Micropiles

ISCHEBECK TITAN

- **IBO®: Injection BOring**
- **The piling solution for difficult ground conditions**
- **No harmful vibrations or noise**
- **Easily installed in confined spaces**
- **Micropiles with capacities up to 1169 kips (5200 kN)**

Con-Tech Systems Ltd.

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CTS/TITAN IBO® (Injection BOre) piles are ideally suited as micropiles, otherwise known as anchor piles, mini piles or root piles (pali radice).

CTS/Titan IBO® micropiles consist of a continuously threaded, hollow bar as reinforcement tendon, combined with a Portland Cement grout body of a minimum 3.63 ksi (25 N/mm^2) strength. The rough, profiled surface of the grout body transfers tension and/or compression loads to the ground.

CTS/TITAN micropiles comply in Europe with DIN 4128, EAU E 28 and final draft CEN/TC288/WG/8 specifications and in North America with FHWA recommendations FHWA-SA-97-070. The material of the hollow bar, as well as the thread deformations comply with **ASTM A-615**.

Advantages over conventional piles

- Works in compression and tension
- Does not require temporary casing
- Improved mechanical ground/grout interaction reduces overall depth
- Dramatically increased production rates
- Lightweight rotary percussive drilling equipment
- Easily installed in confined spaces
- Permits top down mini jet grouting in saturated clays and silts complete with rebar
- Perfect for structural repairs and underpinning
- Remote de-coupling unit facilitates underwater piling from barges or drill platforms
- Injection bored CTS/TITAN micropiles provide a range of working loads from 29.7 kips (132 kN) to 1,169 kips (5,200 kN)
- No harmful vibrations or noise
- Minimal spoil

