



Micropiles: World Wide Evolution

10th Lizzi Lecture

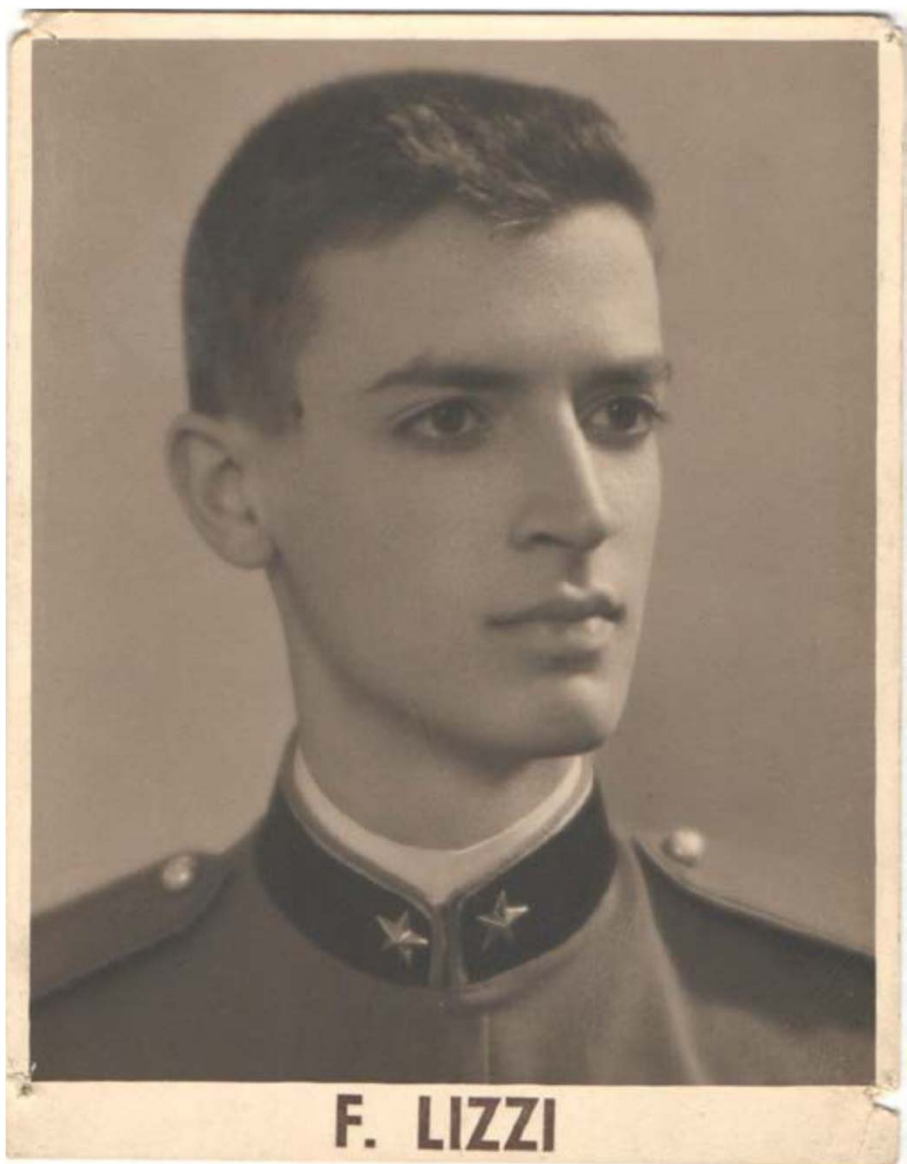
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August 23, 2019



Schnabel
ENGINEERING

Build Better. Together.





January 2, 1914 – August 28, 2003



In the field of foundation piling direct experience precedes design

in some instances we designed “Reticulated Root Piles” structure with positive exuberance

