LIGHT-WEIGHT UHPC-FRP COMPOSITE SYSTEM

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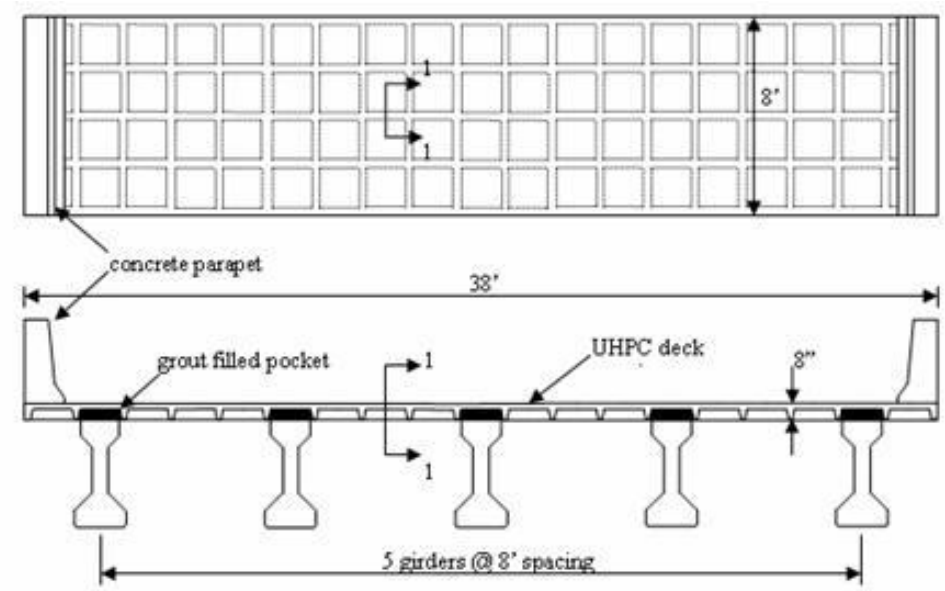
Literature Review

The purpose of the literature review is to provide support for our hypothesis that:

- UHPC–HSS ribbed deck system
- UHPC-FRP waffle deck system
- Hybrid full-depth UHPC-FRP deck system

can be implemented using **Accelerated Bridge Construction (ABC)** techniques to help meet the growing demand for rapid bridge rehabilitation and reconstruction across the United States.

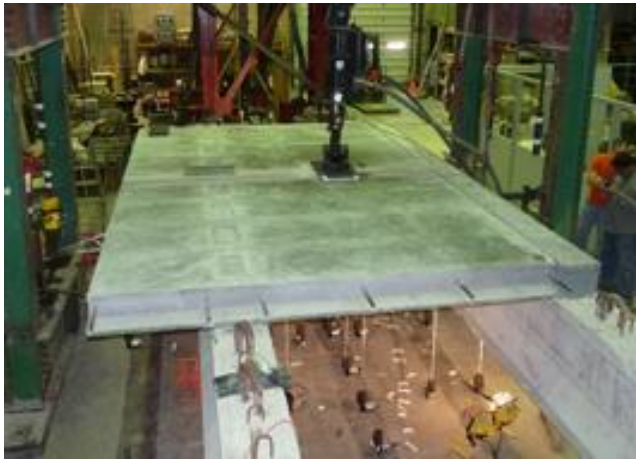
Ultra-High Performance Concrete – High Strength Steel Ribbed Deck System



UHPC Two-Way Ribbed Bridge Deck Panel Plan and Cross Section View

http://www.fhwa.dot.gov/publications/research/infrastructure/bridge/07055/

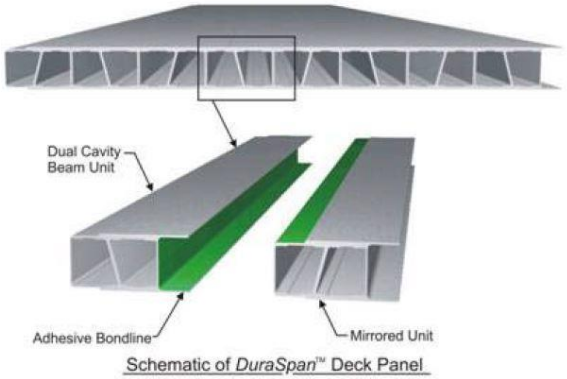
Ultra-High Performance Concrete – Fiber Reinforced Polymer Waffle Deck System



