SPTC Seminar Series

Innovative Multi-Hazard Resistant Bridge Columns for Accelerated Bridge Construction

Jeffery S. Volz, SE, PE, PhD

Southern Plains Transportation Center

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Outline

- Evolution of Concept
  - Hollow-Core Concrete
  - Concrete-Filled Tube
  - Concrete-Filled Double-Tube
- Column Design
  - Initial Sizing Guidelines
  - Sectional Analysis
- Research Project
  - Specimen Design & Fabrication
  - Specimen Testing & Results
  - Next Steps
- Thank Yous & Questions?

Evolution of Concept

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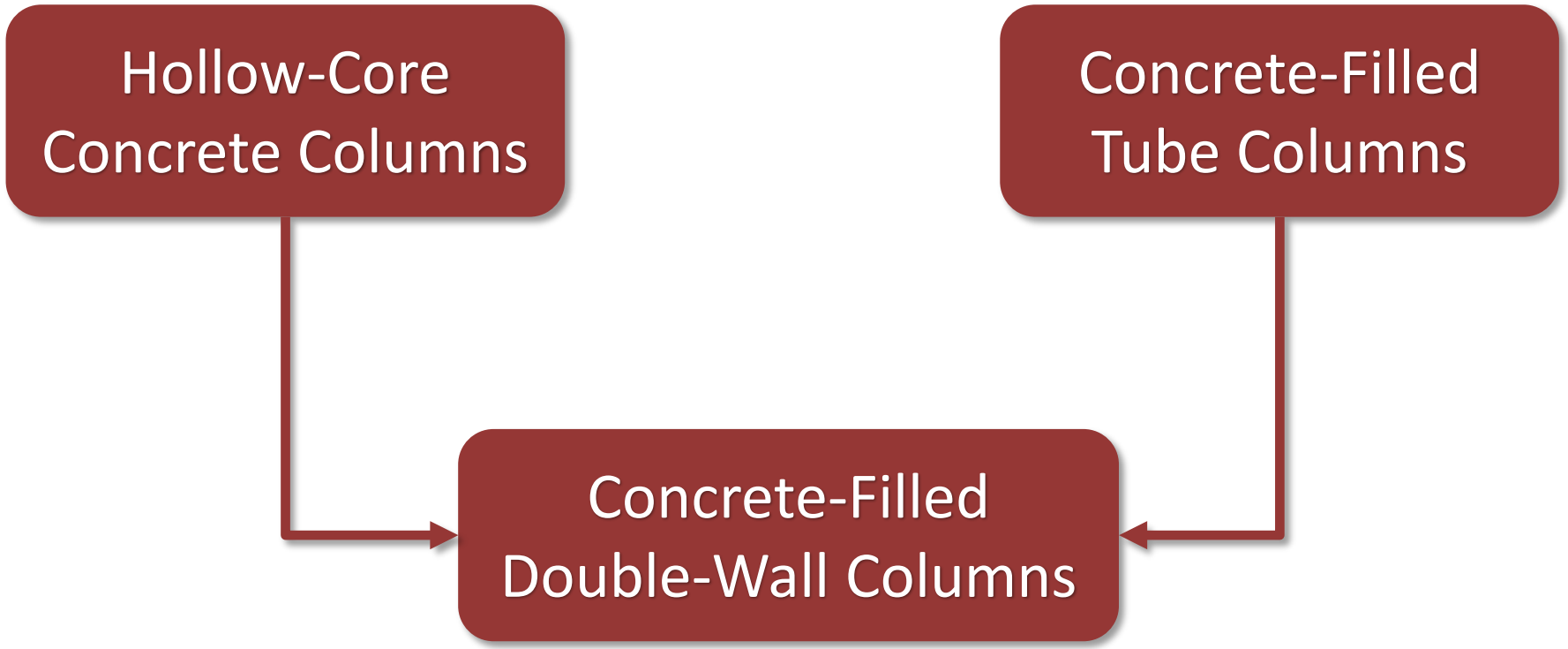
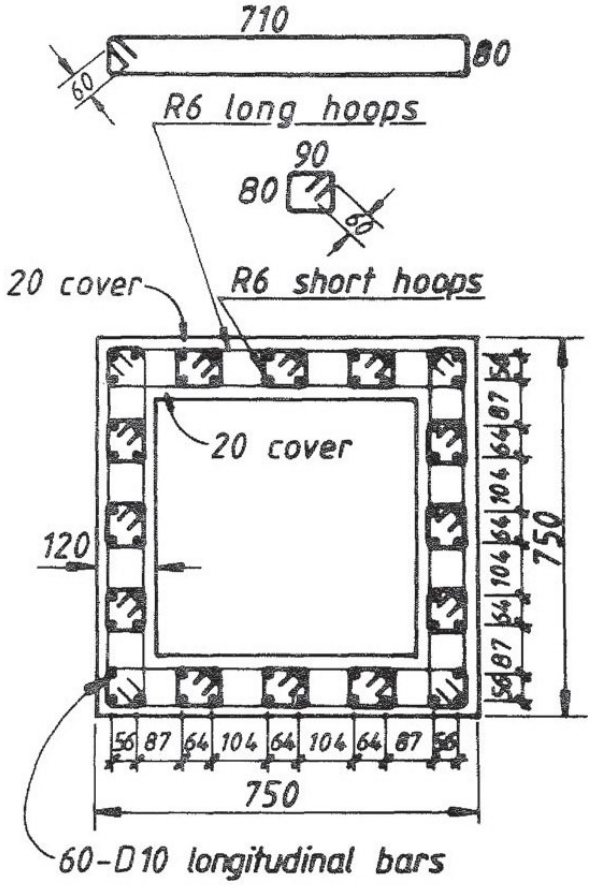
Hollow-Core Concrete Columns

Concrete-Filled Tube Columns

Evolution of Concept



Hollow-Core Concrete Columns



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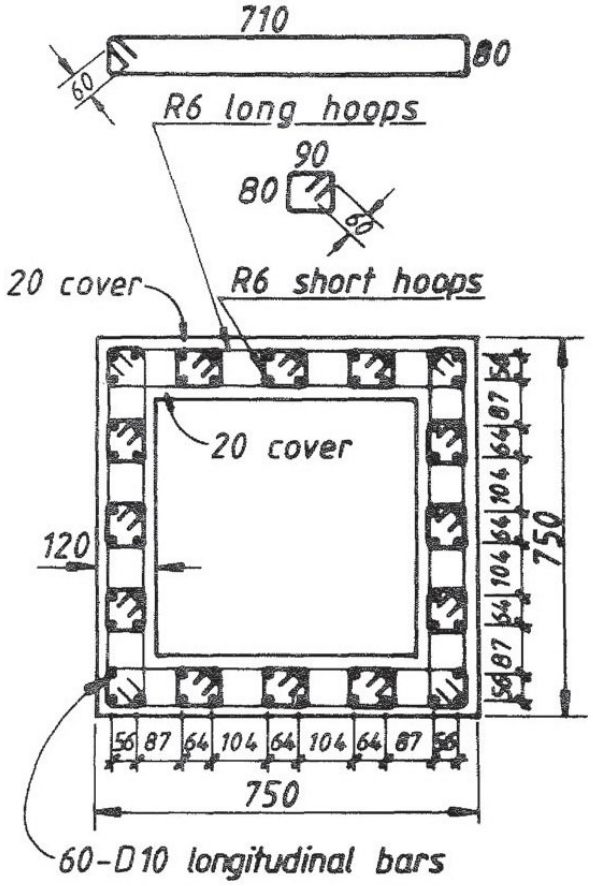

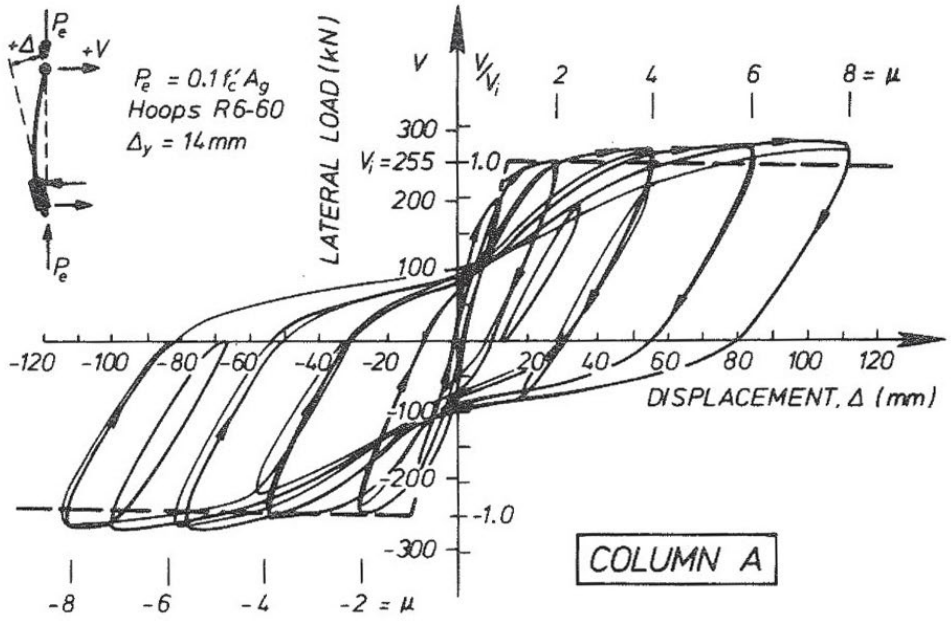

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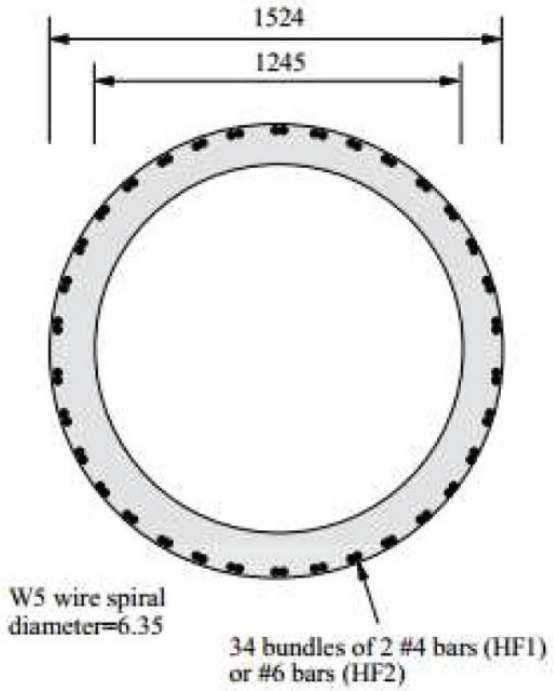

