Use of Ultra-High Performance Concrete in Geotechnical and Substructure Applications

PI: Muhannad Suleiman
Co-PI: Sri Sritharan
Graduate Research Assistant: Thomas L. Vande Voort

January 13, 2009

IHRB
IOWA HIGHWAY RESEARCH BOARD

BRIDGE ENGINEERING CENTER
IOWA STATE UNIVERSITY

Research Funding

- Seed funding received from IHRB for a high-risk, high-reward project that can lead to substantive advancements in highway transportation

American Concrete Institute®
Now offering more value to members!

Objectives

- Demonstrate the potential use of UHPC in geotechnical applications
- Evaluate the behavior of UHPC piles using large-scale tests and analytical procedures

Motivation

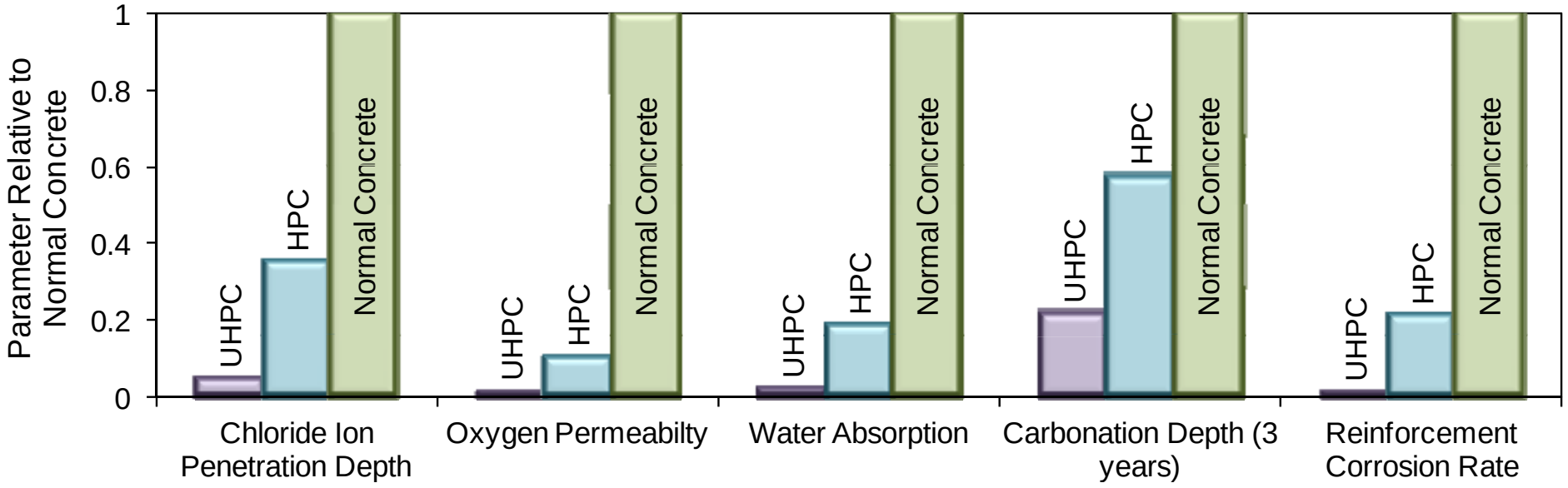
- Grand Challenges issued by AASHTO 2005:
  - Extending service life of bridges to 75 years with minimal maintenance
  - Optimizing structural systems using new materials

- Piles made of conventional materials have suffered damage




Why UHPC?

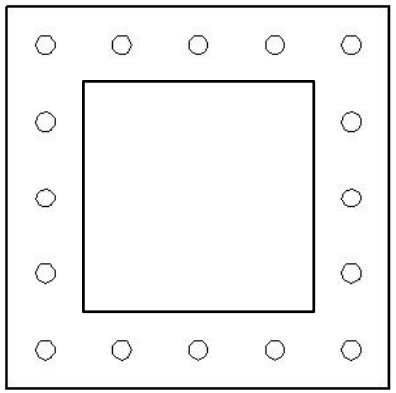
Property	UHPC	HPC	Normal Concrete
Compressive Strength	26-30 ksi	12-18 ksi	4-8 ksi
Tensile Strength	1.7 ksi	0.8-0.9 ksi	0.3-0.7 ksi
Elastic Modulus	8000 ksi	4800-6400 ksi	3600-5100 ksi
Durability		Up to 400x lower	Up to 700x lower

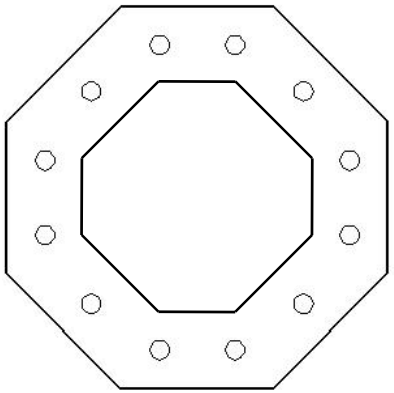


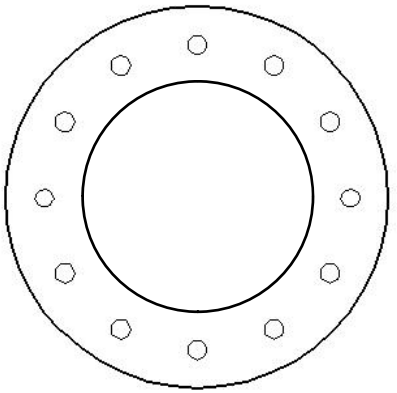
Tasks

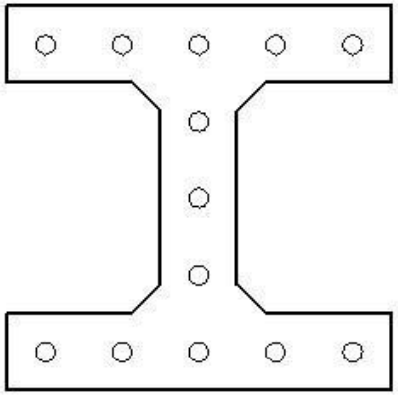
- Conduct a literature review on the use of UHPC in super- and any sub-structural systems related to transportation structures in the United States and abroad
- Design of UHPC pile section
- Conduct comparative driveability study for UHPC and other piles
- Conduct laboratory tests on UHPC pile elements
- Conduct dynamic tests (PDA/CAPWAP) on UHPC and steel piles
- Perform large-scale vertical and lateral load tests on UHPC piles

