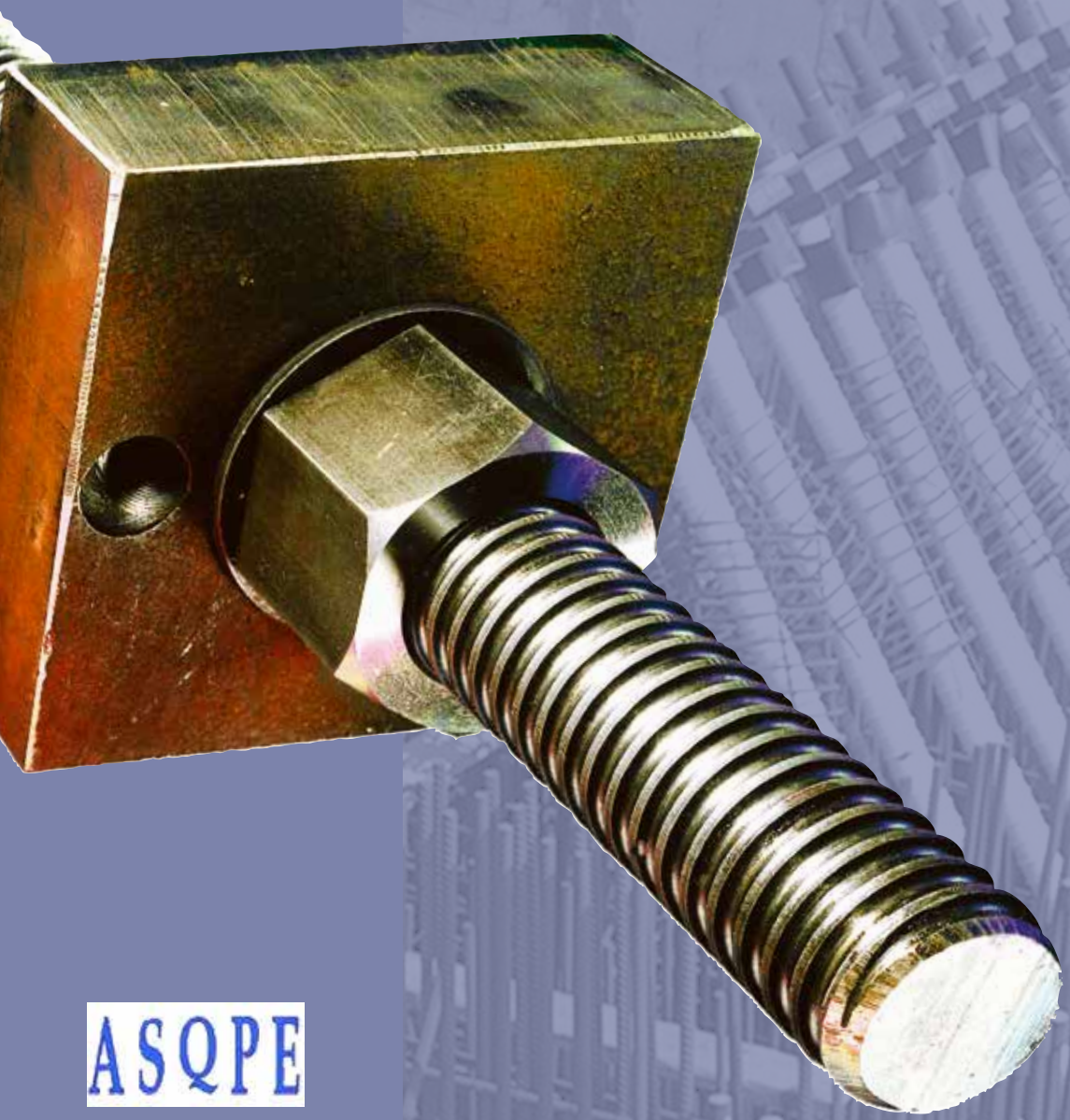
Macalloy

July 2016



ASQPE

CARES 1244-CPD-1007 UKAS PRODUCT CERTIFICATION

CARES 1055 UKAS MANAGEMENT SYSTEMS

CE ETA-07/0046

Macalloy Post Tensioning System

Macalloy 1030

Macalloy S1030

EXPERIENCE INNOVATION QUALITY

Macalloy Post Tensioning System

Macalloy 1030

The Macalloy 1030 Post Tensioning System consists of high tensile alloy steel bars in diameters from 25mm to 75mm, provided with cold rolled threads for part or full length, together with a range of fittings. Bars from 25mm to 40mm diameter obtain their specified properties by cold working. Bars of 50mm and 75mm diameter obtain their specified properties via a quenching and tempering process.

Sizes

Macalloy bars of standard quality are available in lengths up to 11.8m for diameters between 25mm and 40mm and up to 9.6m for 50mm and 75mm diameter. Greater tendon lengths can be obtained by joining Macalloy bars together with threaded Macalloy couplers.

Non-standard bar diameters can also be provided by arrangement. Physical parameters of Macalloy 1030 bar are given in table 1.

Millau Viaduct, France
Architect - Fosters and Partners
Contractor - Eiffage
Engineers - Michel Virlogeux, Bureau d'études Greisch, Setec

Table 1: Range of Macalloy 1030 Bar

Nominal Diameter	Cross sectional area	Mass		Major diameter of threads	Minimum hole diameter in Steelwork
		Macalloy 1030	Macalloy S1030 Stainless		
mm	mm^2	kg/m	kg/m	mm	mm
20	322	-	2.57	22.0	24
25	530	4.17	4.2	28.9	31
26.5	572	4.49	-	30.4	33
32	847	6.65	6.65	36.2	40
36	1075	8.44	-	40.2	44
40	1320	10.36	10.36	45.3	49
50	1963	15.66	15.66	54.8	59
75	4185	32.86	32.86	77.2	82

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Steel Quality

