

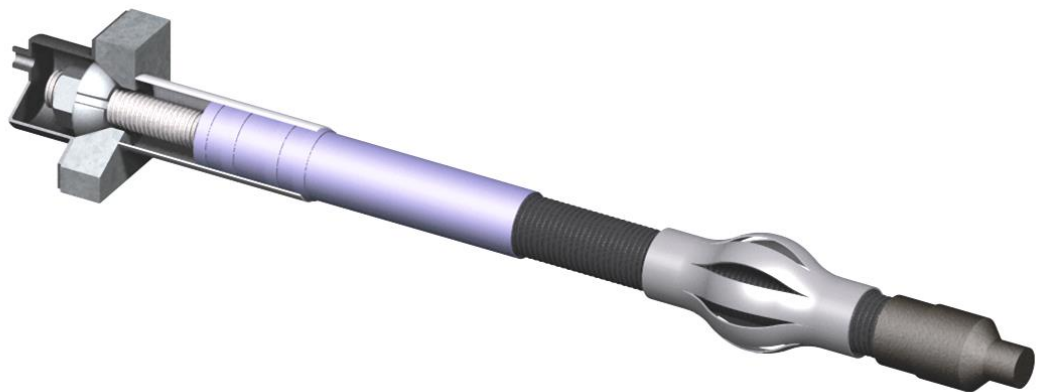


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**FREYSSINET PRODUCTS CO.**

PRODUCT DESCRIPTION

Geotechnics  
Freyssibar  
permanent ground  
anchors



Ref: BGT-010  
Revision: 0  
November 2017



**FREYSSINET**  
SUSTAINABLE TECHNOLOGY

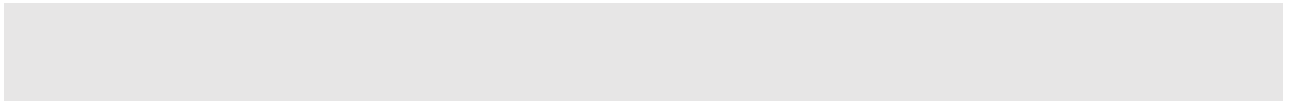
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## REVISION INDICES FOLLOW-UP TABLE

Rev	Date	Modification	Prepared by	Checked by	Approved by
0	16/11/17	First issue	C. GAUCHERAND	F. ROBERT	E. THIBOEUF



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# 1. INTRODUCTION

## 1.1. Scope of the document

This document is intended to describe the product in term of design, manufacturing and inspection.

## 1.2. Geotechnics

The Freyssinet Group is the world leader in specialized civil engineering, working in two fields: structures and soil. The soil activities include ground anchors, soil nails, rock bolts, micropiles and port tie-rods. As part as these activities, Freyssinet supplies Freyssibar Permanent Anchors.

The Freyssinet Group is organized in geographical zones around the world with strong local roots, with 70 bases in more than 50 countries. It is a subsidiary of Vinci Construction, world leader in construction and associated services, which combines almost 2,500 companies in more than 100 countries all around the world.

The Freyssibar Permanent Anchors developed by Freyssinet are designed to answer several standards and world normative requirements but also the environmental requirements specific to this type of product. FPC is the industrial branch of the Freyssinet Group and its headquarters are located in St. Eusèbe (France), from where the manufacturing of Freyssinet products (pre-stressing, stay cables, bridge fittings, geotechnical products, etc.) is organized and controlled.

To cope with the increasing demand of all the Freyssinet subsidiaries in the world, FPC has developed an important network of production facilities all over the world, implementing the same Quality Control System worldwide, in accordance with International Quality Standards.

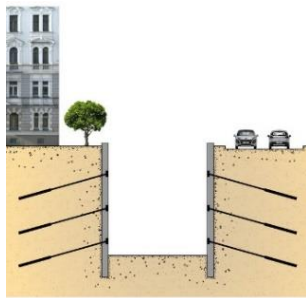
As a result of this group strategy of procurement network, the Freyssinet subsidiaries have improved their services worldwide, and offer flexible and reactive solutions to their clients' needs.

### 1.3. Ground anchors scope of use

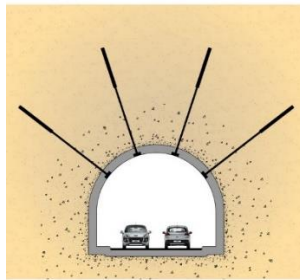
The Freyssibar Permanent Anchors are mainly used for stabilization of slopes, retaining walls and anchorage of structures.

Developed by Freyssinet, the Freyssibar Permanent Anchor is made of Freyssibar and its associated anchorages and couplings.

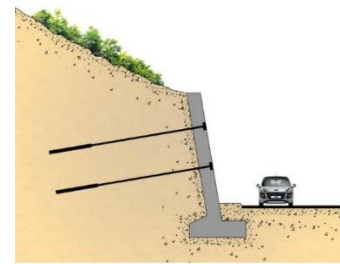
The typical cases are detailed below:



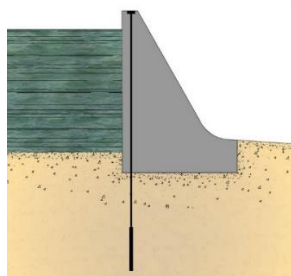
Excavation



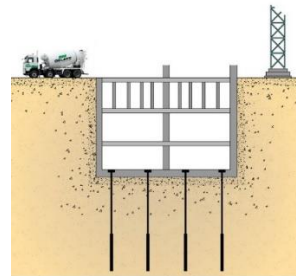
Tunneling



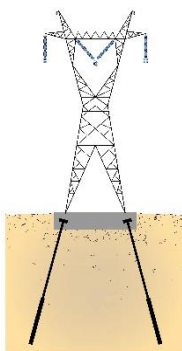
Slope stabilization



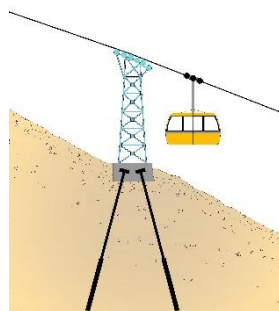
Dams



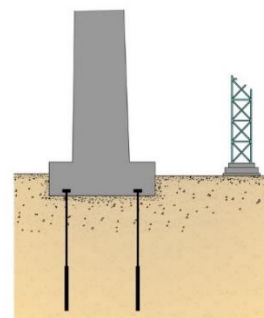
Hydrostatic uplift loads



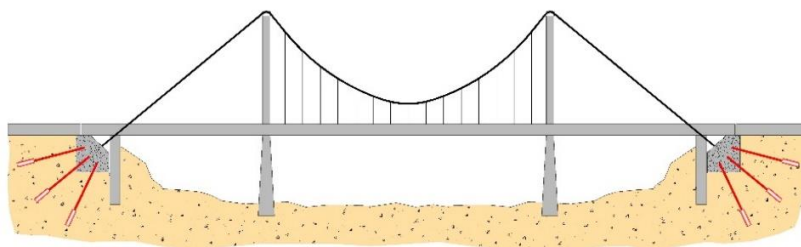
Pylons



Cable cars



Wind mills



Suspended bridges

## 1.4. Design

The Freyssibar Permanent Anchor system complies with EN1537. The design is specific to Freyssinet. It can be adapted upon request.

## 1.5. Manufacturing

As Freyssibar Permanent Anchors are manufactured by Freyssinet, all customers will receive the same level of excellence and quality in the products and services. This complete control over our products and systems means that we can adapt our solutions to a wide range of applications and extreme operating conditions.

