

Advances in Hollow Thread Bar Micro Pile Installation Techniques, Equipment, Materials, Testing and Monitoring

**ISM 2007 Toronto, Canada
Horst Aschenbroich Dipl. Ing.
President & CEO of Con-Tech Systems LTD.**



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There are two different kinds of continuous, external threaded Hollow Bars available, mostly in standard drill rod length of 3.0 Meters, (10 feet).

One with an **R-Thread** or Rope Thread and the other one with the **Titan Thread**.



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**Titan Thread
shoulder 45+ degree**



**R-Thread
shoulder 20- degree**



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This presentation is based on the Hollow TITAN Bar System with the Titan Thread which we found to have certain quality and technical advantages over our R-Thread Bars, specifically for difficult and permanent installations using the IBO[®] method



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What is IBO[®]?

IBO =
Grout
Injection Boring



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Developed in 1985 by the company Ischebeck in Germany and later Con-Tech Systems in Canada and in the USA.

Grout Injection Bored Hollow Bar Micro Piles are gaining increasing acceptance by engineers and the industry.

Quality materials and equipment as well as a professional installation technique has to be applied to achieve a quality end product and also the desired ground improvement.



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Installation Techniques and Equipment

Rotary or rotary-percussion drill with top hammer, sized for the various sizes of bars and bits. Rotation speed shall be up to 160 RPM, left turning for hollow bars up to 52 mm with left hand threads. For all other larger bars with right hand threads use hydraulic drills with right turn motors.

Drill rigs meeting these parameters are provided by:
TEI, Euro Drill, Klemm, Krupp, Huette, Casagrande,
Davy Drill, etc.



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Typical TEI rotary-percussion drill with top hammer and flushing head mounted on an excavator



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Techno Drill



Euro Hammer on a Davy Drill

Limited access or low head room installations



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Grout Mixer and Grout Pump

- Typical equipment which meets these parameters is manufactured by:

-

Obermann, MAT, Hany, Colcrete,
Chem-Grout



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For best results, use a high speed - high shear mixer with separate holding tank and water/cement dosing system to assure:

- continuous grouting, independent from mixing.**
- There should be preferably two mixers, one for the thinner flushing grout and one for the final grout.**

When rock is encountered, water flushing is required.



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To assure high pressure ability during flushing or grouting, a piston or double plunger pump with minimum 60 l/minute capacity and 80 bar (1000 psi) pressure capability is recommended for cleaning out grout or dirt blockages in hoses or hollow bars, to assure uninterrupted grout flushing.



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MAT mixer, one holding tank and double plunger pump



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Obermann VS 63



High speed high shear mixer with two water tanks and two mixers. One for the thinner flushing grout and one for the final grout. Also a double plunger pump.



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Obermann VS 110



**Mixer with water dosing
and cement weighing scales**



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Obermann Logger



The use of an automatic logging system for measuring, recording and documenting of grout volume and pressure is also recommended.



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Installation Techniques

Drilling, Flushing and Grouting



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Flushing head on a Klemm 804.

The holder is bolted to the
hammer to prevent the
housing from rotating.

The hollow Titan bar is
screwed directly into the
flushing head



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Threading on drill bit



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The drill shall be equipped with a hydraulic clamp to prevent un-threading of couplers below ground. (Very important when using R-Thread Bars).



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**Start pumping and make sure
grout will exit drill bit.**



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flushing out drill cuttings



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**Outflow of final grout,
notice different colors.**



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The Structure of Hollow Bar Micro Piles



