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FREYSSINET PRODUCTS CO.

PRODUCT DESCRIPTION

Bars & Geotechnics

Freyssi SD

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FREYSSINET
SUSTAINABLE TECHNOLOGY

REVISION INDICES FOLLOW-UP TABLE

Rev	Date	Modification	Prepared by	Checked by	Approved by
0	26/04/17	First issue	L. FURLAN	C. GAUCHERAND	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, as well as the interaction between the different parts involved in a project.

1.2. Freyssi SD

The Freyssinet Group is the world leader in specialized civil engineering, working in two fields : structures and soil. The structural activities include pre-stressing, cable-stayed structures and strengthening of structures. As part as these activities, Freyssinet supplies bar systems like Freyssi SD anchorage installed in loose or collapsing soil.
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 Freyssi SD developed by Freyssinet is designed to answer several standards and world normative requirements but also the environmental requirements specific to this type of devices. 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. Freyssi SD scope of use

The Freyssi SD anchor system is used for anchors installed in loose or collapsing soil. This system enables drilling operation, installation of the bar and grouting, which avoids the use of a casing.
The simultaneous drilling and injection offers very good bond capacity, compared to a traditional installation process.

1.4. Design

1.4.1. Bars

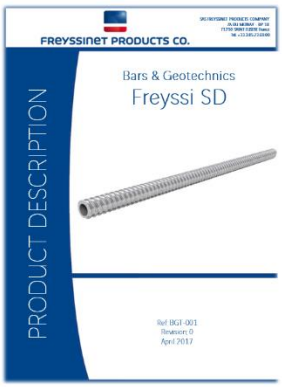
The bars are designed to respect the EN10080 standard.

1.4.2. System

The rock drilling equipment is designed to respect the ISO 10208 standard.
The metallic components are designed to respect the ISO 6892-1.

1.5. Manufacturing

As Freyssi SD is manufactured by Freyssinet, all customers will receive the same level of excellence and quality in the products and services. This complete control over the products and systems means that the solution can be adapted to a wide range of applications and extreme operating conditions.



1.6. Installation

A drill bit is screwed on the first bar. Then the bar is directly connected to the shank of the drilling machine (with a grout injection box if necessary). The drilling operation starts together with the injection of the grout in the bar. The cement grout flows in the ground through injection hole of the drill bit. When the first bar is fully inserted in the ground, the injection and the drilling is stopped, and the bar is unscrewed from the shank. A second bar is connected both to the first one and to the shank, then the process of drilling and grouting starts again until the anchor is fully threaded in soil.

In some cases, the injection is made during a later step. In this case the bore hole is generally flushed by air through the bar and the drill bit, during drilling.

2. APPLICABLE DOCUMENTATIONS

2.1. Specific documentation

The use of the Freyssi SD system is inseparable from the following documentation (last version):

- Technical Specification : GBFRESD-SPA-001 B (internal document)

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 prestressing bar complies with geometrical, mechanical and technological requirements as defined by most of the relevant national and international standards like the prEN10138 standard.

2.2.1. Bars

Designation	Applicable standard	Material
Bars Freyssi SD	10083-3	40 CR

2.2.2. Accessories

Designation	Applicable standard	Material
Sleeves	EN 10083-3	40 CR
Nuts	EN 10083-3	CK 45
Anchor plate	EN 10025-2	S235
Drill bits	EN 10083-3	Depends on model

2.3. Standards for manufacturing

Designation	Applicable standard
Geometrical characteristics (when not mentioned) (bars & accessories)	Drawings
Mechanical & Chemical characteristics (bars)	GBFRESD-SPA-001 B
Mechanical & Chemical characteristics (accessories)	EN 10025

3. DESCRIPTION OF THE FREYSSI SD SYSTEM

3.1. Overview

The Freyssi SD self-drilling anchor system is particularly suited to use in nailing or rock bolting.
In foundations, the system can be used as a micropile.
Temporary active tie rods can also be created with this system by using a sheath over the free length.

This system is used to create anchors in soft or unstable ground. Drilling, positioning of the reinforcement and injection are carried out in a single operation, thereby avoiding the difficult task of drilling a casing hole.