## 1.6. Installation

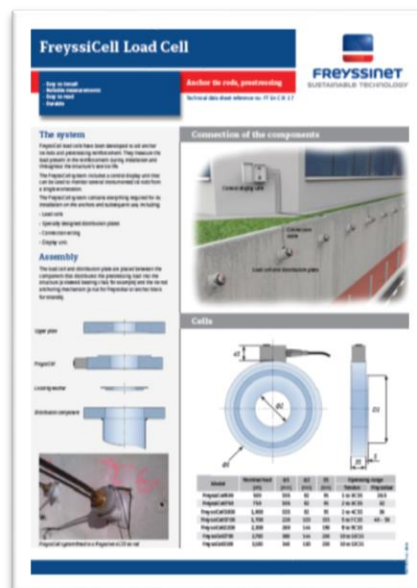
Installation is generally carried out by the customer. Special attentions are detailed in chapter 6.

## 1.7. Surveillance

Like any other system, the surveillance must be defined by the contractor depending on the scope of use.

Also, the anti-corrosion protection ensures durability.

A monitoring of the anchors is generally installed, according to the Freyssicell technical data sheet:



See chapter 3.4.2



## 2. APPLICABLE DOCUMENTATIONS

### 2.1. Specific documentation

The use of the Freyssibar Permanent Anchor is inseparable from the following documentation (last version):

- Internal Technical Specification : PB1030-SPA-001
- ETA-09/0169
- EN1537: Execution of special geotechnical work – Ground anchors

### 2.2. Standards for components

FPC has analyzed all standards in order to satisfy the specific requirements of each norm. FPC uses the same equivalent material standard when it's possible in order to optimize the price of raw material. The system complies with geometrical, mechanical and technological requirements as defined by most of the relevant national and international standards.

#### 2.2.1. Bars Freyssibar

Designation	Applicable standard	Material
Bars	prEN 10138 CSP AP Rc1 ASTM A722-12	Hot rolled Si-Al killed chrome-vanadium alloy steel

#### 2.2.2. Accessories

Designation	Applicable standard	Material
Bearing plates	EN10025-2	Grade S275 or S355 flame cut or cold sheared
Plastic caps	Freyssinet Specifications	30% glass fiber reinforced PA 6
Nuts	BS970 EN10083-2	Grade 070M55 Grade C45/C50/C55
Washers	EN10025-3	S460NL
Sleeves	BS970 EN10083-3 or equivalent	Grade 817 M 40 36CrNiMo4 / 34CrNiMo6 / 30CrNiMo8 or equivalent

### 2.3. Standards for manufacturing

Designation	Applicable standard
Geometrical characteristics (when not mentioned) (bars & accessories)	Drawings
Mechanical & Chemical characteristics (bars)	Freyssinet Specifications
Mechanical & Chemical characteristics (accessories)	EN10025

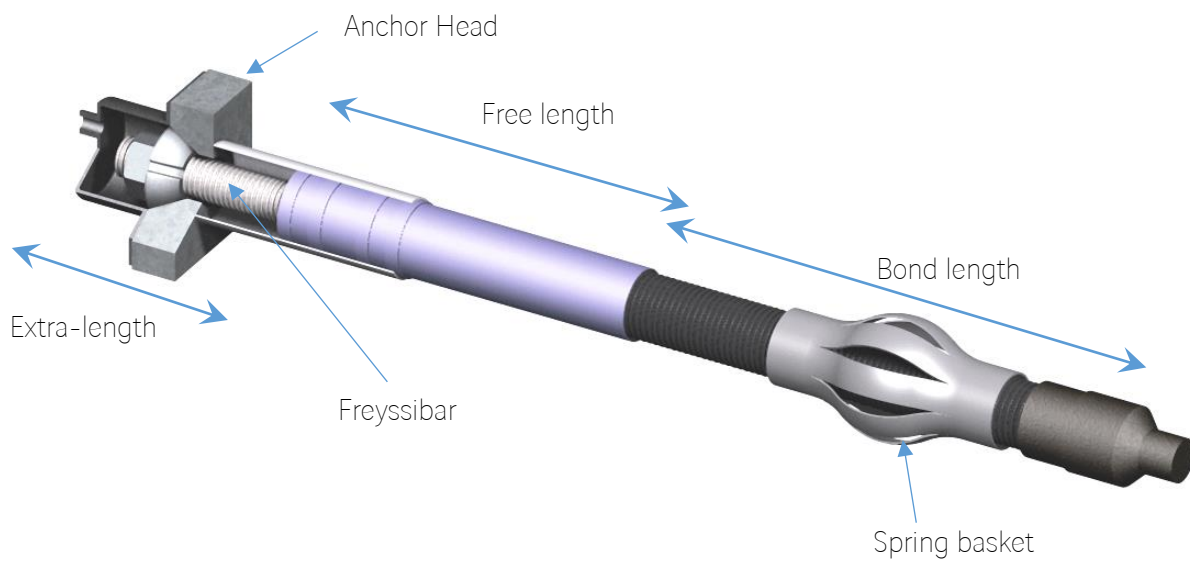
### 2.4. Standards for control

Designation	Applicable standard
Visual examination of welds	EN ISO 17637 / EN ISO 5817
Mill certificates for bars, nuts and couplers	Certificate 3.1 according to EN10204

### 3. DESCRIPTION OF THE FREYSSINET TIE RODS SYSTEM

#### 3.1. Overview

The system is called "Permanent Freyssibar Anchor". The tendon and the anchor head components are coming from the Freyssinet post-tensioning system "Freyssibar". The corrosion protection of the anchor body consists of a corrugated sheathing, filled with cement grout at the factory. On the free length (if there is), the corrugated sheath is covered with a smooth duct. This insures a perfect corrosion protection of the ground anchor.



The bars are limited to 11.80m length. For longer ground anchors or for installation reasons, the anchor body can be made of several single elements linked together with couplers.

### 3.2. Bars

The bars are hot rolled from high strength alloyed steel. They are subsequently threaded over their full length or on the extremities by cold rolling and then cold worked by stretching. The standard range includes nominal diameters below. Non-standard diameter bars can be supplied on request.