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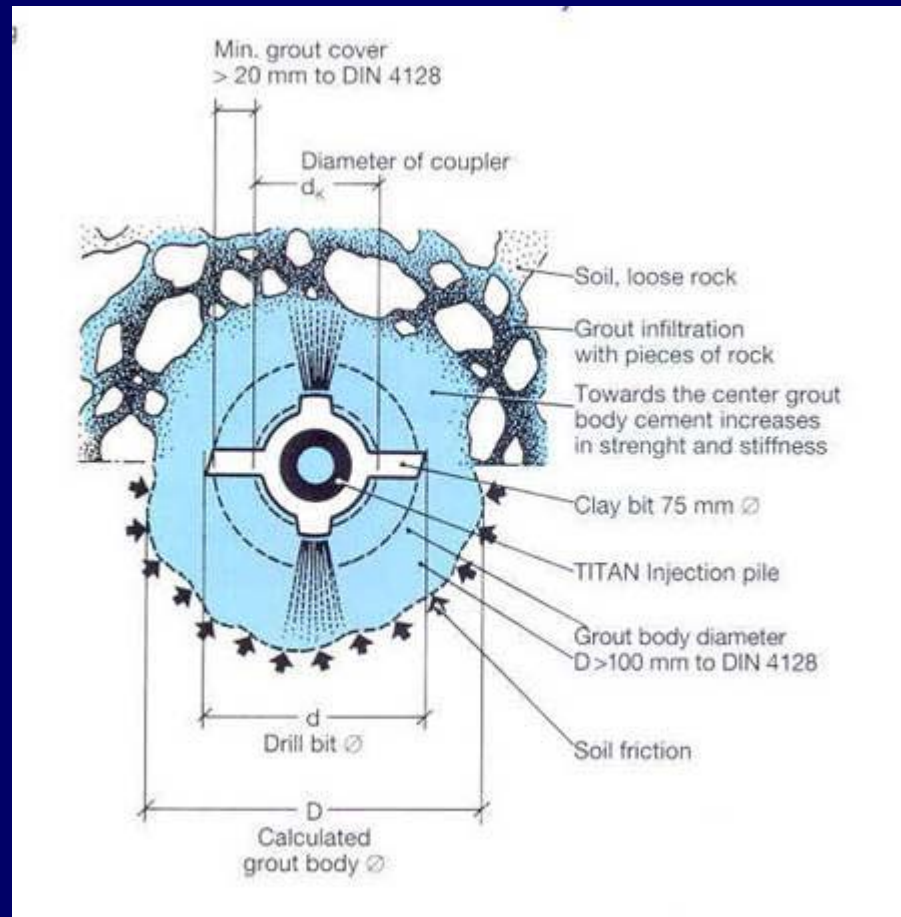
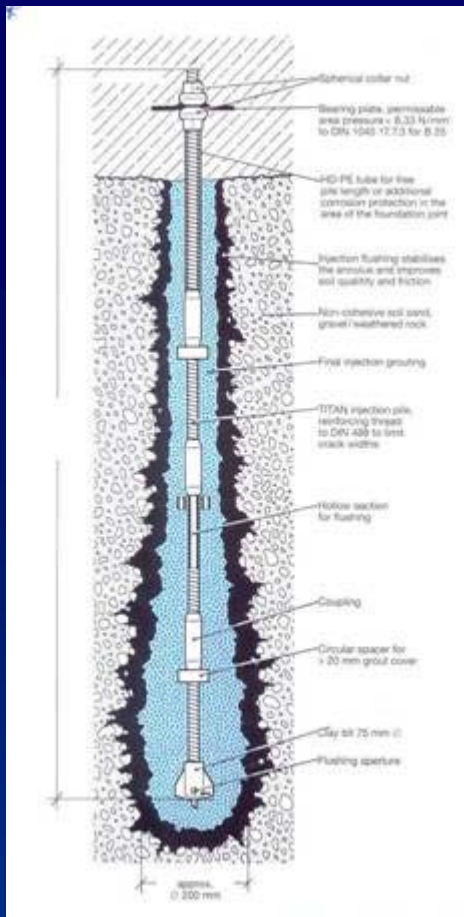
The hollow bar, used as both drill rod and grout conduit, is left in the ground as reinforcing steel to transmit compression, tension, and lateral forces.

Hollow bars have a larger section modulus than solid bars which increases their bending capacity.

With the continuous tremi-grout injection, 100% grout cover and therefore excellent corrosion protection is accomplished, similar to reinforcing steel in concrete.



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The rotation and jetting of the cement grout into the surrounding ground, stabilizes the borehole, consolidates the soil and increases its original shear strength in most soils.

