Session 36

H.R. Hamilton
University of Florida

Crack Control in Toppings for Precast Flat Slab Bridge Deck Construction

Topic Description

This research project evaluated techniques for improving crack control in toppings for precast panels. Steel fibers, synthetic fibers, steel/synthetic fiber blend, carbon fiber reinforced composite(CFRP) grid, and shrinkage reducing admixture were tested four full-scale bridge superstructures. Each superstructure was composed of three 4-ft. x 30-ft precast flat slabs with a 6 in. concrete topping. The precast slabs were constructed off-site by a prestressed concrete manufacturer. The treatments were each incorporated into a standard FDOT approved concrete mixture and cast on-site by FDOT Structures Laboratory staff. The toppings were visually monitored for 30 weeks for crack formation. In addition, load tests were performed on each of the specimens.

Speaker Biography

H. R. (Trey) Hamilton III, P.E., PhD is an Associate Professor of Civil Engineering at the University of Florida in the Department of Civil & Coastal Engineering. His research and teaching interests include reinforced and prestressed concrete.

FICE/FDOT Design Conference 2006

Designing For More Than Bridges and Roads

Crack Control in Toppings for Precast Flat Slab Bridge Deck Construction

Trey Hamilton, P.E., Ph.D.
University of Florida

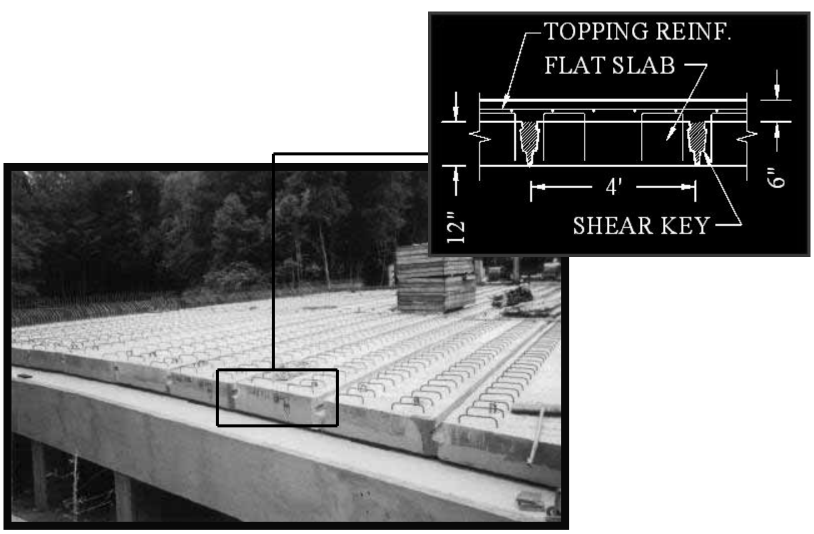
Acknowledgements

- Mr. Laz Alfonso, Graduate Research Assistant
- FDOT Research Office
- Mr. Marc Ansley, Project Manager
- Frank Cobb, Tony Johnston, David Allen, Paul Tighe, and Steve Eudy of the FDOT Structures Research Center

What is a Flat Slab Bridge?

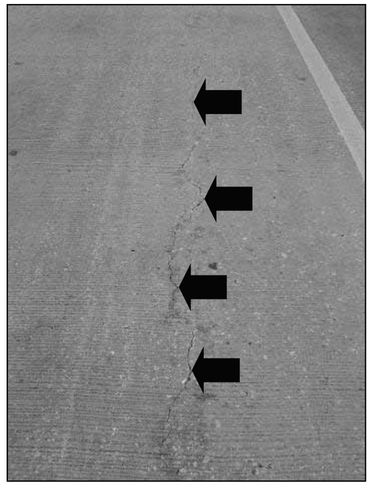
- Precast, pretensioned planks erected on piers.
- Topping placed for integrity and wearing surface

Flat Slab Bridge Details



Problem

- Longitudinal cracks in topping over flat slab joints
- Develop before bridge is open to traffic
- Attributed to drying shrinkage