Macalloy 1030 is a carbon-chrome steel with a composition designed to give the specified properties. All bars are hot rolled. Diameters from 25mm to 40mm are cold worked by stretching. The stretching load and permanent elongation are predetermined by preliminary tests and the properties are monitiored during production to ensure that the bars as supplied comply in all respects with the provisions of BS4486.

Bars of 50mm and 75mm diameter are heat treated after rolling at a controlled temperature and time to ensure that the steel achieves the mechanical properties stated in table 2. Rigorous inspection and testing is carried out, both during and after treatment, to ensure consistent tensile properties. The mechanical performance of the bar is monitored through the tensile testing of machined specimens rather than section testing.

Macalloy S1030

Stainless Macalloy S1030 bars in diameters from 20mm to 75mm are made from precipation hardened stainless steel.

Macalloy S1030 bars are available in lengths up to 6m for all diameters from 20mm to 75mm.

Macalloy S1030 has very good general corrosion properties, similar to grades 1.4305 (303) and 1.4301 (304) austenitic stainless steel bars. In industrial atmospheres some surface discolouration may occur over a period of time.

Macalloy S1030 is a martensitic nickel-chrome alloy steel, hardened during manufacture to attain the specified properties.

The mechanical properties of both Macalloy 1030 and S1030 bars are listed in table 2.

Table 2: Mechanical Properties

Grade	Nominal ultimate tensile strength	Nominal 0.1% proof stress	Minimum elongation	Approximate modulus of elasticity
	N/mm²	N/mm²	%	kN/mm²
Macalloy 1030 25-40mm	1030	835	6	170*
Macalloy 1030 50-75mm	1030	835	6	205
Macalloy S1030 20-75mm	1030	835	10	185

