ISM 2007, 8th International Workshop on Micropiles
September 26-30, 2007, Toronto, Canada

Direct Drilled New Micropile TITAN 127/111 for Underpinning Roman Bullring in Barcelona, Spain

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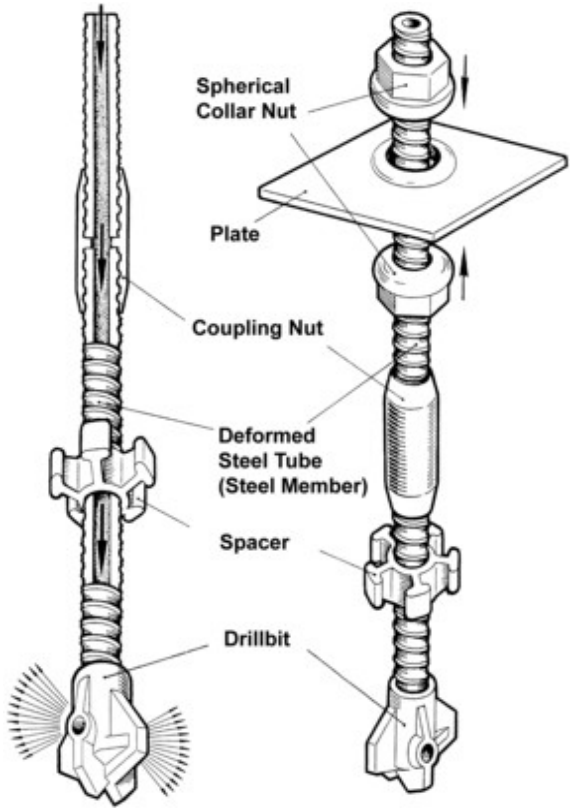
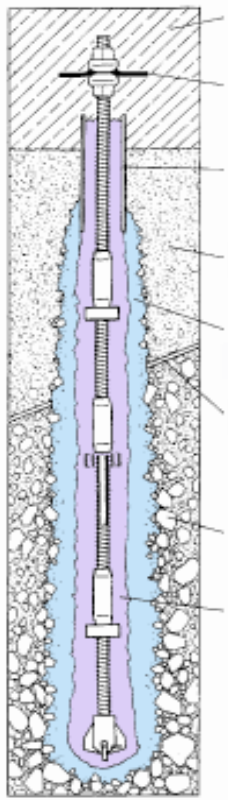
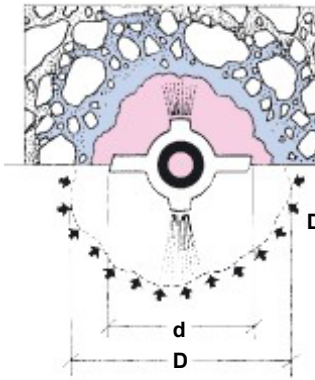
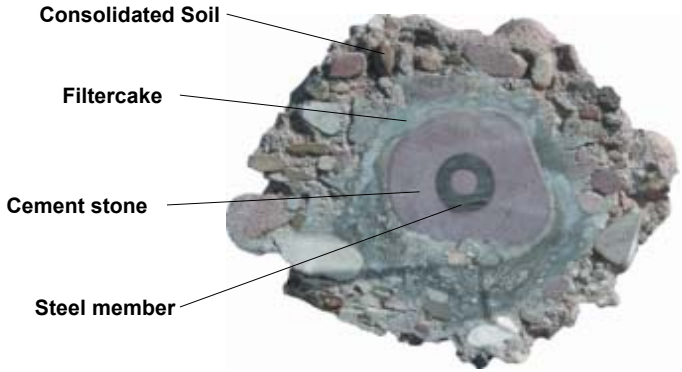
Micropile **TITAN** – Main Components



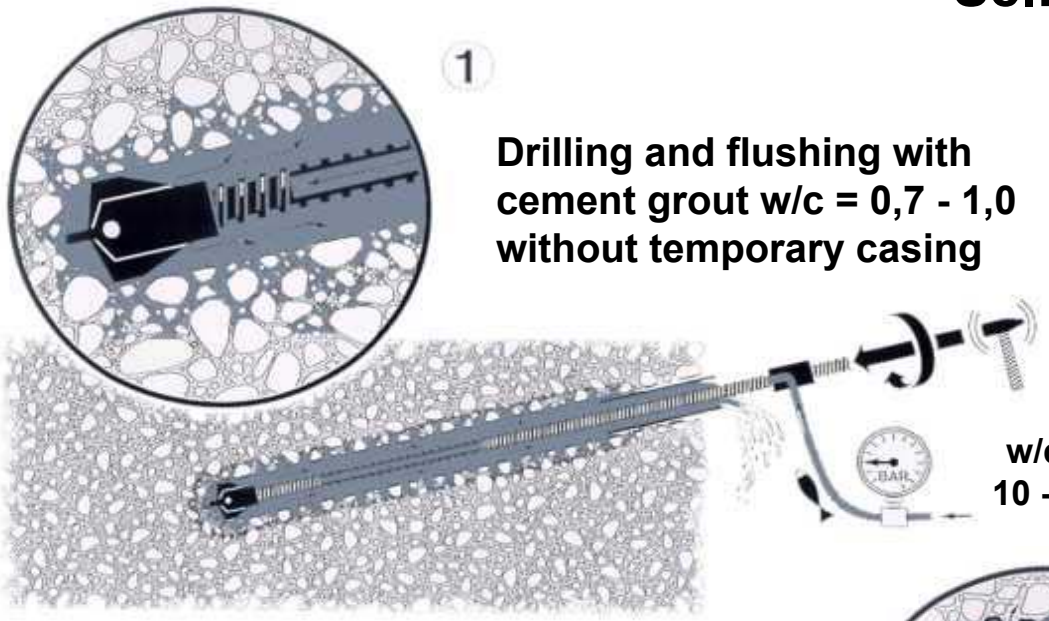




D > 2,0 x d gravel
1,5 x d sand
1,4 x d Sand-clay
1,0 x d wheathered clay stone, shale