Fioravante Bares, 2007



Seattle 1997



IWM 2000 Turku, attendees in front of the Old City Hall



IWM 2002 Venice, delegates in Palazzo Pesario Papafava



IWM 2006 Schrobenhausen

Companion's tour to Nymphenburg Castle in Munich



Outline

- Reflections
- Evolution
- Current Conditions
- Closing



- 1st International Workshop on Micropiles, Seattle, WA 1997
- 2nd International Workshop on Micropiles, Ube, Japan 1999
- 3rd International Workshop on Micropiles, Turku, Finland 2000
- 4th International Workshop on Micropiles, Venice, Italy 2002
- 5th International Workshop on Micropiles, Seattle, WA 2003
- 6th International Workshop on Micropiles, Tokyo, Japan 2004
- 7th ISM Workshop, Schrobenhausen, Germany 2006
- 8th ISM Workshop, Toronto, ON, Canada 2007
- 9th ISM Workshop, London, England, UK 2009
- 10th ISM Workshop, Washington, DC 2010
- 11th ISM Workshop, Milan, Italy 2012
- 12th ISM Workshop, Kraków, Poland 2014
- 13th ISM Workshop, Vancouver, Canada 2017
- 14th ISM Workshop, Gold Coast, Australia, 2019





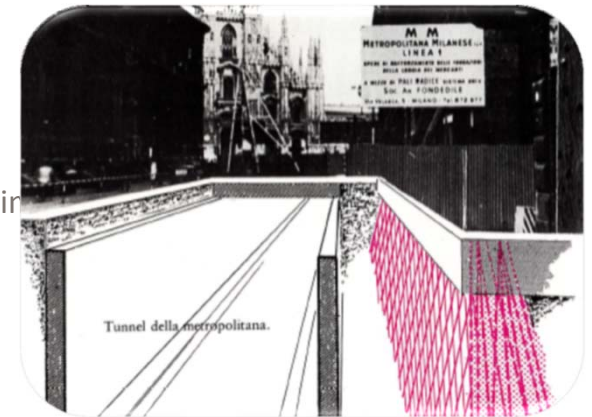
Lizzi Lecture

- Dr. James Mason's, "Lizzi's Philosophy. Concepts to Practice"
- Prof. François Schlosser, "Practice and Research on Micropile Groups and Networks"
- Mr. Jiro Fukui, "Performance of Seismic Retrofits with High Capacity Micropiles"
- Dr. Thomas Herbst, "Historical Review and Analysis of 55 Years of Micropiles"
- Dr. Donald A. Bruce, "Micropiles in Middle Age: Triumphs, Failures and Challenges"
- Dipl.-Ing Ernst F. Ischebeck, "Design of Direct Drilled and Continuous Flush Grouted Micropiles TITAN as Regulated in EU by National German Approval Z-34.14 – 209"
- Paul Woodfield, Lizzi Lecture
- Nadir Ansari, MEng, P.Eng., "Lizzi Lecture: Micropile Life Cycle - Experiences in Mature Markets and Expectations for New Markets"
- John Wolosick, P.E., D.GE, "Loading Effects on Battered Micropiles: Are Most Pile Caps Designed Correctly?"



The Early Years

- 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, Longoeuil subway station).
- 1973: First tangent micropile anchored retaining wall and WMATA project underpinning in the US (Glen Burnie, MD)
- 1977: First use of Root Piles for Slope Stabilization, Forest Highway 7 (Mendocino, CA).
- Late 1970s: Protective patents run out and first use by anchor/drilling contractors (Nicholson, Dywidag).
- 1979: The last reticulated micropile wall constructed in U.S. by Fondedile (Monessen, PA)
- 1980-1990: Decline and closure of Fondedile in U.S.
- Early 1980s: Big “push” by east coast contractors
- 1980: Linn Cove Viaduct, Blue Ridge Pkwy, [Siel, 2006]
- 1984: First “Type A” wall for slope stability (Armstrong, Pennsylvania)
- 1985: CP Rail Viaduct at Roger’s Pass, BC [Lie & Kast, 2007]
- 1989: Loma Prieta and start of micropile market for seismic retrofit on the West Coast.
- Mid-1990s: “Split” of original Nicholson team, stimulates growth on West Coast (DBM, NWC) and East/South (Hayward Baker, SPS, Layne, Moretrench, et al.).