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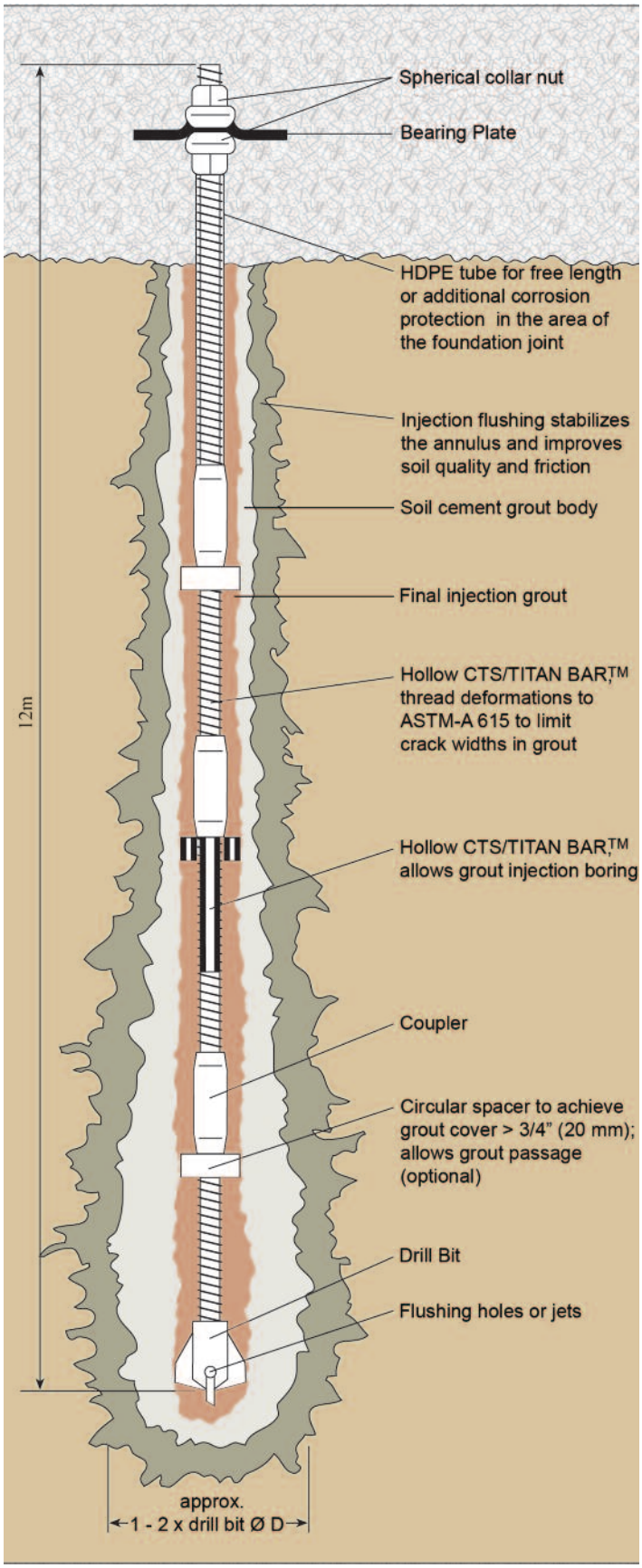
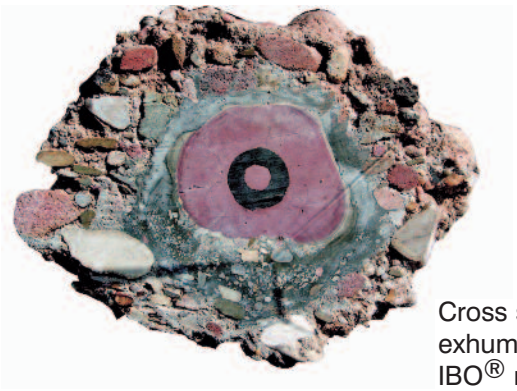
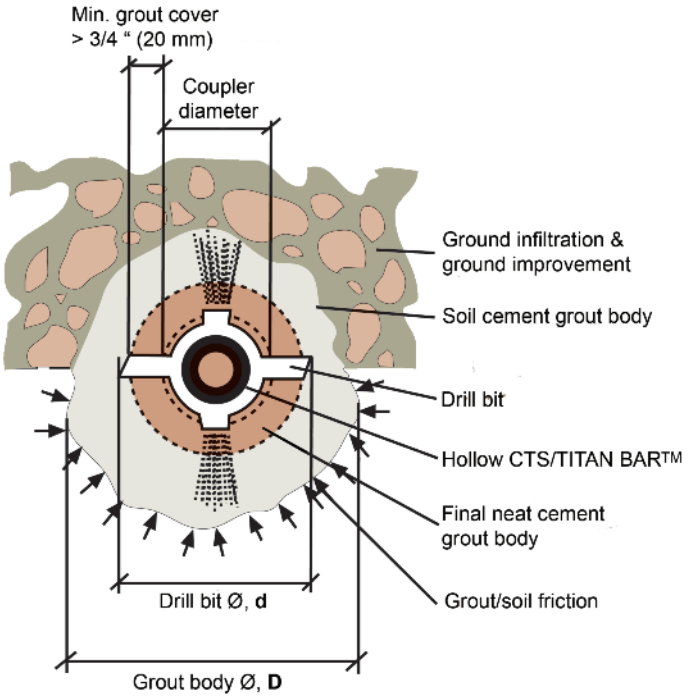




Cross section of exhumed CTS/TITAN IBO® micropile



Grout Body Diameter, D, in different Soils

D ≥ 2.0 x d for medium & coarse gravel
1.5 x d for sand & gravelly sand
1.4 x d for cohesive soil (clay, marl)
1.0 x d for weathered rock

d: Drill bit diameter

Please Note:
The above illustration is based on actual tests and experiences using the CTS/TITAN IBO® system installed with appropriate drilling and grouting equipment.

Micropiles for new foundations

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Reticulated Micropile Wall

Owner: CN Rail
Contractor: Geo-Foundations Contractors Inc.
Location: Ontario, Canada

Installation of an array of 125 micropiles 39.4' (12 meters) deep, with half of them vertical while the other half are inclined towards the core of the embankment. The piles are then tied into a 203' (62 meter) long reinforced concrete beam. Project was completed without interruption to the rail traffic.

