# Session 63


## Lei Zhao

University of Central Florida


## *Testing of an FRP Bridge Deck*

### Topic Description

A low-cost and lightweight FRP deck system is being evluated as a replacement for the commonly used open steel grid decks, which are noisy to ride on, slippery when wet and costly to maintain. Fatigue and failure tests were performed on two full-size panels in a two-span configuration. Fatigue tests up to 2 million cycles did not cause any signs of degradation. The subsequent failure tests indicated that a significant factor of safety exists under the AASHTO truck load.

### Speaker Biography

Dr. Lei Zhao is an assistant professor of civil engineering at the University of Central Florida, Orlando. He received his Ph.D. degree from the University of California-San Diego in 1999. His research interests include FRP bridge decks, strengthening RC structures with FRP, and reinforced and prestressed concrete systems.

# TESTING OF A FRP BRIDGE DECK

LEI ZHAO

UNIVERSITY OF CENTRAL FLORIDA
ORLANDO

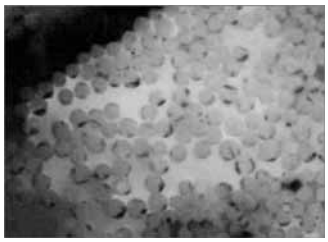


## OUTLINE

- BACKGROUND
- FRP DECK SYSTEM DESCRIPTION
- TEST RESULTS
- SUMMARY

## *FRP* *a.k.a.*

- *Fiber-Reinforced Polymer Composites*
- *Fiber-Reinforced Plastic*
- *Fiberglass*



*Fiber filaments (dia. ~10 μm) and resin matrix*

*Bridge deck panel*



## *WHY FRP ?*
*(AS A BRIDGE DECK MATERIAL)*

- *Corrosion resistant*
- *Lightweight*
- *High strength*
- *Prefabricated (rapid installation)*

## *COST OF FRP DECKS*

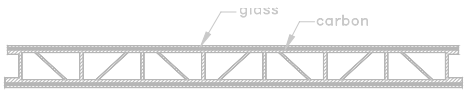
***$65 to $120 per ft$^2$ before installation***

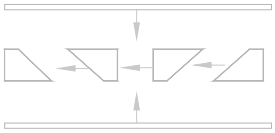
- ***Difficult to justify for a typical bridge***
- ***May prove economical when used in corrosive environments: <u>freeze-thaw</u> or <u>splash zone</u>***
- ***May improve <u>economy</u> and <u>safety</u> when used to replace open steel grid decks on moveable bridges***



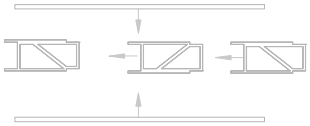
## *FRR BRIDGE DECKS* *(Past experience)*

