End Region Detailing of Pretensioned Concrete Bridge Girders

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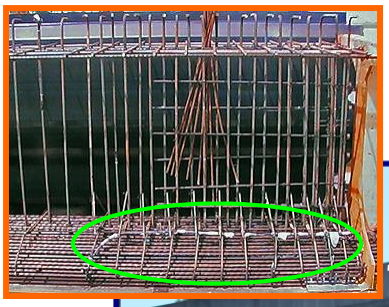
FDOT Contract BDK75 977-05

Presentation Outline

- Prestressing basics
- Background on end region reinforcement
- FIB54 Test Program – Service and Ultimate
- FIB63 Test Program – Service
- Findings

End Region



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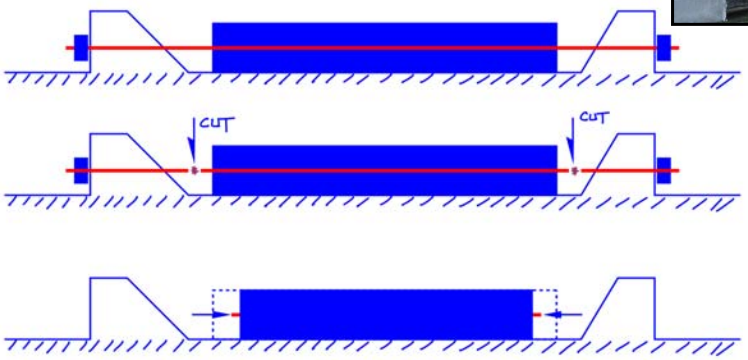
Effect of Prestressing



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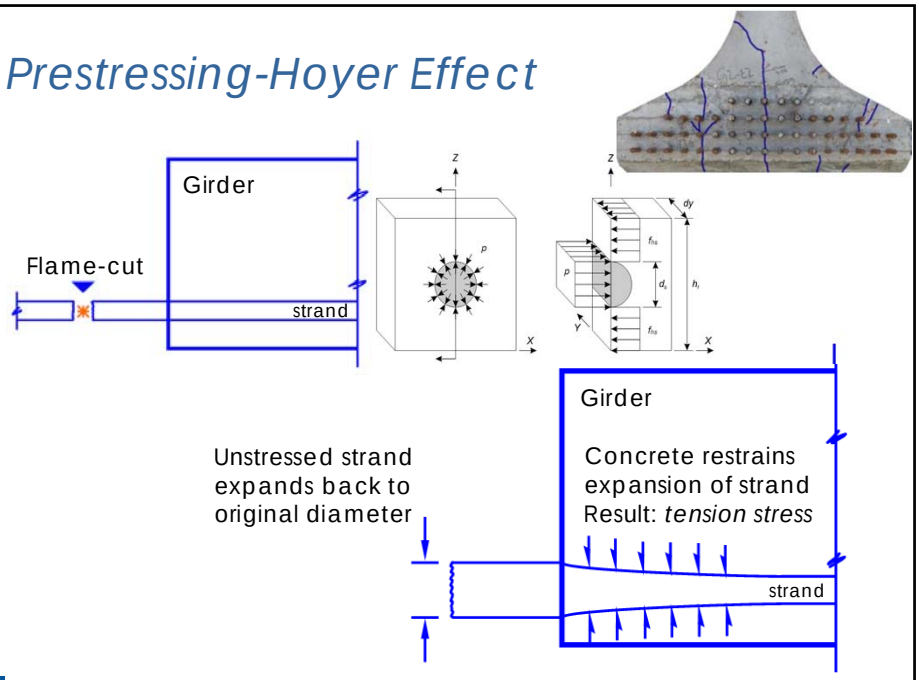
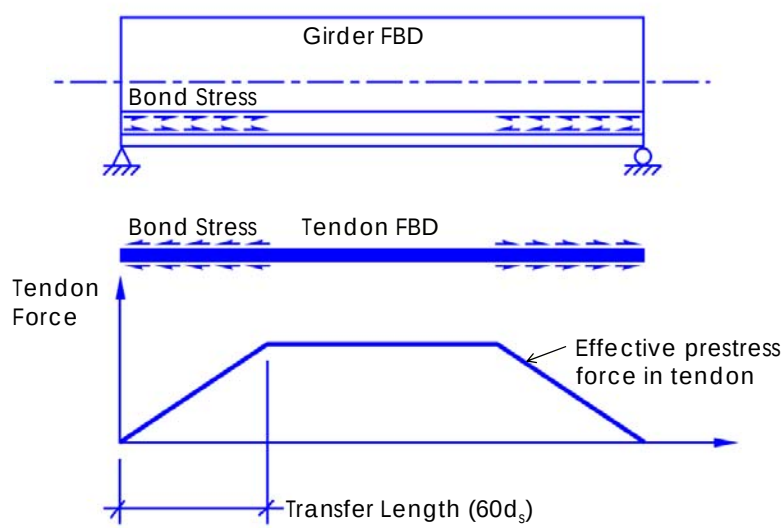
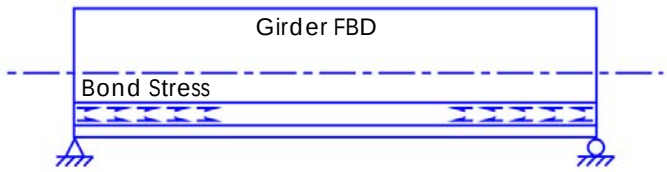
Prestressing-Hoyer Effect

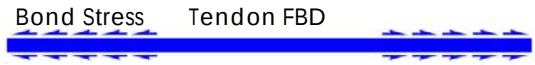


Prestressing-Transfer Length



Prestressing-Transfer Length





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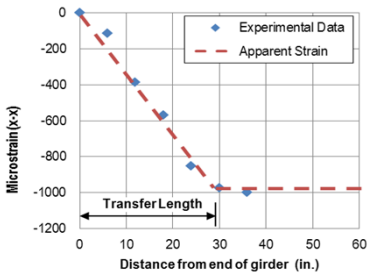

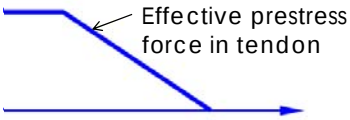

th ($60d_s$)

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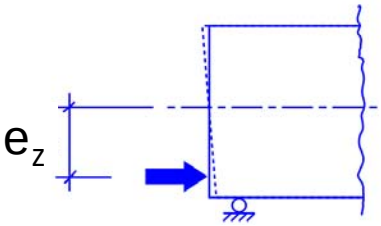
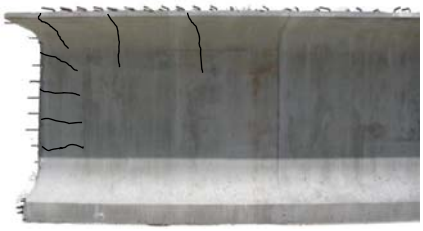
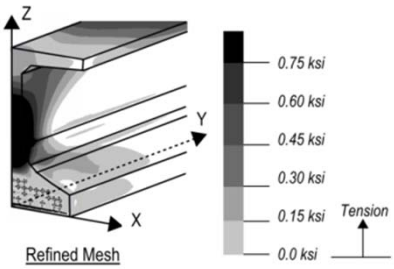
Prestressing Effect-Splitting







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Splitting-Web

5.10.10.1 Factored Bursting Resistance

The bursting resistance of pretensioned anchorage zones provided by vertical reinforcement in the ends of pretensioned beams at the service limit state shall be taken as:

$$P_r = f_s A_s \qquad (5.10.10.1\text{-}1)$$

where:

f_s = stress in steel not exceeding 20 ksi

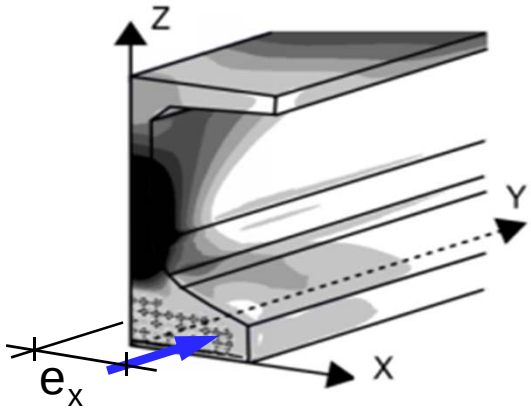
A_s = total area of vertical reinforcement located within the distance $h/4$ from the end of the beam (in.^{2})

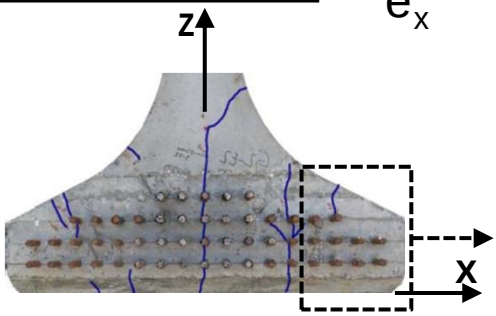
h = overall depth of precast member (in.)