*Secant Modulus of Elasticity in range 5 - 70% UTS

Izmit Bay Bridge, Turkey
Main Contractor IHI

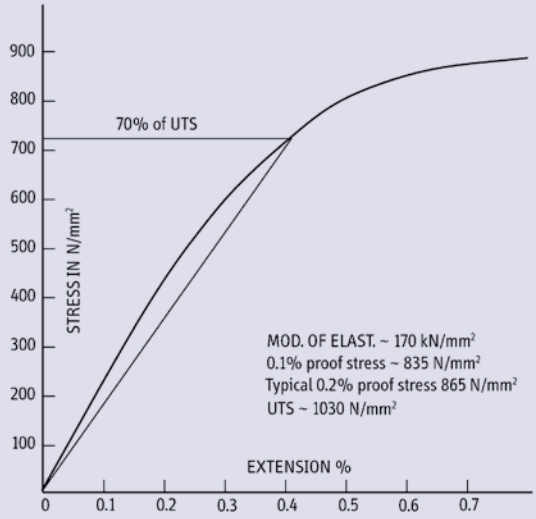
Macalloy Post Tensioning System

Strength

The specified characteristic failing loads and 0.1% proof loads for Macalloy and Macalloy S1030 bar steels are given in Table 3.

Bars can be supplied with nuts, washers, plates, or couplers as required. All fittings are designed to exceed the failing load of the threaded bars.

Typical stress strain diagram for cold worked Macalloy 1030 bar (25-40mm)



Quality Control

Macalloy operates a quality assurance system complying with the provisions of BS EN ISO 9001. Macalloy 1030 bars are independently approved to the requirements of BS4486. The Macalloy 1030 system up to 40mm is independently approved to the requirements of ETAG 013. It is a prerequisite of ETAG 013 that the bars comply with the preliminary European standard prEN 10138.

The Macalloy 1030 Post Tensioning System European Technical Approval document ETA-07/0046 is available as a separate document.

The details within this brochure are in accordance with the current British and European Standards. The system also has approval to the National Standards in France.

In accordance with the requirements of ETAG 013 a factory production control test plan is implemented. Bars and fittings are routinely tested in accordance with this document.

Proof Loading: Facilities are available to load test tendon assemblies up to 2500kN in house or to greater capacities, out of house.

Table 3: Characteristic Loads

Nominal	Failing Load		0.1% proof load	
Diameter	Macalloy 1030	Macalloy S1030	Macalloy 1030	Macalloy S1030
mm	kN	kN	kN	kN
20	-	323	-	262
25	506	506	410	410
26.5	569	-	460	-
32	828	828	670	670
36	1049	-	850	-
40	1295	1295	1050	1050
50	2022	2022	1639	1639
75	4311	4311	3495	3495

Working Load Factors

The working load factor to be used in a design is at the discretion of the Engineer but will normally be that specified in the appropriate Standard.

For prestressed concrete construction, the current standard for buildings is BS8110 and for bridges BS5400, which suggest an initial prestressing force of 70% of the characteristic failing load. For ties and similar applications in structural steel construction, the requirements of BS5950: Parts 1 and 2 apply.

Maximum prestress forces in accordance with EN 1992-1-1: 2004 Eurocode 2: Design of concrete structures, are given in the Macalloy 1030 Post Tensioning System European Technical document ETA-07/0046.

Ground anchorage design is dealt with in BS8081, which gives recommended load factors for permanent and temporary applications.

Properties

Extensive data and test reports on bars and components are available from Macalloy's Technical Department.

The main properties of the 1030 bars are summarised as follows:

Fatigue – threaded assemblies have a fatigue resistance in excess of two million cycles of loading over a tensile stress range of 590-670 N/mm^2, exceeding the requirements laid down in ETAG 013.

Relaxation – the requirement laid down in BS4486 for the loss of stress due to relaxation in a bar loaded to 70% of its characteristic failure load, after 1000 hours at room temperature, is 3.5% maximum. This is comfortably achieved by the 1030 bars, with typical results below 3.0%.

Anchorage strength – anchorage efficiency tests in accordance with the requirements of ETAG 013 are carried out to verify that the failing load in the anchorage is not less than 95% of the actual failing load in the parent bar or 95% of the specified characteristic failure load. Anchorage testing also verifies that the ultimate failure occurs in the bar and is not influenced by the anchorage or coupler.

Stress Corrosion – Macalloy 1030 bars have been subjected to the F.I.P. standard stress corrosion test. No bars failed during the 200 hour duration of the test and subsequent tensile tests to failure showed no significant reduction in the ultimate or 0.1% proof stresses.

