TENSACCIAI

TENSO-INOX

STAINLESS STEEL BARS
POST-TENSIONING SYSTEM

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Technical Department TENSACCIAI

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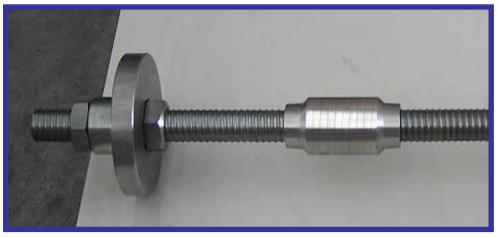
1. Introduction



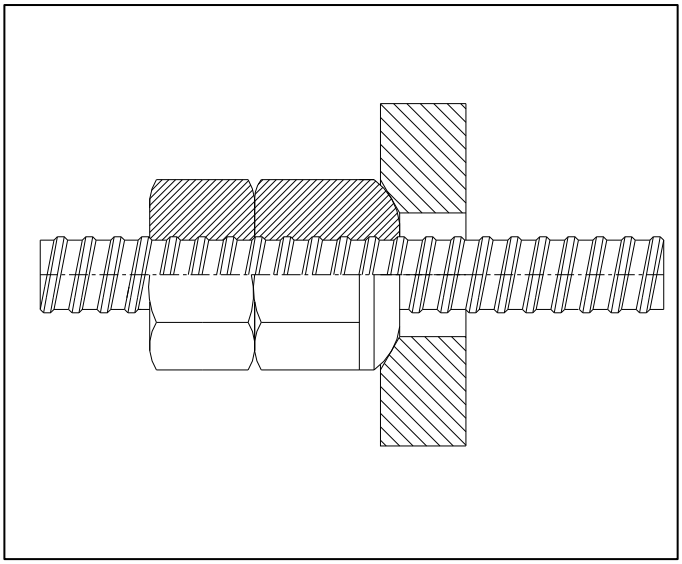
When it is necessary to ensure a long service life to the structure, even if it is exposed in a particularly aggressive environment, when you want to have a high resistance to corrosion and fatigue and also high mechanical strength and ductility, you can utilize ***TENSO-INOX*** systems:
modern systems with a wide scope for employment.
Developed to meet the demand for solutions with high mechanical characteristics and a best ratio quality / price. That is why we provide the indications necessary to design for the most appropriate applications.
TENSO-INOX anchor systems consists of bars of special stainless steels with continued or partial thread, in diameters from 20 up to 50 mm and of special devices, such as plates, nuts and sleeves joint. They're generally used as temporary or definitive anchor, fixed or to "strive".

2. System description – Continuous thread bars

TENSO-INOX bars are made of special stainless steels by process of hot rolling, according to EN 10088 / 3 standards and certified according to EN 10204 3.1.B.
They are then corrected and rolled in a facility by special shaped rollers, with automated process parameters constantly monitored, according to EN 10138 to 4: 2000 standards.
TENSO-INOX bars are manufactured through hot rolling process, in special high resistance and high yield strength steels, with resilience at -20 ° C> = 27 J.
Stainless steel bars are subjected to further controls as testing of dimensional characteristics; mechanical and chemical properties are constantly monitored, according to EN standards.
The special thread called ***TENSO-INOX*** and/or ISO metric thread at the ends of each module, is obtained by removing material or rolling; both methodologies guarantee in any case efficient and resistant to fatigue pairing between bars and accessories.
The high pressure, controlled temperature and speed rolling procedure, leads to an increase of mechanical properties of steel bars, and gives the form and special thread continues right-hand profile, with a constant step. The thread obtained by those proceedings, in no way implies section reductions (resistant area).
It can also be achieved only at the ends of the bars, maintaining the interim smooth, guaranteeing in any event efficient and resistant to fatigue pairing between bars and accessories.