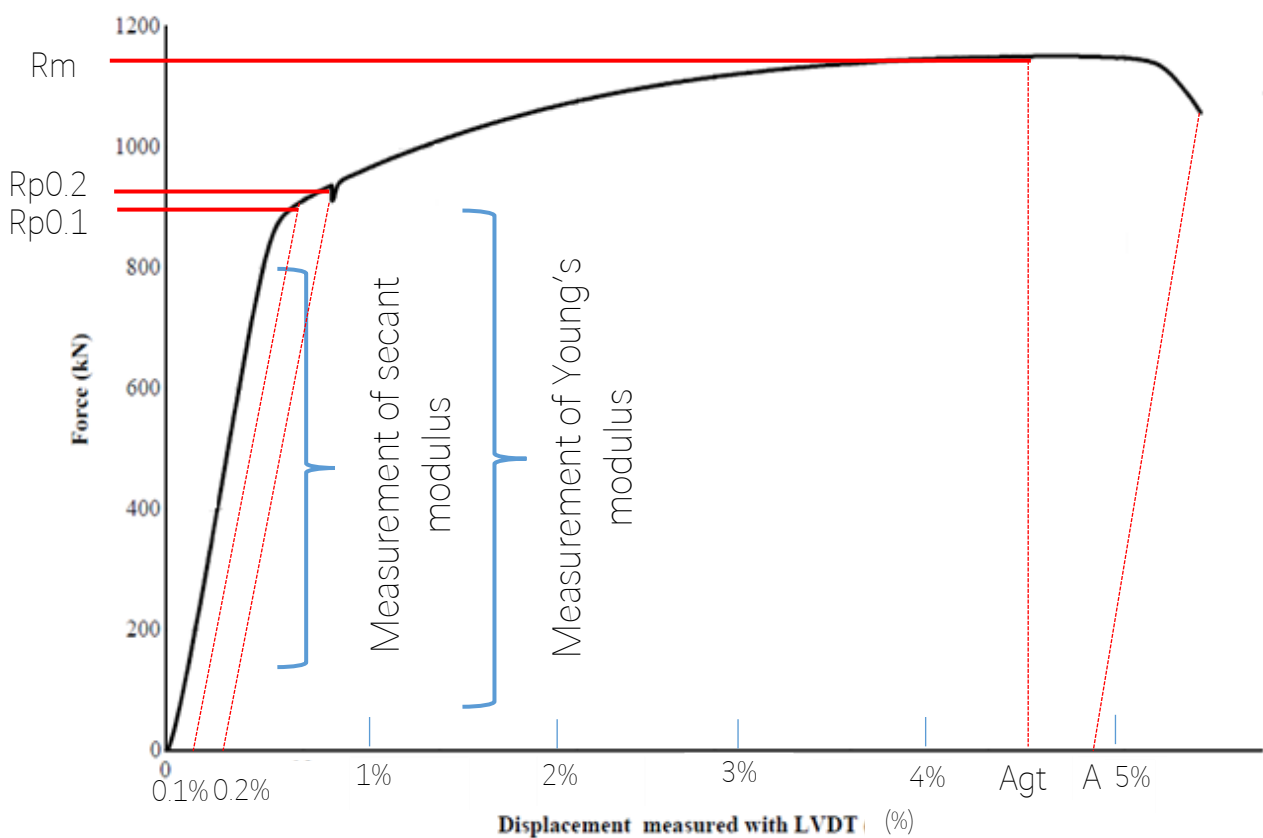
Characteristic	Unit	Nominal diameter (mm)				
		26.5	32	36	40	50
Steel grade	MPa	1030	1030	1030	1030	1030
Cross section area	mm <sup>2</sup>	552	804	1018	1257	1964
Linear Mass	kg/m	4.56	6.66	8.45	10.41	16.02
External diameter	mm	30.3	36.1	40.1	45.3	55.1
Characteristic value of maximum Force : Fpk	kN	568	828	1048	1295	2022
Characteristic value of 0.1% proof force : Fp0.1%	kN	461	672	850	1049	1640
Maximum tensioning force According to EN (0.9*Fp0.1%)	kN	414	604	765	944	1475
Thread pitch	mm	6	6	6	8	8
Average Secant's modulus	GPa	170	170	170	170	170
Minimum elongation at maximum force (Agt)	%	3.5	3.5	3.5	3.5	3.5
Certification	/	<b>CE</b>	<b>CE</b>	<b>CE</b>	<b>CE</b>	<b>CE</b>

Note on modulus of elasticity:

Young's modulus and Secant modulus are properties of steel. They are directly related to the way the steel is manufactured. They are not exactly measured the same way. The secant modulus is measured between 5% and 70% of  $F_{pk}$  (characteristic breaking load) which is a linear interpolation of the slope in this part. In the AS standard for Australia the secant modulus is measured between 20% and 70% of  $F_{pk}$ .

The Young modulus is calculated on the linear part of the tensile test graph curve. For a same sample, the secant modulus and the Young's modulus can be different because of their way of measurement.

For Freyssibar, the Secant Modulus is the only reference in term of modulus of elasticity.



### 3.3. Anchor body

The bars are delivered already encapsulated in a corrugated sheathing full of cement grout. The ground anchor can be made of on single element or several elements, connected together with couplers. The layout, including the length of each element, must be define before delivery.

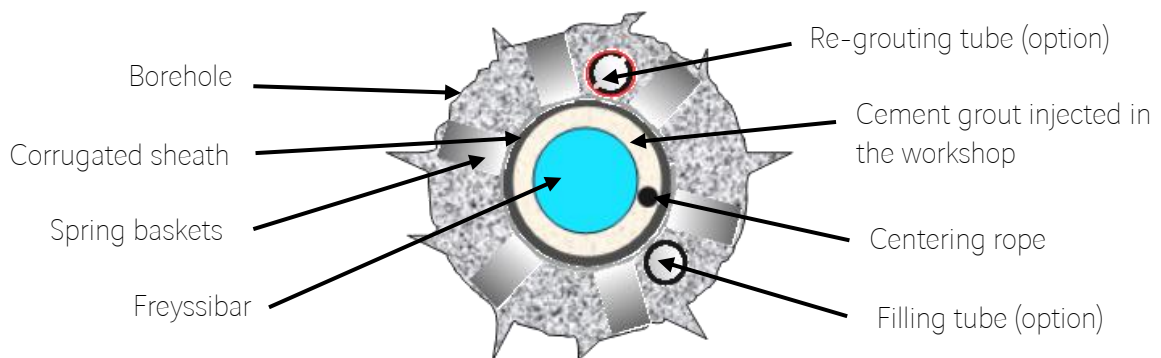
#### 3.3.1. Extra length

In order to install the anchor head and allow stressing, a clearance, not protected, shall be provided. This clearance is called extra length.

#### 3.3.2. Bond length

The bond length consists of Freyssibar, embedded in cement grout, approved for the anticorrosive protection of prestressing steels. This cement is itself contained in a sealed corrugated sheath. During tensioning, the stresses induced in the bar are transmitted to the protective grout, then to the grout and to the ground, after having passed through the corrugated sheath ribs.

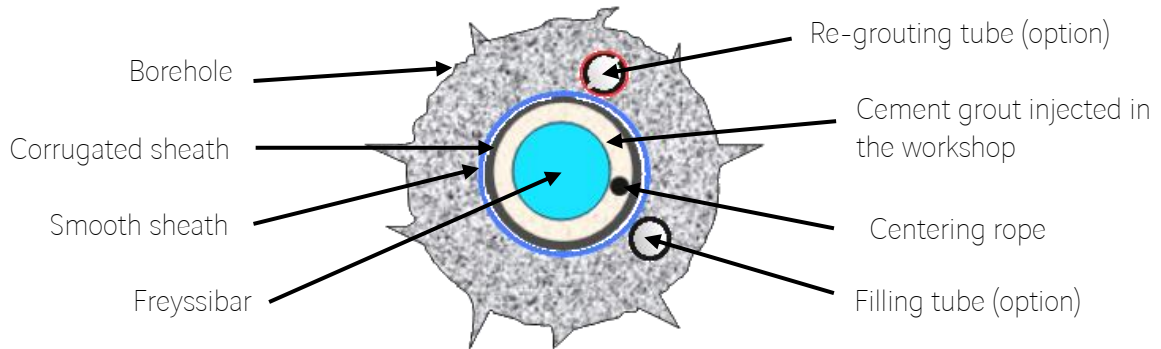
In order to guarantee a minimum 5 mm cement coating on the inside of the sheath at all points of the reinforcement, a polyethylene rope with a diameter of 6 mm (minimum) is placed as an helix around the FREYSSIBAR. The minimum 10 mm grout cover around the ground anchor is ensured by trough spacers placed every 2 meters.



Nominal Diameter (mm)	26.5	32	36	40	50
External diameter on bond length	60	60	65	80	80

### 3.3.1. Free length

On the free length, the FREYSSIBAR is protected exactly as on the bond length. A smooth sheath is used to cover the corrugated sheath in order to guarantee the longitudinal freedom of movement of the ground anchor. When the bar is stressed, it can extend freely, resulting in micro cracking of the cement grout contained in the corrugated sheath. Since micro cracks have a very small width, the anti-corrosion protection of the bars is perfectly ensured

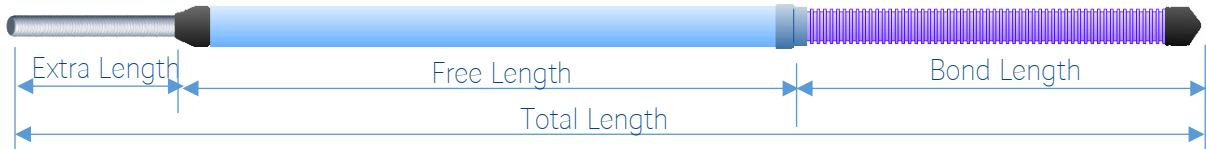


Nominal Diameter (mm)	26.5	32	36	40	50
External diameter on free length	75	75	75	90	90