NOTE: ETAG 013 approvals are for 1030 system only not S1030.

Millenium Bridge, London
Architect - Fosters and Partners
Main Contractor - Monberg Thorsen and Sir Robert McAlpine
Engineer - Arups

Macalloy Post Tensioning System

Stress corrosion testing has also been conducted in accordance with pr EN 10138-4: 2005-2009 and satisfies the requirements in full.

Under normal circumstances, Macalloy 1030 is not susceptible to stress corrosion. Macalloy 1030 is, of course, subject to surface corrosion when exposed to moisture and deep corrosion pitting is harmful. Further data is available from the Technical Department.

Welding

Macalloy 1030 and Macalloy S1030 must not be welded, subjected to high local heating or splashed with weld metal.

Threads

A coarse thread is cold rolled directly on to the bar. Bars can be end threaded or fully threaded.

The bond value of the coarse thread, when cast into concrete, or grouted into a preformed hole, complies with requirements for a Class 2 deformed bar. This is as per 8110-1:1997 Section 3.12.8.

Short, fully threaded bars can be used satisfactorily for short tendons and bolts, as loss of load due to 'take up' in the threads on transfer of load, is minimised by the controlled limits on clearance, between internal and external threads.

KL8 Footbridge, near Pozńan, Poland
Architect - Bartołomiej Grotte,
Contractor - Skanska / Intercor,
Engineer - Transprojekt Warszawa, prof. Henryk Zobel

Wind Turbines, Uljabuouda, Sweden
Foundation Sub-Contractor – Peikko Sverige
Turbine Manufacturer – Dynawind AB, Sweden
Client – Skellefteå Kraft AB

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Protection Against Corrosion

For normal prestressed concrete construction, the alkaline environment, provided by a layer of cement grout, injected into the duct enclosing the bar gives good protection.

If bars are used in any exposed application, corrosion protection is essential for Macalloy 1030 and can be advantageous for Macalloy S1030.

The type of protection will be governed by the conditions of exposure, appearance and cost. Amongst the available options are:-

- paint systems (comprising of primer and one or more finishing coats)
- grease impregnated tape wrapping
- adhesive coated plastic tape wrapping
- shrink wrap
- plastic tubing
- ridged plastic tubing, with injected grease or grout.
- Thermal metal spray

Macalloy 1030 should never be galvanised.

Two or more of these systems may be combined, to enhance the degree of protection.

Particular care is always needed at end connections and coupled joints, to ensure continuity of protection, over the whole tendon.

Advice is available from Macalloy's Technical department.

Torque Loadings

Macalloy 1030 bars are also used for non post tensioned concrete applications, which require only a relatively small tensioning load.

For these applications, it is possible to develop a load in a Macalloy bar up to 25% of the characteristic failure load, by applying a predetermined torque to the Macalloy nut. Torque wrenches are available from Macalloy that have a dial, indicating the torque value exerted, or which can be preset to slip at a specified torque value.

The axial tension, induced by a given torque, depends upon the diameter and pitch of the threads and upon the friction within the threads and between nut, washer and end plate. Accuracy of the tensile force cannot be expected to be more than ±25%.

The relationship, between the torque applied to a nut bearing onto a standard washer and the resultant load, is as shown in Table 4.

Table 4: K Values for Macalloy Coarse Threads

$$\text{Torque (Nm)} = \frac{P \times D}{K}$$

Where

P is desired axial load in kN

D is the nominal bar diameter in mm

K is a constant obtained by test measurements

Bar Diameter mm	K
25	4.1
26.5	4.3
32	4.7
36	4.9
40	4.5
50	4.1

Macalloy Post Tensioning System

Stressing Procedure

Hydraulic jacking equipment is available to apply load to the bars. Jacks are provided, with gauges calibrated against a certified load cell, to register the force exerted on the bars. In addition, load cells are available to give an independent check on the accuracy of the pump gauge, if necessary.

