COLLEGE OF ENGINEERING
THE CHARLES E. VIA, JR. DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING
VIRGINIA TECH

VTRC
Virginia Transportation Research Council

aci CONCRETE CONVENTION

Performance of welded grid reinforcement as crack control in end zones of pretensioned bulb-tee beams

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Agenda

1. Introduction
2. Tensile Testing
   a) Goals
   b) Testing Setup
   c) Results
3. Pretensioned concrete bulb-tee beam (PCBT) Testing
   a) Goals
   b) Implementation
   c) Results
4. Conclusions and Future Work

Introduction

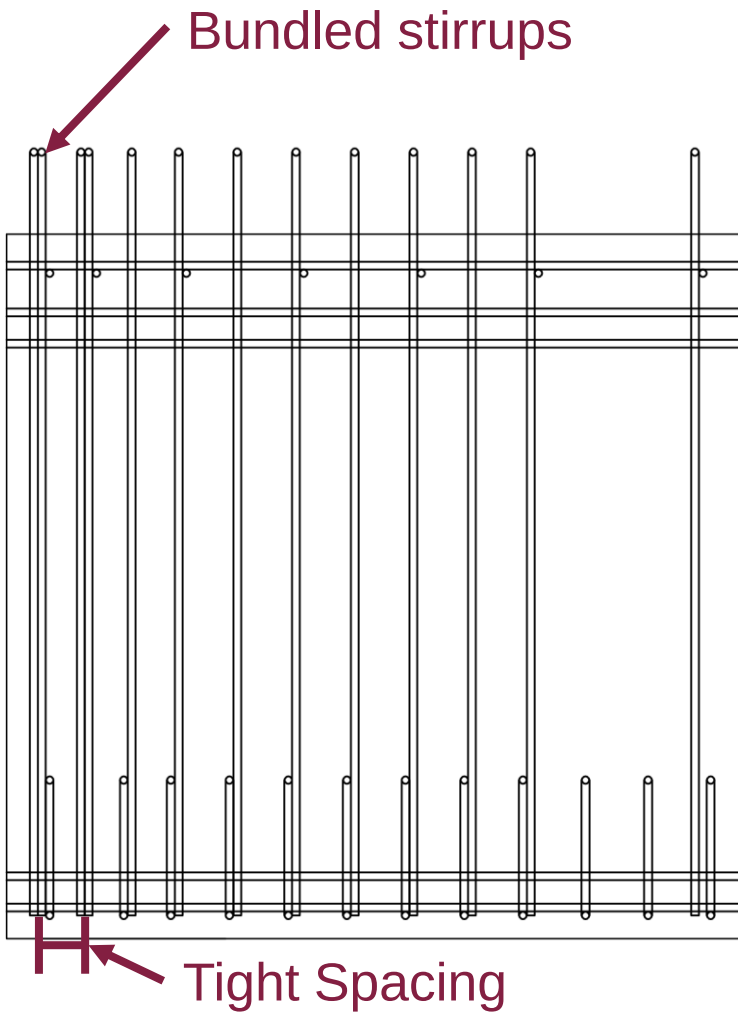
PCBT End Zone Cracking

- During strand detensioning and beam lifting operations large transverse tensile stresses occur
- As a result, cracks often occur posing a durability concern
- Current design codes often do not adequately resist end zone cracking

Introduction

Motivation

- Virginia follows design tables created for the Virginia Department of Transportation in mid-2000s
- Current methodology works reasonably well, but reinforcement congestion and cracks still occur

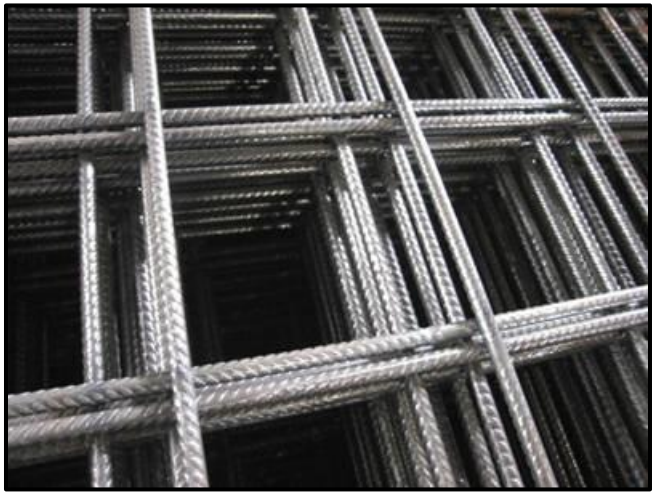


Introduction

Motivation - WGR

- Limited studies suggest that welded grid reinforcement (WGR) may control cracking better than tied reinforcement
- WGR can be made of deformed bars, with large diameter bars

(ENZAR, n.d.)

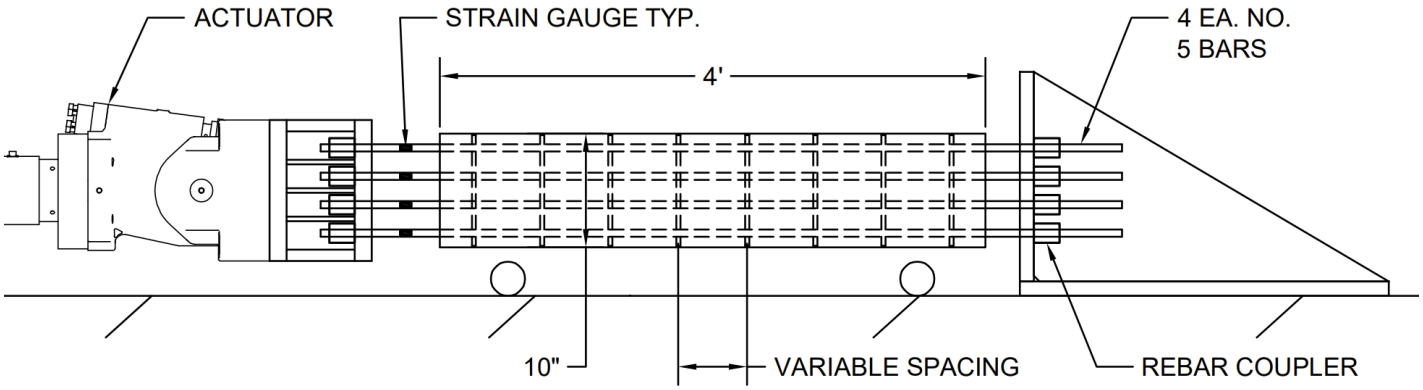


(ENZAR, n.d.)