Pile Section Shapes Considered

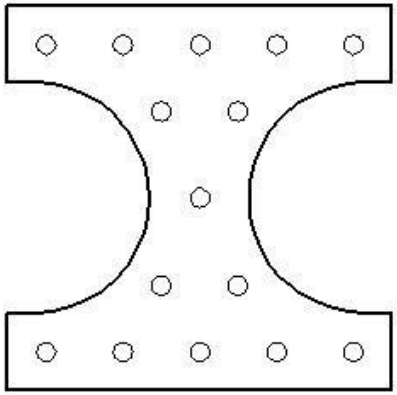




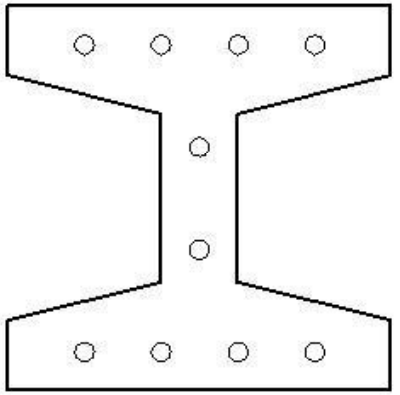




Simple H-Shape

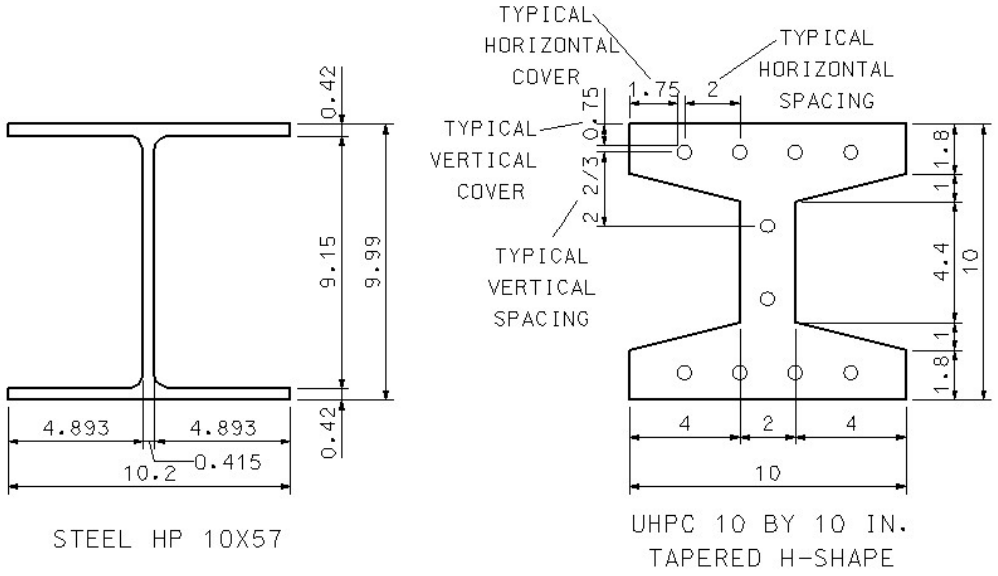


X-Shape



Tapered H-Shape

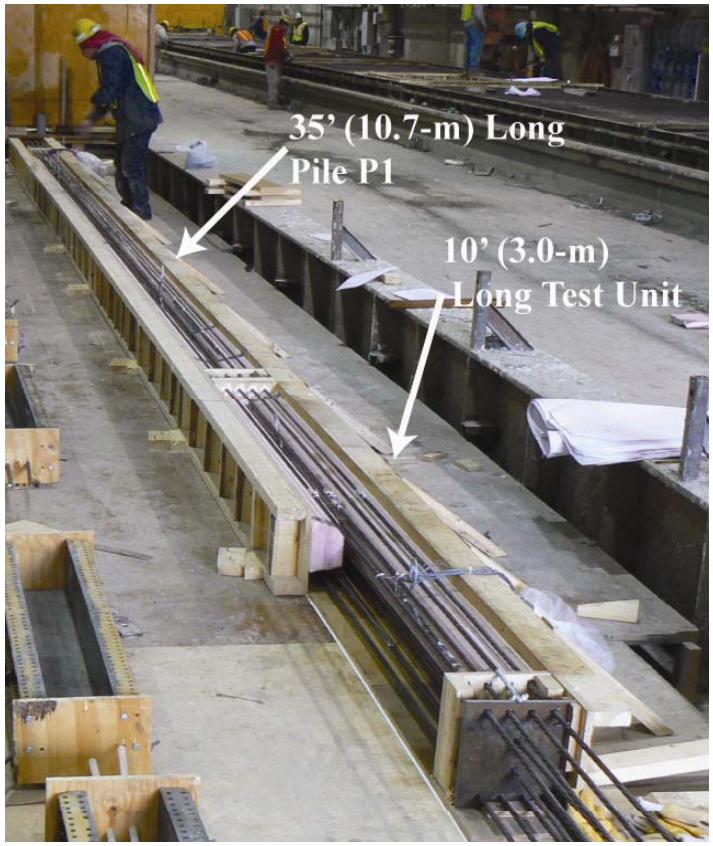
Final Section Properties

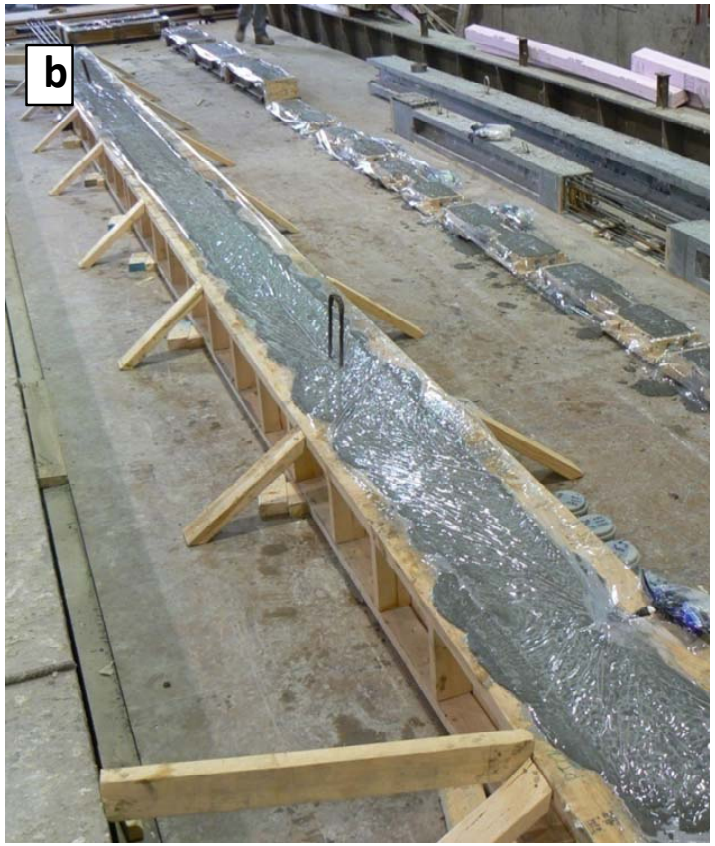


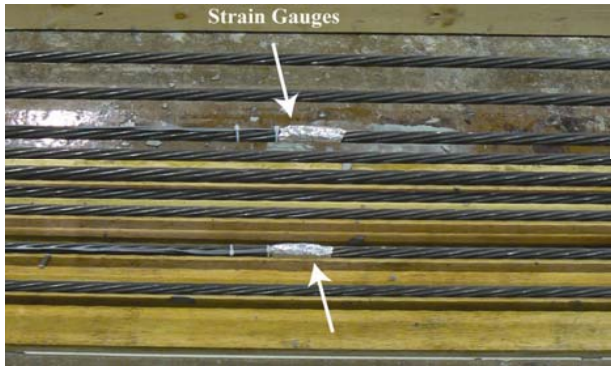
*ALL DIMENSIONS IN INCHES; 1 INCH = 25.4 MM