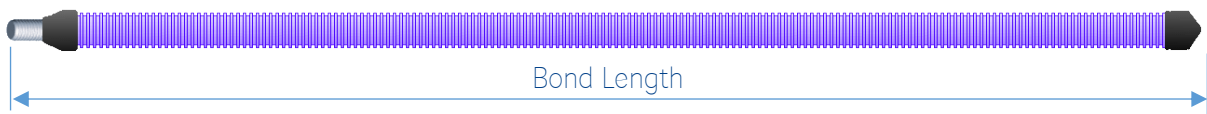
### 3.3.2. Prefabricated elements

The customer must define the different prefabricated elements necessary for his project among the typical arrangement presented below:

Single element



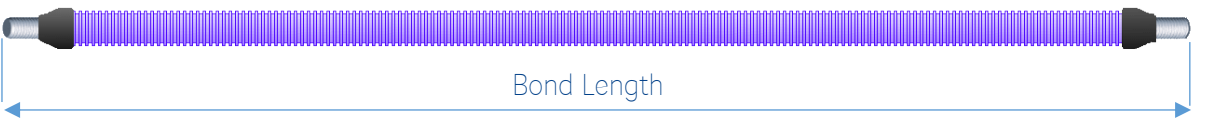
Foot element



Head element



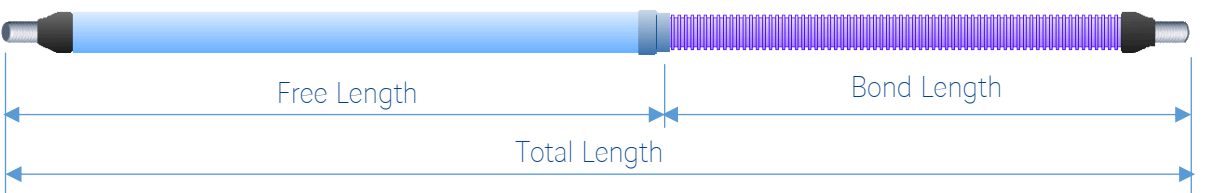
Middle element with bond length



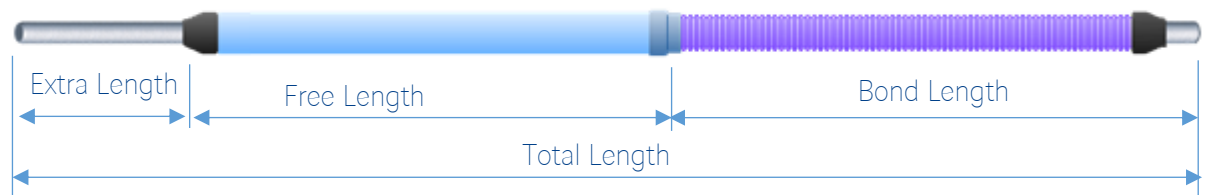
Middle element with free length



Middle element with bond and free length



Head element with bond length

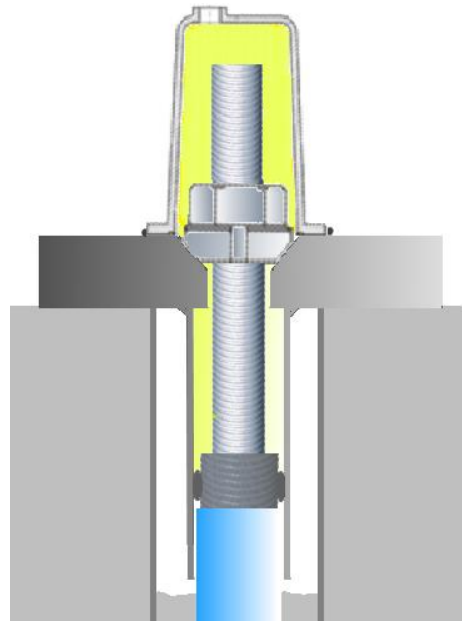




### 3.4. Anchor head

#### 3.4.1. Standard

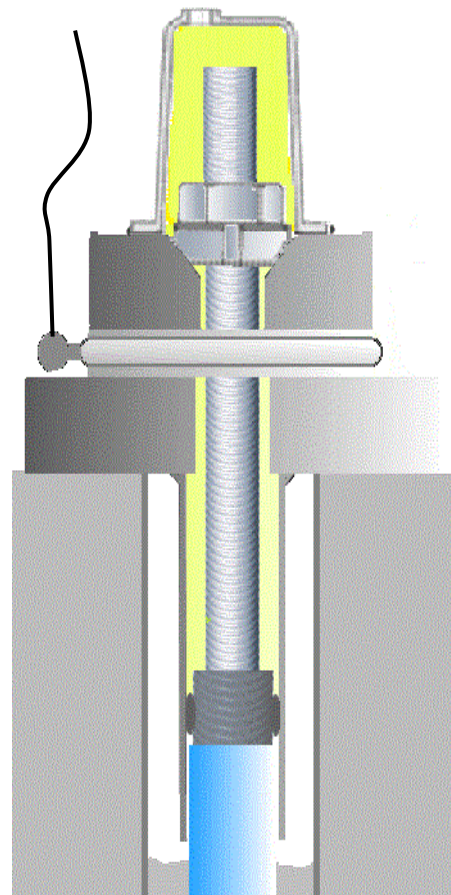
A standard anchor head is made of a plate, mounted on the extra length of the ground anchor, a joint positioned at extra length of the ground anchor. The overall is protected with a trumpet tube filled with wax. A cap is screwed and also filled with wax. The clearance of the bar behind the nut allows stressing.



#### 3.4.2. Monitored

A load cell is placed between the anchor plate and a bearing plate. It is connected to the reading device according to the standard solution shown in the technical data sheet FREYSSICELL.

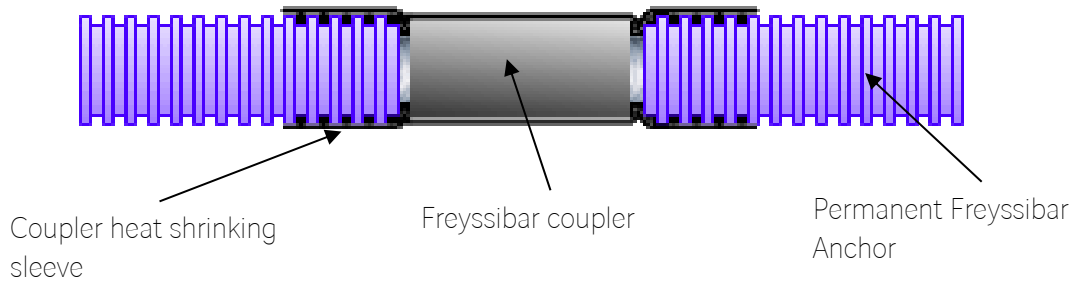
If the anchor head is totally confined in a recess, a special cap must be installed, covering the load cell and the cap.



### 3.5. Coupling

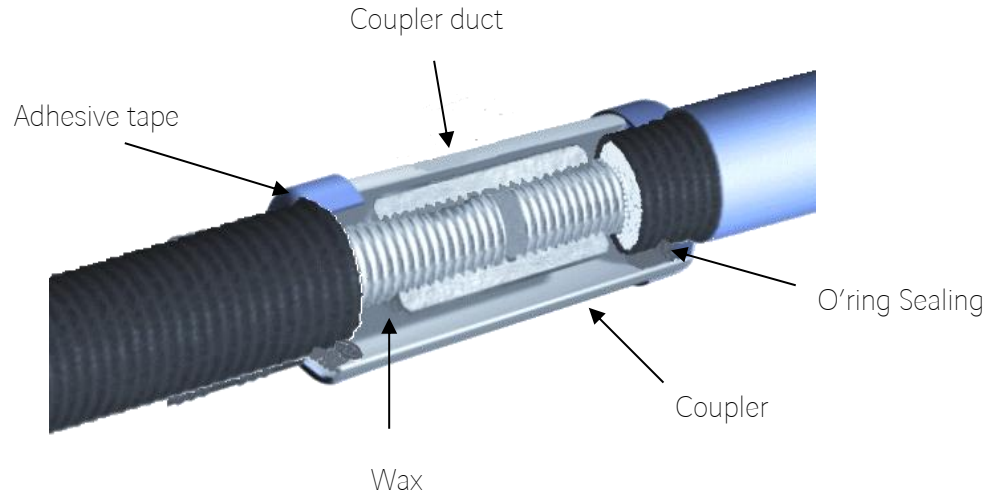
The coupling is used for connecting the prefabricated elements of the anchor. The length of every single element is limited at 11,80 m, and can be reduced in difficult installation conditions.

