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PEER

SELF COMPACTING HYBRID FIBER REINFORCED CONCRETE COMPOSITES FOR BRIDGE COLUMNS

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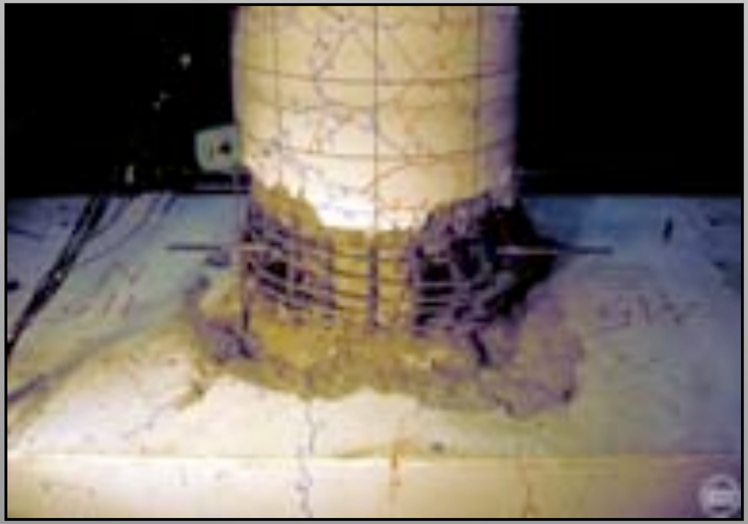
SELF COMPACTING HyFRC FOR BRIDGE COLUMNS

Outline

- OBJECTIVES OF RESEARCH PROGRAM
- RESEARCH TASKS
- ACCOMPLISHMENTS
- BRIEF SUMMARY OF RESULTS
- FUTURE DIRECTIONS

OBJECTIVES OF RESEARCH PROGRAM

Environmental Damage



Seismic Damage

- *Enhancing damage resistance of bridge columns subjected to both environmental and seismic loading conditions.*

OBJECTIVES OF RESEARCH PROGRAM (continued)

- *Improving load carrying capacity of bridge columns at large drift ratios.*

- *High workability, full compaction & ease of construction (faster construction times and improved consolidation around reinforcements).*

Self Compacting HyFRC (SC-HyFRC) for bridge columns

RESEARCH TASKS

- *Task I: Development and Design of SC-HyFRC for Bridge Columns.*
- *Task II: Design and Testing of 1:4.7 Scale Specimens using SC-HyFRC.*

ACCOMPLISHMENTS

- *Task I: Development and Design of SC-HyFRC for Bridge Columns Completed.* *(Gabriel Jen, David Lallemant, Will Trono)*

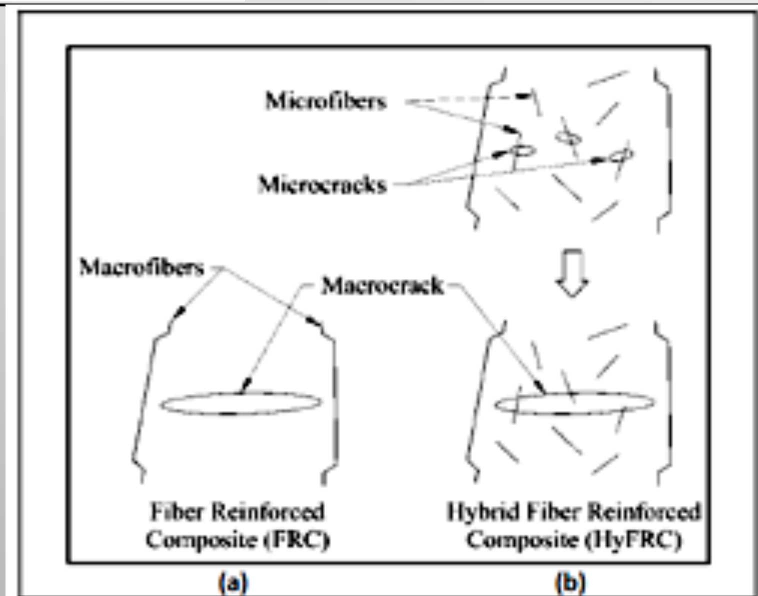
- *Task II: Design and Testing of Two out of Three Test Specimens using SC-HyFRC Completed.* *(Pardeep Kumar, Gabriel Jen)*

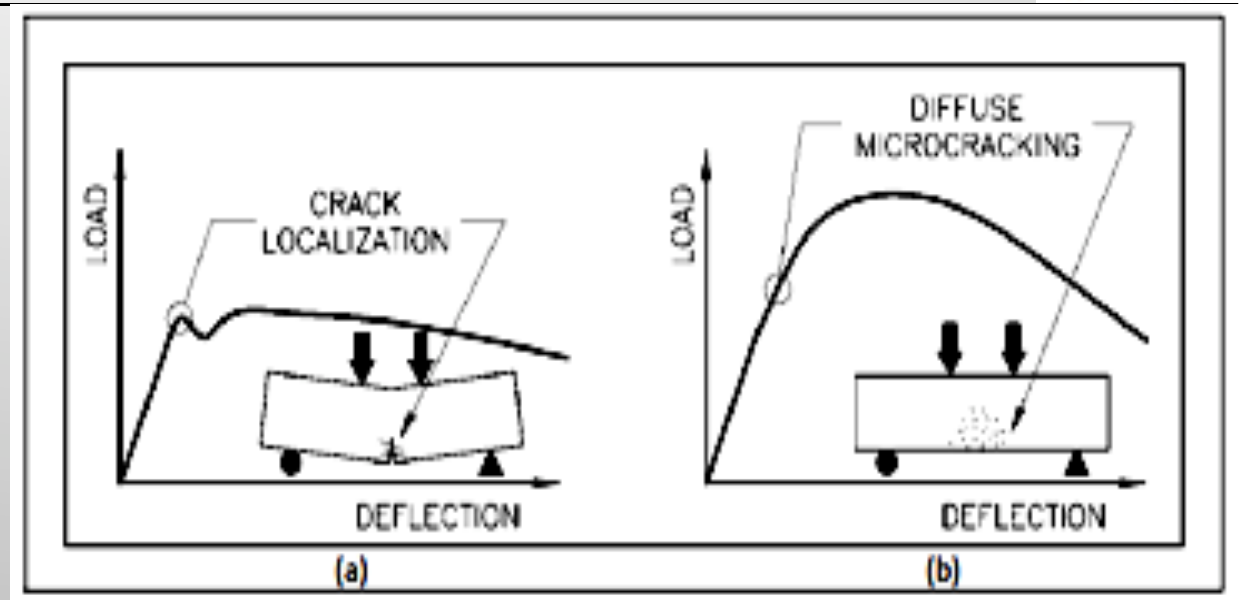
- *PEER Report Submitted.*

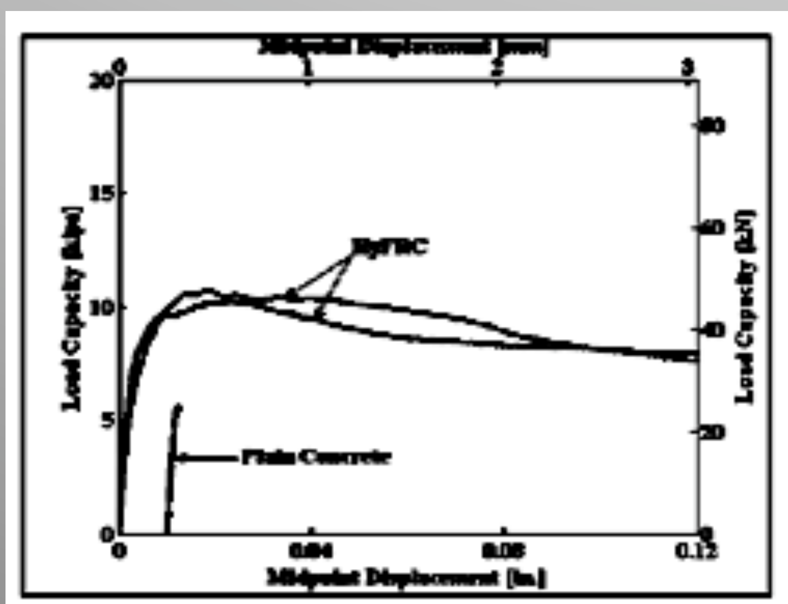
BRIEF SUMMARY OF TEST RESULTS

- *Task I: Development and Design of SC-HyFRC for Bridge Columns.*

ADVANTAGES OF SC-HyFRC OVER CONVENTIONAL FRC







SC-HyFRC provides crack control on multi-scale for durability, high ductility in tension & compression, and higher shear resistance.