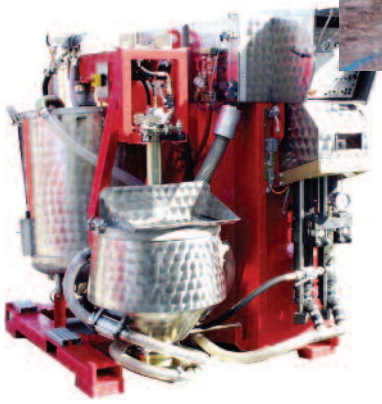
Phoenix Sky Harbor Airport Terminal 4 Expansion

Contractor: Scheffler Nevada Corp.
Location: Phoenix, AZ

CTS/TITAN IBO® micropile foundation

Obermann Grouting Stations

VS 110 (left) and VS 63 grouting stations for flushing and grouting of micropiles



Micropiles for structural underpinning

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The White Sands of La Jolla

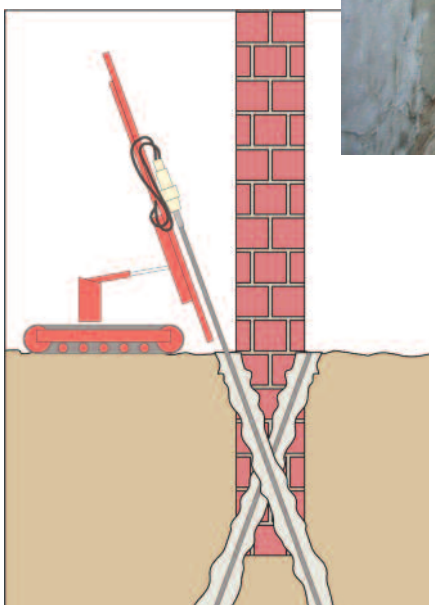
Owner: Southern California Presbyterian Home Owners
Contractor: Condon Johnson, San Diego, CA
Location: La Jolla, CA

Underpinning of soil nail shoring wall

Titan Micropiles for Underpinning

General Cont.: Levine Builders
Engineer: Mueser Rutledge Consulting Engineers
Found. Cont.: Moretrench
Location: New York City, NY

Moretrench installed hollow CTS/TITAN BARS™ 40/16 at 28 locations for micropiles. The 55' (17 m) long micropiles, underpin a turn of the century, two story, brick warehouse. The underpinning was necessary because of excavation work for the construction of a new building adjacent to the existing warehouse.



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Utah State Capitol Building

Contractor: Becho Inc.
Engineers: Geotechnical Design Services INC.
Location: Salt Lake City, Utah

Largest micropile installation in the USA (over 3000) for seismic base-isolation and restoration.

LDS Church Temple Square

Owner: LDS Church
Contractor: Becho Inc.
Engineers: Geotechnical Design Services INC.
Location: Salt Lake City, Utah

Tabernacle seismic upgrading and renovation using CTS/TITAN IBO® micropiles.

Micropiles for tower bases

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Wind Turbine Tower Foundations

Contractor: Pacific Industrial Electric, Brea CA

Wind turbine foundations for NEGMICON 54/950 kW wind turbine generators on 180' (55 m) towers using CTS/TITAN IBO® 52/26 anchors for micropiles.

Foundation of Blast Resistant Enclosures

Numerous Job-Sites

Security tower bases using CTS/TITAN IBO® 73/45 anchors for micropiles.

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Internal carrying capacity

The internal carrying capacity is influenced by friction behavior, crack width limitation and corrosion protection. The reinforcement type thread of the hollow CTS/TITAN BAR™ conforms to ASTM A-615 and other international standards. The related rib area of 0.13 is very close to the maximum values for reinforcing bars. Consequently, optimum bond is achieved as in reinforced concrete. **This is a unique feature of the CTS/TITAN IBO® micropile.**

Corrosion protection

As with reinforced concrete these ribs induce a uniform crack distribution in the grout. Investigations by the University of Munich on excavated grout bodies reinforced with hollow CTS/TITAN BARS™ 30/11 have shown that up to 125% of the design load (according to DIN) the characteristic crack widths are below the permissible value of 0.004" (0.1 mm) as required by ASTM A-615 and other international standards. This proves that the system complies with DIN 4128 9.2 and that the corrosion protection with minimum grout cover of 3/4" (20 mm), as with reinforced concrete, is sufficient for permanent piles

Internal carrying capacity fully utilized

The internal carrying capacity derived from the yield load can be fully utilized for permanent tension piles.

External carrying capacity

For the dimensioning of the load bearing length, L , of a pile with grout body diameter, D, the external carrying capacity is critical. It is determined by the ultimate soil friction, q_{sk}, the surface area of the grout body and a safety factor, according to DIN 4128 table 2.