#### 3.5.1. On bond length



On the bond length, the corrosion protection of the coupling is done by a special heat shrinking sleeve. It insures the corrosion protection and the bonding of the tendon on this area

#### 3.5.2. On free length



The coupler is covered by a duct filled with wax.  
This duct also covers the corrugated duct of the anchor body.

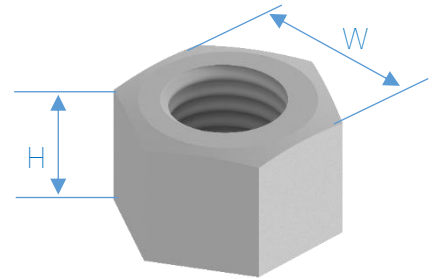
### 3.6. Components

#### 3.6.1. Nuts & washers

Different nuts and washers can be used :

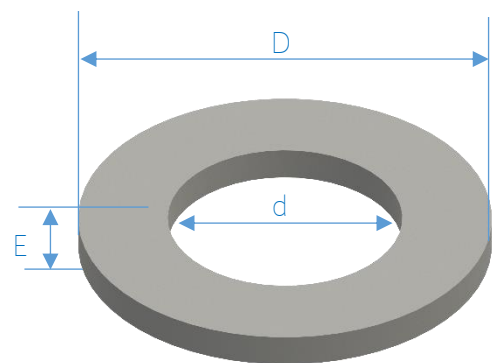
Nut for flat anchorage

Dimensions	Unit	Nominal bar diameter (mm)				
		26.5	32	36	40	50
H	mm	37	41	46	55	71
W	mm	50	56	62	65	90



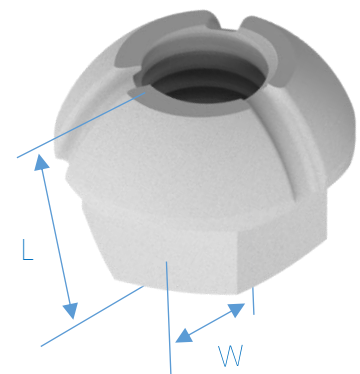
Washer for flat anchorage

Dimensions	Unit	Nominal bar diameter (mm)				
		26.5	32	36	40	50
E	mm	6	6	6	6	6
Ø Dext	mm	65	70	75	80	105
Ø Dint	mm	32.5	38.5	42.5	48.5	58



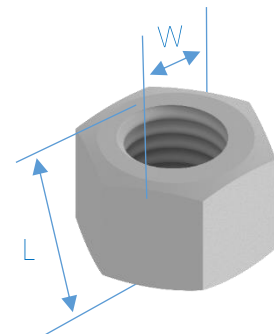
Spherical nut type 1

Dimensions	Unit	Nominal bar diameter (mm)				
		26.5	32	36	40	50
L	mm	45	51	56	60	85
W	mm	50	56	62	65	90



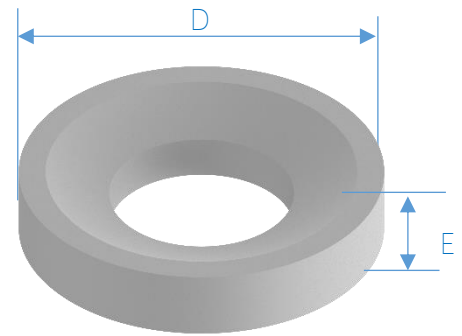
Spherical nut type 2

Dimensions	Unit	Nominal bar diameter (mm)				
		26.5	32	36	40	50
L	mm	34.5	38.3	46.0	55.2	70.3
W	mm	50	56	62	65	90



Spherical washer for type 2 anchorage

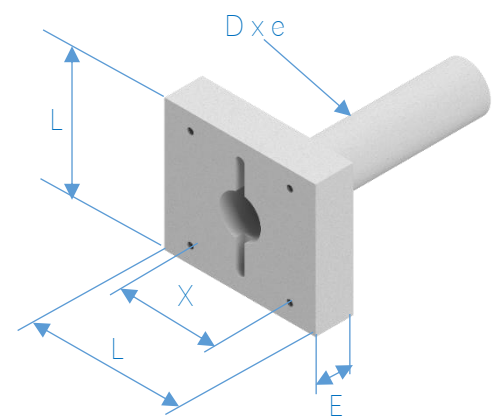
Dimensions	Unit	Nominal bar diameter (mm)				
		26.5	32	36	40	50
External diameter	mm	75	80	90	95	125
E	mm	10	10	10	10	15



### 3.6.2. Bearing plates

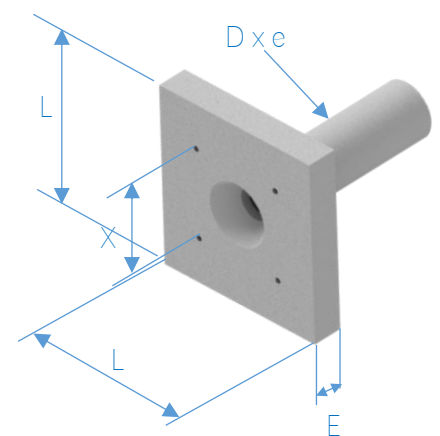
Bearing plate for flat and type 2 anchorage

Dimensions	Unit	Nominal bar diameter (mm)				
		26.5	32	36	40	50
L x L	mm	200	200	200	220	250
E	mm	30	35	40	45	50
X x X	mm	90	90	105	105	145
D x e	mm	88,9x3,2	88,9x3,2	88,9x3,2	88,9x3,2	101,6x36



Bearing plate for type 1 anchorage

Dimensions	Unit	Nominal bar diameter (mm)				
		26.5	32	36	40	50
L x L	mm	200	200	200	220	250
E	mm	30	35	40	45	50
X	mm	90	90	105	105	145
D x e	mm	88,9x3,2	88,9x3,2	88,9x3,2	88,9x3,2	101,6x36



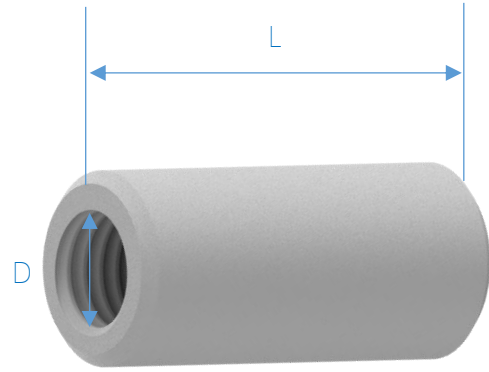
Plates are delivered without corrosion protection

Options :

Painting or any other corrosion protection on request

### 3.6.3. Coupler

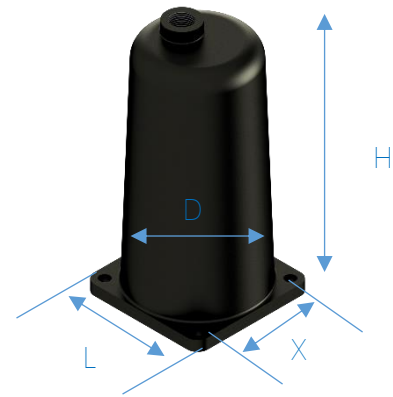
Dimensions	Unit	Nominal bar diameter (mm)				
		26.5	32	36	40	50
D	mm	45	50	60	65	76
L	mm	90	115	130	140	170