Images taken from full scale laboratory test of UHPC waffle slab bridge deck for Wapello County, Iowa

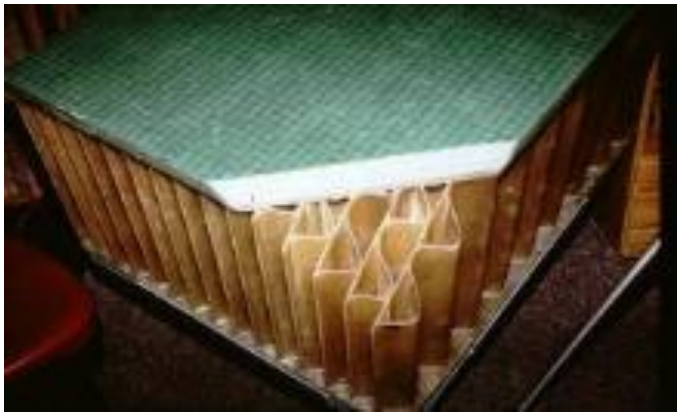
http://www.hpcbridgeviews.com/i65/Article2.asp

No.	Bridge	State	Deck Type	Year
1	Huntsville, Alabama	WV	Huntsville, Alabama	2000
2	Hanover Bridge	WV	Kansas Structural Composites deck	2001
3	Cats Creek Bridge	OH	DuraSpan deck	2002
4	County Road 153	NY	Hardcore composite	2002
5	Katty Truss Bridge	WV	Superdeck	2002
6	Goat Farm Bridge	WV	Kansas Structural Composites deck	2003
7	Chief Joseph Dam Bridge	WA	DuraSpan deck	2003
8	Tangier Island	VA	ZellComp deck	2006
9	Belle Glade	FL	ZellComp deck	2009
10	Redstone Arsenal	AL	ZellComp deck	2010



Schematic of *DuraSpan*™ Deck Panel

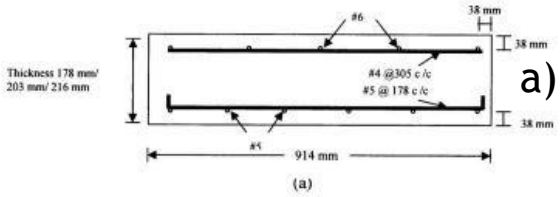
Duraspan
(pultrusion)



Kansas
(open mold hand lay-up method)

Hardcore
(VARTM)

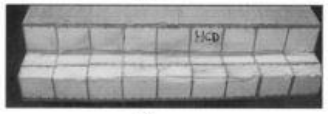
Hybrid Full-Depth Ultra-High Performance Concrete – Fiber Reinforced Polymer Deck System



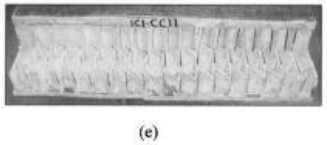
a) Reinforced concrete

b) Double trapezoidal and hexagonal pultruded components

c) Concrete reinforced with glass FRP reinforcement bars



d) Cell foam wrapped with fiberglass fabric



e) FRP fiberglass deck panel with a corrugated sandwich system

Tests conducted by Alagusundaramoorthy et. al. on four different FRP panels by criteria of the Ohio DOT using reinforced concrete as a baseline.

Alagusundaramoorthy, P., Harik, I., & Choo, C. (2006). *Structural Behavior of FRP Composite Bridge Deck Panels*. American Society of Civil Engineers.