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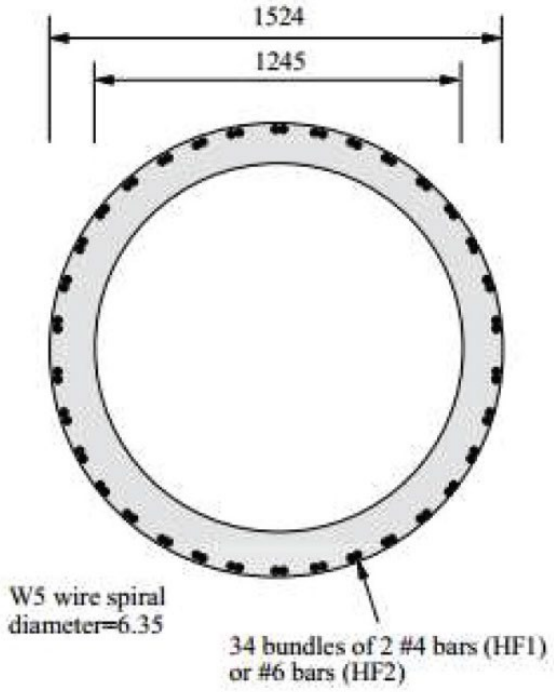

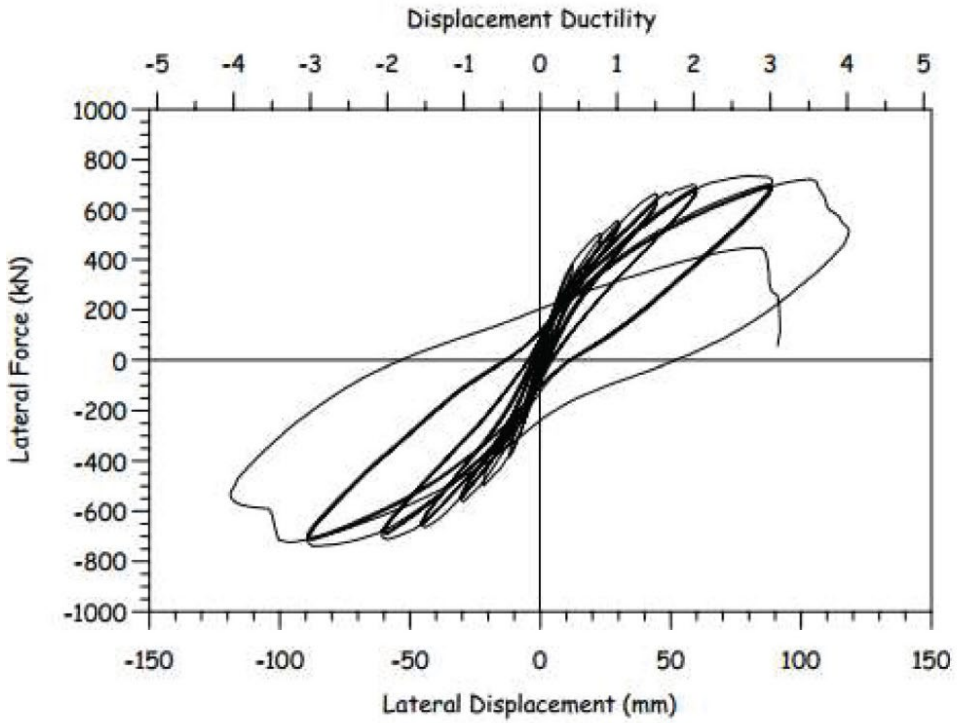

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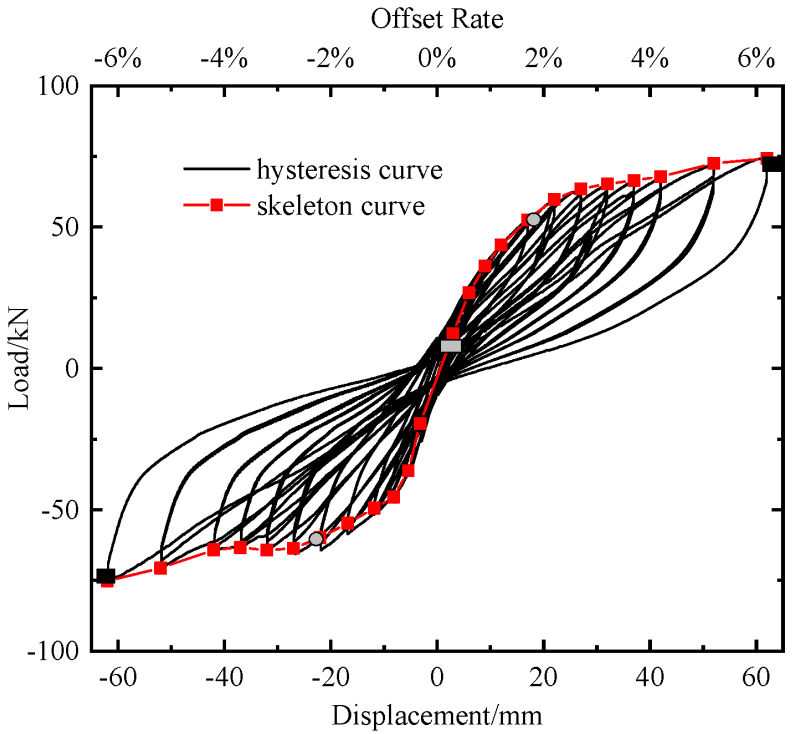

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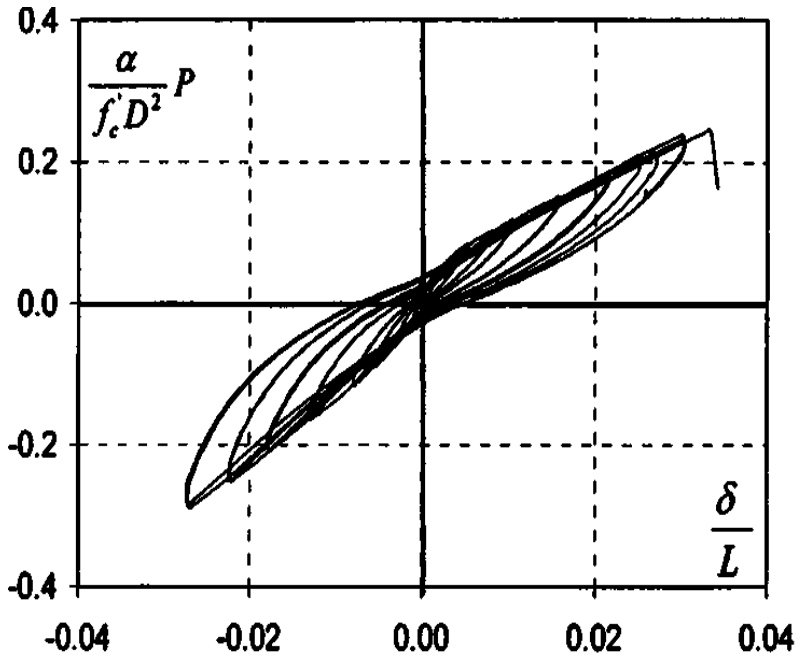
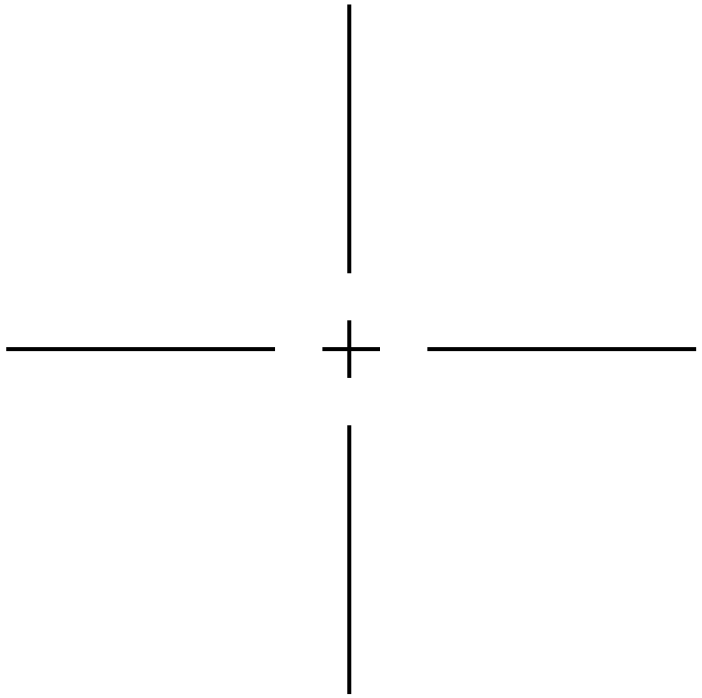


Concrete-Filled Double-Wall Columns



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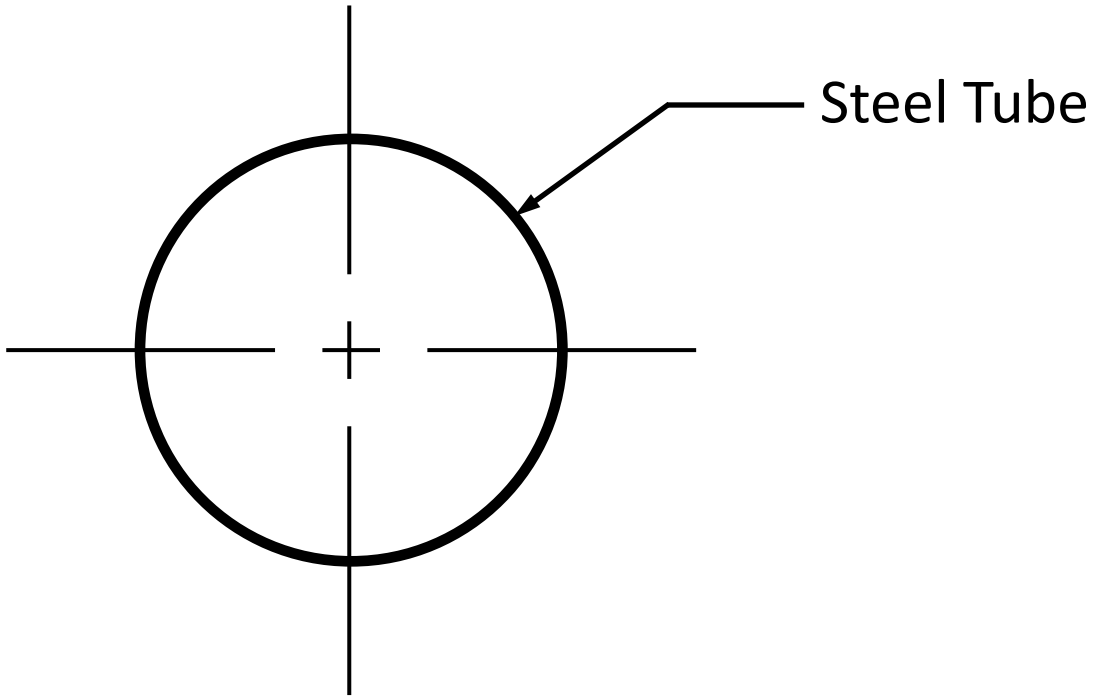

