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Enhancing the Torsional Capacity of RC Flanged Beams with Glass FRP Strengthening: An Analytical and Experimental Investigation

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Abstract: *The degradation of the environment, increased service demands, aging infrastructure, poor construction materials, and the need for seismic retrofitting have led to the repair and rehabilitation of existing structures. Fiber reinforced polymers (FRPs) have emerged as a successful solution in such applications due to their lightweight, high strength, and durability. While previous research has focused on torsional strengthening of solid rectangular reinforced concrete (RC) beams, there is limited literature on the torsional behavior of RC T-beams.*

Keywords: Torsional Strengthening

I. INTRODUCTION

The degradation of the environment, increased service demands, aging infrastructure, poor construction materials, and the need for seismic retrofitting have led to the repair and rehabilitation of existing structures. Fiber reinforced polymers (FRPs) have emerged as a successful solution in such applications due to their lightweight, high strength, and durability. While previous research has focused on torsional strengthening of solid rectangular reinforced concrete (RC) beams, there is limited literature on the torsional behavior of RC T-beams. This study aims to enhance the understanding of the behavior of torsional strengthening in solid RC flanged T-beams through experimental testing. The objective is to evaluate the effectiveness of epoxy-bonded glass FRP (GFRP) fabrics as external transverse reinforcement for RC T-beams subjected to torsion.

II. LITERATURE REVIEW

1. Torsional Strengthening of RC Beams Previous studies have investigated various strip layouts and types of fibers for torsional strengthening of solid rectangular RC beams. Analytical models have been developed to predict torsional behavior and validate experimental work. These studies have significantly contributed to the understanding of torsional strengthening techniques.
2. Torsional Strengthening of RC T-Beams However, research specific to torsional strengthening of RC T-beams is scarce. RC T-beams differ from rectangular beams due to the presence of a flange, which poses challenges in terms of torsional behavior. To date, the effect of the flange on resisting torsion and the impact of altering the flange width have not been extensively studied. This study aims to address these gaps in knowledge.

III. EXPERIMENTAL PROGRAM

1. Test Specimen Preparation The experimental program involves the analysis and design of RC T-beam specimens for torsion, similar to RC rectangular beams, with the neglect of the effect of concrete on the flange, as per code provisions. The controlled beams are designed with varying flange widths to investigate the influence of the flange on torsional behavior. Different strengthening configurations and fiber orientations are also examined.

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2. Strengthening with GFRP The study focuses on the use of epoxy-bonded GFRP fabrics as external transverse reinforcement for RC T-beams subjected to torsion. The GFRP fabrics are applied to strengthen the T-beams, while control beams without FRP reinforcement are also tested for comparison.
3. Experimental Testing and Analysis The torsional behavior of the strengthened beams is evaluated through experimental testing using a specialized torsion testing apparatus. Torsional load is applied incrementally until failure, and torsional capacity and behavior are recorded. Torsional results from the strengthened beams are compared to the experimental results of the control beams without FRP reinforcement.

IV. RESULTS AND DISCUSSION

1. Experimental Findings The experimental results demonstrate a significant improvement in the torsional behavior of all GFRP-strengthened RC T-beams compared to the control beams. The strengthened beams exhibit higher torsional capacity and stiffness, indicating the effectiveness of the GFRP reinforcement in enhancing torsional strength.
2. Analytical Model Validation To validate the experimental findings, an analytical model developed by A. Deifalla and A. Ghobarah is utilized. The model accounts for the GFRP reinforcement and accurately predicts the torsional behavior of the strengthened beams. The comparison between experimental and analytical results confirms good agreement, further supporting the validity of the experimental findings.

V. CONCLUSION

This study investigates the torsional behavior and strengthening of RC flanged T-beams using epoxy-bonded GFRP fabrics as external transverse reinforcement. The experimental results demonstrate a remarkable improvement in the torsional behavior of all GFRP-strengthened beams compared to the control beams. The analytical model developed by A. Deifalla and A. Ghobarah successfully predicts the behavior of the strengthened beams and validates the experimental findings. The study contributes to the understanding of torsional strengthening techniques for RC T-beams and provides insights for the design and rehabilitation of existing structures.

VI. RECOMMENDATIONS FOR FUTURE RESEARCH

Based on the findings of this study, several recommendations for future research can be made:

Investigate the long-term durability and performance of GFRP-strengthened RC flanged T-beams under various environmental conditions.

Explore the influence of different strengthening configurations and fiber orientations on the torsional behavior of RC T-beams.

Conduct parametric studies to assess the effect of varying flange widths and other geometric parameters on torsional strengthening.

Consider economic feasibility and practicality for large-scale implementation of GFRP strengthening techniques in real-world structures.

Continued research in torsional strengthening of RC flanged T-beams will advance knowledge in the field and contribute to the development of more effective and sustainable strategies for repairing and rehabilitating existing structures.

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