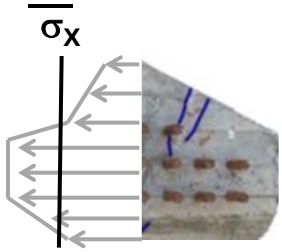
The resistance shall not be less than 4 percent of the prestressing force at transfer.

The end vertical reinforcement shall be as close to the end of the beam as practicable.

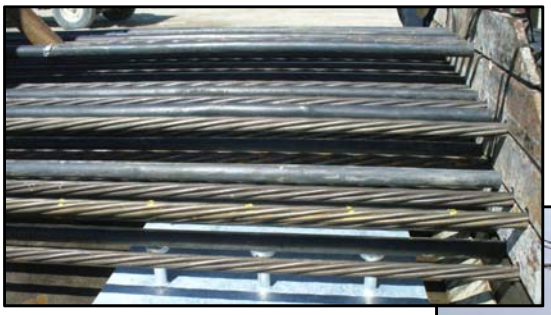
Splitting-Flange

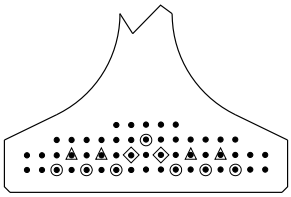






Prestressing Effect-Partial Debonding





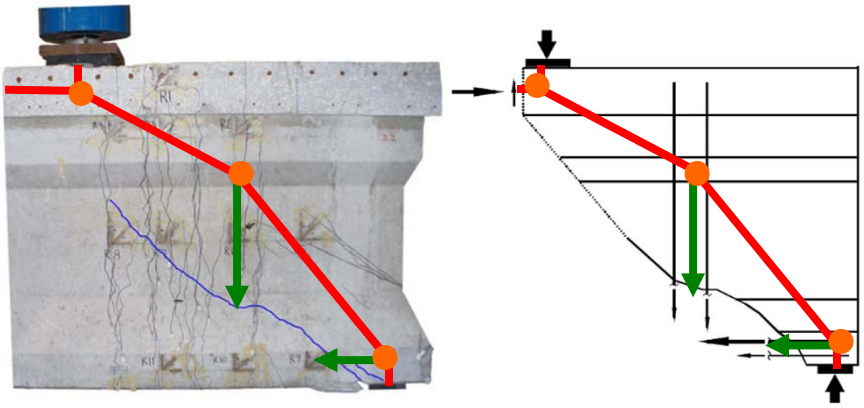
5.11.4.3 Partially Debonded Strands

Excerpt:

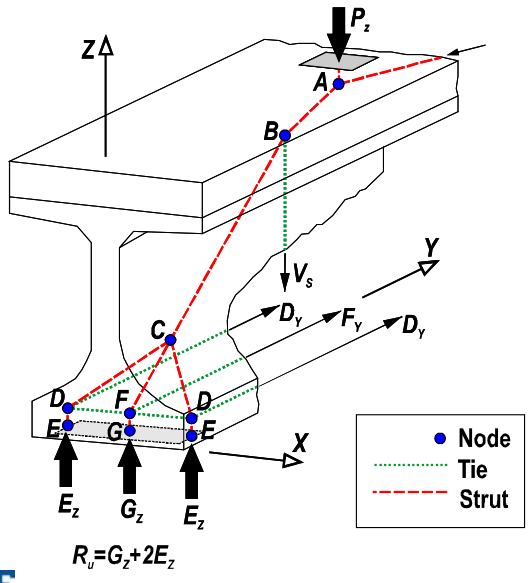
The number of partially debonded strands should not exceed 25 percent of the total number of strands.

The number of debonded strands in any horizontal row shall not exceed 40 percent of the strands in that row.

Ultimate Strength-Strut and Tie



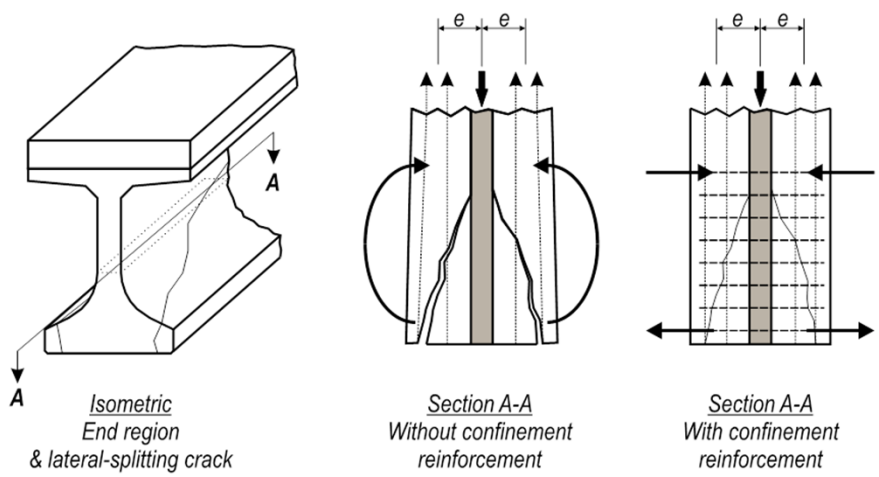
Ultimate strength-Strut and Tie



Considerations

Factored Load
Flange Geometry
Bearing Geometry
Strand Locations

Lateral-Splitting Failure



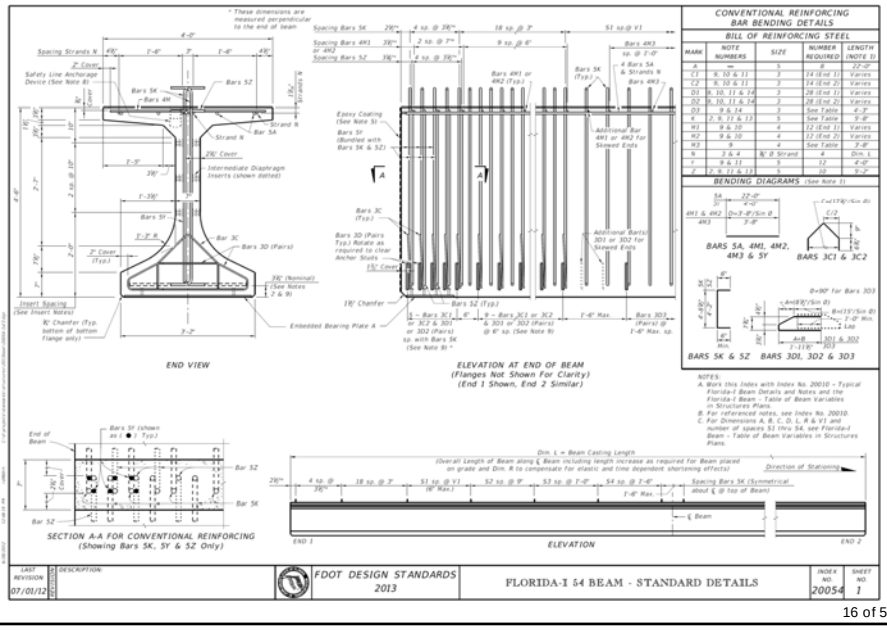
LRFD "Confinement"

5.10.10.2 Confinement Reinforcement

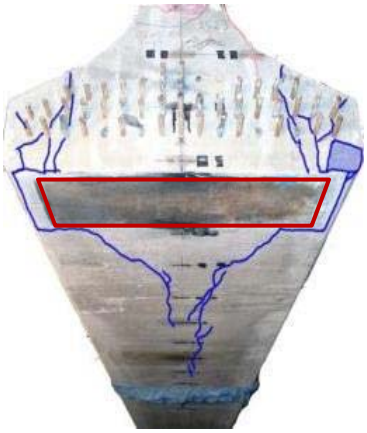
For the distance of 1.5*d* from the end of the beams other than box beams, reinforcement shall be placed to confine the prestressing steel in the bottom flange. The reinforcement shall not be less than No. 3 deformed bars, with spacing not exceeding 6.0 in. and shaped to enclose the strands.

For box beams, transverse reinforcement shall be provided and anchored by extending the leg of stirrup into the web of the girder.