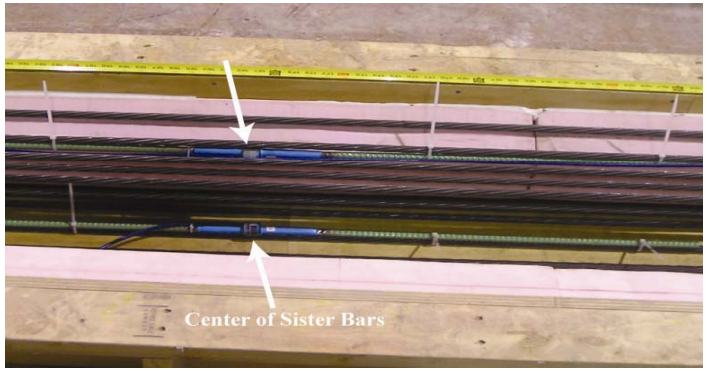
Parameter	Steel HP 10 x 57	UHPC Tapered H-Shape
Area	16.8 in^2	56.8 in^2
Weight/ft	57.2 lb	61.1 lb
Moment of Inertia	294 in^4	795 in^4
Stiffness Term (E·I)	8.53×10^6 $kip\cdot in^2$	6.36×10^6 $kip\cdot in^2$

