

# The History of Micropiles in North America



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**ABSC**  
April 3-4, 2008  
Las Vegas, NV

1. Background
  - Definitions
  - Characteristics
  - Basic Construction Steps
  - Applications and Constraints
  - Classification Systems
2. History of Use in N. America
3. History of Research in N. America
4. Trends in U.S. Practice
5. Evolution and Role of ISM

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# 1. BACKGROUND DEFINITIONS

Two basic types of piles:

- Displacement piles: driven or vibrated into the ground thereby displacing the soil laterally during installation.
- Replacement piles: placed within a previously drilled borehole thus replacing the excavated ground.



A large number of historical/national/proprietary names have been used for micropiles including:

- pali radice
- micropali
- mini piles
- pin piles
- root piles
- needle piles

This highlights the need for international standardization i.e., "micropile" as adopted by FHWA/IWM (1993).



## Definition of a High Capacity Drilled and Grouted Micropile

A small diameter (less than 300mm) replacement, drilled pile, composed of placed or injected grout, and having some form of steel reinforcement to resist a high proportion (or all) of the design load.

Other types exist in specific market regions, e.g., jacked, driven, vibrated, screwed.

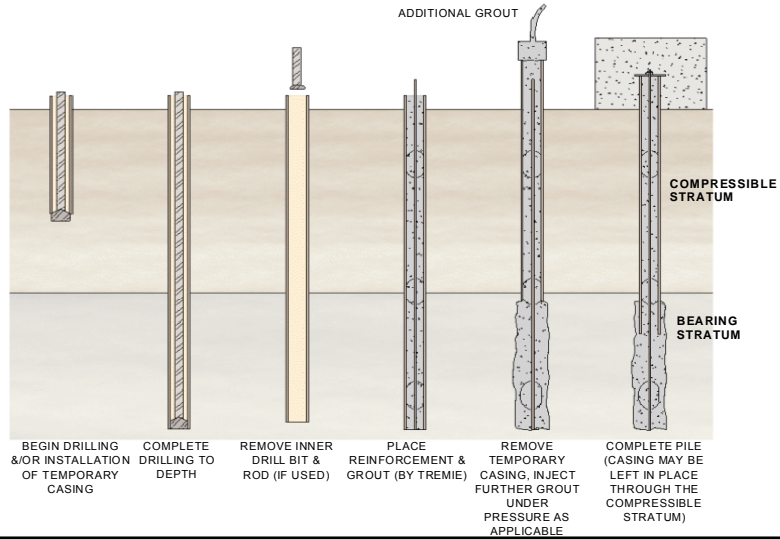


## Typical Grouted Micropile Characteristics

- Over 4500 kN (500 tons) in rock
- 180 to 1800 kN (20 to 200 tons) in soil
- Structural capacity usually governs design
- Micropile lengths are usually less than 30 m (100 ft)
- Relatively stiff in axial loading (both senses)



## Basic Construction Steps



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## Noroton River Railroad Bridge, Stamford, CT

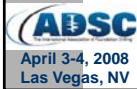


1. Sacrificial Test Pile

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### Production Pile Installation: 50 tons DWL (26 ea.)



### 3. Cap Beam Formwork



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#### 4. Cap Beam Concreted



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#### 5. Liner Placed and Backgrouted

## Applications:

### 1. Geotechnical Applicability

In addition to “normal” soils and rock masses, micropiles can be installed in:

- Karstic limestone
- Mined rock
- Glacial tills with boulders
- Soils with high water table
- Variable urban fills
- Existing foundations or obstructions