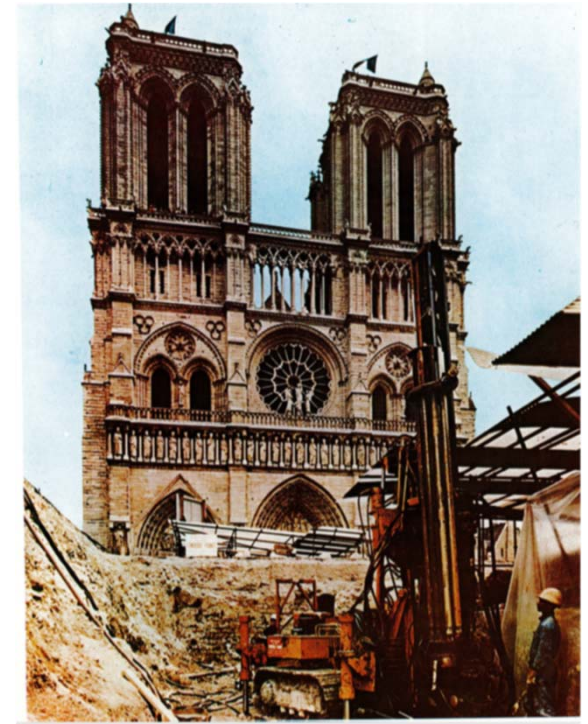
“Modern” evolution

Late 1990s: Expansion of the technology

- Williamsburg Bridge, NYC (1996-1998)
- Engle Machine, York, PA; I78 over Delaware River
- Mandalay Bay, Las Vegas (1998) [Vanderpool, 2002]
- Exton Square Mall, Exton, PA (1999)

New Millenium

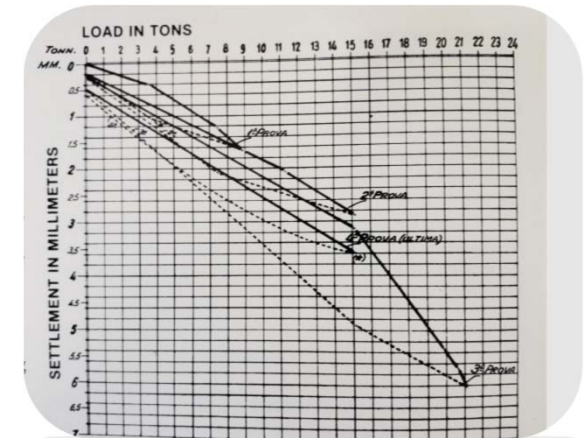
- U.S. Marines Research Project – Baltimore, MD (1999) [Bruce & Weinstein, 2002]
- Spallation Neutron Source, Oak Ridge, TN (2001)
- Richmond-San Rafael Project, CA (2000-2003) [Hadzariga, 2002]
- “Macropiles” (Long Island, Queens, NY, Mid 2005) [Wolosick, 2006]
- Big Qualicum Bridge, BC (2006) [Li & Kast, 2007]
- NJ Turnpike Hollow Bar Micropiles [Gomez, 2007]
- Underpin 1000 yr old tree [Aschenbroich, 2010]
- Sunrise Power Link – First World Cup winner [Salisbury & Davidow, 2014]





Changes - Capacity

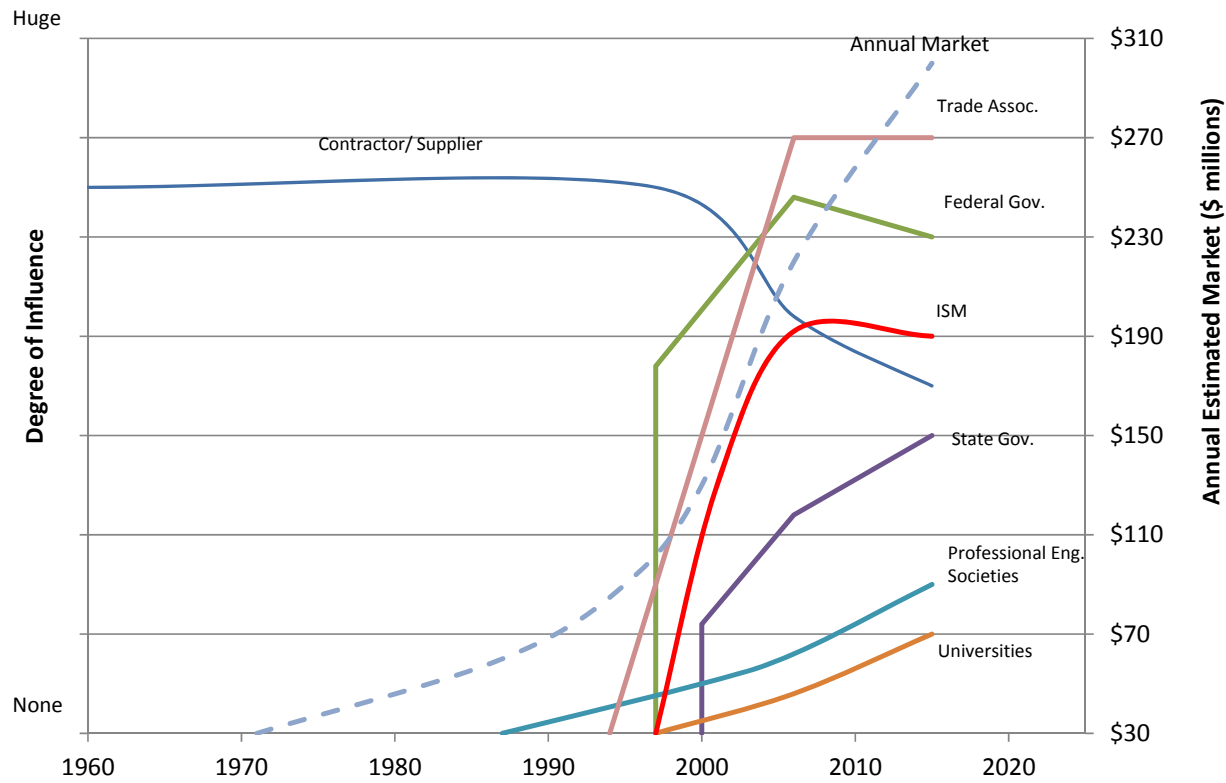
- Early Days - 20-30 tons was typical
- Economic factors and experience allowed a rapid increase to 50-100 tons
- Aggressive engineering and competition pushed the envelope to over 1000 tons.