Tensile Testing

Goals/Testing Setup

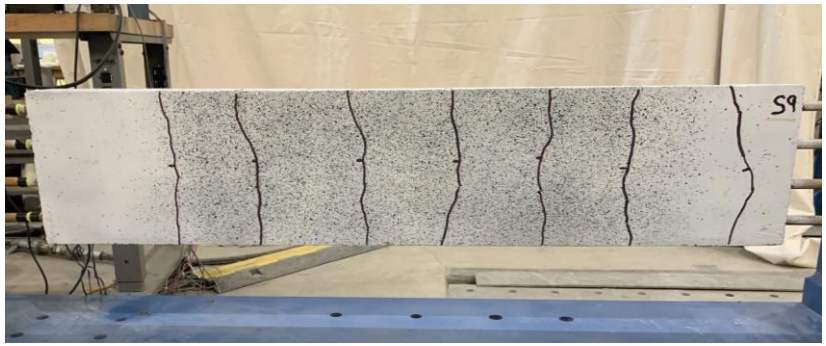
- Evaluate how the cracking behavior changes based on:
  - Cross wire spacing
  - Cross wire diameter
  - Longitudinal wire stress levels



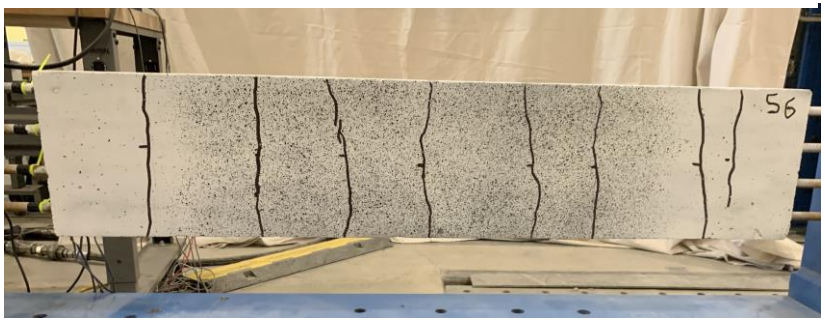
Tensile Testing

Results – photos of testing and preliminary takeaways

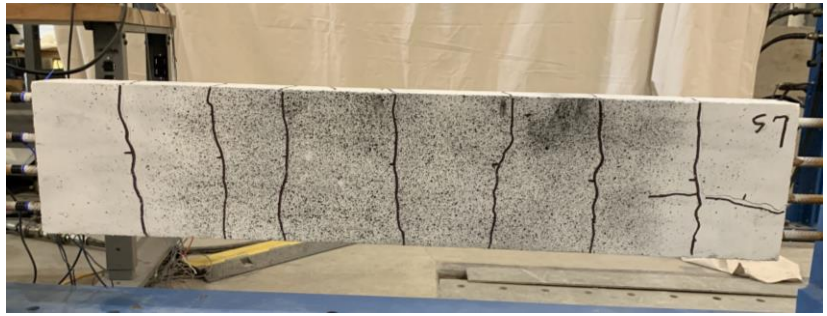
D4 @ 3”



D20 @ 6”