Reflective Cracking

Research Objective

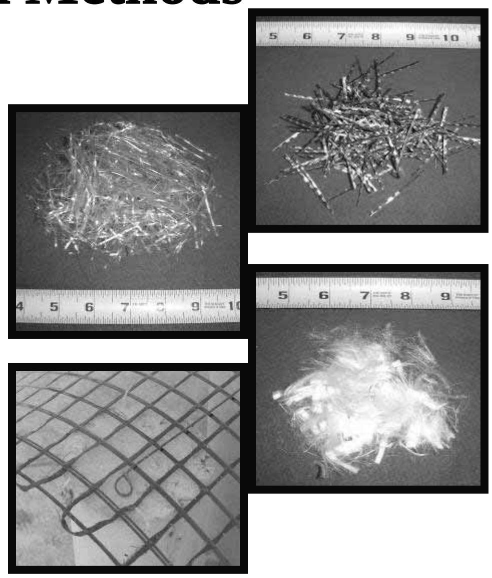
- Evaluate techniques for providing crack control

Some Crack Control Methods

- Synthetic fibers (Nylon, Polypropylene, Polyvinyl Alcohol) - Most commonly used in flat slab work to control bleeding and plastic shrinkage
- Transverse Post-tensioning
- Steel fibers
- Shrinkage-Reducing Admixtures - Reduces capillary tension that develops within the concrete pores as it cures.
- Carbon fiber-reinforced polymer grid

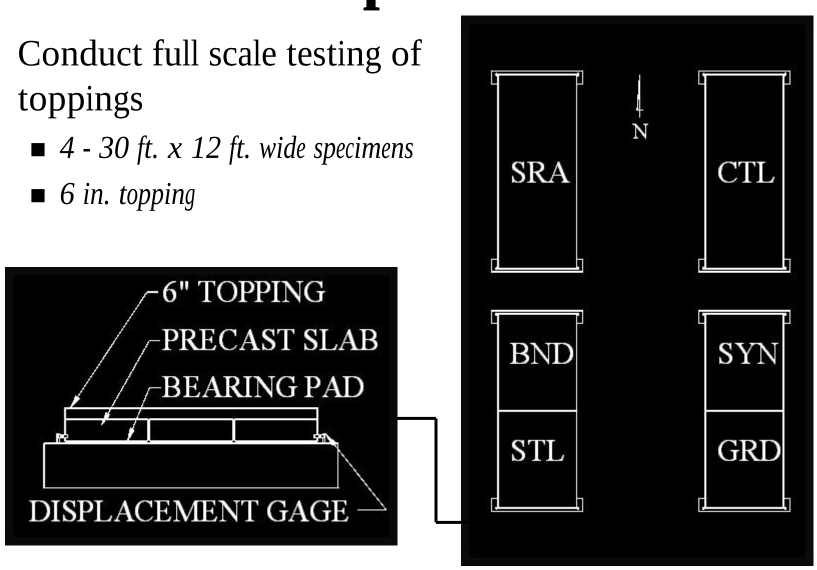
Selected Methods

- 2 in. Steel Fiber (STL)
- 1½ in. Synthetic (poly-propylene) Fiber (SYN)
- ¾ in. Synthetic (nylon)/Steel Fiber Blend (BND)
- Shrinkage Reducing Admixture (SRA)
- Rigid Carbon Fiber Grid (GRD)
- Selected methods



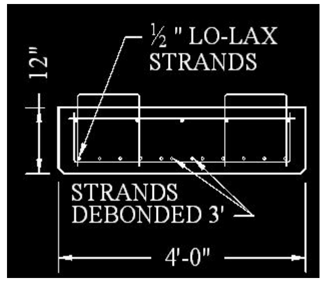
Test Specimens

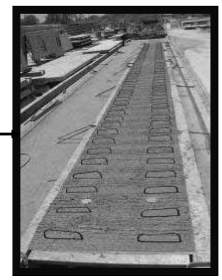
- Conduct full scale testing of toppings
  - *4 - 30 ft. x 12 ft. wide specimens*
  - *6 in. topping*



