THE EVOLUTION *OF MICRO PILES IN AMERICA*

PETER J NICHOLSON
Nicholson Consulting

DAVID E PINYOT
Pinyot Consulting

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EARLY YEARS FOR LOAD CARRYING MICRO PRE 1980

- In U.S. Nicholson/Fondedile typically 100-180 mm Diameter 180 kN, unreinforced, rotary drilled
- Project size typically $50-100,000; Annual market $1-2 million
- Installation rates 50-100 feet(15-30M) p
- Design loads in soils of 20 tons (180 kN)

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Brookgreen Gardens SC

CYPRESS BIRD SANCTUARY

The new Aviary at Brookgreen Gardens is nearing completion. This major project, started over two years ago, will offer the visitor an opportunity to stroll through a cypress swamp forest and observe the birds and plants indigenous to this interesting habitat. This exhibit is the second of a series to be finished: the first being the White-tailed Deer Savannah which was opened last spring.

The site for this new wildlife exhibit was selected carefully after taking into consideration its proximity to other areas of the Gardens and natural features required for the habitat. Detailed photographs and measurements of the swamp forest, including data on the trees as well as surface conditions, were made so the location and size of the structure could be adapted to the site.

Drilling foundations

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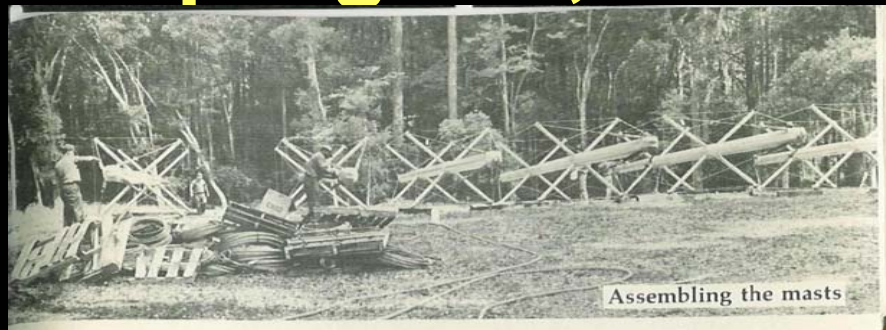
Brookgreen Garden SC From the Award program, Micro Piles in Swamp



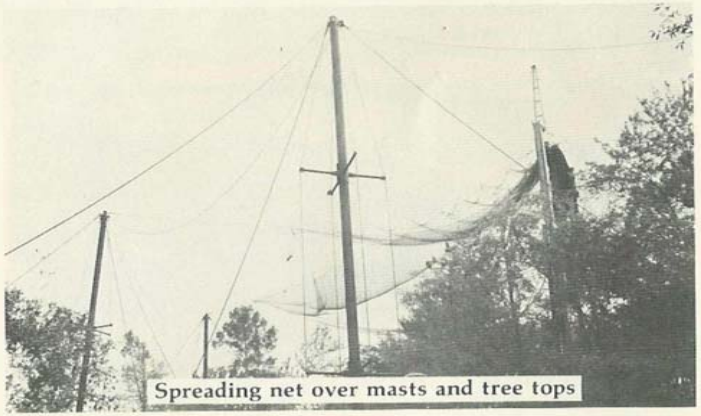
Assembling the masts

The area selected included a second growth forest composed of bald cypress, red maple, swamp black gum along with scattered specimens of Carolina ash. Judging from the condition of this forest it is apparent that it grew after the previous forest was cut over about 80 years ago. The age of the trees removed prior to construction was determined by annual ring count to be about 75 years old. Just outside of the selected area, several large old cypress trees are present. These limby individuals were left because they were probably considered culls when the previous forest was cut over. Trees within the Aviary site measure from samplings, to those with diameters up to 24 inches and 90 feet in height.

In order to stretch the netting over the tree tops, it was necessary to reduce the height of some of the dominant trees to accomodate future growth and provide space for the birds to fly around. The swamp tree species within the Aviary all respond to pruning by sprout growth. Several loblolly pine within the selected area and others adjacent to it were removed as they had a relatively short life expectancy and will not sprout after pruning. A small open pond was dug in the area where

The realization of the concept presented a challenge to the engineers, fabricators and erectors of the Aviary. The prime consideration in the design, construction and erection procedures of the exhibit was to create the aviary over the existing forest with a minimum of site disturbance. The fact that this was accomplished in such difficult terrain makes this project truly unique.

In the construction of the foundations and the erection of the masts, it was necessary to move the drill rig and cranes, each weighing up to 30 tons, across the deep swamp mud. This was accomplished by placing beds of corduroy across the soft ground. The nine mast foundations, eight main anchors and eight catenary tie-downs were

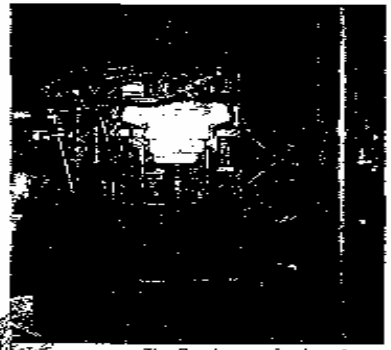


Spreading net over masts and tree tops

constructed of piles made by boring casings 70 feet into the ground and pumping cement grout into them under high pressure forcing it out of the bottom of the casings and into the ground strata forming elongated, inverted mushroom-shaped anchors. Steel tendons, embedded in the grout, formed the attachments for the anchors and pile caps. The 90 foot center mast and the eight 70 foot outer masts were fabricated from aluminum tubes, 12 inches in diameter, with cable outriggers to provide rigidity. Netting to enclose the birds within the cable-tensioned octagonal structure, 180 feet across and 90 feet high, is two inch dacron safety net, treated for ultraviolet ray and fire resistance. The lower portion of the netting was made from

Brookgreen Garden Micro Piles for compression and tension in Swamp

Note from this copy of the brochure how
The micro piles were utilized in the canopy
Poles foundations



Pin Piles—Small diameter, high-capacity pin piles have been developed for use in confined areas or where vibration associated with conventional systems would be unacceptable. This method, which involves installation of drilled-in-place, pressure-grouted piles, can be employed at less than half the cost of conventional hand-dug pits or jacked piles.

