REVIEW OF FHWA MICROPILE IMPLEMENTATION MANUAL

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Seattle, Washington

Handout
for
FHWA
"Micropile Design and Construction Guidelines"
Implementation Manual

prepared by
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Portland, Oregon

1

FHWA Micropile Manual PTP Project

- Title: FHWA **"Micropile Design and Construction Guidelines"** Implementation Manual.
- Objective: Facilitate implementation and use of micropiles on USDOT projects. Will be "Practitioner - Oriented." Includes two worked design examples- heavy emphasis on construction QA/QC, inspection & testing - example plans & guide construction specifications (for both Owner-Design & Design-Build projects).

2

Micropile Definition & Description

- A micropile is a small diameter-typically less than 300 mm (12 inch)-drilled and grouted pile that is reinforced with reinforcing bar and/or thick wall structural casing. Common size 175 mm (7 inch) o.d. Also known as minipiles, pin piles, needle piles or root piles.

3

Micropile Definition & Description (cont'd)

- Installed with small compact high-powered drill rigs that cause minimal disturbance to ground, existing structures and environment and minimal vibrations or noise.
- Can be installed in any type of ground, including difficult ground with cobbles, boulders or obstructions.
- Manual Impetus from FLH (Fed Lands Hwy Divs) -NPS/Forest Hwy/ Scenic Byway Projs

4

Historical Background

- First developed in Italy in 1950s by Dr. Fernando Lizzi of Fondedile, Inc. Now available from several U.S. Foundation Specialty Contractors.
- Can achieve Design Loads of 50 kN to 2500+ kN (5 to 250+ tons). Higher capacities achieved by pressure grouting bond zone.

5

Micropile Applications

- Main transportation applications include:
- Structural Support
  - Foundations for New Structures
  - Underpinning of Existing Foundations
  - Seismic Retrofitting of Existing Foundations
- Insitu Reinforcement
  - Slope Stabilization
  - Earth retention

6 **U.S. Micropile Cost Data**

- Cost Range: $165-$500 per lineal meter ($50-$150 per lineal foot) installed.
- Although typically more costly than conventional piling on per unit length basis, can offer viable cost effective "total cost" alternative to conventional piling - particularly for restricted access, low headroom, difficult ground or environmentally sensitive sites. Provide one more tool in fdtn engr "toolbag".

7 **Funding Coop Partners**

- 5 Specialty Contractors and 1 Materials Supplier
- Donald B. Murphy Contractors Inc. (DBM)
- Hayward - Baker Inc. (HBI)
- Kulchin - Condon & Assocs. Inc. (KCA)
- Malcolm Drilling Inc. (MDI)
- Nicholson Construction Co. (NCC)
- Dywidag-Systems Intl. (DSI)
- FLH & FHWA Region 10

8 **Coop Funding Summary**

- Total $120,000 (Manual)
  $ 25,000 (CD-ROM)

Funding Split

- CONTRACTORS $49,000 (Industry)
- FHWA FLH $44,000 (PTP-OTA)
- FHWA Region 10 $52,000 (PTP-OTA)

9 **Contracting and Schedule**

- Manual Preparation Contracted via Coop Agreement (WFLHD-Al Kilian COTR)
- Manual Preparation By: DBM Contractors Inc., Federal Way, WA
- Interactive CD-ROM Preparation By:
  Prof. Sunil Sharma, Univ. of Idaho
- TWG Members: CONTRACTORS/FHWA CALTRANS/ODOT/WSDOT (17 Folks)
- Schedule: Manual Available Fall 1997
  CD-ROM Available Spring 1998

10 ☐ **CD-ROM Version of Manual**

FEATURES

- Will be INTERACTIVE (Hypertext Links)
- Full Table of Contents
- 10 Chapters-Individual Table of Contents
- Figures/Photos/Tables/References
- Design Equations & Design Examples

11 ☐ **CREDITS**

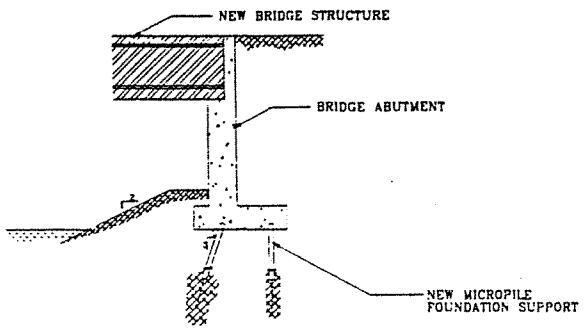
- Thank You Industry Funding Contributors
- Thank You FHWA Office of Technology Applications- for PTP Funds
- Thank You all TWG Members
- **Special Thanks to Tom Armour & Paul Groneck of DBM - who did the "Heavy Lifting" on manual preparation!**
- Any Questions??