Construction

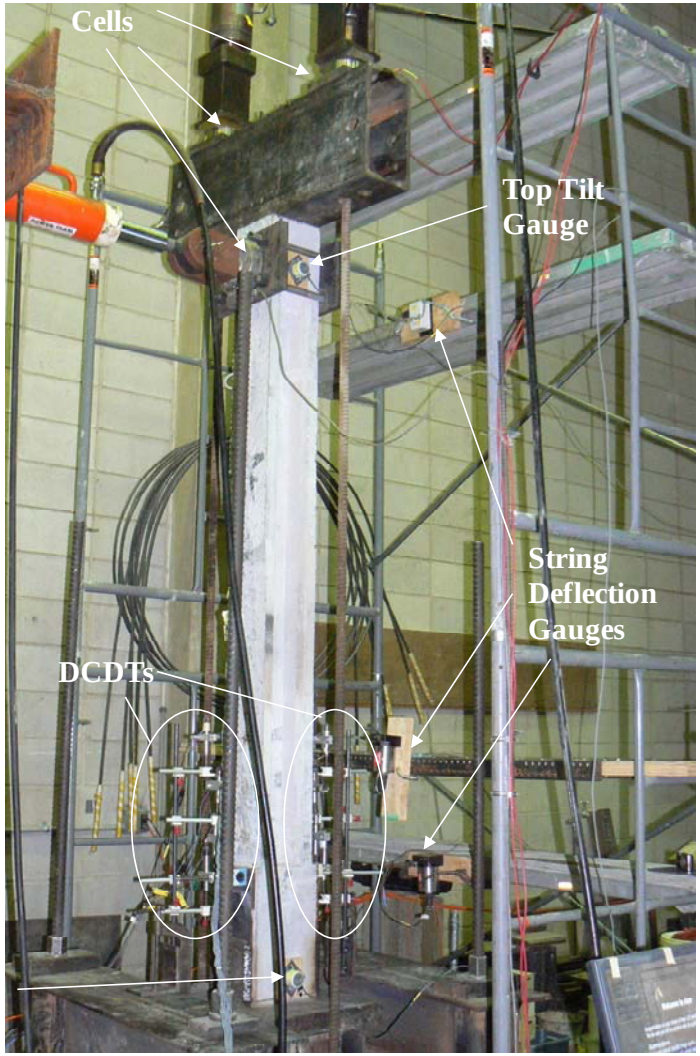


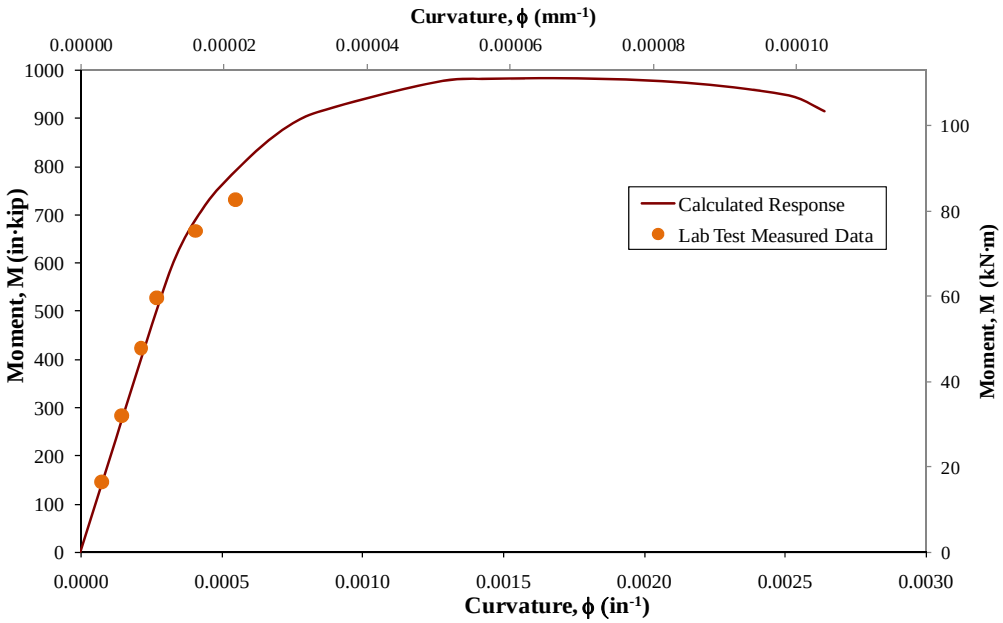




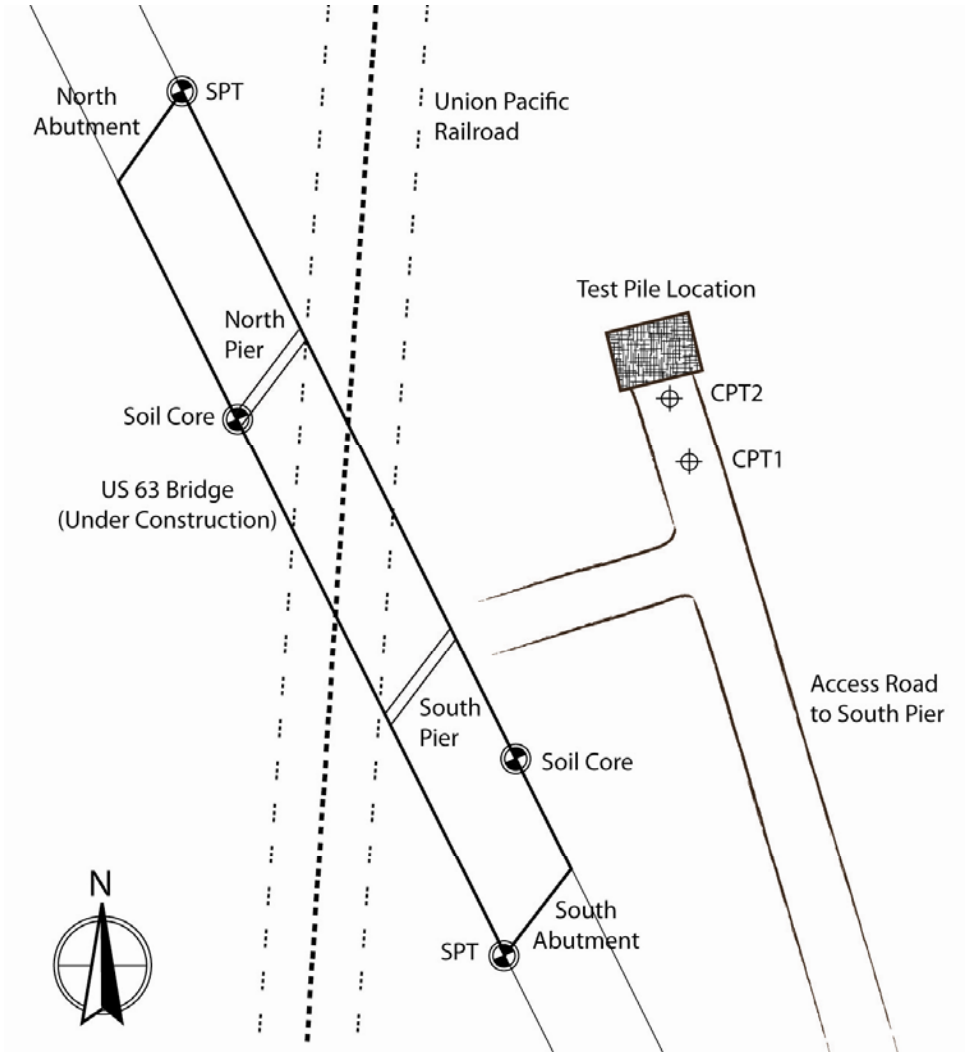


Laboratory Testing

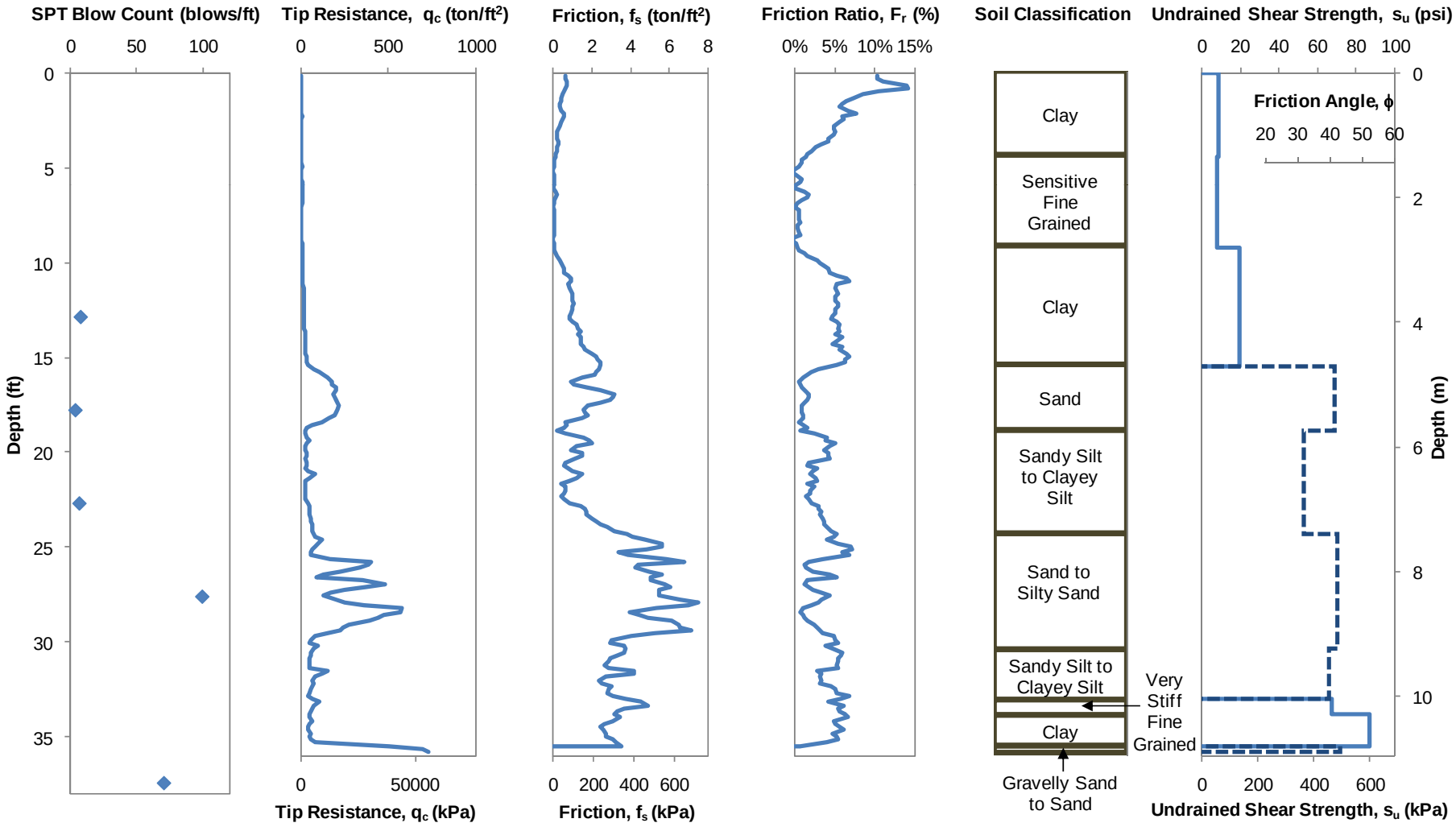