Contractors can use anchor/grouting equipment



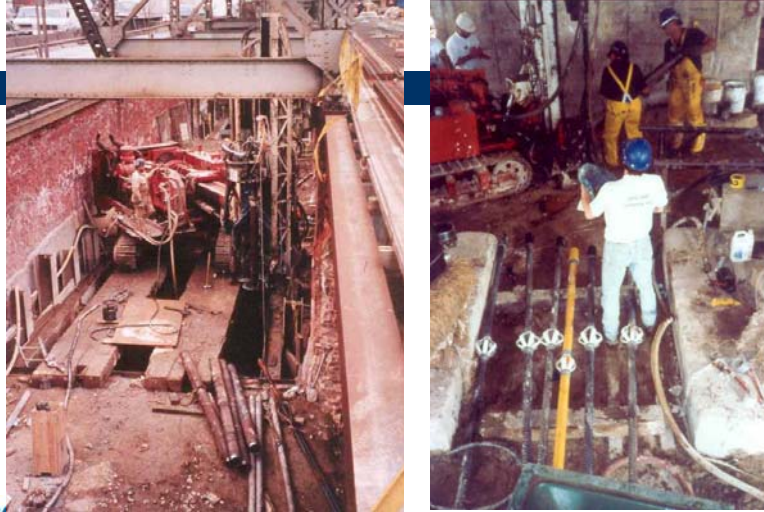
### 2. Physical Constraints

Micropiles can be installed in sites with:

- Limited overhead
- Vibration concerns
- Settlement or disturbance concerns
- Limited access
- Existing structures in close proximity
- Other simultaneous activities
- Environmental challenges (noise, dust, contamination)



## Typical Micropile Working Conditions



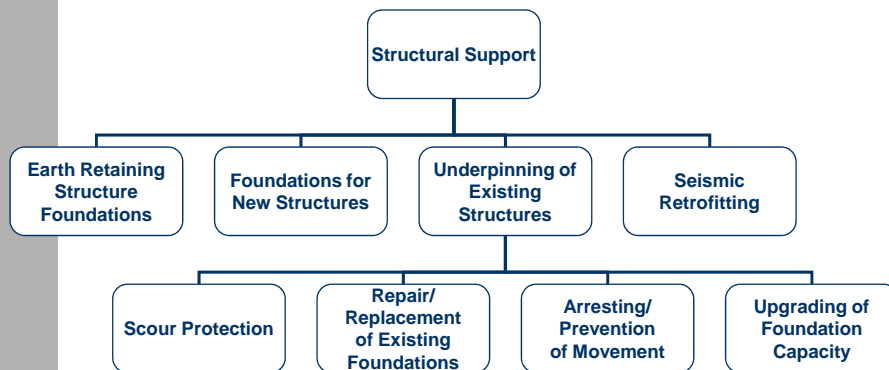
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## Limitations of Micropiles

- Lateral capacity limitations for vertical micropiles
- Because of high slenderness ratio (length/diameter), may not be appropriate for seismic retrofit (vertical micropiles)
- High lineal cost relative to “conventional” piling systems – but consider “cost/tonne”
- Limited experience in their use for slope stabilization

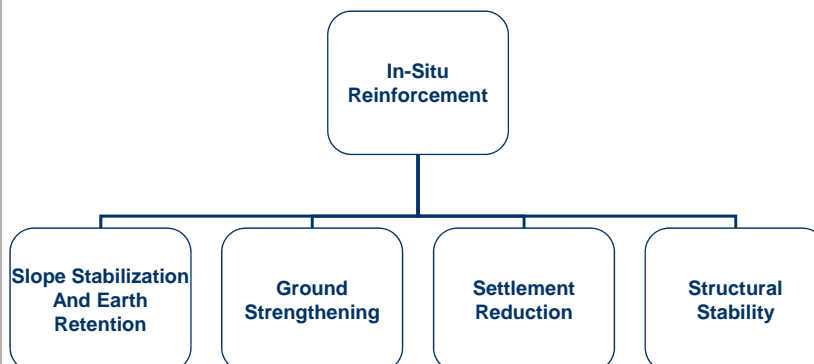
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## Classification of Applications: Structural Support



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## Classification of Applications: In-Situ Reinforcement Applications



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## Micropile Classification System

### 1) Based on Design Concept

- designated by Case 1 or Case 2

### 2) Based on Grouting

- method of grout placement defines the grout/ground bond capacity
- designated by a letter A through E

to form a 2-part designator, e.g., Type 1A or Type 2B



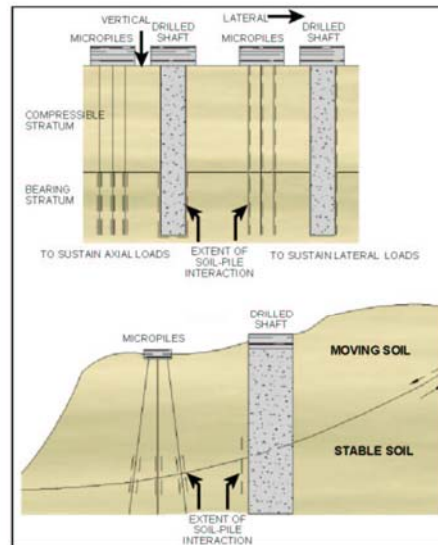
## Micropile Classification System Based on Design Concept