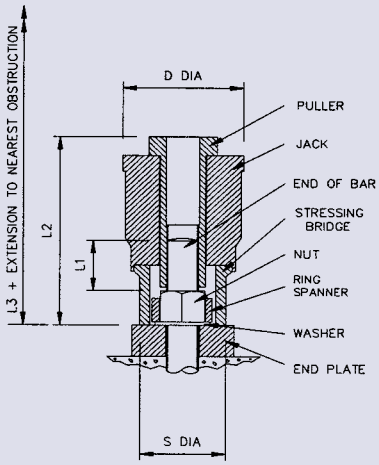
Anchorage recess dimensions must give clearance for the stressing bridge or stool, to seat on the end plate and for access to the ring or box spanner, to tighten the nut. Clearance is also required on one axis for the hose connections to the body of the jack.

Hand and air operated pumps are available, to drive the full range of jacks.

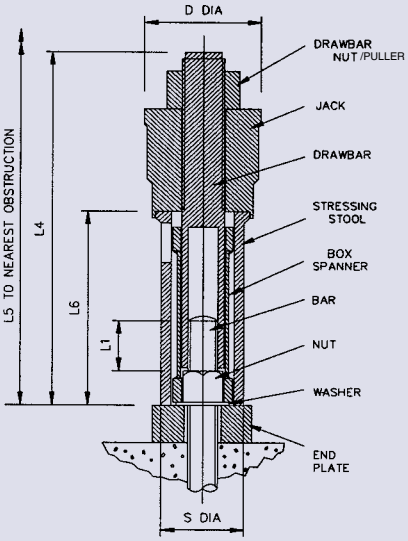
Stressing procedures and jack details are available from Macalloy's Technical Department.

Figure 1 Jack details

NOTE If it is necessary to stress 75mm bars with a stressing bridge L1 must be 320 long and the puller is replaced by Bearing Plate and Nuts.



25 - 50mm Bars (See above note)
Jack with stressing bridge and puller



75mm Bars and 25mm-50mm Bar in 200mm deep pockets jack with stressing stool and drawbar

Table 5: Jacking Dimensions

Jack type	Weight	Max load	Bar dia.	Min bar centres	D.Dia	S. Dia	L1 (min)	L2	L3	L4	L5	L6	Min pocket dia.
3000	50 kgs	3000kN	75	170	250	187	135	330	-	865	1300	500	200
			50	160			90		450				
1000	26kgs	1000kN	40	120	176	125	75	301	385	564	850	300	135
			36	116			65		370				
			32	114			60		360				
450	15kgs	450kN	26.5	90	129	100	50	281	340	566	870	300	110
			25	88			45		330				

All jacks have 50mm stroke. All dimensions in mm

Table 6: Physical Parameters

	Item	Unit	†	Nominal Bar Diameter -mm						
			20	25	26.5	32	36	40	50	75
Bars	Sectional Area	mm^2	322	530	572	847	1075	1320	1963.5	4185.4
	Mass per metre	kg	2.57	4.17	4.49	6.65	8.44	10.36	15.66	32.86
	Metre run of bar per tonne	mm^2	404	246	219	150	118	96	62	30
	Characteristic failing load	kN	314	506	569	828	1049	1295	2022	4311
	Prestress at 70% characteristic	kN	220	354	398	580	734	907	1415	3018
Flat Nuts*	Nut reference		FSSN20	FN25	FN26.5	FN32	FN36	FN40	FN50	FN75
	Length	mm	25	34.5	38.5	43	48	53	73.5	100
	Wide across flats (DIA for 75mm bar)	mm	42	46	50	56	62	72	90	135
Flat Washers*	Washer reference		FSSW20	FSW25	FSW26.5	FSW32	FSW36	FSW40	FSW50	FSW75
	Outside diameter	mm	50	60	65	70	75	90	105	-
	Thickness	mm	5	5	5	5	5	5	5	-
Couplers	Coupler reference		FSSC20	FC25	FC26.5	FC32	FC36	FC40	FC50	FC75
	Outside diameter	mm	35	42.5	42.5	50	57.5	62.5	76	110
	Length - standard	mm	-	85	90	115	130	140	170	230
	Length - stainless	mm	65	80	-	95	-	120	-	-
End Plates	Plate reference		FSSP20	FP25	FP26.5	FP32	FP36	FP40	FP50	FP75
	Length	mm	100	100	110	125	140	160	200	300
	Width	mm	100	100	110	125	140	160	200	300
	Thickness - standard	mm	25	40	40	50	50	60	60	75
	Hole diameter	mm	24	34	36	41	45	51	61	82
	Thickness - threaded	mm	0	40	40	50	60	60	70	110
Ducts**	Recommended Duct ID	mm	30	38	40	48	54	60	75	109
	LARGER DIAMETER DUCTS MAY BE REQUIRED LOCALLY TO ACCOMODATE COUPLERS.									
Threads	Pitch	mm	2.5	6	6	6	6	8	8	8
Standard thread lengths (see fig 2)	Length - jacking end (standard) S1	mm	250	250	250	250	250	250	250	360
	- Dead end (standard) S2	mm	100	100	100	100	100	100	100	160
	- Coupler (standard)	mm	40	45	50	60	65	75	85	150
	X1 (MIN)	mm	75	90	100	120	125	140	175	240
	X2 (MIN)	mm	42	49	53	57	62	71	91	116
	X3 (MIN)	mm	12	12	12	12	12	16	16	16