Since they can be installed through or close to existing structures, pin piles can be utilized as underpinning or to provide additional support to existing structures. Using versatile, custom-fabricated equipment, Nicholson teams can construct pin piles at any angle, from nearly horizontal to vertical. Moreover, pin piles afford additional flexibility in that they can be drilled as close as 8 inches to existing structures, and installed in areas with headroom as low as 6 feet. In actual field applications, tested capacities as high as 110 tons have been achieved on 5.5 inch diameter piles.

Pokomoke River tension compression sleeves ready for Micro Piles

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Pokomoke River Bridge Collapsed timber piles replaced by Micro Piles

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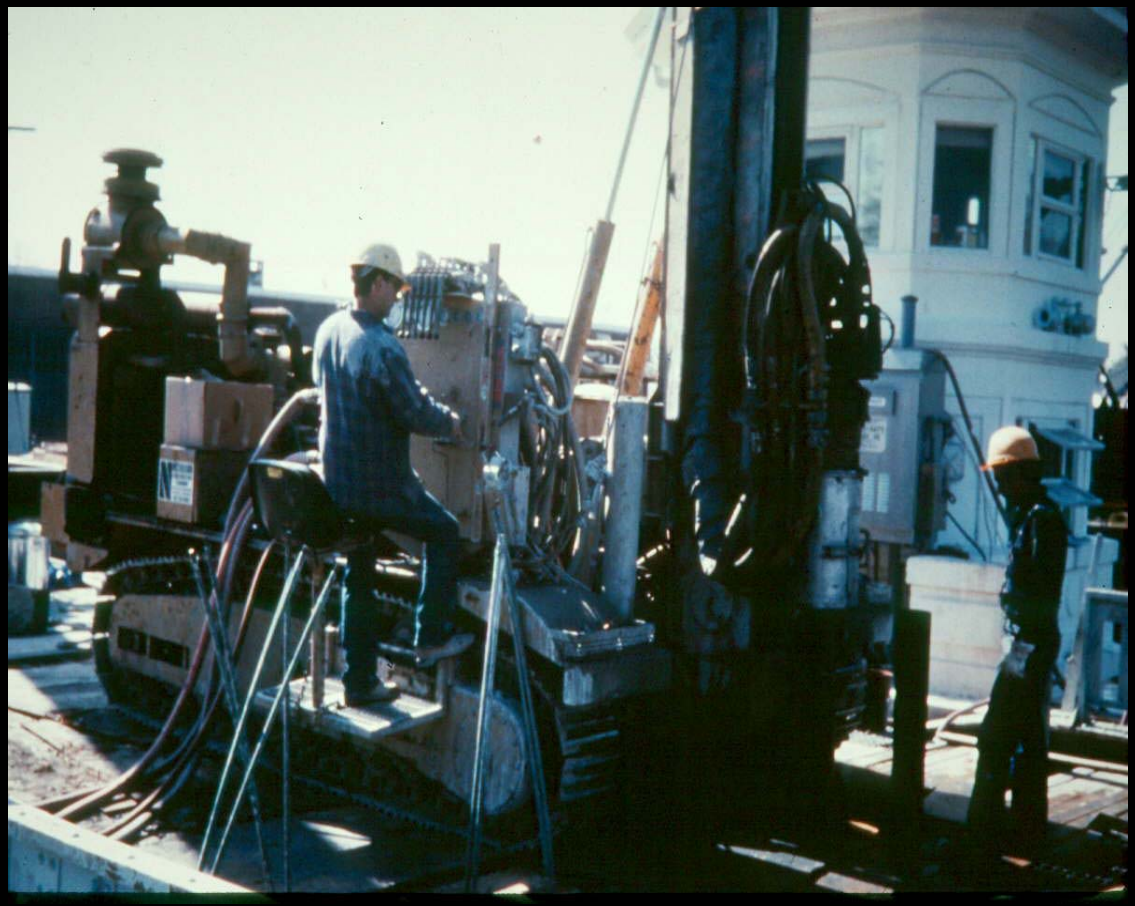
Pokomoke River Bascule Bridge
Tension and compression Micro Piles



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Orange County New York Prison
Micro Piles 1980

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Orange County New York Prison

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Alcoa Bauxite Reduction Plant
Mobile Alabama 1982

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EVOLUTION OF RETICULATED

- Lizzi; Italy, Slope stability and light loads for rehabilitation of structures
- Reticulated (interlaced to force composite action) for slope stability
- Demonstration of group action more than sum of parts for both slopes and compressive loads
- Other practitioners in Europe begin slope work under Lizzi patents
- In U.S. Nicholson and Fondedile construct reticulated and non-reticulated structures
- Expiration of Lizzi patent Fondedile ceases U.S. work in 1980's
- Soil nailing and VERT at Texas A&M demonstrate composite action

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Mendocino County California Reticulated MicroPile Wall

