FACULTY OF ENGINEERING
STRUCTURAL ENGINEERING DEPARTMENT

FLEXURAL STRENGTHENING OF REINFORCED CONCRETE GIRDERS USING POST-TENSIONED CONCRETE JACKETS

Thesis

Submitted in partial fulfillment of the
requirements for the degree of

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by

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STATEMENT

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

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

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SUMMARY

Flexural strengthening of reinforced concrete girders is an important side of the construction industry and its importance is on the rise. There are different techniques used to study the response of repaired and strengthened girders, each with different advantages and drawbacks. External pre-stressing was initially developed for retrofitting of bridges, but now it is used for both retrofitting and in building new structures. Due to its simplicity and cost effectiveness, pre-stressed concrete bridges with external pre-stressing are becoming popular.

This study discusses the flexural behavior of reinforced concrete girders strengthened using post-tensioning embedded in concrete jackets. The concept benefits from the external jacket to help increase the cross-section inertia as well as to host the post-tensioning tendons without the need of external deviators. This study incorporated two phases namely, experimental and analytical phases.

The experimental phase of this study was conducted on two stages. The first stage deals with girders loaded on their original section firstly and then strengthened with the post-tensioned jacket and loaded to failure, while the second had the girders that were strengthened before being subjected to loads. In addition to the stage of jacket introduction, the difference between the original girder and the jacket's concrete compressive strength was also studied. The experimental results showed that both the strength and the stiffness of the girders were enhanced significantly, this means that this technique can be used for mitigating the effect of increased deflections as well as loss of strength, the stage at which the jacket is introduced slightly affects the strength and stiffness of the girders.

In the analytical phase of the study, a numerical model was built using the finite element method to simulate the response of the tested girders in the experimental phase. The analytical results show a very good match and correlation with the experimental results. A parametric study was developed on the flexural behavior of strengthen girders to investigate the effect of the damage level of girder before strengthening as well as increasing the pre-stressing ratio, also to study the effect of increasing the compressive strength of the original girder. The analytical results showed that, the stiffness and the

strength of the strengthened girders increase with the decrease of the damage level for the original girder, and the load carrying capacity increases by increasing the percentage of pre-stressing area to the total cross-sectional area. Also, it was observed that the stiffness of the girders was enhanced significantly by increasing the concrete compressive strength of the original girder.

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ABSTRACT

This thesis discusses the flexural behavior of reinforced concrete girders strengthened using post-tensioning strands embedded in concrete jackets. The concept benefits from the external jacket to help increasing the cross-section inertia as well as to host the post-tensioning tendons without the need of external deviators. This results a significant enhancement to the strength and stiffness of the original girder. This technique may be used to strengthen severly deflected girders or cracked beams in buildings and bridges. This study incorporated two phases namely, experimental and analytical phases.

The experimental phase of the study was conducted on two stages the first deals with two girders loaded on their original section firstly and then strengthened with the jacket and loaded to failure, while the second had the two girders that were strengthened before being subjected to loads. In addition to the stage of jacket introduction, the difference between the original girder and the jacket's concrete compressive strength was also studied. Key test results first proved that both the strength and the stiffness of the girders were enhanced significantly. Secondly, it was found that the stage at which the jacket is introduced slightly affects the strength and stiffness of the girders. Finally, increasing the jacket concrete compressive strength may result in a slight increase in the strength by about 10% of the original girder capacity.

In the analytical phase of the study, a numerical model was built using the finite element method to simulate the response of the tested girders in the two experimental stages. This thesis presents findings of the experimental program as well as the comparison with the analytical results of the model which shows a very good match and correlation. A parametric study was developed on the