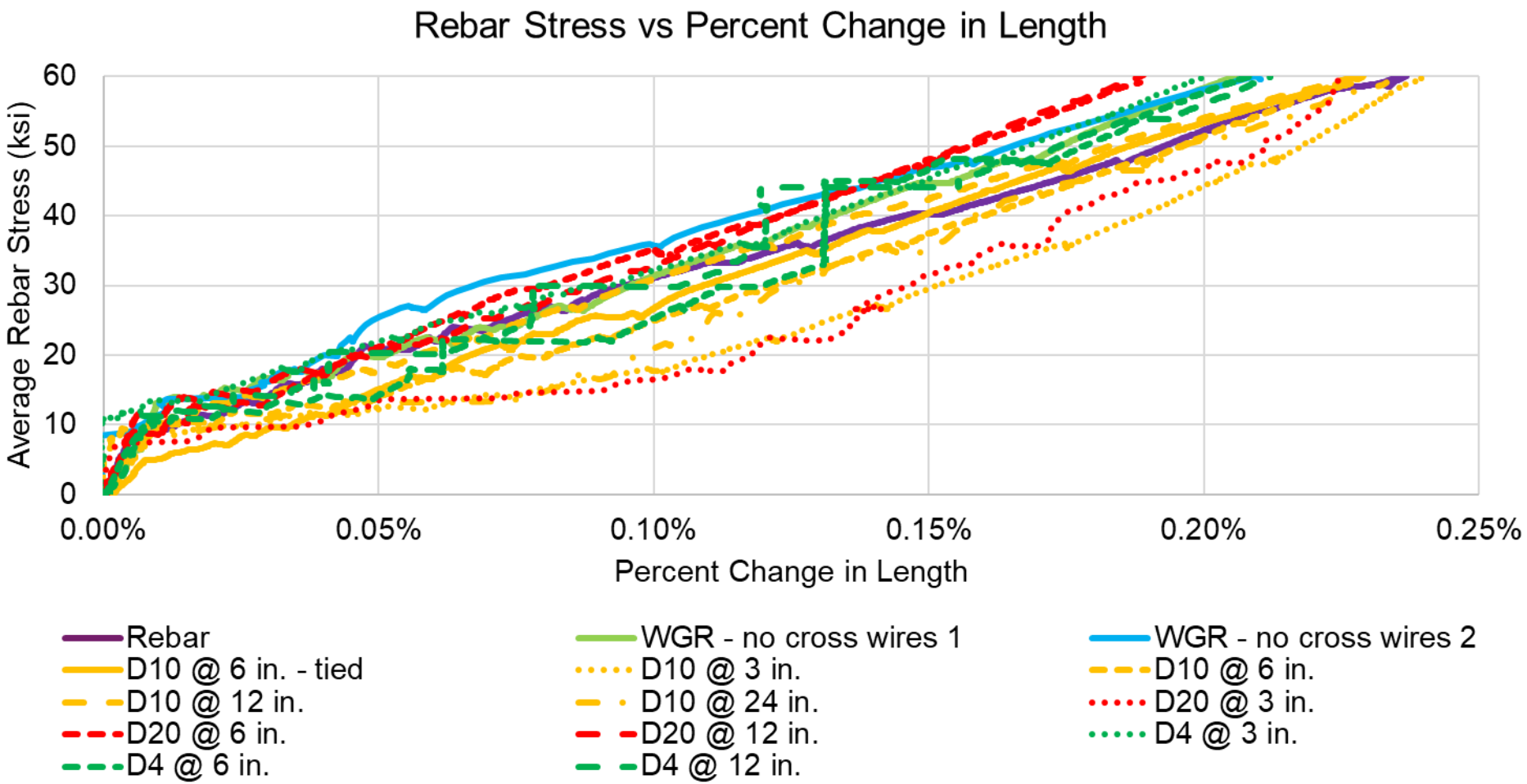


D10 @ 12”



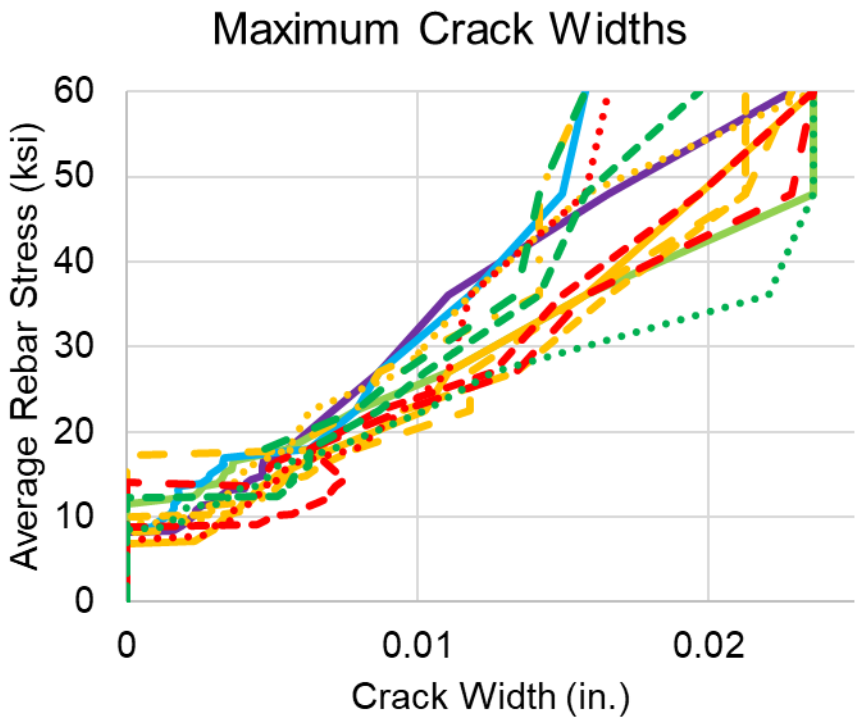
D10 @ 24”