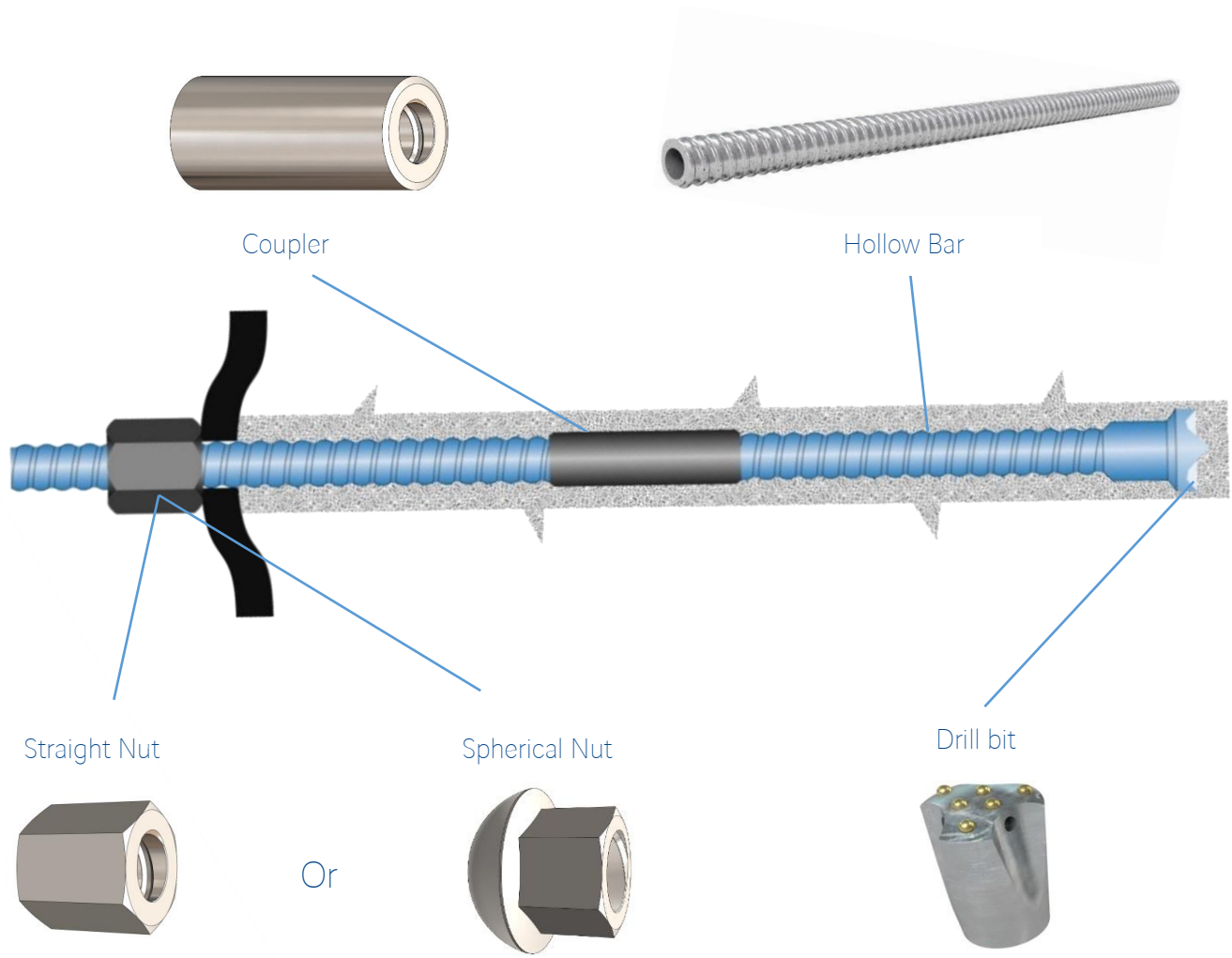
A disposable drill bit is screwed onto the first bar. The bar is then connected directly to the drill shank (if necessary using an injection swivel). Drilling starts with simultaneous injection via the central hole in the bar. As the drill bit features a hole, the cement grout spreads into the ground as the drill moves forward.

When the first bar is fully inserted in the ground, injection and drilling are stopped, and the bar is unscrewed from the drill shank. The second bar can then be coupled to the first bar and the machine, and the operation can be resumed.

The system is composed of :

- Hollow bars fully threaded
- Sleeves
- Nuts and anchor plates
- Drill bits

It is especially adapted for the use in soil nailing or rock bolting.



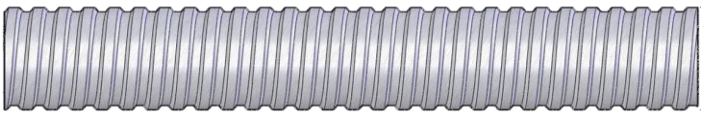
3.2. Hollow Bars

3.2.1. Main characteristic

Type	R32 N	R32 S	R38 N	R51 L	R51 N	T76 L	T76 N	T76 S
Nominal diameter (mm)	32	32	38	51	51	76	76	76
Ultimate Load (kN)	280	360	500	550	800	1200	1.600	1.900
Yield load (kN)	230	280	400	450	630	1.000	1.200	1.500
Outside diameter for calculation (mm)	29.1	29.6	36.5	46.6	47.9	71.3	71.1	71.2
Minimum guaranteed stress area (mm^2)	350	430	590	740	940	1.650	2.080	2.460
Minimum guaranteed mass (kg/m)	2.7	3.4	4.7	5.9	7.4	12.9	16.3	19.3
Average Young's modulus (kN/mm^2)	200							
Ultimate Strength (N/mm^2)	600 to 850							
Yield Strength (N/mm^2)	500 to 680							

All threads are left hand.

R Thread profile



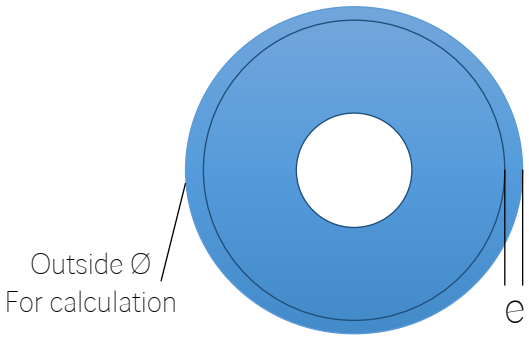
T Thread profile

3.2.2. Design without corrosion protection

To design properly without protection corrosion you need to calculate the loss of the section over the life of the hollow bar. Insofar as the inside of the bar is full of cement grout and therefore passivated, only the outer surface will be concerned. A "resistant" section after corrosion will therefore be defined using this formula :

$$Fr = F[1 - \frac{\pi}{S}(\emptyset moy.e - e^2)]$$

F : initial reference load (ultimate or yield) (kN)
Fr : residual load after loss of sacrificial steel (ultimate or yield)



This thickness depends on the application and the standard in place in the requesting country. It must be clearly defined to design the anchor properly.