Department of Transportation Survey Results

- Department of Transportation (DOT) Surveys
  - A questionnaire was sent to several DOTs in the Southeastern U.S. to gather data about basic bridge types and geometries as well as the region's exposure to accelerated bridge construction (ABC)
  - Conclusions
    - Many older bridges have steel girder systems but pre-stressed concrete girders are the preference for new bridges
    - Several states are implementing UHPC, FRP, and HSS in both experimental and actual projects.
    - Most states surveyed have used or plan to use ABC in various ways including precast deck panels, emergency repairs, and lateral slide elements.

National Bridge Inventory Data

- Based on the American Association of State Highway and Transportation Officials (AASHTO) NBI for Region 2 (Southeastern U.S.):
  - Of the 168,000+ bridges listed for region 2, 9.1% are classified as structurally deficient
  - Of the 15,357 bridges that are structurally deficient, 22.8% have deficient bridge decks.
  - On average, 22.5% of each state's deficient bridges is due in part to deficient bridge decks.

Accelerated Bridge Construction Examples

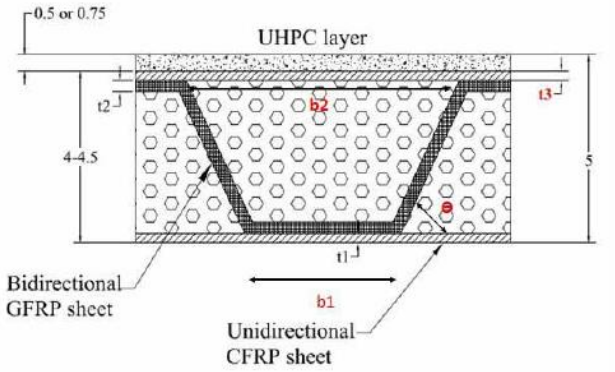
- Sam White Bridge (Salt Lake City, Utah)
  - 354’ two-span bridge moved into place in 5 hours using self-propelled modular transporters
  - 10” lightweight concrete precast deck panels with steel plate girders
- U.S. 6 Bridge over Keg Creek (Iowa DOT)
  - 210’ three-span steel/precast concrete bridge
  - Used UHPC in the joints to lower the permeability and increase the strength
  - ABC methods decreased construction time from six months to sixteen days

SPMTs moving Sam White Bridge into place
ftp.dot.state.tx.us/pub/txdot-info/brg/0611_webinar/farris.pdf

Objective

- The primary objective of the proposed research is to develop an innovative modular high performance lightweight deck options that lend themselves to accelerated bridge construction (ABC).

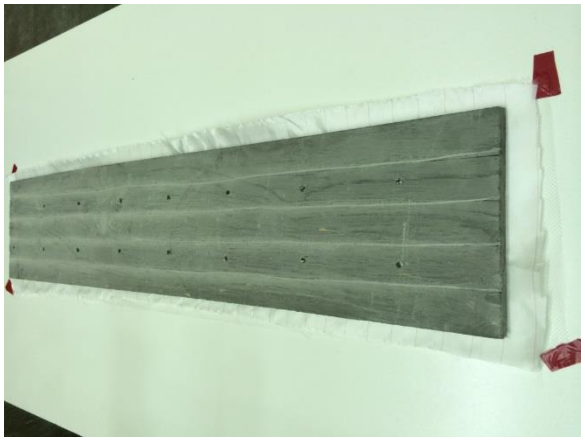
- An FRP bridge deck weighs approximately 80% less than a concrete deck.
  - Very Light
  - Convenient to transport
  - Easy to install
  - Short construction period.
- UHPC : Very high compression strength
  - Can be used as wearing surface
- FRP : High tension strength
  - CFRP ---bottom layer for tension resistance.
  - GFRP ---shear reinforcement