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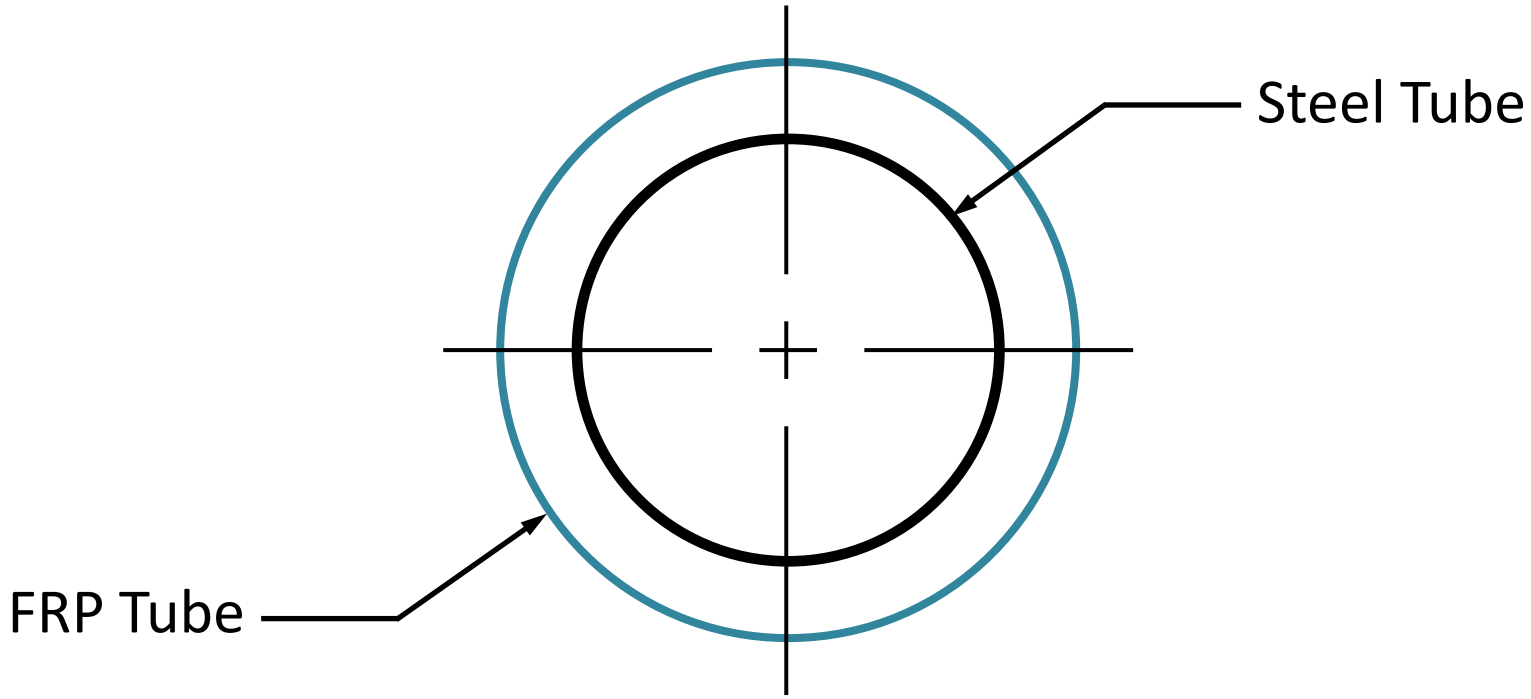

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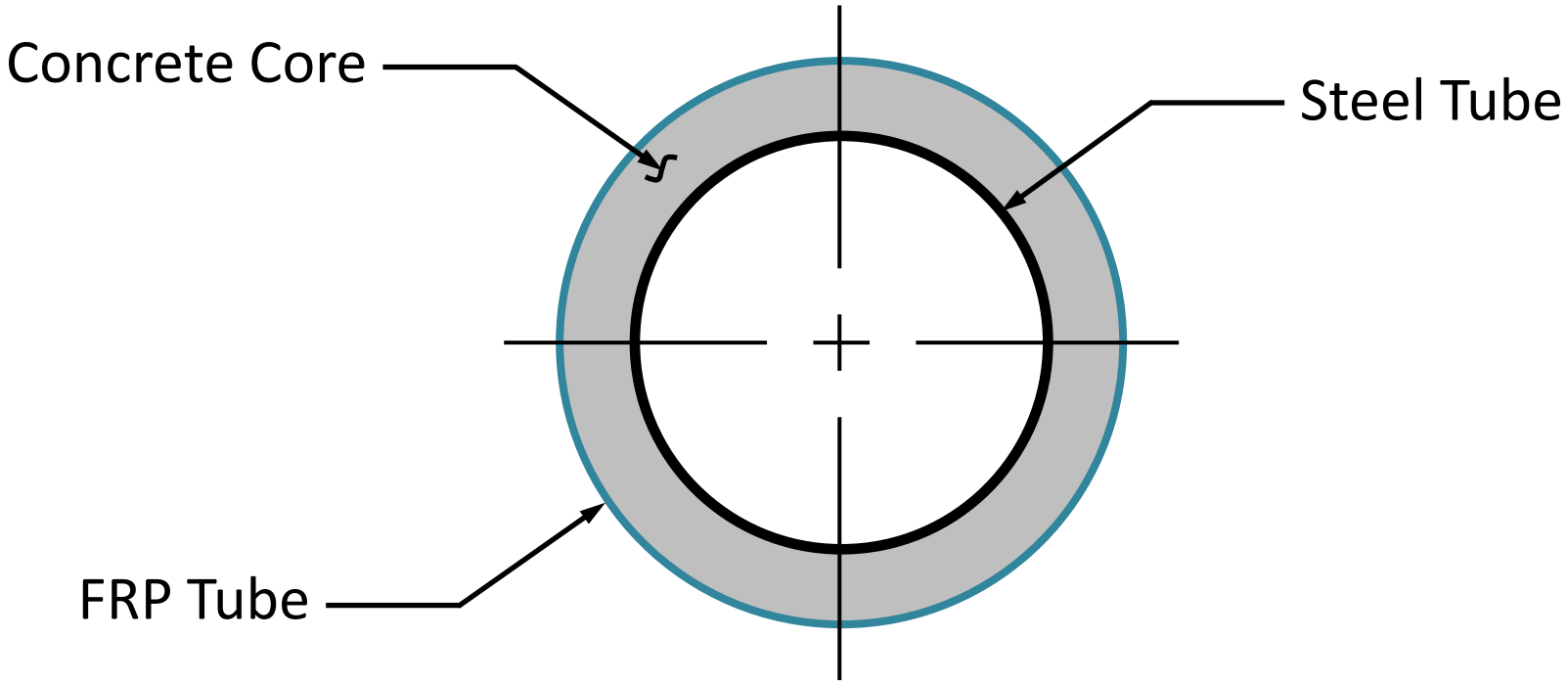

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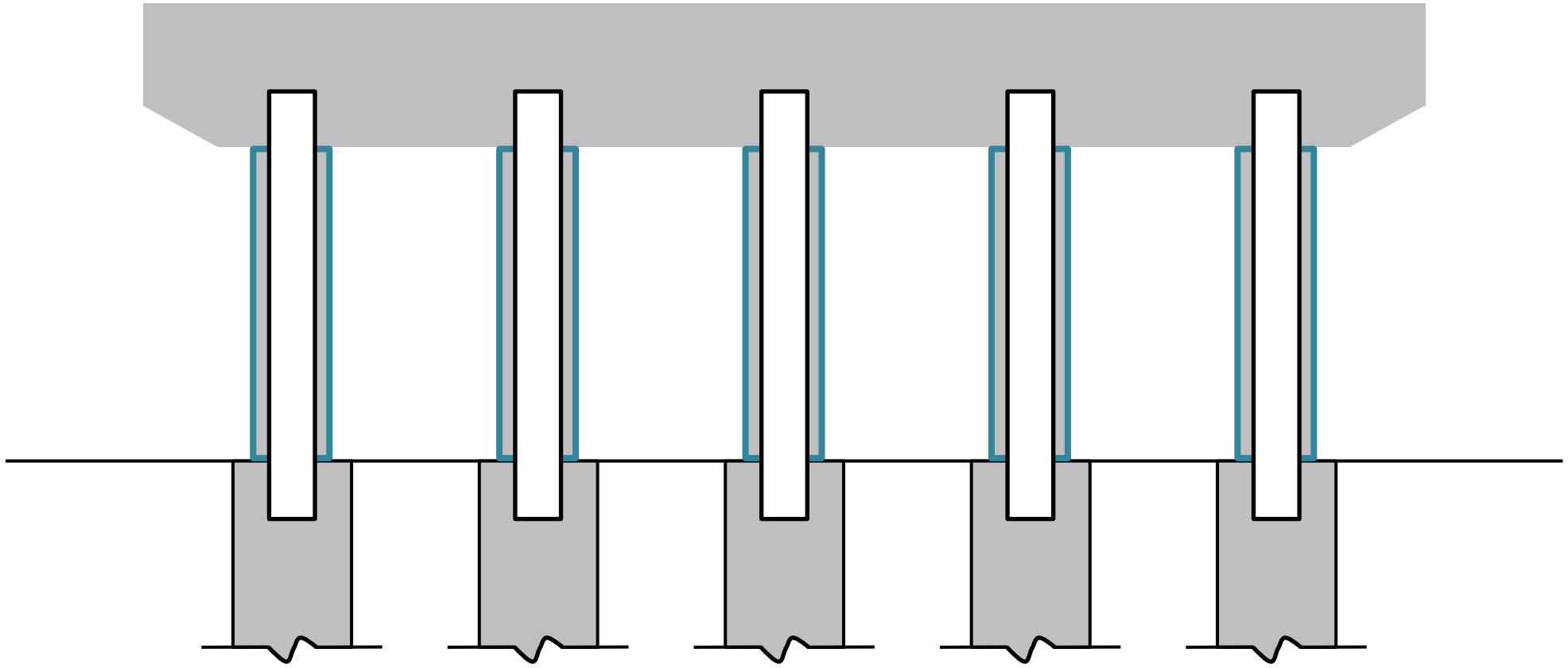


Initial Sizing Guidelines

- Select outer column diameter, D_o
- Calculate minimum concrete wall thickness, t_c

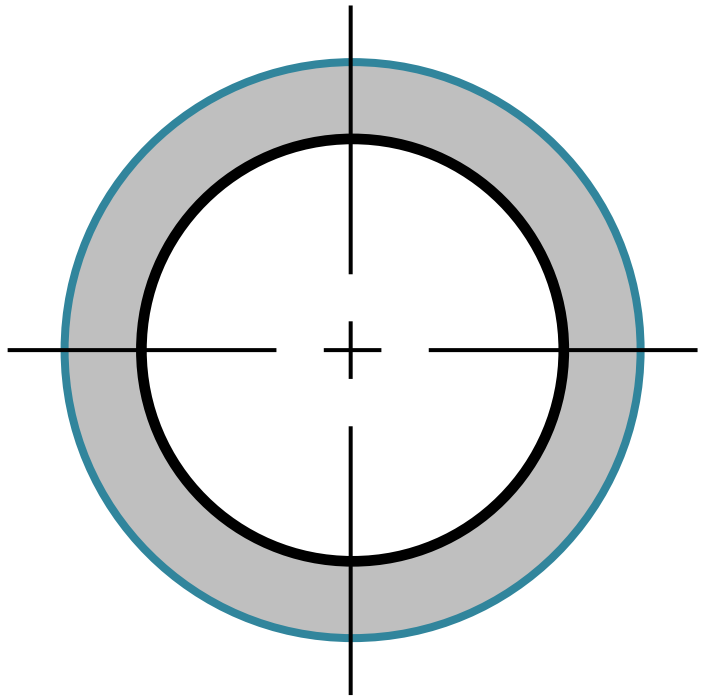
  $t_c = 0.10D_o$ to $0.15D_o$
- Calculate steel tube outer diameter, D_i