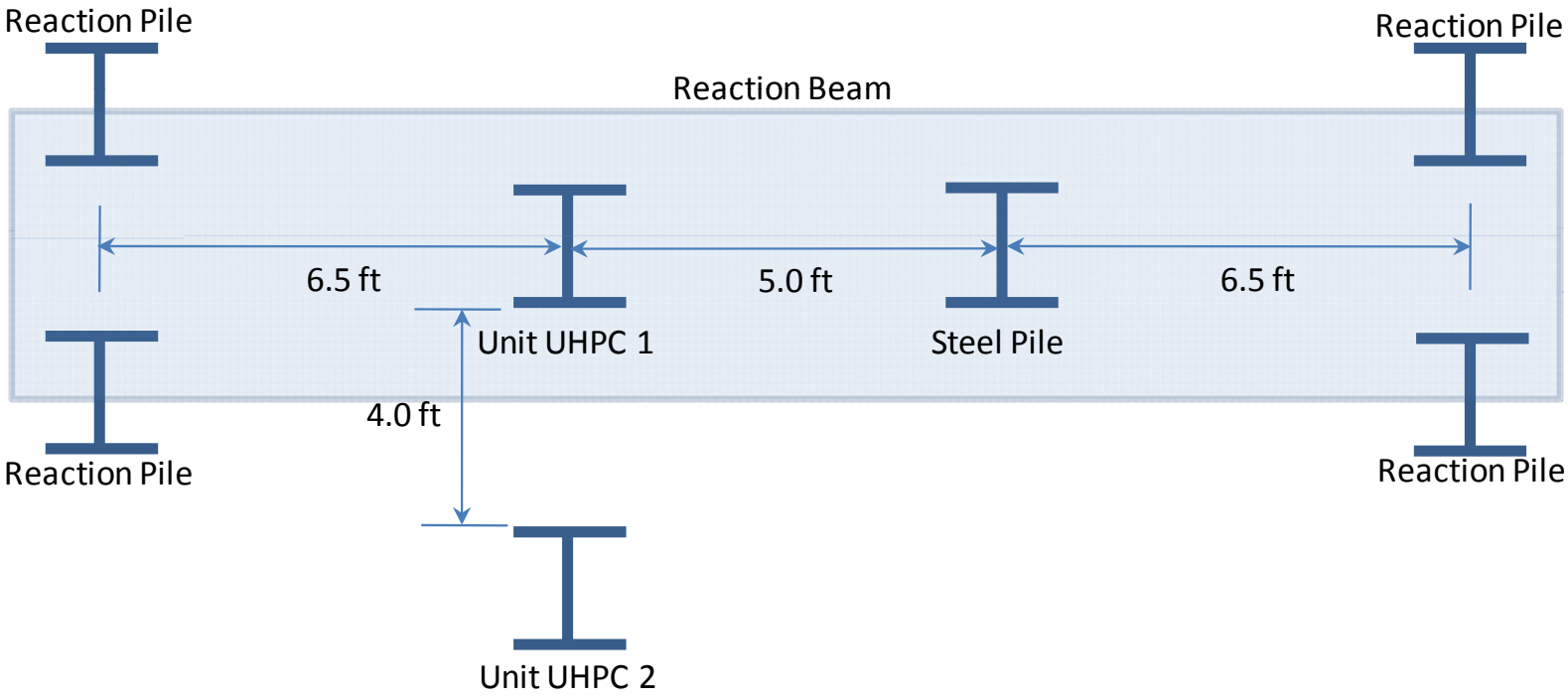
Field Investigation: US63 Oskaloosa, IA



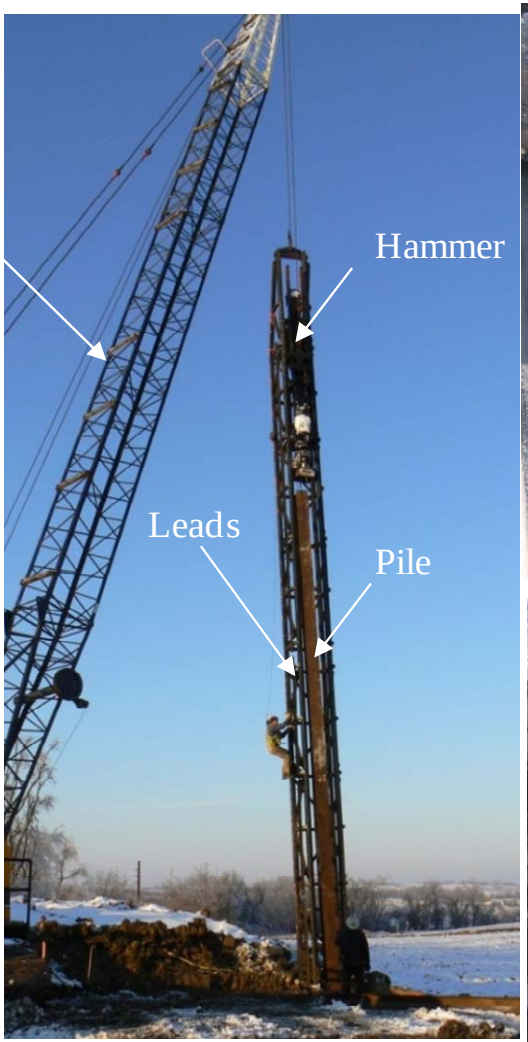
Site Soil Profile



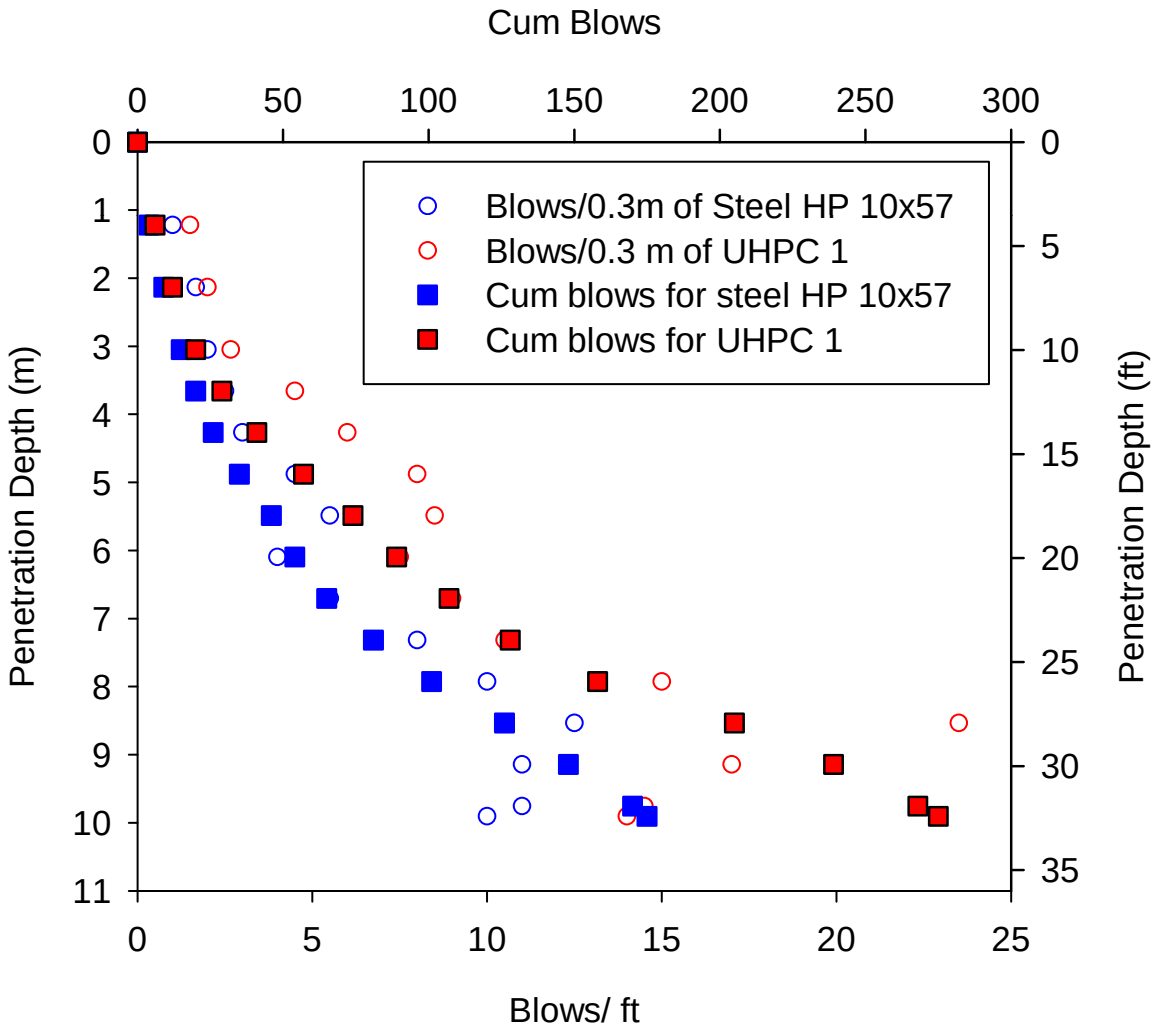
Field Testing Plan