### Case 1

- Micropiles are loaded directly (either axially or laterally)
- Reinforcement resists the majority of the applied load and transfers load to the soil via grout-ground bond
- Piles can be installed individually or in groups
- Virtually all N. American micropiles have been Case 1



## CASE 1 Micropile Arrangements



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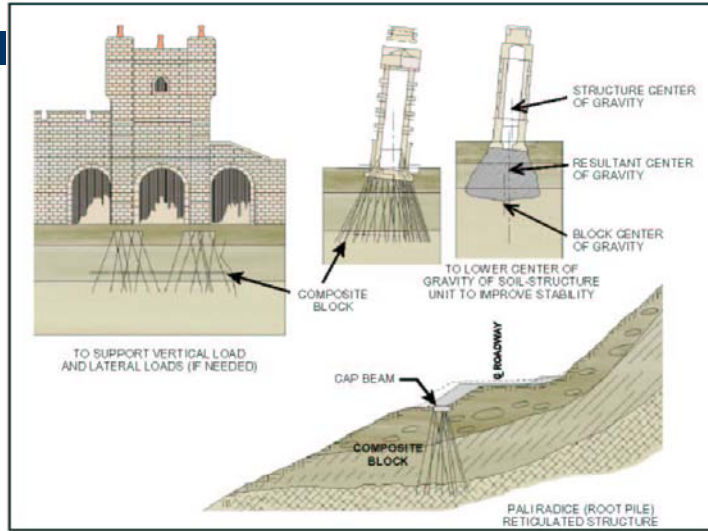
## Micropile Classification System Based on Design Concept

### Case 2

- Networks of micropiles circumscribe and internally reinforce a soil mass to make a reinforced soil composite
- Load is resisted by the soil mass internally strengthened by lightly reinforced elements
- Very few N. American examples (demonstrations): more popular in W. Europe

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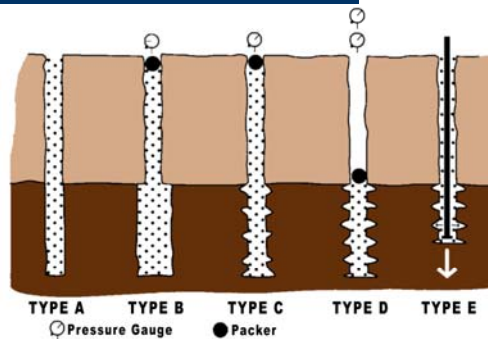
## CASE 2 Micropile Arrangements



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## Classification Based on Grouting Method

- **Type A:** Gravity
- **Type B:** Pressure grouting through casing
- **Type C:** Single, global post grout
- **Type D:** Multiple, repeatable post grout



**ABSC** Type E: Injection  
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## Principle of Tube à Manchette Method Postgrouting (i.e., Type D)

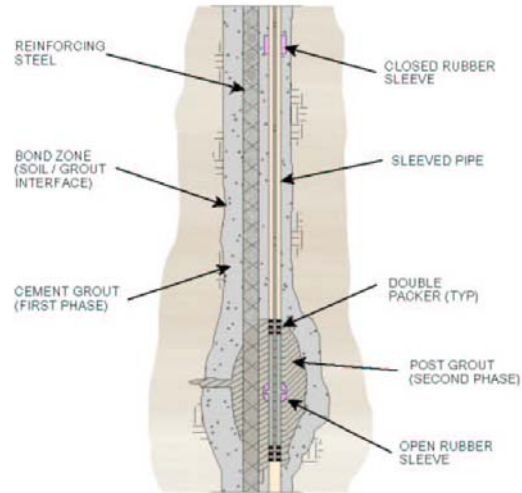


Figure 4-13

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## Summary of Typical Applicabilities