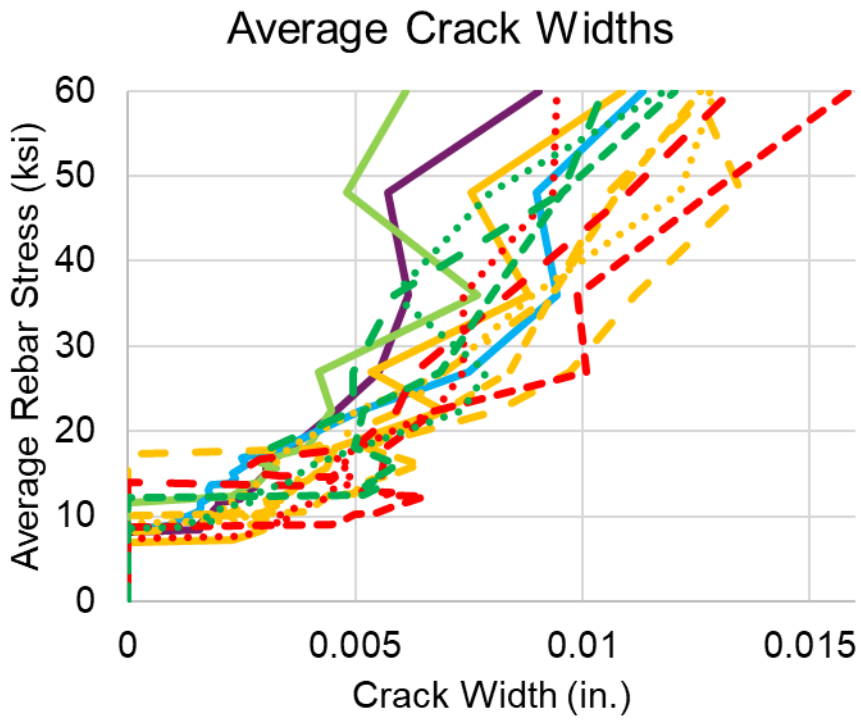
Results – Length Change



Tensile Testing

Results – Crack Widths

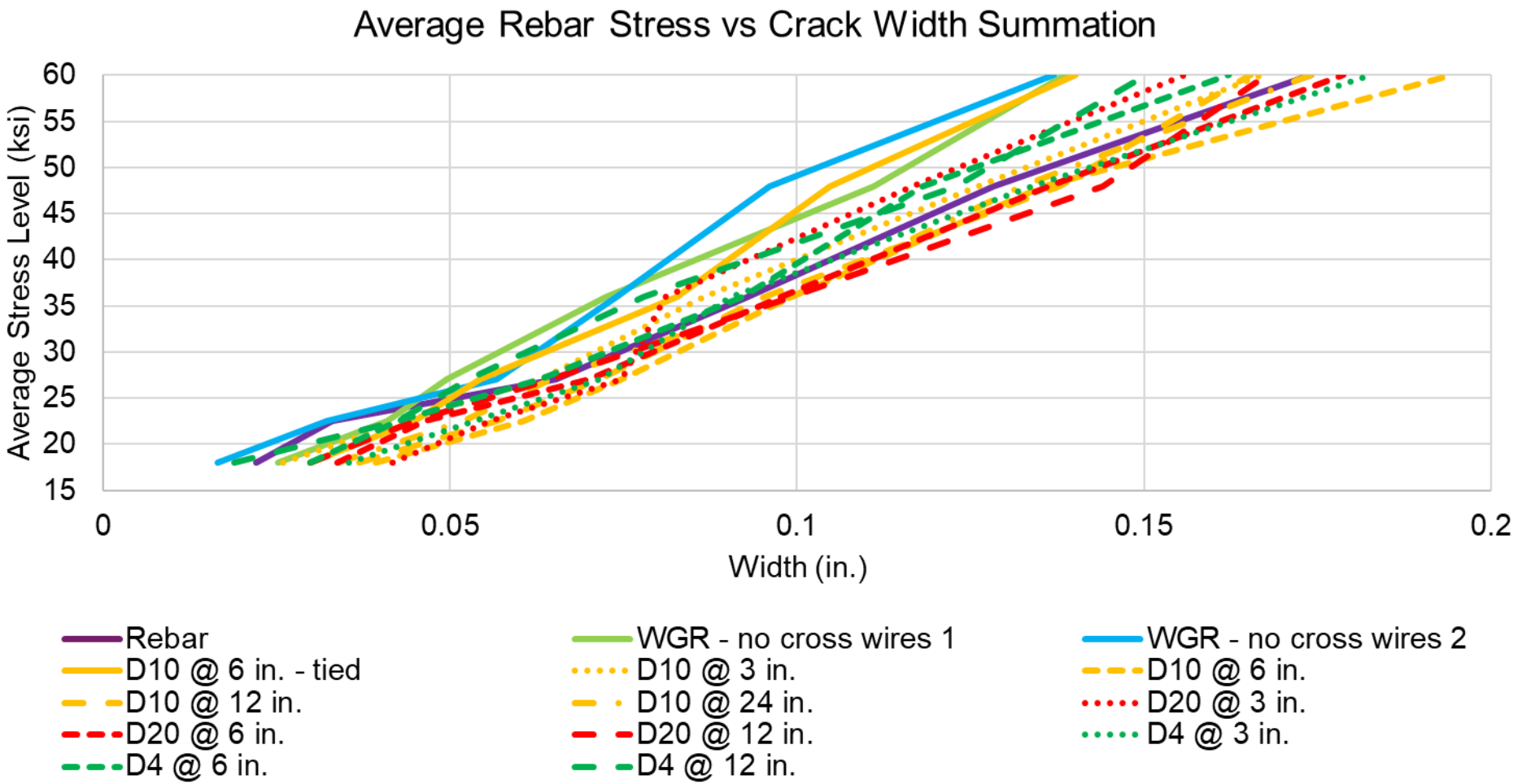




Rebar
D10 @ 6 in. - tied
D10 @ 12 in.
D20 @ 6 in.
D4 @ 6 in.
WGR - no cross wires 1
D10 @ 3 in.
D10 @ 24 in.
D20 @ 12 in.
D4 @ 12 in.
WGR - no cross wires 2
D10 @ 6 in.
D20 @ 3 in.
D4 @ 3 in.

Tensile Testing

Results – Crack Widths



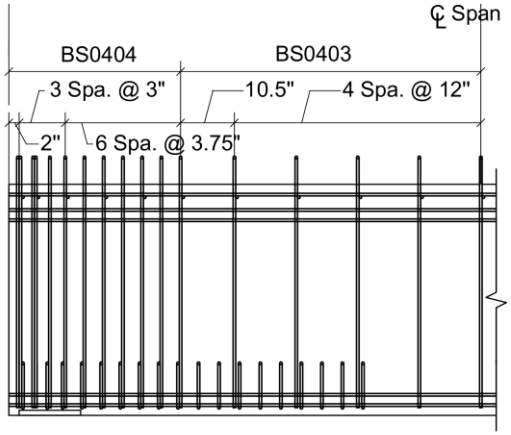
PCBT Testing

Goals

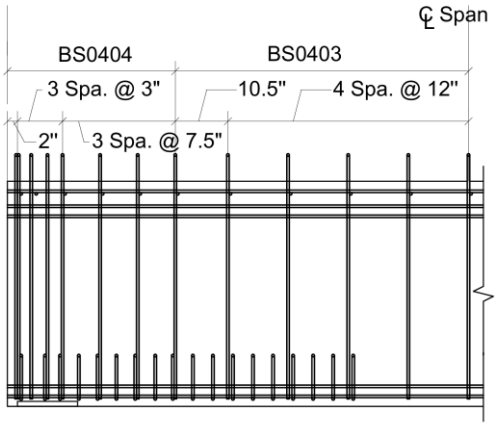
- Observe the cracking performance of PCBTs with varying levels of reinforcement in end regions
- Observe the cracking performance of PCBTs with rebar and WGR as end zone reinforcement and compare between the two