Dimensional and mechanical characteristics of continues thread bars
(Yielding stress $R_{p0,2}$ 850 N/mm^2 / Breaking stress R_m 1030 N/mm^2)

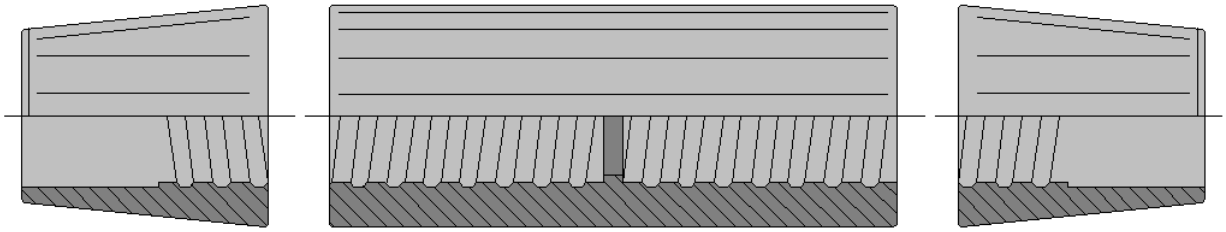
	Nominal diameter [mm]	Area [mm^2]	Yielding load $F_{p0,2}$ [KN]	Breaking load F_t [KN]	Weigth [Kg/m]
TENSO-INOX 1030SS	20	320	272	329	2.54
	22	387	329	398	3,05
	24	461	392	475	3.60
	26	541	460	557	4.30
	28	627	533	646	4,85
	32	819	696	843	6,40
	36	1035	879	1066	8,15
	38	1156	982	1190	9,05
	40	1280	1088	1318	10,05
	50	1985	1687	2044	15,75



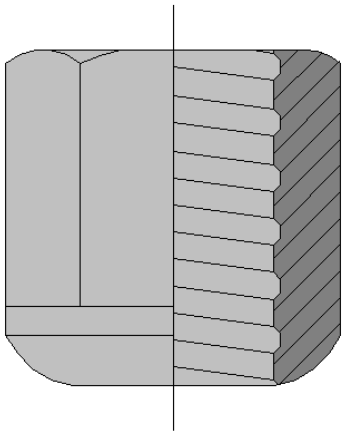
The special thread called ***TENSO-INOX*** and/or ISO metric thread at the ends of each module, is obtained by removing material or rolling; both methodologies guarantee in any case efficient and resistant to fatigue pairing between bars and accessories. The size range is available in diameters 20, 22, 24, 26, 28, 32, 36, 38, 40 and 50 mm, with standard lengths from 6 m, possible up to 8 m and breaking loads from 329 to 2,044 kN. In case of applications with dynamic load, couplers can be supplied with a firm against the possibility of movement in the central part, performed by interruption of thread, allowing the tightening of the bar, always paired with two washers shaped fastenings at the ends. TENSACCIAI can also realize diameters out of catalogue, according to the design requirements.

3. Accessories

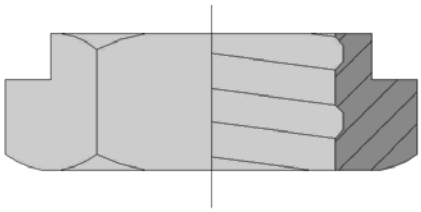
TENSO-INOX bars can be provided with fastening and coupling systems, depending on the needs of specific projects.



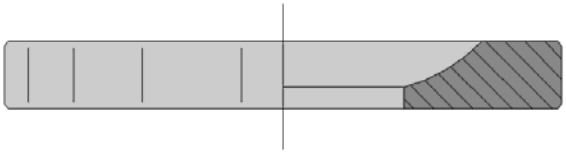
Coupler type TENSO-INOX MGST + locking nuts type TENSO-INOX DCM



Locking nuts type TENSO-INOX DA



Locking nuts type TENSO-INOX DCB



Cylindrical washers TENSO-INOX RCS

4. Structural applications

Stainless steel bars are generally used to realize stressed connections between concrete and steel. ***TENSO-INOX*** bars could be utilized for many structural application, both in concrete, steel and composite structures:

- Bridges and viaducts
- Tunnels
- Rehabilitation works
- Low temperature service works
- Fire resistant works
- Anti-seismic works

TENSACCIAI systems for applications in structural engineering consists of special steel bars in diameters from 20 mm to 50 mm and of special devices, such as terminals (forks), joining sleeves, tensioners and plates for connection.

