Early-Age Cracking in Bridge Deck Slabs Reinforced with GFRP Bars

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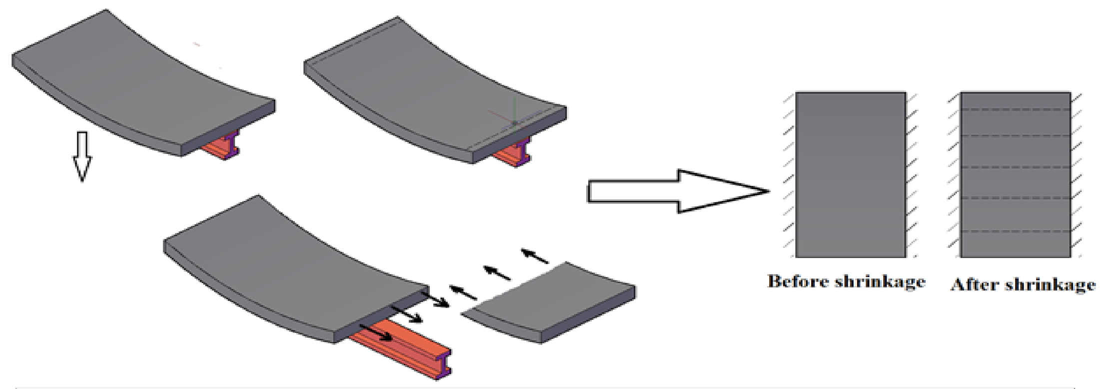
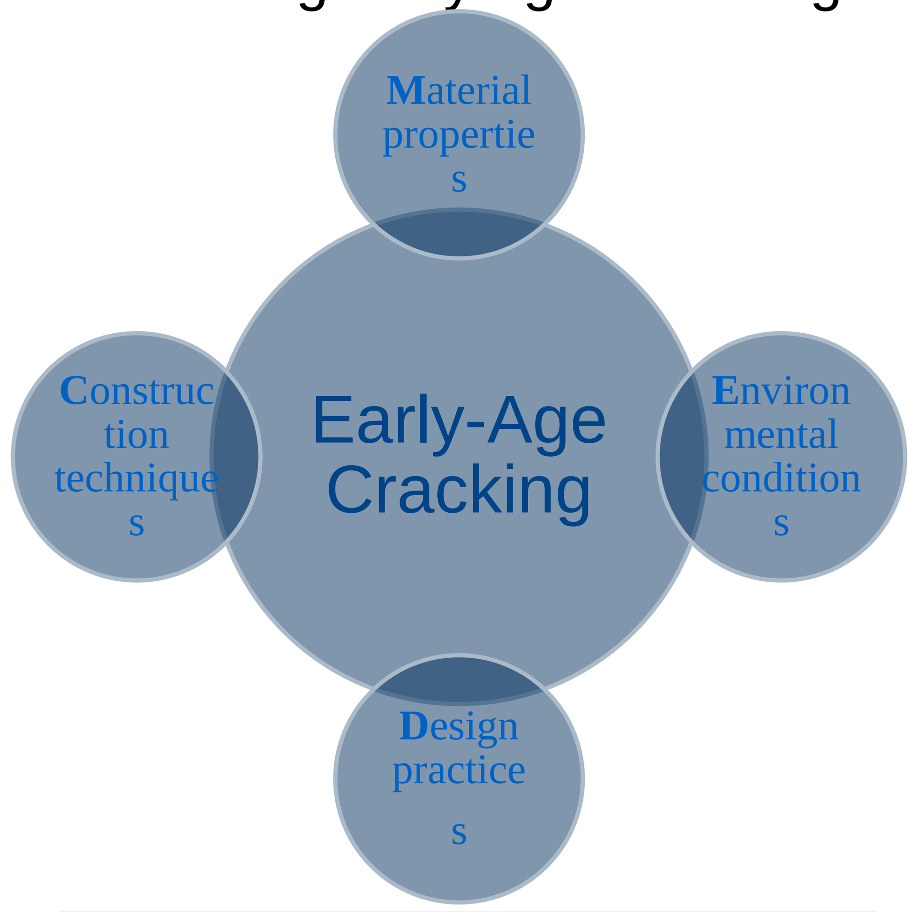
INTRODUCTION

In restrained bridge deck slabs, volume changing due to shrinkage and temperature can cause tensile stresses large enough to produce cracks.