PCBT Testing

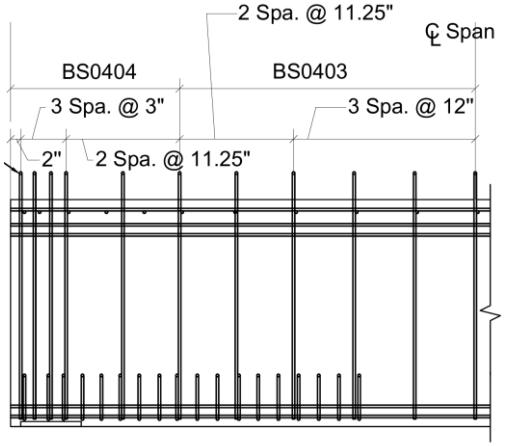
Beam Details



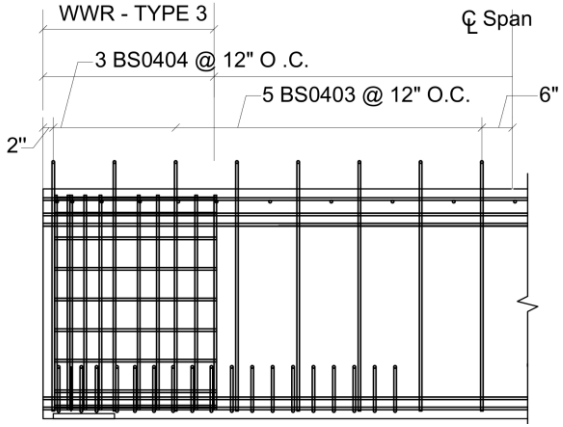
18 ksi rebar



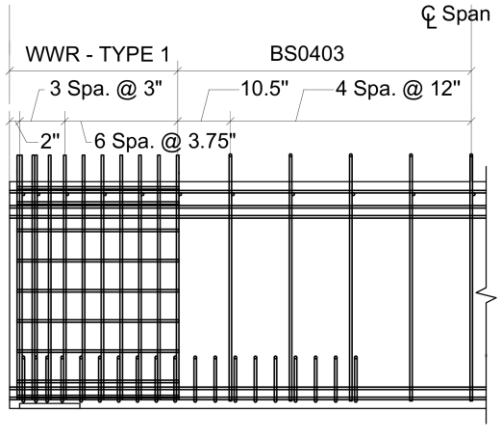
27 ksi rebar



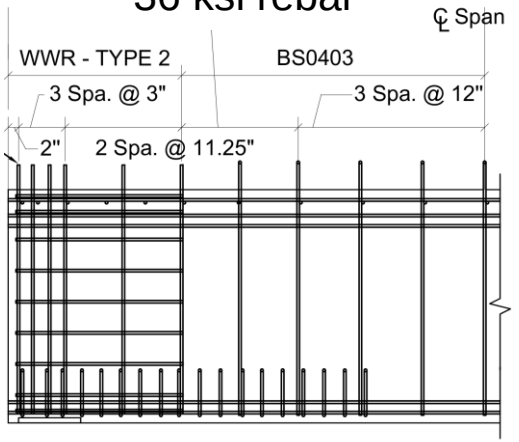
36 ksi rebar



18 ksi WGR and rebar



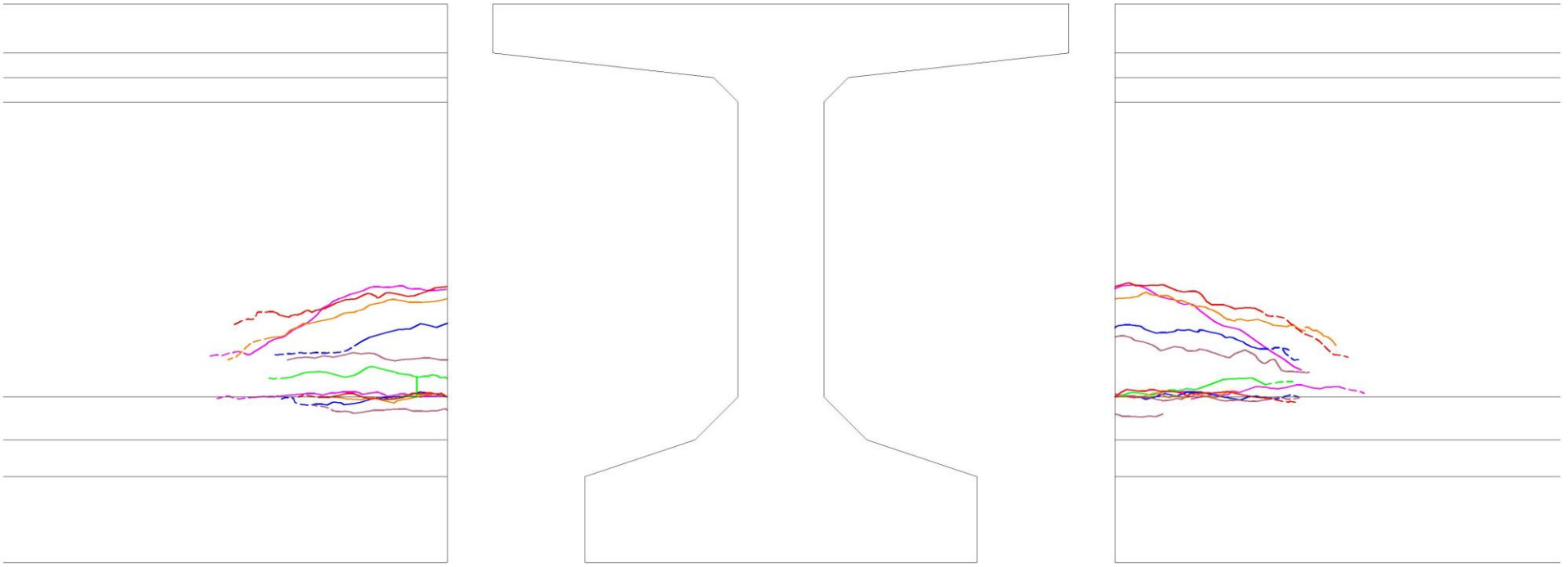
18 ksi WGR



36 ksi WGR

PCBT Testing

Results – Cracking after lifting from casting bed

