ISM
International Society for Micropiles

8th International Workshop on Micropiles

Toronto
September 26 to 29, 2007

Axial Compression, Axial Tension and Lateral Load Response of Pre-Production Micropiles for the CPR Mile 62.4 Nipigon Subdivision Bridge

Golder Associates

Case History

- **Underpinning and jacketing of existing Canadian Pacific Railway (CPR) bridge foundations at Mile 62.4, Nipigon Subdivision (near Thunder Bay, Ontario)**
  - Capital cost savings of 20 % compared to replacement.
  - First of its kind project in Canada.
- **Approximately 130 year old structure**
  - Steel Superstructure
  - Stone Masonry Piers (3 Piers)
  - Timber Piles and Mat Foundations (overstressed)

Project Team

- **Canadian Pacific Railway** (Owner)
- **Golder** (Geotechnical Consultant, Micropile Designer and Construction Monitoring)
  - Donald Bruce (Advisor)
- **HMM** (Construction Manager)
- **LAS** (General Contractor)
- **GFC** (Micropiling Contractor)
  - Isherwood Associates

Golder Project Team

- **Calgary**
  - Dennis Becker
  - Peter Thomson
  - Blake Leew
- **Mississauga**
  - Paul Dittrich
  - Arash Zakeri
- **Saskatoon**
  - Greg Misfeldt
  - Dean Lorras

Ground Conditions

- **Pier 1**
  - Sand, cobbles and masonry rubble fill
  - Compact to dense sand and gravel
  - **Compact to very dense silt**
  - Very stiff silty clay
- **Pier 2**
  - Compact to dense sand and gravel
  - Compact to very dense silt
- **Pier 3**
  - Sand, cobbles and masonry rubble fill
  - **Compact to dense sand and gravel**
  - Dense to very dense silt

Design Criteria (Single Pile)

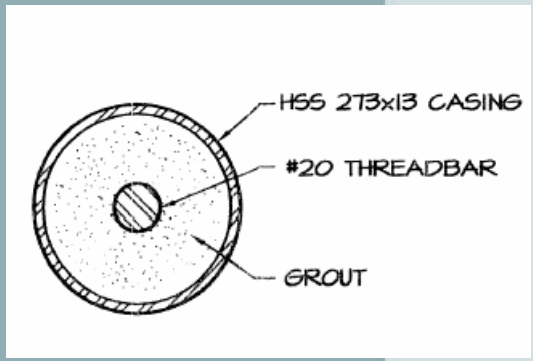
- **Service loading conditions:**
  - Maximum axial load = 1,200 kN
  - Maximum lateral load = 100 kN
  - Maximum moment = 100 kN-m
- **At design serviceability loading:**
  - Settlement ≤ 6 mm
  - Differential settlement ≤ 3 mm
  - Lateral displacement ≤ 13 mm