3.2.3. Choice of the bars

A factor is applied on the yield load or ultimate load depending of the applicable standard.
There are also other criteria that are implied into the choice of the adapted bars:

- Resistance to buckling during drilling
- Shear strength
- Torque resistance during drilling

3.2.4. Hot Deep Galvanization

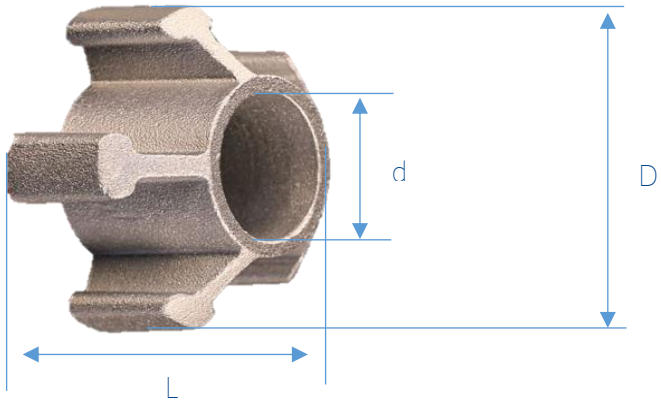
The bars can be hot deep galvanized upon request.
If they are not protected, you must take it into account while designing (Confer to : 3.2.2, design without corrosion protection)
The galvanization process respects the ISO 1461 standard.

3.3. Accessories

The connection between the anchor itself and the structure is ensured by the anchor head made of a nut and a plate.

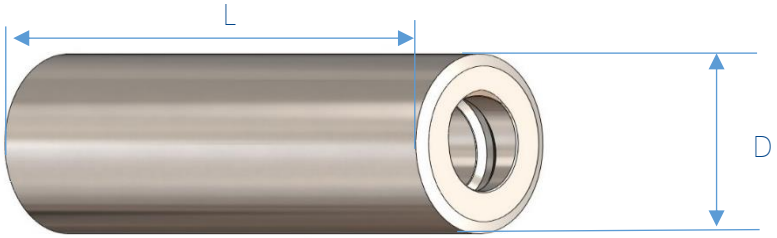
3.3.1. Centralizer

Dimensions (mm)	Bar Thread							
	R32 N	R32 S	R38 N	R51 L	R51 N	T76 L	T76 N	T76 S
D	72	72	72	90	90	-	-	-
L	30	30	41	54	54	-	-	-
d	41	41	50	60	60	-	-	-



3.3.2. Coupler

They allow the assembly of the bars from one another. The thread is not continuous so that a screwed bar on one side only screws up to half the sleeve. In the sleeve, the bars are in contact, which ensures good transmission of energy from one bar to the other, thus a good efficiency of the percussion. All anchor coupling are sized to withstand traction greater than the breaking point of the bar.



Dimensions (mm)	Bar Thread							
	R32 N	R32 S	R38 N	R51 L	R51 N	T76 L	T76 N	T76 S
D	43	43	52	62	62	97	97	97
L	160	160	220	200	200	220	220	220

3.3.3. Drill bits

The drill bit is essential, it determines the effectiveness of the system. The details below allow to make a first selection, but only the experiment or the tests carried out in a given soil will make possible the optimization of the choice of the cutting edge.

3.3.3.1. Cross-bit, steel

It consists of 4 edges arranged in cross.

Particularly suitable for non-cohesive loose sand, marl type. It may cross some boulders fractured insofar as the latter isn't abrasive.

This drill bit is available in R25, R32, and R38 threads in different diameters.
(refer yourself to 3.3.3.8)

3.3.3.2. Cross-bit, carbide

It consists of 4 carbide edges arranged in cross
Particularly suitable for non-cohesive loose sand, marls including pebbles or blocks.
Allows drilling in abrasive soil.

This drill bit is available in R25, R32, and R38 threads in different diameters.
(refer yourself to 3.3.3.8)

3.3.3.3. Button bit, steel

It has a domed surface on which spherical shapes are arranged. It is made of treated steel. Particularly suitable for soft rock and ground with boulders or blocks insofar as they are not abrasive.

This drill bit is available in R25, R32, R38, and R51 threads in different diameters.
(refer yourself to 3.3.3.8)

3.3.3.4. Button bit, carbide

It has a domed surface on which are arranged spherical inserts made of carbide. It is made of treated steel.
Particularly suitable for hard rock and ground with pebbles or blocks.

This drill bit is available in R25, R32, R38, and R51 threads in different diameters.
(refer yourself to 3.3.3.8)

3.3.3.5. Arching button bit, steel

It's made of three arches on the periphery, for cutting and drive the material being drilled, and the center button to destroy any boulders encountered during drilling.
It is made of treated steel.

Particularly suitable for loose soils and land with pebbles or blocks insofar as they are not abrasive.

This drill bit is available in threads R32, R38, and R51 threads in different diameters.
(refer yourself to 3.3.3.8)

3.3.3.6. Arching button bit, carbide

It has 3 carbide curved edges inserted on the periphery, allowing the drilled material to be cut out and drilled, and carbide buttons at the center allowing to destroy the possible rock blocks encountered during the drilling.
It is made of heat treated steel.
Particularly suitable for soft terrains, sand with pebbles or blocks of hard rock.