Test Matrix

SP	UHPC thickness	Total Height	Web Angle	Web GFRP Layer	CFRP Layers	Top GFRP (Uni)	Specimen's Length
First Cast							
2	0.5 in.	5 in.	63	3(BI)	4	3	48
3	0.5 in.	5 in.	63	3(BI)	4	2	48
4	0.5 in.	5 in.	63	4(BI)	3	3	48
5	0.75 in.	5 in.	60	4(BI)	5	3	48
6	0.5 in.	5 in.	60	3(BI)	4	3	48
Second Cast							
7	0.5 in.	4 in	60	5(BI)	4	4	30
8	0.5 in.	4 in	60	5(BI)	4	4	30
9	0.5 in.	4 in	60	5(BI)	4	4	30

Specimens' Fabrications

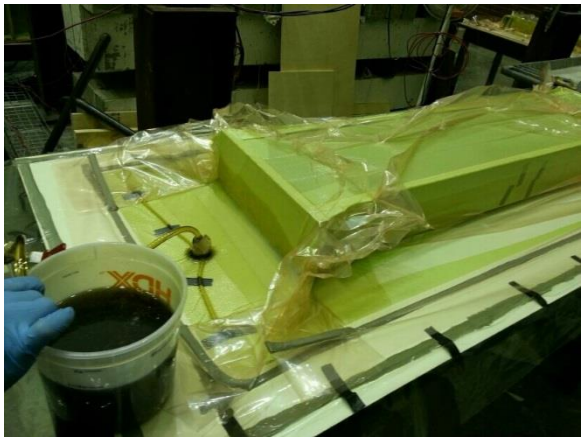


Laying the peel ply, infusion mesh, and UHPC plate

Putting the side mold and laying the top glass fiber sheets

Installing foam and laying shear fiber

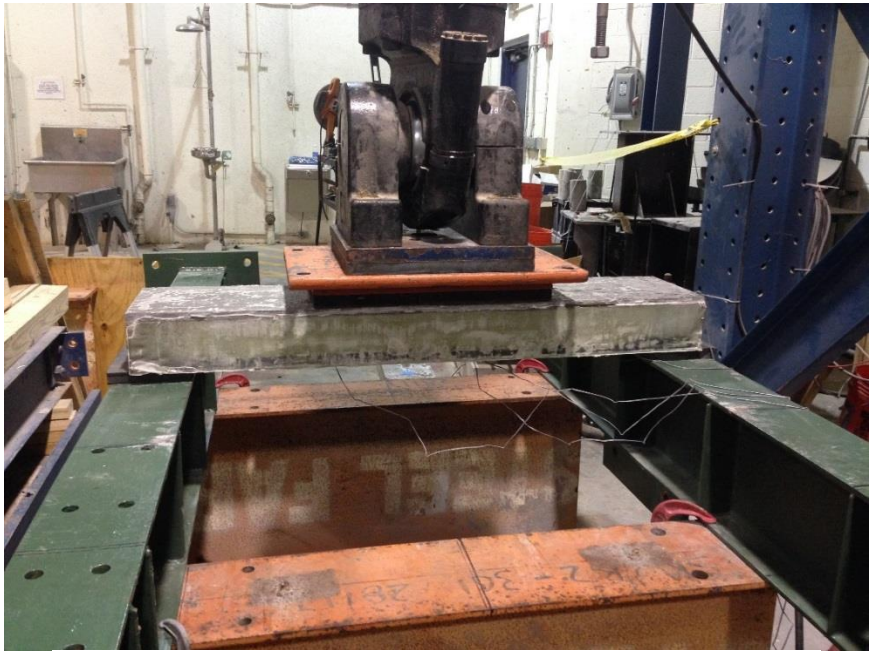