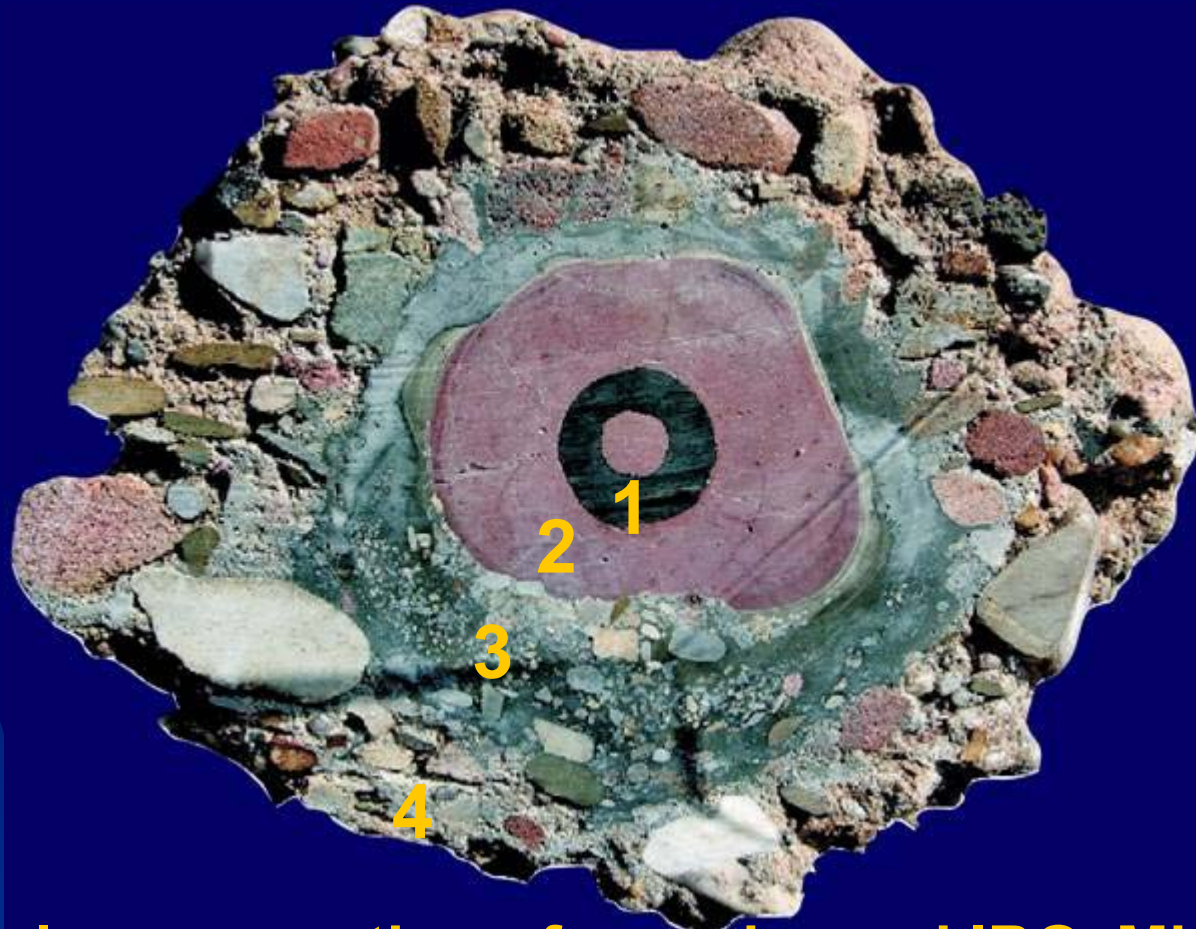


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Typical cross section of an exhumed IBO® Micro-Pile

- 1- Hollow Bar
- 2- Final Grout W/C 0.45
- 3- Flushing grout W/C 0.7 Soil Cement mix
- 4- Ground improvement

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Materials

Since the hollow bars are used as drill rods and subjected to high torque forces, the steel shall be of a fine grain and ductile quality.

The thread type deformations shall develop bond to the grout, the same as with deformations on concrete reinforcing bars.



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TITAN Hollow Bars range in size from 30 to 130 mm (1 1/4" to 5") diameter with ultimate tensile loads up to 7940 kN, (1785 Kips), 892 tons



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Important Requirement:

The thread shall be designed to transfer loads through the couplings (every 10 feet) without excessive slippage inside couplers and shall comply to requirements for mechanical splices of reinforcing bars



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Typical TITAN Bars meeting the requirements of reinforcing steel ASTM A615 specifications for deformation requirement and bond development.



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TITAN Drill bits



A: clay and sand bit

**B: cross cut bit for gravel,
hardened for sand stone and weathered rock**

C: carbide cross cut bits for varies rocks

D: button bits for hard rock



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Grout ports in Drill Bits



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Jets can be threaded into the bits to create higher pressure to enlarge pile diameter .



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Full strength Couplers



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**Special bayonet
coupler for special
under- water
installations**



Couplers with centre stop and seals



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**Steel
Centralizer to
allow for grout
passage**



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**Spherical hex nuts,
2 nuts for
tension/compression
piles,
(bearing plate with top and
bottom nut)**



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Testing

There is no difference between testing Hollow Bar Micro Piles and Standard Micro Piles



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Typical tension test set up for a pile group



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Typical compression tests



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Monitoring

Hollow Bar Micro-Piles with Vibrating Wire strain gauges inside



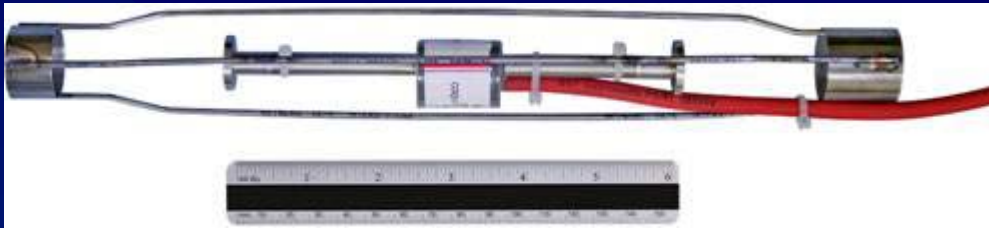
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Strain Gauge with Centralizer