This drill bit is available in threads R32, R38, and R51 threads in different diameters.
(refer yourself to 3.3.3.8)

3.3.3.7. Retro-flush bit, steel

It has two 180 ° edges to cut the ground. Perpendicularly, two points allow to prepare the drilling. The injection holes directed towards the rear of the cutting edge are located under these points.
Particularly suitable for cohesive soil (clay) and soft ground

This drill bit is available in threads R32, R38, R51, T76 in different diameters
(refer yourself to 3.3.3.8)

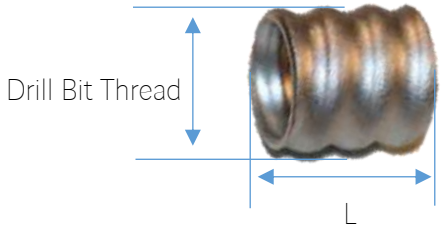
3.3.3.8. Range of drill bits

Shape	Description	R32	R38	R51	T76
	Cross-bit, steel	Ø 51	Ø 76 Ø 90	Ø 90 Ø 100	Ø 130 Ø 200
	Cross-bit, carbide	Ø 51 Ø 76	Ø 76 Ø 90	-	Ø 130 Ø 200
	Button bit, steel	X	X	X	X
	Button bit, carbide	Ø 51	Ø 76	Ø 100 Ø 115	-
	Arching button bit, steel	Ø 76	Ø 76 Ø 90 Ø 115	Ø 115	Ø 115 Ø 130
	Arching button bit, carbide	Ø 76	Ø 76 Ø 90	Ø 90	Ø 130
	Retro-flush bit, steel	Ø 76 Ø 100	Ø 90 Ø 110 Ø 130	Ø 100 Ø 150	Ø 130 Ø 175 Ø 200 Ø 300

Other diameters can be manufacture upon request.

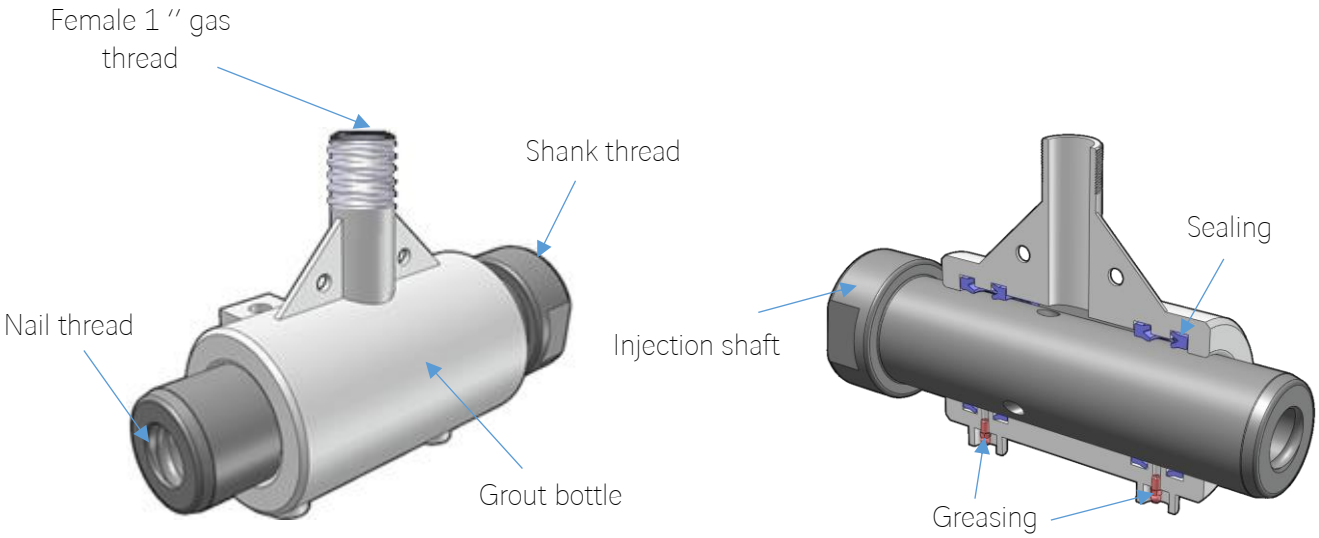
3.3.4. Drill bit adapter

Dimensions (mm)	Nominal bar diameter (mm)				
	R32 N	R32 S	R38 N	R51 L	R51 N
Drill Bit Thread	R38	R38	R51	T76	T76
L	50	50	50	50	50



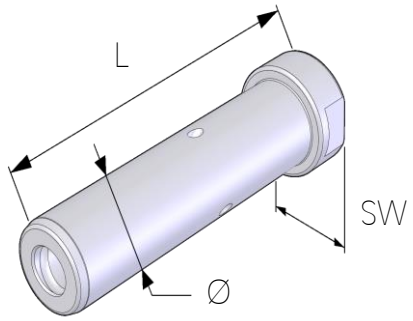
A drill bit adapter allows, for a thread given, to use a drill of a bigger thread due to the external thread of the drill bit adapter.