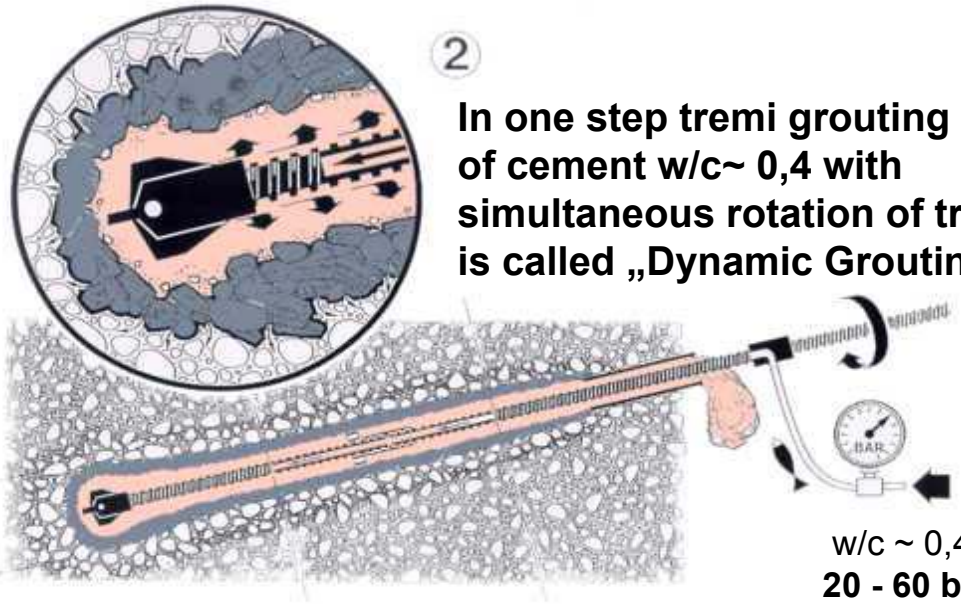


Self-Drilling and Dynamic Grouted Micropiles TITAN



Drilling and flushing with cement grout w/c = 0,7 - 1,0 without temporary casing

w/c ~ 0,7
10 -20 bar

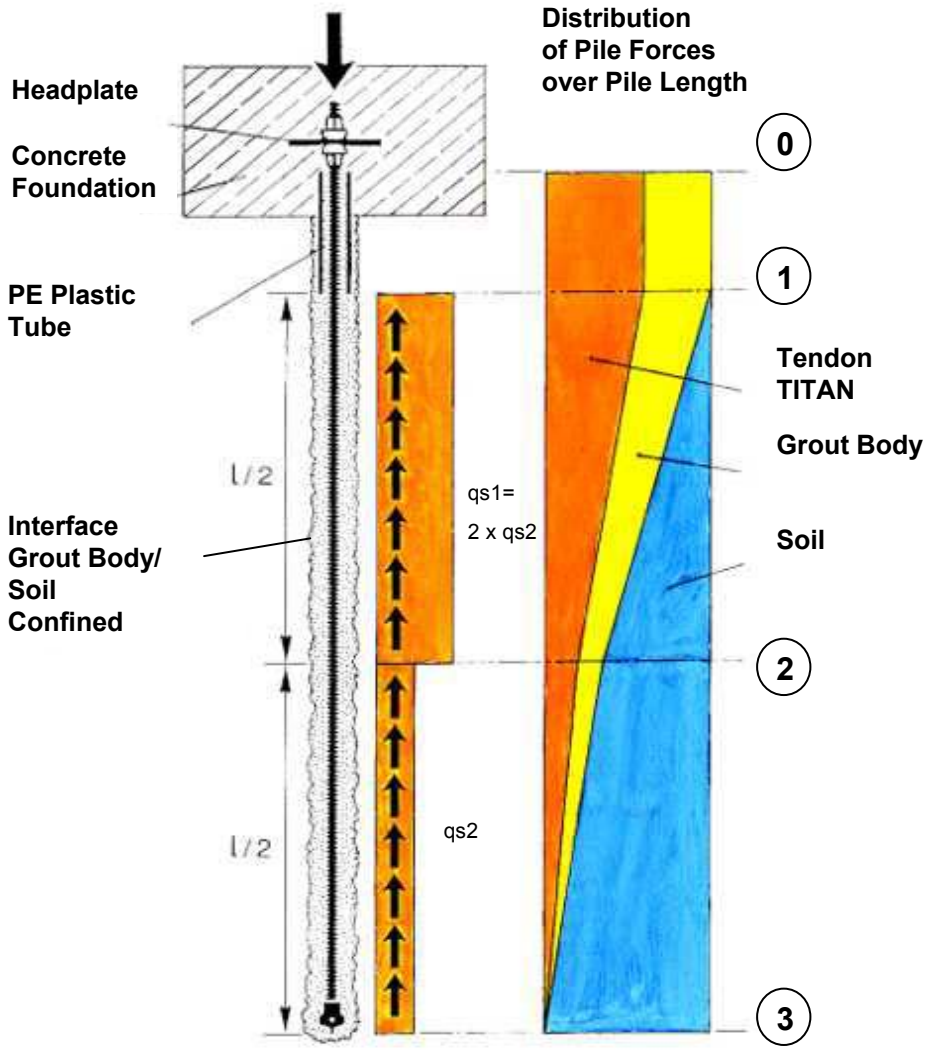


In one step tremi grouting of cement w/c~ 0,4 with simultaneous rotation of tremi is called „Dynamic Grouting“