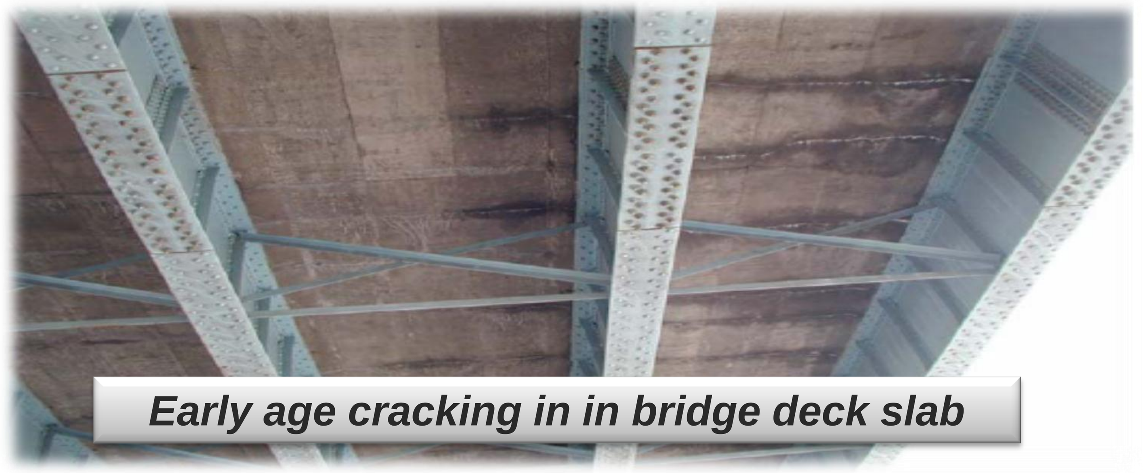
Early age cracking mechanism in bridge deck slab

Factors affecting early age cracking:



Effective factors on early age cracking

Full-depth cracks are generally considered the most severe form of bridge deck slab cracking because they are usually very wide allowing moisture, UV, and aggressive chemicals to infiltrate the concrete rapidly.



Early age cracking in in bridge deck slab

Recently, non-corrodible glass fiber reinforced polymer (GFRP) bars have been used as reinforcement for concrete structures to mitigate the corrosion problem of conventional steel.

FRP application in RC bridge deck slabs

Since GFRP bars have a lower modulus of elasticity than steel, concrete elements reinforced with similar amounts of GFRP exhibit larger deformation leading to wider cracks. This is an on-going research program, which is considered a pioneer study, investigating the details of longitudinal GFRP reinforcement in bridge deck slabs.

PROBLEM DIFINITION

Many codes and guidelines are based on modifying corresponding formulas originally developed for steel bars and take into account the difference in properties and behaviour between FRP and steel material.

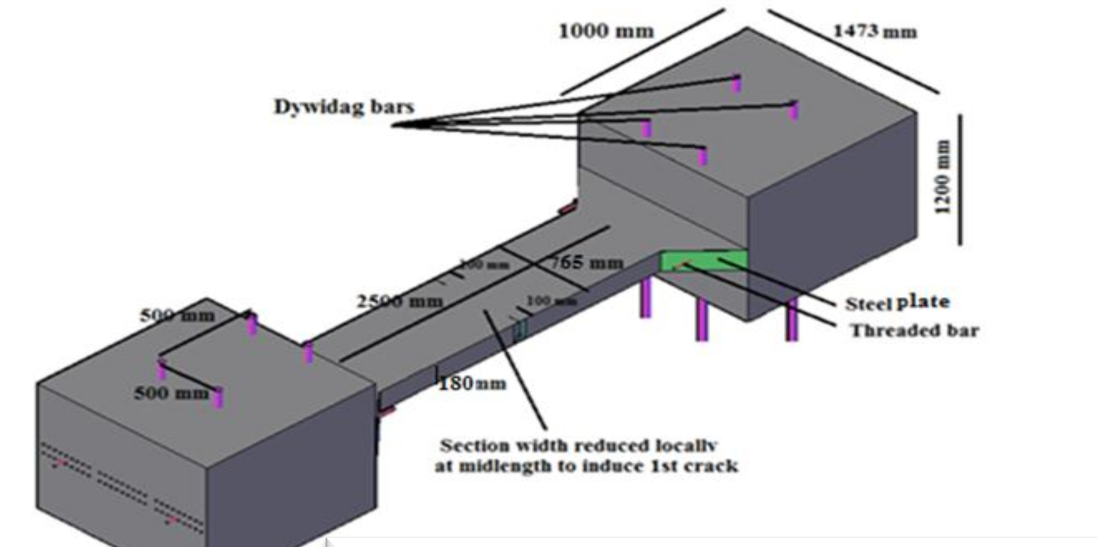
Code [Clause]	Rebar Type	Area and/or Ratio	Formula	Spacing	Comments from codes
ACI 440.1R-06 [Chapter 10]	FRP	A_{frp}/d	$= 0.0018 \times (60.000/f_{fu}) \times (Es/Ef)$ ≤0.0036	≤3h ≤12”	No experimental data are available for the minimum FRP reinforcement ratio for shrinkage and temperature.
CHBDC,(CSA 2006)[16.8.8.1]	GFRP	A_{frp}/d	≤0.0035 (based on empirical method for the longitudinal bars in the bottom assembly and the transverse and longitudinal bars in the top assembly)	≤300 mm	
CSA/S806-12 [8.4.2.3]	FRP	A_{frp}	= 400EF/Ag > 0.0025 Ag mm^2 (in each of the two orthogonal direction)	≤3h ≤300 mm	