  $D_i = D_o - 2t_c$
- Calculate steel tube thickness, t_s

  $t_s = D_i/64$ to $D_i/32$
- Calculate FRP tube thickness, t_f

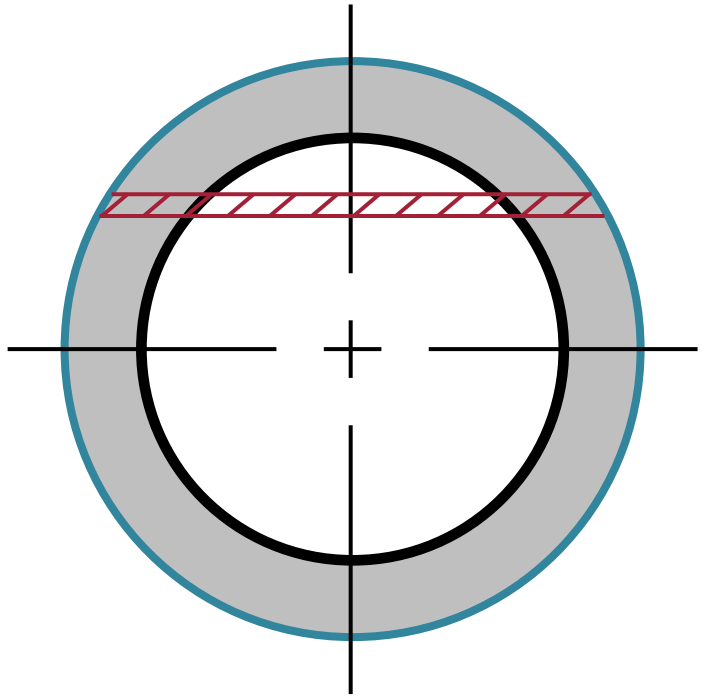
  $t_f = 0.035D_o\,(f'_c / f_t)$ (low seismic regions)

  $t_f = 0.105D_o\,(f'_c / f_t)$ (high seismic regions)



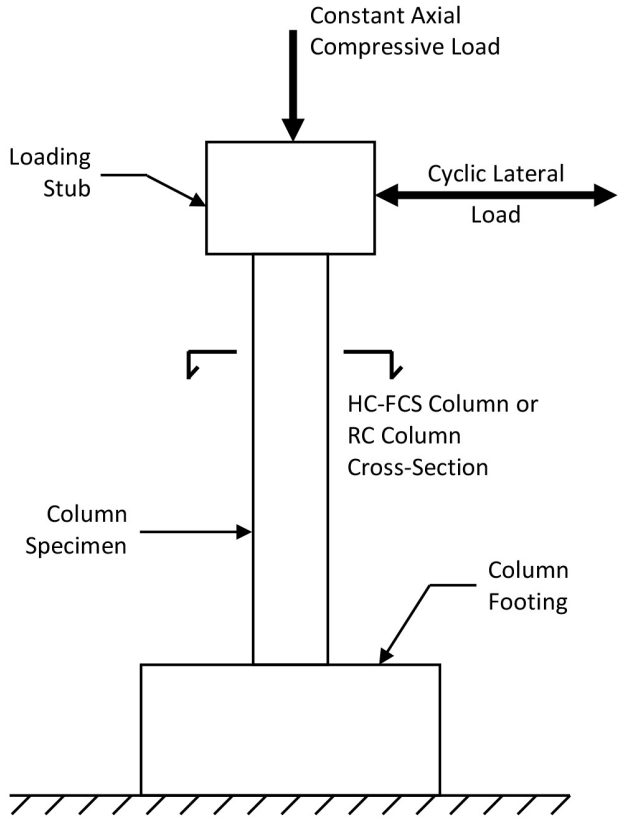
Sectional Analysis

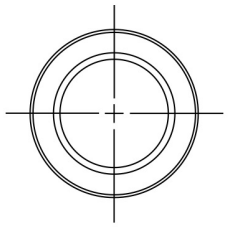
- Discretize cross section into horizontal segments
- Perform a non-linear strain compatibility analysis
  - Assume neutral axis location
  - Calculate strains in each material in each strip
  - Calculate stress and force in each strip
  - Calculate internal moment and axial force
- Assumptions
  - Plane sections remain plane
  - Perfect bond between the steel and concrete
  - Elastic-perfectly plastic steel stress-strain behavior
  - Confined concrete stress-strain behavior
  - Ignore tensile strength of concrete
  - Ignore longitudinal capacity of FRP



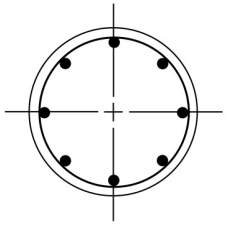
Specimen Design & Fabrication

- Specimen Parameters
  - Column height = 8’-0”
  - FRP outer diameter, D_o = 18-5/8”
  - FRP tube wall thickness, t_f = 3/16”
  - Steel tube outer diameter, D_i = 12-3/4”
  - Steel tube wall thickness, t_s = 1/4”
  - Concrete wall thickness, t_c = 2-3/4”
- Material Parameters
  - FRP tube: GFRP, 40 ksi hoop tensile strength
  - Steel tube: API 5L X52, 52 ksi yield, 66 ksi ultimate strength
  - Concrete core: SCC, 10 ksi 28-day strength or UHPC, 20 ksi 28-day strength



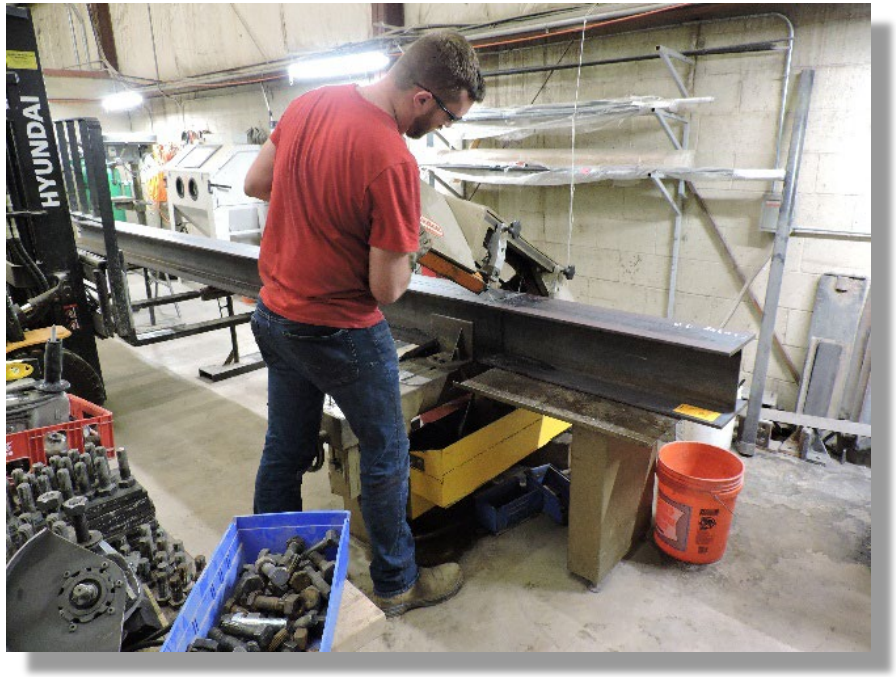


HC-FCS Column Cross-Section



RC Column Cross-Section

Specimen Design & Fabrication



Specimen Design & Fabrication

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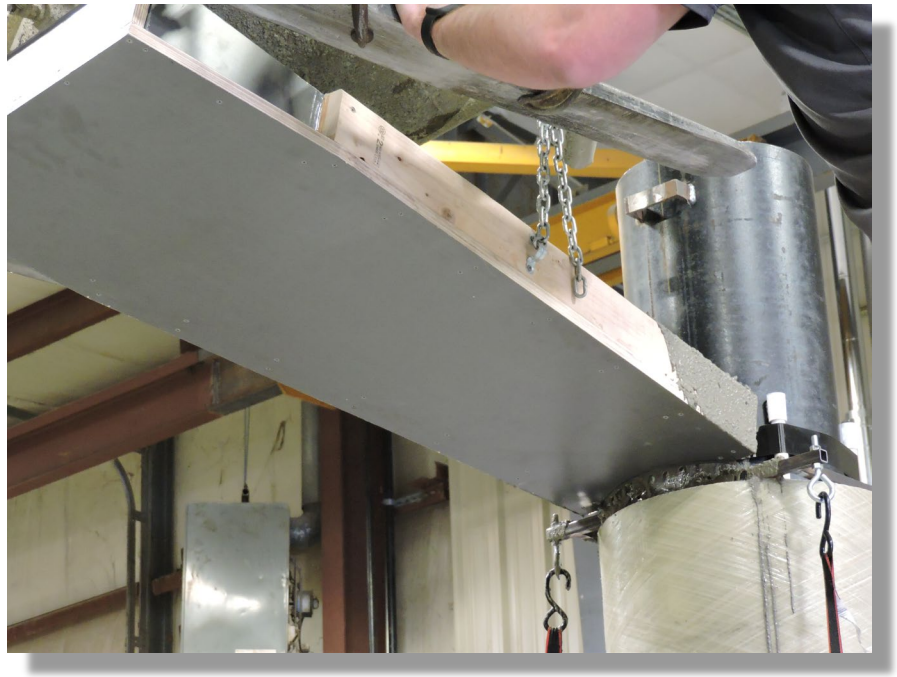

