GFRP Reinforced Concrete Beams

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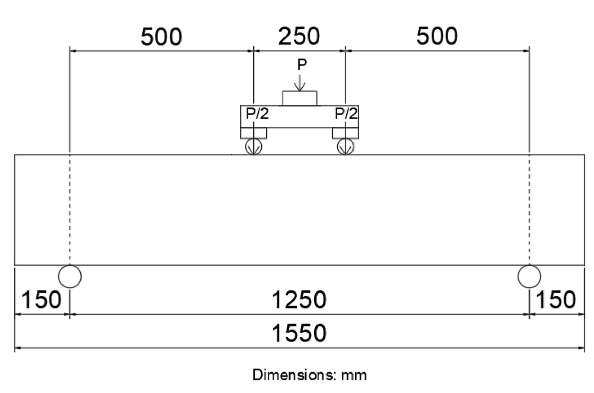
Introduction

Glass Fibre Reinforced Polymer's (GFRP's) are a lightweight, high strength, non-magnetic, and corrosion resistant material that can be used to reinforce concrete members in civil infrastructure. In Canadian infrastructure, corrosion is a major durability concern due to the concrete reinforcements seasonal contact with de-icing salts; for this reason, GFRP's corrosion resistance is an attribute that naturally makes it an ideal replacement to conventional steel rebar. As GFRP's can be considered a relatively new reinforcing material, an uncertainty remains as to how a variation of parameters can precisely impact the materials mechanism of failure under a sustained shear load. This study attempts to provide experimental evidence to support a method that can accurately predict the shear strength of GFRP reinforced concrete. The parameter focused on in this research experiment was how a varying configuration of the GFRP reinforcement will impact the shear strength of the concrete. A monitoring system known as Digital Image Correlation will be used to effectively model the crack formations as the beams are subjected to a shear load.

Methodology

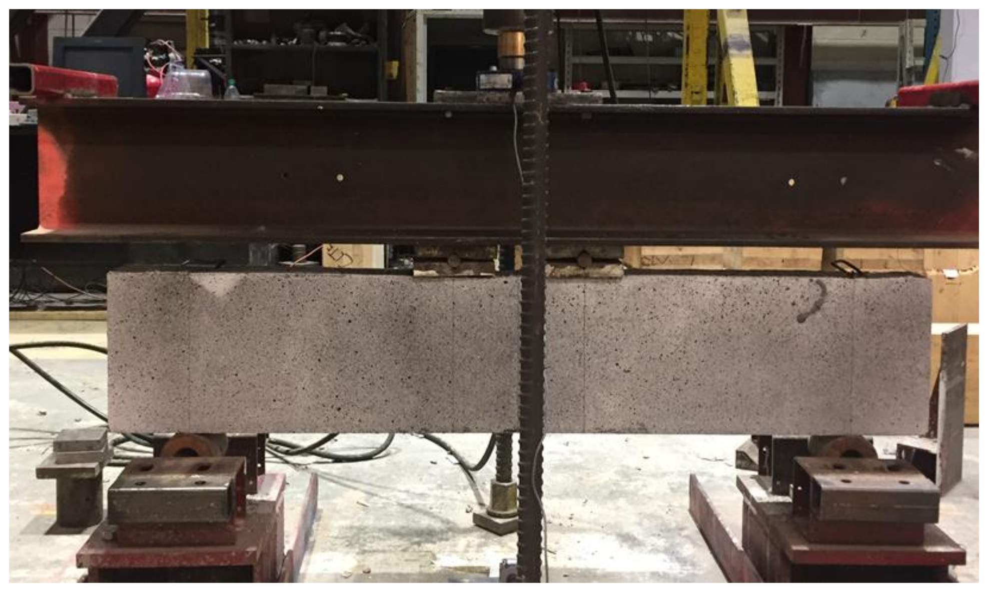


Six concrete beams were casted for experimental analysis. 3 beams were designed with two longitudinal GFRP reinforcements of 12.5mm along the bottom. The other 3 beams were designed with a GFRP stirrup configuration of two longitudinal reinforcements of 12.5mm along the top and bottom, and eight transverse components at a spacing of 150mm.

These six specimens were loaded with a four-point bending configuration as illustrated. The deformations in millimetres were recorded as the load applied on the specimens was increased. This experimental data can then be used to generate load-deflection graphs to further analyse the comparisons between the regular, and stirrup configured specimens.