OBJECTIVE

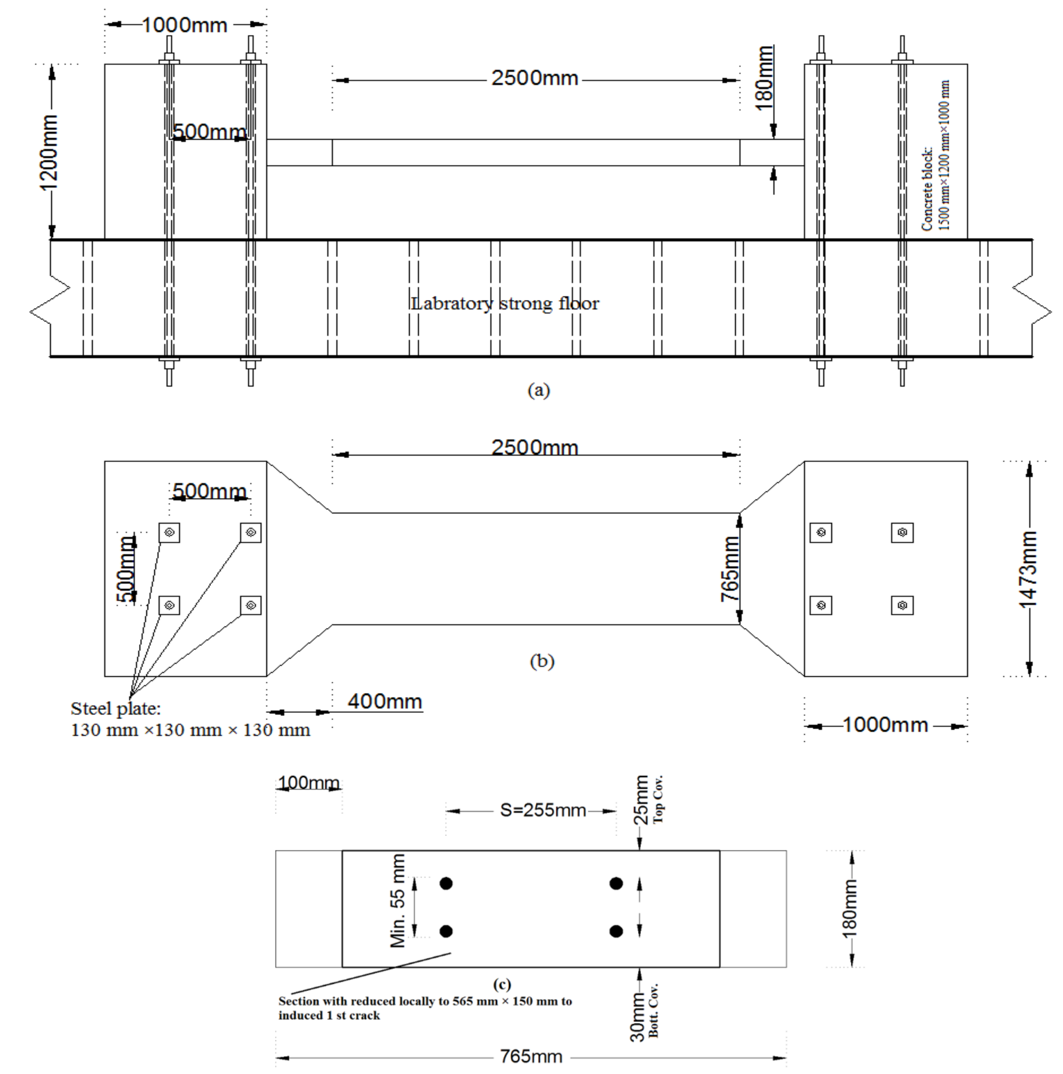
The main objective of this study is to reach a suitable design methodology to control early-age transverse cracking in GFRP-RC deck slabs.