Precast Construction

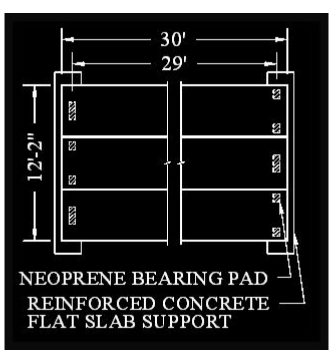
- Design and Fabrication
  - *Flat Slab Design*
    - *Used Cow Creek as model*
    - *LRFD PSBeam v1.85*
  - *Dura-Stress, Inc.*





Precast Construction

- Flat slabs delivered to Tallahassee, FL
- Provide bearing system used on Cow Creek
- Minimum reinforcement req.



Topping Concrete

- Toppings
  - FDOT Class II (Bridge Deck) Concrete
    - *f`c: 4,500 psi*
    - *Max w/c: 0.44*
    - *Allowance for slump and air*
- Materials Testing
  - *Air Content*
  - *Slump*
  - *Compressive Strength*
  - *Modulus of Elasticity*
  - *Tensile Strength (Pressure Tension Test)*

Topping Placement

- Casting Operations
  - *Three slump tests*
  - *Add crack control treatment*
  - *Add H_20, air content test, and cast*
  - *Apply curing compound*

- Workability
  - *Ranking based on physical observations and personnel feedback*

Rank	Workability
1	Very Good
2	Good
3	Poor
4	Very Poor

Topping Placement

- SYN Topping
  - *6 lbs/CY synthetic fiber*
  - *Underdose of cementitious materials*
  - *Workability: Poor*
- BND Topping
  - *1 lb/CY synthetic fiber*
  - *25 lbs/CY steel fiber*
  - *Workability: Good*

Topping Placement

- GRD Topping
  - *Embedded 1 in. below surface*
  - *Screeded twice*
  - *Workability: Very Good*

- STL Topping
  - *60 lbs/CY steel fiber*
  - *Workability: Very Poor*

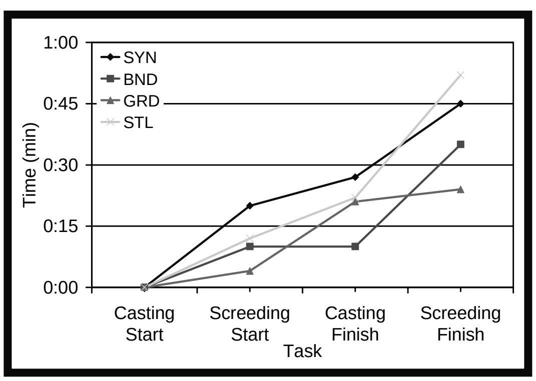
Topping Placement

- SRA Topping
  - *Slump unaffected by admixture*
  - *Easiest to incorporate*
  - *Workability: Very Good*

- CTL Topping
  - *Standard mixture*
  - *Workability: Very Good*

Topping Placement

- *Air contents were low*
- *No bleed water in fiber reinforced mixtures*
- *Slump and workability affected by high fiber volume*
- *Workability affected finishing time*

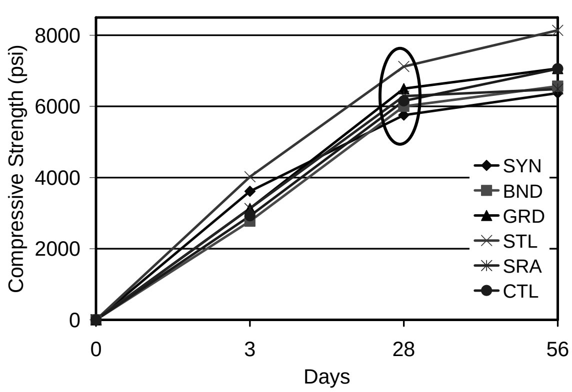


Results

- No cracks in toppings after 30 weeks
- Placement and curing were conducted in relatively ideal conditions
- Slabs were constructed in the very humid summer months
- Smaller specimen width than typical bridges