w/c ~ 0,4
20 - 60 bar

Micropile Diameter D =
1,0 ÷ 2,0 x drill bit diameter depending on type of soil

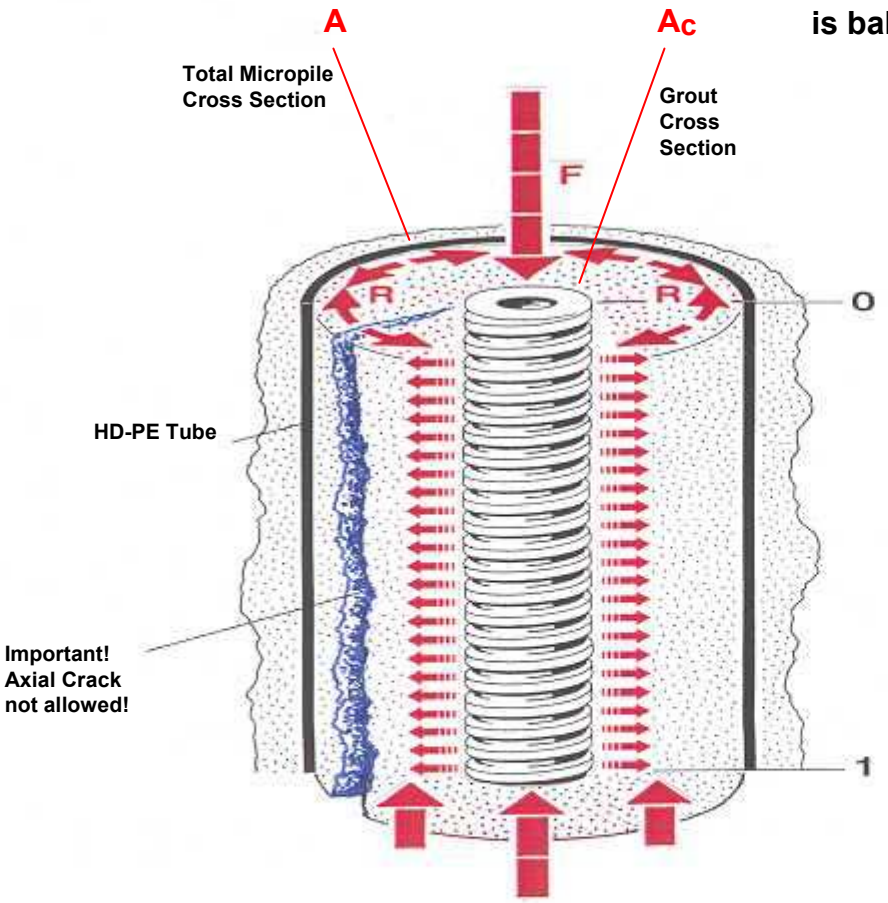
Load Transfer in Composite Micropiles TITAN for one Homogenous Layer of Soil

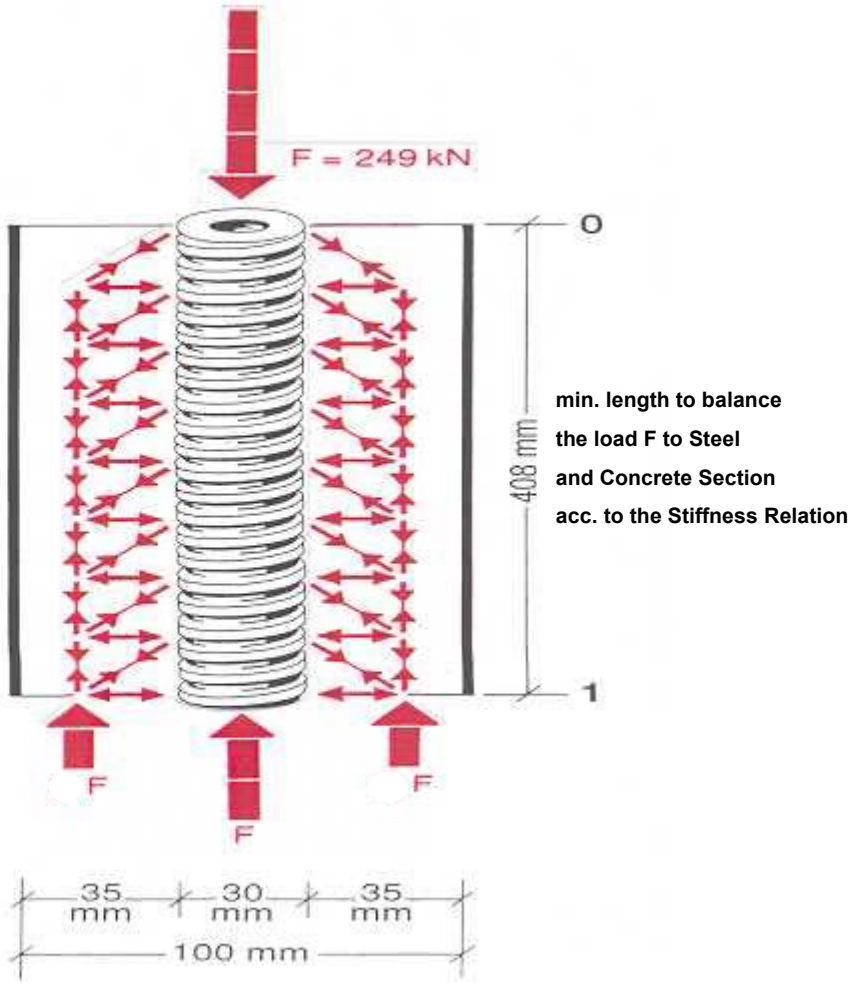


Monitoring the Distribution of Load Transfer to the Soil by Extensometers, installed inside the hollow Micropile TITAN

Inner Capacity of Composite Micropiles to avoid Splitting e.g. TITAN 30/11

For $\frac{A_C}{A} \geq 0{,}85$ and Yield Stress of Tendon ≤ 550 Mpa Circular Force R is balanced





Necessary Length 0 – 1 for Load Transfer F from Tendon to Grout Body

Circular Force R in Grout Body, caused by

- Different Poisson ratio and
- Shear Bond

Circular Force R has to be balanced to avoid Axial Cracks

Micropiles TITAN 40/16 are included in the
FRENCH NATIONAL RESEARCH PROJECT (FOREVER)
to improve design of single and reticulated micropiles.

