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# High Capacity Micropiles in Mined Ground for Bridge Support: Joplin County, Missouri



## Paper 4 LOAD TESTING

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# Scope

1. Introduction
  2. Technical Requirements
    - 2.1 Specifications
      - 2.2.1 Verification Load Tests
      - 2.1.2 Proof Tests
    - 2.2 Contractor's Conforming Submittal
  3. Results of Verification Tests (4) - (Paper 2: Foster, Peters, Bruce, Chuaqui and Norrish)
  4. Results of the Proof Tests (16)
  5. Final Observations
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## 2. Technical Requirements

### 2.1 Specifications

- Minimum anticipated cased and bond zone lengths provided per pile.
  - Minimum load requirements provided per pile.
  - GBR bond values to be verified by 4 preproduction Verification piles, and directed thereafter by the Engineer.
  - Contractor to design and conduct load tests and collect all load/movement data.
  - Proof testing of production piles: one per each of the 16 bents to 1.2 DL.
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## 2.1.1 Verification Load Tests: Summary

- 4 vertical piles in different ground conditions.
  - Test cyclically to 2.0 DL.
  - Conduct creep tests.
  - No acceptance criteria, i.e., no pass-fail.
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## Actual Verification Pile Dimensions and Ground Conditions

	VP1	VP2	VP3	VP4
Ground Surface Elevation (m)	302.0	302.0	301.0	303.0
Actual Top of Rock Elevation (m)	293.0	292.6	296.0	297.0
Actual Bottom of Casing Elevation (m)	292.0	292.6	289.5	290.0
Actual Pile Tip Elevation (m)	288.0	288.2	286.4	287.0
Butt Elevation* (m)	302.3	302.3	301.3	303.3
Summary Rock Classification	Relatively sound limestone	PregROUTED shales and clay	Relatively poor quality limestone	Shale
Grout Volume	0.80 m <sup>3</sup>	0.45 m <sup>3</sup>	0.49 m <sup>3</sup>	0.49 m <sup>3</sup>

\* Elevation of plate (below beam and jack) on which movements were measured during testing.

- Note: 1) Bond zones were each 152 mm in diameter.  
2) Each bond zone contained one coupler on the bar.