Cylinder and MOE Results

- Slightly higher 28 day compressive strength in STL mixture
- MOE unaffected by treatments



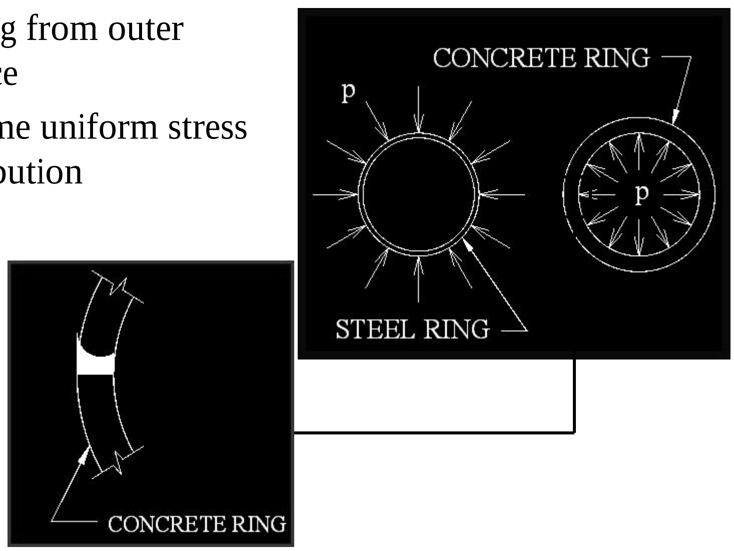
Topping	w/c
SYN	0.38
BND	0.44
GRD	0.40
STL	0.44
SRA	0.39
CTL	0.43

Restrained Ring Test

- Modeled after existing ring test
- Sealed top surface

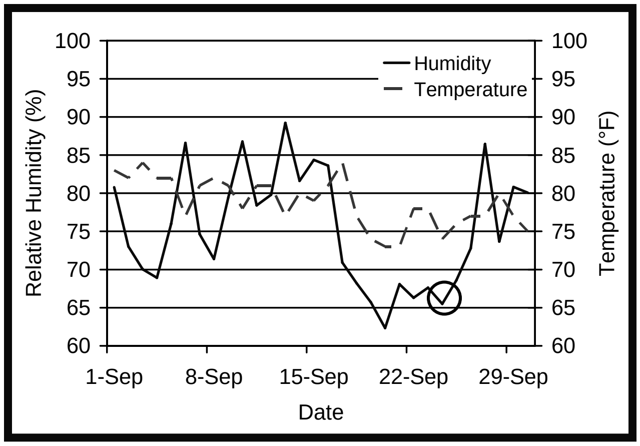
Restrained Ring Test

- Drying from outer surface
- Assume uniform stress distribution



Restrained Ring Test

- *Cracks first observed after R.H. below 70% for 8 day period*



Restrained Ring Results

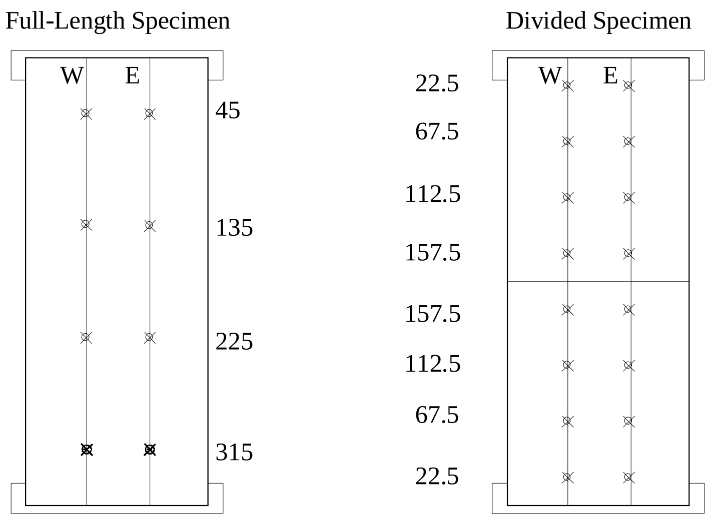
- *CTL and GRD generated widest cracks*
- *GRD not accounted for*
- *Rings with higher fiber volume performed better*