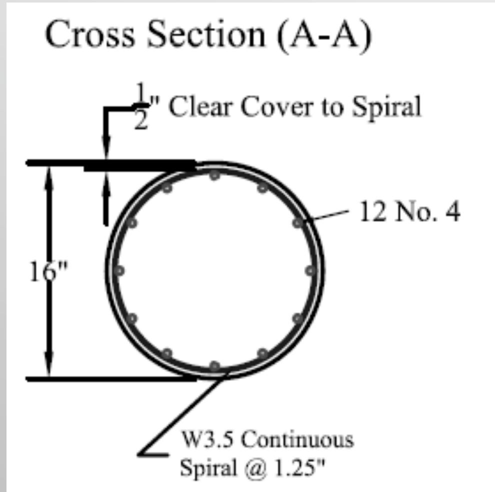
SC-HyFRC FOR BRIDGE COLUMNS

Final SC-HyFRC for bridge columns.

Desired flow diameter of 24 in. without segregation of fibers and aggregates accomplished through parametric study:

- *Chemical mixture proportion and SP / VMA ratio,*
- *Fiber types and volume fraction,*
- *Paste / aggregate volume ratio,*
- *Aggregate content and FA / CA ratio.*

SC-HyFRC FOR BRIDGE COLUMNS



J-Ring Test
→ Measures: Passing ability, presence of fiber pile-up as function of rebar spacing

Ease of Flow around reinforcements measured with Custom designed J-ring with same rebar spacing as bridge columns

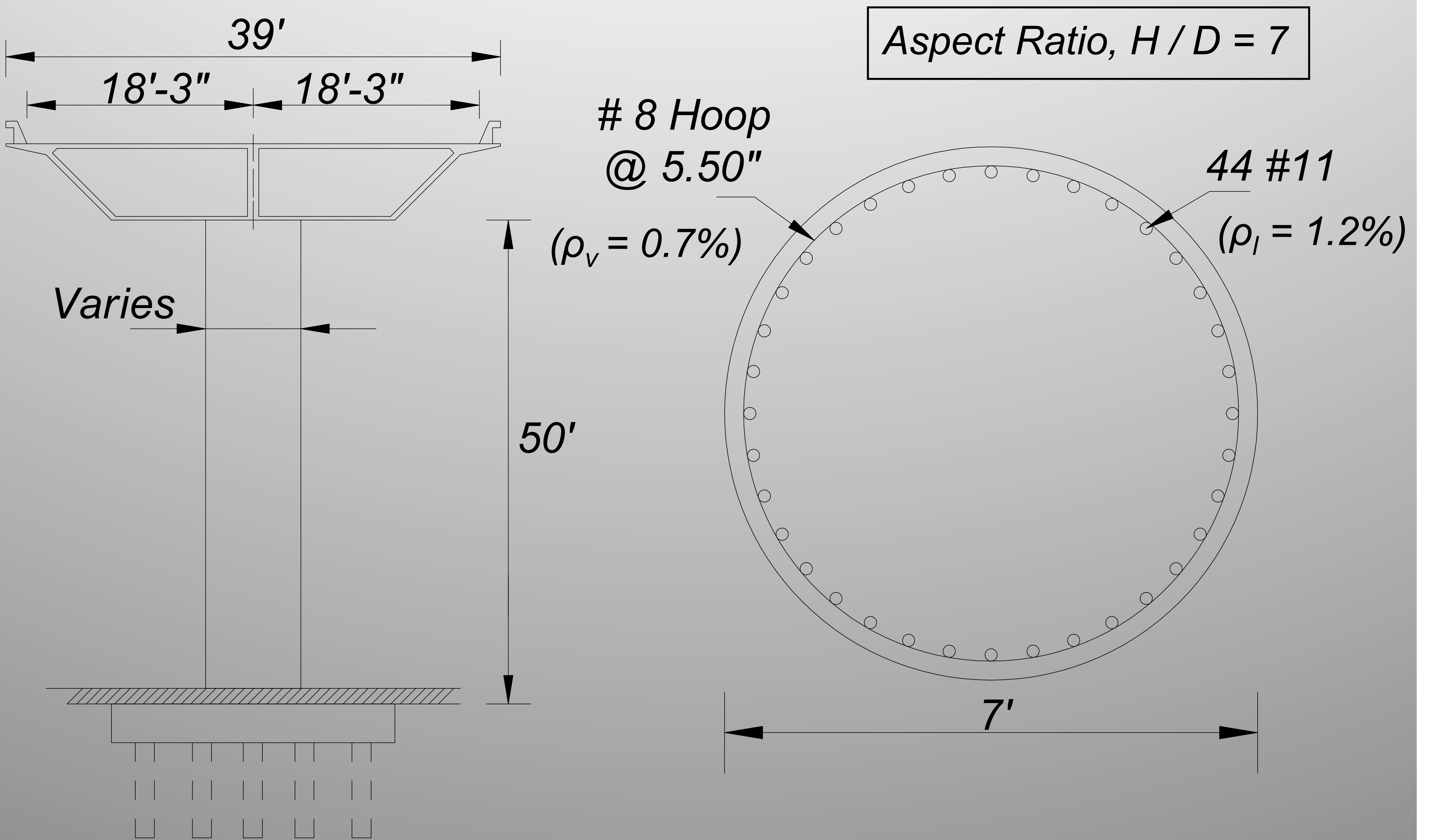
	Cement (lb)	Fly Ash (lb)	Water (lb)	FA (lb)	CA (lb)	SP (wt. % binder)	VMA (wt. % binder)	30mm (V_f)	8mm (V_f)
Mix (#58)	1	0.33	0.6	2.63	1.05	0.46	2.22	1.3	0.2