5. Geotechnical applications

TENSO-INOX systems can be used, in general, for foundation structures, to create the so-called "soil-structure interaction" as:

- containment works
- ground anchors
- micro piles
- rock bolts
- soil nails

Are included also methodologies for improving the mechanical properties of soil and rocks through the implementation of support walls, of bulkheads anchored, walls, etc.
TENSO-INOX systems are used in consolidation works, in reinforcement of geotechnical works, in repair works and consolidation of seabed works, for tunnels construction, for underground works and mining equipment, etc..

This is our range of applications, which we also refine on demand in cooperation with our customers for special projects. Our technical department is available to find and work out special solutions with the highest functionality.

6. Stainless steel durability

6.1 Introduction

We can define stainless steels that family of steel resistant to corrosion, whit a wide variety of mechanical and physical characteristics in relation to their chemical composition. In standards EN 10088-1 are defined as "stainless" those steels that contain a minimum of 10.5% chromium and a maximum of 1% of carbon. Their high corrosion resistance stems from the formation of a thin and colourless oxide film (predominantly Cr_2O_3), well-adherent to the surface of steel and that makes it virtually inert material in the surrounding aggressive environment.

6.2 Corrosion resistance

In stainless steels the presence of relevant quantities of chromium gives the ability to "autopassivate" so spontaneous when the clean surface comes into contact with an external corrosive or oxidant environment. In addition to chromium, the elements that contribute to increasing the corrosion resistance are:

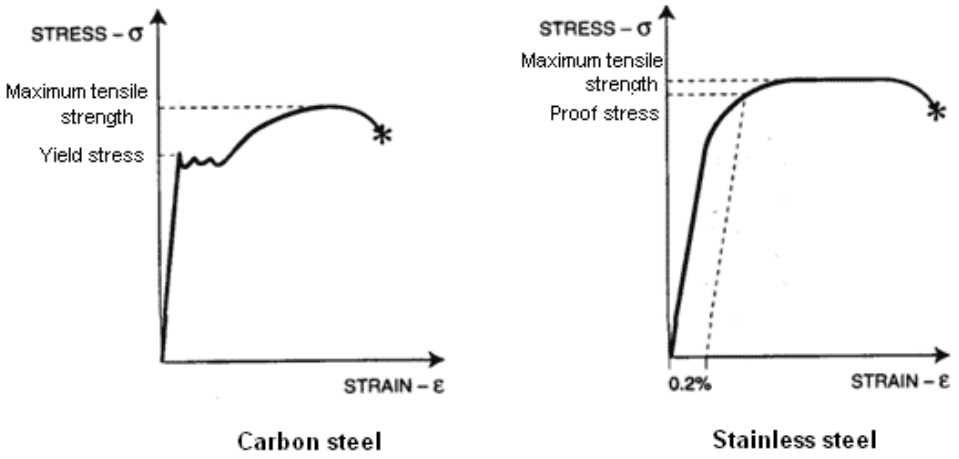
- Molybdenum
- Nickel
- Nitrogen

The carbon acts as a function inversely proportional: lower is the content, greater is the resistance to corrosion. Phenomena of corrosion of reinforcement bars in stainless steel are observed only in the presence of a significant concentration of chlorides penetrated through the porous concrete made by the carbonation (if application in concrete).
Once this contraction exceeds a critical threshold then there is a reduction and cancellation of localized layer of oxide passive and corrosion, at that point, may begin, provided that this is an appropriate amount of oxygen. The phenomenon is better known as pitting (or pitting). An easy way to evaluate the corrosion resistance pitting for stainless steel is the so-called coefficient or index PREN (Pitting Resistance Equivalence Number) given by the formulae:

PREN = %Cr + 3,3%Mo + 16%N (for austenitic steels)
PREN = %Cr + 3 ,3%Mo + 30%N (for duplex steels)

6.3 Ductility

Because of their flexible nature, austenitic and austenitic-ferritic stainless steels present percentage elongation at break, and ratios f_t / f_y rather high.
The curve stress - strain is rather different from that of carbon steel as represented schematically in Fig.1:



Comparison between carbon steel and stainless steel

Recalling that the area behind the two curves is proportional to mechanical energy absorbed in the tensile test, immediately understands the substantial difference in the ability to dissipate the energy associated with events involving important deformations. However, a high ductility of the material certainly does not correspond to a high ductility of the structure, as in reinforced concrete involved other phenomena related to the behaviour of the section or from structural and other specific problems that could penalize the ductility.