***ASSEMBLY OF PULTRUDED PARTS (ADHESIVE BONDING)***



***Lockheed Martin***



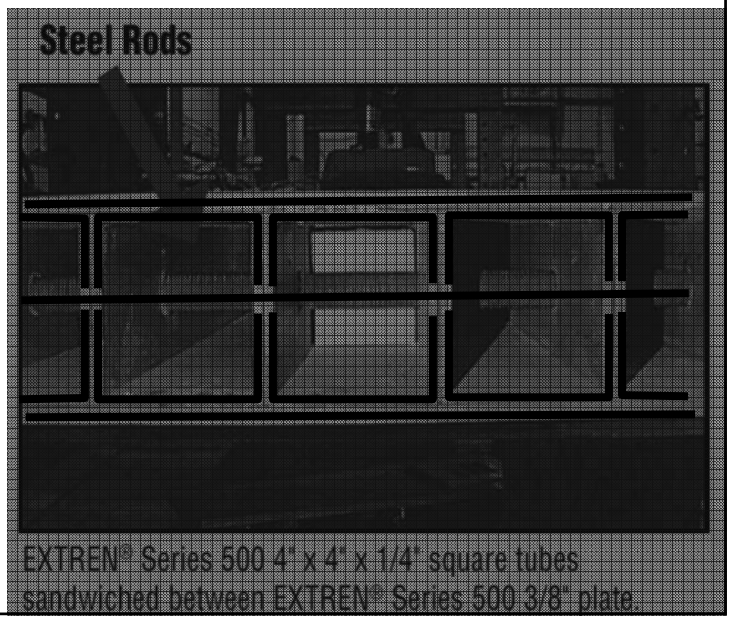
***Martin Marietta***

## *FRR BRIDGE DECKS* *(Past experience)*

*Kings Stormwater Composite Bridge, California, 2001*

## *FRR BRIDGE DECKS*
*(Past experience)*

*ASSEMBLY OF PULTRUDED PARTS (ADHESIVE BONDING AND MECH. FASTENING)*

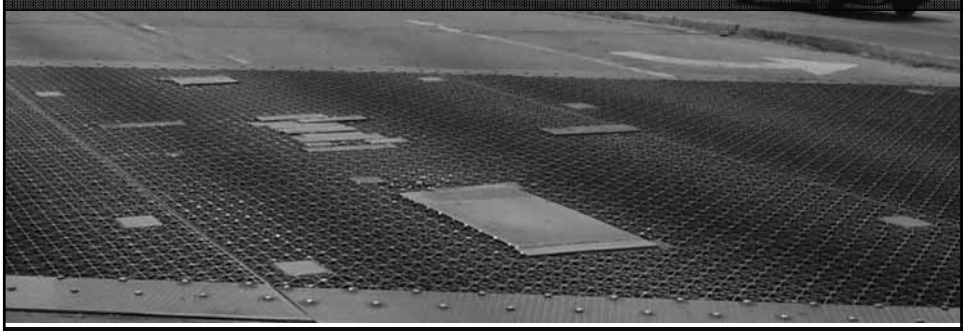



*Strongwell*

UCF

## PROBLEMS OF OPEN STEEL GRID DECKS

- Safety: Slippery when wet
- Maintenance: Damage-prone and costly to repair
- Environmental: Noisy
- Falling debris: Safety, girder corrosion
- Alternatives: Few, due to weight restriction (25 psf)



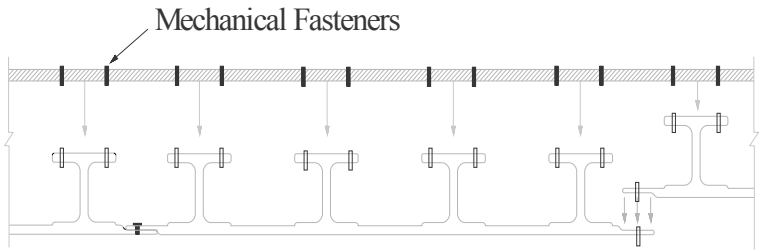
Hillsboro Canal Bridge, Belle Glade (FDOT D4, NIB 930338 )

## FRP DECKS (as replacement for steel grid decks)

- Weight: $\leq$ 25 psf
- Solid riding surface
  - Safer rides
  - Quieter
  - No falling debris
- Low maintenance
- Demonstration and monitoring on the Hillsboro Canal Bridge (Funding anticipated from FHWA-IBRC)

## FRR BRIDGE DECK SYSTEM UNDER INVESTIGATION

***ASSEMBLY OF PULTRUDED PARTS (MECHANICAL FASTENING)***



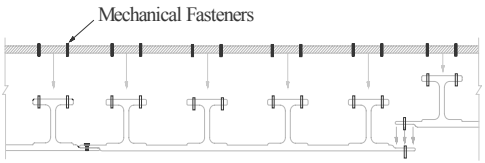

***ZellComp FRP deck system***



## ZELLCOMP SYSTEM VERSUS OTHER COMMERICALLY AVAILABLE SYSTEMS

***ADVANTAGES***

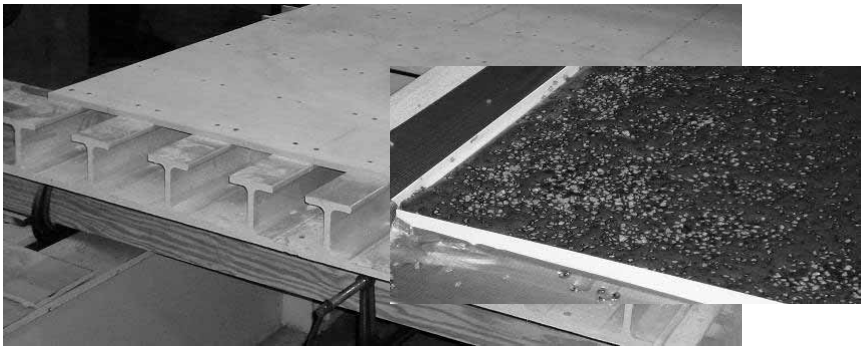
- ***LOWER COST***
- ***EASY CONNECTION***
- ***REPAIRABILITY***