U.S. Department of Transportation

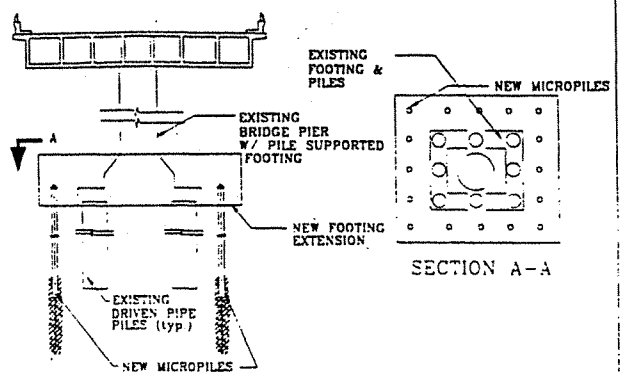
Federal Highway Administration

Priority Technologies Program

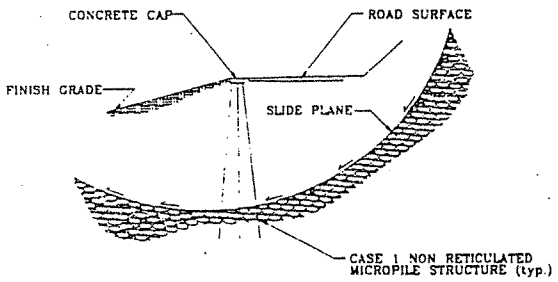
MICROPILE DESIGN AND CONSTRUCTION GUIDELINES



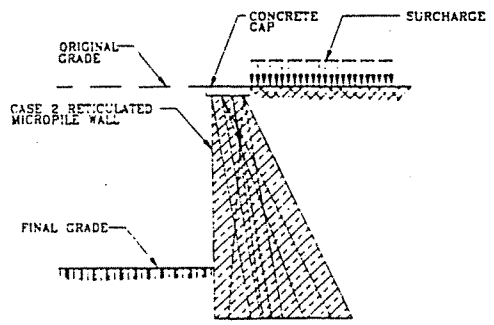
FOUNDATION SUPPORT



SEISMIC RETROFIT OF BRIDGES



SLOPE STABILIZATION



EARTH RETENTION

IMPLEMENTATION MANUAL

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15. Supplementary Notes

FHWA COTR: Alan P. Kilian, P.E. Western Federal Lands Highway Division, Vancouver, WA

16. Abstract

The use of micropiles has grown significantly since their conception in the 1950s, and in particular since the mid-1980s. Micropiles have been used mainly as elements for foundation support to resist static and seismic loading conditions and as in-situ reinforcements for slope and excavation stability. Many of these applications are suitable for transportation structures.

Implementation of micropile technology on U.S. transportation projects has been hindered by lack of practical design and construction guidelines. In response to this need, the FHWA sponsored the development of this Micropile Design and Construction Guidelines Implementation Manual. Funding and development of the manual has been a cooperative effort between FHWA, several U.S. micropile specialty contractors, and several State DOT's. This manual is intended as a "practitioner-oriented" document containing sufficient information on micropile design, construction specifications, inspection and testing procedures, cost data, and contracting methods to facilitate and speed the implementation and cost effective use of micropiles on United States transportation projects.

Chapter 1 provides a general definition and historic framework of micropiles. Chapter 2 describes the newly developed classifications of micropile type and application. Chapter 3 illustrates the use of micropiles for transportation applications. Chapter 4 discusses construction techniques and materials. Chapters 5 and 6 detail design methodologies for structural foundation support and slope stabilization, respectively. Chapter 7 describes micropile load testing. Chapter 8 reviews construction inspection and quality control procedures. Chapter 9 discusses contracting methods for micropile applications. Chapter 10 presents feasibility and cost data. Appendix A presents sample plans and specifications for both Owner Controlled Design and for Contractor Design-Build type contracts.

17. Key Words	18. Distribution Statement
micropile, structure foundation, slope stabilization, underpinning, seismic retrofiting, specifications, load testing, insitu reinforcement	No restrictions. This document is available to the public from the National Technical Information Service, Springfield, Virginia 22161.

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Unclassified	Unclassified	317	

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PREFACE

The long-term performance of micropiles has been proven after 25+ years of use in Europe and North America. The purpose of this "practitioner-oriented" manual is to facilitate the implementation of micropile technology into American transportation design and construction practice and to provide guidance for selecting, designing and specifying micropiles for those applications to which it is technically suited and economically attractive. A comprehensive review of current design and construction methods has been made and results complied into a guideline procedure. The intent of presenting the guideline procedure is to help ensure that agencies adopting use of micropile technology follow a safe, rational procedure from site investigation through construction.