6.4 Tenacity

Is the resistance of a material to fragile fracture fragile, that can be determined with the Charpy test that measures the energy required to break with impact a particular sample. Austenitic stainless steels differ from carbon steel for their high level of tenacity (in some cases it comes to overcome a level double).

It is worth noting two interesting factors:

- tenacity of stainless steels don't vary significantly with changing the level of hardening; This is interesting because the different production technologies (drawing cold or hot rolling) did not attract large differences in resistance to cycles of fatigue, which can generate effects of carving the basis of ribs
- tenacity of stainless steels is not particularly influenced by temperature, or lacks a transitional regime ductile-brittle around 0-20 ° C as is the case in carbon steels. This means that the mechanical behaviour of a stainless steel (especially austenitic structure) does not change significantly even for low temperatures (typically up to -196 ° C)

6.5 High and low temperature

Stainless steel austenitic maintains strong resistance to high temperatures; at a temperature of 500 ° C the decrease in yield strength is still negligible. This is less true for austenitic steels-ferritic that in addition to 300 ° C significantly reduce its toughness.
Overall, the behaviour of stainless steel is better compared to carbon steels because collapses at higher temperatures.
The largest thermal expansion coefficient that stainless steels with respect to carbon steels doesn't have negative effect on carbon steel because this effect is offset by lower thermal conductivity of stainless steel. Equally interesting is the behaviour of stainless steel at low temperatures where it appears better tenacity of steel without ductile-brittle transition effects as for carbon steel around 0° C.

6.6 Fatigue resistance

Better fatigue resistance is guaranteed by superiority of stainless steel against steel carbon optimized in terms of ductility.

7. Main works

7.1 Verona arena

The great Roman monument, the symbol of the city, dates back to the first half of the 1st Century AD and since 1913, it has been known throughout the world as the most important open air opera theatre, accommodating up to 22,000 spectators. Recent restoration work involved the construction of new covering for the central pit, where the orchestra sits, the underground room and the underground sewage tunnels, following the replacement of previous reinforced concrete structures. Consequently, the new covering slab for the “large central pit” made of 24 cm thick reinforced concrete was built, with a main span of 11.5 m, supported in its structural function by a system of roof struts and post tension tie rods which minimises strains and deformation owing to the acting loads. The post tension system used, comprising stainless steel bars, goes under the name of ***TENSO-INOX*** and it guarantees the structural safety, quality and durability of the installation, helping the new structures comply with current legislation.

7.2 Cittadella fortification

Restoration work and exploiting of Cittadella’s fortification system.
The project provides solutions relating to the consolidation of the walls, that could ensure at the same time an efficient structural adjustment and a durability of the historic fortified walls.

The choice fell on the system ***TENSO-INOX*** system, which has successfully fulfilled the design requirements.