BRIEF SUMMARY OF TEST RESULTS

- *Task II: Design and Testing of Two Test Specimens Using SC-HyFRC Completed.*

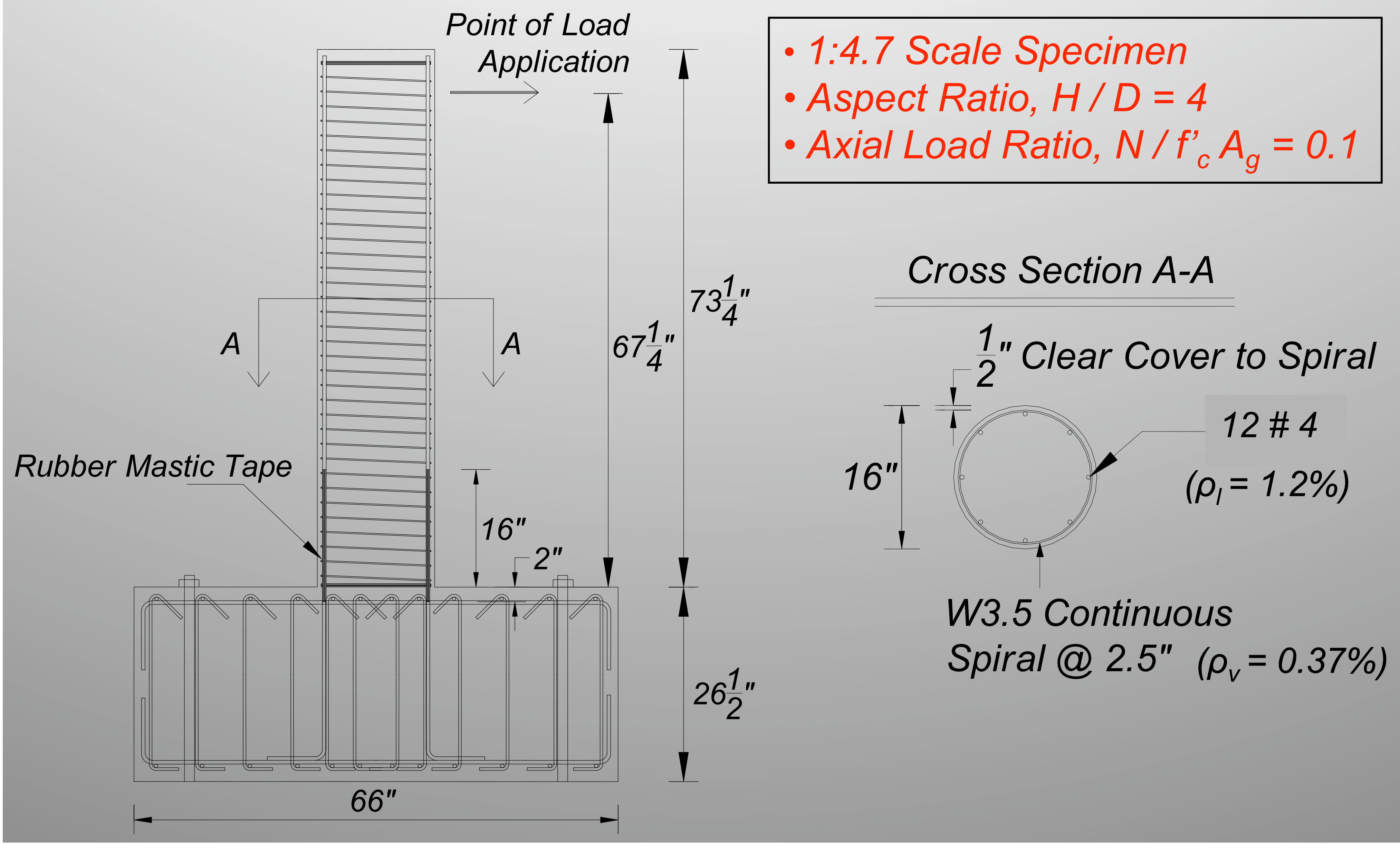
PROTOTYE COLUMN

(Ketchum et. al. 2004)



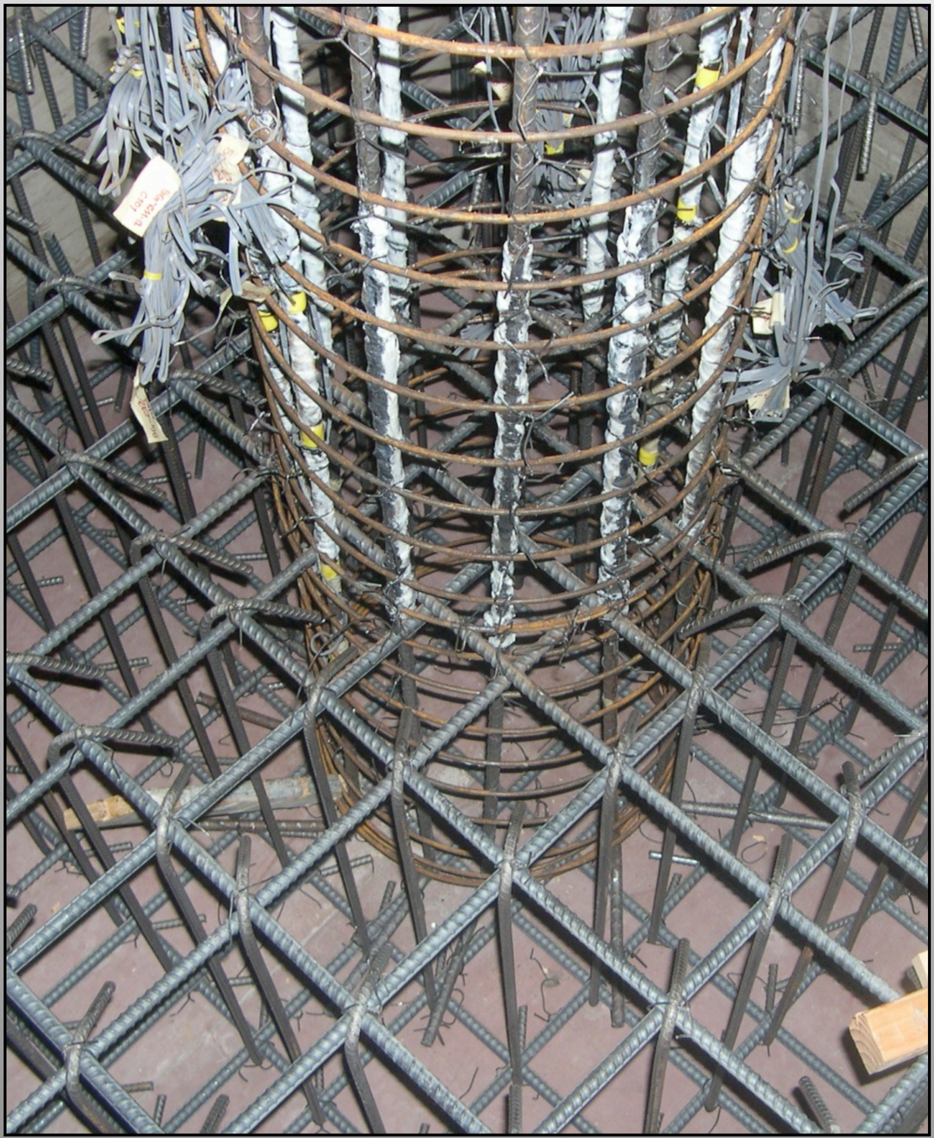
TEST SPECIMEN-1 (TS-1)

- 1:4.7 Scale Specimen
- Aspect Ratio, $H / D = 4$
- Axial Load Ratio, $N / f'_c A_g = 0.1$