In the field of foundation piling direct experience precedes design

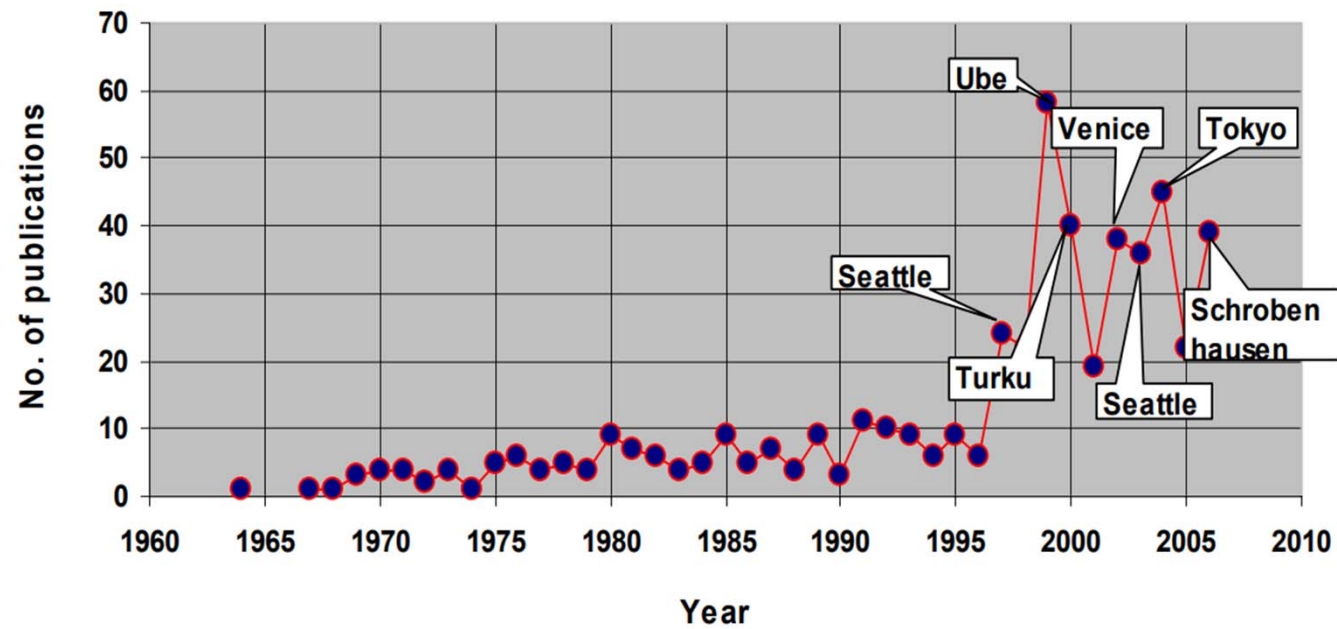


Education - Knowledge Transfer





Micropile publications per year

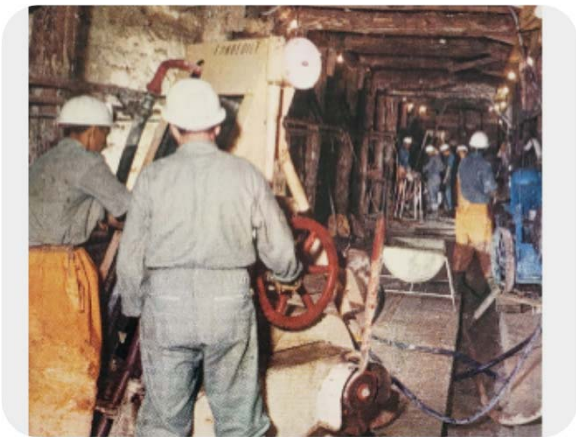


- Herbst 2nd Lizzi Lecture



Market Evolutions

- Equipment
- Materials
- Tooling





Informal Industry Survey

- Expand on Bruce 2006 and my study of North America in 2007
- 26 responses



Drivers: Where and Why Did it Begin





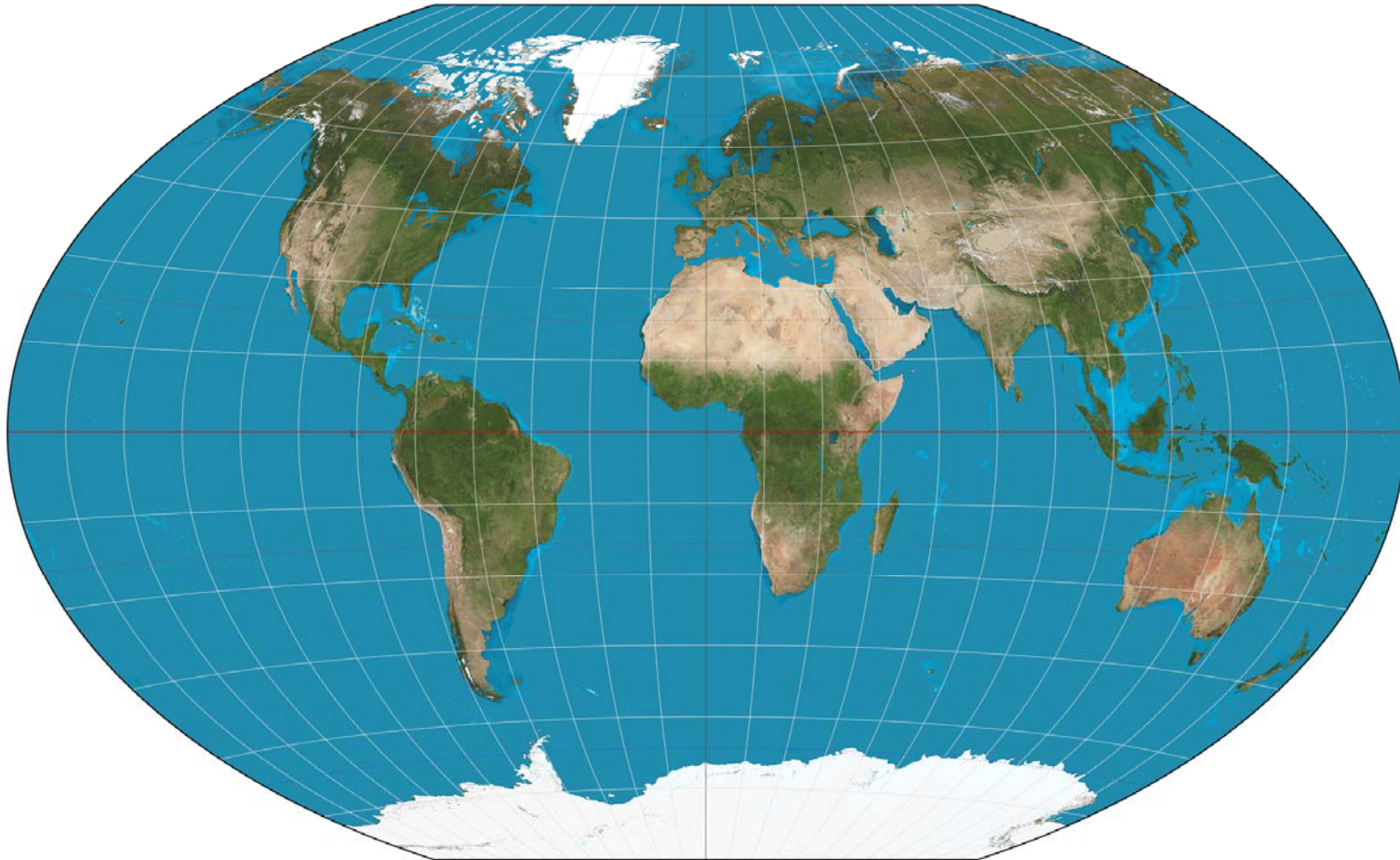
Driving Factors

- Seismic
- Karst
- Transmission/Power
- Excavation Support
- Uplift
- Slope Reinforcement
- Emergency response
- Economics & Schedule





Prevalent Type of Micropile





Design Code Impact

- Trust and Experience
- Industry Guidance Document (DFI, FHWA, JAMP, FOREVER)
- New Millenium
 - Eurocode EN1997 and EN14199
 - International Building Code, IBC
 - AASHTO Design and Construction sections
- Local Annex documents
- Industry Specific - Power





The People - a small sampling

UK:	Mike Turner
Germany:	Wolfgang Brunner
Poland:	Bolek Klosinski – retired IBDiM (Poland Research Institute of Roads and Bridges)
Finland:	Prof. J. Hartikainen, Mr. J. Lehtonen, and Mr. R. Heikinheimo
Norway:	Bo Berglars, Håkan Bredenberg, Göran Camitz, Ulf Bergdahl, Tor-Gunnar Vinka – Gunnar Holmberg
Sweden:	Gary Axelsson, Arne Schram Simonsen
Venezuela:	Antonio Martin – Franki South America