*** Spherical nuts and washers are available to accommodate rotation if required. †Available in stainless grade only.**
**** Note Duct size does not accomodate a coupler**

Figure 2 End thread dimensions

X1 = live end
X2 = dead end
X3 = length of bar past nut or threaded plate
= 12 for 6mm
16 for 8mm

S1 = live end thread
S2 = dead end thread

L = length over plates

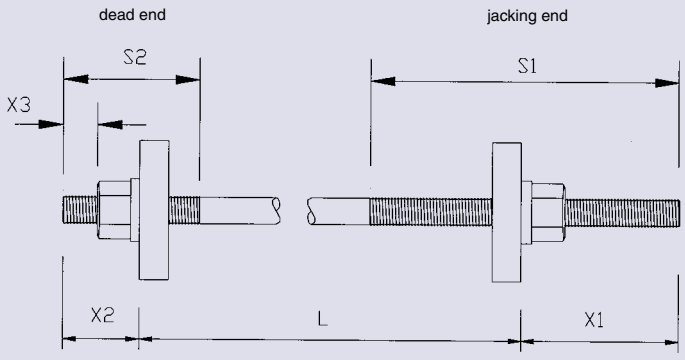


Figure 3 Typical end block reinforcement

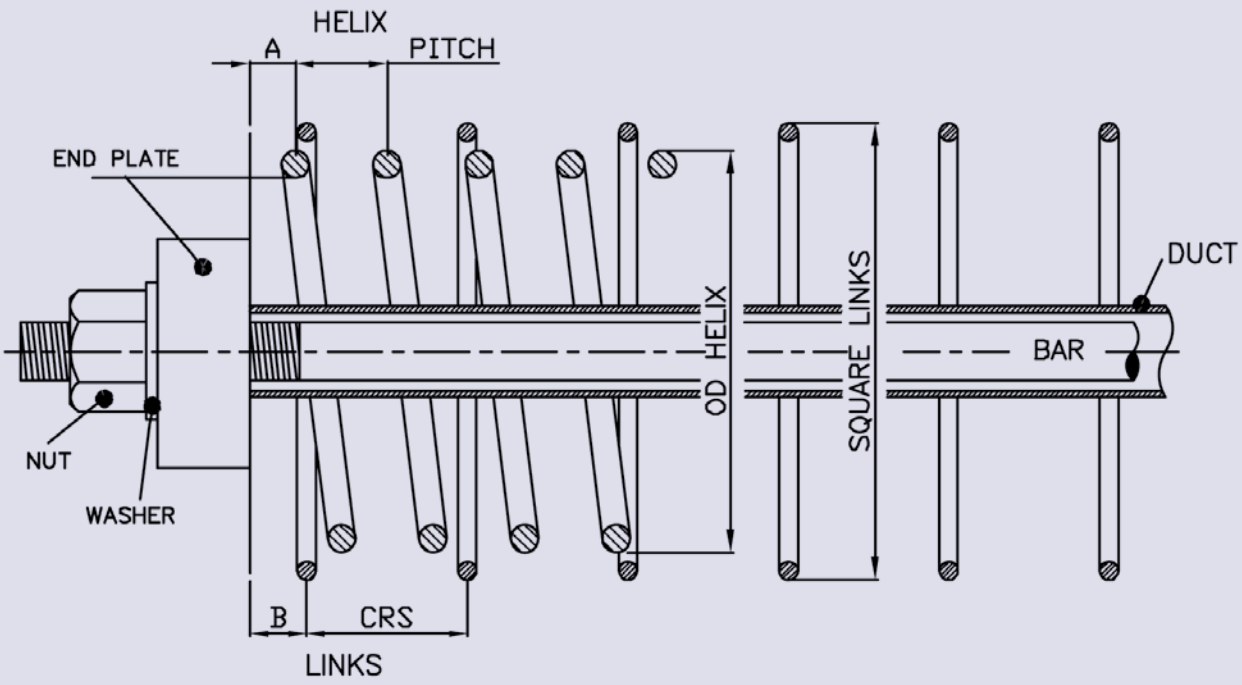


Table 7 Reinforcement details

Macalloy dia. mm	HELIX					LINKS					RECOMMENDED DUCT INSIDE DIAMETER
	Bar	A	Pitch mm	OD	Turns mm	Bar	B	CRS mm	SQU	Number	
25	12	20	40	175	4	8	25	70	199	6	38
26.5	12	20	40	180	4	8	25	70	205	6	40
32	12	20	40	190	5	8	30	70	216	7	48
36	12	20	40	210	6	8	30	70	235	7	54
40	12	20	40	240	7	10	35	75	265	8	60
50	12	20	40	300	8	12	40	80	330	9	75
75	16	30	50	450	8	16	50	100	490	10	109

Anchorage Zone Reinforcement

Bursting tensile forces are induced, in the concrete, immediately behind the anchorage end plates, due to the compressive load applied through the end plates. Reinforcement in the form of links, helices, or a combination of these, should be provided in each end block. The design of the anchorage reinforcement is covered by Section 4.1 of BS8110 and described in greater detail by CIRIA GUIDE 1- June 1976.

Macalloy does not design or supply the helical reinforcement. A more detailed explanation of the Macalloy Post Tensioning System, including Anchorage Zone Reinforcement, is available in the Macalloy Design Data Handbook. Contact the Technical Department for further information.