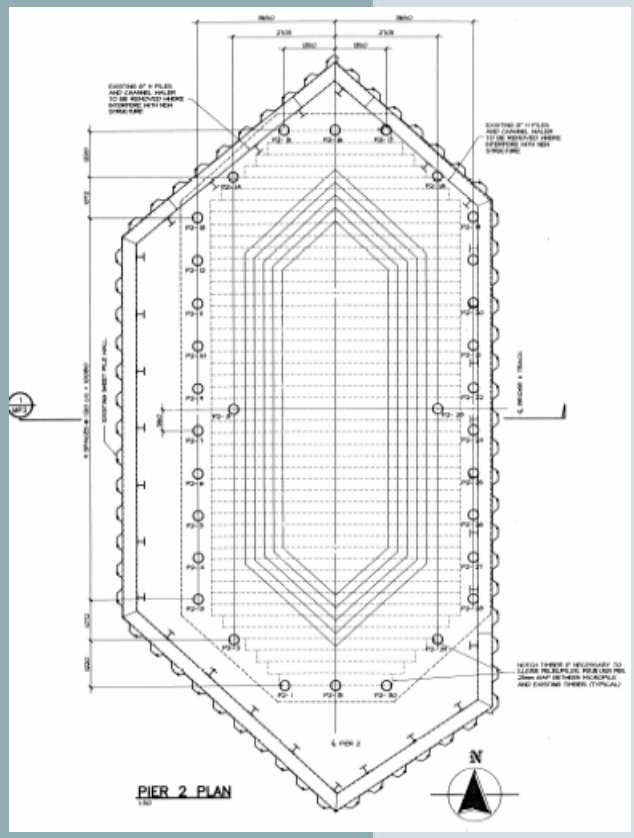
Design and Analysis

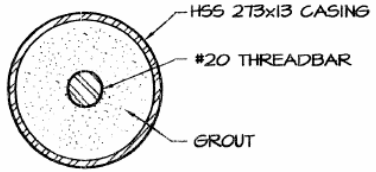
- Preliminary micropile sections and lengths selected using conventional methods
- Micropile sections and lengths refined and finalized using 3D finite element program (**FB-Pier**)
- Manual checks following **AREMA**

Micropile Section Details

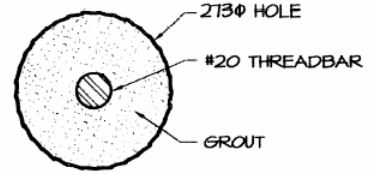
- **Total pile lengths varied between 17.9 m (Pier 3) and 20.6 m (Pier 2)**
  - Outer steel casing:
    - 273 mm diameter ; 5.8 m to 9.3 m long
    - 13 mm wall thickness
  - Central steel reinforcement:
    - DSI #20 (69 mm diameter) threadbar
    - 80 ksi (551 MPa)
  - Additional inner casing at Pier 1:
    - to resist high bending moments
    - 168 mm diameter and 6.6 m long
    - 9.5 mm wall thickness