Chile:	Pilotes Terratest S.A.
United States:	Nicholson Construction – everyone seems to have had ties to them in the early days – (Peter Nicholson, Seth Perlman, Spark Johnson, Butch Tripplet) and FHWA Advisory Panel; Jesús Gómez
Canada:	GeoFoundations – Jim Bruce, Isherwood – Nadir Ansari, and Geopacific Consultants Ltd. – Matt Kokan
Australia:	Our host, Allan Herse, and Robert Bollman , PCA Construction
China:	Feng Qin developed the micropile and anchor equipment for the Chinese market
Korea:	Changho Choi, Bansuk Foundations Co., ExtPile Co., and the Korea Institute of Construction Technology
Ischebeck Corp.:	A driver in education and research





2007 Trends

- The typical size of projects will remain constant (~\$100k to \$1M)
- There has been a slight slowing of growth rate in past couple years
- Power Industry and Transportation could result in an increase of Mega Projects
- Equipment and Manpower will be constraints
- Innovative solution growth – Hollow Bars, Sonic
- Increase in smaller contractors to market





Market Sizes

- Europe: responses were country or pile type specific, I would suspect the market across Europe exceeds \$50 to \$100 Million US.
- Northern Europe: likely matches or exceeds this value potentially totaling \$100 to 150M US.
- South American market is believed to be small – less than \$5M US – Seismic need is growing
- Central American countries could approach \$5 to 10M US.
- United States: The predictions varied significantly, \$100 to \$300M US with a higher estimate of about \$750M US when consideration is given to some very large emergency or infrastructure projects.
- Canada: seems to have about \$25M in each major urban area, so an estimate of about \$75 to \$100M would be reasonable for urban areas, with additional revenue being generated again from major power transmission markets.
- Asia – Australia is currently estimated at about \$20M US; China has a huge potential, but is currently believed to be at about \$20M with a growth rate of 20%; South Korea is likely at about \$1M US



Closing

- Advancements are slowing
- Prescriptive codes are limiting opportunity - Performance based guidance needed
- Continued education is needed - relearn the same old lessons
- Knowledge transfer to emerging markets
- Continued research:
 - seismic retrofit-connection, lateral performance, strain compatibility, group behavior, benefit of reticulation
 - Reliability of bond zones in various geologies
 - Quality Control – Monitoring While Drilling



ISM 14TH INTERNATIONAL WORKSHOP FOR MICROPILES



Schnabel
ENGINEERING

Build Better. Together.

Georgia	South Carolina
Maryland	Tennessee
New Jersey	Texas
New York	Virginia
North Carolina	Washington
Pennsylvania	Washington, DC