Driving of UHPC and Steel Piles



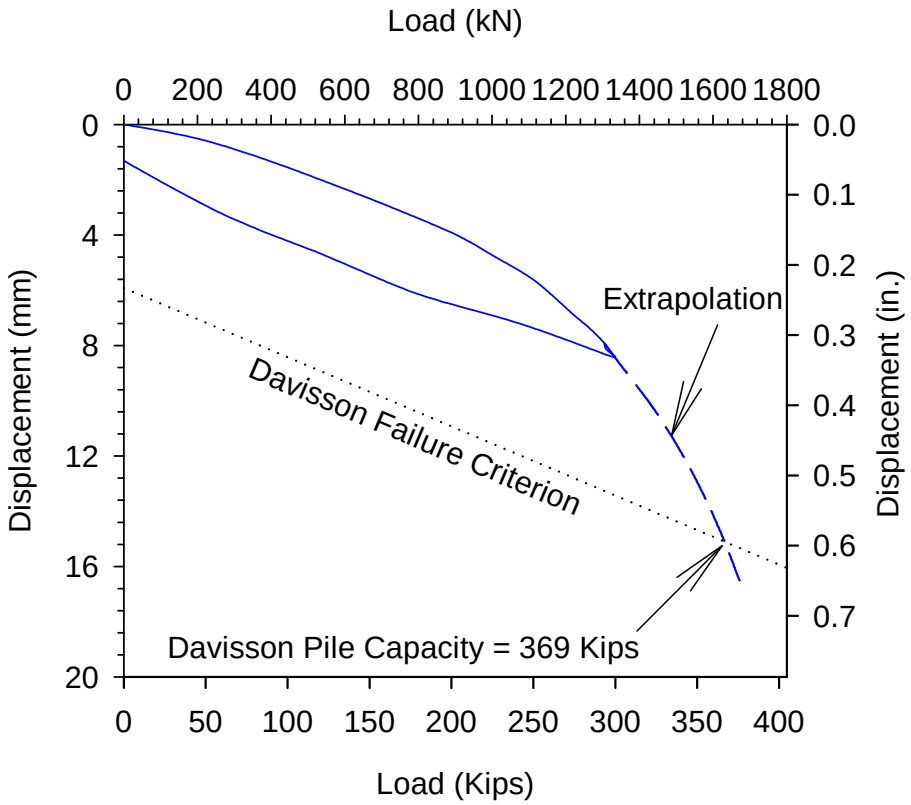
Driving Logs



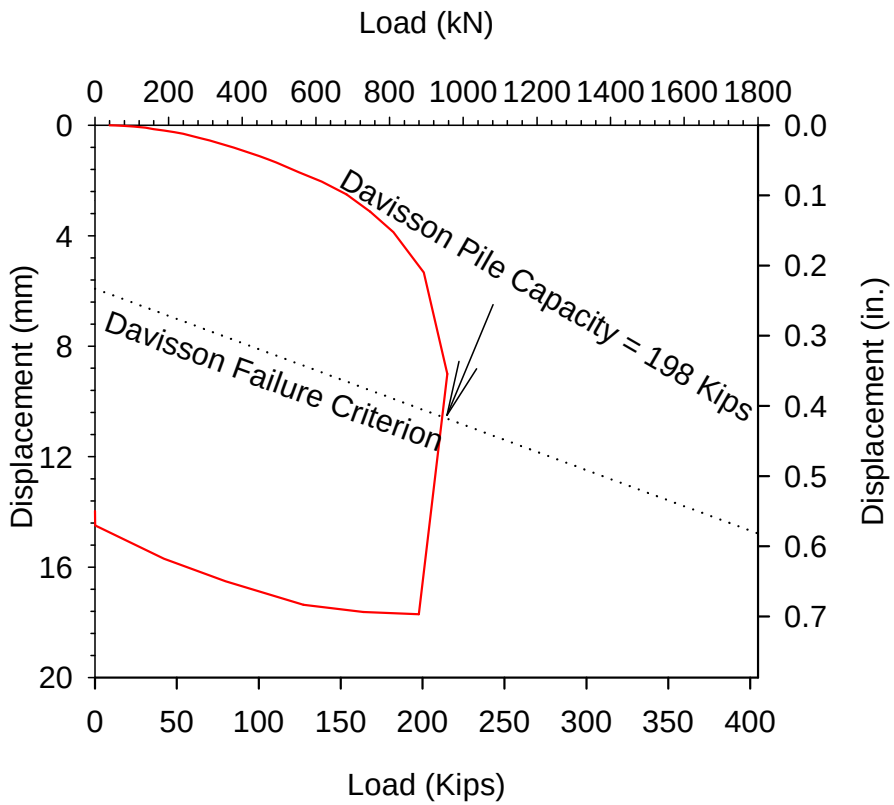
Driving

Vertical Load Tests

Load-Displacement Relationship