### 3.6.4. Caps

Long plastic cap

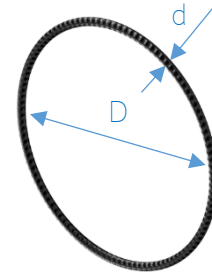
Dimensions	Unit	Nominal bar diameter (mm)				
		26.5	32	36	40	50
L	mm	110	110	130	130	165
H	mm	205	205	205	205	300
X	mm	90	90	105	105	145
D	mm	92	92	111	111	145



Material : Polyamide fiber (30%) + anti UV additive  
fixed with 4 x M8x20 (upto D40) and M8x60 (for D50) zinc-plated screws

Freysibar plastic cap o'ring

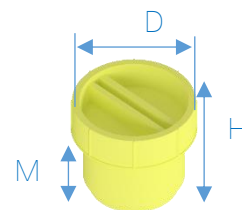
Dimensions	Unit	Nominal bar diameter (mm)				
		26.5	32	36	40	50
D	mm	95	95	114	114	149
d	mm	3,5	3,5	3,5	3,5	3,5



Material : Nitrile

Plastic plug

Dimensions	Unit	Nominal bar diameter (mm)				
		26.5	32	36	40	50
D	mm	31.5	31.5	31.5	31.5	31.5
M	mm	12	12	12	12	12
H	mm	22	22	22	22	22



### 3.6.5. Ducts

#### Corrugated duct

Dimensions	Unit	Nominal bar diameter (mm)				
		26.5	32	36	40	50
Outer diameter	mm	60	60	65	80	80
Inner diameter	mm	50	50	52	69	69
Approx. thickness	mm	1,0	1,0	1,4	1,4	1,4



Material : HDPE

#### Smooth duct

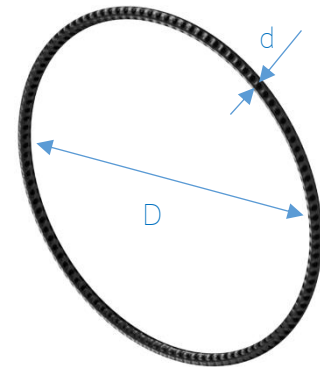
Dimensions	Unit	Nominal bar diameter (mm)				
		26.5	32	36	40	50
Outer diameter	mm	75	75	75	90	90
Inner diameter	mm	69	69	69	86	86



Material : PVC

#### O'ring for corrugated duct

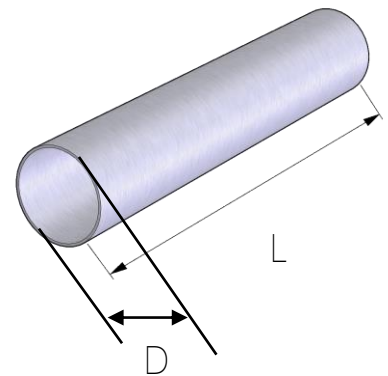
Dimensions	Unit	Nominal bar diameter (mm)				
		26.5	32	36	40	50
D	mm	50	50	55	70	70
d	mm	16	16	14	9	9



Material : Nitrile

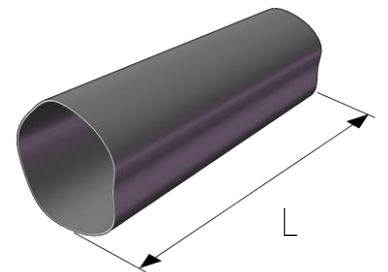
Coupler duct (for free length)

Dimensions	Unit	Nominal bar diameter (mm)				
		26.5	32	36	40	50
D	mm	90	90	90	100	100
d	mm	86	86	86	94	94
L	mm	300	300	300	300	300



Coupler heat shrinking sleeve (for bond length)

Dimensions	Unit	Nominal bar diameter (mm)				
		26.5	32	36	40	50
Ø before shrinkage	mm	75	75	75	95	95
Ø after shrinkage	mm	22	22	22	30	30
L	mm	250	250	250	330	330



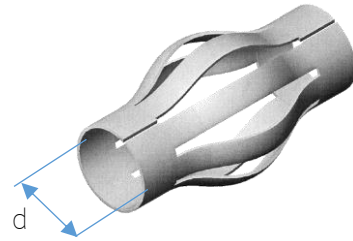
The heat shrinking sleeve is used for corrosion protection of Freyssibar ground anchors couplers. It's applied on the zone to protect by heating with a war air blower or a torch Its internal face is covered by a corrosion protection compound which melts during installation and fills the voids.

### 3.6.6. Spring basket

One spring basket must be installed every 2 meters on the bond length.

Dimensions	Unit	Nominal bar diameter (mm)				
		26.5	32	36	40	50
d	mm	57	57	57	75	75

Material : PVC



### 3.6.7. Injection pipe

#### 3.6.7.1. Filling pipe

This filling pipe is generally installed along the bar on the job site. On the bottom, a bevelled cut must be done on site, and some holes must be drilled (3 on the last 1,50 m), to allow the flow of the cement grout, even if the pipe is blocked by earth on the bottom during insertion of the anchor.

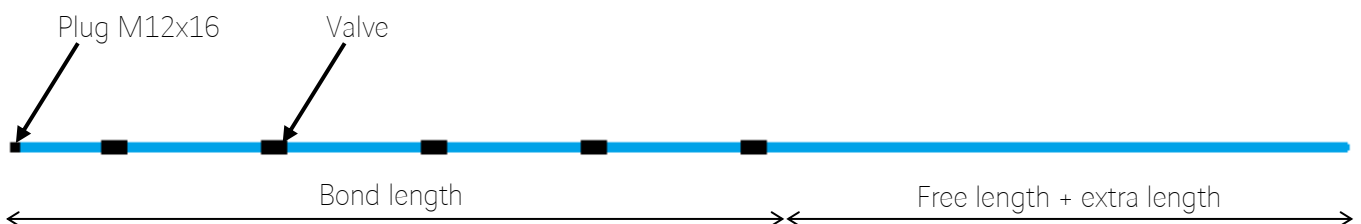


Delivered in 500 lm coils

#### 3.6.7.2. Single re-grouting pipe

This reinjection pipe is generally installed along the bar on the job site. It is generally added to a filling pipe. The first grouting is made with the filling pipe, and the reinjection with the top reinjection pipe. The bottom is obtruded with a screw M12x16. On the bond length, a valve is made every 0,50 m by a hole D=6mm obtruded with an adhesive tape.

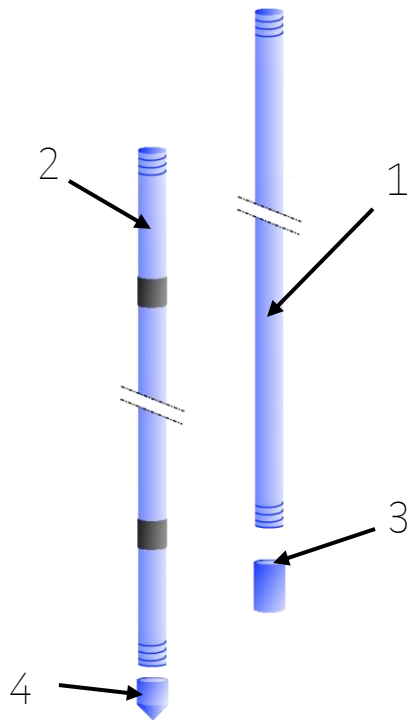
Diameter (d x D)	Limite pressure	Delivered
12 x 16	28 bar	Prepared at the right length, as required, and rolled





### 3.6.7.3. Sleeved re-grouting pipe

The pipe is made of PVC+, anti- shock. It is delivered in bars of 3 or 6 meters long which can be connected with a special coupler. Some elements are totally smooth with a male thread on both sides. Some elements include one sleeve per meter. These sleeves are outside the pipe. On the bottom, a female threaded plug is screwed to seal the pipe. The bursting pressure of the pipe is 70 bars. The external diameter is 50 mm, the inner diameter is 40 mm.