Laying carbon fiber sheets

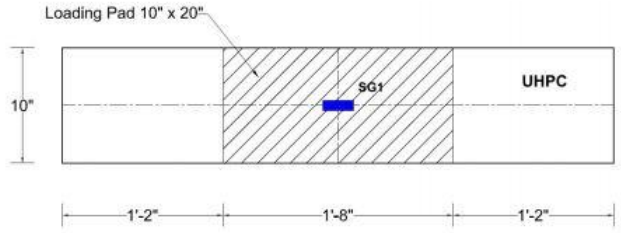


VARTM Process

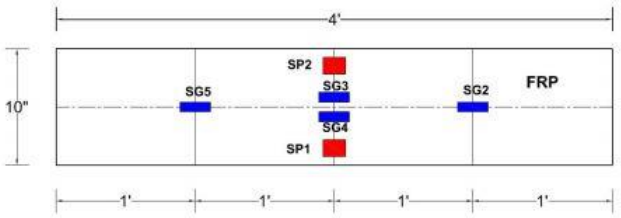
Final deck after demolding

Test Setup



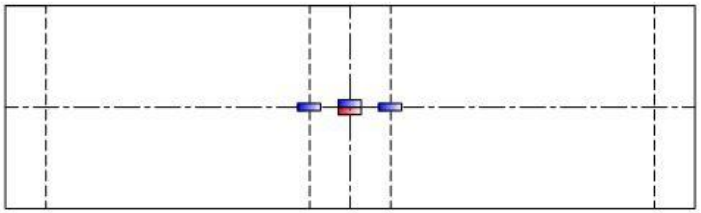


(a) Top view

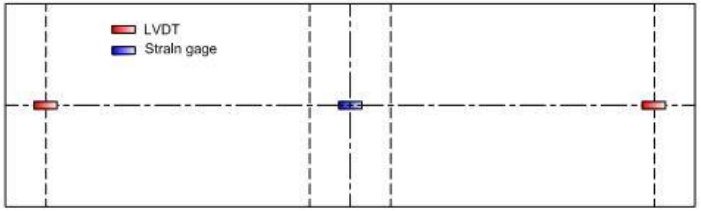


(b) Bottom view

Test Setup