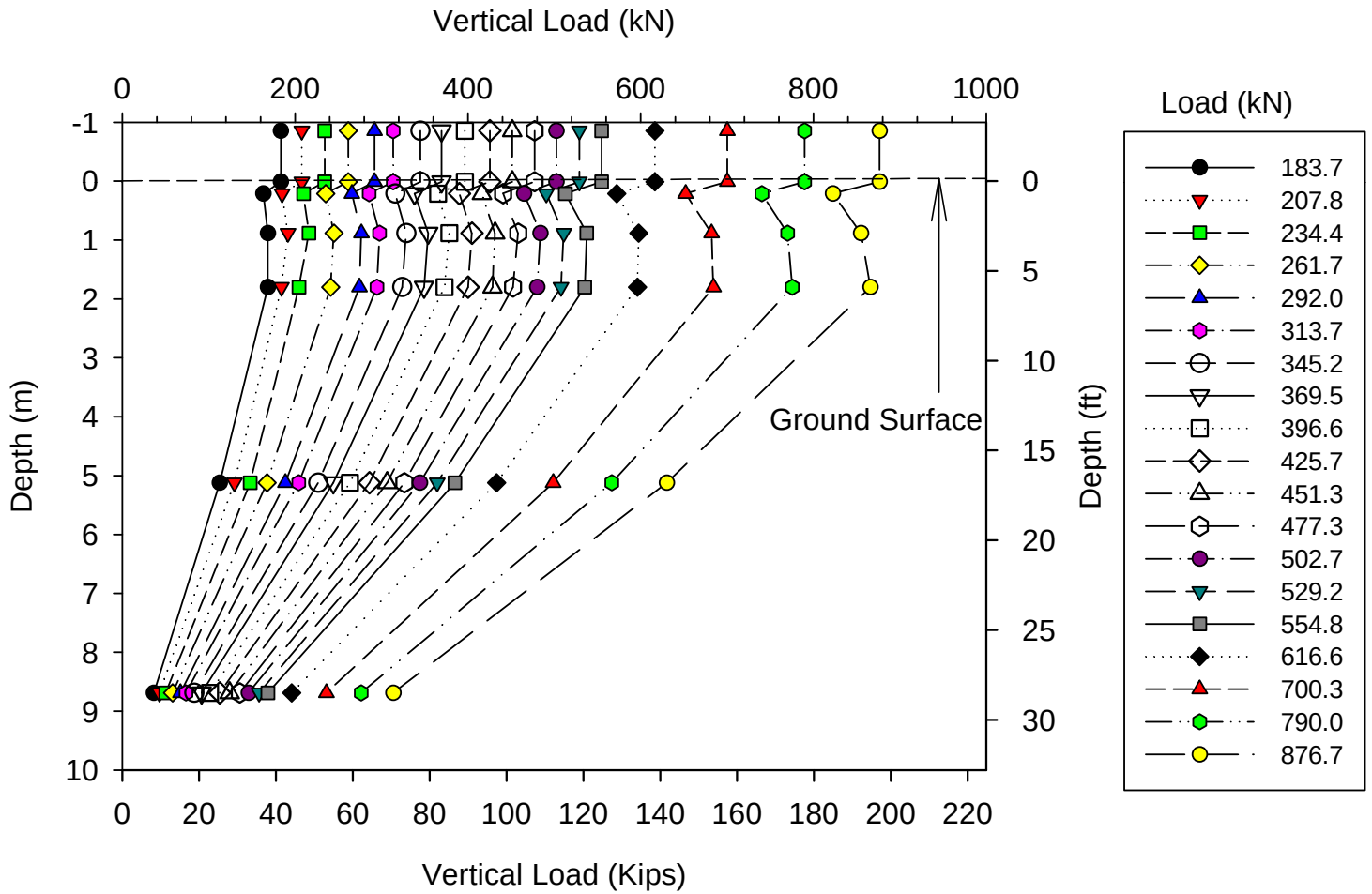


UHPC

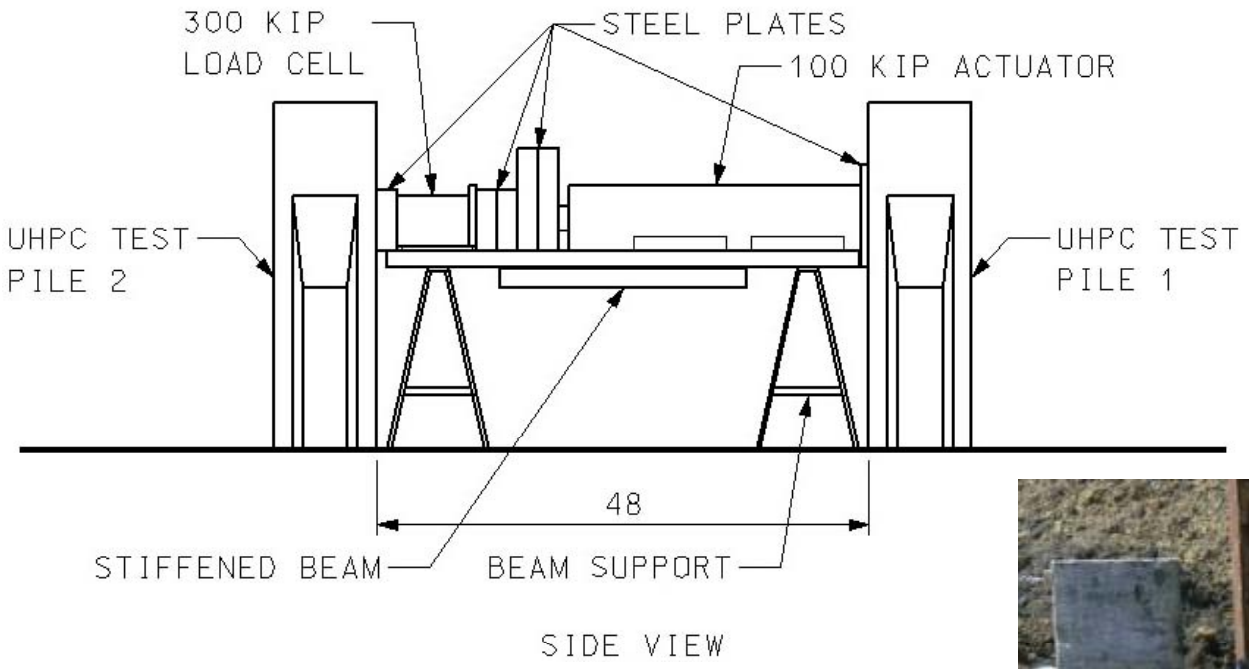


Steel Pile

Load Transfer

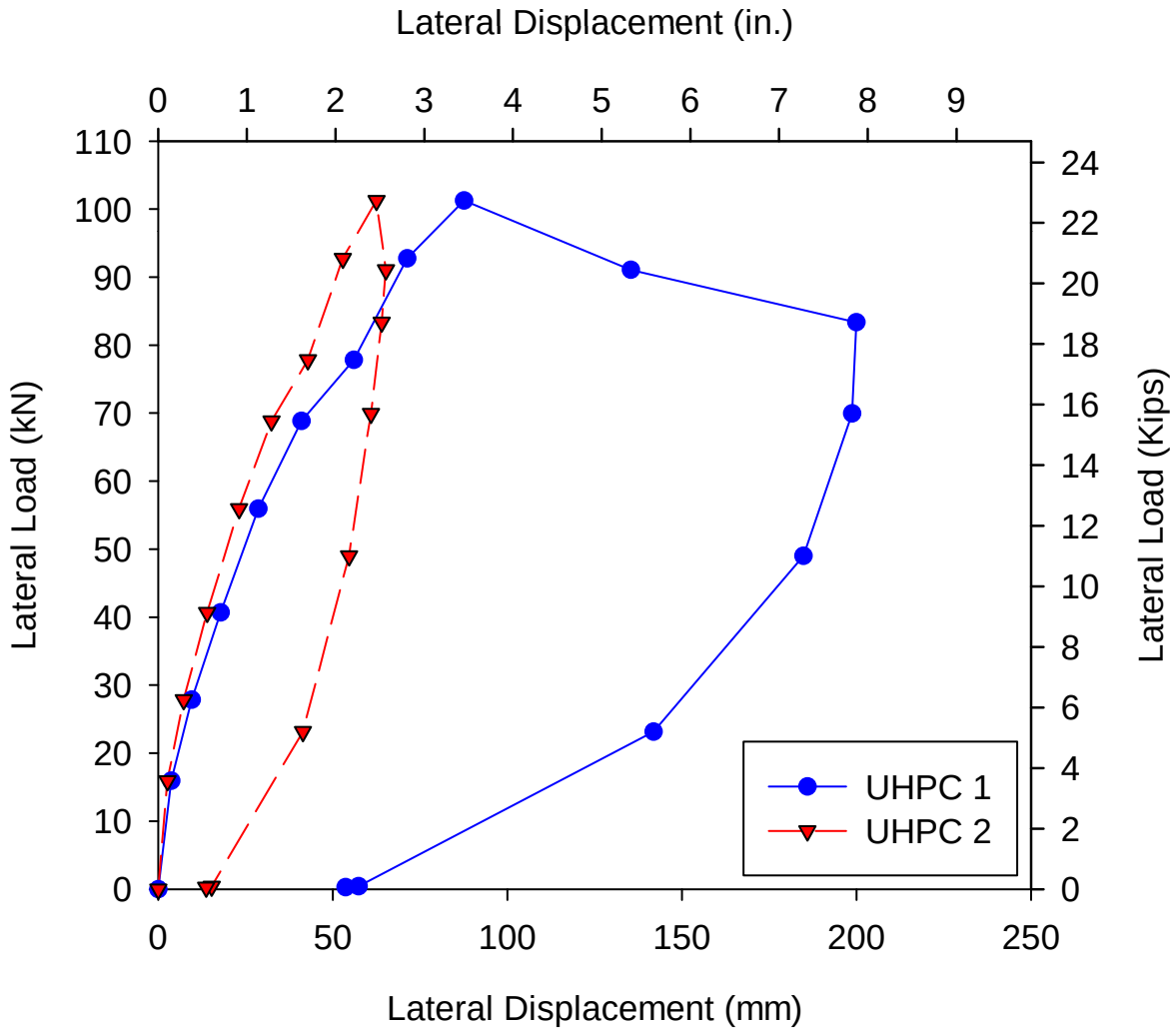


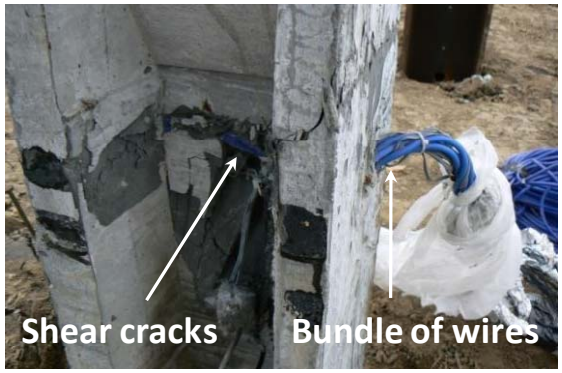