CHARACTERISTICS OF TS-1

PEER



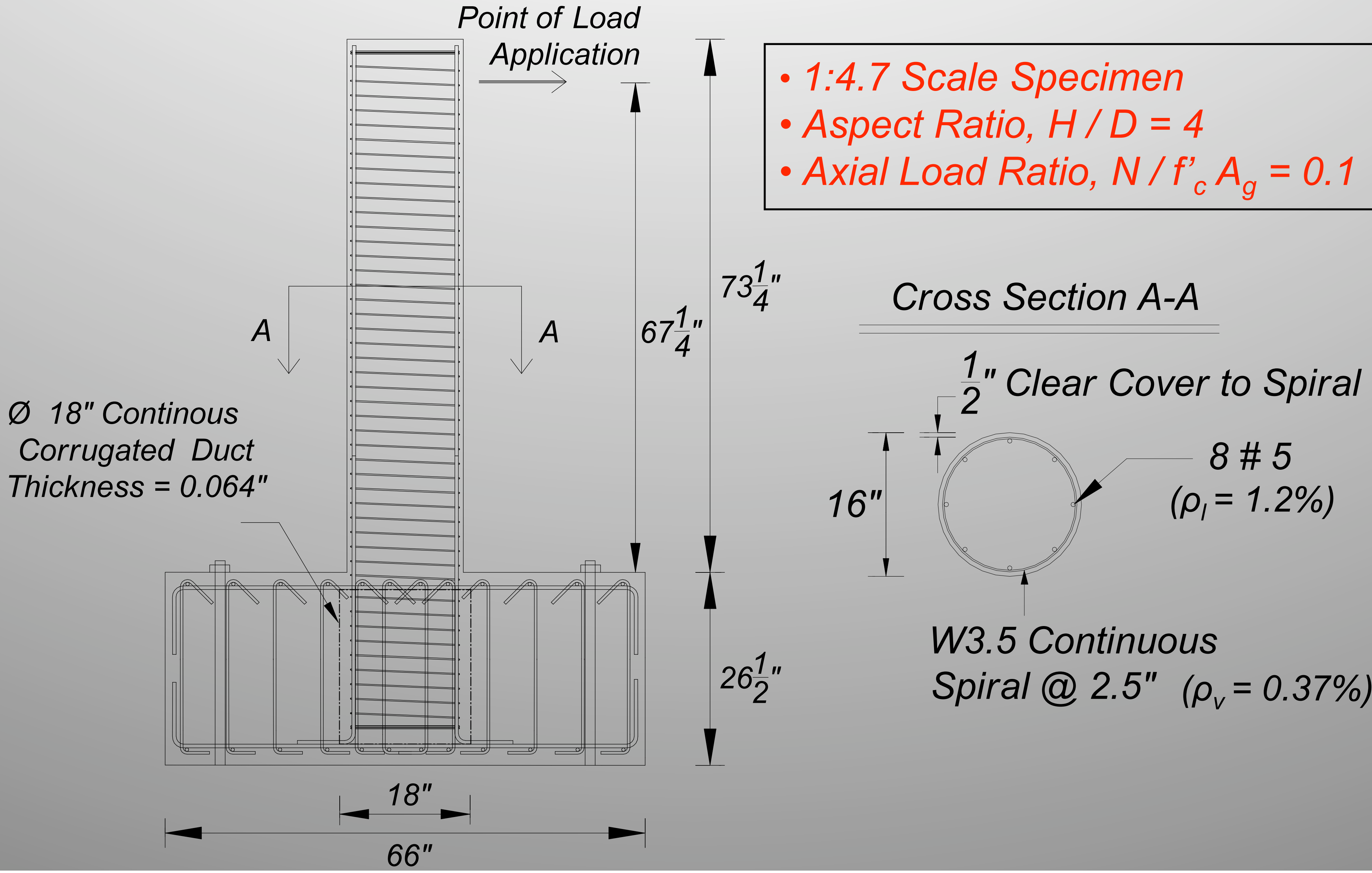
- *Rocking at column / foundation interface.*
- *Target smeared strain of 4.4% at drift ratio of 5%.*

<u>Assumptions:</u>

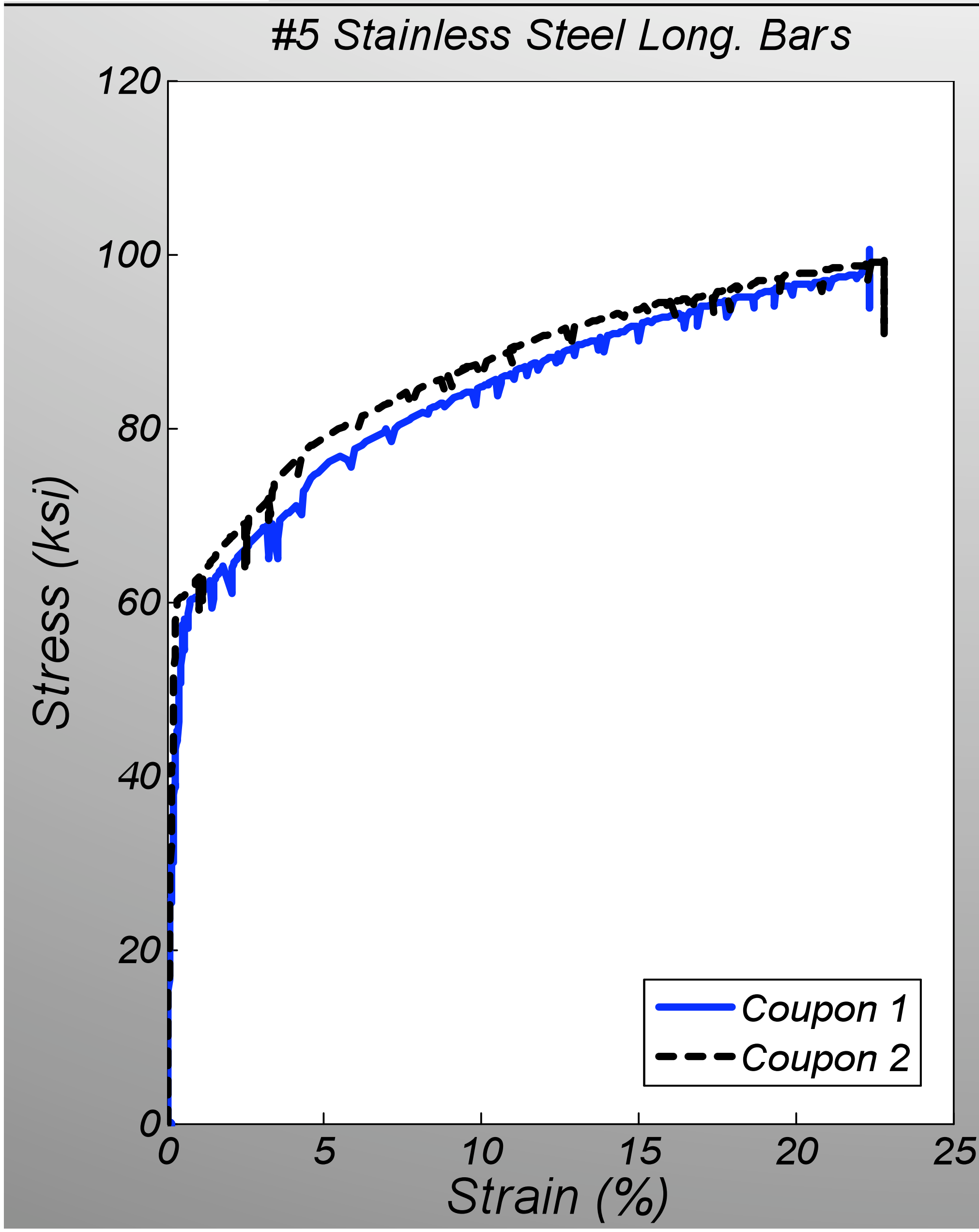
- *Column deforms as rigid body.*
- *Ignores strain penetration at both ends of the unbonded length.*

TEST SPECIMEN-2 (TS-2)

- 1:4.7 Scale Specimen
- Aspect Ratio, $H / D = 4$
- Axial Load Ratio, $N / f'_c A_g = 0.1$