Pile Type	Concept	Usage
1A	Low capacity in soil. Very high capacity in rock	Very common in clays and rock
1B	High capacity in coarser soils	Very common
1C	High-medium capacity in soil	Common only in France
1D	High capacity in finer soils	Becoming more common
2A	Low capacity in soil	Relatively rare
2B	-	Never used
2C	-	Never used
2D	-	Never used

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## 2. HISTORY OF USE IN N. AMERICA

### 2.1 “Broad Brush”

- 1952: Micropiles (Root Piles) patented by Fondedile in Italy.
- 1970: Fondedile Corp established in the U.S. (Bares, 2007).
- 1972: First use of Root Piles in U.S. (April 1972: Illinois).
- 1973: First use of Root Piles in Canada (Montreal).
- 1977: First use of Root Piles for Slope Stabilization (Mendocino, CA).
- Late 1970's: First use by anchor/drilling contractors (NCC; Dywidag).
- 1980-1990: Decline and closure of Fondedile in U.S.



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- Early 1980's: Big “push” by East Coast Contractors, especially Boston, DC and New York City.
- 1984: First “type A” wall for slope stability (PA).
- 1989: Loma Prieta and start of micropile market for seismic retrofit in West Coast.
- Mid-1990's: “Split” of original NCC team, to stimulate growth in West Coast (DBM, NWC) and East/South (SPS, Layne, Moretrench, HBI, et al.).
- Late 1990's: Other specialty contractors become very active (e.g., Malcolm, CJA, et al.).



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- 1996-1998: Williamsburg Bridge, NYC (Huge Bridge Retrofit).
- 1998: Mandalay Bay Project, Las Vegas (Active Settlement Control).
- 1999: U.S. Marines Project – Baltimore (“Self Drilling” bars).
- 2000-2003: Richmond-San Rafael Project, CA (Very High Capacity Seismic Over Water).
- 2005: IBM, NY (Huge, High Capacity in Karst).
- Mid-2000’s: “Micropiles” (Wolosick, 2006).
- Mid-2000’s: Joplin, MO (High Capacity, in Pretreated Mined Area).



## 2.2 Illustrations

### Original Micropile (Palo Radice) (1952 onwards)

(< 15 tons DWL)



## Use of High Yield Bars (1970s onwards)

(30-60 tons DWL)



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## High Capacity Micropiles (1980s onwards)

(100-750 tons DWL)



Courtesy: Hayward Baker



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## “Injection Bore” Micropiles (“Self Drilling”) (late 1990s onwards)

(15-100 tons DWL)



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## Stabilization of Mandalay Bay Hotel Las Vegas, Nevada



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## W. Coast: Post Loma Prieta



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## Seismic Retrofit of Richmond/ San Rafael Bridge, CA



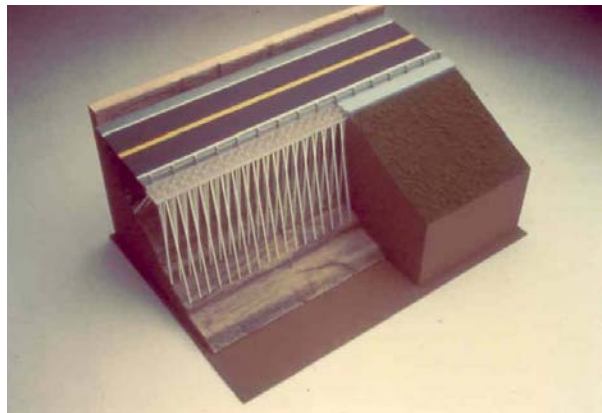
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## Joplin Co., Missouri



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## Concept of Case 1 Micropile Wall for Slope Stabilization



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## Slope Stabilization, FH-7, Mendocino National Forest, California (Case 2 Design)