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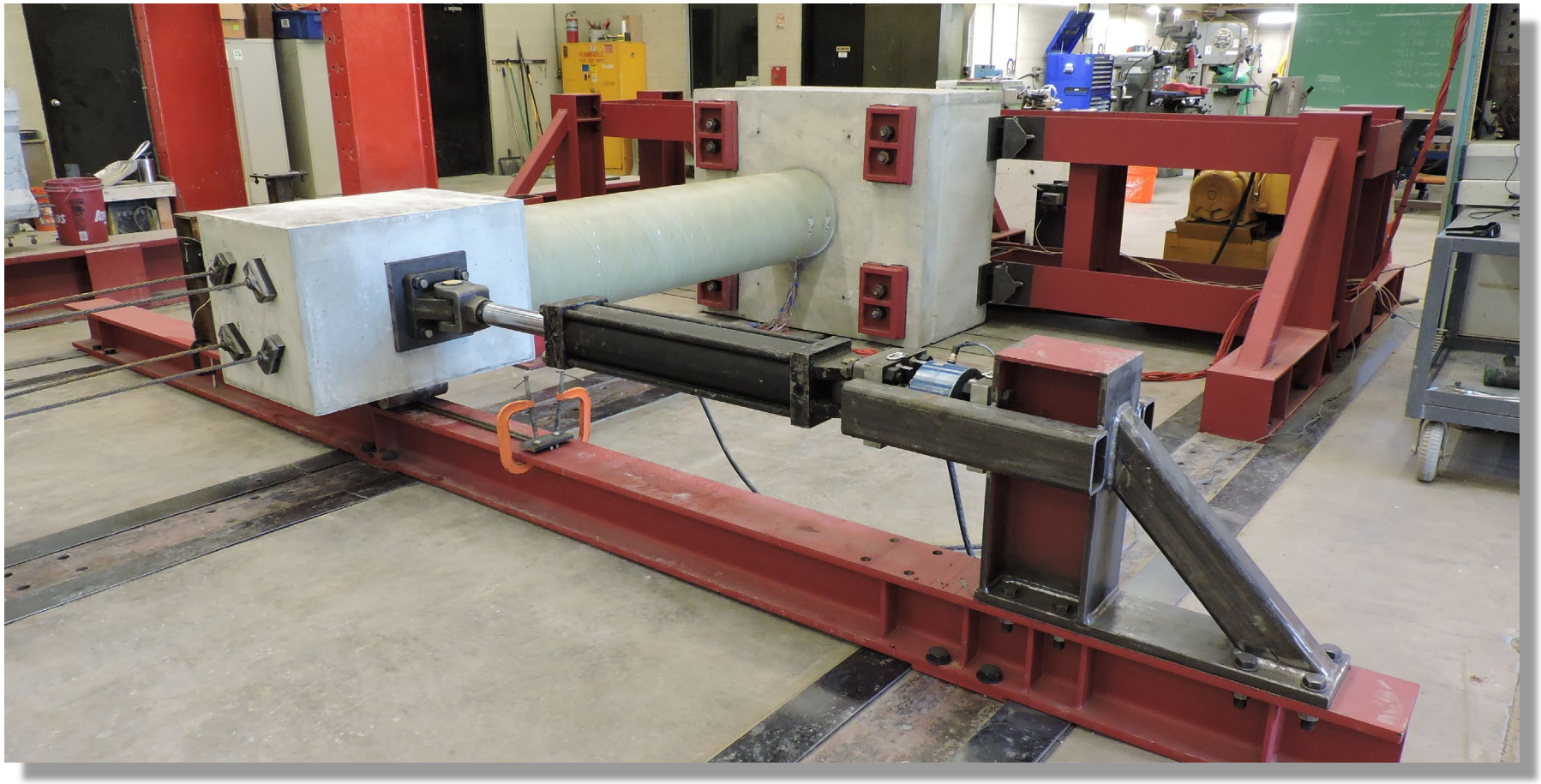
Specimen Testing & Results



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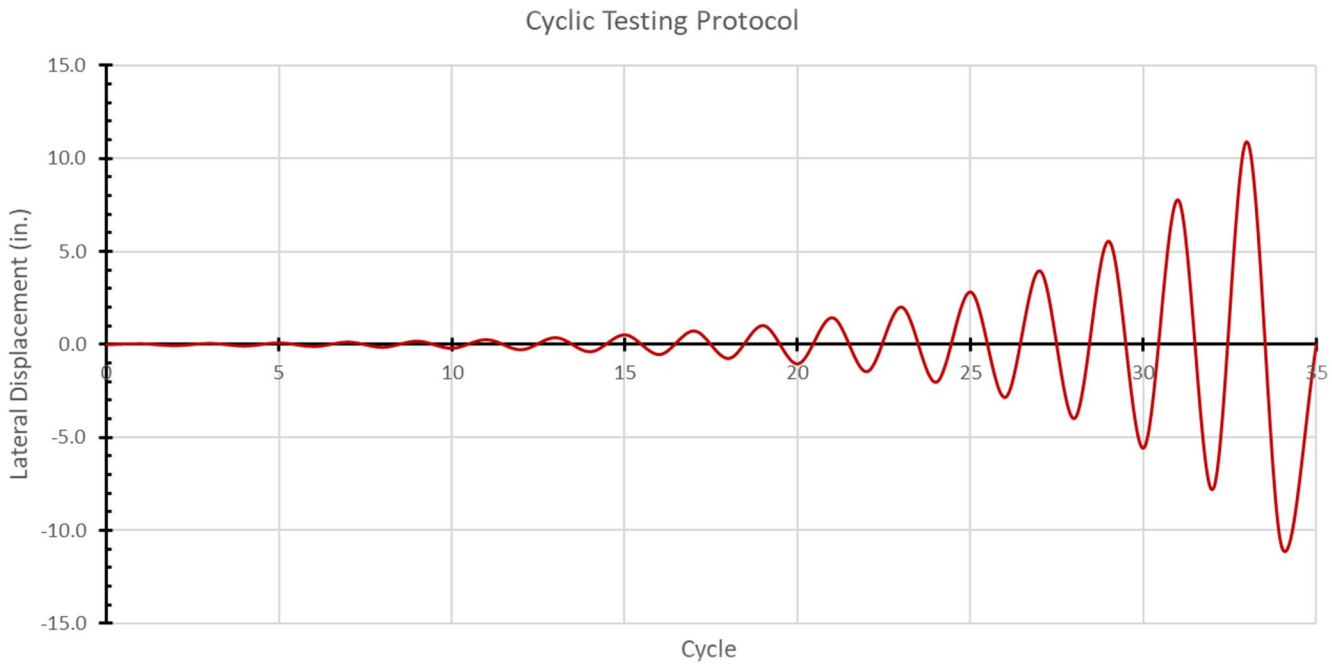

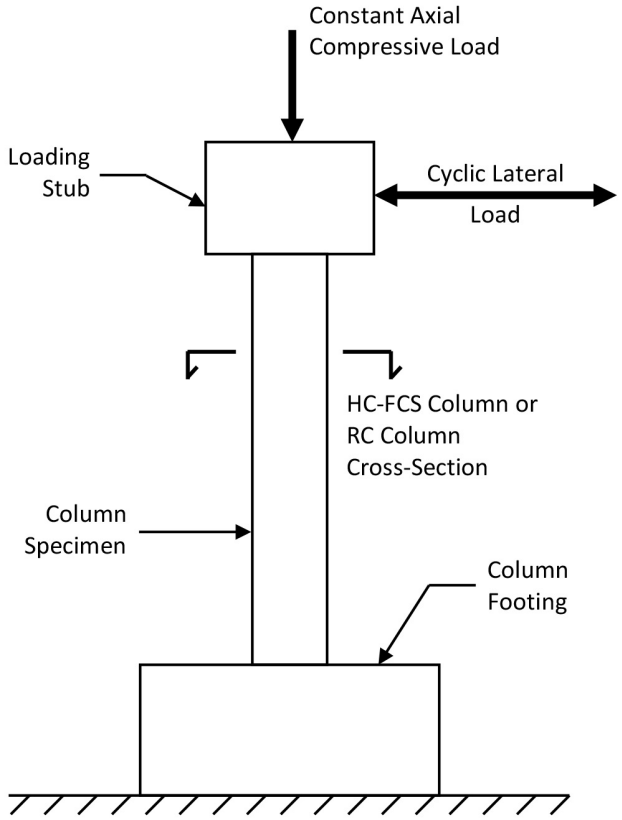

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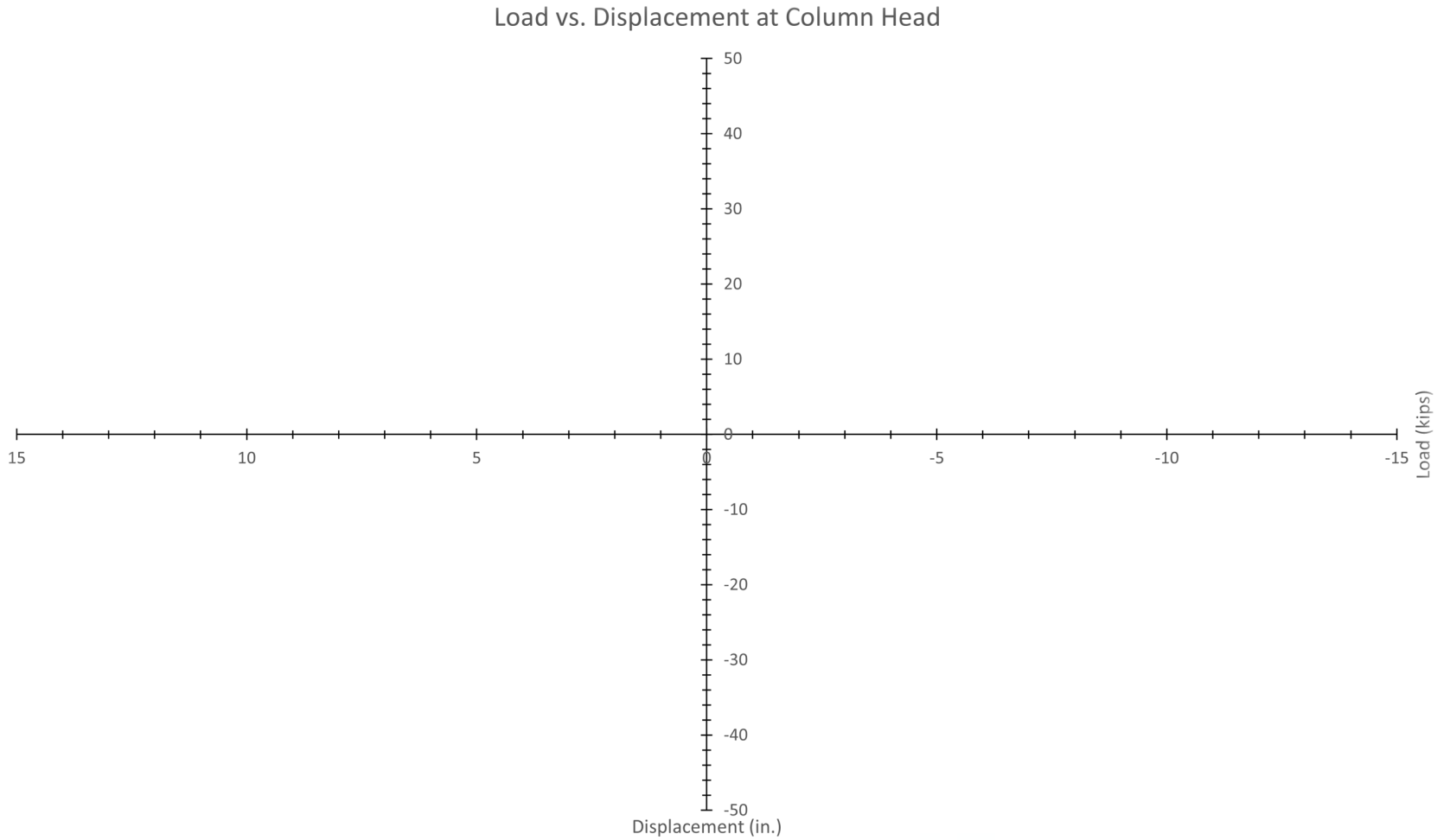