FDOT Standard Details



Research Approach



FIB54: Flange Cracks & Ultimate Capacity
FIB63: Web Cracks
Finite Element Analysis

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FIB54

- 10 Specimens (5 beams)
- Fabrication
  - ✓ Strain data
  - ✓ Crack data
- Load tests
  - ✓ Behavior
  - ✓ Capacity

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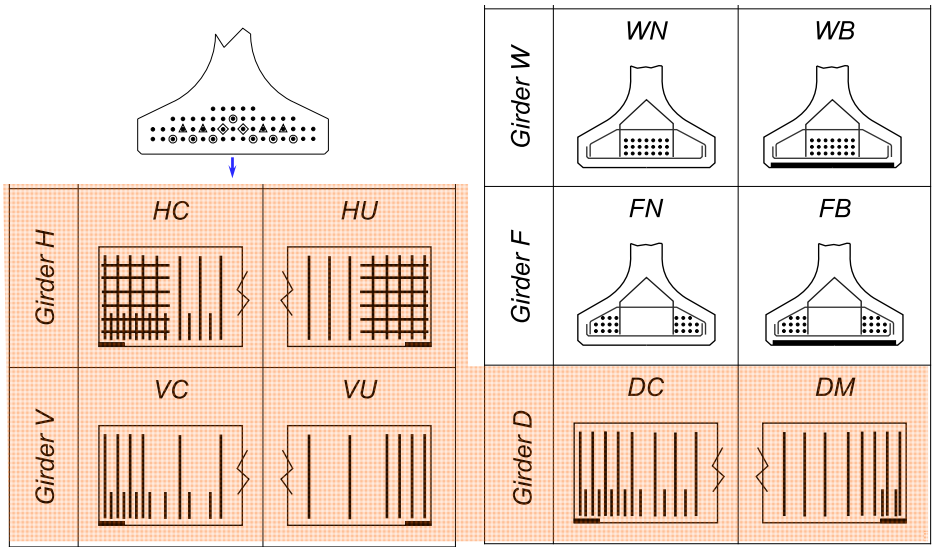
FIB54 Reinforcement and Prestressing Scheme



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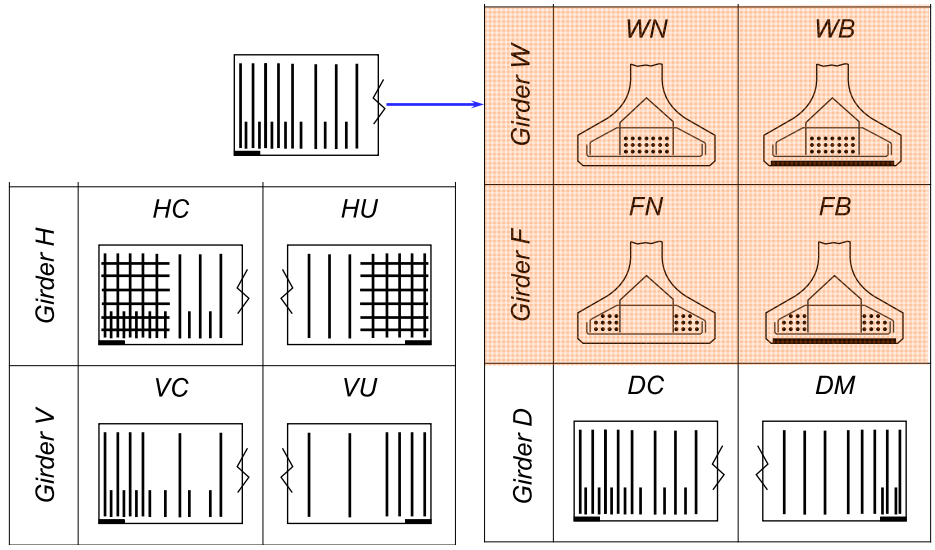
FIB54 Reinforcement and Prestressing Scheme



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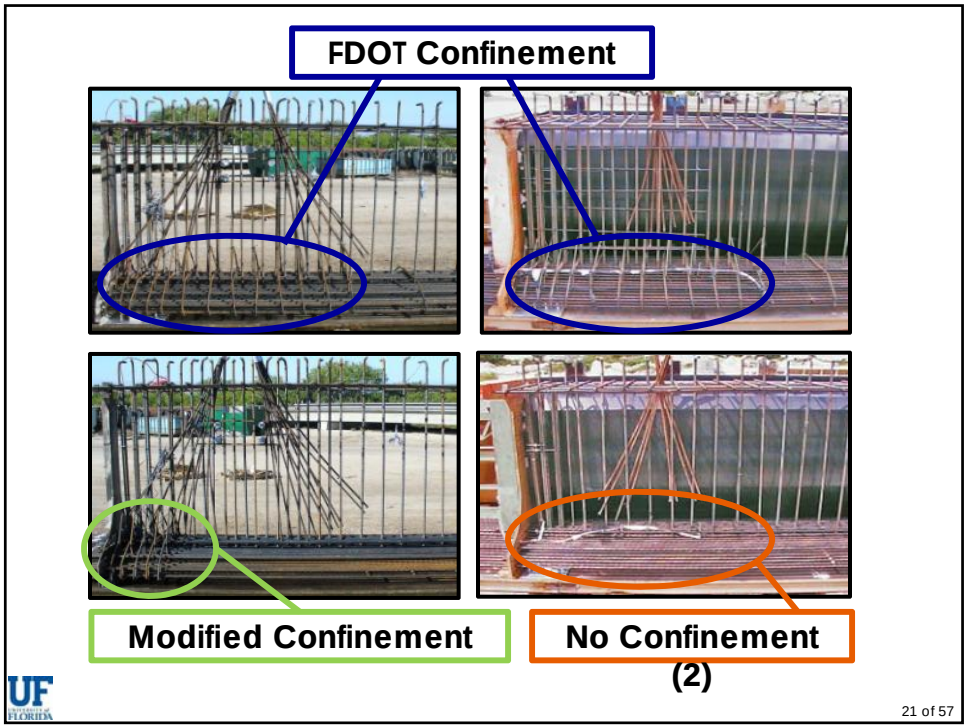
FDOT Confinement
Modified Confinement
No Confinement
(2)
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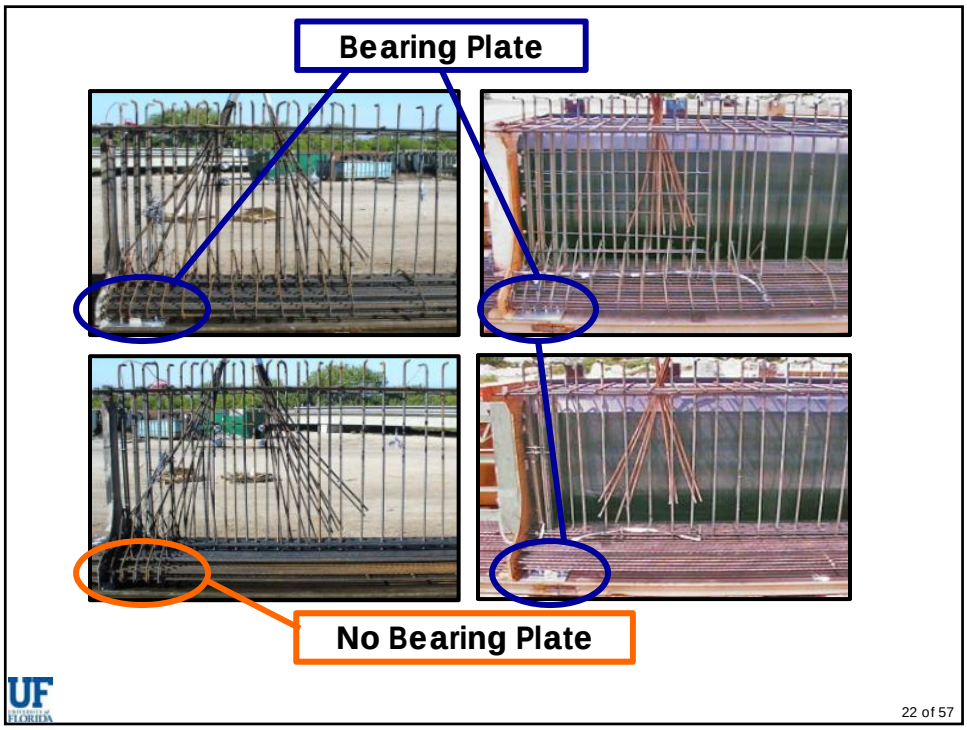
Bearing Plate
No Bearing Plate
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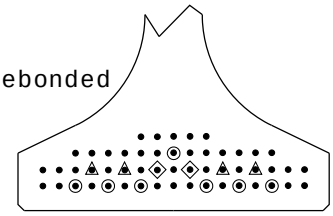
FIB54 Debonding