CHARACTERISTICS OF TS-2



<u>Stainless steel longitudinal rebars</u>

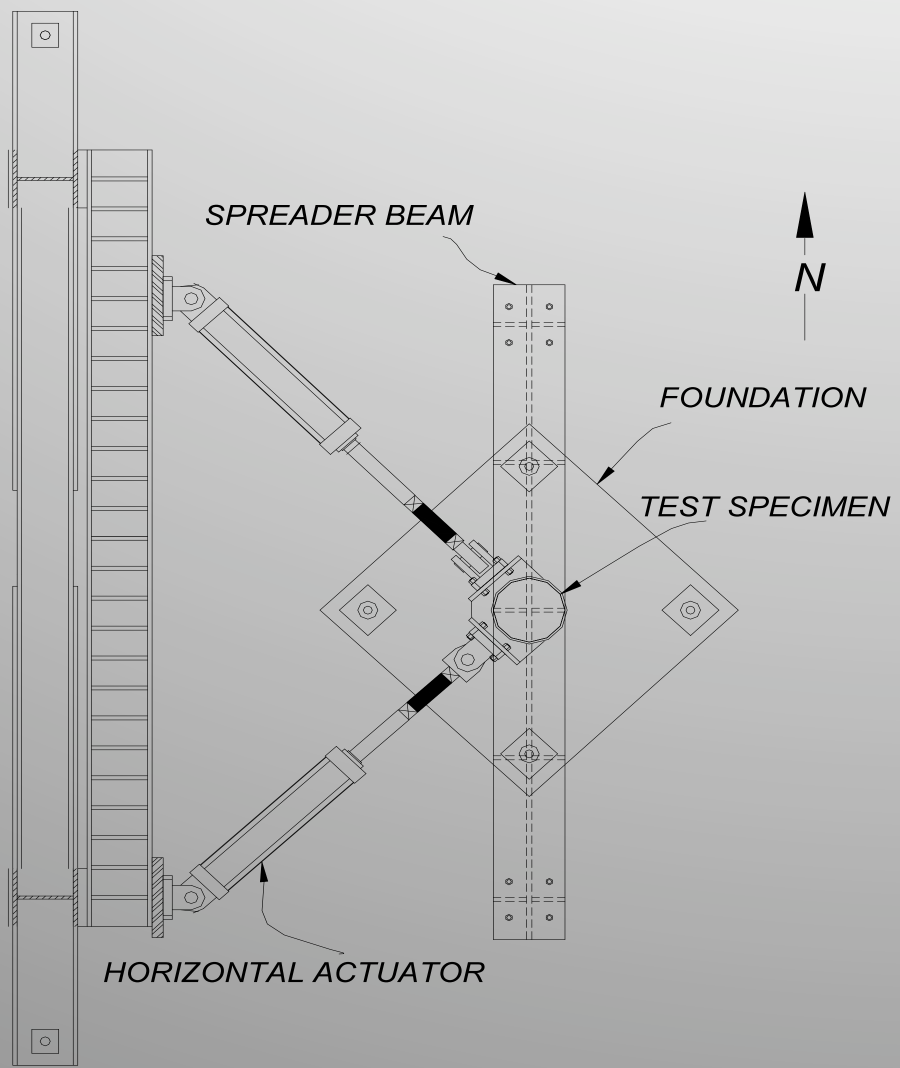
- *To enhance spread of plasticity (avoid localized cracking).*
- *Delay bar fracture.*