Macalloy Post Tensioning System

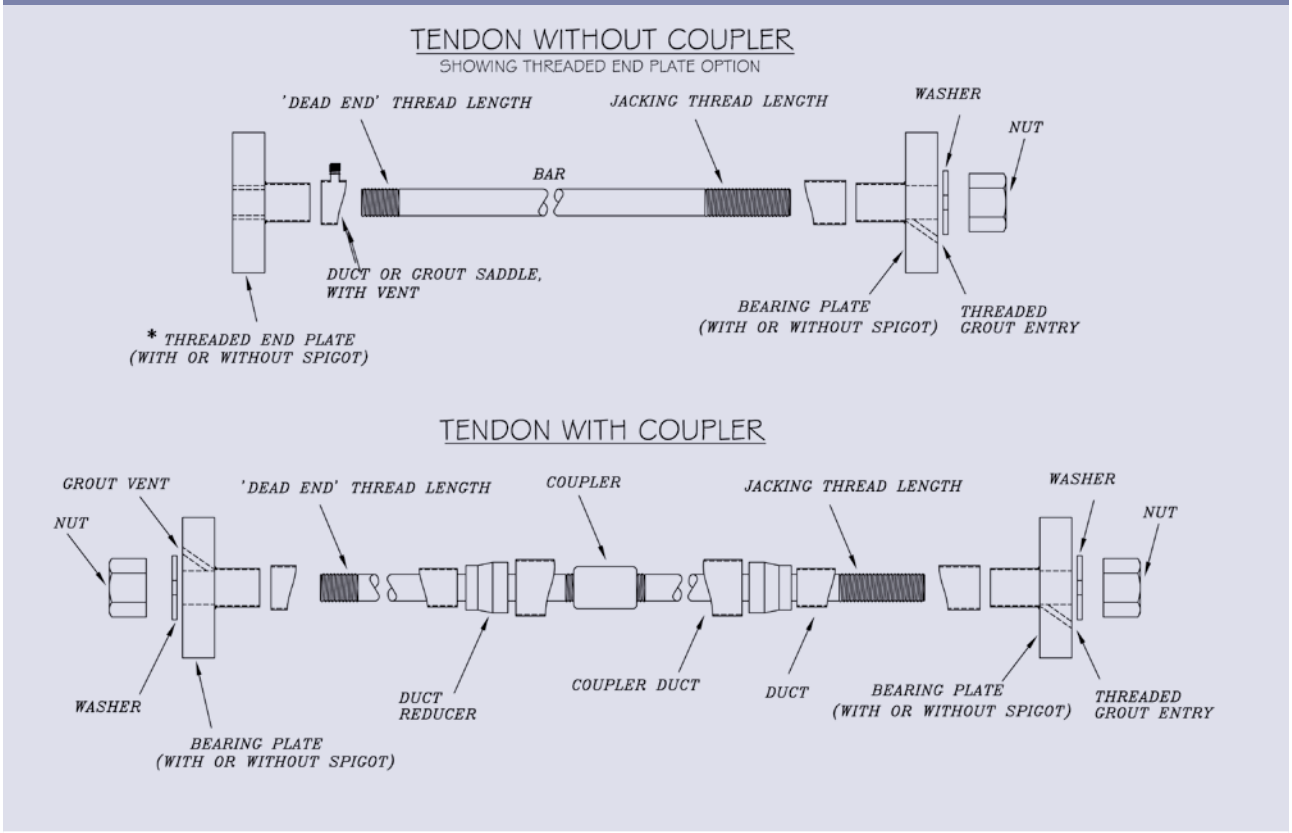
Detailing

There are many permutations possible, to achieve satisfactory construction details and advice is readily available from the Technical Department.

Figure 4 shows typical tendon assemblies.

A more detailed explanation of the Macalloy Post Tensioning System is available in the Macalloy 1030 European Technical Approval, document ETA-07/0046.

Figure 4 Typical tendon assembly for Macalloy bars



*Threaded end plate not currently part of European Technical Approval

Site Services

Macalloy Site Services offers a wide range of hydraulic jacks, pumps and torque wrenches, plus the patented Macalloy TechnoTensioner, which enables the stressing of every type of bar and tendon that is produced by Macalloy.

Services offered by Macalloy Site Services includes advice and supervision, on and off site training or complete site stressing.

Should you require your own technicians to carry out the site stressing then all equipment can be hired directly from Macalloy. For further information on Macalloy Site Services please contact the Technical Department.

Macalloy Post Tensioning System

Applications

Macalloy bars were developed, initially, for use in prestressed concrete construction but have been adapted for many structural applications. Among these are:-

- Stressed connections
  - -concrete to concrete
  - -concrete to steel
  - -steel to steel
- Prestressed block and brick construction
- Anchor bolts for tension ties
- Holding down bolts
- Friction grip bolts and clamps
- Hangers
- Structural steel frame ties
- Ground and rock anchorages
- High strength portal, ground or sheet pile ties
- Temporary or partial prestressing
- Pile testing

Sheikh Zayed Bridge, Contract 3, Abu Dhabi
Main Contractor - Archirodon Construction (O) Co. S.A.
Architect - Zaha Hadid Architects
Engineer - High Point Rendel, London

Yavuz Sultan Selim Bridge
(aka Third Bosphorus Bridge)
Designer Hyundai & SK Engineering JV Installation and Stressing by Intekno

This publication provides the technical details currently used by Macalloy in the manufacture of its components.
The company reserves the right to amend technical details as and where necessary in line with its policy of continuous development.

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