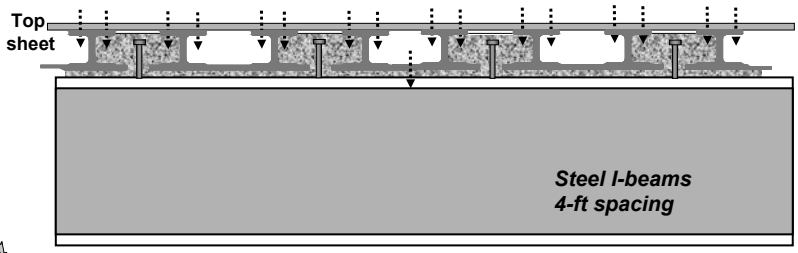



***DISADVANTAGES***

- ***EXTENSIVE ON-SITE DRILLING/FASTENING***
- ***POOR TRANSVERSE FORCE TRANSFER***

## FRP DECK ON STEEL I-BEAMS

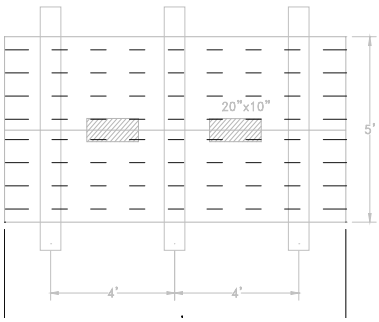


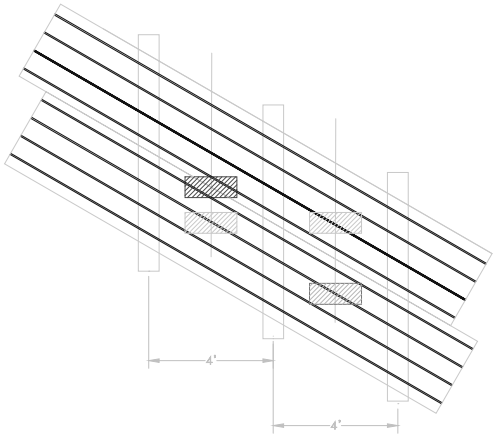



UCF

FICE/FDOT Design Conference 2006

## LABORATORY TESTING



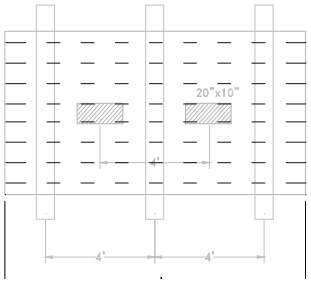

*Non-skew*

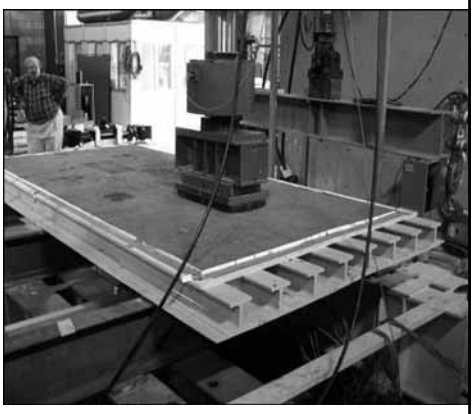
*30°-skew*

UCF

FICE/FDOT Design Conference 2006

## LABORATORY TESTING (Non-skew)

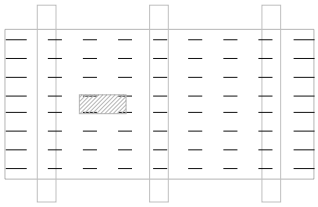


**Fatigue**

*18 kip each pt*

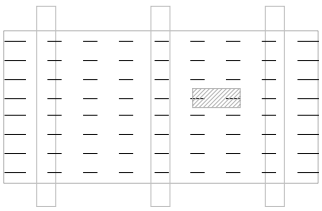
*2 mil. cycles*