**Installing strain gauges
on a fiberglass rod pushed
into a hollow bar**

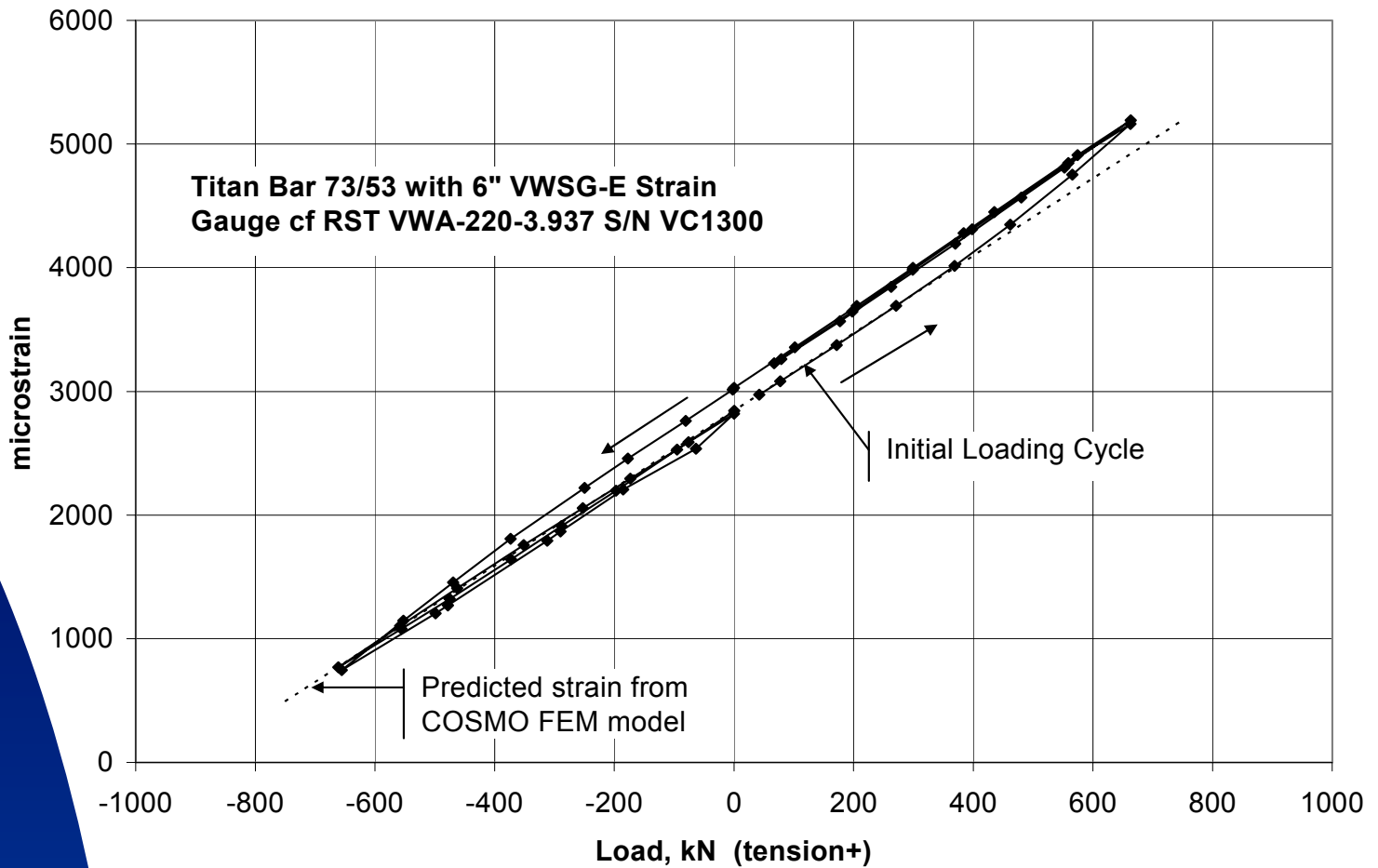


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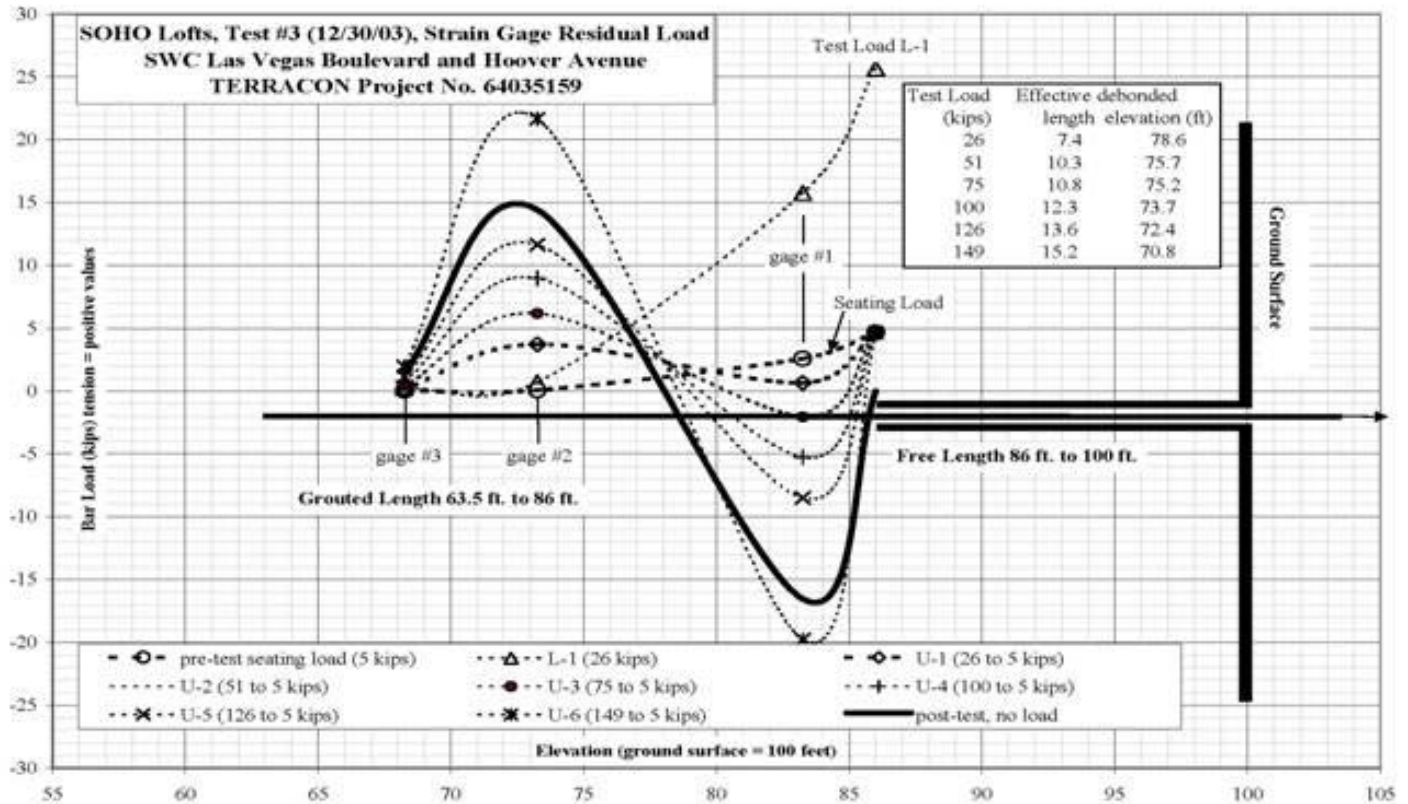
Calibration loading response chart



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This test plot shows the loads in the three gauges. Only the test load L-1 and all locked-in residual loads are shown after relaxing the load to 5 Kips and zero load.



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Some Interesting Current Projects



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The following projects are examples where this product contributed in large to their success, not only economically but also technically.



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**Seismic upgrading and Underpinning of the Capitol State Building
in Salt Lake City, Utah