Chapter 1 provides a general definition and historic framework of micropiles. Chapter 2 describes the newly developed classifications of micropile type and application. Chapter 3 illustrates the use of micropiles for transportation applications. Chapter 4 discusses construction techniques and materials. Chapters 5 and 6 detail design methodologies for structural foundation support and slope stabilization, respectively, including worked design examples. Chapter 7 describes pile load testing. Chapter 8 reviews construction inspection and quality control procedures. Chapter 9 discusses contracting methods for micropile applications. Chapter 10 presents feasibility and cost data. Appendix A presents guideline plans and specifications for Owner Controlled Design and Contractor Design-Build type contracts.

MANUAL LIMITATIONS

ACKNOWLEDGMENTS

The preparation of this manual has been funded through a cooperative effort between FHWA and several U.S. micropile specialty contractors and manufacturers, including:

FHWA Region 10 and Federal Lands Division Offices (using Priority Technology Program Funds provided by the FHWA Office of Technology Applications.)

DBM Contractors, Inc.
Dywidag Systems International, Inc.
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Kulchin-Condon and Associates, Inc.
Malcolm Drilling Company, Inc.
Nicholson Construction Company
Schnabel Foundation Company

Special thanks are due particularly to Mr. Al Kilian-FHWA, Western Federal Lands Division and Mr. Ron Chassie-FHWA, Region 10, for providing the constant assistance, encouragement and funding support that made this manual possible.

Special acknowledgment is made to the following volunteer Technical Working Group members for significant contributions to the manual and for providing the QA/QC to help assure that the design and construction guidelines and guide specifications presented in the manual are sound, rational, and practitioner oriented:

Tom Armour	DBM Contractors, Inc.	(Lead Coordinator)
Paul Groneck	DBM Contractors, Inc.	
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ENGLISH TO METRIC (SI) CONVERSION FACTORS

The primary metric (SI) units used in civil and structural engineering are:

- meter (m)
- kilogram (kg)
- second (s)
- newton (N)
- pascal (Pa = N/m^2)

The following are the conversion factors for units presented in this manual:

Quantity	From English Units	To Metric (SI) Units	Multiply by	For Aid to Quick Mental Calculations
Mass	lb	kg	0.453592	1 lb(mass) = 0.5kg
Force	lb kip	N kN	4.44822 4.44822	1 lb(force) = 4.5N I kip(force) = 4.5kN
Force/unit length	plf klf	N/m kN/m	14.5939 14.5939	1 plf = 14.5N/m 1 klf = 14.5kN/m
Pressure, stress, modulus of elasticity	psf ksf psi ksi	Pa kPa kPa MPa	47.8803 47.8803 6.89476 6.89476	1 psf = 48 Pa 1 ksf = 48 kPa 1 psi = 6.9 kPa 1 ksi = 6.9 MPa
Length	inch foot	mm m mm	25.4 0.3048 304.8	1 in = 25 mm 1 ft = 0.3 m 1 ft = 300 mm
Area	square inch square foot square yard	mm^2 m^2 m^2	645.16 0.09290304 0.83612736	1 sq in = 650 mm^2 1 sq ft = 0.09 m^2 1 sq yd = 0.84 m^2
Volume	cubic inch cubic foot cubic yard	mm^3 m^3 m^3	16386.064 0.0283168 0.764555	1 cu in = 16,400 mm^3 1 cu ft = 0.03 m^3 1 cu yd = 0.76 m^3

A few points to remember:

1. In a **"soft"** conversion, an English measurement is mathematically converted to its **exact** metric equivalent.
2. In a **"hard"** conversion, a new **rounded**, metric number is created that is convenient to work with and remember.
3. Use only the meter and millimeter for length (avoid centimeter).
4. The pascal (Pa) is the unit for pressure and stress (Pa and N/m).
5. Structural calculations should be shown in MPa or kPa.
6. A few basic comparisons worth remembering to help visualize metric dimensions are:
   - One mm is about 1/25 inch or slightly less than the thickness of a dime.
   - One m is the length of a yardstick plus about 3 inches.
   - One inch is just a fraction (1/64 inch) longer than 25 mm (1 inch = 25.4 mm).
   - Four inches are about 1/16 inch longer than 100 mm (4 inches = 101.6 mm).
   - One foot is about 3/16 inch longer than 300 mm (12 inches = 304.8 mm).

MICROPILE DESIGN AND CONSTRUCTION GUIDELINES
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Chapter 5 -- Design Methodology-Micropiles for Structure Foundations (CASE 1 Piles)