3.3.5. Rotary injector adaptor



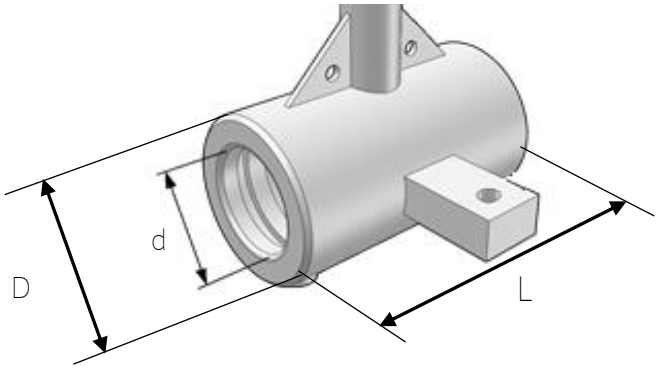
3.3.5.1. Shank

For bar	Shank thread	Ø (mm)	SW (mm)	L (mm)
R32	R32	65	75	285
	T45	80	90	300
	H55	85	95	335
R38	T45	80	90	300
	H55	85	95	335
R51	T45	80	90	300
	H55	85	95	335
T76	H55	110	120	335
	H64	110	120	335



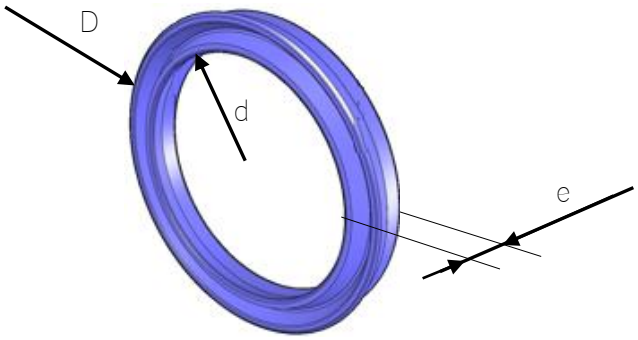
3.3.5.2. Grout bottle

Diameter of the shank (mm)	d (mm)	D (mm)	L (mm)
65	65	105	180
80	80	118	180
85	85	130	180
110	110	155	180



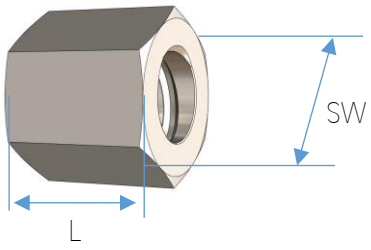
3.3.5.3. Sealing

Diameter of the shank (mm)	d (mm)	D (mm)	e (mm)
65	65	85	10
80	80	100	10
85	85	105	12
110	110	130	15



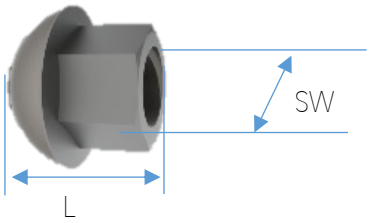
3.3.6. Flat nut

Dimensions (mm)	Nominal bar diameter (mm)							
	R32 N	R32 S	R38 N	R51 L	R51 N	T76 L	T76 N	T76 S
L	ON DEMAND					80	80	80
SW						100	100	100



3.3.7. Spherical nut

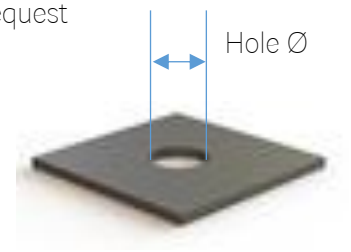
Dimensions (mm)	Nominal bar diameter (mm)							
	R32 N	R32 S	R38 N	R51 L	R51 N	T76 L	T76 N	T76 S
L	46	46	61	70	70	85	85	85
SW	46	46	50	75	75	100	100	100



3.3.8. Anchor plate

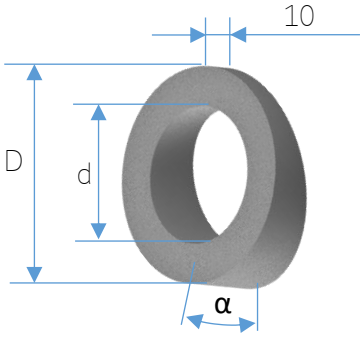
Dimensions (mm)	Nominal bar diameter (mm)							
	R32 N	R32 S	R38 N	R51 L	R51 N	T76 L	T76 N	T76 S
Size	200x200	200x200	200x200	200x200	200x200	300x300	300x300	300x300
Thickness	10	10	10	20	20	40	40	40
Hole Ø for spherical nut	52	52	58	70	70	110	110	110
Hole Ø for flat nut	-	-	-	-	-	87	87	87