over 3000 Hollow Bar Micro Piles were installed**



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Difficult installation, under low head room

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Limited access



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Drilling pile groups

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Pile groups for underpinning existing foundations

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Testing pile groups in tension with a single jack



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forming pile caps

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Seismic Upgrading of a Bank Building in Berkeley California

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Micro Pile Foundations for Wind Power Turbines



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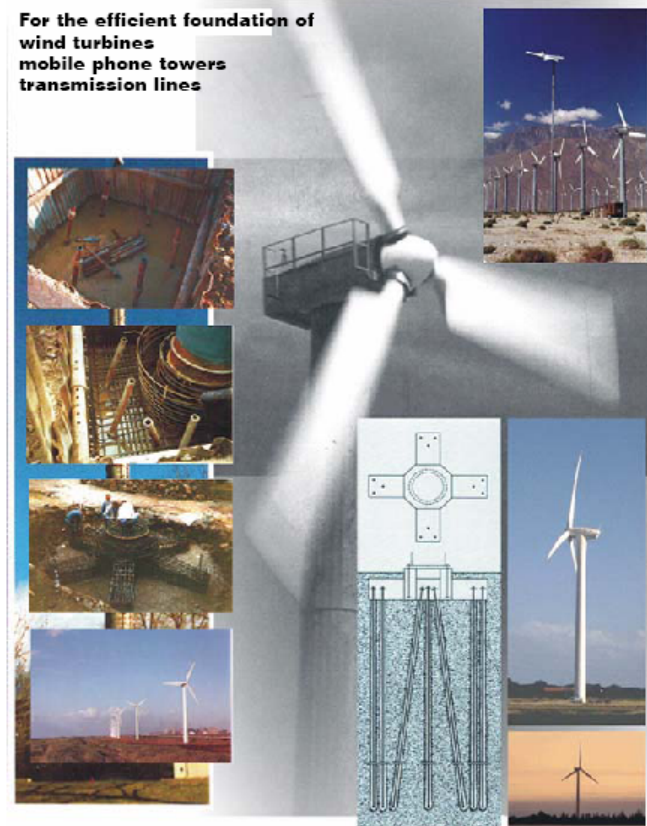