**FAIL 1**

*West span*

*Between webs*



**FAIL 2**

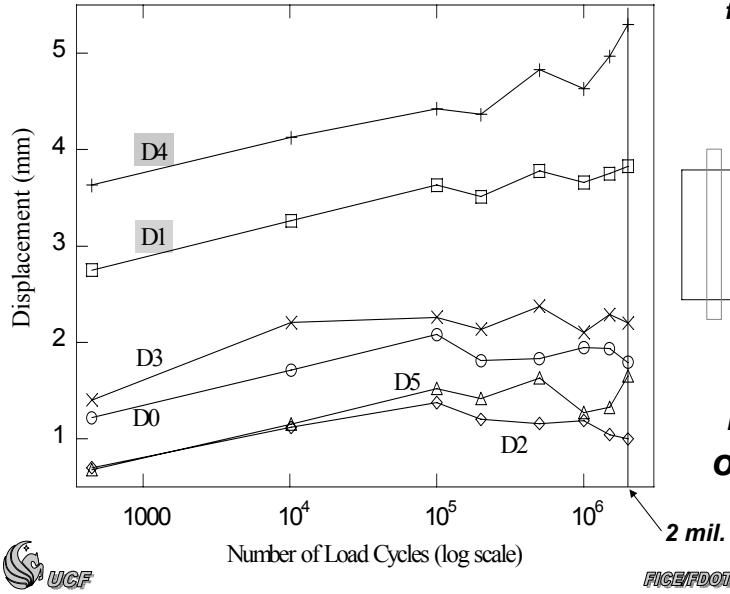
*East span*

*On web*

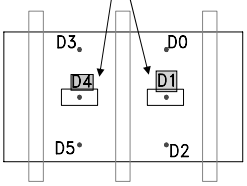
UCF

FICE/FDOT Design Conference 2006

## MID-SPAN DISPLACEMENT PROPAGATION UNDER FATIGUE LOAD




*Simultaneous fatigue loading up to 18 kips each span*

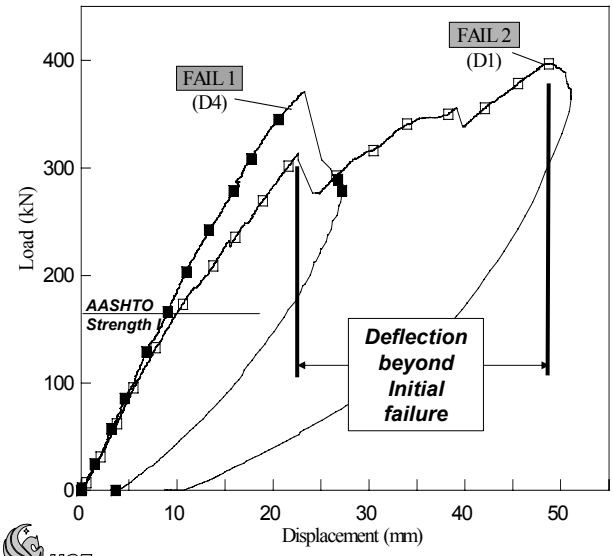


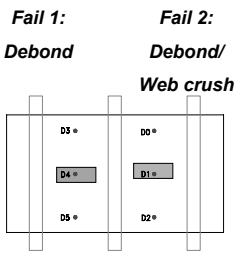

***No signs of damage.***

UCF

FICE/FDOT Design Conference 2006

## FAILURE TESTS



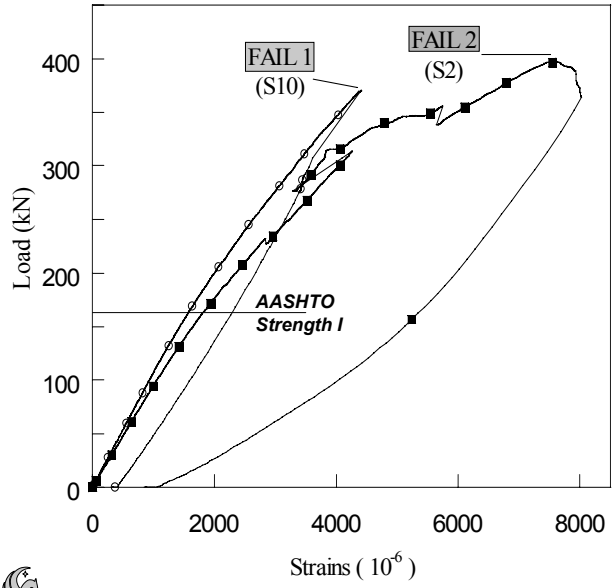



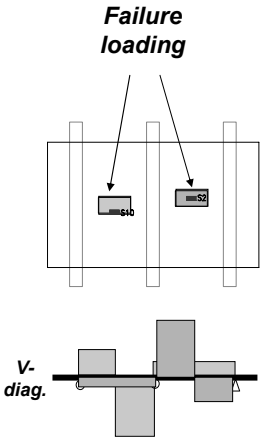

**Debond not visible.**

UCF

FICE/FDOT Design Conference 2006