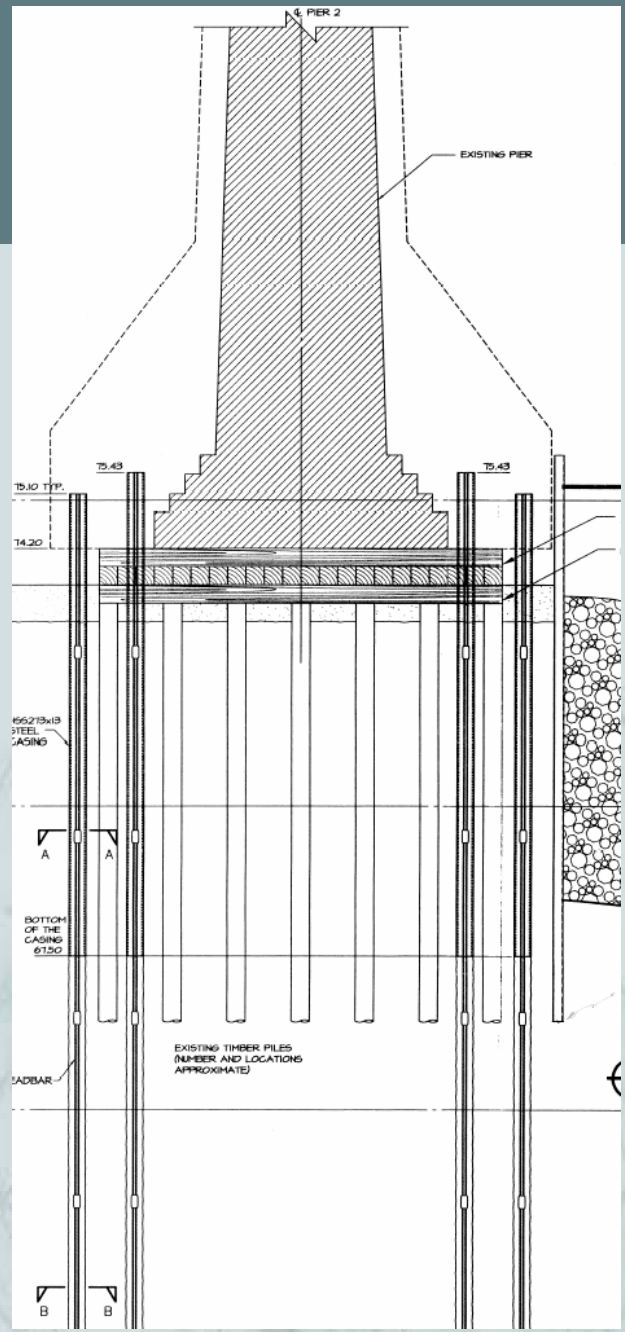

PIER 2 PLAN
N


HSS 273x13 CASING
#20 THREADBAR
GROUT

A–A
1:10


273Φ HOLE
#20 THREADBAR
GROUT

B–B
1:10


℄ PIER 2
EXISTING PIER
T5.43
T5.43
T5.10 TYP.
T4.20
A
A
BOTTOM OF THE CASING 67.50
EXISTING TIMBER PILES (NUMBER AND LOCATIONS APPROXIMATE)
B
B

Pre-Production Load Testing

- **Important to load axially to failure to determine ultimate bond values for:**