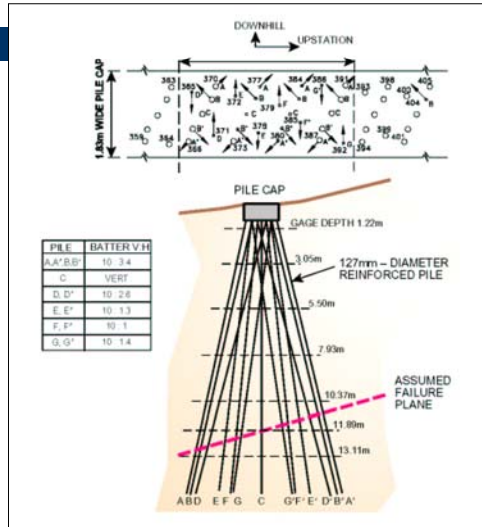


Figure 3-14  
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## Injection Bore Case 2 Micropiles for US Marine Corps Field Test Program, Baltimore, Maryland



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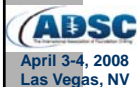
### 3. HIGH CAPACITY MICROPILES IN THE U.S. - RESEARCH SUMMARY

- Mid 1980s\* Systematic field testing by specialty contractors – still continuing
- 1992 First "FHWA-DOT-Industry" collaborative field test  
San Francisco, CA
- 1993 – 1997 FHWA State of Practice Report (4 Volumes)
- 1994 – 2000 "FOREVER" Project (France)
- 1996 – 1999 FHWA Implementation Manual (Chapter 6 – 2002)
- 1996 – 2001 DFI Specifications
- 1997\* Seismic Research at Brooklyn
- 1997\* IWM Founded
- 1997 JAMP (Japan) Founded
- 1998 – 2001\* U.S. Marine Corps Trials
- 2001 New Research at WSU, CSU, Cambridge University
- 2001\* ADSC Involvement (IWM, FHWA, etc.) via funding for research and organization of seminars, support for ISM
- 2001\* States Pooled Fund Project Commences
- 2002\* ADSC Develops Teaching Course for FHWA/NHI
- 2002\* ADSC IAF and Micropile Committee
- 2005 ISM is formed
- 2005 ADSC's GeoCubed Conference



### 4. TRENDS IN U.S. PRACTICE

- FHWA 1997 State of Practice generally used (including classification) together with Implementation Manual (1999-2000)
- Market growing perhaps over \$200 million per year
- Major applications
  - Urban development and redevelopment
  - Construction on karst
  - Existing industrial facilities
  - Seismic retrofit (Richmond – San Rafael Bridge)
  - "Emergency" applications (Las Vegas, Dulles)
  - Slope stabilization (Case I)



## 4. TRENDS IN U.S. PRACTICE

(continued)

- Construction Trends
  - Growing use of Double Head Duplex and self-drilling bars (e.g., Ischebeck)
  - Colloidal multi-component grouts / Type D piles
  - More rigorous testing methods to higher loads (ASTM and PTI)
  - Strong input by equipment and materials suppliers



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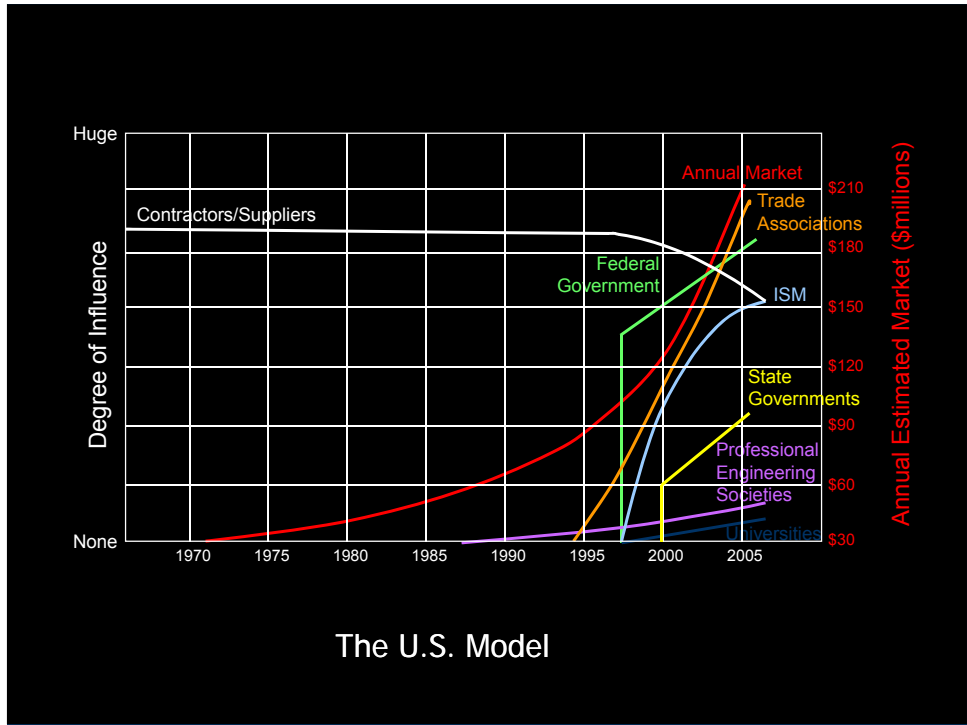
## 4. TRENDS IN U.S. PRACTICE