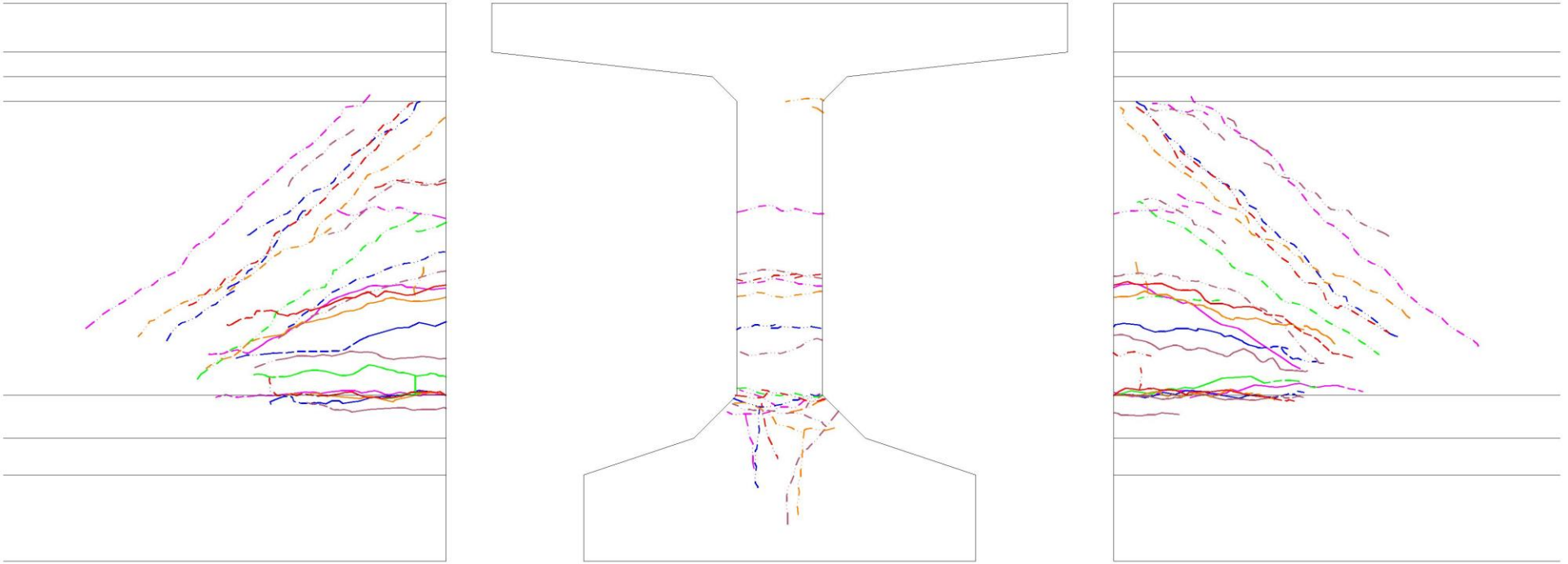


Note: The beam end was covered by formwork during detensioning and removal from prestressing bed, so no cracks were observed at those times.

18 ksi stirrups
27 ksi stirrups
36 ksi stirrups
18 ksi WGR and stirrups
18 ksi WGR
36 ksi WGR

PCBT Testing

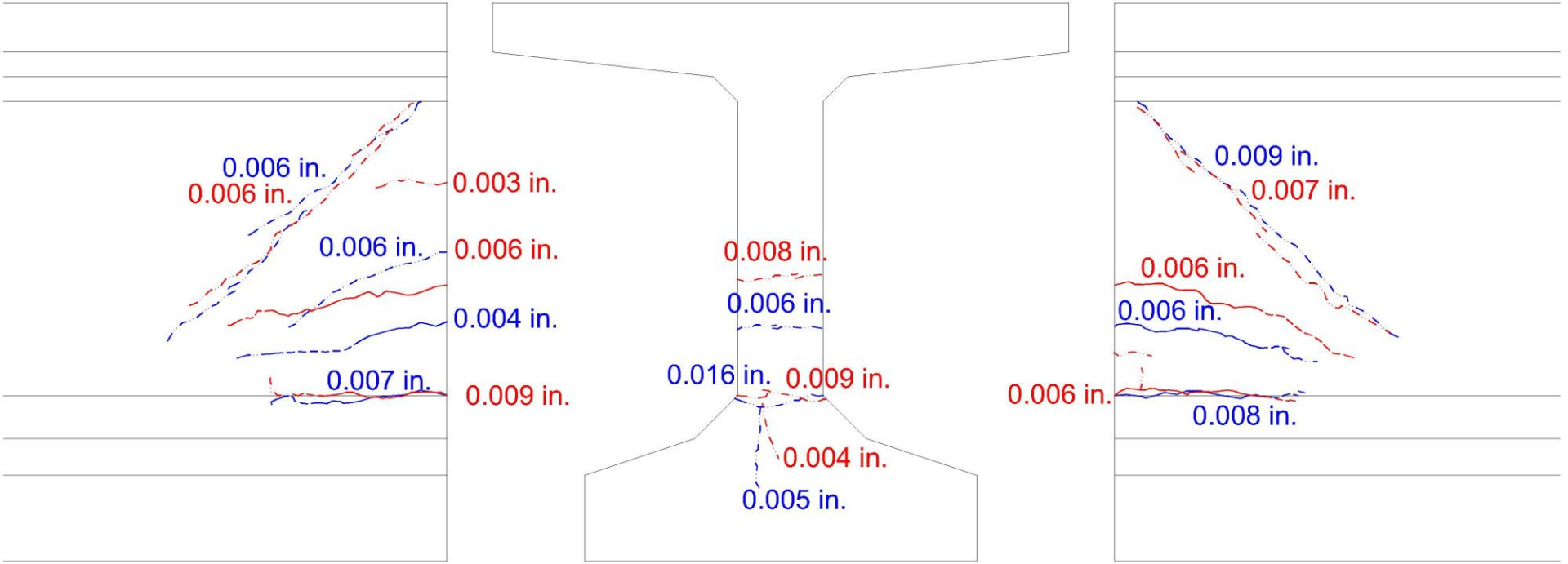
Results – Cracking after delivery to Virginia Tech