EXPERIMENTAL PROGRAM

The experimental investigation in this study includes eight cast-in-place GFRP-RC restrained deck slab prototypes. The prototypes measure 2500-mm long × 765-mm wide × 180-mm thick (Full size as per Section 16 of the Canadian Highway Bridge Design Code).



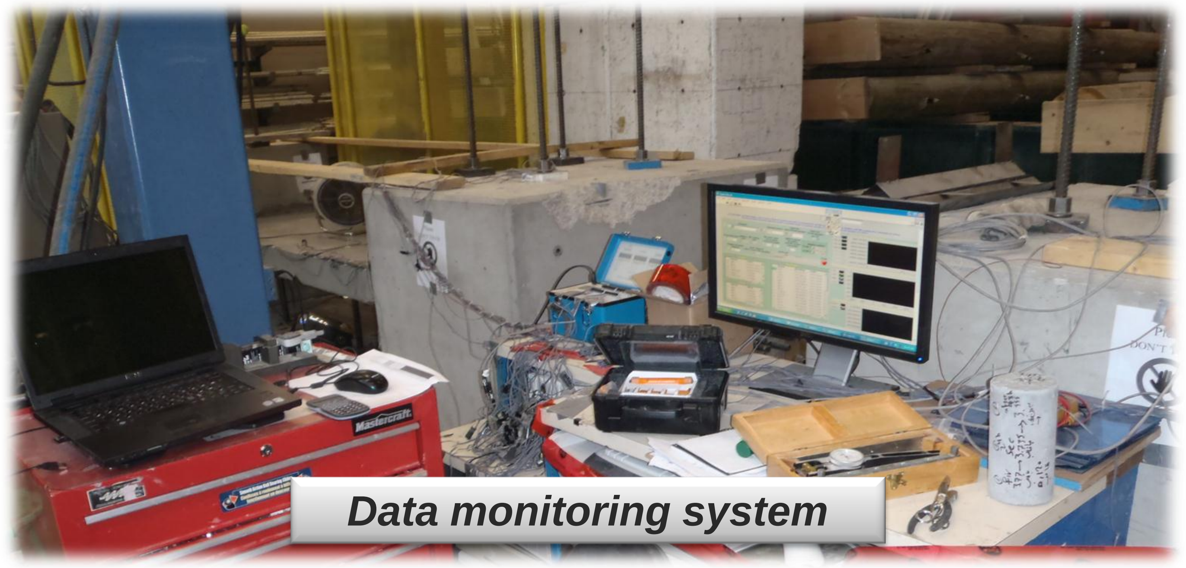
Schematic view of the test specimen



a-Side view, b-Top view, and c-Cross section A-A

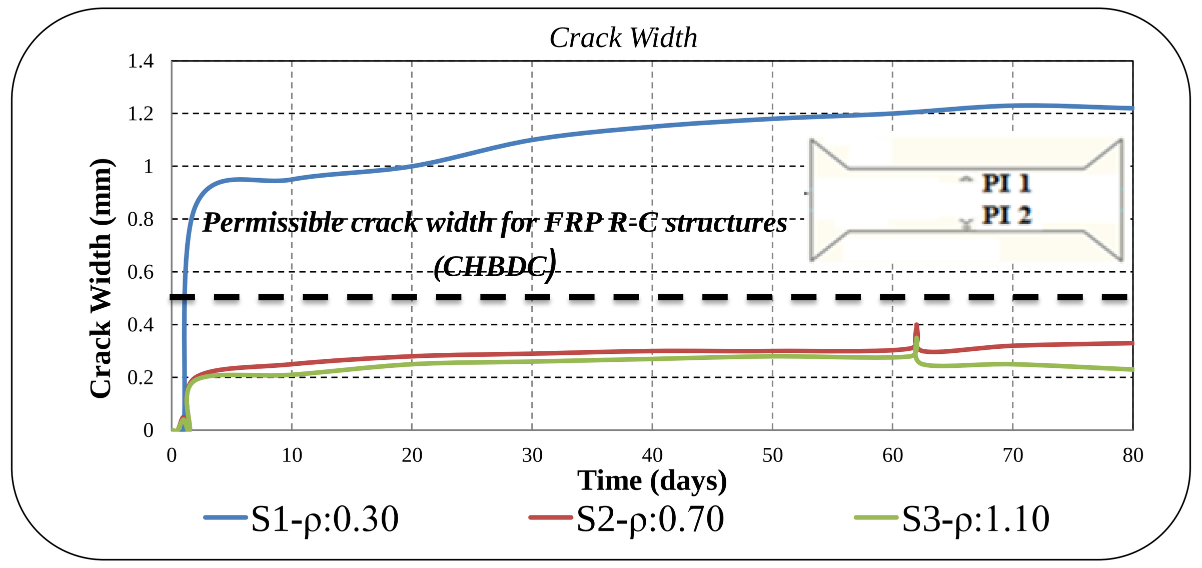
Formwork and reinforcement

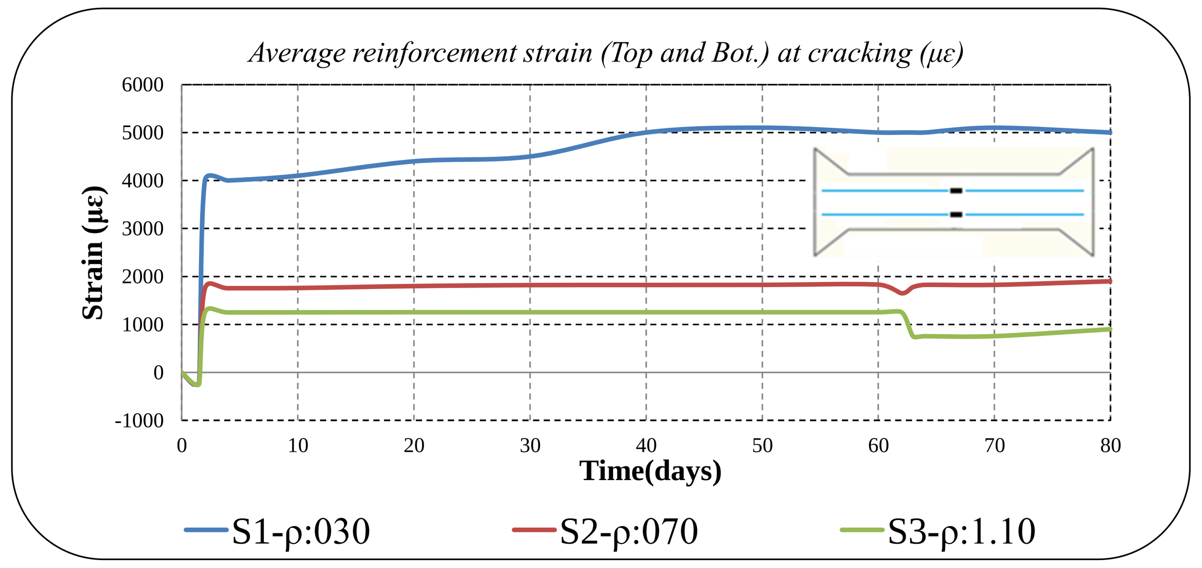
Concrete casting



Data monitoring system

TEST RESAULTS & CONCLUSION





- ✓ As the GFRP reinforcement ratio increases from **0.3%** to **0.7%** and to **1.1%**, the total average crack width decreases from **0.92** mm to **0.31** mm and to **0.22** mm, respectively.
- ✓ The average strain readings of all instrumented bars (top and bottom) in vicinity of the crack decreases from **3750** με to **1850** με and to **800** με as the reinforcement ratio increases from **0.3%** to **0.7%** and to **1.1%**.