Several tests on natural size (size 1:1) in St-REMY-LES-CHEVREUSE in 1998,
all with loose, fine and dry sand of Fontainebleau
Micropiles TITAN 40/16, length 5 m, drill bit 70 mm, flushing grout w/c=0,9,
grout pressure 8 - 20 bar

Results:

1. Skin friction qs = 74 kN/m²
   Micropiles TITAN fulfil requirements of French DTU 13.2 micropieux
   Typ IV (IRS or postgrouted)

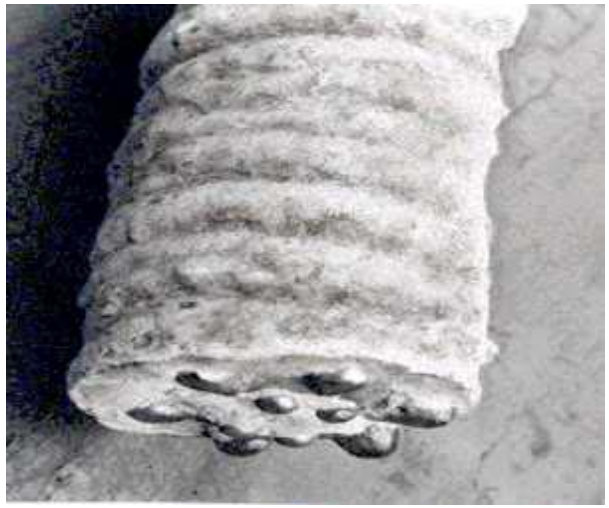
2. In compression 7% loadtransfer by end bearing, 93% by friction

3. Micropile Diameter D=113 mm
   Drill bit d= 70 mm,
   D = (1,5 ÷ 1,8) x d

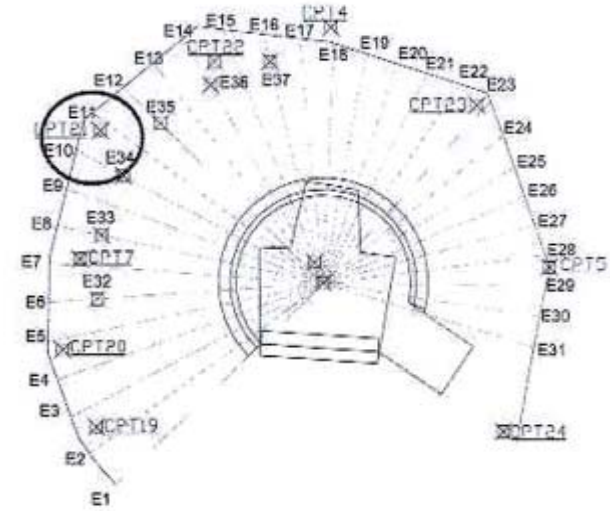
4. No visible cracks observed in the grout body

5. Steel member centered in the grout body

6. Dynamical testing of integrity and length of micropiles TITAN by French method SIMBAT works and is confirmed by CEBTP



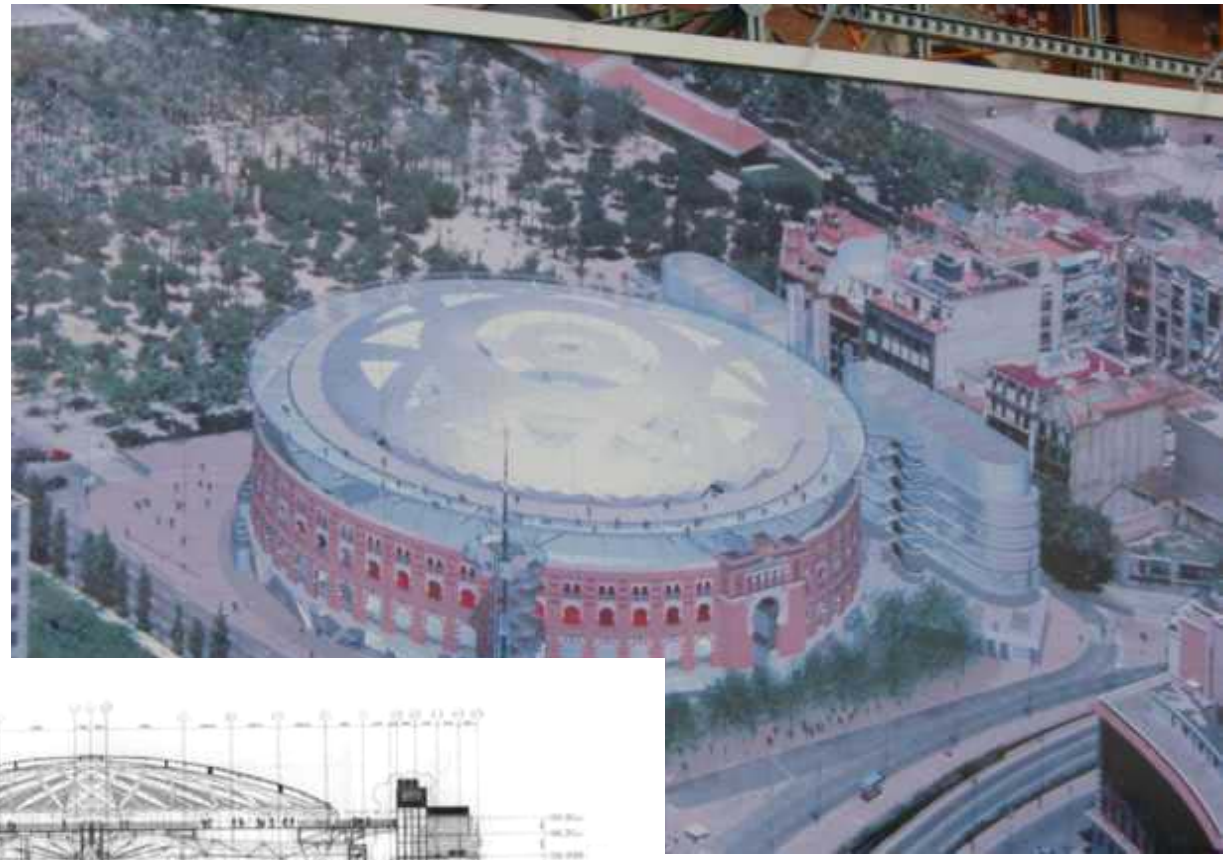
Belgium National Research Program Groundanchors
BBRI Research, Limelette in 2006-2007