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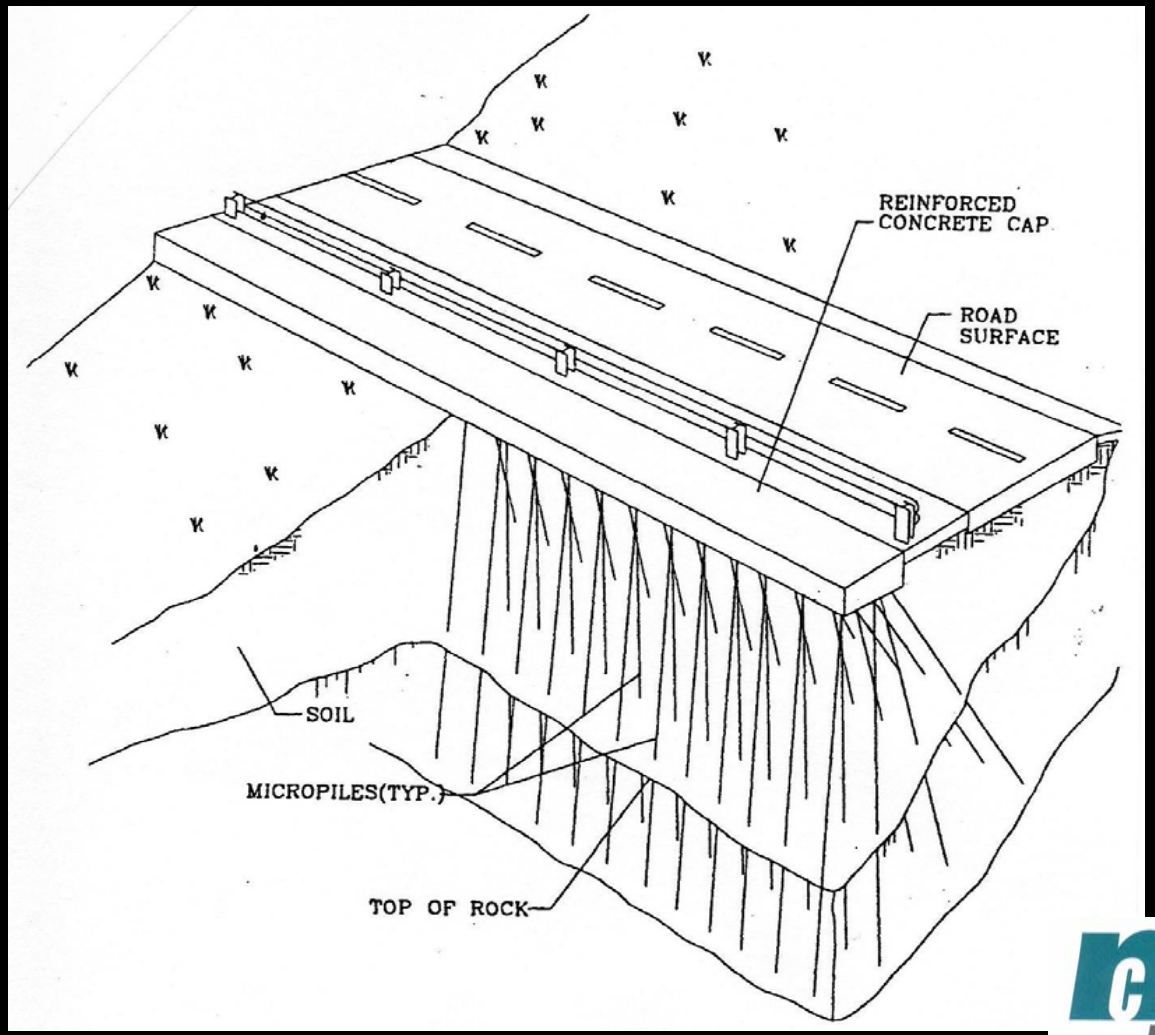
Non-Reticulated Micropile Structure



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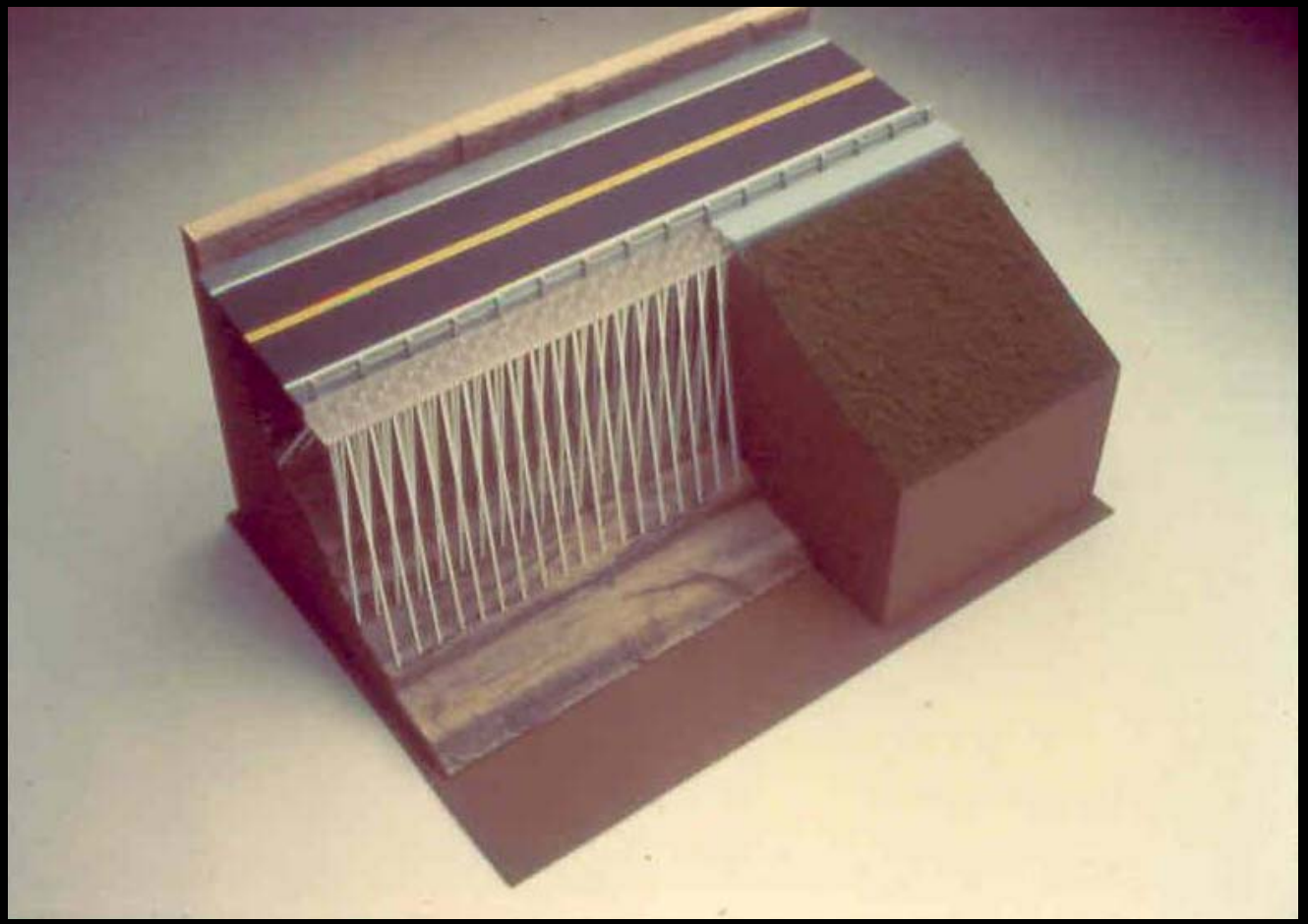
LR 69 Type A Wall Non Reticulated