CHARACTERISTICS OF TS-2

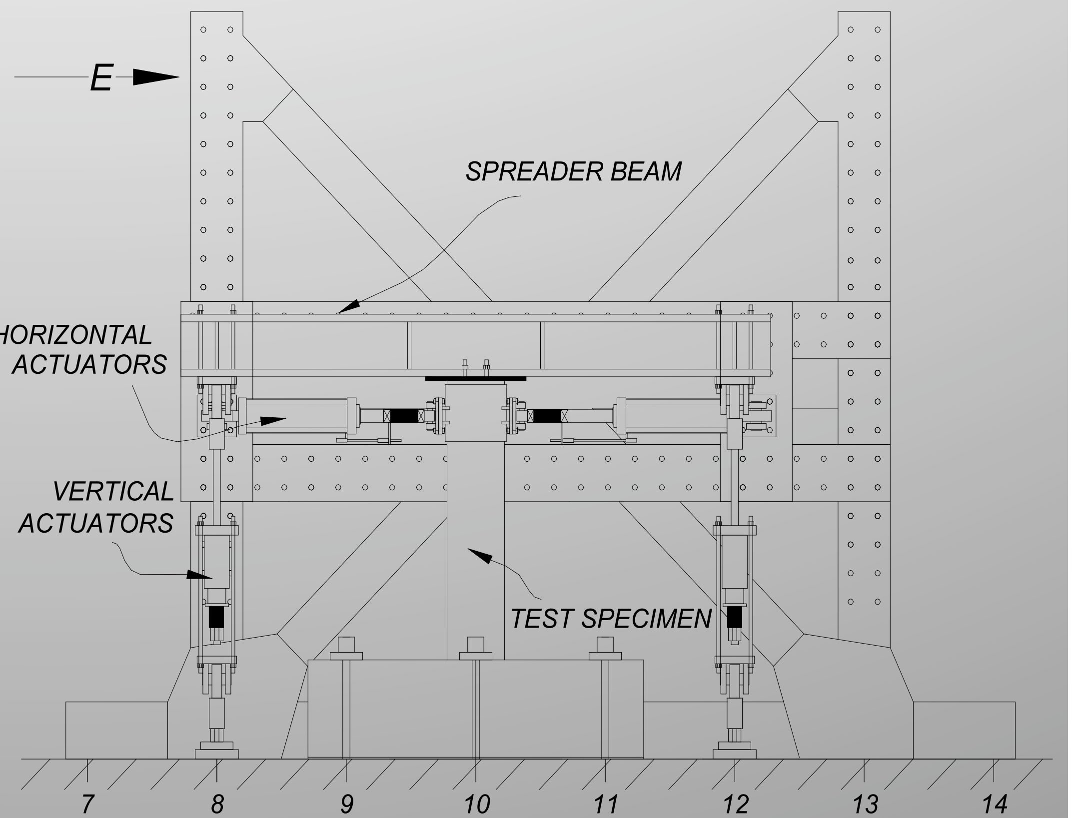
Corrugated steel pipe

Avoid crack localization at column / foundation interface

EXPERIMENTAL SETUP



Plan View



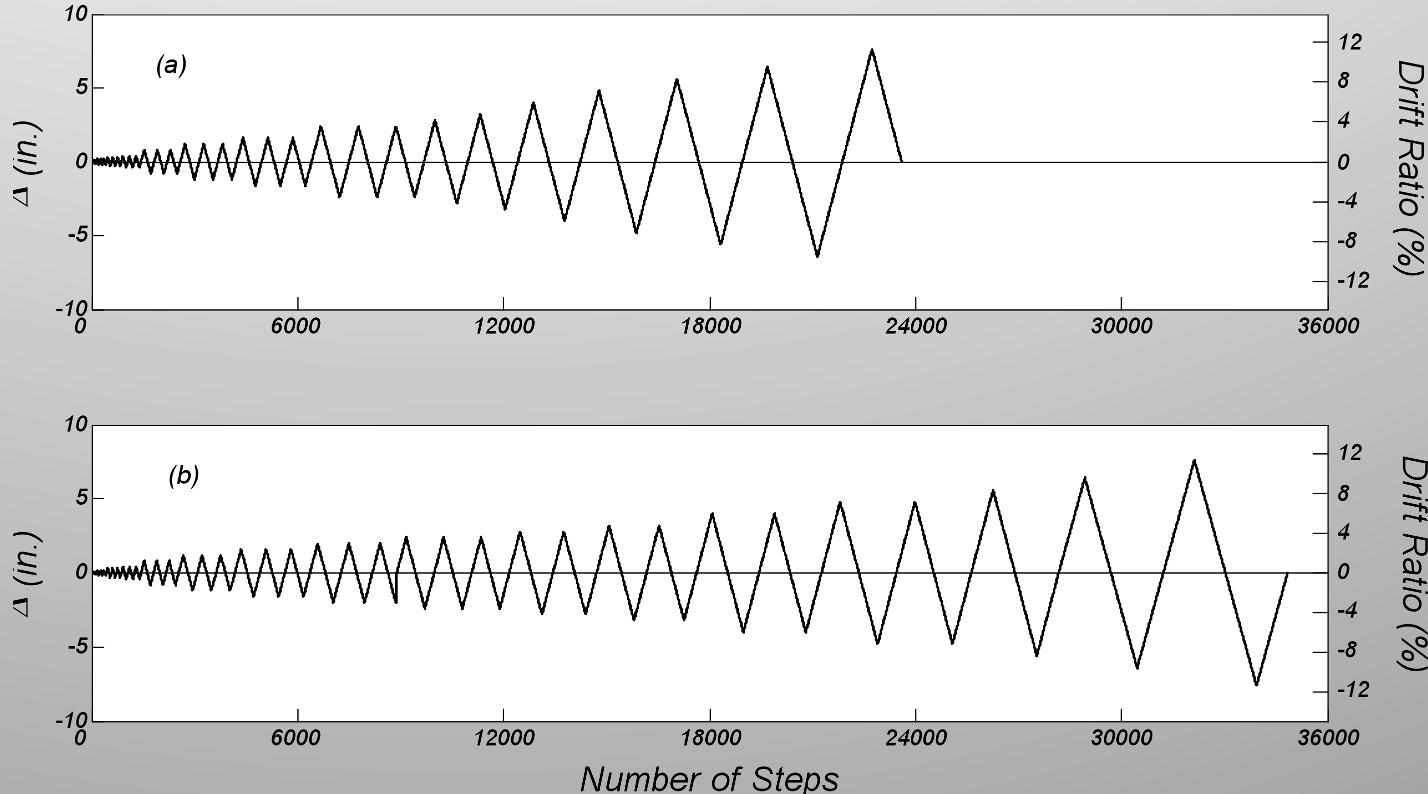
Elevation View

EXPERIMENTAL SETUP

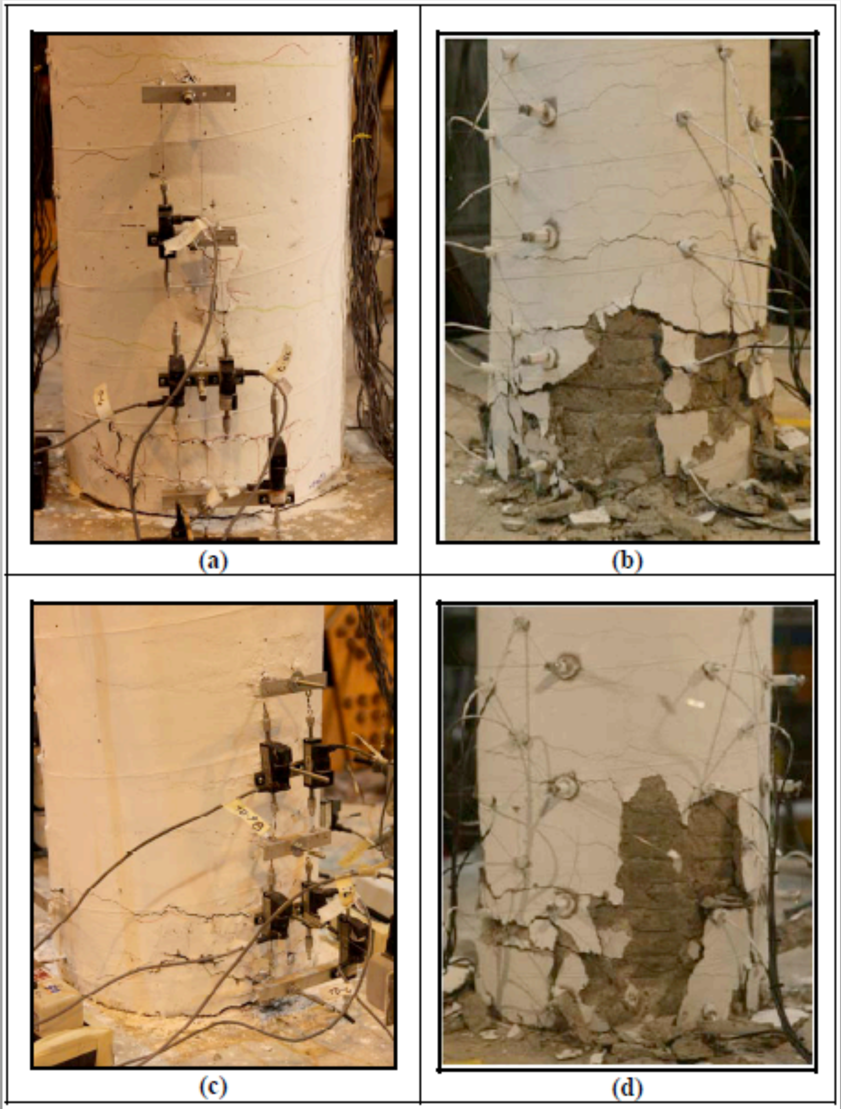
Global View of Test Setup

LOADING PROTOCOL

Top Displacement, Δ (in)	Drift Ratio, (θ_r) %
0.1	0.15
0.2	0.30
0.3	0.44
0.4	0.60
0.8	1.2
1.2	1.8
1.6	2.4
2.0	3.0
2.4	3.6
2.8	4.2
3.2	4.8
4.0	6.0
4.8	7.1
5.6	8.3
6.4	9.5
7.6	11.3



DAMAGE REDUCTION
COMPARED WITH CONVENTIONAL COLUMNS

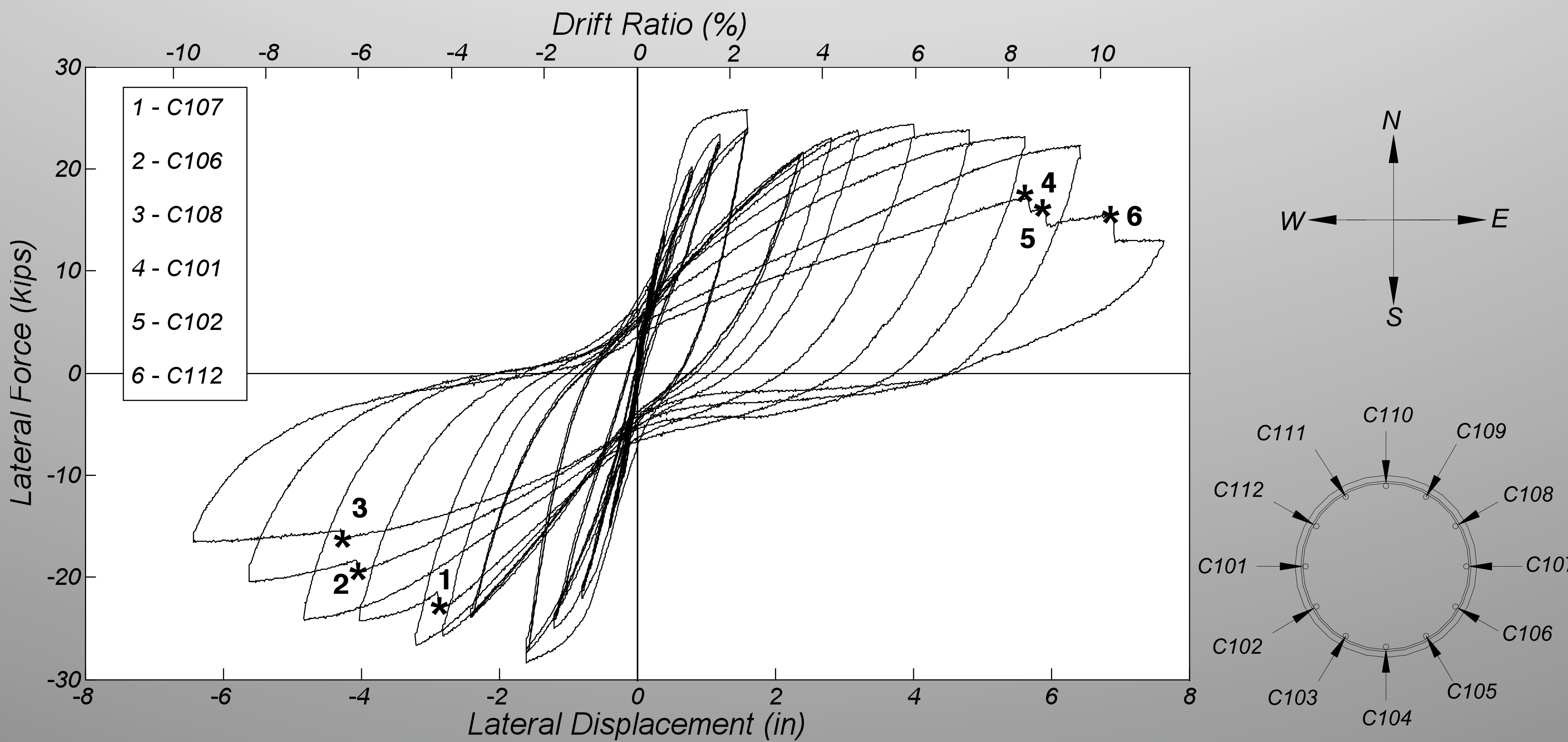


TS-1(a), TS-2 (c); ρ_v= 0.37%; *Conv. Concrete* ρ_v= 0.7%

- *There was significant damage reduction in the test specimens built using SC-HyFRC, compared to conventional concrete columns.*
- *In both specimens spalling of cover occurs only locally and is delayed up to 3.6% drift ratio despite half the transverse reinforcement ratio, (ρ_v), 0.37% vs. 0.7%).*