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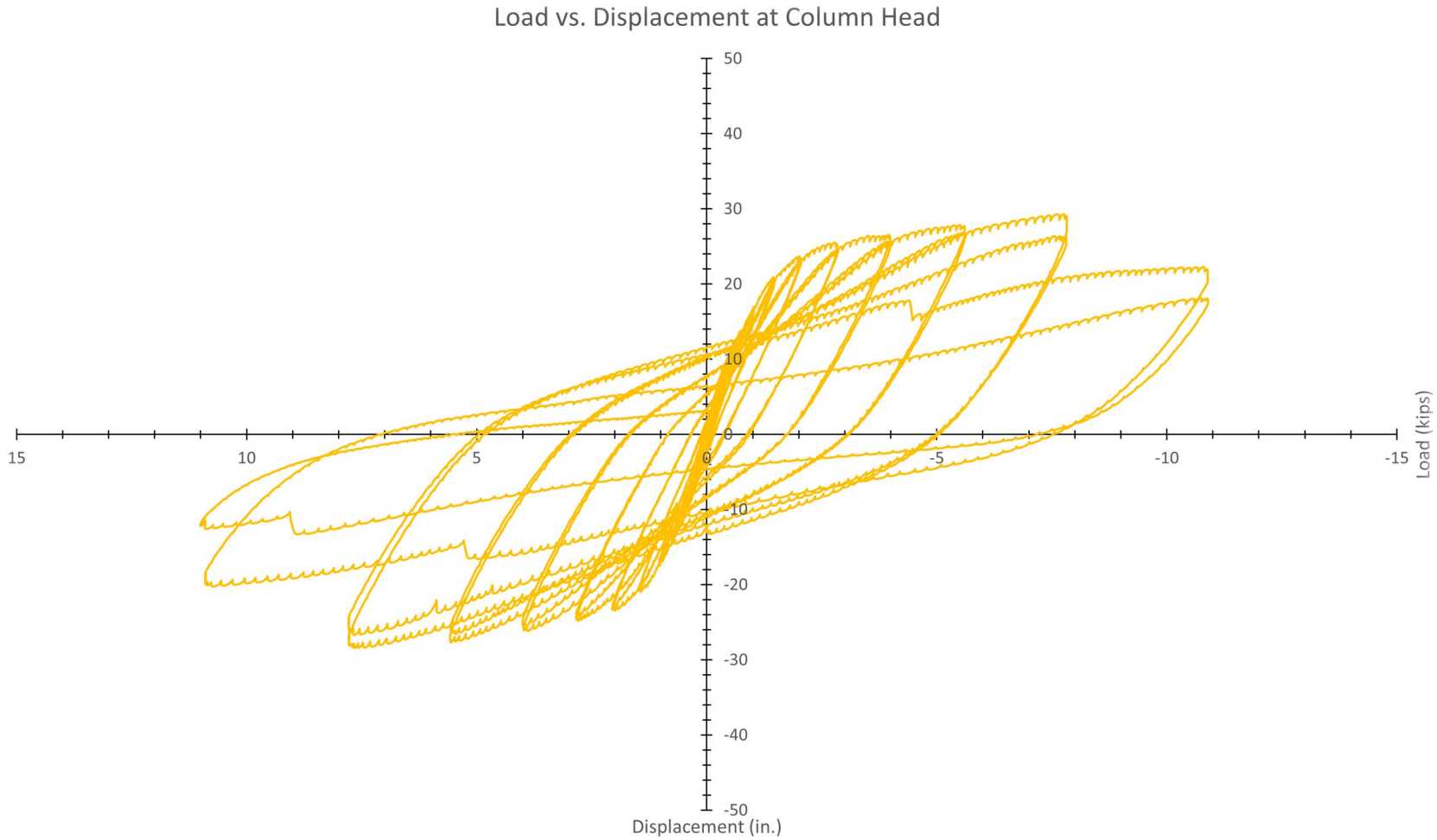

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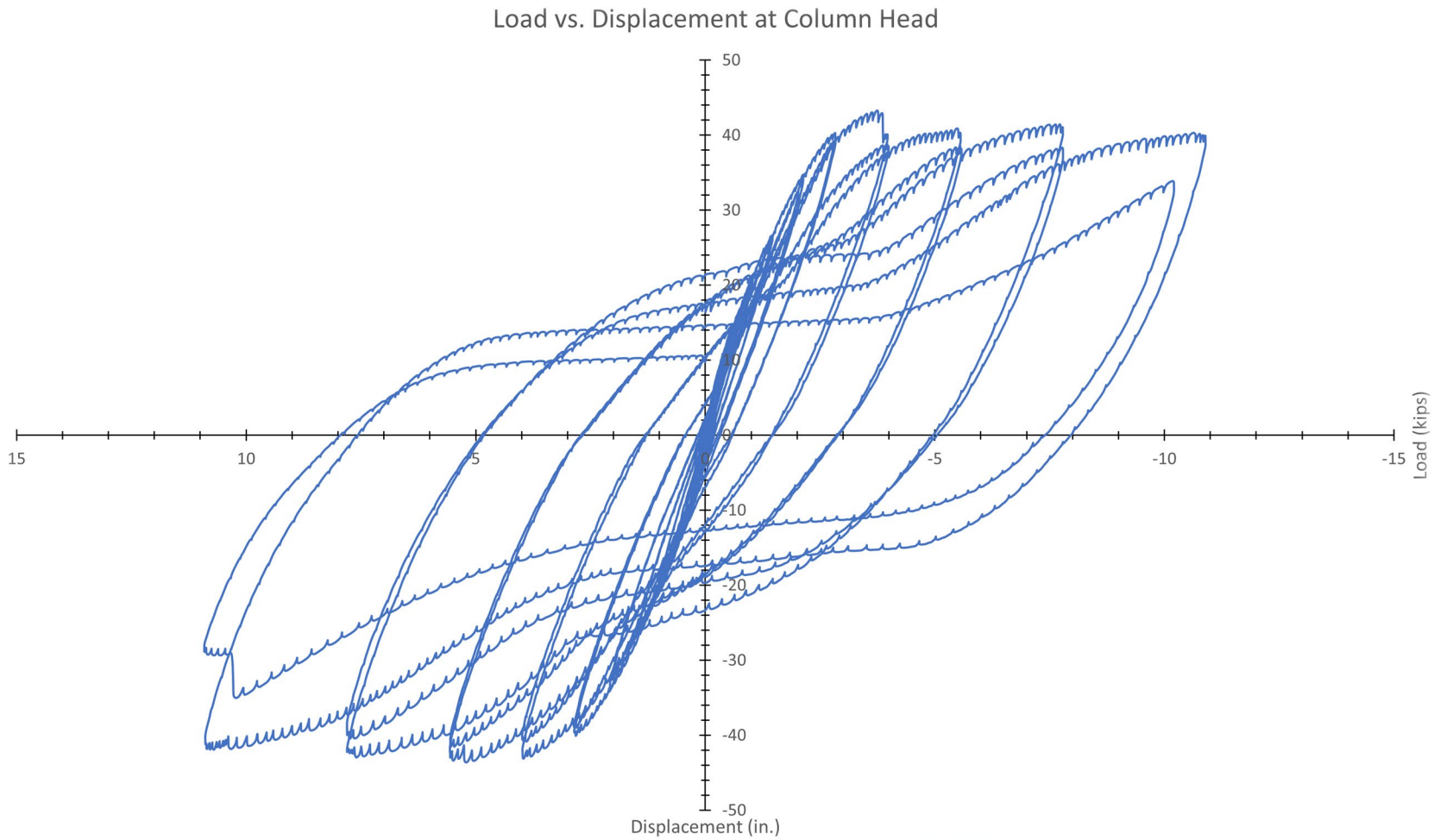

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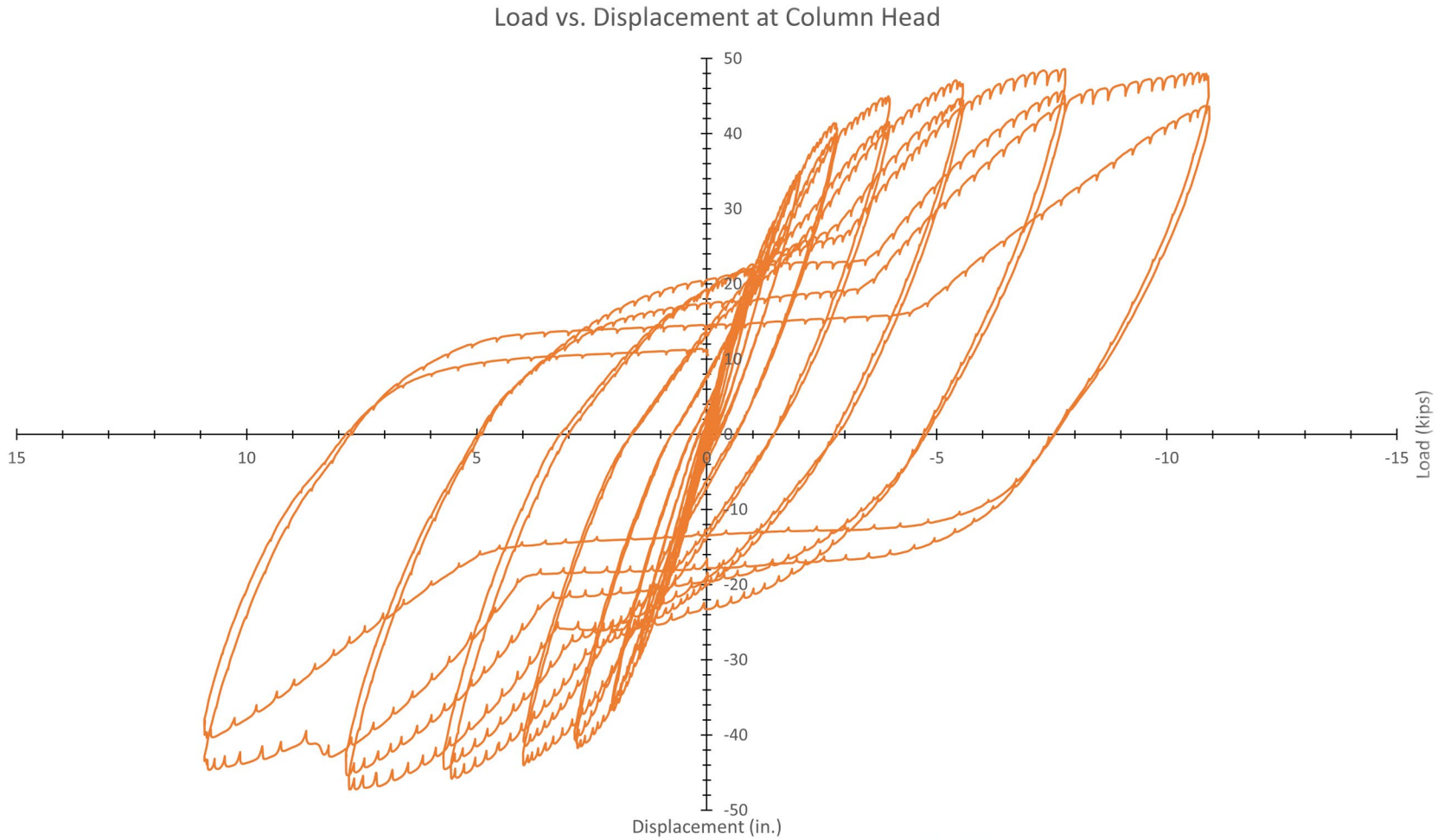