End bearing capacity of the CTS TITAN IBO® micropile can be ignored. Ultimate skin friction values should be derived from site investigations and tests. DIN (German Industrial Standard) V 1054-100 table F1 offers conservative q_{sk} values for some soil types:

Type of soil	Ultimate skin friction q_{sk}	
	psi	kN/m^2
Medium to coarse gravel[1)]	29	200
sand and gravelly sand[1)]	21.75	150
cohesive soil[2)]	14.5	100

[1)] D ≥ 0.4 resp. q_{ck} ≥ 1.45 ksi (10MN/m^2)
[2)] Ic ≈ 0.1 resp. c_{uk} 14.5 psi (100 kN/m^2)

Buckling

According to DIN 4128 9.3 calculations for buckling have only to be done if the undrained shear strength of the soil Cu is below 1.45 psi (10 kN/m^2). Critical cohesive soils according to E9 EAU are:

Type of Soil	Shear Strength Cu	
	psi	kN/m^2
clay, soft & easily kneadable	1.45 - 3.6	10 - 25
loam, soft	1.45 - 3.6	10 - 25
chalk	1.45 - 7.25	10 - 50
clay	1.45 - 2.9	10 - 20
peat	0.73 - 1.45	5 - 10

For references on standards and principal tests performed, please contact us or visit our Web-Site at **www.micro-piles.com**.

1 mm = 0.03937 in 1 m = 3.281 ft 1 MPa = 0.145 ksi 1kN/m^2 = 0.02088 kips/sqft

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Load bearing length, L, for tension or compression piles

$$L = \frac{F_W \cdot S}{\pi \cdot D \cdot q_{sk}}$$

Fw	Safe working load
S	Safety factor
π	3.142
D	Grout body diameter
q_{sk}	Ultimate skin friction

Example:

Required load:	22.5 kips
Material:	sand
Drill bit diameter, d:	4.4”
Ultimate skin friction q_{sk}	21 psi

1) Grout body diameter, D:
D = d · (enlargement factor for sand)
The enlargement factor for sand is 1.5 (please see page 3).

2) Load bearing length, L:

$$L = \frac{(22.5 \text{ kips} \cdot 1000) \cdot 3}{\pi \cdot (4.4 \text{ inch} \cdot 1.5) \cdot 21 \text{ psi}}$$

$$L \geq 155 \text{ inch} = 12.9 \text{ ft}$$

Load bearing capacity, F_{CP}, of compression only piles

Compression only piles have the ability to spread the load over the steel section and the grout body as a composite pile.

Example:

CTS/TITAN BAR™	52/26
Outer bar diameter	2”
Ultimate strength of bar, **F_U**	209 kips
Drill bit diameter, **d**	6.9”
Enlargement factor for ground (conservative estimate)	1
Grout compressive strength **G_C** after 28 days	5.8 ksi

Load taken on grout (conservative estimate)

$$F_G = A_G \cdot \frac{G_C}{4}$$

F_G	Load taken on grout
A_G	Grout area
G_C	Grout compressive strength

The area of the grout is calculated as the area of the grout body minus the steel area. (In the example, the grout body diameter is assumed to be the same as the drill bit diameter):

$$A_G = ((6.9)^2 - 2^2) \cdot \frac{\pi}{4} = 10.9 \cdot \pi \text{ inch}^2$$

Consequently, the load taken by the grout is

$$F_G = 10.9 \cdot \pi \cdot \frac{5.8}{4} \text{ kips}$$

$$F_G \approx 50 \text{ kips}$$

The Design Load taken on steel, F_S

$$F_S = F_U \cdot 0.6$$

becomes, with the ultimate strength F_U of the CTS/TITAN BAR™ 52/26,

$$F_S = 125 \text{ kips}$$

The total working load, **F_{CP}**, of the pile in this conservative estimate is

$$F_{CP} = F_G + F_S \approx 50 + 125 \text{ kips or}$$

$F_{CP} \approx$ 175 kips

Please Note: These examples are applicable to CTS/TITAN IBO® micro piles only. Design requirements and safety factors may vary.

