

Chapter 6

Conclusions and Recommendations

6.1 Conclusions

The following conclusions were drawn from the experimental testing and theoretical analysis of the research.

6.1.1 Flexural Load Capacity

The load capacity of the reinforced concrete beam was increased by properly applying CFRP laminates. The load capacity of a reinforced concrete beam with a steel reinforcement ratio of $0.5\rho_b$ increased as much as 19% and 12% with $0^\circ/90^\circ$ and $\pm 45^\circ$ orientation, respectively. The research indicated beams applied with the $0^\circ/90^\circ$ orientation provide a larger increase in load capacity than beams with the $\pm 45^\circ$ orientation.

6.1.2 Ductility

The ductility of the reinforced concrete beam was reduced by properly applying CFRP laminates. The ductility index of a reinforced concrete beam with a steel reinforcement ratio of $0.5\rho_b$ decreased by as much as 32% and 6% by properly applying $0^\circ/90^\circ$ and $\pm 45^\circ$ orientation, respectively. The research indicated $\pm 45^\circ$ CFRP orientation provided less of a reduction in ductility when applied properly to a reinforced concrete beam than the $0^\circ/90^\circ$ CFRP orientation. No trend was seen between ductility and the addition of more layers of either orientation.

6.1.3 Ductility Measurement Methods

The energy measurement method produced lower values than the conventional measurement method for the ductility index of the strengthened beams. The ductility index for the control beam was similar using the two measurement methods. This could imply the conventional ductility measurement method overestimates the actual ductility of a CFRP strengthened reinforced concrete beam.

6.1.4 Theoretical Flexure Behavior Model

The theoretical model accurately predicted the moment-deflection behavior for a majority of the $0^\circ/90^\circ$ and $\pm 45^\circ$ composite beams. The tested moment at yielding of the steel reinforcement and the tested maximum moment were predicted within 5% accuracy for every test specimen. However, the model was less accurate in the predictions of the deflections. This was especially evident with the deflections at yielding of the steel reinforcement.

6.2 Recommendations

The following recommendations are based on the experimental testing and analytical analysis of the research:

1. Since only seven specimens were used in this study, a larger number of specimens should be tested for more accurate conclusions to be drawn.
2. The research could not determine a relationship between ductility and the increase of CFRP layers. More research should be conducted on this topic.
3. The critical portion of the composite beam is the concrete/CFRP joint. This should be examined extensively including use of different epoxies, surface preparations, and application processes.
4. This research focused on the flexural behavior of the composite beams. Other behaviors, such as shear and fatigue, should be considered.
5. The theoretical flexure model did not take into account the debonding of the CFRP from the concrete or the actual modulus of elasticity of the steel reinforcement. These should be developed into the model for more accurate predictions of deflection.