Long-Term Tests

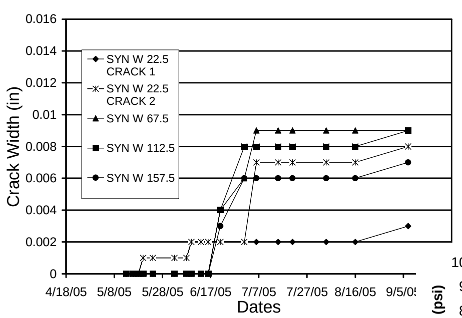
- Impose flexural stresses on concrete at precast joint
- Measure crack widths over time

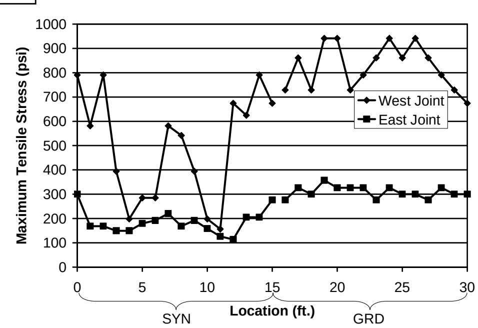
Long-Term Tests

Crack Width Measurement



Crack Width Measurement

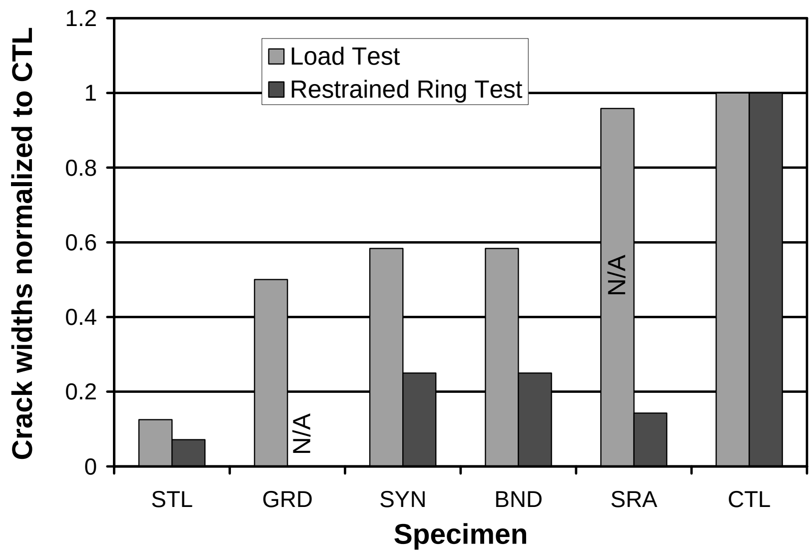




Crack Width Results – Load Tests

Specimen	Average Crack Width (in.)	Average Stress (psi)	Crack width / Stress (in / ksi)
STL	0.002	613	0.003
GRD	0.009	772	0.012
SYN	0.007	497	0.014
BND	0.005	353	0.014
SRA	0.012	519	0.023
CTL	0.004	166	0.024

Crack Width Results – Combined



Conclusions and Recommendations

- Treatments did not affect MOE or tensile strength.
- Added assurance in the control of drying shrinkage cracking can be attained with the use of additives tested in this research.
- Conduct trial mixes with fibers to avoid having to add water at site. High-range water reducer will help workability.