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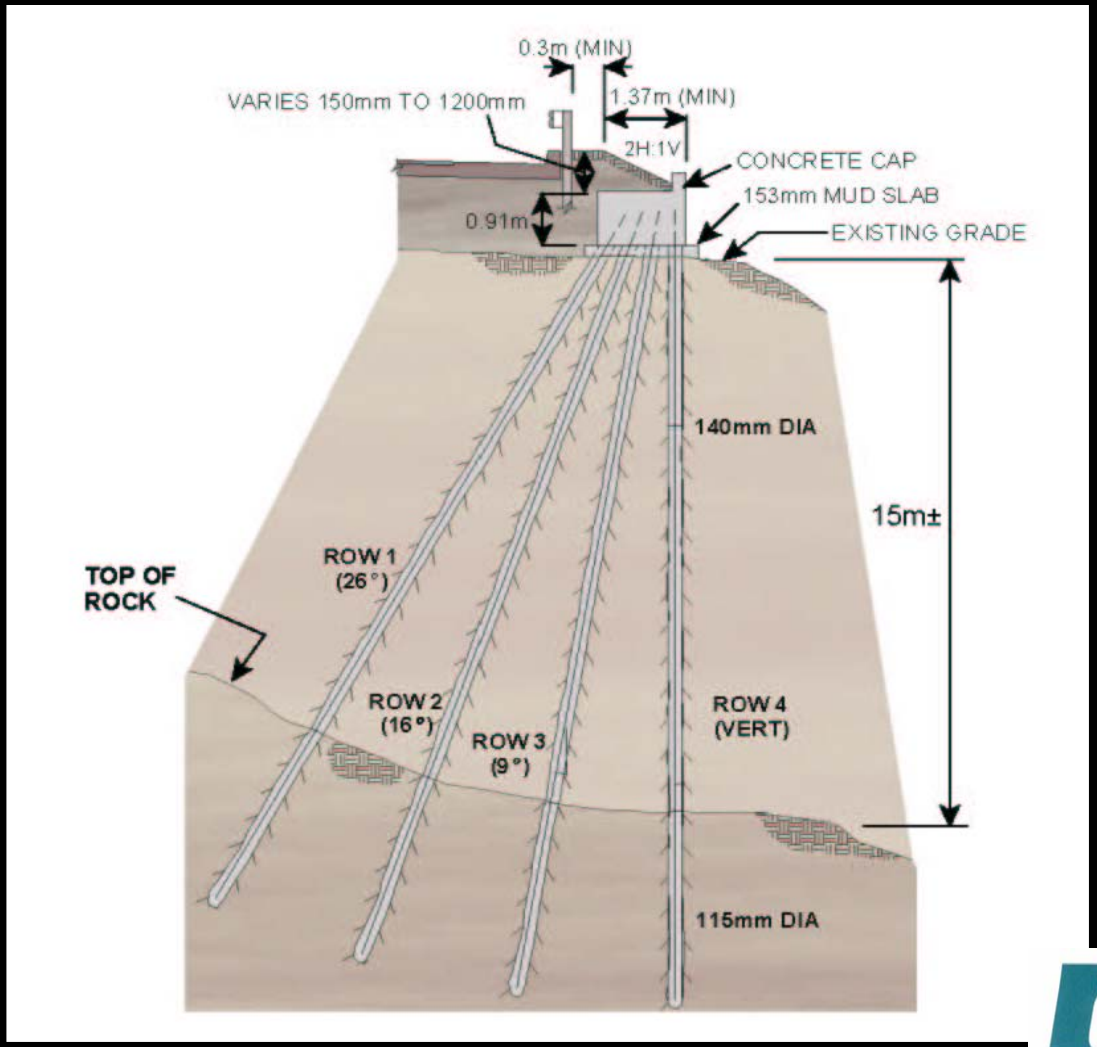
LR 69 Pennsylvania
Micro Piles for landslide control



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LR 69 Construction Concrete cap over micro piles on Shoulder of roadway

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Vertical Earth Reinforcing Technique NGES Texas A&M 1998

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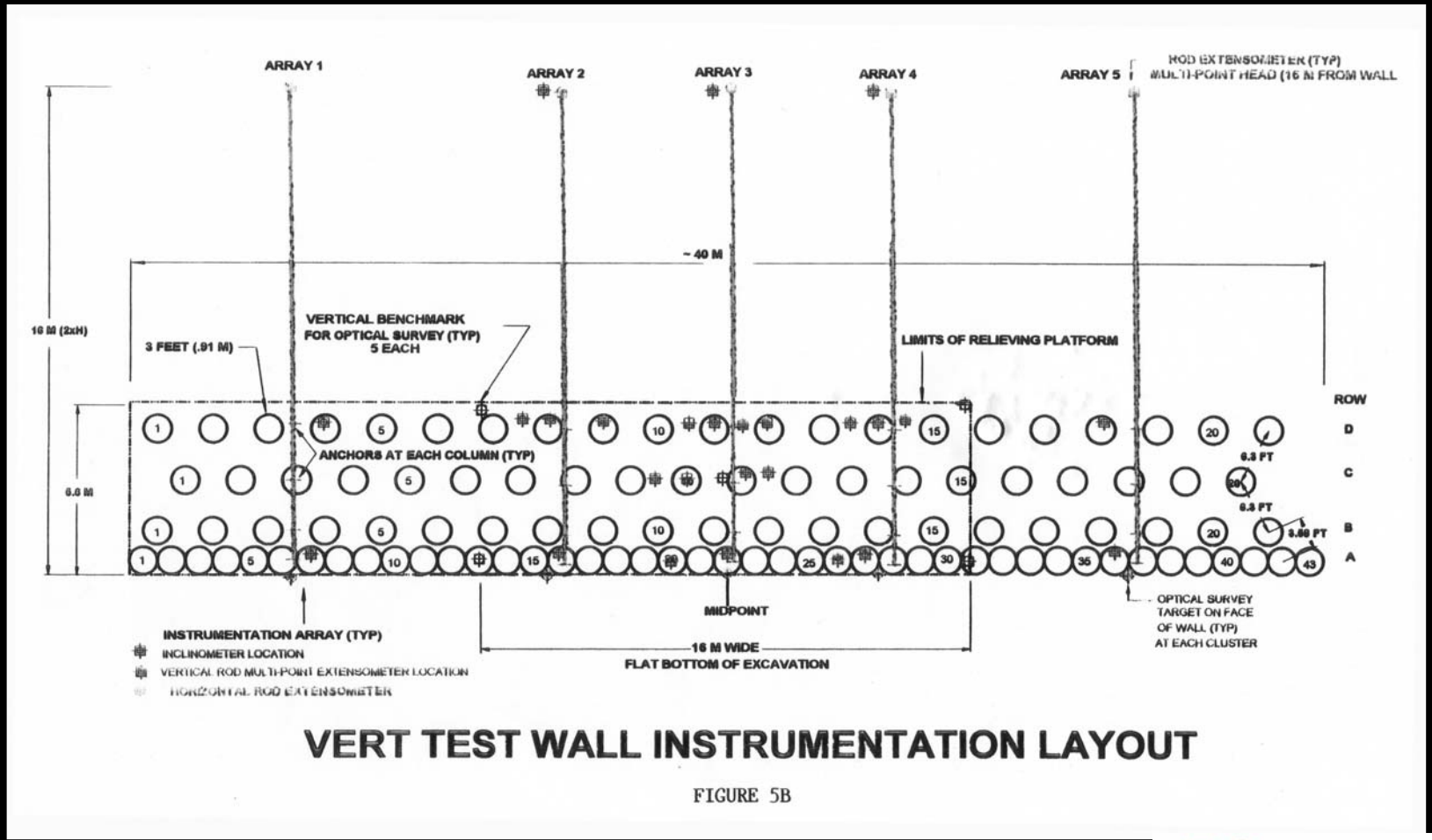
Plan View VERT Wall