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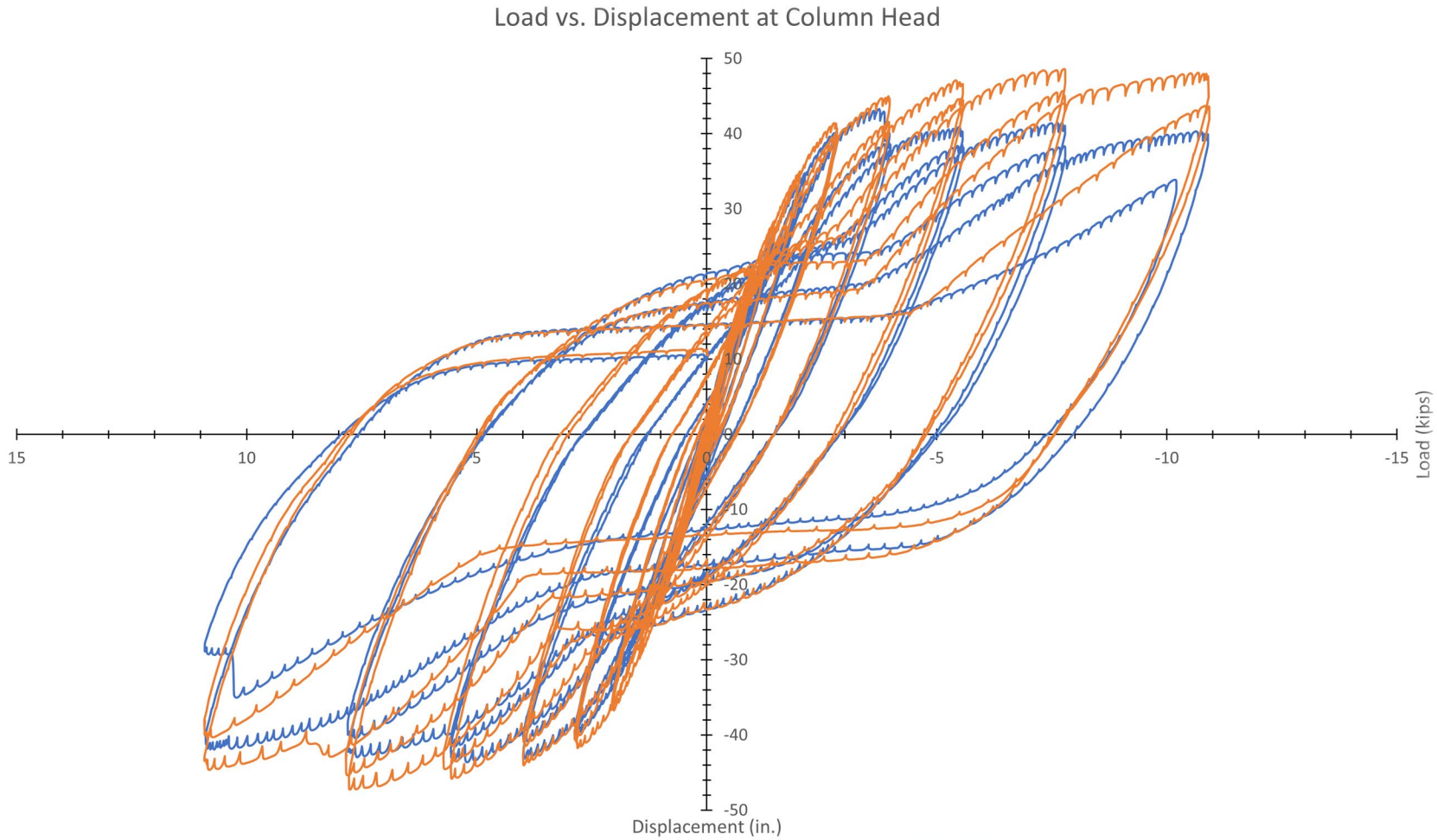

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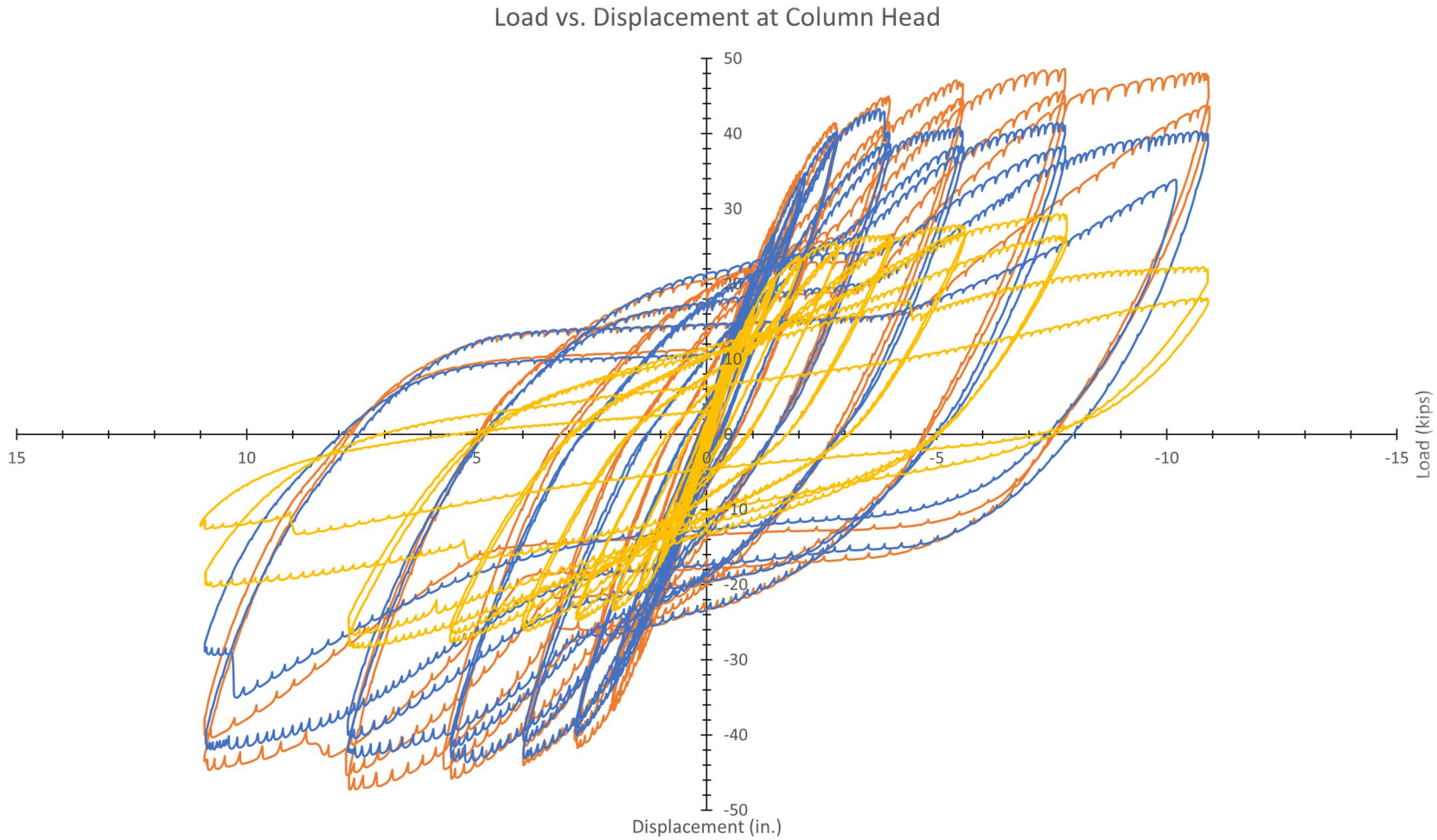

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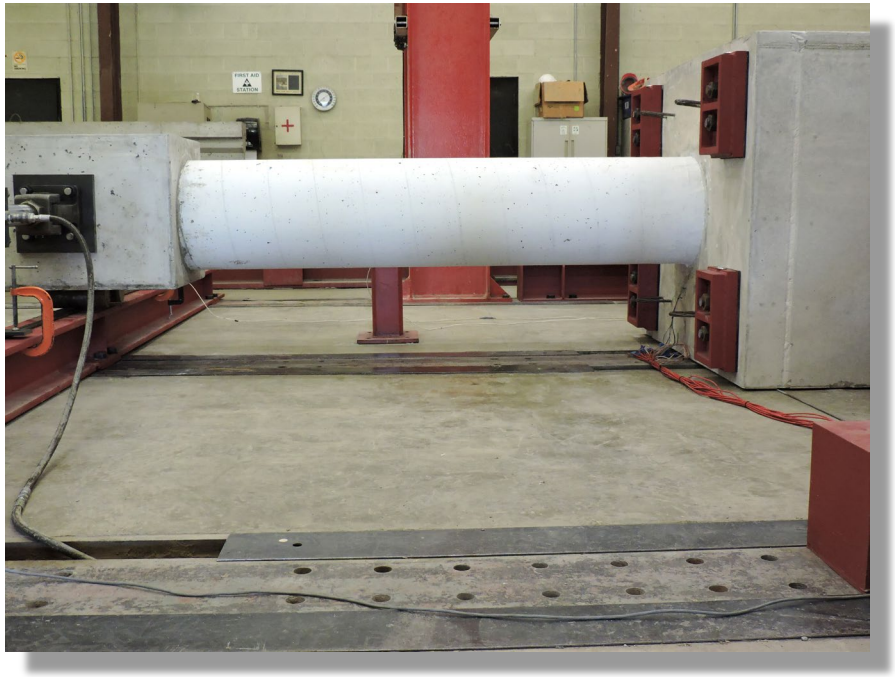

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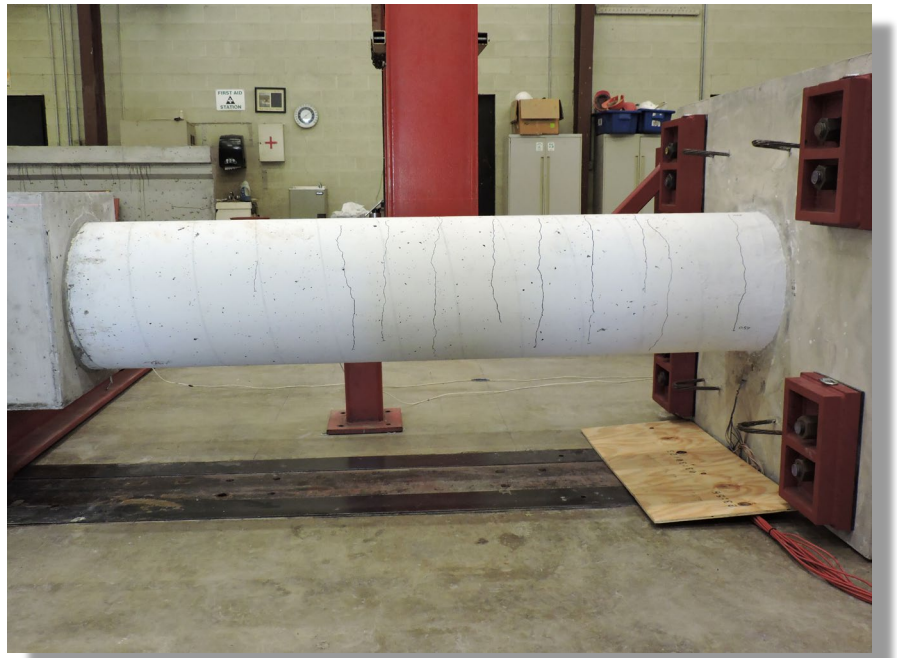