  - Verification of design assumptions and installation methodology
  - Assess if micropiles lengths and/or diameters can be reduced
- **Instrumentation adds value in refining design and understanding behaviour:**

Installation Methodology

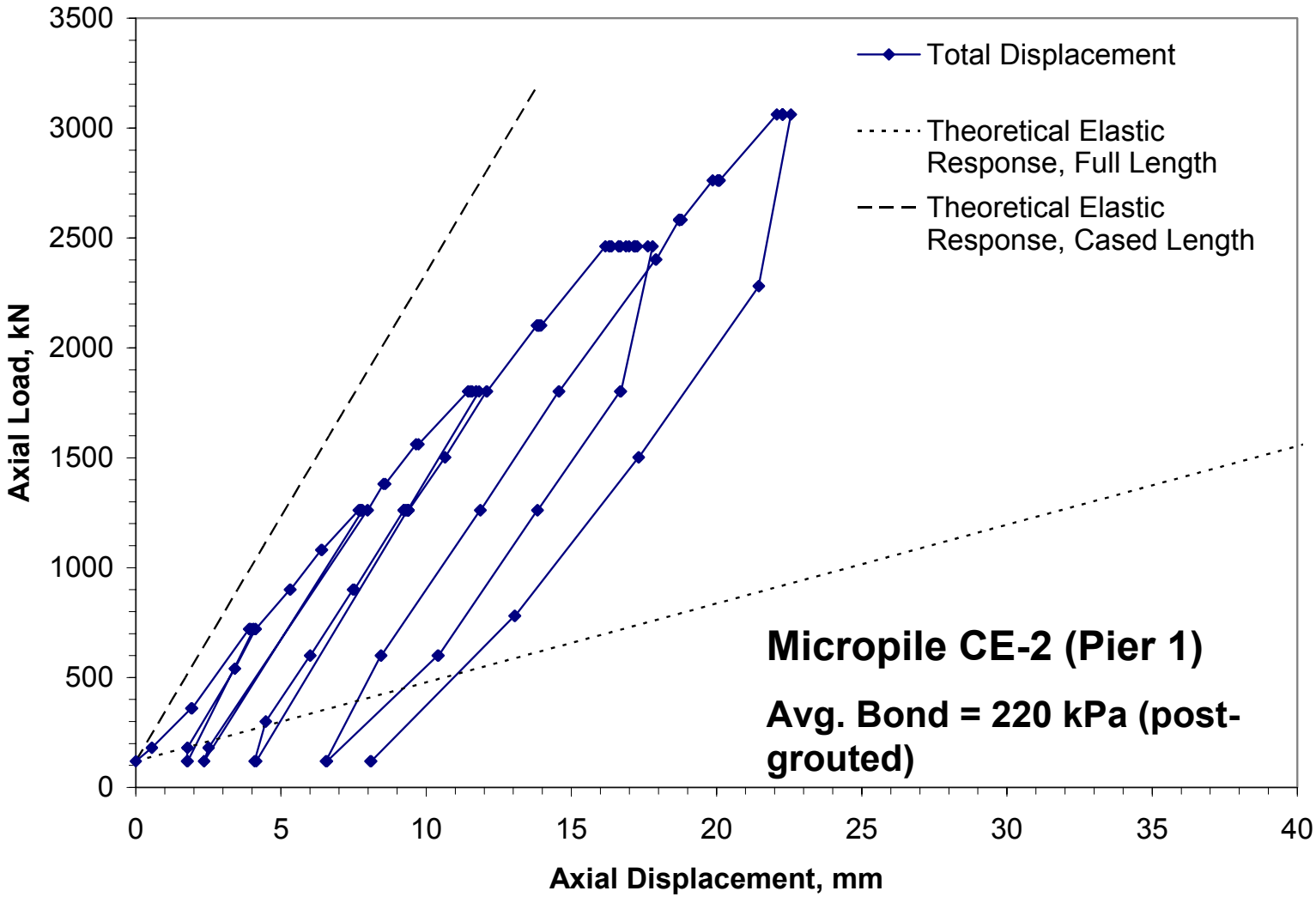
- Duplex drilling system with eccentric down-hole hammer