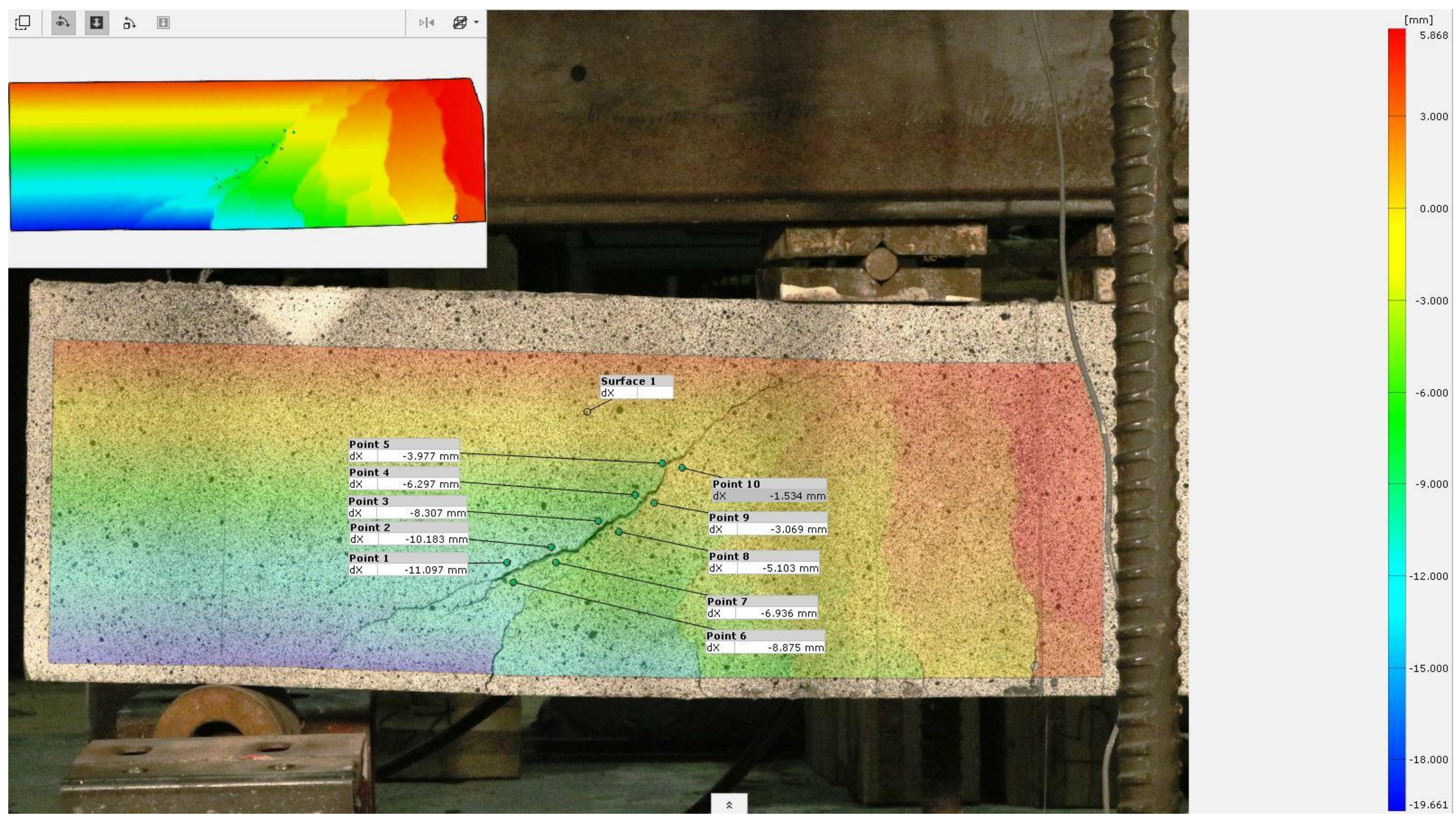
Results

Concrete beam prior to testing

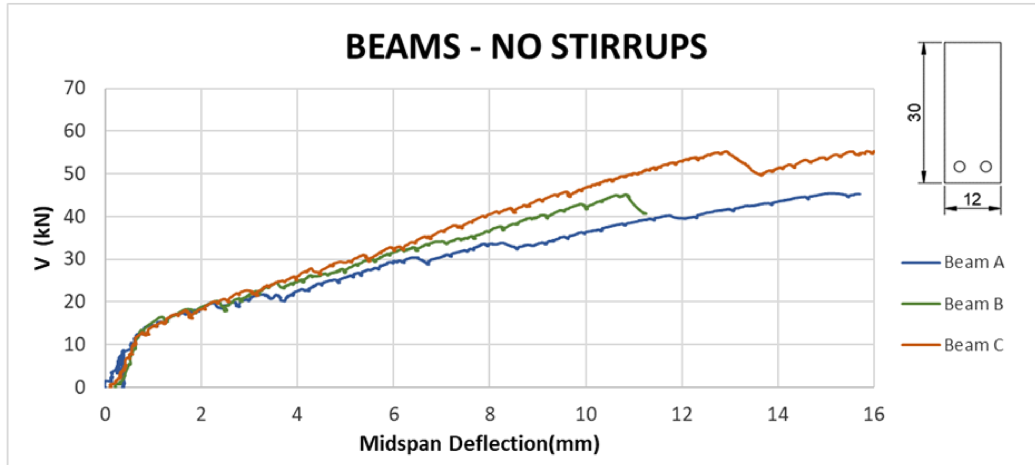


Concrete beam after testing

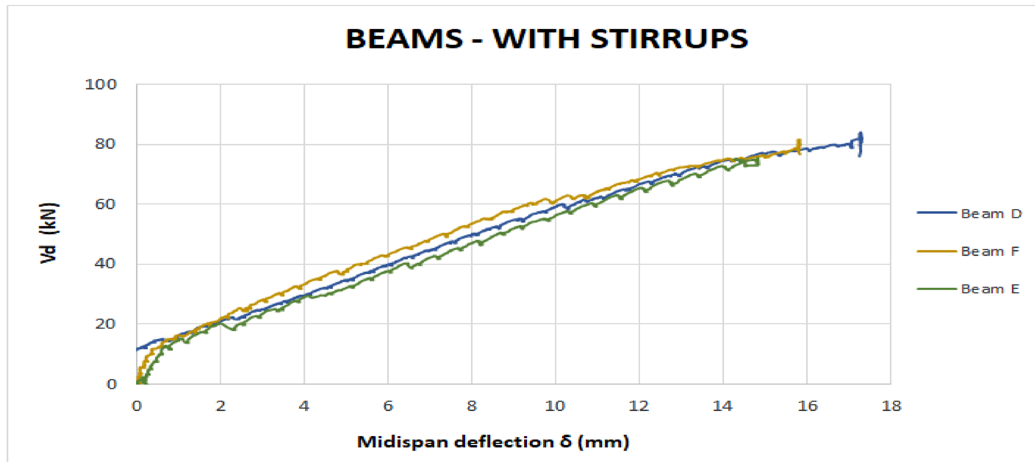
DIC Analysis



DIC (Digital Image Correlation) is an analysis technique that was used to measure the deformation of the concrete beams. This analysis involved taking stationary photographs of the beams as they deformed. A singular point on the beam can be expected to experience a displacement vector as fractures begin to spread under the shear load. Cross-correlation between consecutive photographs was used to quantify, and visually map this displacement.



Beams	F_{Max} (mm)	V_{Max} (mm)	Max Deflection (mm)	F_C (Mpa)
Beam A	90,877	45,439	15,085	33
Beam B	108,298	54,149	11,585	33
Beam C	120,439	60,219	24,316	33



Beams	F_{Max} (mm)	V_{Max} (mm)	Max Deflection (mm)	F_C (Mpa)
Beam D	168,140	84,070	17,264	27
Beam E	192,386	96,193	17,667	27
Beam F	163,140	81,570	15,798	27

Conclusions

In conclusion it can be said that the results of this research have been successful. Complications could have arose throughout the casting and set-up phase of the beams; however, as proper safety precautions were taken throughout the duration of this research, it allowed for the generation and testing of successful specimens. Upon analyzing the data, it can be noted that on average the beams with stirrups were able to withstand a larger maximum shear force and total mid-span deflection than the beams without the stirrups. Through DIC analysis of the beams with stirrups, it can be seen that cracks formed from the corners and spread at a steeper angle than those without the stirrups. Furthermore, through post-experimental analysis it was observed that failure was governed by the rupture of the stirrup. The results from this experimental will be used in correlation with push-off and dowel action tests, to generate a rational shear model to track the crack kinematics of GFRP reinforced concrete beams.

References

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