18 ksi stirrups
27 ksi stirrups
36 ksi stirrups
18 ksi WGR and stirrups
18 ksi WGR
36 ksi WGR

PCBT Testing

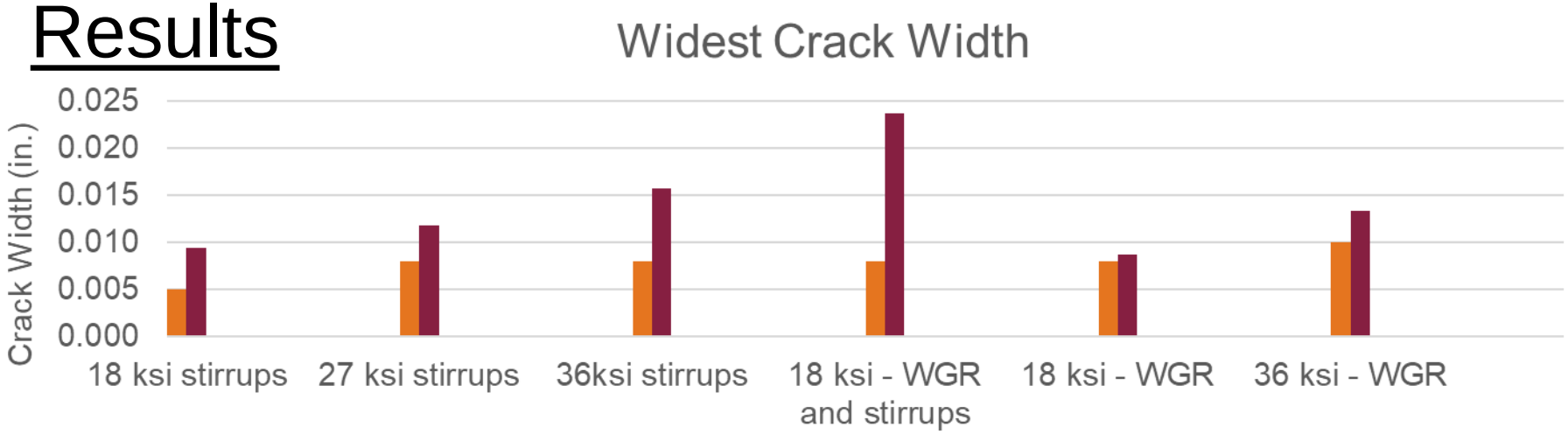
Results – 18 ksi stirrups and WGR after delivery