## Details of Verification Pile Testing

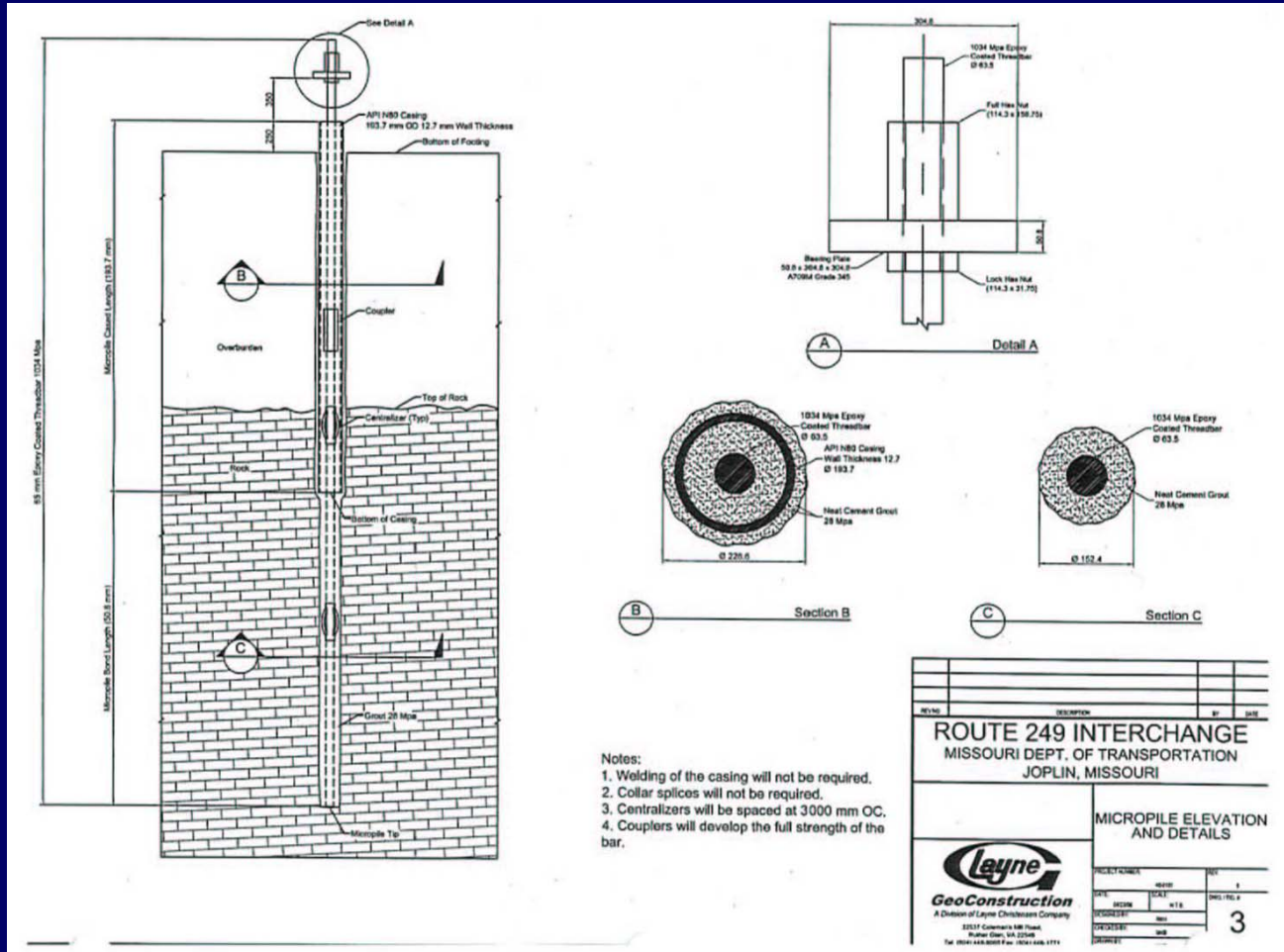
PILE	6149B1			6165B1
	VP1	VP2	VP3	VP4
Max Load (kN)	2,210 kN	2,210 kN	2,210 kN	2,088 kN
Elastic Movement at Max Load	32.5 mm	34.92 mm	35.30 mm	N/A
Permanent Movement after Max Load	2.82 mm	12.90 mm	2.600 mm	N/A
Creep 1-10 Minutes	0.248 mm	2.248 mm	0.057 mm	N/A
Creep 6-60 Minutes	0.387 mm	3.247 mm	Not Available	N/A
Comment on Load-Movement Diagram	Very linear, repeatable, no failure	Debonding to 1,105 kN, linear above, very close to failure at TL	Very linear, repeatable, no failure	Linear to 1,934 kN, but abrupt failure at 2,088
At Test Load				
Calculated Debonding	-0.5 m	3.3 m	-1.3 m	N/A
Average Rock/Grout Bond	1.16 MPa (Test Bond)	1.15 MPa (Failure Bond)	1.54 MPa (Test Bond)	1.46 MPa (Failure Bond)
Comparable Working Bond of Production Piles	0.26 to 0.38 MPa	0.26 to 0.38 MPa	0.45 to 0.58 MPa	0.18 to 0.33 MPa