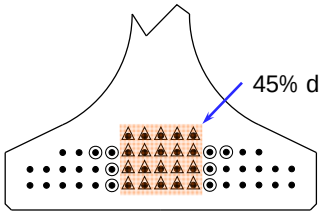
- Fully Bonded
- Shielded entire length
- Shielded 10 ft
- Shielded 5 ft

13% debonded

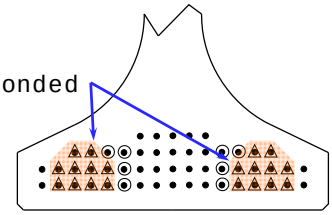


Design Pattern

45% debonded



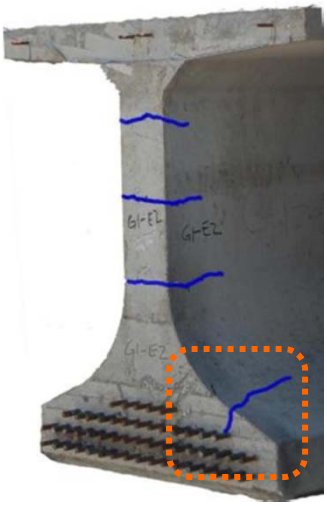
Flange Pattern

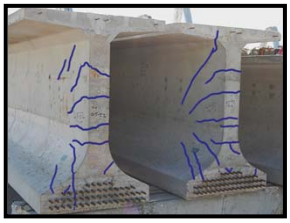


Web Pattern

FIB54-Results

Flange Splitting Cracks





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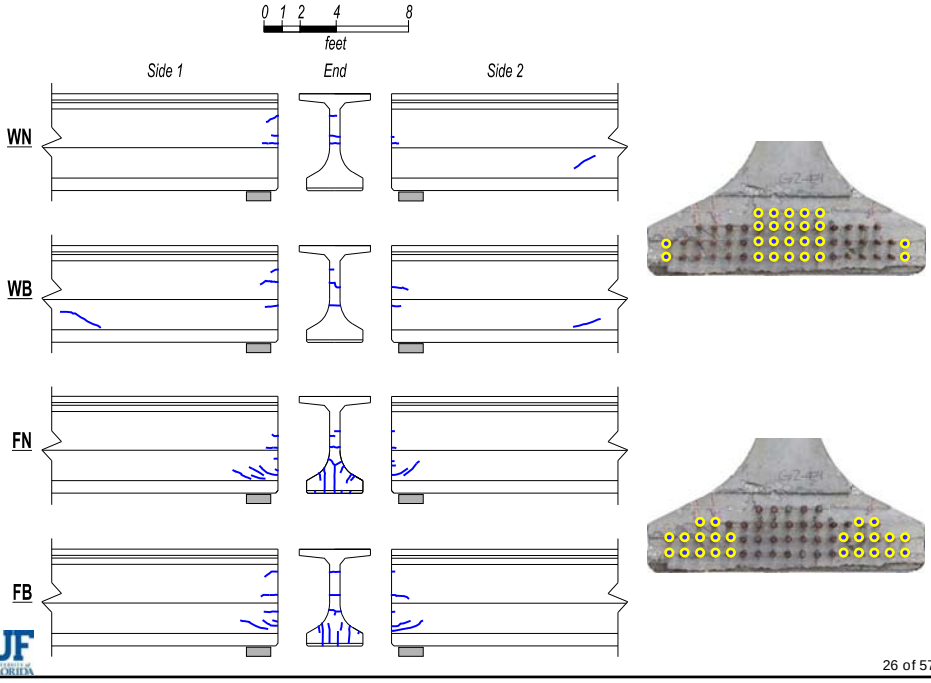

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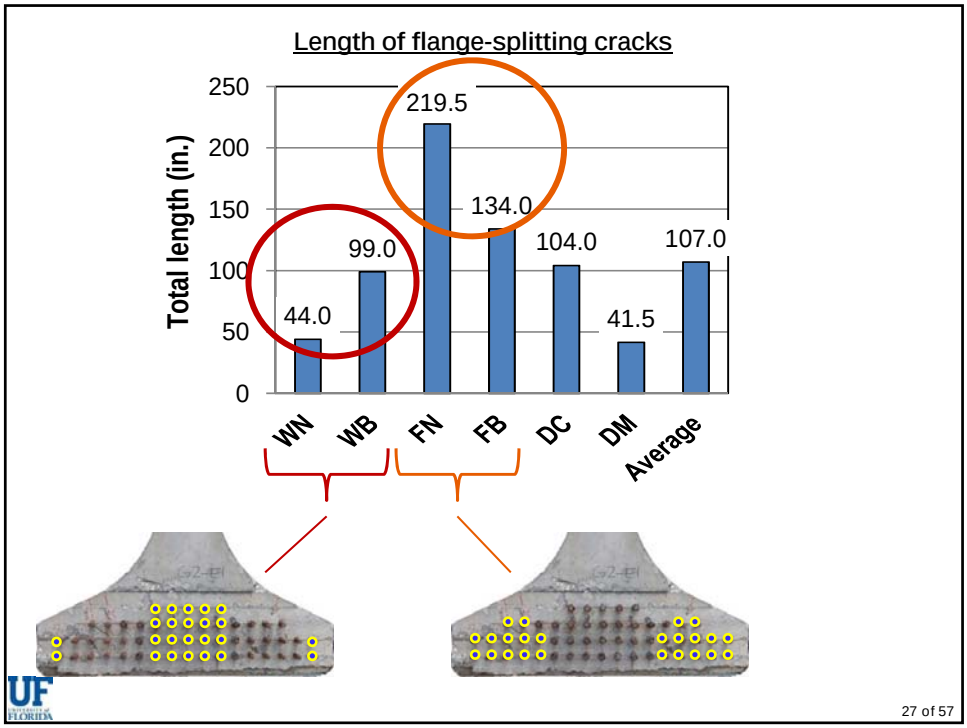
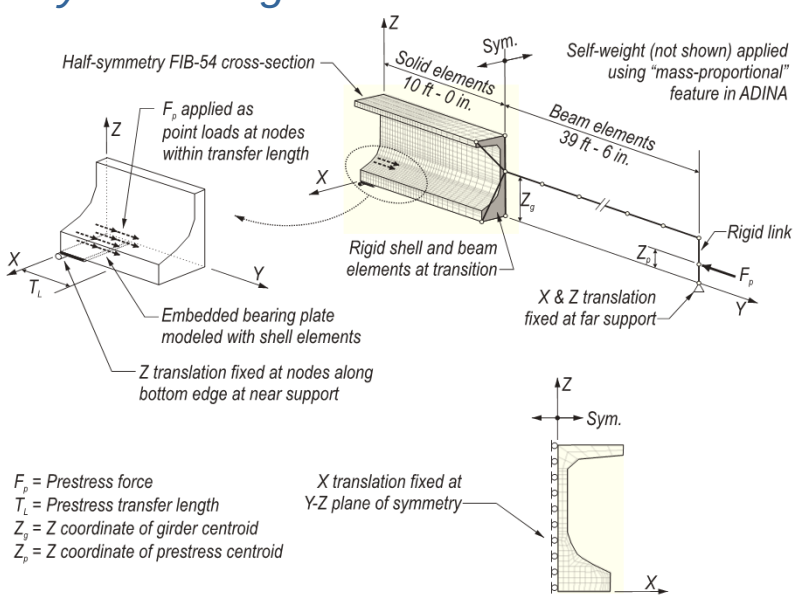
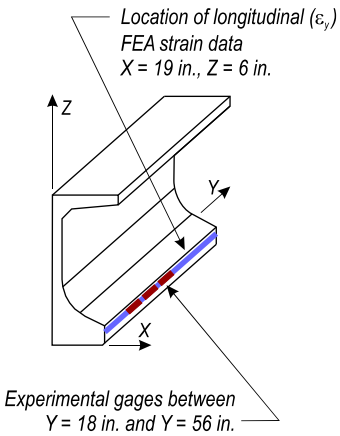


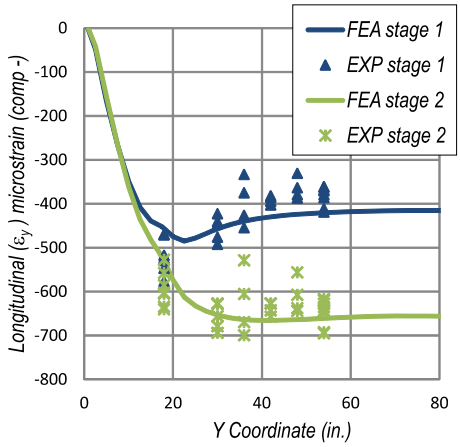
Analytical Program



F_p = Prestress force
T_L = Prestress transfer length
Z_g = Z coordinate of girder centroid
Z_p = Z coordinate of prestress centroid