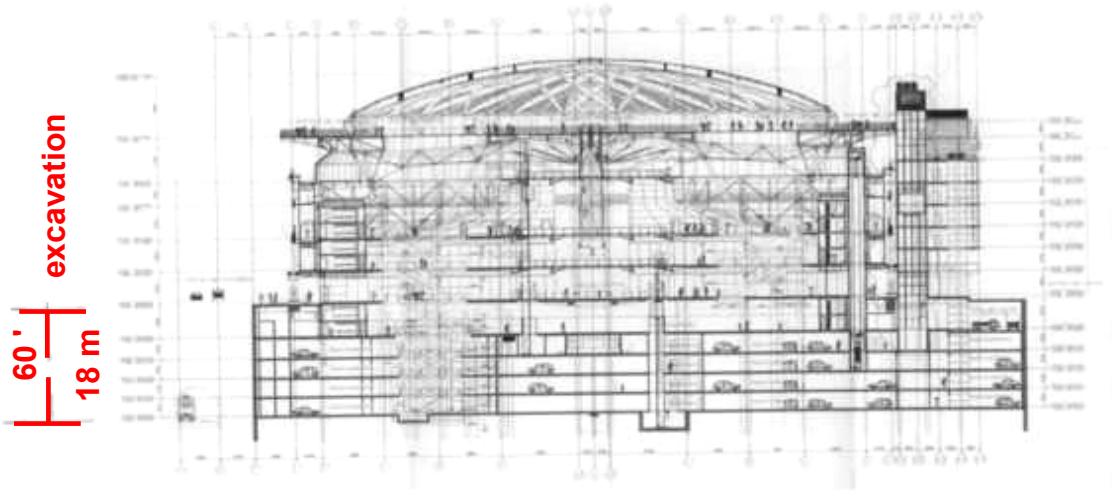


The site with a glacial profile offers: sand, gravel, clay
7 types Micropiles TITAN 73/45, 18 m long, are included.
Each equipped with 7 extensometers.