Micropile Load Testing

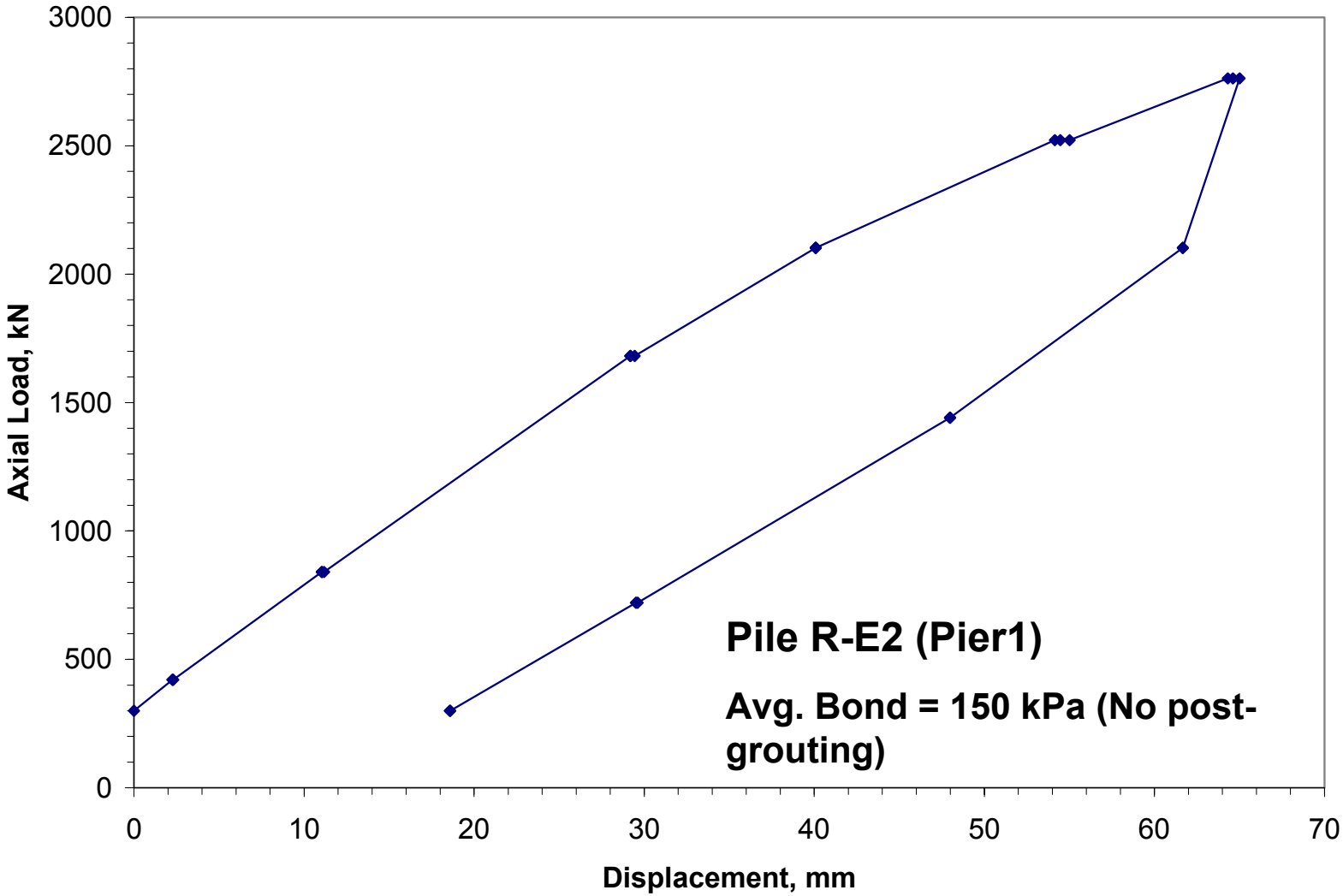
- **Pre-production axial load tests:**
  - Compression Test to 2.5 DL (3000 kN)
  - Lateral Test to 2.5 DL (250 kN)
  - Tension Test to 2.3 DL (2760 kN)
  - Two Sets (East Side and West Side)
- **Proof Tests:**
  - Tension Test to 1.3 DL (1560 kN)
  - 12 piles tested (4 at each pier)