FEA + Experimental-Transfer Length

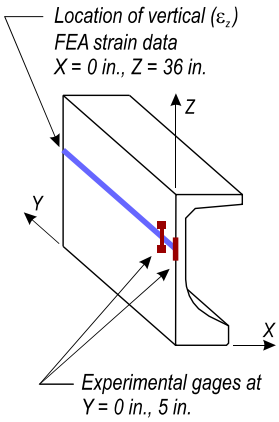


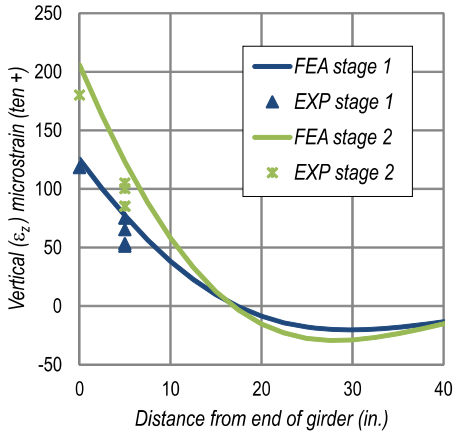


Stage 1 – outer strands released

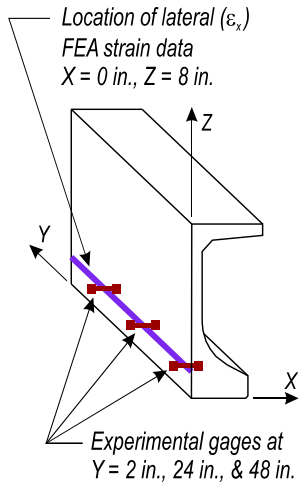
Stage 2 – all strands released

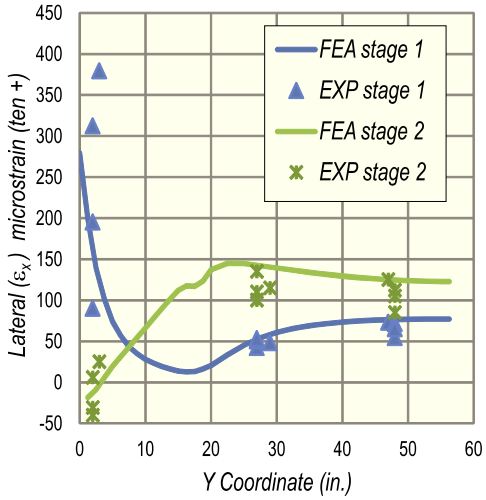
FEA + Experimental-Web Stresses





FEA + Experimental-Transverse Tension





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FIB54-Topping

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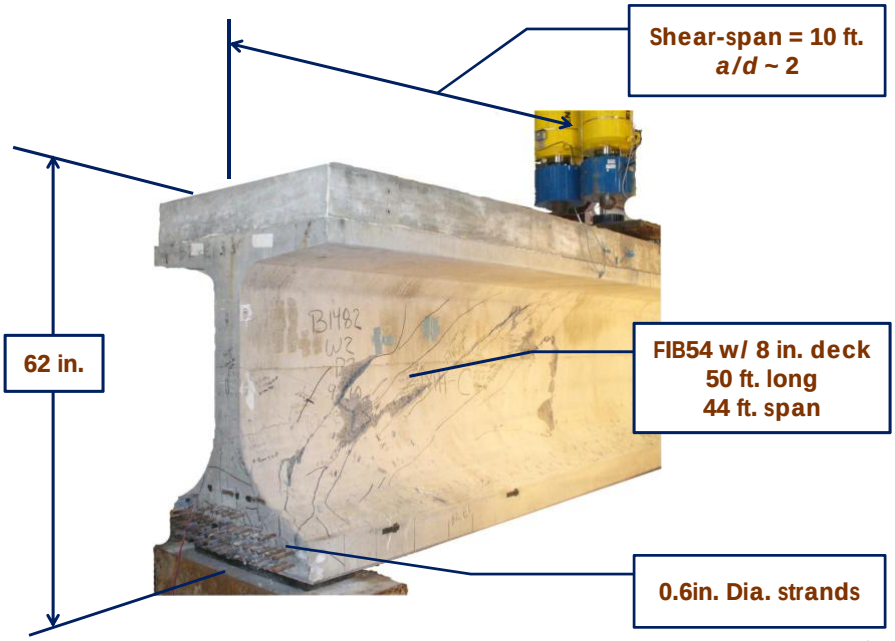
FIB54-Test Setup



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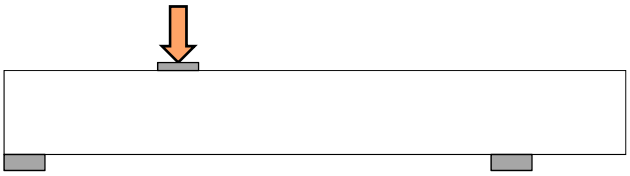
FIB54-Test Procedures



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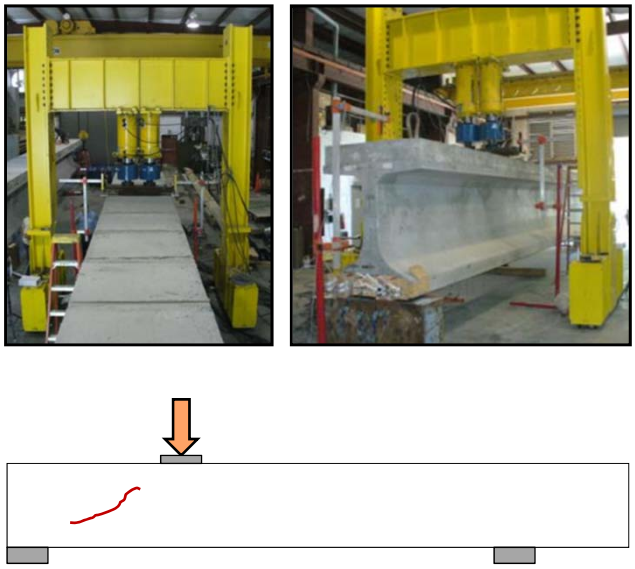
FIB54-Test Procedures



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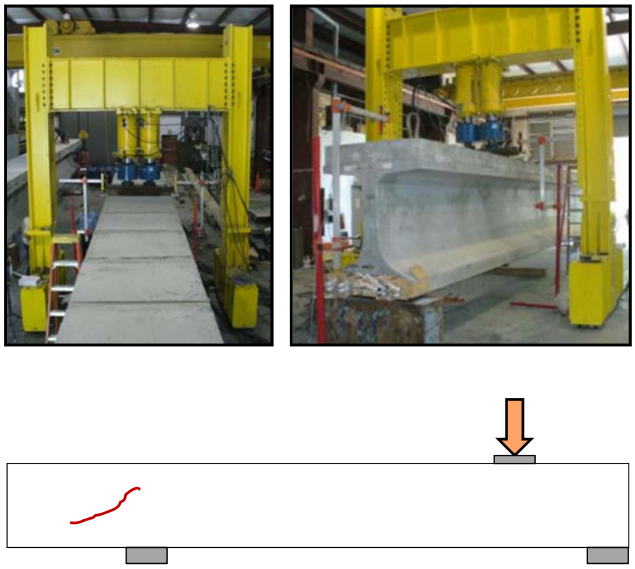
FIB54-Test Procedures



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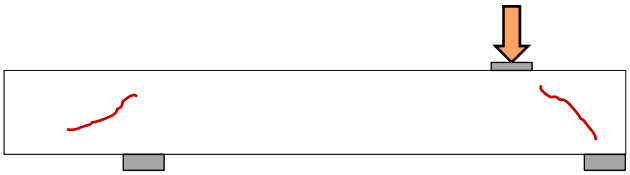
FIB54-Test Procedures



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FIB54-Results
Ultimate Capacity

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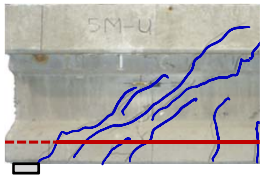
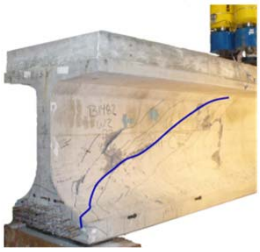
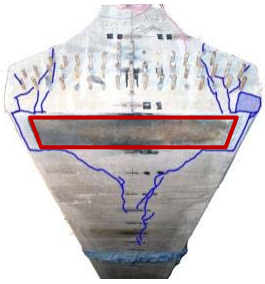
Failure Modes