VERT TEST WALL INSTRUMENTATION LAYOUT

FIGURE 5B

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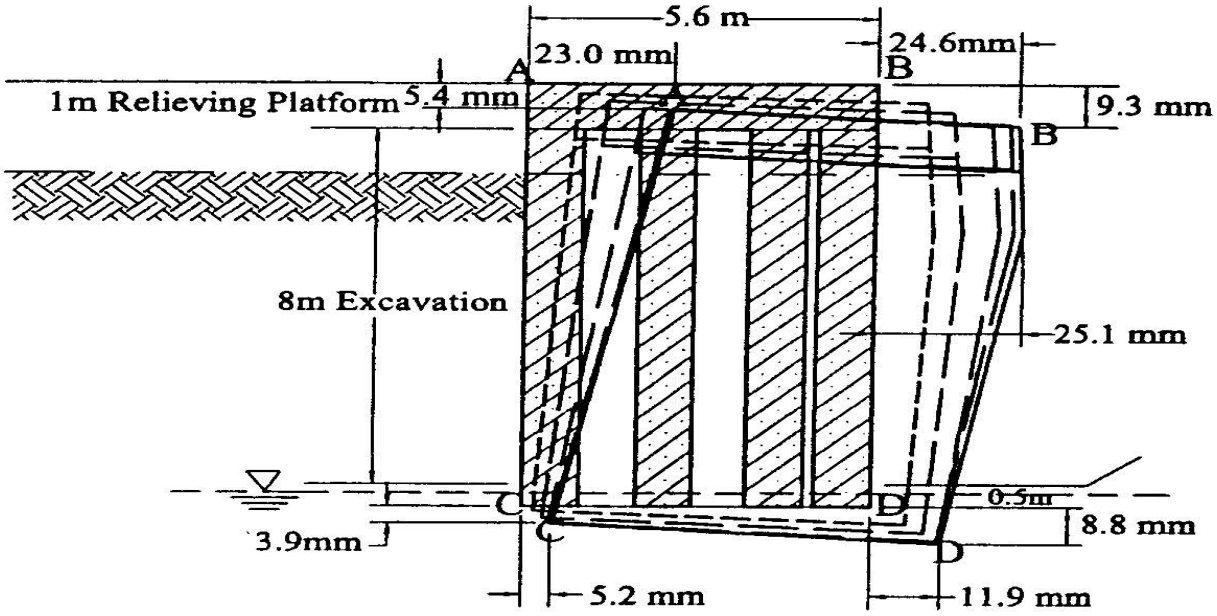
VERT Global Movement Demonstrates Composite Action



[SCALE] Displacement : Wall Size = 1:1000

LEGEND	
- - -	After 7m Excavation (5/17/98)
— —	After 3m Surcharge (5/27/98)
— —	Long Term Movement II (10/2/98)
— —	Long Term Movement IV (4/2/99)
——	Long Term Movement VII(1/12/00)
▨	Soil-Cement Mixed Columns

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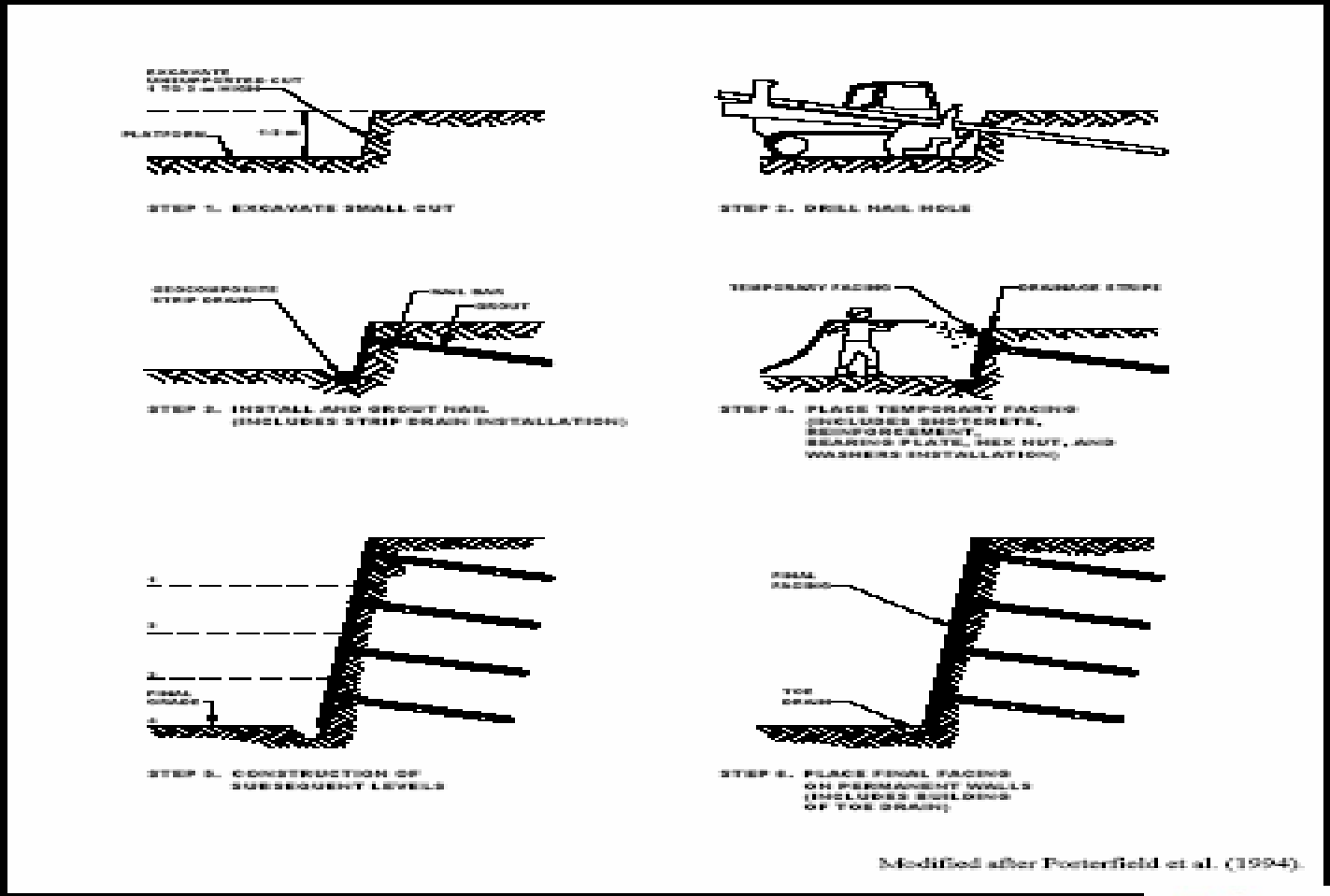
Horizontal Composite Action