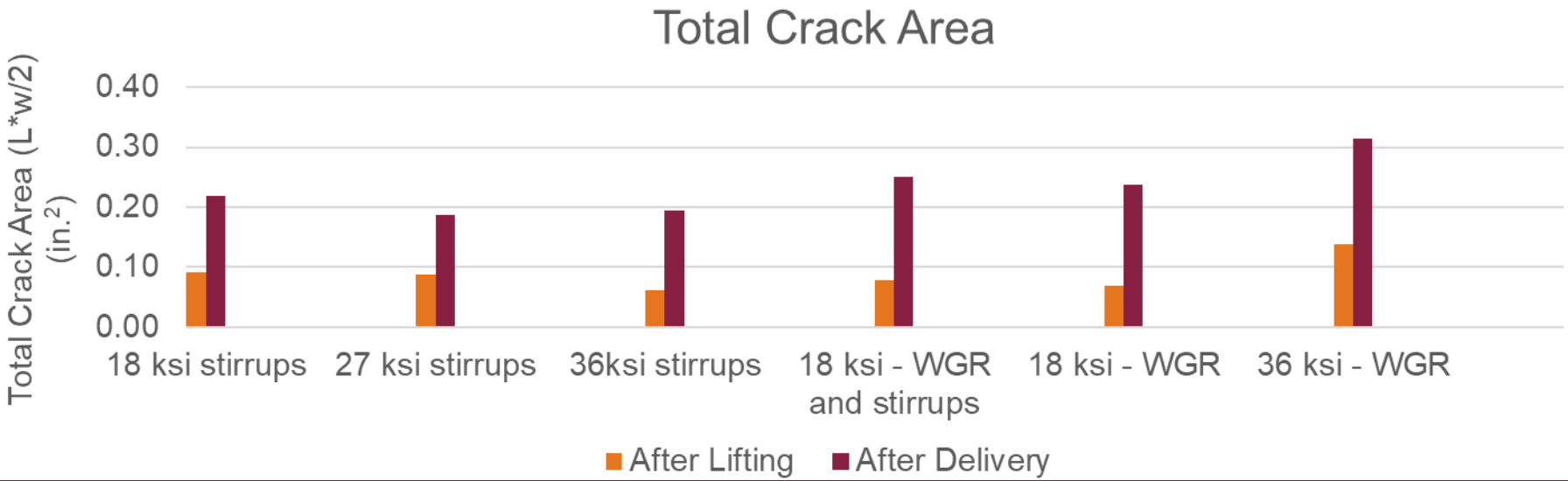


18 ksi stirrups
18 ksi WGR

PCBT Testing

Results





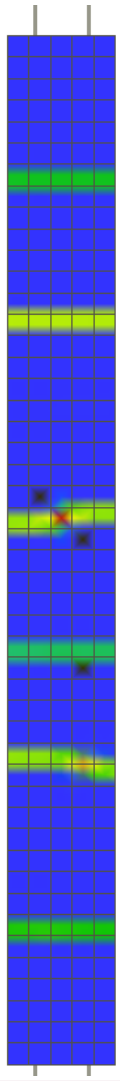
Conclusions and Future Work

Conclusions

- The implementation of WGR does not appear to improve tensile cracking performance compared to using traditional rebar
- Cracking severity in end zones does not scale linearly with design stress

Future Work

- Finite element modeling of results
- Analysis of different end zone cracking solutions
- Development of design guidelines



Questions?

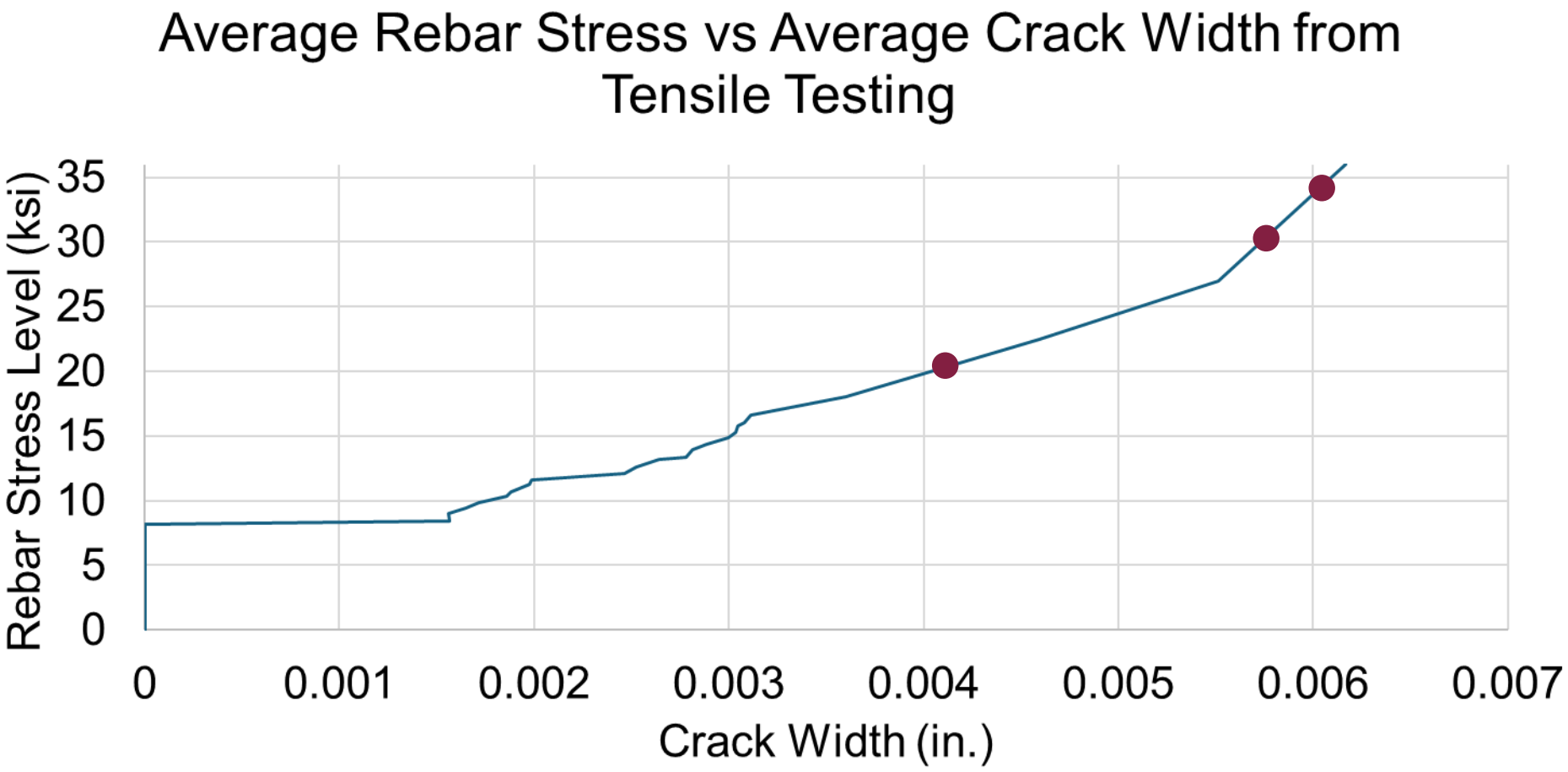
References

Crispino, E. D., Cousins, T. E., & Roberts-Wollmann, C. L. (2008). Anchorage Zone Design for Pretensioned Bulb-Tee Bridge Girders in Virginia. Virginia Polytechnic Institute and State University, Via Department of Civil and Environmental Engineering. Charlottesville, Virginia: Virginia Transportation Research Council.

Lee, S. L., M. A. Mansur, K. H. Tan, and K. Kasiraju. 1987. “Cracking behavior of concrete tension members reinforced with welded wire fabric.” ACI Structural Journal 84(6), 481-491

“Reinforcing Meshes Strengthen Concrete and Reduce Breaking Ratio.” Enzar. Accessed February 28, 2024. https://www.weldedwiresupplier.com/products/reinforcingbarmesh.html

Comparison of PCBT Cracking to Tensile Testing



Supplementary Information

Crispino *et al.*'s (2008) Strut and Tie Model