Still Existing Facade of Bullring

Vision of New Building
Contractor: DRAGADOS



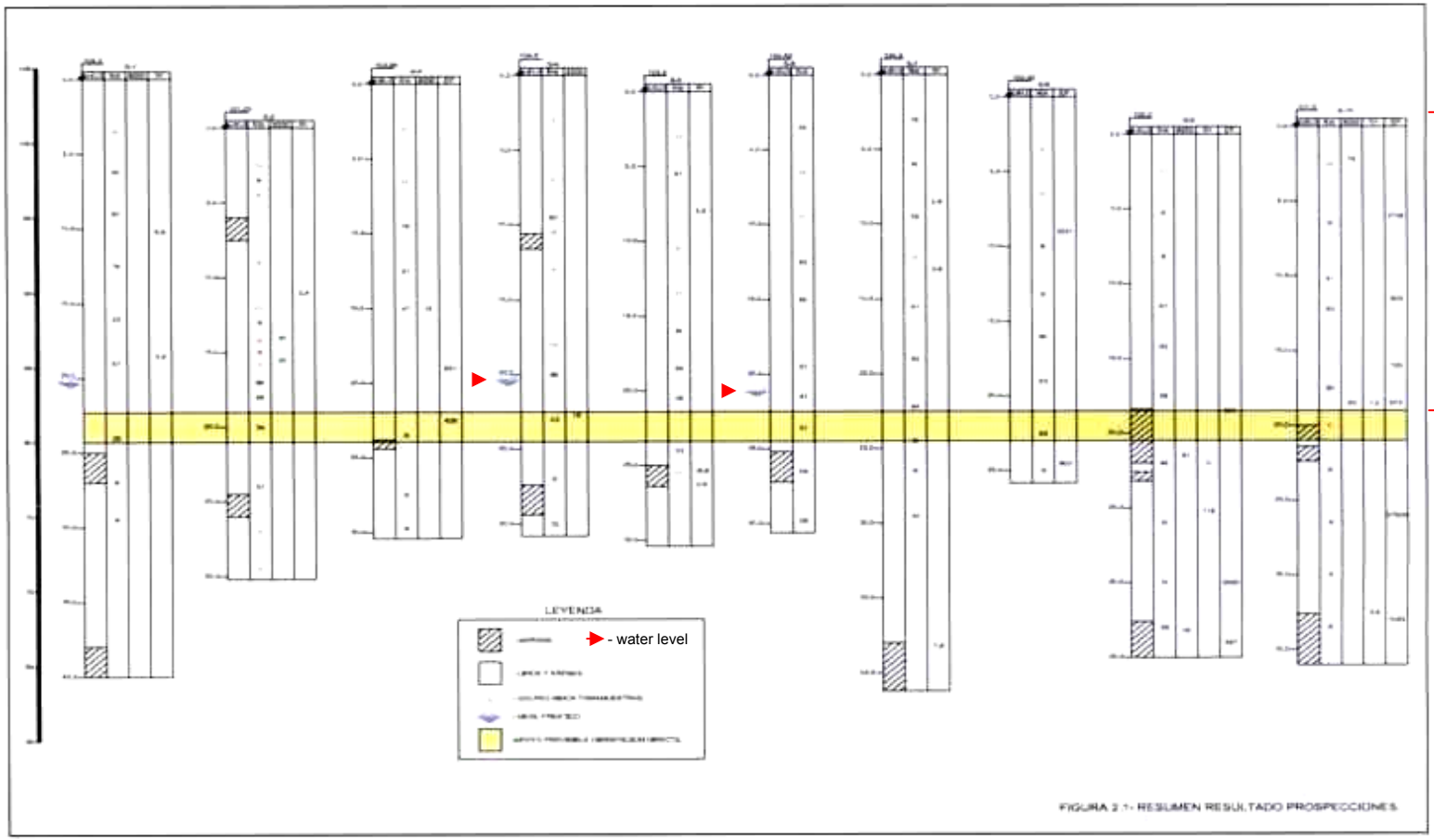


Old Facade integrated in New Structure, Office Building with Parking

Soil Investigation

Unidades geotécnicas	Profundidad Desde la cota 105 aprox.	Módulo de deformación E		Coeficiente de balasto		Resistencia al corte	
		Según UPC	Según Presiómetros y ensayos SPT	Según UPC	Según Presiómetros y ensayos SPT	ϕ	c (t/m^2)
Limos y arenas marrones	De 0 a 5 m	100 MPa	332 MPa	4375 kp/cm^3	146 kp/cm^3	31°	5
Arenas cementadas	De 5 a 8 m	300 MPa	274 MPa	132 kp/cm^3	120 kp/cm^3	17 a 35°	8 a 9
Limos y arenas	De 8 a 26 m	60 MPa	57-255 MPa	26.4 kp/cm^3	8.5-112.2 kp/cm^3	31 a 36°	3 a 5
Arenas cementadas inferiores	De 26 a 30 m	500 MPa	255-3780 MPa	220 kp/cm^3	112-1663 kp/cm^3	-	-
Margas negras	> 30 m	100 MPa	104 MPa	44 kp/cm^3	44 kp/cm^3	21°	7.5

Soil Investigation
Estimated vertical Displacement 8 to 12 mm



Free standing facade of bullring, supported by micropiles and braced by framework. Beginning of excavation.

Details of temporary support.

Step by step with excavation the 4 freestanding micropiles TITAN are braced. The braces are not welded; but the connection-houses are filled with grout.

The facade is suspended.
The micropiles are installed in the free area of the facade (arches).
The weight of the facade is supported by 2 concrete beams, parallel outside and inside the facade, which are clamped together with the facade by prestressing strands.

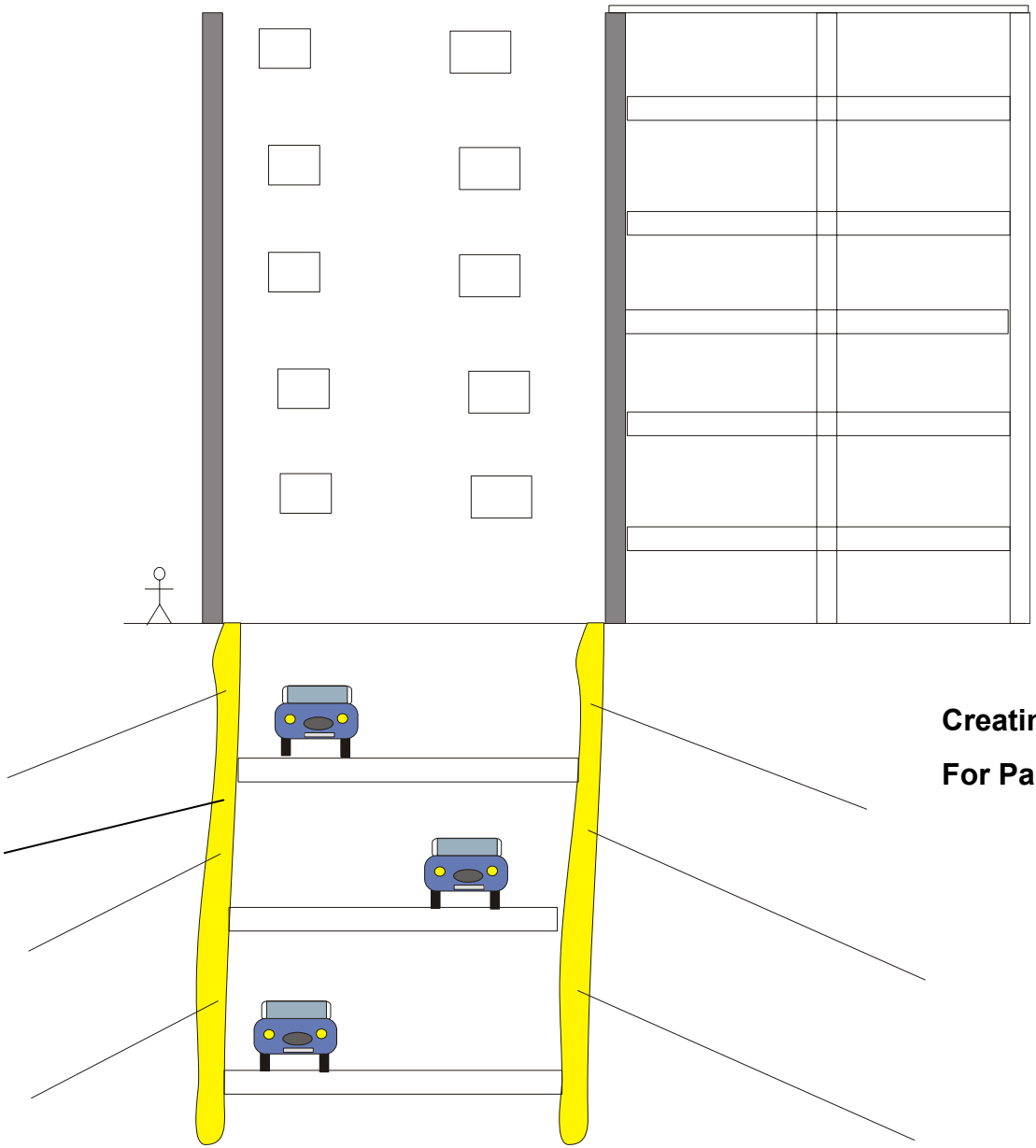
Suspended old facade. Load transfer by 2 concrete beams to the braced micropiles.

Heavy structure of the portal suspended by beams.
Beams are supported by micropiles.

Starting Underpinning in the Openings under the Arches.

Access for the drilling machine.

Difficult Access for Drilling and Grouting the Micropiles.