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## 2.1.2 Proof Tests

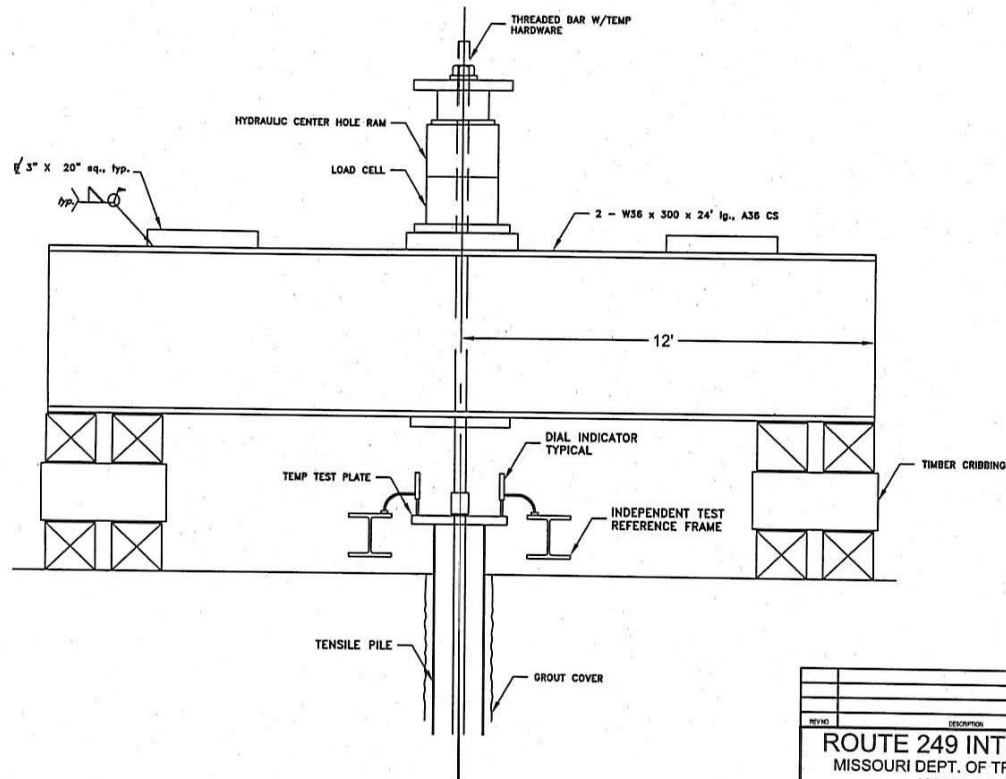
- Total of 220 production piles (vertical and inclined).
  - 16 Proof Tests – locations at each bent to be selected in the field by the Engineer.
  - Simple incremental tensile loading to 1.2 DL, with 60-minute creep test (Modified ASTM D3689 Quick Test).
  - Acceptance criteria:
    1. No failure at TL.
    2. Debonding at TL  $\leq$  50% bond length.
    3. Creep rate  $\leq$  1 mm per log cycle (1-10 mins.) or  $\leq$  2mm per log cycle (6-60 mins.).
  - If failure occurs, test another pile in the same bent, and consider modifications, down rating, replacement, etc.
  - Each test paid for on lump-sum basis.
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# 2.2 Contractor's Conforming Submittal





# Tension Test Setup



REV#	DESCRIPTION	BY	DATE
<b>ROUTE 249 INTERCHANGE</b>			
MISSOURI DEPT. OF TRANSPORTATION			
JOPLIN, MISSOURI			
 <b>GeoConstruction</b> <small>A Division of Layne Construction Company</small> 22517 Colman's Mill Road Butler Ohio, VA 25518 Tel. (801) 448-8000 Fax: (801) 448-1771		VERIFICATION / PROOF TEST ASSEMBLY	
		PROJECT NUMBER: _____ DRAWING SCALE: _____ DATE: _____ DESIGNED BY: _____ CHECKED BY: _____ DRAWN BY: _____	REV. _____ PROJ. / FIG. # _____ 1

# Load Testing in Progress



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## 4. Results of the Proof Tests

- Every micropile reached the test loads (986-2,269 kN).
  - At TL debonded lengths were exceptionally small and in only one case did it extend beyond the cased length.
  - Permanent movements at TL ranged from 0.34 to 6.45 mm (typically  $< 3$  mm).
  - All load-movement curves were very linear.
  - Every pile comfortably satisfied the creep criteria.
  - Paper contains full details (Table 7).
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# 5. Final Observations

- The “chaotic” ground had the potential to:
  - render design very challenging;
  - cause difficulties and dangers during construction;
  - cause performance problems during service.
- An intensive site investigation, relying also on historical data, permitted a bent-specific GBR to be prepared.
- The GBR drove the concept and details of pretreatment by grouting as an exploratory tool as well as a ground remediation/preparation in advance of micropiling or spread footing construction.



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## 5. Final Observations (continued)

- The Verification Piles allowed the preliminary design of bond lengths to be confirmed/modified.
  - During construction, no exceptional problems were encountered, and the pretreatment was monitored and directed in real time.
  - All Proof Tests were successful and no remedial piles were required.
  - The field program was implemented within an acceptable schedule and with only minor changes/ overruns.
  - The keys to success were technical risk management at every phase of the project, and efficient collaboration between a team of specialists of different but complimentary skills and experiences.
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