Geosupport
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Technical Information



CTS/TITAN Injection Bore (IBO) Micropiles

For the efficient foundation of
wind turbines
mobile phone towers
transmission lines



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GTMO WINDTURBINE
ROCK ANCHOR BOX
INSTALLATION WITH
5" PIPE FROM BOX DOWN

10/19/2004
0713

Placing of Reinforcing Steel and Sleeves



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Placing of Concrete Pile Cap

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Drilling Hollow Bars Through Pile Cap

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GTMO WINDTURBINE
TESTING ANCHORS AT
WT #1 SITE



2004/11/19

Post-Tensioning and Testing

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Placing of Tower

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Two Devil Slide Projects for Caltrans, Pacific Coastal Highway, PCH-1 40 Miles south of San Francisco

- **Emergency slide stabilization
as per Chapter 6 of the FHWA
Implementation Manual,
Design of Micro Piles for slope stabilization**
- **South Tunnel Portal,
New Retaining Wall Support**



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The project

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No. 1

**Emergency Slide Stabilization with
Micro Piles as per chapter 6 of the
FHWA Micro Pile Implementation
Manual**



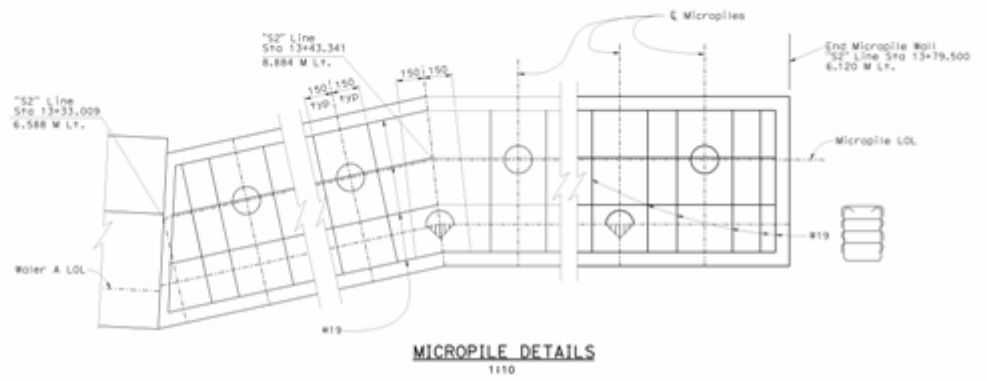
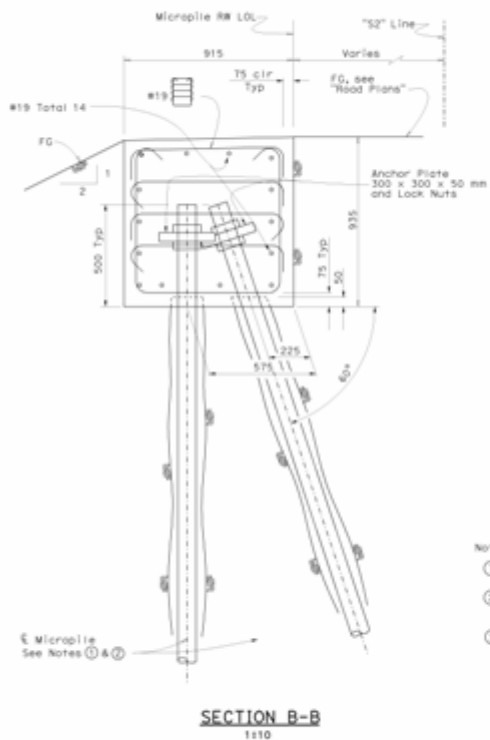
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SHEET	COUNTY	ROUTE	ALLOWED	POST	DATE	NOTES
04	SM	1				
REGISTERED CIVIL ENGINEER "DATE"						
PLANS APPROVAL DATE						
The State of California or its officers or agents shall not be responsible for the accuracy or completeness of electronic copies of this plan sheet.						
To get to the Caltrans web site, go to http://dot.ca.gov						



- Notes:
- Direction of batter for battered piles is perpendicular to "52" Line
 - Micropiles, 150 mm ϕ drilled hole x 13.0 m long. (TITAN-103/78 Bar or DS/LAND-T76S bar or equivalent)
 - For location of "Section B-B", see "Micropile Layout No. 1" sheet

NOTE:
THE CONTRACTOR SHALL VERIFY ALL CONTROLLING FIELD DIMENSIONS BEFORE ORDERING OR FABRICATING ANY MATERIAL.