Drilled and pressure grouted micropiles

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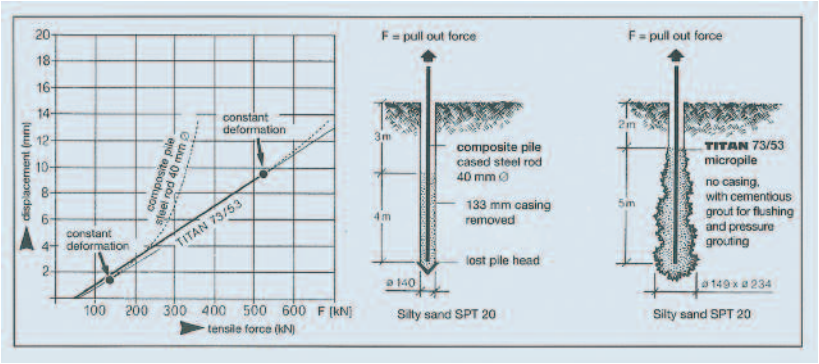
Load deformation chart of 7m (23 ft) long grouted piles

Load deformations are compared in the same silty sand for a solid steel bar 40 mm (1 1/2") diameter with cased hole and a CTS/TITAN IBO® 73/53 (2 7/8" / 2 1/8") micropile with grout flushing W/C ratio 0.7 and final grout W/C 0.4 pressure grouted at max. 60 bar (870 psi).



Installation procedure for CTS/TITAN IBO® micropiles

To utilize the CTS/TITAN IBO® micropiles to their full potential, it is essential that they are installed properly. We do not advise using air instead of grout while drilling, as it will potentially lead to reduced skin friction of the finished pile.

Please contact Con-Tech Systems Ltd. for best practices when installing CTS/TITAN IBO® micropiles.

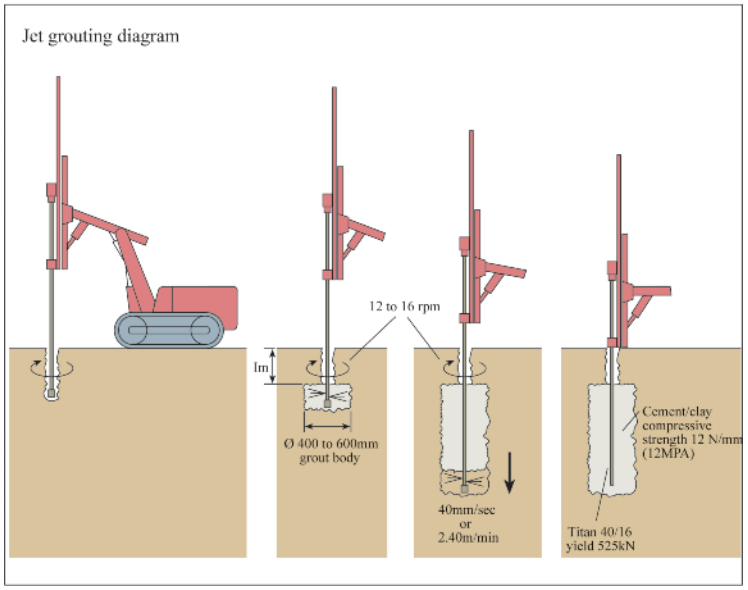
Mini jet grouting

In order to install a working micropile in plastic clays and/or silty (SPT 3-4) conditions, Ischebeck Titan mini jet grouted micropiles can be used.

The system involves installing the pile without grout for the first 3 feet (1 meter) and then injecting a grout mix with a W/C ratio in the range of 0.8, at a grout pump pressure of up to 2900 psi (200 bar).

A grout body in the order of 15 3/4" (400 mm) to 23 5/8" (600 mm), with a compressive strength of 1.7 ksi (12 MPa) can be achieved in these ground conditions.

The 40/16 CTS/Titan IBO® micropile, together with a 4 3/8" (110 mm) hardened clay drill bit with adapted nozzles, is used for this application.



1 mm = 0.03937 in 1 m = 3.281 ft 1 MPa = 0.145 ksi 1kN/m^2 = 0.02088 kips/sqft

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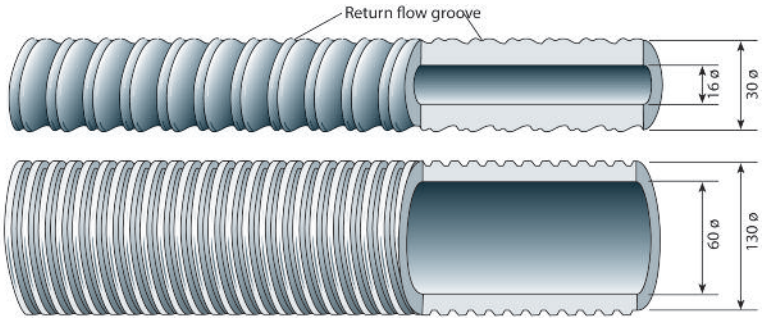
Product specifications

Ischebeck hollow CTS/TITAN BAR™ type denotes external diameter of bar followed by its internal diameter. For example, a Titan 30/16 bar has an external diameter of 30mm and an internal diameter of 16mm.