Lateral Load Test



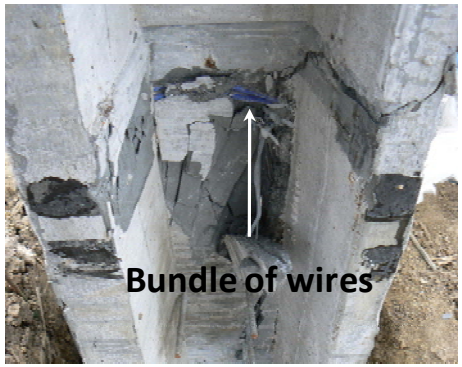
SIDE VIEW

UHPC Pile Lateral Load-Displacement



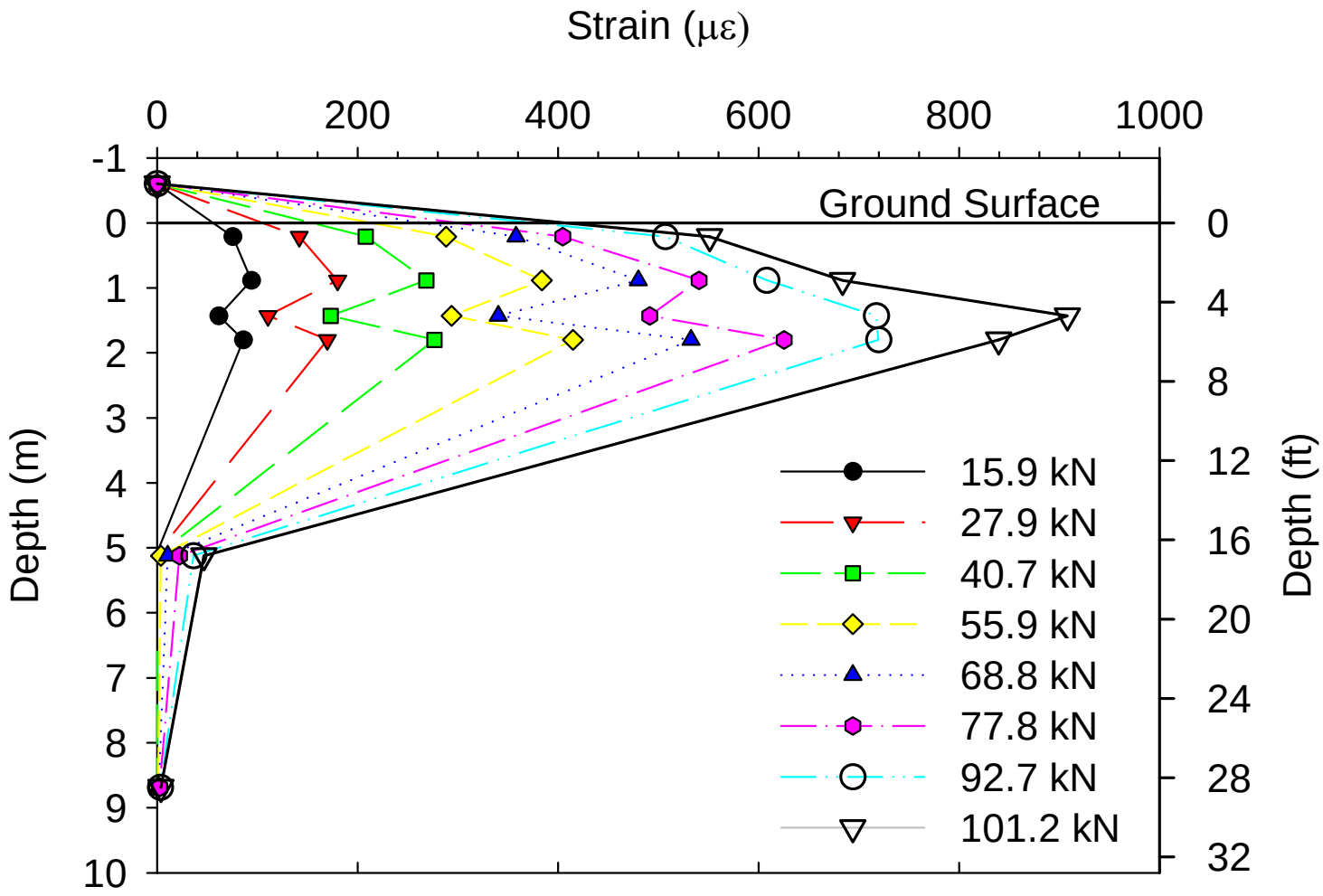


(a)



(b)

UHPC Pile Lateral Load-Displacement



Questions