8. Appendix A. TENSO-INOX 1030SS

8.1 Sheet n°1 – Diameters from 20 to 28mm

BARS							
EN 10088-3 EN 10138-4:2000	Diameter	[mm]	**20**	**22**	**24**	**26**	**28**
	Breaking load	[KN]	329	398	475	557	646
	Yielding load	[KN]	272	329	392	460	533
	Area	[mm²]	320	387	461	541	627
	Weight	[Kg/m]	2,54	3,05	3,60	4,30	4,85
ACCESSORIES							
			T1030inox 20	**TT1050inox 22**	**TT1050inox 24**	**TT1050inox 26**	**TT1050inox 28**
EN 10204 3.1.B. EN 10138-4:2000	Dynamic nut dis.T1030inoxDACD	DACD	H 50 D 45	H 50 D 50	H 55 D 50	H 60 D 55	H 60 D 55
	Fix nut dis.T1030inoxDBEC	DBC	H 30 CH 42	H 30 CH 42	H 30 CH 42	H 30 CH 46	H 30 CH 50
	Anchor nut dis.T1030inoxDAEC	DA	H 50 CH 42	H 50 CH 42	H 55 CH 42	H 60 CH 46	H 60 CH 50
	Rounded washer dis.T1030inoxRS	RCS	H 15 D 50	H 15 D 50	H 15 D 65	H 15 D 65	H 15 D 65
	Dynamic joint coupler dis.T1030inoxMGD	MGD	L 110 D 45	L 110 D 50	L 120 D 50	L 150 D 50	L 160 D 55
	Joint coupler dis.T1030inoxMG	MGST	L 110 D 45	L 110 D 50	L 120 D 50	L 140 D 50	L 140 D 55
	Joint coupler tensioner is.T1030inoxMGT	MGT	on demand	on demand	on demand	on demand	on demand
	Rounded flat plate dis.T1030inoxPPS	PPS	120x120x15	120x120x20	120x120x20	140x140x30	140x140x30
	Flat plate dis.T1030inoxPP	PP	on demand	on demand	on demand	on demand	on demand
	Rounded circular plate dis.T1030inoxPCS	PCS	120x120x15	120x120x20	120x120x20	140x140x30	140x140x30
	Circular steel plate dis.T1030inoxPP	PC	on demand	on demand	on demand	on demand	on demand
Tolerances			+/- 1 mm	+/- 1 mm	+/- 1 mm	+/- 1 mm	+/- 1 mm

8.2 Sheet n°2 - Diameters from 32 to 50mm

BARS							
EN 10088-3 EN 10138-4:2000	Diameter	[mm]	**32**	**36**	**38**	**40**	**50**
	Breaking load	[KN]	843	1.066	1.190	1.318	2.044
	Yielding load	[KN]	696	879	982	1.088	1.687
	Area	[mm²]	819	1.035	1.156	1.280	1.985
	Weight	[Kg/m]	6,40	8,15	9,05	10,05	15,75
ACCESSORIES							
			T1030inox 32	**TT1050inox 36**	**TT1050inox 38**	**TT1050inox 40**	**TT1050inox 50**
EN 10204 3.1.B. EN 10138-4:2000	Dynamic nut dis.T1030inoxDACD	DACD	H 70 D 60	H 80 D 65	H 80 D 65	H 80 D 70	H 120 D 90
	Fix nut dis.T1030inoxDBEC	DBC	H 30 CH 55	H 30 CH 60	H 30 CH 60	H 30 CH 65	H 30 D 80
	Anchor nut dis.T1030inoxDAEC	DA	H 70 CH 55	H 80 CH 60	H 80 CH 65	H 80 CH 70	H 90 D 90
	Rounded washer dis.T1030inoxRS	RCS	H 15 D 70	H 15 D 75	H 15 D 75	H 15 D 80	H 15 D 125
	Dynamic joint coupler dis.T1030inoxMGD	MGD	L 170 D 60	L 180 D 65	L 190 D 65	L 200 D 70	L 240 D 90
	Joint coupler dis.T1030inoxMG	MGST	L 160 D 60	L 170 D 65	L 180 D 65	L 190 D 70	L 230 D 90
	Joint coupler tensioner is.T1030inoxMGT	MGT	on demand	on demand	on demand	on demand	on demand
	Rounded flat plate dis.T1030inoxPPS	PPS	160x160x35	180x180x35	180x180x40	200x200x40	200x200x45
	Flat plate dis.T1030inoxPP	PP	on demand	on demand	on demand	on demand	on demand
	Rounded circular plate dis.T1030inoxPCS	PCS	D 160x35	D 180x35	D 180x40	D 200x40	D 200x45
	Circular steel plate dis.T1030inoxPP	PC	on demand	on demand	on demand	on demand	on demand
Tolerances			+/- 1 mm	+/- 1 mm	+/- 1 mm	+/- 1 mm	+/- 1 mm