## FAILURE TESTS



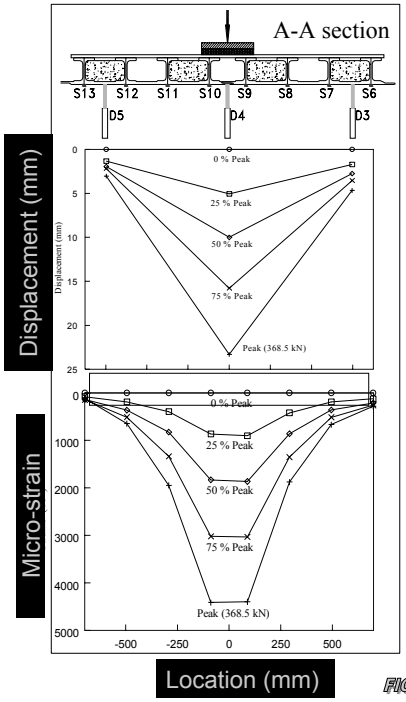

UCF

FICE/FDOT Design Conference 2006

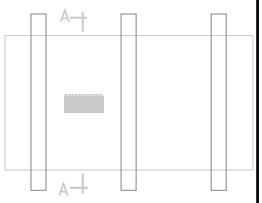
## FAILURE TEST

*Displacement profile*

*Strain profile*




***FAIL 1***
***West Span***



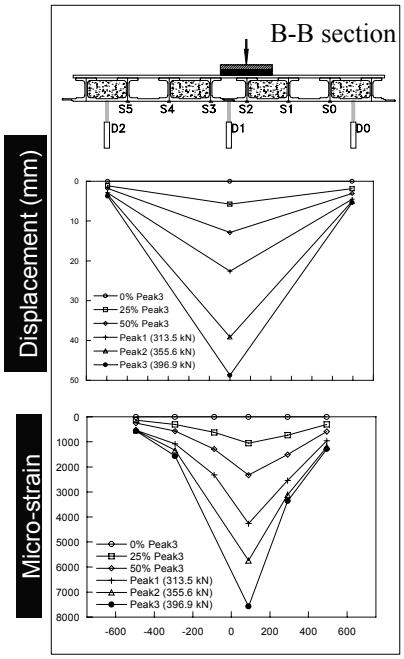

UCF

FICE/FDOT Design Conference 2006

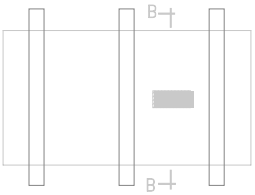
## FAILURE TEST

***Displacement Profile***

***Strain profile***



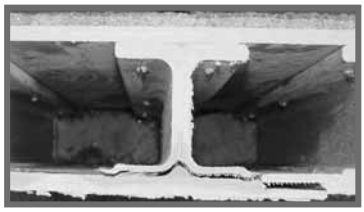

***FAIL 2***
***East span***



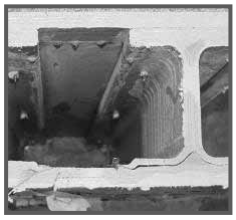

UCF

FICE/FDOT Design Conference 2006

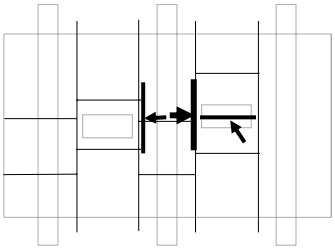