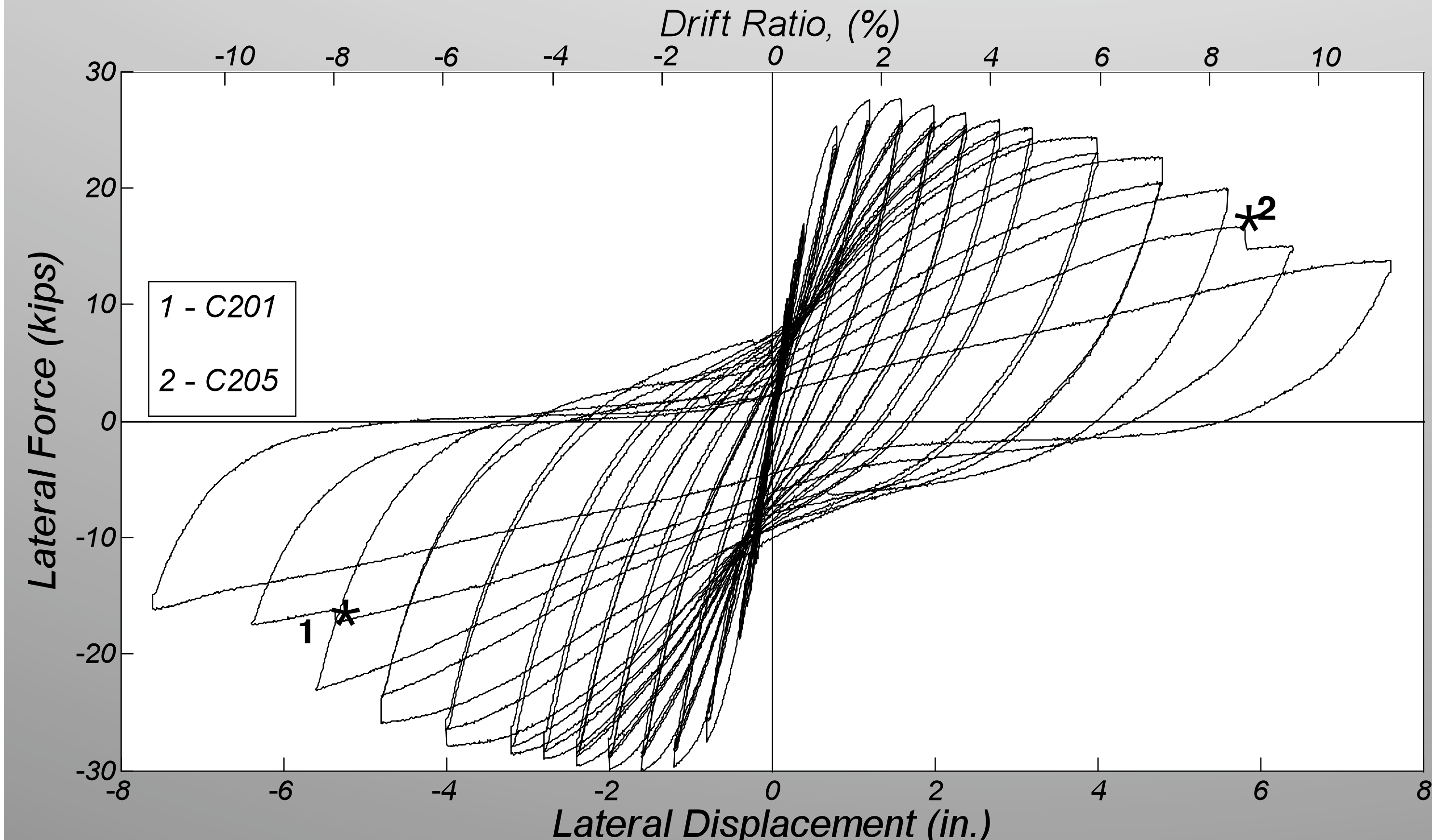
LATERAL FORCE-DISPLACEMENT RESPONSE

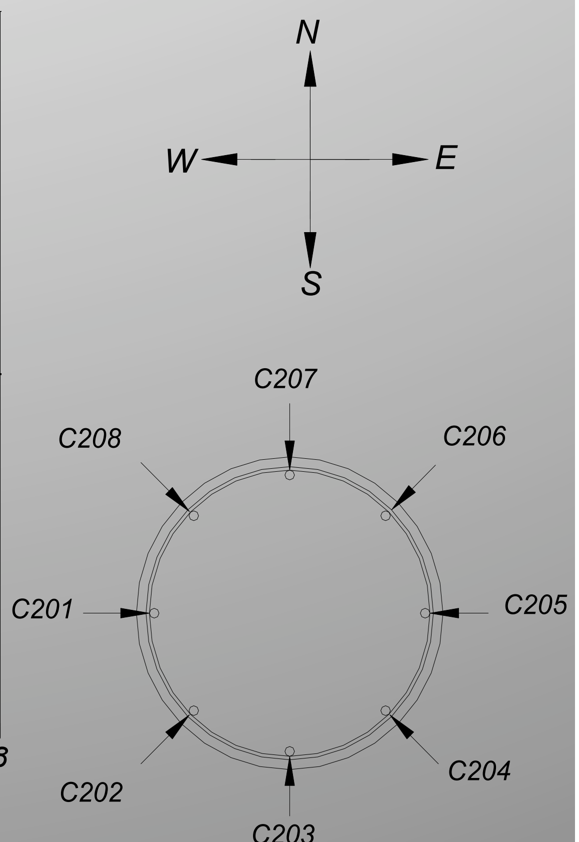
Lateral Force – Lateral Displacement Response of TS-1



