Secondary Reinforcement for FRP Reinforced Concrete

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Sponsored by: NSF Industry/University Cooperative Research Center

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Objectives:
- To investigate the development of an empirical based secondary reinforcement ratio which controls shrinkage and temperature cracks in applications such as bridge decks and other areas where durability is of concern.
- To investigate possible standard test methods for secondary reinforcement that includes boundary restraint.

Background:
- GFRP secondary reinforcement ratio based on material stiffness comparison
- No experimental data available
- In most applications, Secondary Reinf. > Primary Reinf.
- Considered excessive by many experts

Test Program:
Three Phase Study:
- Phase I – Early-age tensile test subjected to environmental conditions
- Phase II – Later-age tensile test
- Phase III – Cracks control of panels tested in flexure.

Phase I Environmental Chamber

Phase I Test Setup

Phase I Crack Width vs. Restraint Load
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Conclusions:

- Three times more GFRP is required to produce similar crack control characteristics when subjected to similar axial restraint loads at early-age.
- At later-age, steel is 1.3 times more efficient (load/area) at crack control than GFRP reinforcement.
- In flexure, twice as much GFRP is required to produce similar crack control as steel.
- Two and half time more GFRP yields similar mid-span deflection characteristics as steel when subjected to flexure.

![Phase II Test Setup](image1)

![Phase III Test Setup](image2)

![Phase II Tensile Load vs. Crack Area](image3)

![Phase III Load vs. Crack Area](image4)