## FAILURE MODES ANALYSIS



Bottom plate delamination



Delamination

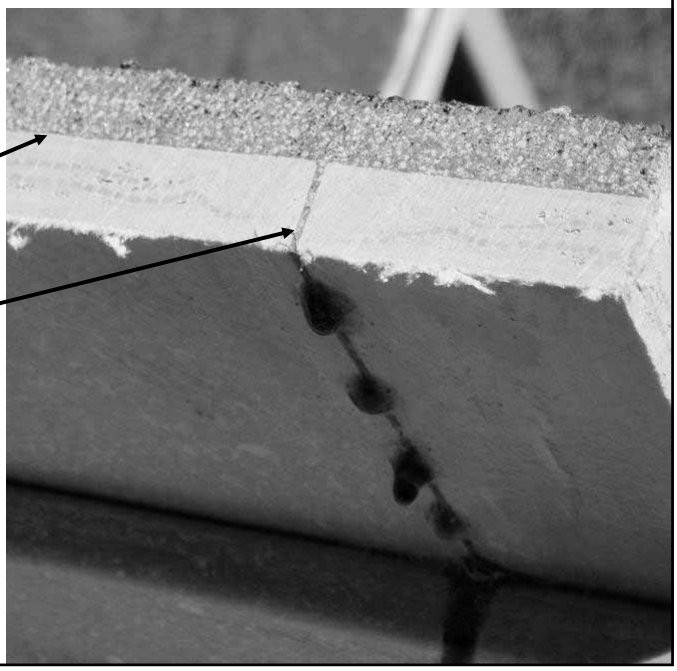


Web buckling

UCF

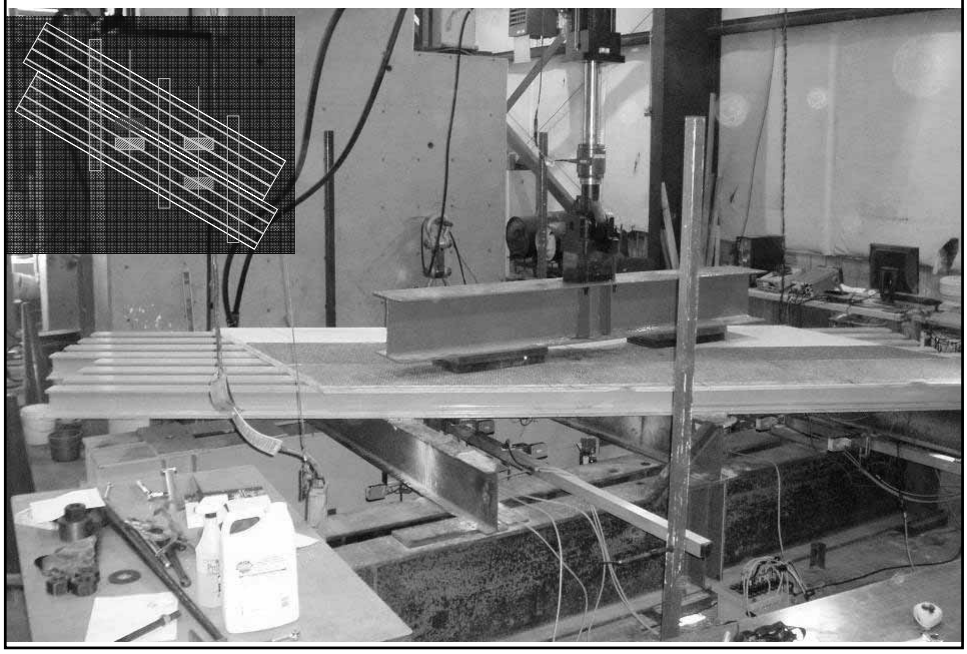
FICE/FDOT Design Conference 2006

## WEAR SURFACE AND TOP PLATE JOINTS

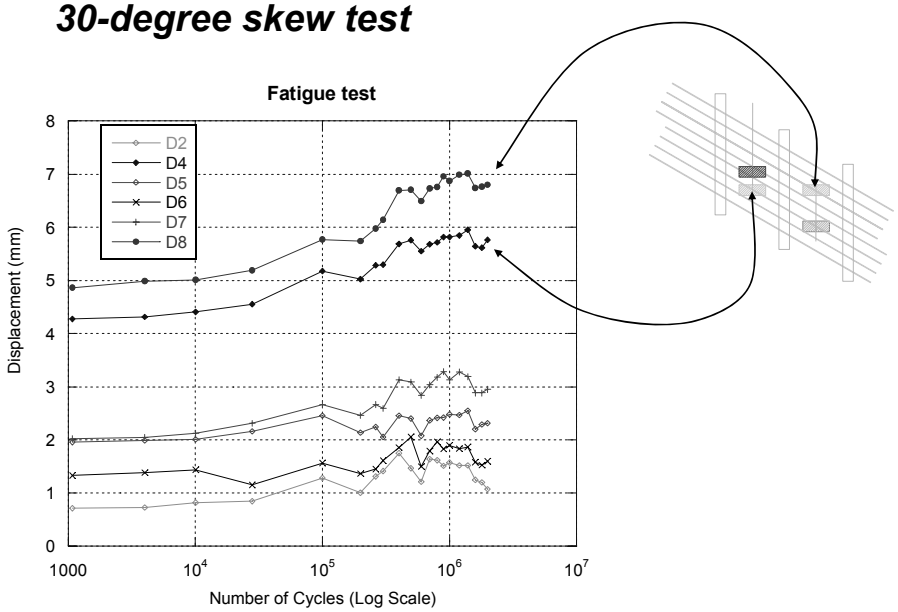



UCF

## TESTING OF A SKEWED DECK SYSTEM



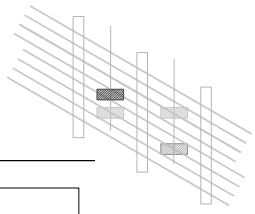
## 30-degree skew test

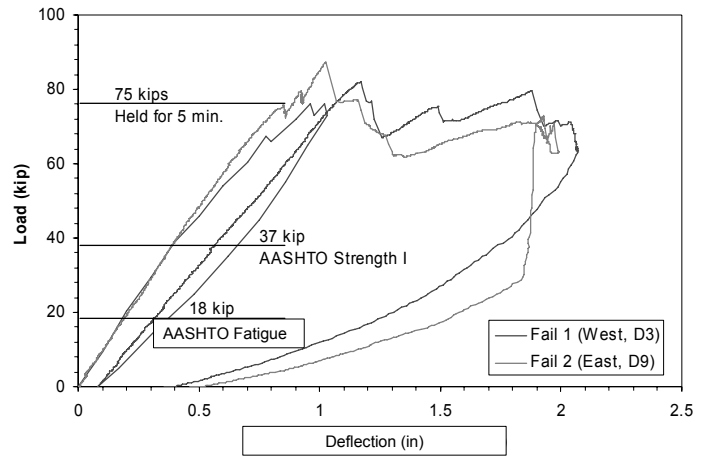



UCF

FICE/FDOT Design Conference 2006

## 30-degree skew test






UCF

FICE/FDOT Design Conference 2006

## SUMMARY

- ***Fatigue performance (2 mil. cycles)***

  ***- No noticeable signs of degradation***
  ***- Steady displacement propagation on a log-scale.***

- ***Significant strength reserves***

  ***- AASHTO Strength I: 37 kips (factored)***
  ***- Non-skew (FAIL 1/2): 83 / 89 kips***
  ***- Skew (FAIL 1/2): 83 / 86 kips***

- ***Significant deflection capability beyond initial failure. A DUCTILE FAILURE!***

UCF

FICE/FDOT Design Conference 2006

## ACKNOWLEDGEMENTS


- FDOT STRUCTURES LABORATORY, TALLAHASSEE

  Marcus Ansley, Frank Cobb, Paul Tighe, David Allen, and Steve Eudy.
- UCF

  Jignesh Vyas (Grad student)
- FDOT DISTRICT 4
- ZELLCOMP, DURHAM, NC
- TRANSPO INDUSTRIES, ROSWELL, GA
- QUIKBOND, INC., CA