FROM FHWA MANUAL

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MODERN MICRO PILES

- Design loads of 250 tons (2300 kN) or more for piles in both soil and rock
- Test Loads of up to 600 tons (5340 kN)
- Diameters up to 300 mm
- Cased 80k yield steel and reinforced
- Job sizes of to $50 million and more
- Total market estimated at $100 million annually

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The beginnings of larger capacities permanent casing Late 1970's

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Early 100 ton capacity Micro Piles in Karst Delaware River Crossing

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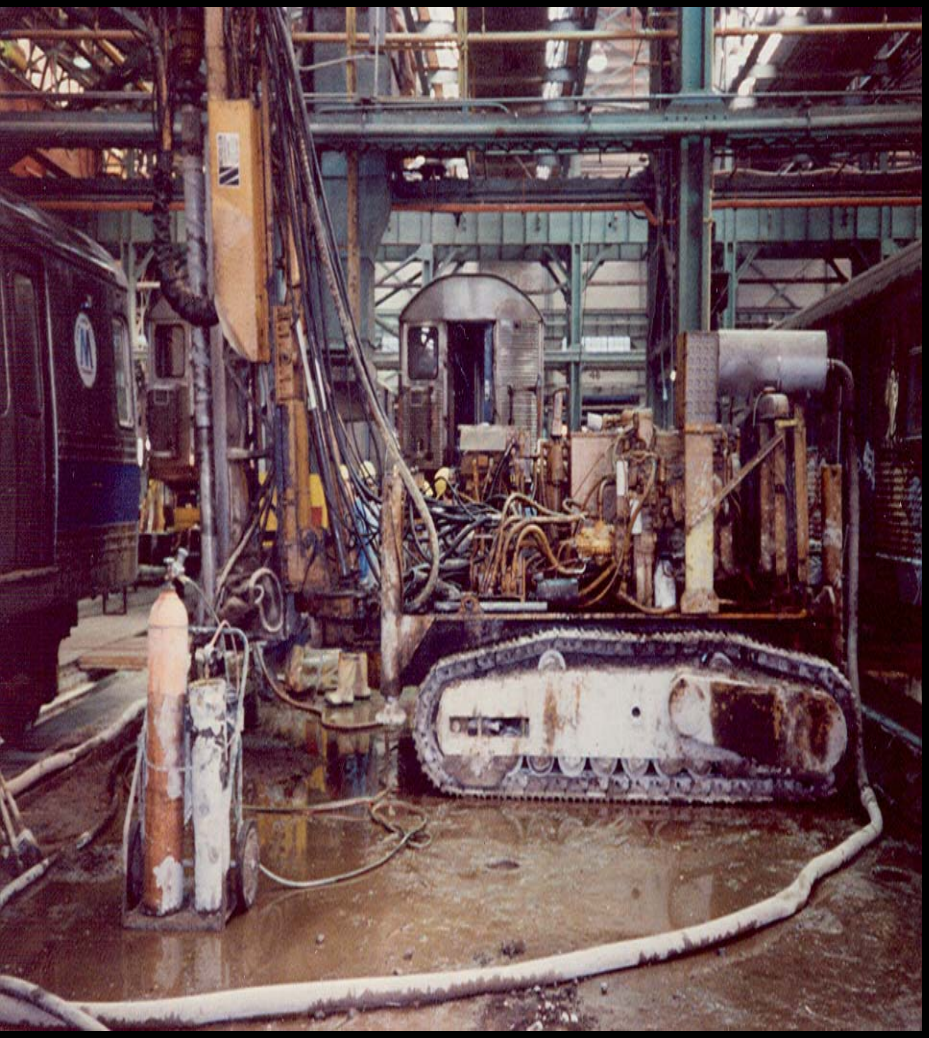
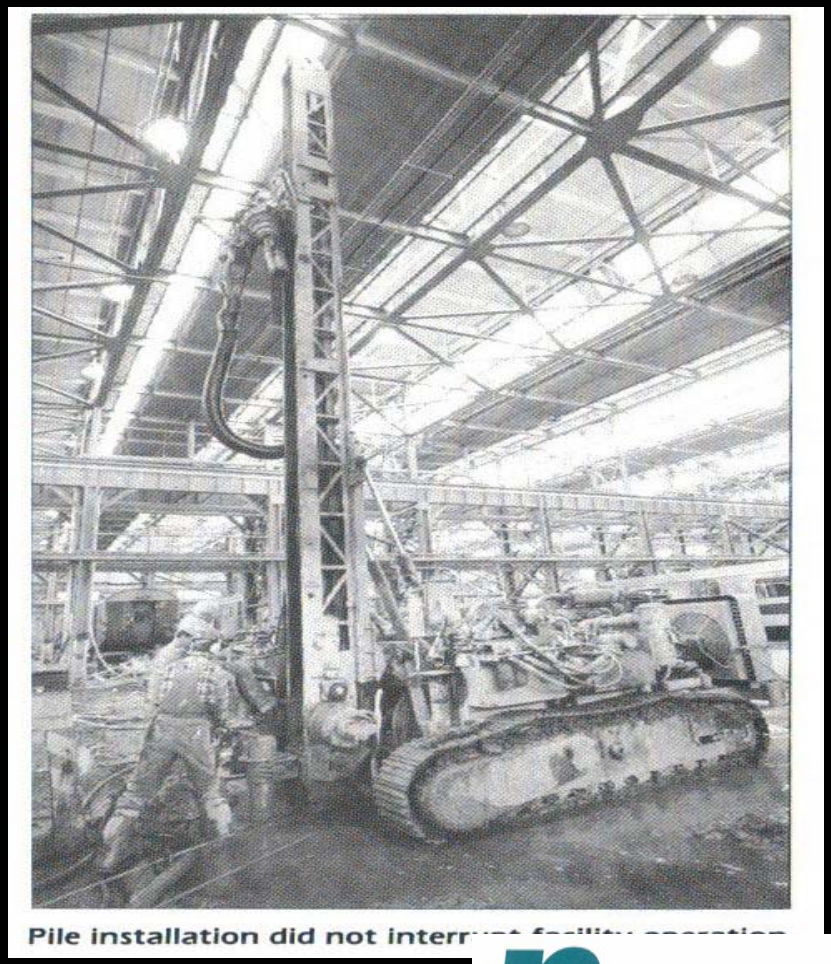
New York M T A transit car repair facility at Coney Island, New York