Compression Test

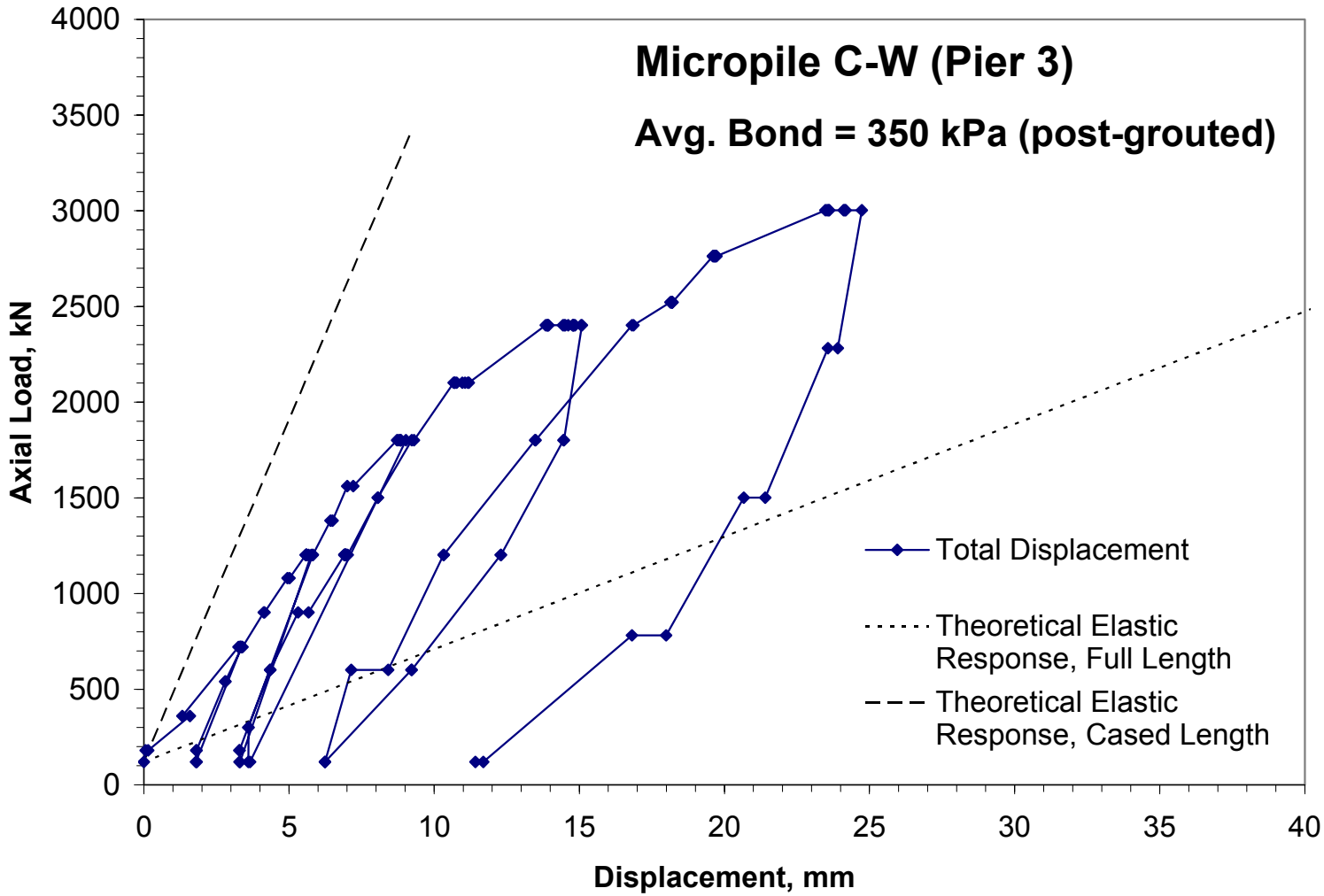
Compression Test Results – East Side



Tension (Uplift) Test Results



Compression Test Results – West Side



Comparison Between Design and Measured Bond values

- **Pier 3 (Sand and Gravel):**

  Design Value = 140 and 250 kPa

  Measured Value = +190 to 350 kPa

- **Pier 1 (Dense Silt):**

  Design = 190 kPa

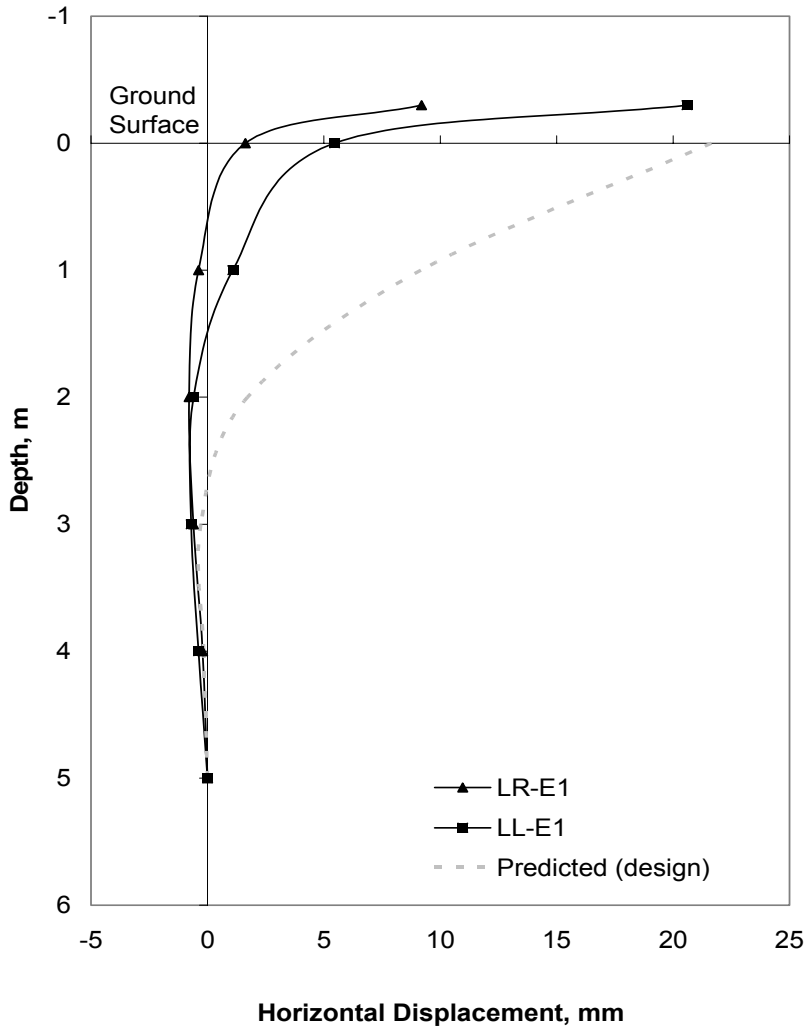
  Measured = +150 to 220 kPa

Lateral Load Test

Piles Instrumented with In-Place Inclinometers

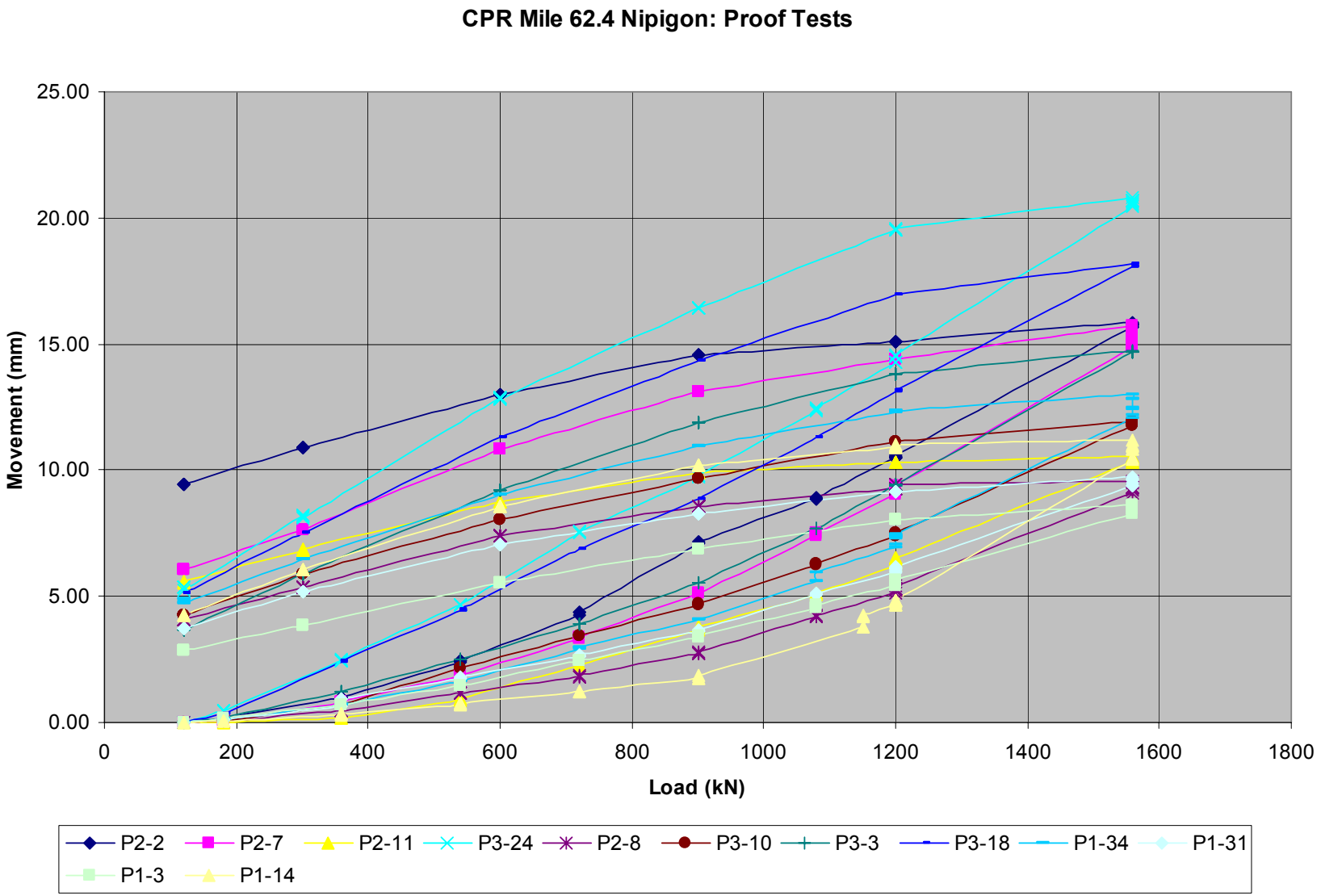
Lateral Test Results

Pile response was stiffer than expected



Proof (Uplift) Axial Load Tests

Proof Test Results



Test Results Summary

- Failures were not induced during pre-production load tests
- Pre-production results confirmed design bond estimates and micropile sections and lengths
- Proof tests satisfied acceptance criteria developed by CPR

Summary

- Micropiles successfully applied as a cost-effective foundation upgrade system
- Proven resistance to high axial and lateral loads and to applied moments
- Existing state-of-practice and tools appear to be sufficient for design purposes

QUESTIONS?