## 3.7. Marking

### 3.7.1. Bars

Each bundle of bars is identified with a steel label containing:

- Freyssinet Company Name
- Size: "Freyssibar" nominal diameter
- Length
- Steel grade
- Bundle number
- Batch number
- Purchase order
- Weight: net and gross
- Quantity of bars

### 3.7.2. Accessories

The marking of the accessories is done on a label attached to the case or pallet.

## 4. DESIGN

### 4.1. Calculation

The design of the anchor head (Nut+washer according to EN1537) complies with ETAG 013 and the design of the bar comply with ASQPE and prEN10138.

### 4.2. Testing

According to the ASQPE regulation:

- Fatigue resistance under axial force,
- Isothermal relaxation,
- Stress corrosion test in distilled water

All these tests take place at accredited laboratories COFRAC or equivalent EA (European Accreditation)

## 5. MANUFACTURING

### 5.1. Site of production & distribution

The bars and anchorage are manufactured in South Africa. Then, the bars are stored and transformed to become prefabricated bars at Freyssibar Center, in France. A detailed presentation of those several sites is available on request.



### 5.2. Manufacturing process

#### 5.2.1. Products incoming inspection

The bars and accessories are received at the Freyssibar Center in France from South Africa. All mill certificates are checked and recorded.



Then, the prefabrication is done in house according to internal procedure and controls.

### 5.3. QSE

The quality assurance system in force in the factory supplying the ground anchors units shall comply with, or be equivalent to, the standard ISO 9001: 2008.

#### 5.3.1 Quality - ISO 9001

FPC is certified since September 1997 (according to successive standards as ISO 9002 v94 and ISO 9001 v2000). Since the renewal audit of September 2009, the company is certified ISO 9001 v2008. Manufacturing, sale and trade of structure equipment (road expansion joints, bearings and seismic protection devices) and components for cable stays and concrete prestressing. Trade of products for structure reinforcement.

#### 5.3.2 Safety - OHSAS 18001

FPC is certified OHSAS 18001 v 2007 since April 2011.

#### 5.3.3 Environment – ISO 14001

FPC is certified ISO 14001 since October 2010



### 5.3.4. Quality documentation

Different levels of quality documentation can be proposed (level 0, 1 or 2). The level of the quality documentation has to be determined at the beginning of the project. Each level includes the following documents:

Item	Documentation	Level 0	Level 1	Level 2
General Documentation	Delivery bill	X	X	X
Bars	Steel material certificate 3.1	-	X	X
Plates	Steel plates material certificate 3.1	-	X	X
Washers	Steel material certificate 3.1	-	X	X
Nuts	Steel material certificate 3.1	-	X	X
Final control	Geometrical control report of the prefabricated elements	-	-	X
Cement grout control	Cement grout production control	-	-	X

All documents can be shown during an audit.

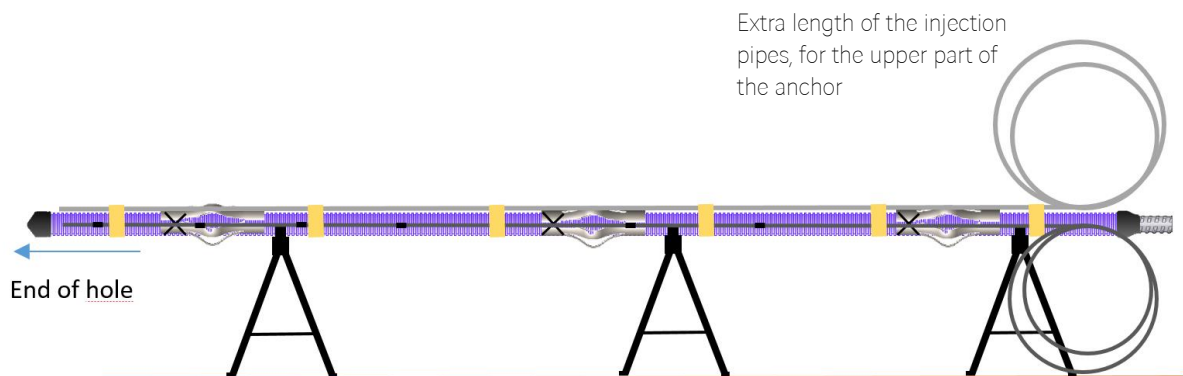
## 6. INSTALLATION ON SITE

### 6.1. Preparation of the anchors

The elements of the anchor body must be prepared before the introduction in the borehole. They have to be installed on trestles, well designed to support the weight according the applicable calculation rules. A minimum of 1 trestle every 2 meters is required.

The spring baskets are installed around the corrugated sheathing and correctly fixed with a wire. The link must be done only on the side "end of hole" in order to allow the spring basket to fulfill its function "spring".

The injection system is also fixed around the anchor with wires or adhesive tape.



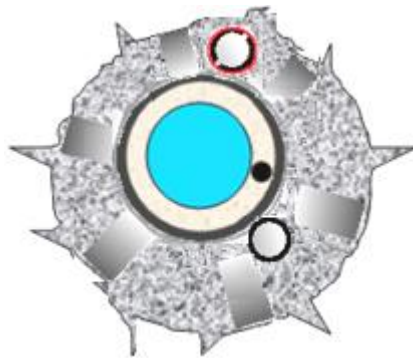
### 6.2. Drilling

The drilling operation is done by the main contractor. The following requirements must be fulfilled:

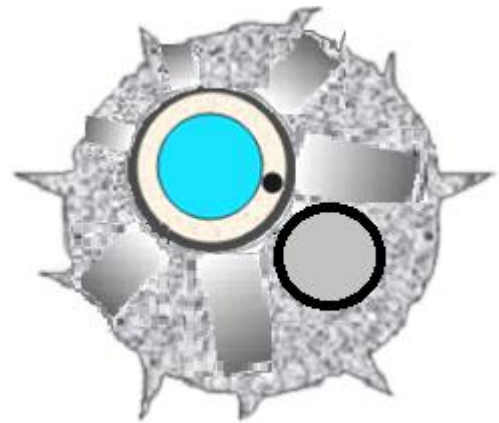
1. The deepness of the bore hole should allow the introduction of the anchor. If necessary, an over drilling of 0,5 to 1 meter can be done to ensure that the available length is enough, even if cuttings are falling to the bottom.
2. The diameter should allow the introduction of the anchor with the injection pipes and a final grout cover of 10 mm minimum. If a casing is used, its internal diameter must be considered to check the capability to install the anchors.
3. The borehole should not collapse from the time of the drilling to the time of injection. If the ground is too loose, a dense injection fluid can be used (bentonite, cement grout, foam, mud) or a casing hole method can be adopted (ODEX, OD, TUBEX, ...).



Simple injection



Simple Reinjection



Selective Reinjection

The size of the injection pipe must be considered in order to allow an easy installation. The drilling diameter should allow a space of approximately 10mm around the anchor and the pipe.

	26	32	36	40	50
Simple injection		127		140	
Simple reinjection		127		140	
Selective reinjection		150		170	

Recommended drilling diameter\*

Other parameter can influence the drilling diameter: length of the bore hole, inclination, couplers or not,

...



### 6.3. Installation of the anchors

This operation is done by the main contractor. The adapted and safe lifting equipment must be used. The foot of the anchor is guided in the borehole and the top end is lifted up (1). Then the anchor is progressively introduced in the borehole.

When the first element is introduced, it must be maintained with a strap and a wedge system, to avoid it to fall to the bottom of the hole.

The following element is lifted up and connected to the previous one with a coupler (2). The corrosion protection of the coupler must be installed prior the assembling.