Pile installation did not interr

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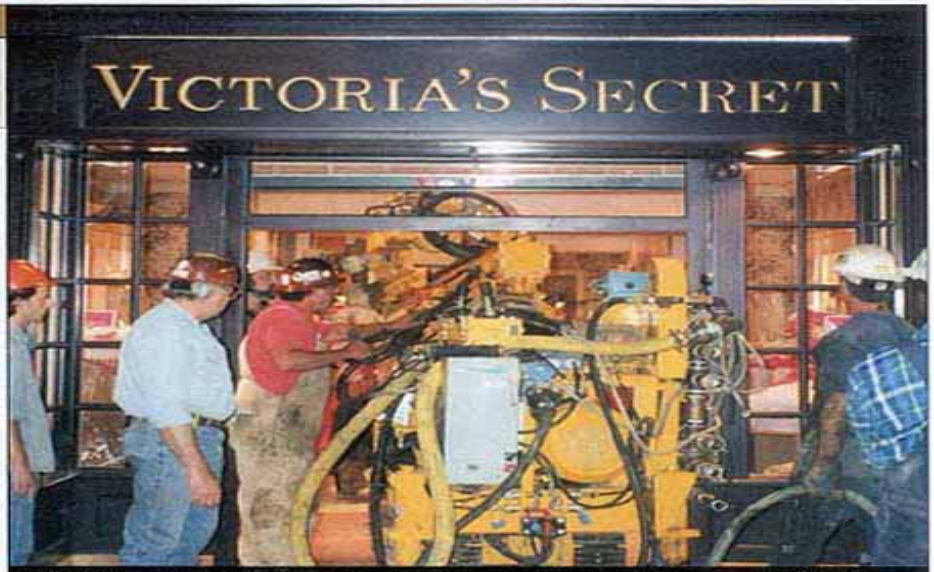
Mastering Marginal Soils: Pin Piles

A novel underpinning technique leads the way for successful foundation support

The Bottom Line

Pin piles can be installed through virtually any ground condition, and inside the tightest spaces



This night crew is not Christmas shopping: they are using pin piles to overcome difficult ground conditions and tight access requirements at an expansion of Exton Square Mall, in Exton, Pa. The construction team moves in specialized equipment to install piles at night; by morning, business in the store carried on as usual, without any evidence of drilling.

High-capacity drilled piles — also known as minipiles, micropiles and pin piles — have been providing foundation support for new and renovated structures for at least two decades. Nicholson Construction Co. has been employing its own, unique method and product, which it markets under the name "Pin Piles," for about 25 years. They can be used effectively to replace and strengthen deteriorated foundation systems, provide extra support during renovation, support adjacent structures during excavation and support new structures.

Yet, while this novel structural technique features an advanced design, pin piles are constructed with conventional materials and installed using proven drilling and grouting equipment. And because their use has been highly successful, the market for micropile construction is growing.

The small-diameter, high-capacity drilled piles range from 5 inches to 12 inches in diameter and typically consist of steel pipe (casing), steel reinforcement and cement grout. They derive capacity in the ground from side friction and perform well in both compression and tension. Working load capacities typically range from 50 to 200 tons, and the pin piles can be installed in a wide range of access and ground conditions.

Inside or adjacent to existing structures

Pin piles are an ideal foundation element for the *restoration of support* or **underpinning** of existing structures. These are often situations where it is neither feasible nor practical to install other deep foundation elements, such as driven piles or drilled shafts. Physical constraints for such projects may include:

- Low overhead clearance.
- Tight working conditions inside existing buildings and structures.
- Sites with limited plan area access.
- Situations where it is necessary to attach small piling elements directly through existing foundation elements.

Geotechnical constraints may include conditions such as: karstic limestone geology; bouldery ground or glacial till; variable or random fill; underlying existing foundations or man-made obstructions; rock formations with variable weathering; and soils under a high water table.

The ability to install pin piles in the most difficult and problematic geotechnical situations is a major advantage. This capability is gained principally by the optimal selection of **drilling and grouting techniques**. They are installed using *rotary drilling* techniques similar to those used in the oil and gas industry. The piles develop their geotechnical capacity through grout-to-ground adhesion in the bond zone. In soils, this bond is achieved using *pressure grouting*. In rock, it is achieved through *tremie grouting*.

It was the innovation of the American contracting community to incorporate a *steel casing* in the pile design, thus providing a high degree of structural resistance in soft upper soils and allowing full optimization of the underlying competent material. This has been very useful in dealing with the most challenging soils.