Bar Type	Unit	30/16	30/14	30/11	40/20	40/16	52/26	73/56	73/53	73/45	73/35	103/78	103/51	127/111	130/60
Nom. outside dia.	mm	30	30	30	40	40	52	73	73	73	73	103	103	127	130
Nominal Inside dia.	mm	16	14	11	20	16	26	56	53	45	35	78	51	111	60
Ultimate load	kN	220	260	320	539	660	929	1194	1160	1630	1980	2282	3460	2400	7940
Yield Point	kN	180	220	260	430	525	730	785	970	1180	1355	1800	2750	1810	5250
Yield Stress	N/mm^2	471	557	583	592	597	546	555	594	522	500	572	500	603	550
Cross Section	mm^2	382	395	446	726	879	1337	1414	1631	2260	2710	3146	5501	3000	9540
Weight	kg/m	2.7	2.9	3.3	5.6	7	10	11.1	12.3	17.8	21.2	24.9	43.4	23.5	75
Thread direct.	-	left	left	left	left	left	left	right	right	right	right	right	right	right	right
Lengths	m	3/4	3/4	3/4	3	3	3	6.25	3	3	3	3	3	3	3

The ultimate load at yield (or the corresponding load which occurs at a constant elongation of 0.2%) was tested by MPA, (the material testing institute of the state of Northrhine Westfalia, Dortmund/Germany). This also applies to the cross sections. Above figures are valid for INOX anchors as well. The stresses mentioned were calculated from the load and cross section values of MPA.

Key features

1. **Utilization of a steel hollow bar as the tendon** From the static point of view, a hollow bar is superior to a solid rod of the same cross sectional area with respect to bending moment, shear resistance and surface bond/friction.

2. **Hollow TITAN BAR™ is manufactured from high yield micro alloy high quality structural steel offering** high notch toughness > 39J. This steel is not affected by hydrogen embrittlement or by stress crack corrosion.

3. **The threads on hollow TITAN BAR™ are formed much like the ribs on a reinforcing bar fabricated according to DIN 488 & ASTM-A 615.** The deep Titan threads result in 2.4 times higher bond friction compared to standard drill steel coil-threads of R 32 (1¼") or R 38 (1½")

4. **Continuous threads guarantee the TITAN BAR™ can be cut or coupled anywhere along its length.** Cutting, extending, pre-stressing and load releasing on the tendon are possible. A thread pitch of 6° eliminates the need for locking nuts at each coupling.

1 mm = 0.03937 in 1 m = 3.281 ft 1 kN = 0.225 kips 1 N/mm^2 = 0.145 ksi 1kg/m = 0.672 lbs/ft

Contacts

Tom Miller Dam, Texas, USA
Owner: Lower Colorado River Authority
Engineer: Freese and Nichols
Contractor: Nicholson Construction

CTS/TITAN IBO® 40/20 Stitch Anchors , installed under Water

Con-Tech Systems Ltd.

Head Office and Western Division
8150 River Road
Delta, BC V4G 1B5, Canada
Toll Free: 1-888-818 4826
Fax: 604 946-5548

Plants: Delta, BC; & Blaine, WA

Eastern Division
4502 Hanna Drive
Elizabethtown, ON K6T 1A9
Canada
Tel: 613 342-0041
Fax: 613 342-0609

East Stroudsburg, PA USA
Tel: (570) 872-9090
Fax: (570) 872-0901
Cell: (570) 807-9617

Charlotte, NC USA
Toll Free: 1-866-848-6800
Cell: 704 506-8472
Cell: 727 992-4142

Plants: Elizabethtown, ON &
Charlotte, NC

World Wide Web
www.contechsystems.com

E-Mail
Western Division
ctswest@contechsystems.com

Eastern Division
ctseast@contechsystems.com

Con-Tech Systems Ltd.

Ver: 1208