFRP and GFRP), the strengthening technique (NSM, Prestressed NSM, External Prestressing), the position of NSM bars (bottom and side), the initial prestressing level (30% and 50% of ultimate tensile capacity of BFRP bars), and the effect of restraining prestressing bars for external prestressing technique (restrained and unrestrained). The test results are discussed and analyzed in terms of cracking, yielding, and ultimate behavior, in addition to the crack pattern and failure modes.

The test results showed the efficiency of strengthening RC beams with different techniques using BFRP bars in enhancing the overall flexural behavior. Moreover, the test results demonstrated the priority of using BFRP bars compared to GFRP bars for strengthening of RC beams specially in prestressing techniques. Furthermore, the test results showed the positive impact of using deviators for enhancing the ultimate load

capacity of strengthened beams using external prestressed technique. Additionally, based on the test results, increasing the initial prestressing level recorded the highest improvement in the cracking and ultimate loads. What's more, the test results demonstrated the efficiency of newly developed technique (PNSM) for enhancing the cracking and ultimate load compared to other techniques but with sacrificing a portion of beam's ductility. Finally, based on a comparative analysis between the predicted and measured results, the analyzed results showed a good correlation reflecting the compatibility of applying the available recommendations presented herein for RC beams strengthened using BFRP bars.

Keywords: Flexure Strengthening; Basalt Fiber Reinforced Polymer (BFRP); Creep Behavior; Creep Rupture; External Prestressing; NSM; Prestressed NSM; Prestressed BFRP bars.

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