Mandalay Bay Resort and Casino
Las Vegas Nevada

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Mandalay Bay Las Vegas
360 MicroPiles
360 Permanent Jacks

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Mandalay Bay Construction

Each Pile
Was equipped
With it's own
Hydraulic ram
To insure leveling
Of the foundation
slabs

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Williamsburg Bridge
New York City (NYCDOT)

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Williamsburg Bridge Construction

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BQE Elevated Highway New York Micro Pile Retrofit

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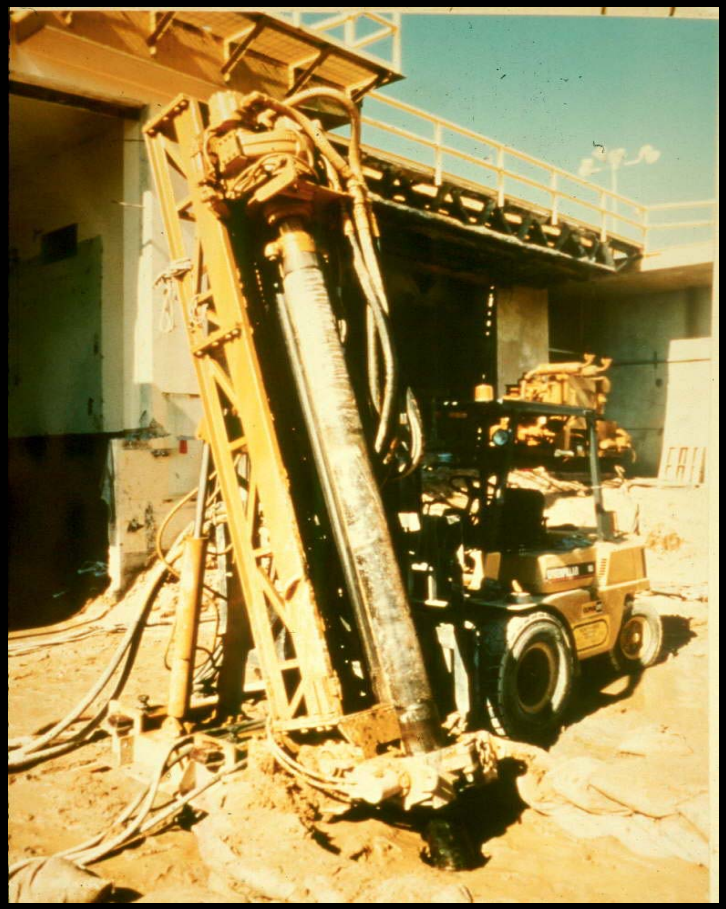
Vandenberg AFB inside and outside Micro Pile installation



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Vandenberg AFB Micro Pile Test

Note number and Size of tie-down Bars for this 500 Ton test

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United Grain Silos Vancouver
Washington Drilling 250 ton Micro Piles

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Richmond San Rafael Bridge Ca 2001 Test to 1070 kips

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I-110 California Seismic Retrofit Drilling and testing micro piles

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Lewistown Narrows Project
State College Pennsylvania

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Lewiston, Pa Micro Piles used for global stability

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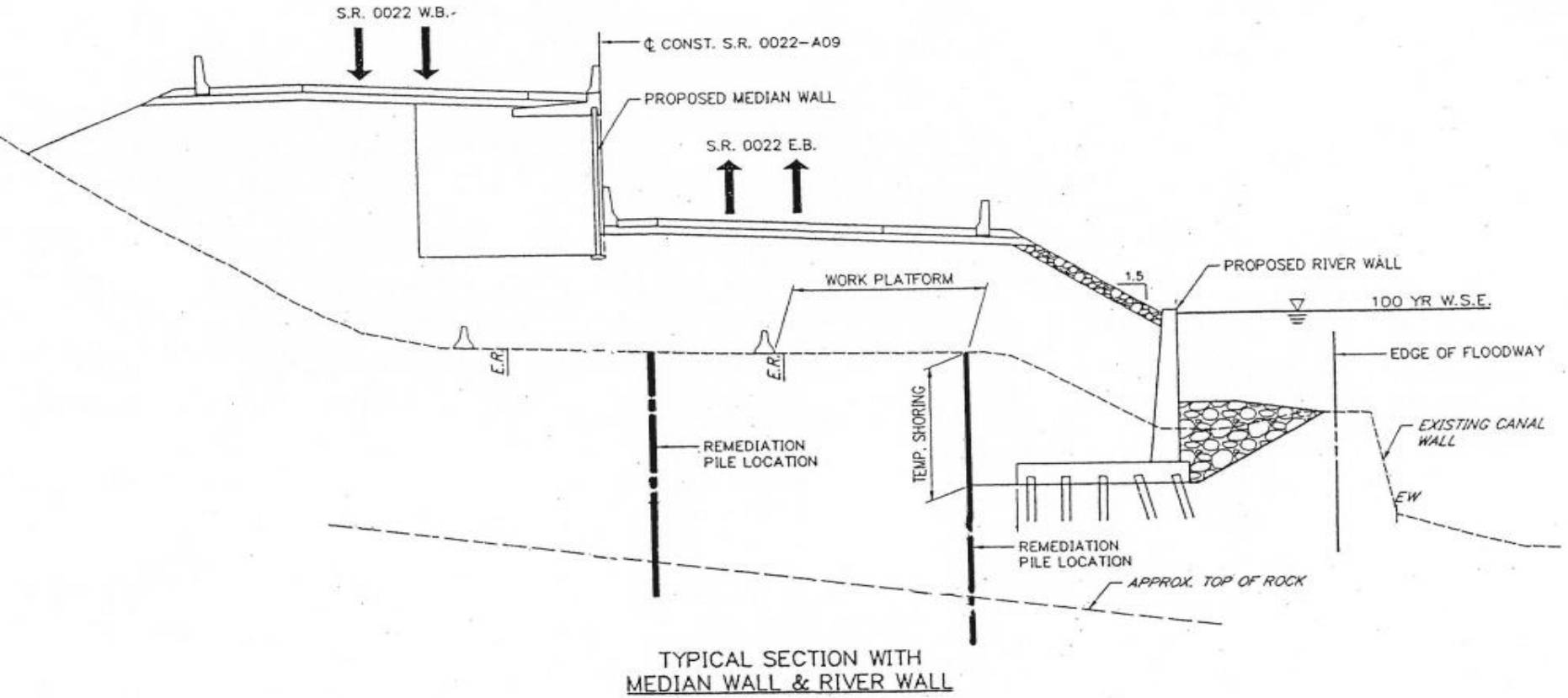
Lewistown Micro Piles for Global Stability Drawing



TYPICAL SECTION WITH
MEDIAN WALL & RIVER WALL

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Lewiston Micro Piles for Global Stability both temporary and permanent

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New River Bridge Florida Department of Transportation

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New River Bridge Fl Night work from barge in River note existing RR Bridge

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Florida New River Bridge Completed Crutch Bent Micro Piles inside caissons

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