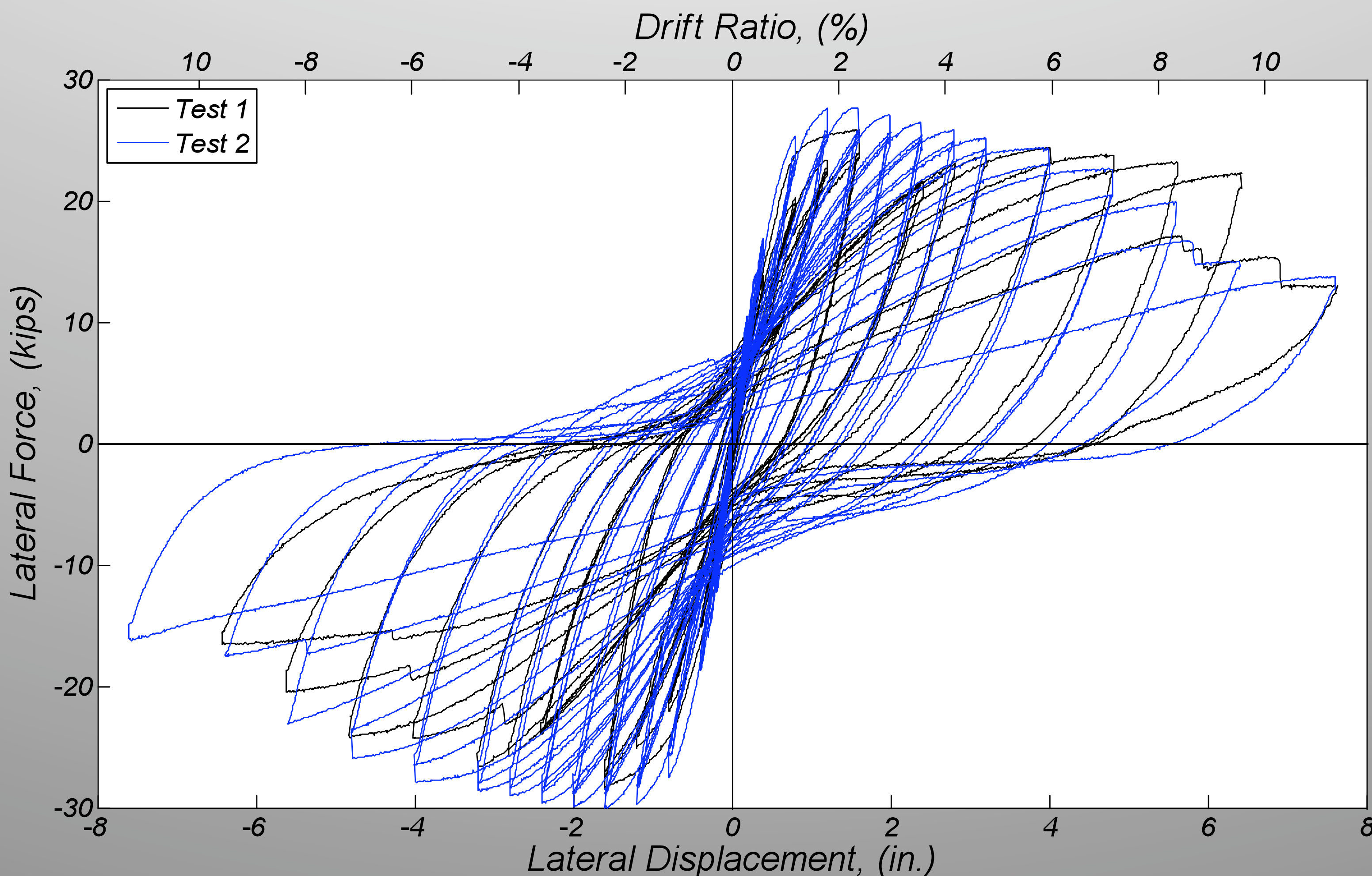
LATERAL FORCE-DISPLACEMENT RESPONSE

Lateral Force – Lateral Displacement Response of TS-2





Comparison of Lateral Force – Lateral Displacement Response of TS-1 and TS-2



OBJECTIVES ACCOMPLISHED

- Damage Reduction √

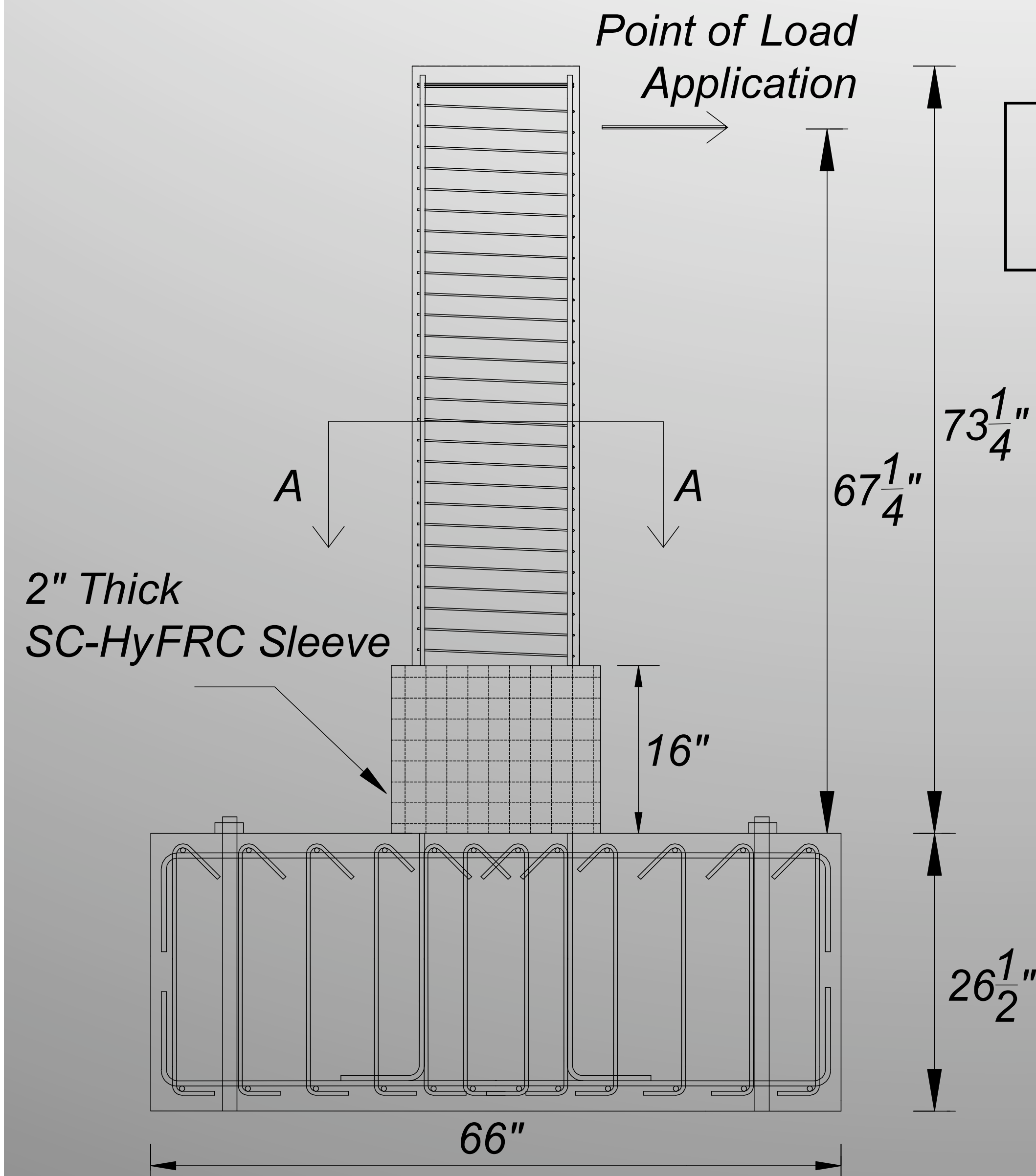
  (no damage due to spalling up to drift ratio of 3.6% despite half transverse reinforcement ratio)

- Axial load carrying capacity at large drift ratios √

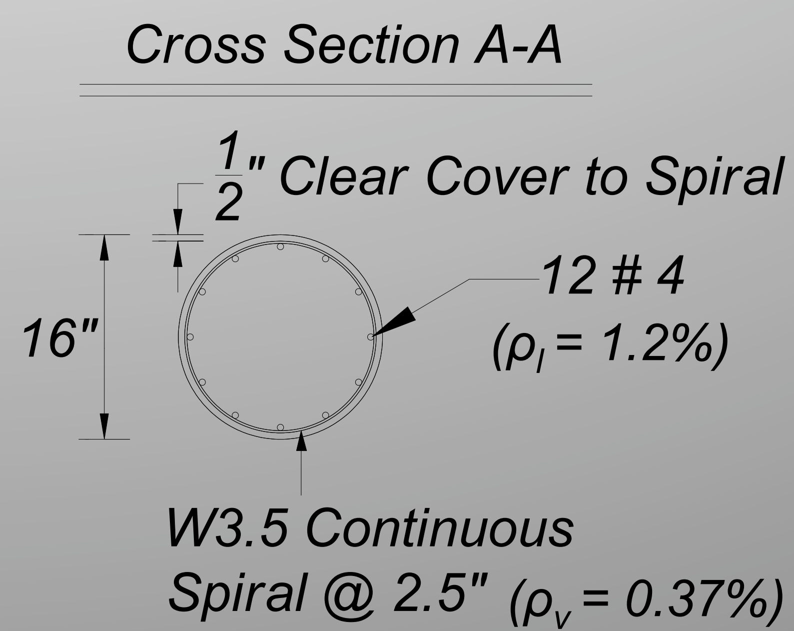
  (up to drift ratio of 11.3%)

- High compaction & fast construction √

FUTURE DIRECTIONS



Design and testing of bridge columns with SC-HyFRC sleeve.



Thank you for your attention