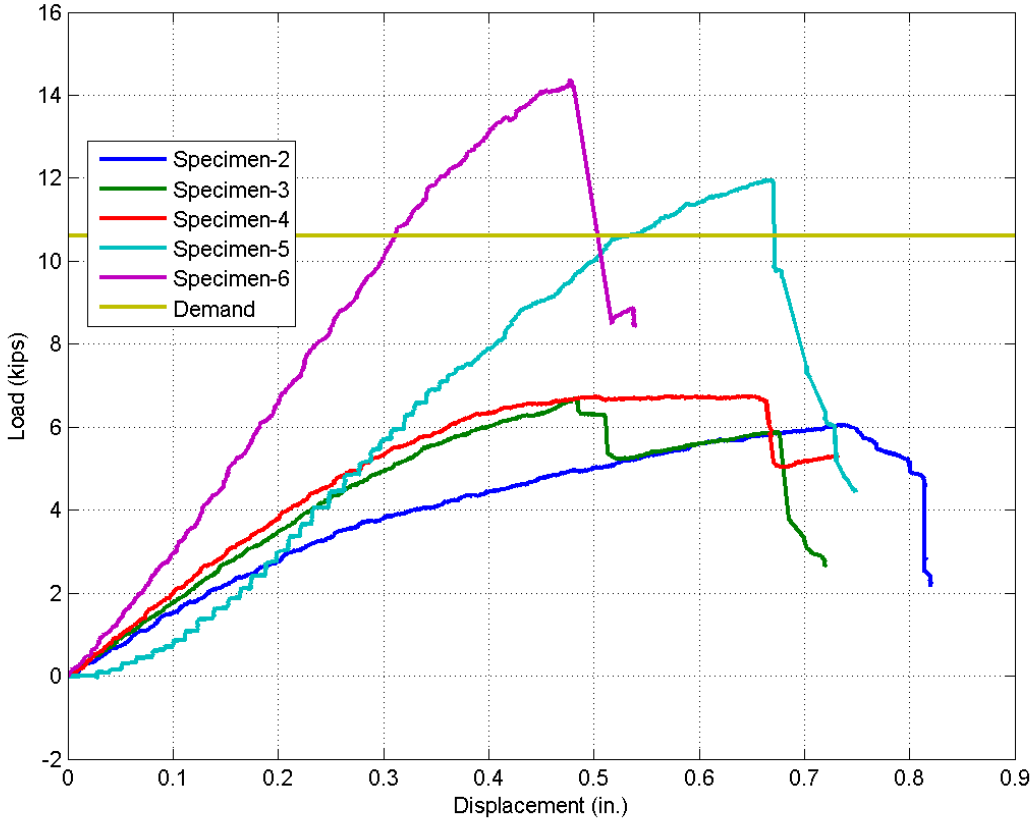


Bottom FRP

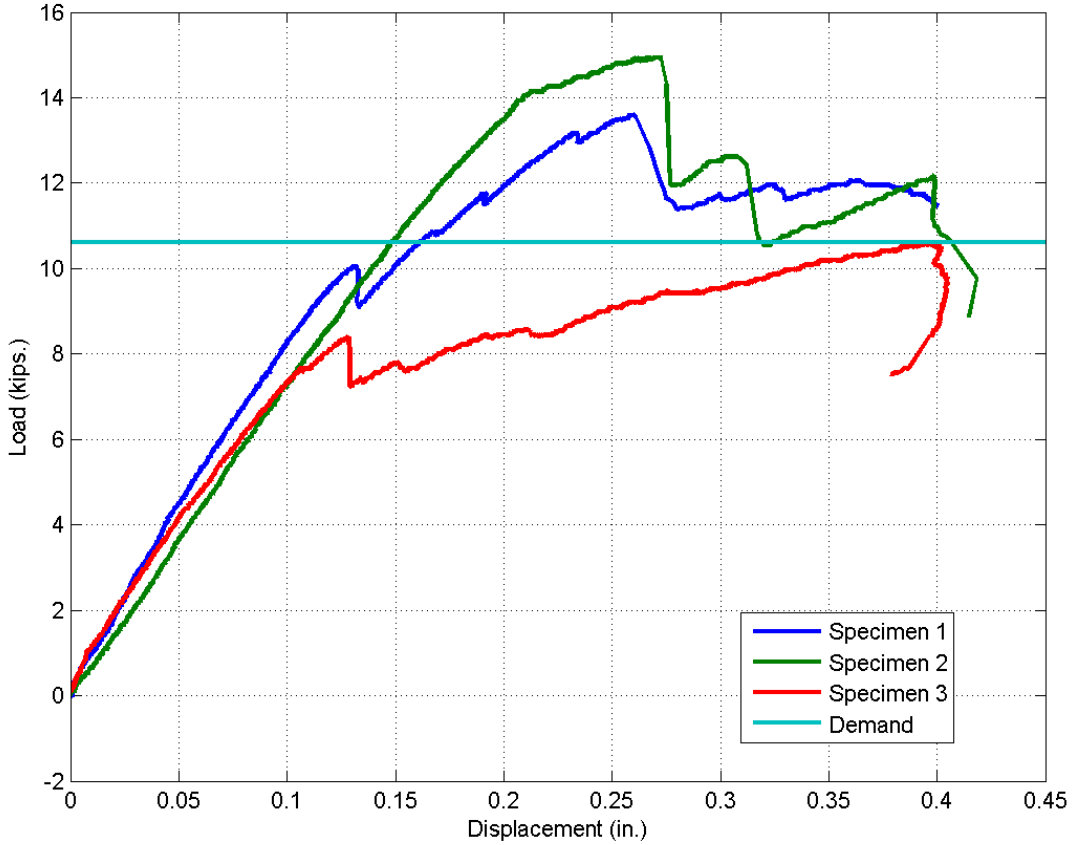


Top UHPC

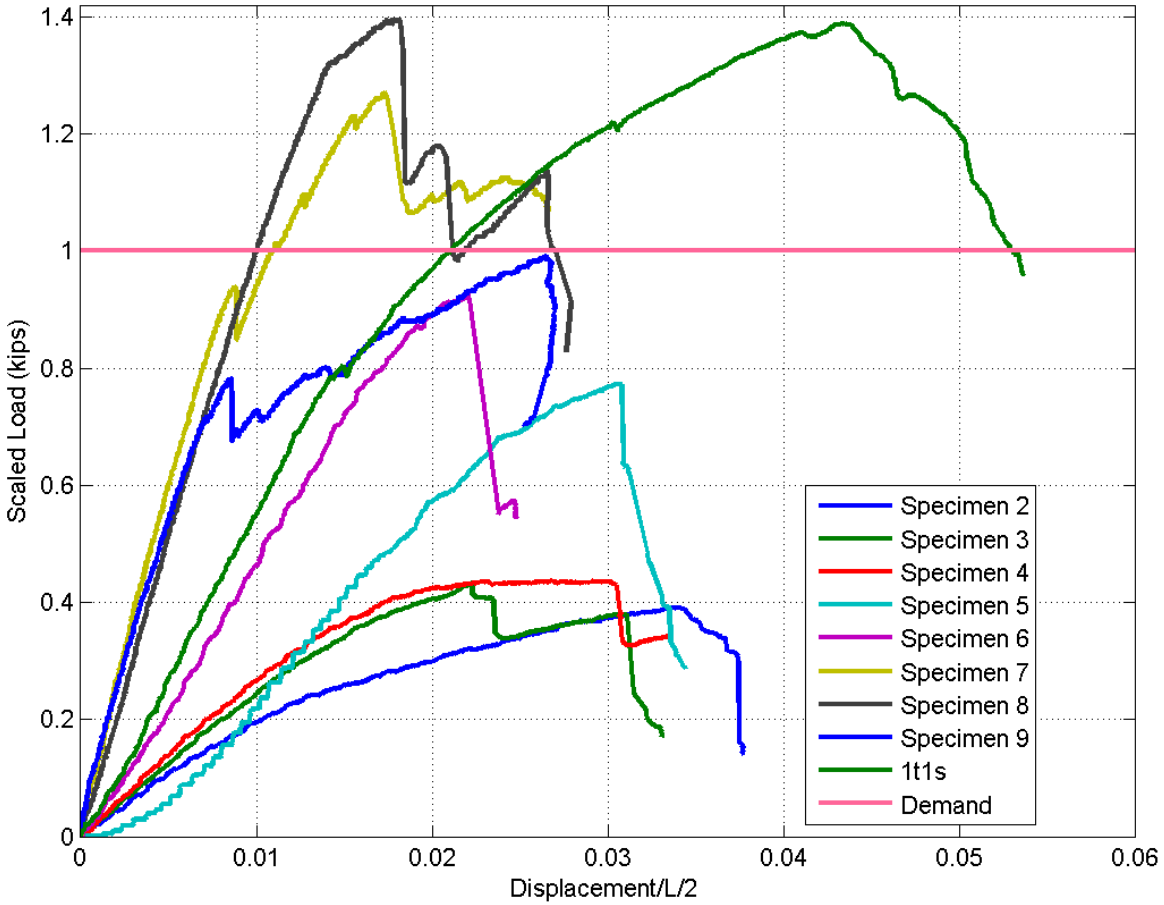
Results


Specimen-2
Specimen-3
Specimen-4
Specimen-5
Specimen-6
Demand
Load (kips)
Displacement (in.)
16
14
12
10
8
6
4
2
0
-2
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9