Bond-Shear
(2) specimens



Web-Shear
(4) specimens



Lateral-Splitting
(4) specimens

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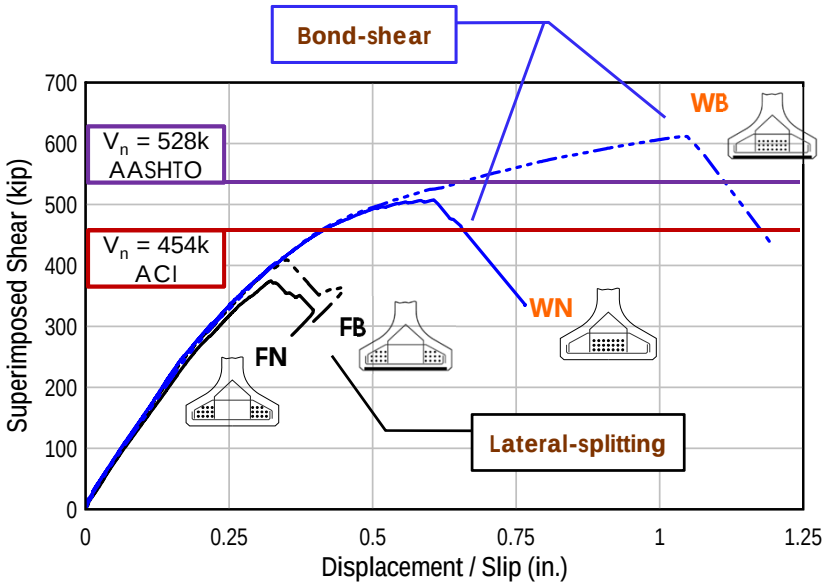
Ultimate Capacity



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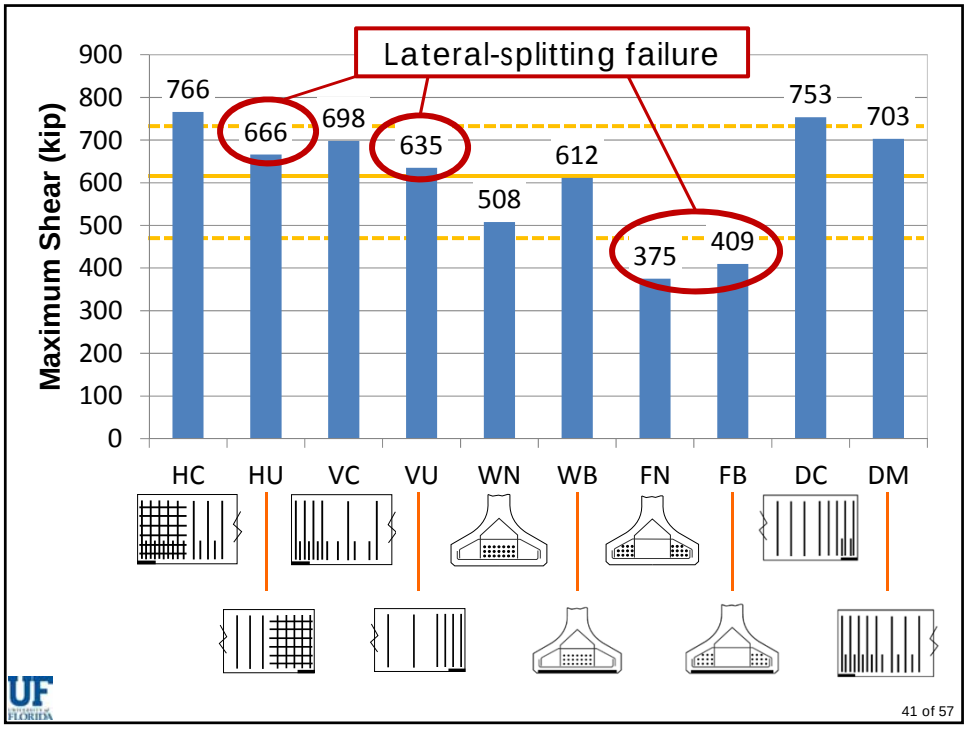
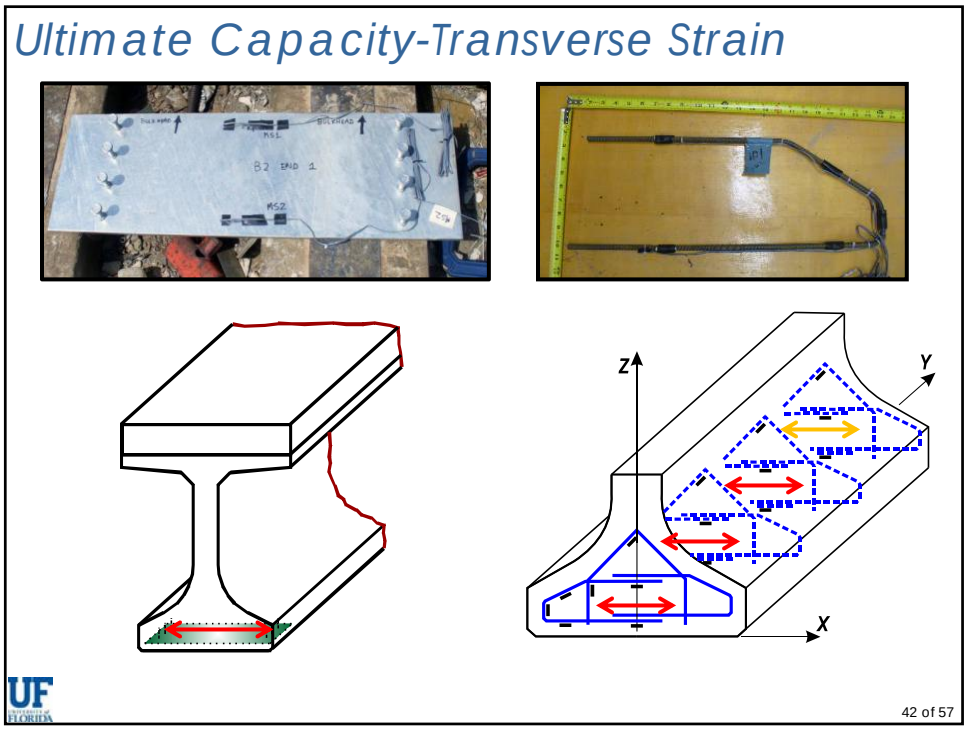

Lateral-splitting failure
Maximum Shear (kip)
900
800
700
600
500
400
300
200
100
0
766
666
698
635
508
612
375
409
753
703
HC
HU
VC
VU
WN
WB
FN
FB
DC
DM
41 of 57