2. Site

Deep Excavation in

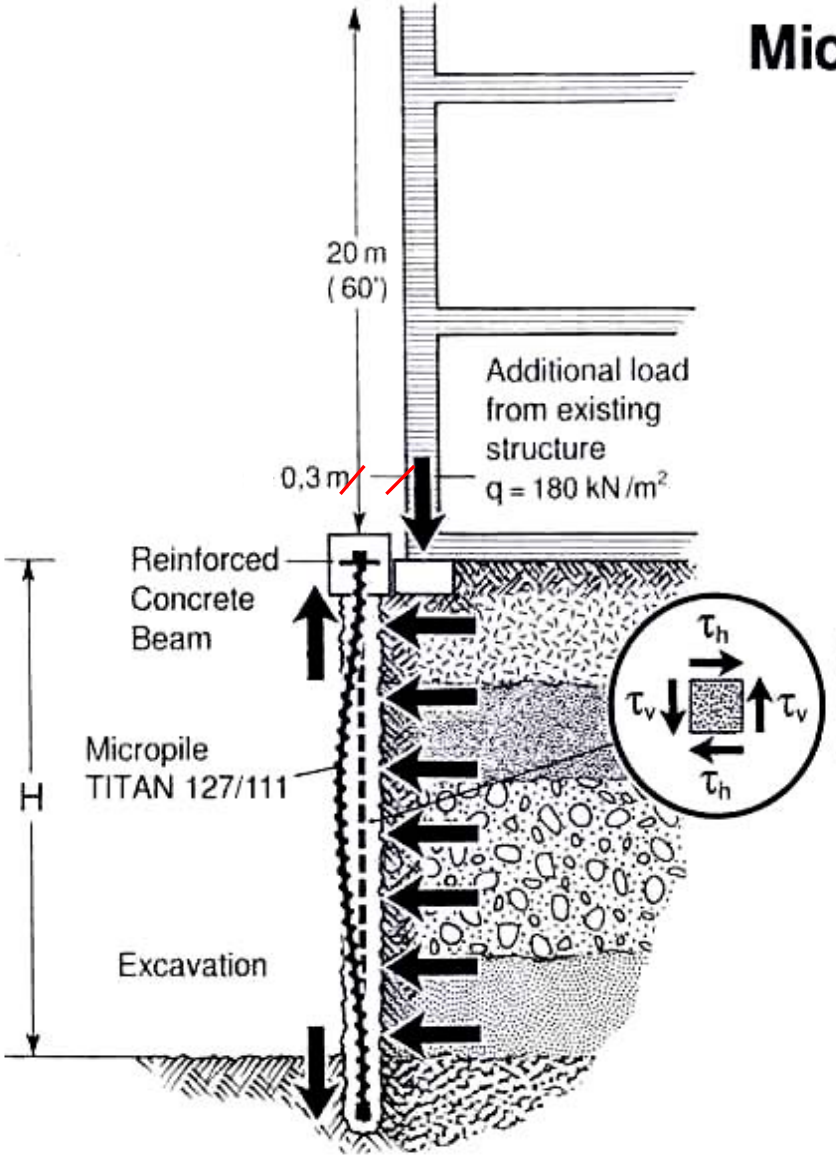
Downtown Barcelona

Creating additional Space

For Parking Underground.

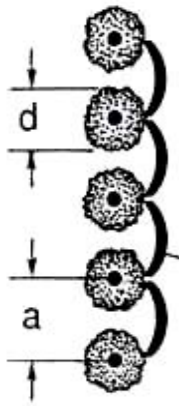
Micropile Wall for Deep Excavation

- for difficult access with small machines
- for low headroom
- close to heavy existing structures
- no settlements allowed
- reduced transport volume
- different layers of soil



Shear Stress Equilibrum means $\tau_v = \tau_h$

Horizontal Deformation of Micropile creates tension in micropile and stiff response against earth pressure.
This effect limits deplacement of head beam $\Delta \leq 1‰ \times H$ e.g.
$H = 20$ m $\quad \Delta \leqq 20$ mm
no loosening of soil, no outflow of soil



Arch Effect
$a = {}^1/_2 \cdot d$ for sand
$a = d$ for more cohesive soils

Small Access to the Site in Downtown.

Distance of Micropiles TITAN 127/111: 3 pcs. per m.
Distance of Walers: 4,5 m
Ground: Sand, Schist, $\varphi = 35\ °$, $C_u = 100\ kN/m^2$, no water

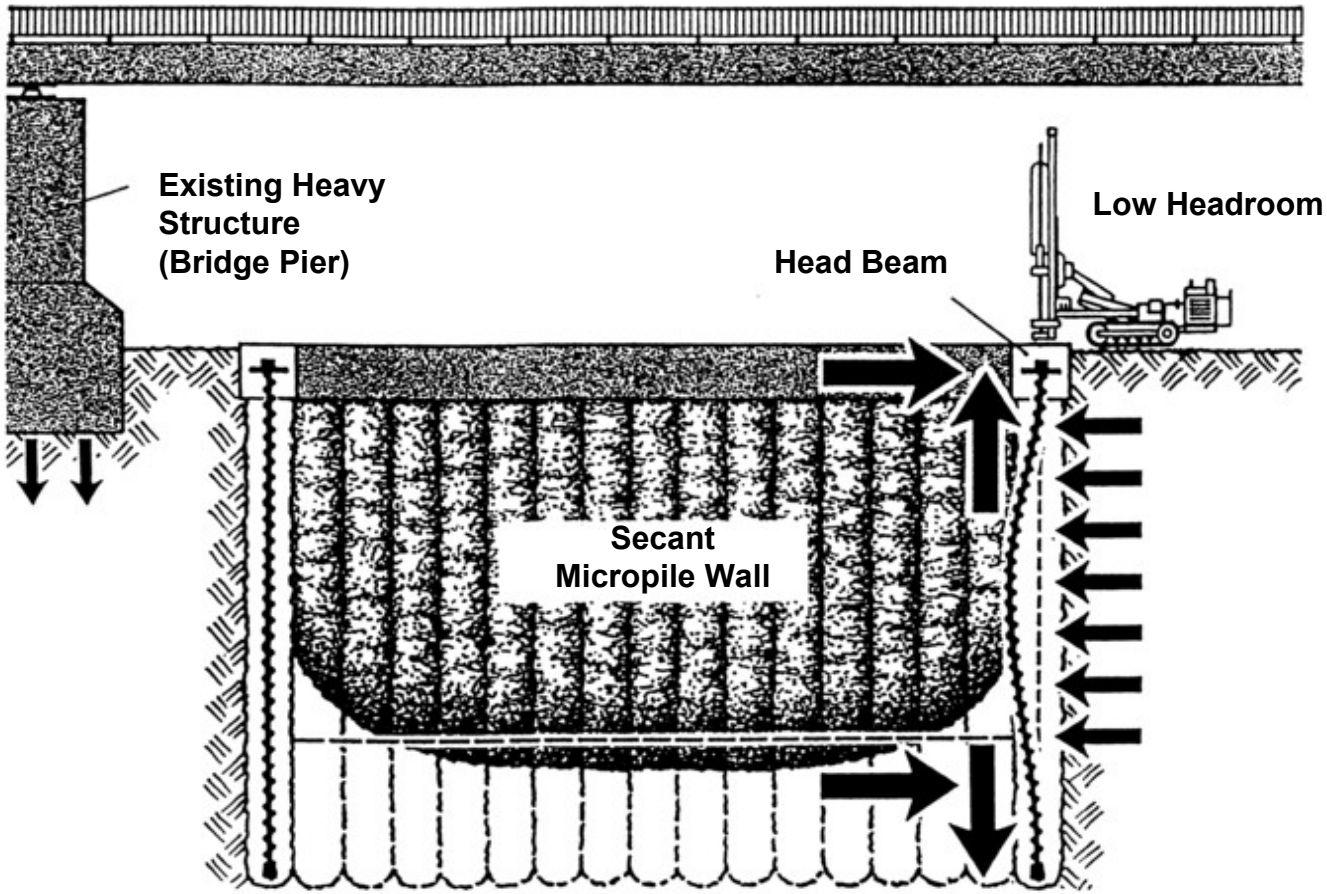
Installing the micropiles
very close - 0,3 m distance - to the existing wall.
Stock of micropiles TITAN 127/111, 3 m long, bundles of 10 pieces.