(continued)

- Specifications and Procurement
  - Increasing use of “turnkey” solutions involving teams of contractors/engineers
  - “Best value” as opposed to “Low Bid”
  - Much more “education” of consultants and clients (especially DOTs) by specialists, operating as companies, or under NH/ADSC umbrellas



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## 5. ISM/ADSC INITIATIVE

- **History of ISM Growth**

**Vision**

ISM will be respected internationally as the preeminent center of knowledge for the development, advancement, and promotion of micropile technology.

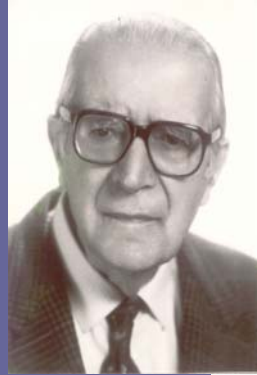
**Mission**

A permanent, proactive ISM organization will act as the international forum for coordinating and promoting all phases and aspects of micropile technology. It will act in the best interests of the technology and the potential users, will be easily accessed and will be strictly non-partisan. It will collect and disseminate knowledge via meetings, reports, and databases, and act as a forum for promoting relevant research.



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Dedicated to the Vision of Fernando Lizzi



Dr. Fernando Lizzi  
(1914-2003)

The Godfather of Micropiles

IWM 2002  
International Workshop on Micropiles  
Venice, Italy  
30 May - June 1



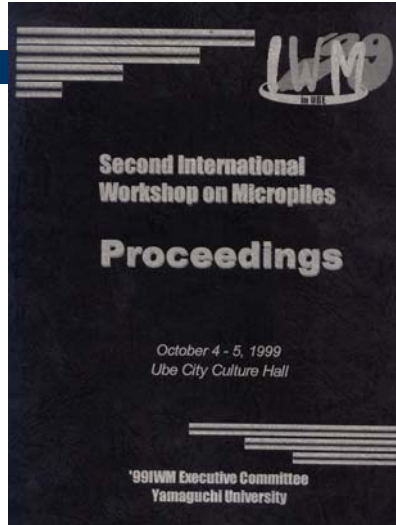
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## 1st IWM 1997 – SEATTLE, WA



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**2nd IWM  
1999 – UBE, JAPAN**



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**3rd IWM  
2000 – TURKU, FINLAND**



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**4th IWM  
2002 – VENICE, ITALY**



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**5th IWM  
2003 – SEATTLE, WASHINGTON**



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**6th IWM  
2004 – TOKYO, JAPAN**



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**7th IWM  
2006 – SCHROBENHAUSEN, GERMANY**



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**8th IWM  
2007 – TORONTO, CANADA**



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**9th IWM  
2009 – LONDON, U.K.**



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## PRIME GOALS OF ISM

- Organize regular workshop meetings (every 18 months on average).
- Establish micropile databases of case histories, publications, and testing data for use by designers, contractors, and educators worldwide.
- Act as a facilitator/disseminator of micropile information generated worldwide – provide (with support from ADSC) Teaching Courses to U.K. and South Africa.



Establish Micropile Load Test Database.

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## BENEFITS OF INDIVIDUAL AND CORPORATE MEMBERSHIPS

- Networking
- Education ▪ Workshops
- International Exposure
- Posting of Corporate Logo on ISM Website and Website Linking
- Access to Technical Resources
- Membership Directory
- Annual Practice Updates
- Access to Micropile Literature Database
- Access to Micropile Load Test Database



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[www.ismicropiles.org](http://www.ismicropiles.org)

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Questions?