Ultimate Capacity-Transverse Strain
Z
Y
X
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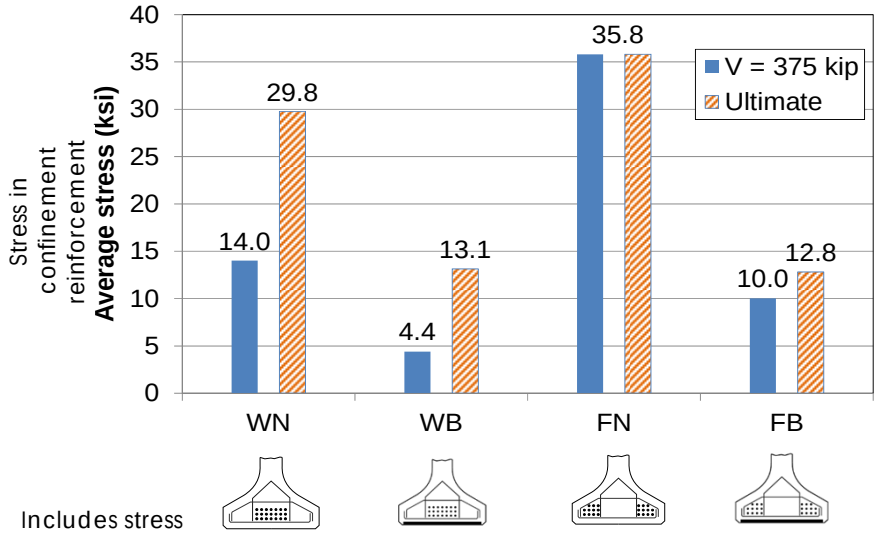
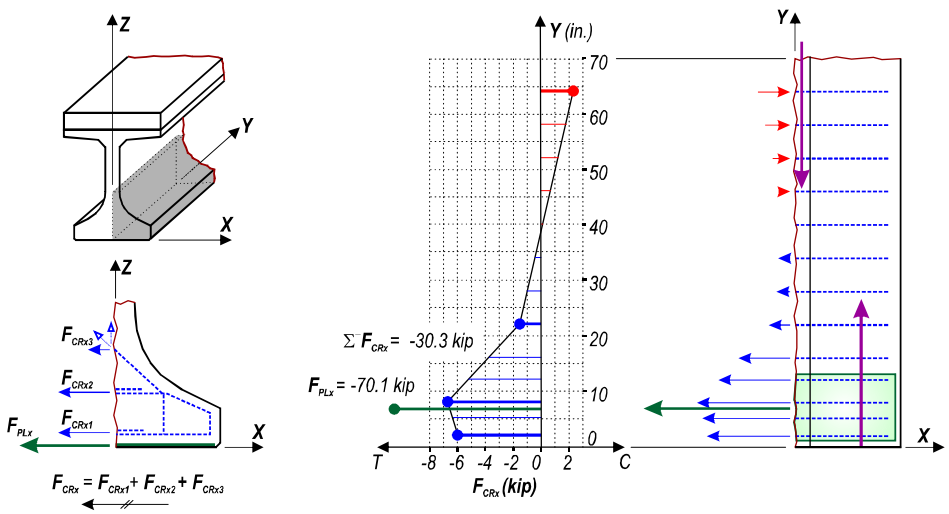
Ultimate Capacity-Transverse Strain

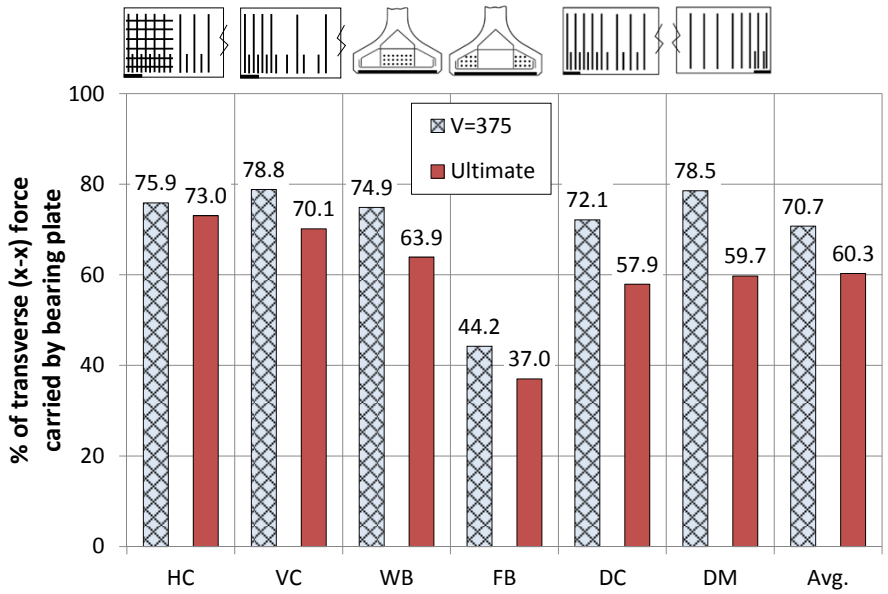


Includes stress from loading & prestressing

Ultimate Capacity-Transverse Strain



Ultimate Capacity-Transverse Strain



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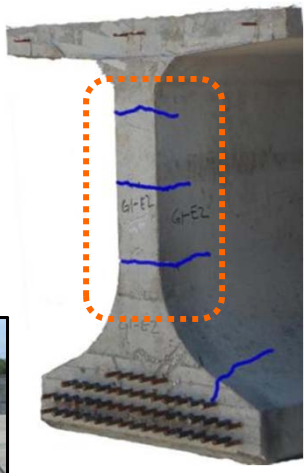
FIB63

- 4 specimens (2 beams)
- Monitor cracks after release
- Load test



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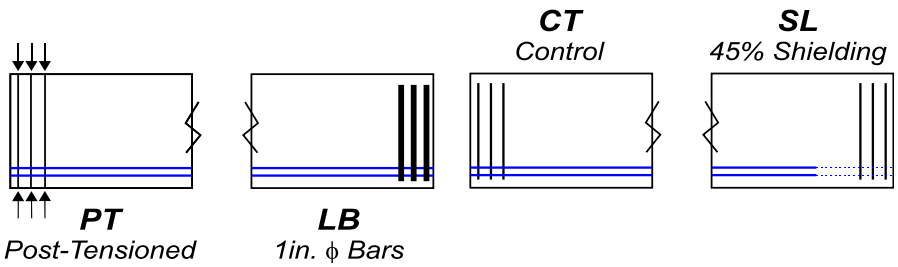
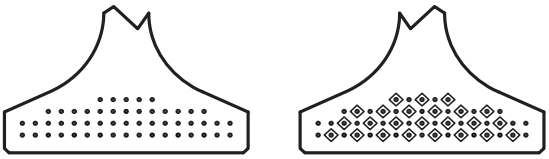
FIB63 Reinforcement and Prestressing Scheme



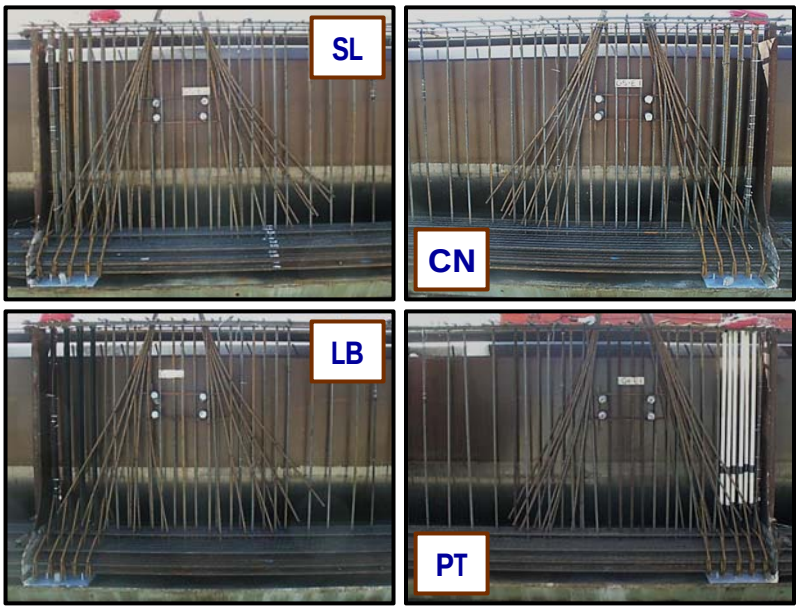
Shielding Legend
- • – No shielding
- ◈ – Shielded 5'-0" from end