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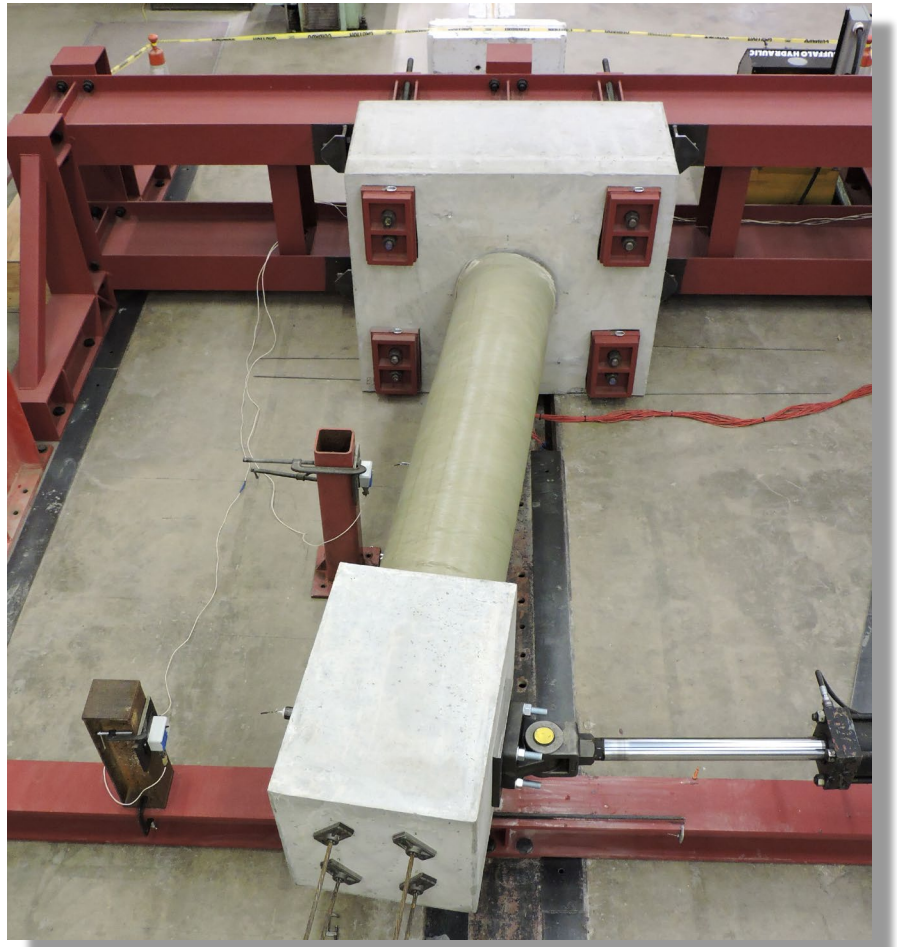

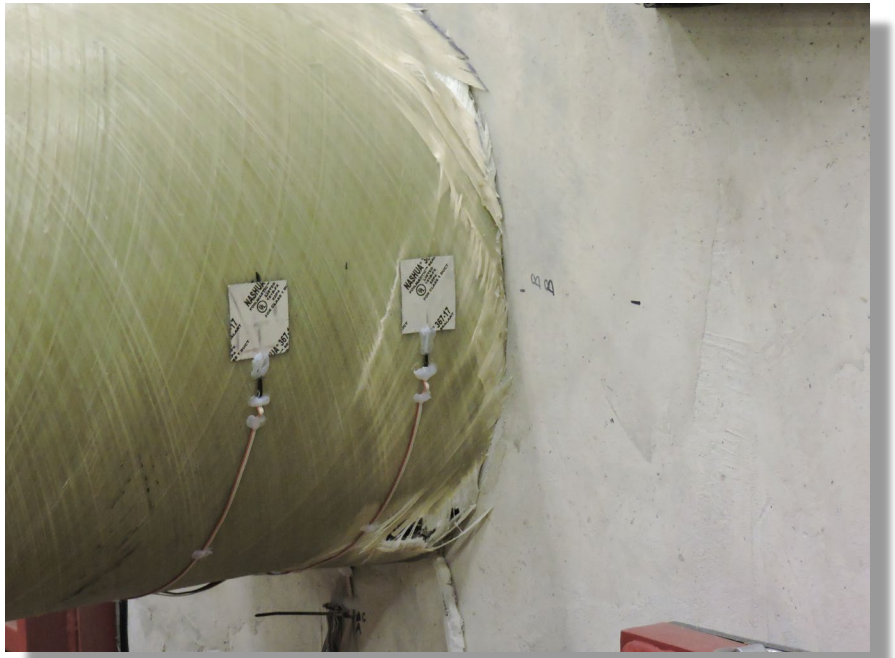

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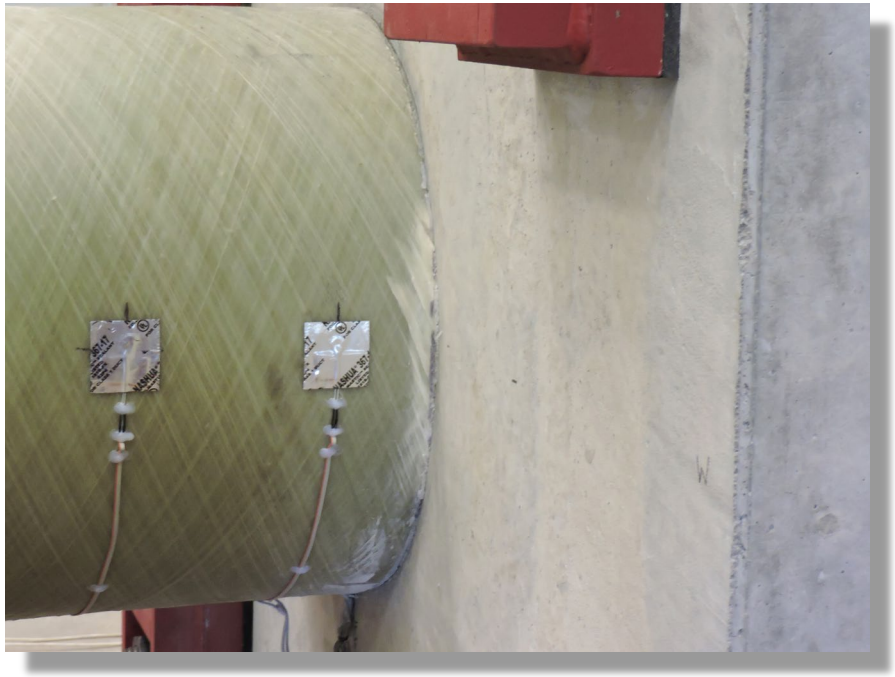

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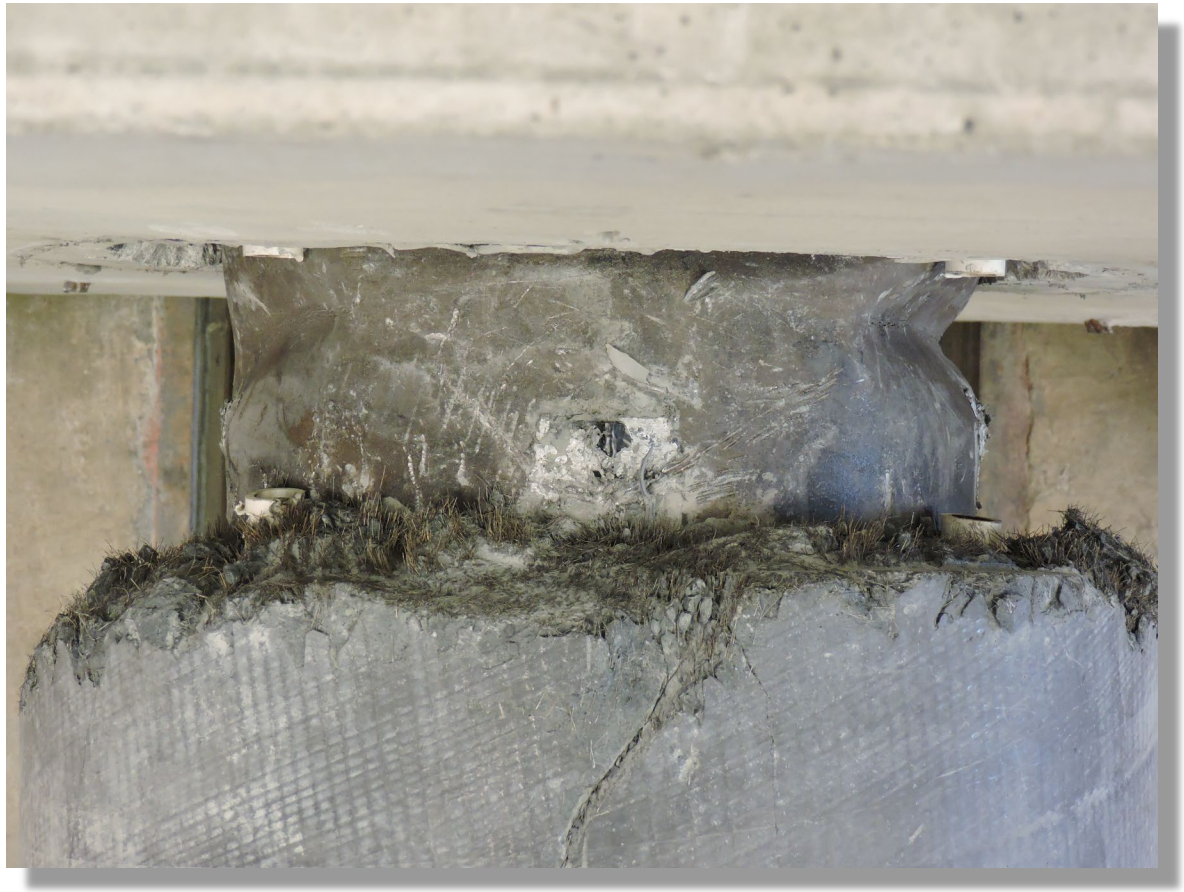

Research Project Next Steps

Thank You

Oklahoma Transportation

Dolese

Royce Floyd

Jackson Milner

ABC UTC
Accelerated Bridge Construction University Transportation Center

GraceComposites

John Bullock

Omar Yadak

Chris Ramseyer

Southern Plains Transportation Center

W&W | AFCO Steel

Scott Harvey

Jacob Choate

Questions?