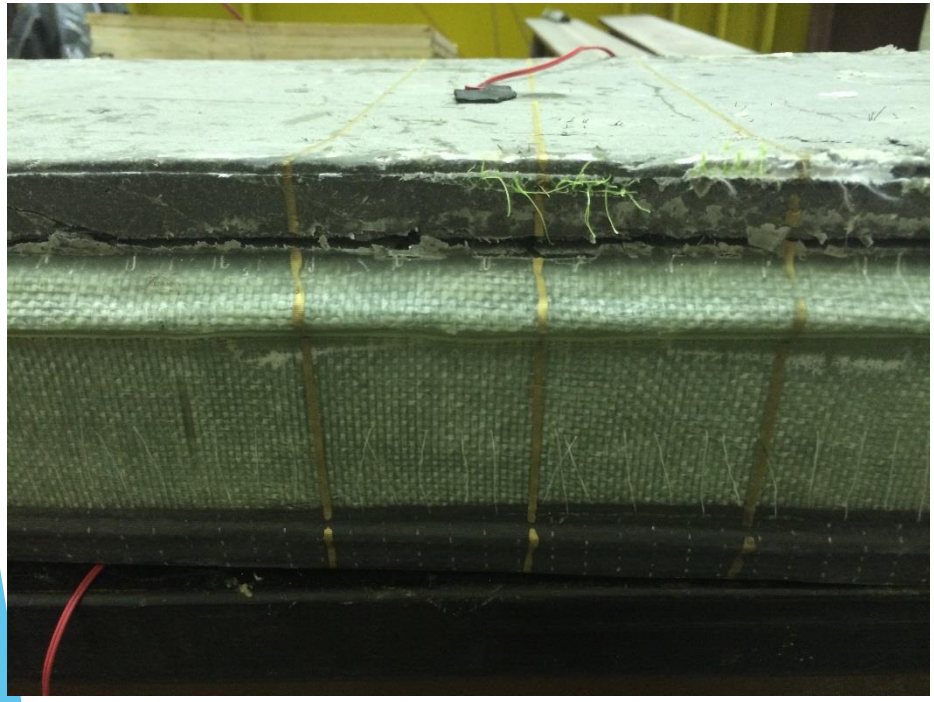
Results

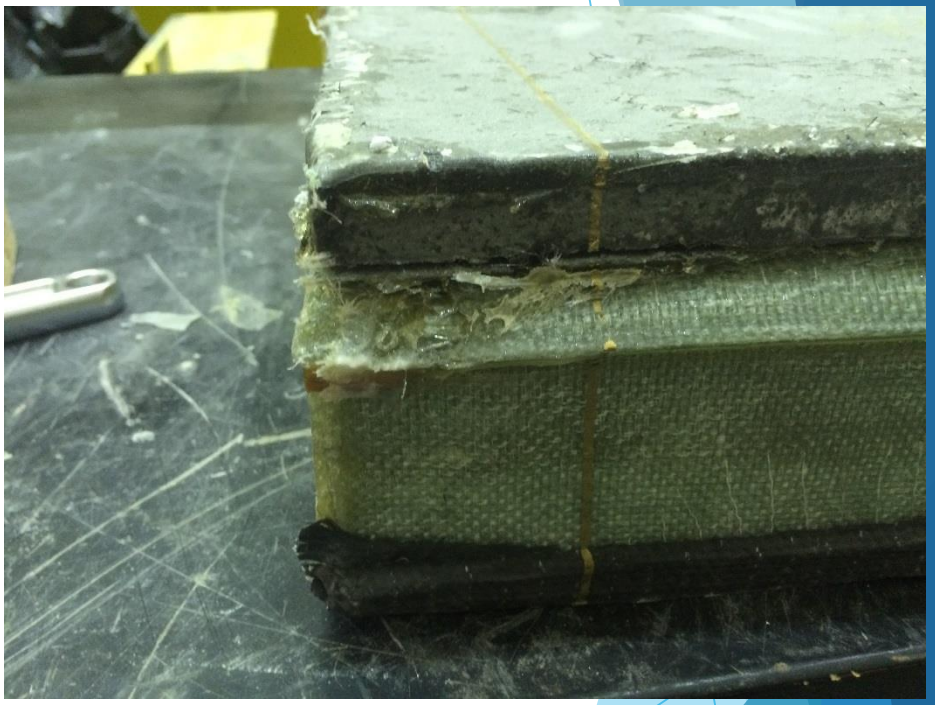

Load (kips.)
Displacement (in.)
16
14
12
10
8
6
4
2
0
-2
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
Specimen 1
Specimen 2
Specimen 3
Demand

Results Comparison



Failure Mode





Conclusions

- This system is good option in ABC field.
- This system Meets the load demand requirement
- More investigations are needed about the interface behavior.
- Future investigations need to include full scale test.

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THANK YOU
Questions