Construction of the waler in reinforced concrete. No loose in load transfer. The gap between the micropiles can be closed with shotcrete added with epoxy resin, if there is high watertable.

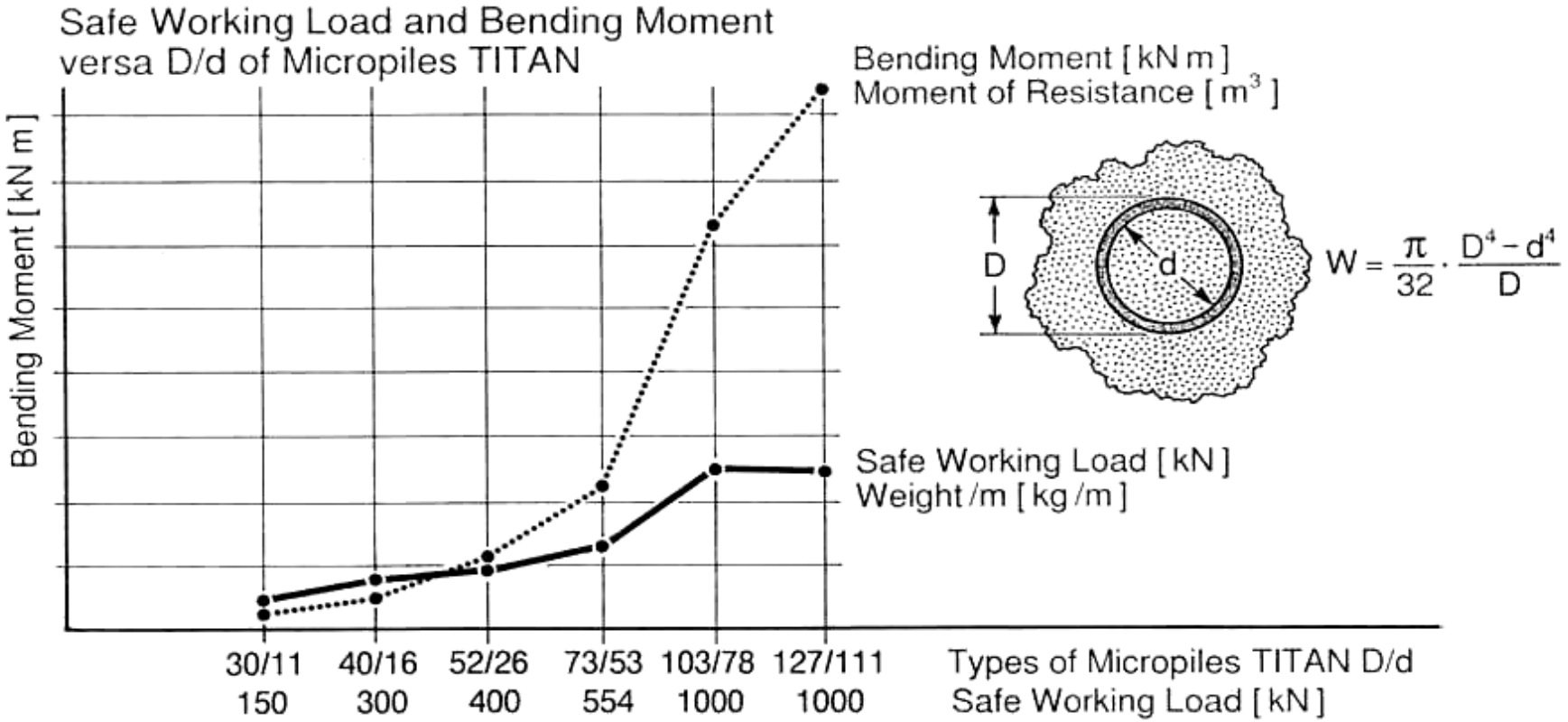
Existing Foundations or obstacles are penetrated by the micropiles.

Anchored Micropiles in Uncontinuous Diaphragm Walls, in confined areas, taking bending moments.

Protection of Circular Deep Excavation Shaft by Micropile Wall under Flyover.



Development of Special Micropiles TITAN 127/111 with High Bending Resistance



First micropiles were designed, only to take tension or compression load (no bending). During last years a new generation of larger micropiles was developed with increased outer diameter D, but small walls and increased bending moment.
Typical applications of this generation of micropiles, using bending stiffness, are presented.
Micropiles with bending resistance work as drilled sheet piles.