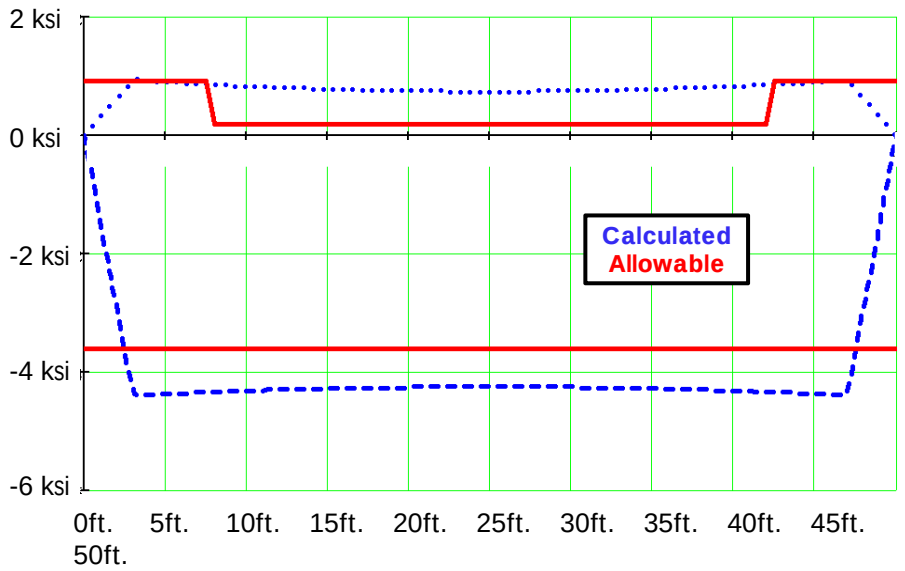
Shielding PT, LB, and CT

Shielding SH

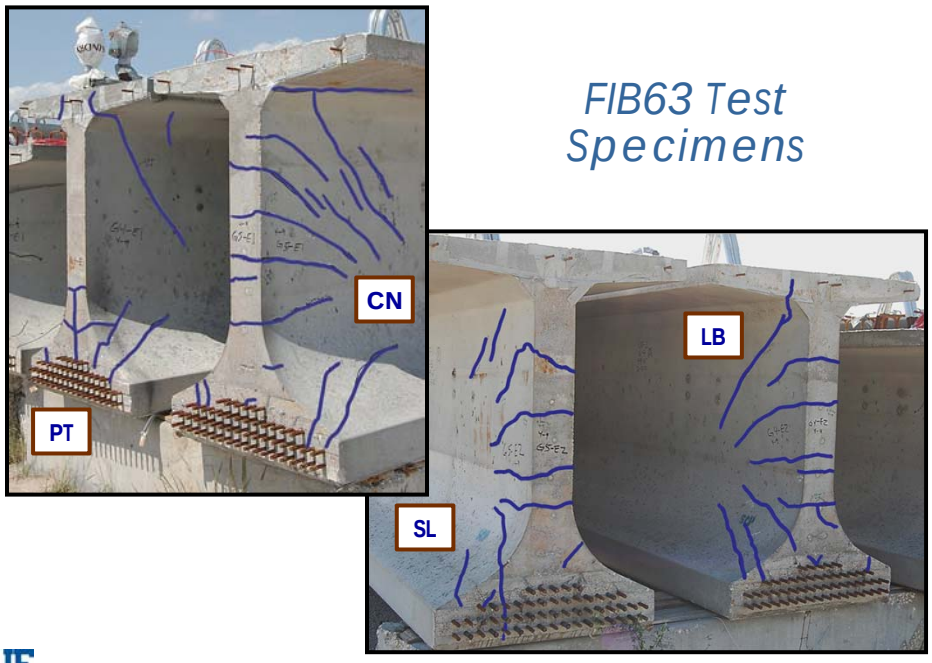
FIB63 Test Specimens



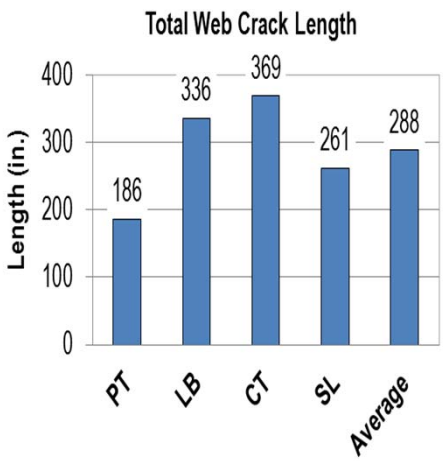
Release Stresses

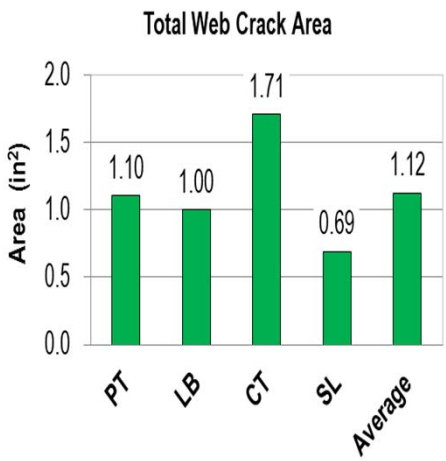


FIB63 Test Specimens



Web Splitting Cracks





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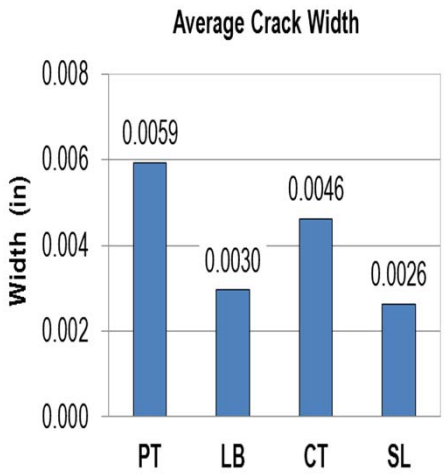
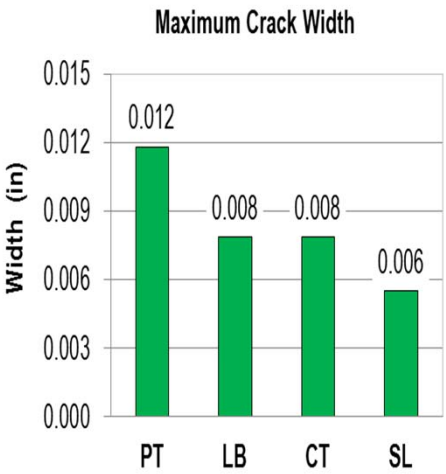
Web Splitting Cracks





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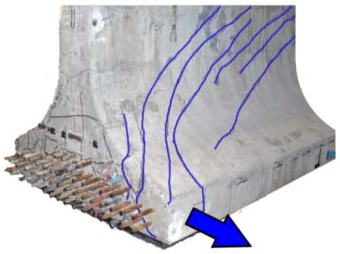
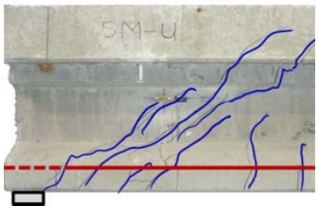
Conclusions-Ultimate Strength

- Horizontal reinforcement – Negligible
- Bearing plate - 9% to 21% improvement
- FDOT confinement reinforcement-13% increase over no reinforcement
- Bonded Strand - 43% increase for strands placed under web





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Conclusions–Flange Splitting

- Tension stress
  - ✓ Outer strands
  - ✓ Hoyer effect
- Strategies
  - ✓ Bonded strand arrangement
  - ✓ Confinement reinforcement
  - ✓ Bearing plate
  - ✓ Partial debonding

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Conclusions–Web Splitting

- Post-tensioning (PT)
  - ✓ Promising
  - ✓ Additional research
- Large diameter bars (LB)
  - ✓ Reduce crack width
  - ✓ No effect on crack length
- 45% strand shielding (SL)
  - ✓ Shorter, smaller cracks
  - ✓ Affects strength

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University of Florida
Civil and Coastal Engineering

Engineering
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Final Report March 2013

END REGION DETAILING OF PRETENSIONED CONCRETE BRIDGE GIRDERS

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Sam Fallaha, P.E. – Project Manager

Contract:
UF Project No. 00072910 & 00074016
FDOT Contract No. BDK75 977-05

Report BDK75 977-05

End Region Detailing of Pretensioned Concrete Bridge Girders

Available on the FDOT Research Website

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Thank You

- **Experimental work conducted at M. H. Ansley Structures Research Center**
- Many thanks to Sam Fallaha and the Center's staff!
- David Allen
- Adam Brennan
- Frank Cobb
- Steve Eudy
- Tony Hobbs
- Will Potter
- Paul Tighe
- David Wagner
- Chris Weigly
- Steven Nolan, P.E., FDOT Structures Design Office

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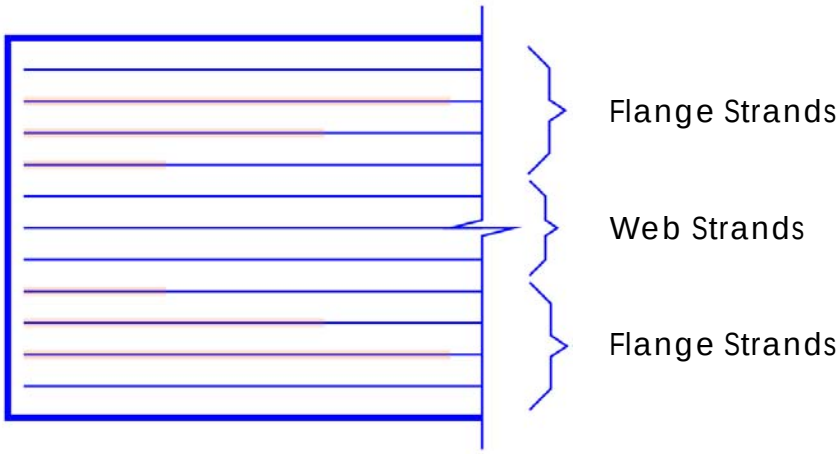
Wish List



Bottom Flange

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