DESIGN	P. Lopez	DRAWN	P. Norbø	STATE OF CALIFORNIA	DIVISION OF ENGINEERING SERVICES	PROJECT NO.	36E0024	DEVIL'S SLIDE BUTTRESS
DETAILS	P. Lopez	CHECKED	P. Norbø	DEPARTMENT OF TRANSPORTATION	STRUCTURE DESIGN	CONTRACT NO.	39-1	MICROPILE TYPICAL SECTION
QUANTITY		DATE		DESIGN BRANCH 9	CU 04	DATE PLOTTED		
ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE SHOWN				CU 04	E.S. 2/1/03	DATE PLOTTED		



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Failing, existing shotcrete slope



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Installing new IBO-Titan Anchors

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Drilling from a cage

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Drilling battered micro piles

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Vertical and battered micro piles



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Forming of Pile Cap

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Finished emergency Slide Repair

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**Using Hollow Bar Micro Piles, for
slope stabilization, Caltrans
could re-open the Pacific Coastal
Highway
two months ahead of schedule.**



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No 2.

**South Tunnel Portal
Retaining Wall Support and
slope stabilization**



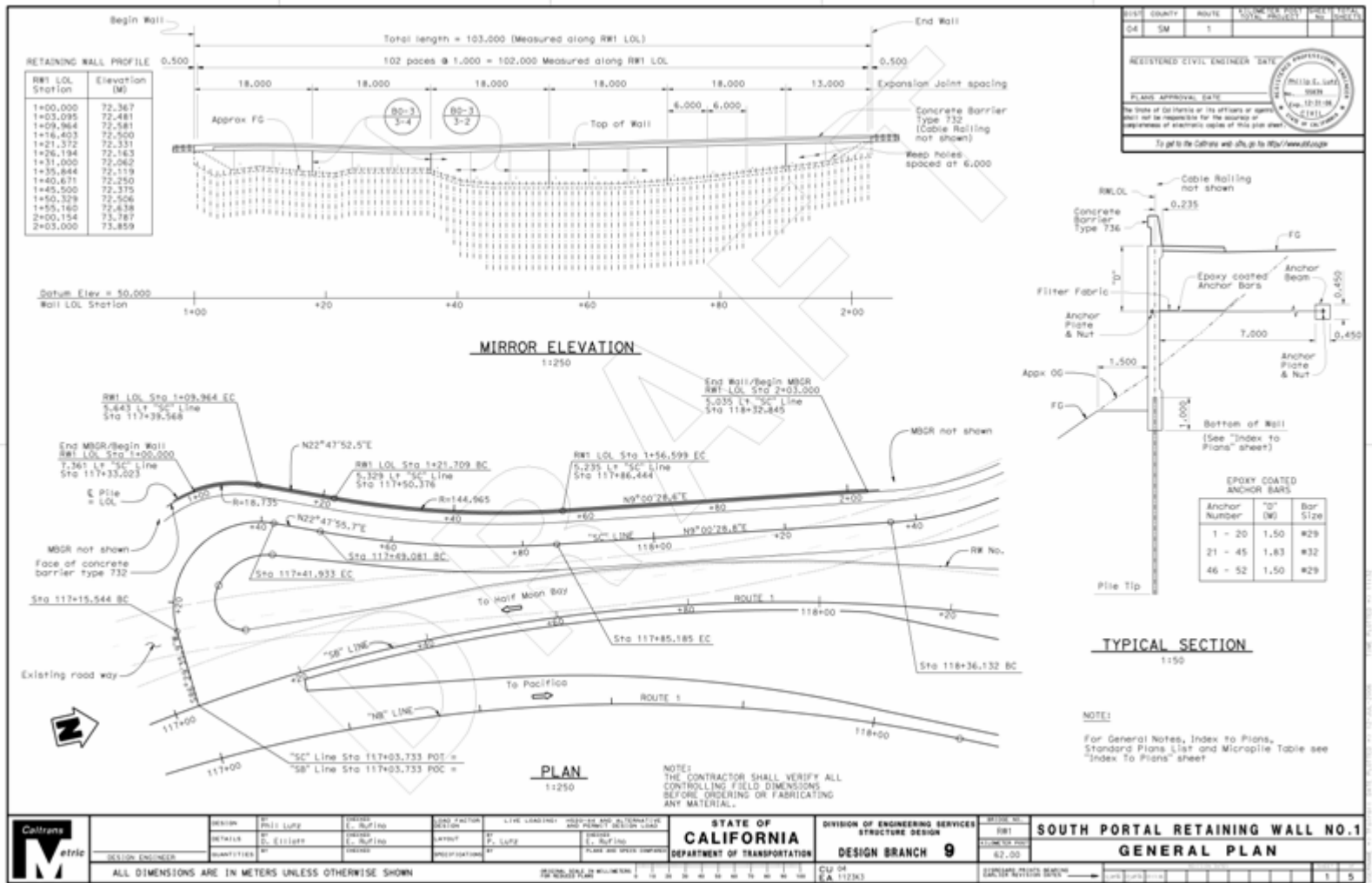
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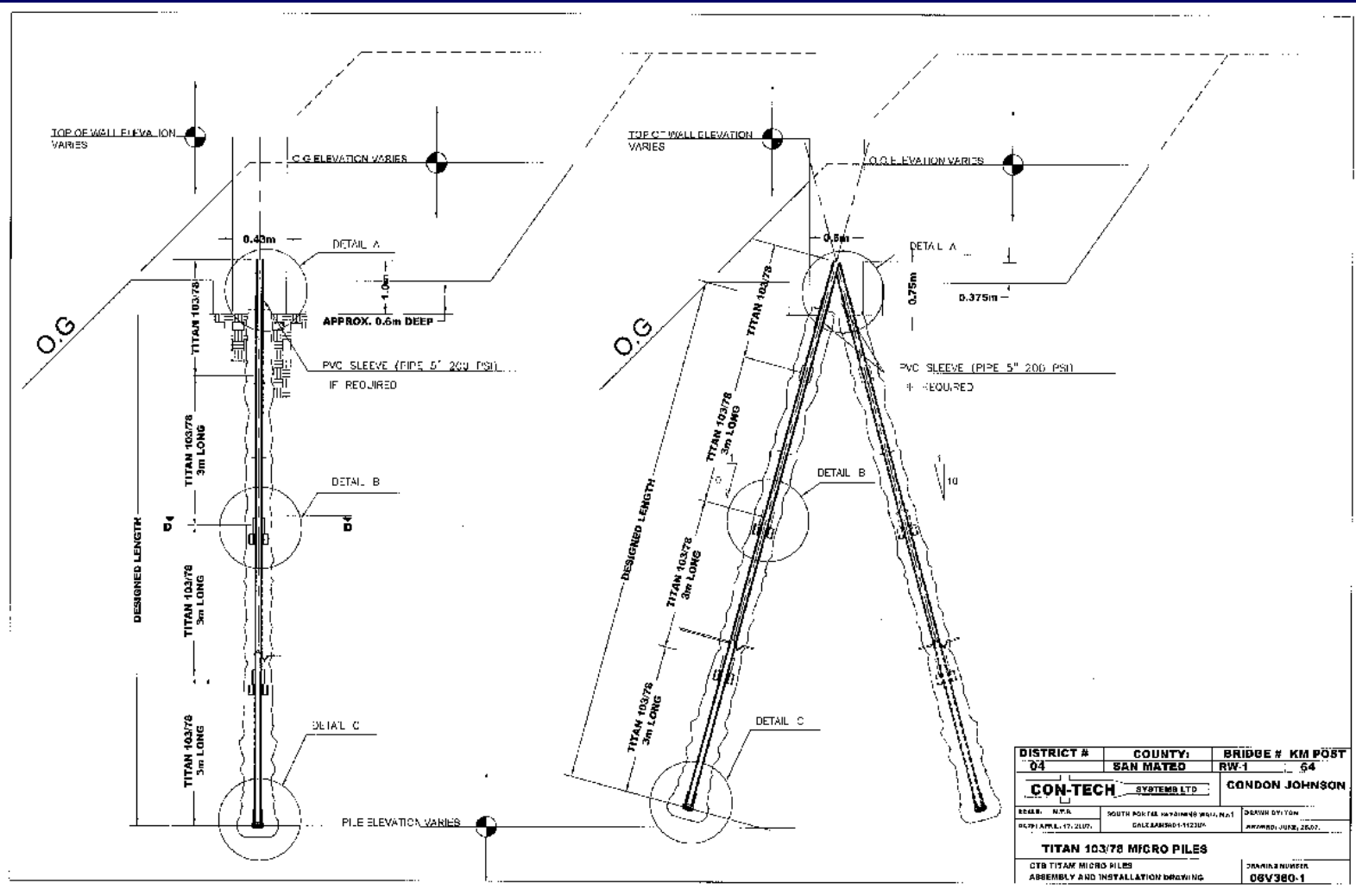
Over 140 straight and battered Micro Piles to support the new retaining Wall and to stabilize the slope below

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Vertical and battered Micro Piles





Grout Injection Boring

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Trench to collect flushing grout



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Random compression tests of production piles

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Exposed excellent ground improvement



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Forming of retaining wall



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Piles are overlapping into wall by 1.0 m



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Road is re-aligned



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Ready for TBM, (Tunnel Boring Machine)

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California coast line at Devil Slide



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