Other dimensions are available upon request



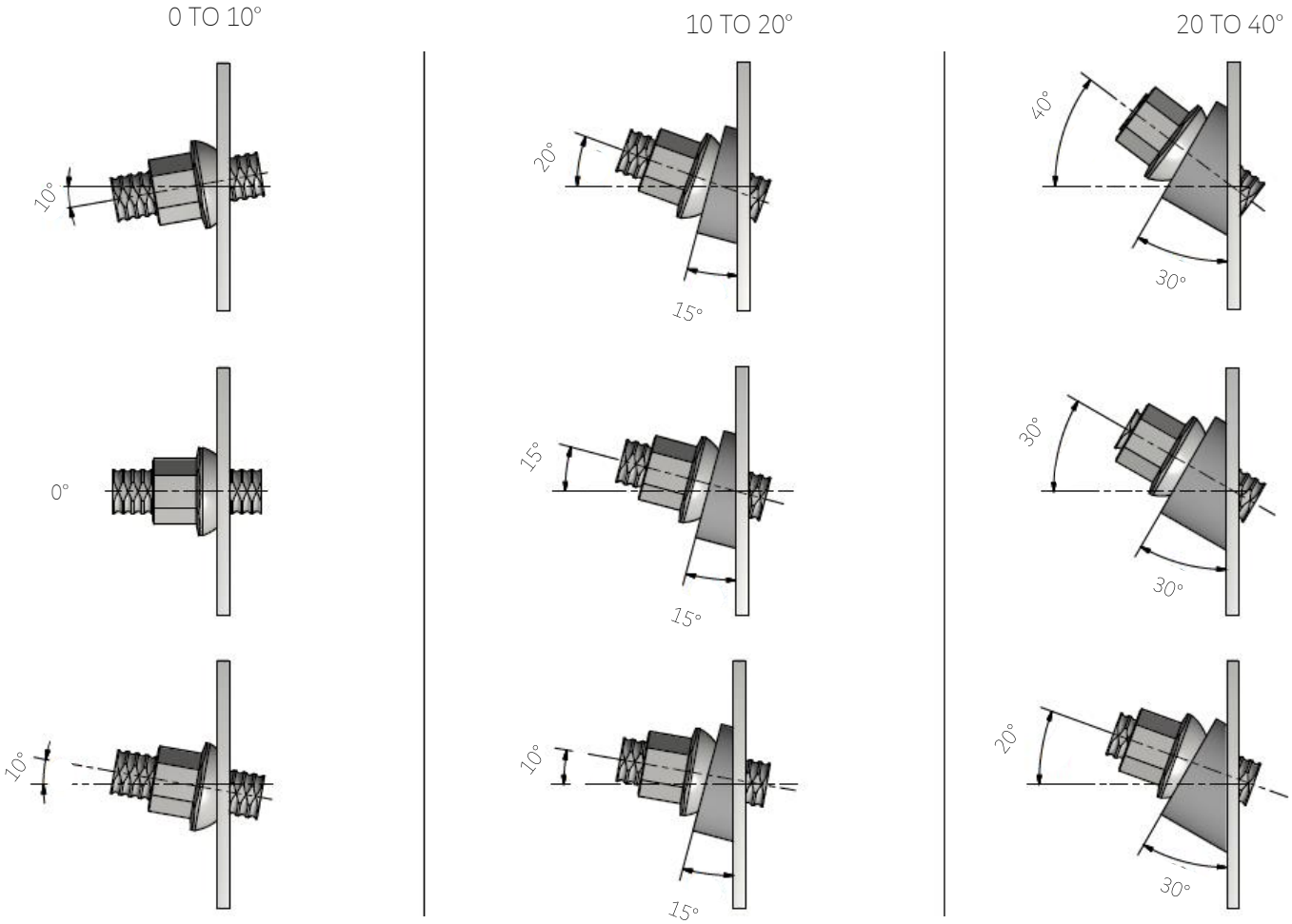
3.3.9. Angular washer

Dimensions	Nominal bar diameter (mm)							
	R32 N	R32 S	R38 N	R51 L	R51 N	T76 L	T76 N	T76 S
D (mm)	76	76	89	102	102	-	-	-
d (mm)	45	45	56	75	75	-	-	-
α(°)	15 or 30	15 or 30	15 or 30	15 or 30	15 or 30	-	-	-

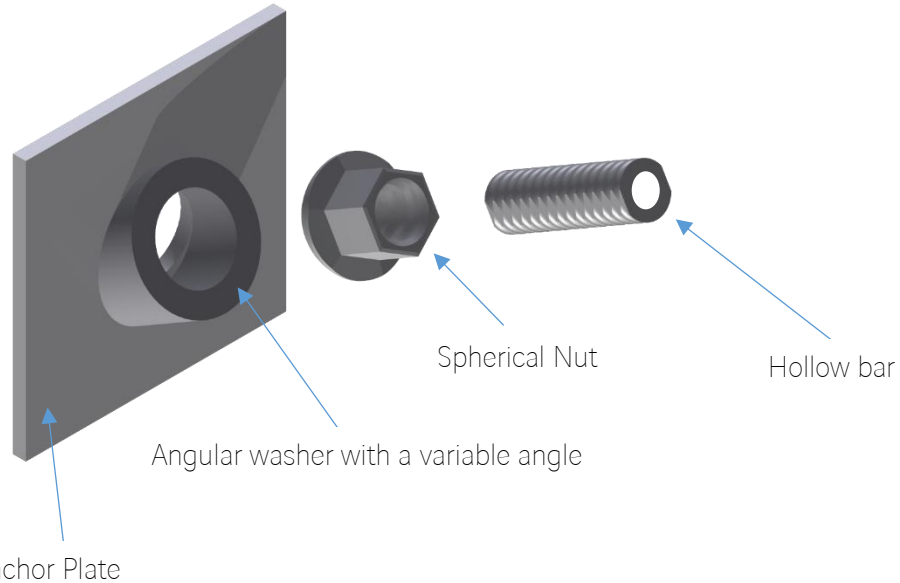


3.4. Assembly

3 ways of assembly are possible: from 0 to 10°, from 10 to 20° and from 20 to 40°. It depends on how the system is fitted in the structure as you can see below:



In any case, the plate stays vertical and it's a biased check that catches up the inclinaison.