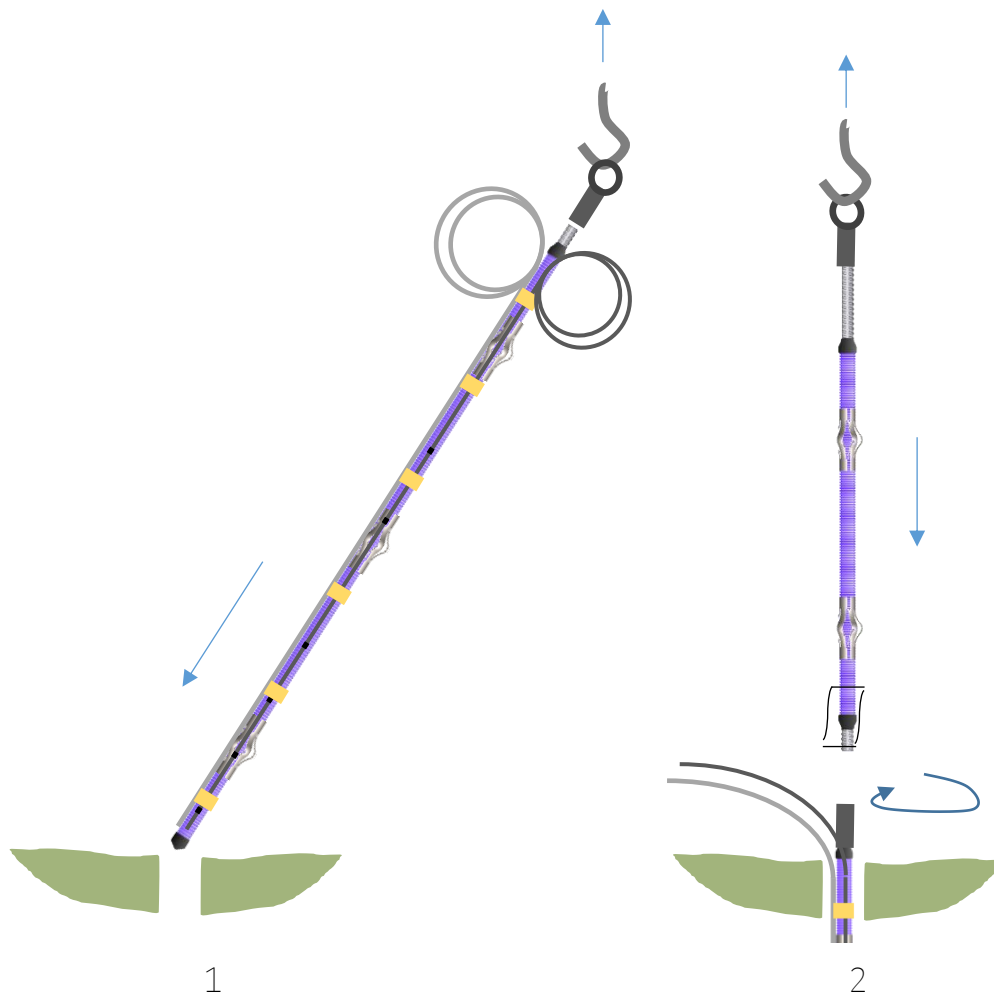
On the bond length, the coupler is protected with the heat shrinking sleeve (see §3.5.1), which is retracted with a hot air blower or a blowtorch (low flame):



On the free length, the coupler is covered by a coupler duct full of wax (see 3.5.2). The corrosion protection of the coupler is installed as follow:

- The coupler duct is threaded on one of the two elements to connect
- The two O-rings are installed on both ends of the corrugated sheath. They must be introduced in a groove of the corrugated duct
- The two elements are connected with the coupler
- The coupler is covered of wax by hand. The quantity of wax should be sufficient to fill the coupler duct.
- The coupler duct is placed symmetrically, to cover each end of the elements. It should cover the 2 O-rings.
- Additionally, an adhesive tape is applied on each end of the coupler duct.

During introduction of the anchor, the injection pipes are progressively guided by hand and fixed on the anchor with adhesive tape.



Special attention:

The coupler must be screwed half and half on the two bars to be connected. To insure its good position, the following precautions must be exercised:

- Mark the bars on a distance of 1/2 length of the coupler
- Glue the coupler in the bar with a fast hardening glue (e.g. cyanoacrylate glue)
- After assembling, control of the position of the coupler with the marks

## 6.4. Grouting

This operation is done by the main contractor.

The injection process should allow a good filling of the borehole and should allow to obtain the required resistance of the bonding of the anchor in the ground.

On the top of the borehole, the cement grout should be correctly stopped in order to allow a good installation of the anchor head.

When the injection is finished, the extra length of injection pipes must be cut off and removed.

### 6.4.1. Gravity injection

This method involves filling the bore hole with cement grout via the bottom. A filling pipe is installed along the anchor. Once the anchor has been inserted in the bore hole, the cement grout is injected via the tube until it reappears at the surface. In some cases, there is no injection pipe and the bore hole is filled with cement grout before the anchor is inserted. The injection pressure corresponds to the pressure needed to form the column of grout.

This simple yet effective method provides acceptable anchorage strength in rock and compact sand, but is often inadequate in loose soil and clay when the ground is fractured, the anchor can be fitted with a geotextile cover to prevent grout loss.

### 6.4.2. Global reinjection (IGU)

The aim is to inject cement grout into the anchor zone at a higher pressure than with gravity injection. The anchor is fitted with a reinjection pipe featuring sleeves and is closed at the end.

Gravity injection is carried out first. When the grout starts to set (10 to 24 hours after gravity injection), further injection is carried out via the reinjection pipe has at least one sleeve per meter.

The pressure of the grout at the end of injection is generally between 10 bar and half the pressure limit for the ground.

This method is highly effective for ground anchors grouted in sand or compact ground for passive anchors in all types of ground.

In some cases, it is used in fractured rock for reinjection into areas where grout has been lost.

### 6.4.3. Selective reinjection (IRS)

This method ensures perfect control over the injection volume and pressure in each grouting zone.

A sleeved reinjection pipe enabling a double packer to be inserted is installed along the anchor. After an initial gravity injection phase, reinjection is carried out using the double packer inserted in the sleeved reinjection pipe. The injection can thus be precisely controlled at each sleeve.

The pressure at the end of injection is generally higher than the pressure limit for the ground and may not exceed 40 bar.

## 6.5. Installation of the anchor head

A control of the surfaces is done prior to any installation. If necessary, a mortar is made to insure a good bearing surface between the plate and the structure.

The sealing is installed on the corrosion protection of the bar

The trumpet tube of the plate is filled at 2/3 of wax

The bearing plate is installed

The nut is screwed on the bar

After stressing, the cap is installed and filled with wax (see chapter 3.4)

## 6.6. Stressing-testing

All the testing and stressing operations must be done according the applicable norms and specifications. For example, according to EN 1537, the following tests must be done:

- 2 proving test on "lost" anchors
- 3 suitability tests on permanent anchors
- 1 acceptance test on each permanent anchor

### 6.6.1. Proving test

This test is done according "Step method", §9.4.1.c) of the EN 1537

The load applied on the anchor during the test is minimum  $1,5 \times$  estimated resistance of the bonding

The tendon size and the bond length of the tested anchors will be chosen in order to ensure that  $0,9 \times T_{p0,1} >$  test load

The load will be applied in 9 steps of 1 hour duration

These tests will be done prior to permanent anchors works, in order to valid the bond lengths.

### 6.6.2. Suitability test

This test is done according "Step method", §9.4.1.c) of the EN 1537

The load applied on the anchor during the test is minimum  $1,25 \times$  Service load

The load will be applied in 5 steps of 1 hour duration

### 6.6.3. Stressing & acceptance test

During stressing, each anchor will be tested at  $1,25$  Service load.