3.5. Marking

3.5.1. Bars

A batch of bars is defined as a quantity of bars of maximum 30t of the same diameter, issued from a single steel cast and continuous production.

Each lot of bars is identified with a steel label including:

- Freyssinet company name
- Purchase order
- Product name : "Freyssi SD"
- Type of bar
- The length of the bar in mm
- Heat number
- Weight : net and gross
- Quantity of bars

4. SPECIAL CARE FOR INSTALLATION

4.1. Choice of the installation method

The choice of the technical installation (drilling and injection) depends on many parameters: site size, access, type of soil and length of anchorages.

4.1.1. Roto Percussion drilling

For all types of ground, including compact to hard soils. This method allows high drilling ratio, a good master of the direction of the anchorage and increases the characteristics of the burying. This is due to the percussion which destroys the ground in front of the drill bit.

4.1.2. Simple rotation drilling

For soft soils and some chalk. The rotation ensures that the drill bit cuts the material in the borehole to create a steady vacuum around the bar. Can't be used with rollers or blocks.

4.1.3. Simple percussion drilling

For micro piles in soft to moderately compact soils. This method combines displacement with a simultaneous injection to maintain the ground in the borehole. Suitable for soils where the blowing or cutting of rotating terrain is difficult, such as soft chalk or clay.
Can't be used in areas where the drilling is closed behind the cutting edge.

4.1.4. Simultaneous drill and grout

For all types of ground, this method allows the grout to be placed at all points of the borehole. In fact, grout is injected in the same time of the drilling, increasing bond strength by creating bulbing in the softer sections of the borehole.

4.2. Warranty

1. Scope of Warranty

- Supplier warrants that the Goods supplied to the beneficiary of this Warranty are manufactured in compliance with the applicable technical specifications.
- Supplier agrees to indemnify the Warrantee from any direct damages, costs, losses or expenses arising from any error or default in design of the Goods, and/or fault or deficiency in materials or workmanship provided as part of the Goods ("Defect").
- In the event the Warrantee notifies the Supplier of any Defect within:
- Two (2) years for all steel components (bars, sleeves, straight nut and spherical nut) and for corrosion protection – No warranty on drill bit-

following delivery of the Goods to the Warrantee according to applicable Incoterms, the Supplier shall carry out correction work in respect of such Defects in accordance with the provisions below:

- Liability of the Supplier under this Warranty is limited to repair or delivery of replacement Goods at the applicable delivery point, at the Supplier's option;
- For all components supplied as part of the Goods, Supplier's Warranty shall apply to any repaired or replaced Goods, for an extended period of one (1) year following completion of repair or delivery of replacement Goods, not to exceed an overall Warranty period of three (3) years

2. Exclusions

Notwithstanding the foregoing, the Supplier shall not be liable for Goods' failure to comply with the Warranty in any of the following events:

- The Defect arises because the Warrantee failed to follow the Supplier's oral or written instructions as to the storage, commissioning, installation, use and maintenance of the Goods as provided in the manuals listed below;
- The Defect arises as a result of any error or omission of any drawing, design or specification supplied by the Warrantee to the Supplier;
- The Warrantee materially alters or repairs the Goods without the Supplier's prior written consent;
- The Defect arises as a result of normal wear and tear (including corrosion of steel parts), wilful damage, negligence or abnormal storage or working conditions or any misuse of the Goods, including in particular damage resulting from rough handling;
- The Defect arises from the occurrence of any Force Majeure event, Act of God, fire, and other circumstances beyond the Supplier's reasonable control;
- The Defect arises from an exposure at an outside temperature above 50°C;
- The Defect arises from overloads, stresses, impacts, sliding movements and any other parameter exceeding data provided in the applicable technical specifications.

It is further understood that Supplier shall bear no liability for:

- Any consequential damages incurred by the Warrantee and/or its clients (including but not limited to costs for third party inspection, liquidated damages, penalties for delay, loss of use, stand-by costs, etc.) or aesthetic damages; and
- Any dismantling or reinstatement costs;
- Warrantee's or third party's labour costs;
- Specialist equipment, scaffolding, heavy tools and lifting equipment as well as power and water needed for any correction work.

3. Warrantee's duties

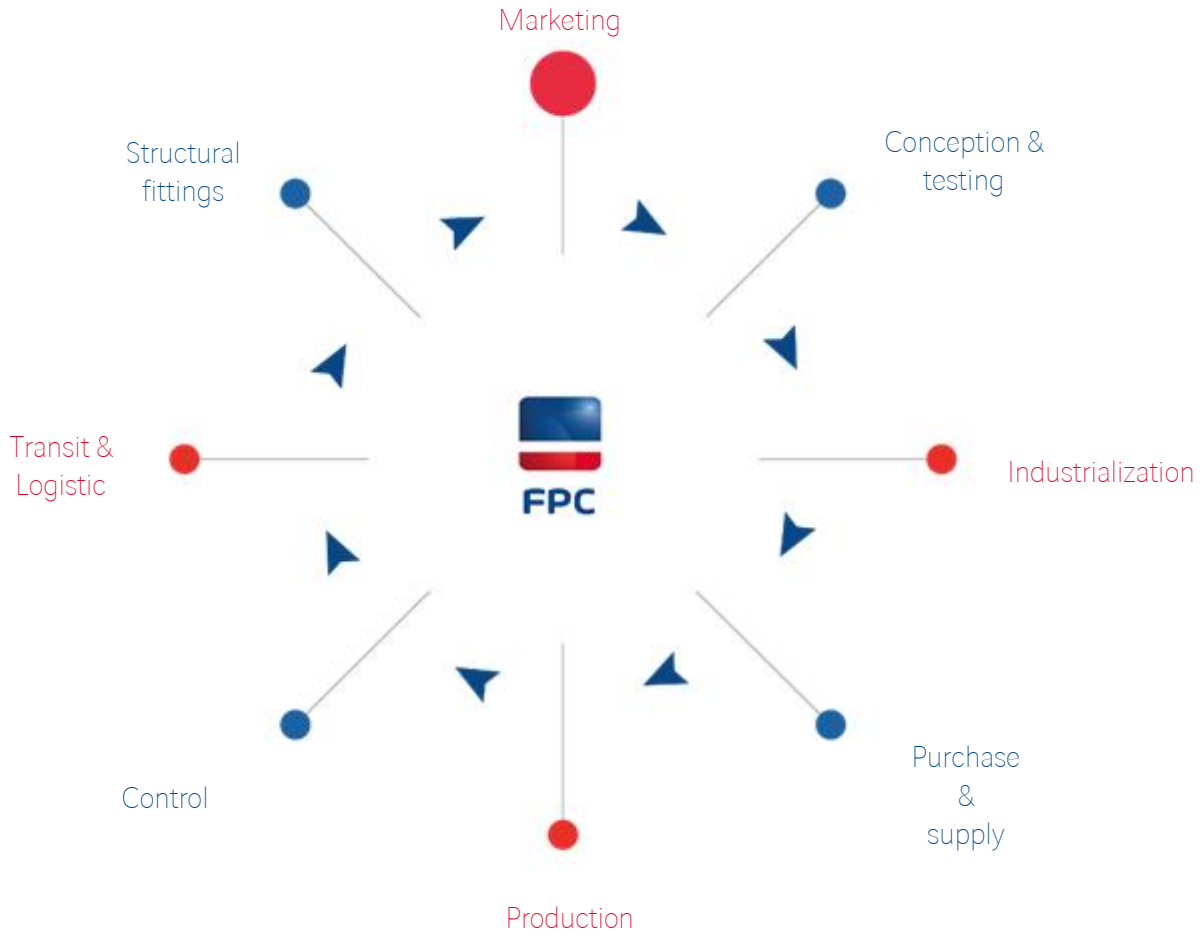
The Warrantee shall follow the instructions provided in the installations and maintenance manuals (in their latest versions)

THIS WARRANTY SHALL BE APPLICABLE AS THE STANDARD WARRANTY RELATING TO ANY OF THE GOODS SOLD BY THE SUPPLIER TO THE WARRANTEE.

TO THE EXTENT PERMITTED BY LAW, THIS WARRANTY EMBODIES THE ENTIRE UNDERSTANDING OF THE SUPPLIER AND THE WARRANTEE, AND SUPERSEDES ANY PRIOR WRITTEN OR OTHER AGREEMENT BETWEEN THE SUPPLIER AND THE WARANTEE, IN RELATION TO ANY WARRANTY RELATING TO THE GOODS.

5. MANUFACTURING & LOGISTICS

FPC coordinates all the steps of the projects. Support departments are also involved in the process:



5.1. Resources

The structural fittings division consists of a team with:

- Division manager
- Technical and sales engineers
- Technical experts
- Design engineers
- Draftsmen

5.2. Manufacturing

5.2.1. Site of production & distribution

The bars and anchorage are manufactured in China, in several sites: Chengdu and Shanghai. Then, the bars are stored at Freyssibar Center, in France. All the production and quality management is coordinated by FPC in France.

5.2.2. Manufacturing process

5.2.2.1. Bars

The hollow bars are fully threaded with a left hand R profile or a T profile. They are available in 1, 2 3, 4 and 6 meters long. The steel quality, the internal diameter and external diameter define the yield load and the ultimate load. The steel tube hardness is between 185 and 240 HB.

Delivery conditions: Bars are delivered of 1m, 2m, 3m or 4m unless otherwise agreed in the purchase order.

- Each bar is individually protected by means of a long duration anti rust oil.
- Bars are delivered in bundles of a same diameter and of a same cast and lot. Weight of a bundle is around 500kg. Bars are encircled together to allow the handling with slings without risk of sliding of the bars.
- Bars shall be carefully handled and supported in the container in order to avoid any excessive deformation, any alternate bending solicitations, and any shocks.
- The bar manufacturer will propose a sea worthy packing for transportation in dry open top containers. Bundle of bars are fully wrapped, ends are protected with PE papers, and the bundle is surrounded with several straps

5.3. QSE

The quality assurance system in force in the factory supplying the prestressing 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.

5.4. Quality documentation

Different levels of quality documentation can be proposed (level 0 & level 1). The definition of each level is available on the quality file price list sent with the offer. The level of the quality documentation has to be determined at the beginning of the project.

Item	Documentation	Level 0	Level 1
General Documentation	Delivery note	X	X
Bar	Material certificate 3.1	-	X
Nut	Material certificate 3.1	-	X
Coupler	Material certificate 3.1	-	X

*All documents can be shown during an audit.

6. REFERENCE

The references list is available on request for all FPC projects.