Macalloy Post Tensioning System

Macalloy 1030
Macalloy S1030
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.

Table 1: Range of Macalloy 1030 Bar

<table>
<thead>
<tr>
<th>Nominal Diameter</th>
<th>Cross sectional area</th>
<th>Mass Macalloy 1030</th>
<th>Mass Macalloy S1030 Stainless</th>
<th>Major diameter of threads</th>
<th>Minimum hole diameter in Steelwork</th>
</tr>
</thead>
<tbody>
<tr>
<td>mm</td>
<td>mm²</td>
<td>kg/m</td>
<td>kg/m</td>
<td>mm</td>
<td>mm</td>
</tr>
<tr>
<td>20</td>
<td>322</td>
<td>-</td>
<td>2.57</td>
<td>22.0</td>
<td>24</td>
</tr>
<tr>
<td>25</td>
<td>530</td>
<td>4.17</td>
<td>4.2</td>
<td>28.9</td>
<td>31</td>
</tr>
<tr>
<td>26.5</td>
<td>572</td>
<td>4.49</td>
<td>-</td>
<td>30.4</td>
<td>33</td>
</tr>
<tr>
<td>32</td>
<td>847</td>
<td>6.65</td>
<td>6.65</td>
<td>36.2</td>
<td>40</td>
</tr>
<tr>
<td>36</td>
<td>1075</td>
<td>8.44</td>
<td>-</td>
<td>40.2</td>
<td>44</td>
</tr>
<tr>
<td>40</td>
<td>1320</td>
<td>10.36</td>
<td>10.36</td>
<td>45.3</td>
<td>49</td>
</tr>
<tr>
<td>50</td>
<td>1963</td>
<td>15.66</td>
<td>15.66</td>
<td>54.8</td>
<td>59</td>
</tr>
<tr>
<td>75</td>
<td>4185</td>
<td>32.86</td>
<td>32.86</td>
<td>772</td>
<td>82</td>
</tr>
</tbody>
</table>
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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 monitored 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 precipitation 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 discoloration 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

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

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

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 EAD 160004-00-0301. It is a prerequisite of EAD 160004-00-0301 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 EAD 160004-00-0301 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

<table>
<thead>
<tr>
<th>Nominal Diameter</th>
<th>Macalloy 1030 Failing Load (kN)</th>
<th>Macalloy S1030 Failing Load (kN)</th>
<th>0.1% proof load Macalloy 1030 (kN)</th>
<th>0.1% proof load Macalloy S1030 (kN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>mm</td>
<td>Macalloy 1030</td>
<td>Macalloy S1030</td>
<td>Macalloy 1030</td>
<td>Macalloy S1030</td>
</tr>
<tr>
<td>20</td>
<td>323</td>
<td>323</td>
<td>410</td>
<td>410</td>
</tr>
<tr>
<td>25</td>
<td>506</td>
<td>506</td>
<td>410</td>
<td>410</td>
</tr>
<tr>
<td>26.5</td>
<td>569</td>
<td>-</td>
<td>460</td>
<td>-</td>
</tr>
<tr>
<td>32</td>
<td>828</td>
<td>828</td>
<td>670</td>
<td>670</td>
</tr>
<tr>
<td>36</td>
<td>1049</td>
<td>-</td>
<td>850</td>
<td>-</td>
</tr>
<tr>
<td>40</td>
<td>1295</td>
<td>1295</td>
<td>1050</td>
<td>1050</td>
</tr>
<tr>
<td>50</td>
<td>2022</td>
<td>2022</td>
<td>1639</td>
<td>1639</td>
</tr>
<tr>
<td>75</td>
<td>4311</td>
<td>4311</td>
<td>3495</td>
<td>3495</td>
</tr>
</tbody>
</table>

NOTE: UK Cares Certification does not cover Macalloy 1030 75mm and Macalloy S1030 20mm and 75mm.

Millenium Bridge, London

Architect - Fosters and Partners

Main Contractor - Monberg Thorsen and Sir Robert McAlpine

Engineer - Arups
Macalloy Post Tensioning System

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.


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/mm², exceeding the requirements laid down in EAD 160004-00-0301.

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 EAD 160004-00-0301 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: BBA Certification does not cover Macalloy 1030 75mm or Macalloy S1030.
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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.
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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

<table>
<thead>
<tr>
<th>Bar Diameter mm</th>
<th>K</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>4.1</td>
</tr>
<tr>
<td>26.5</td>
<td>4.3</td>
</tr>
<tr>
<td>32</td>
<td>4.7</td>
</tr>
<tr>
<td>36</td>
<td>4.9</td>
</tr>
<tr>
<td>40</td>
<td>4.5</td>
</tr>
<tr>
<td>50</td>
<td>4.1</td>
</tr>
</tbody>
</table>

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

Where

- \( P \) is desired axial load in kN
- \( D \) is the nominal bar diameter in mm
- \( K \) is a constant obtained by test measurements
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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.

Macalloy require 3 weeks-notice to calibrate equipment and assign personnel, for assistance it always advised to contact Macalloy early in the design of the project phase to provide advice on the tensioning procedure.

Figure 1 Jack details

Table 5: Jacking Dimensions

<table>
<thead>
<tr>
<th>Ref</th>
<th>Max Load (KN)</th>
<th>Dimensions in MM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>M1 for 20.0 Diameter Bar</td>
<td>234</td>
<td>74</td>
</tr>
<tr>
<td>M2 for 20, 25 &amp; 26.5 Diameter Bar</td>
<td>457</td>
<td>102</td>
</tr>
<tr>
<td>M3 for 32 &amp; 36 Diameter Bar</td>
<td>822</td>
<td>133</td>
</tr>
<tr>
<td>M4 for 36 &amp; 40 Diameter Bar</td>
<td>1264</td>
<td>163</td>
</tr>
<tr>
<td>M5 for 40 &amp; 50.0 Diameter Bar</td>
<td>1833</td>
<td>193</td>
</tr>
<tr>
<td>M6 for 50 &amp; 75.0 Diameter Bar</td>
<td>2649</td>
<td>233</td>
</tr>
<tr>
<td>Please contact Macalloy for details of 3000kn jacks if required</td>
<td>3000</td>
<td></td>
</tr>
</tbody>
</table>

Jack size may be changed to suit loads required, however other tensioning equipment may need to be manufactured.
### Table 5: Jacking Dimensions

<table>
<thead>
<tr>
<th>Jack type</th>
<th>Weight (Max load)</th>
<th>Bar dia. (Min)</th>
<th>Bar dia. (Max)</th>
<th>Bar centres (L1)</th>
<th>Pocket dia. (L2)</th>
<th>Pocket dia. (L3)</th>
<th>Pocket dia. (L4)</th>
<th>Pocket dia. (L5)</th>
<th>Pocket dia. (L6)</th>
<th>Min pocket dia.</th>
</tr>
</thead>
<tbody>
<tr>
<td>3000 kgs</td>
<td>3000kN</td>
<td>75</td>
<td>170</td>
<td>250</td>
<td>1871</td>
<td>35</td>
<td>33</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>50 kgs</td>
<td>50kN</td>
<td>100</td>
<td>40</td>
<td>120</td>
<td>76</td>
<td>12</td>
<td>51</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>1000 kgs</td>
<td>1000kN</td>
<td>40</td>
<td>120</td>
<td>76</td>
<td>12</td>
<td>51</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

All jacks have 50mm stroke. All dimensions in mm.

### 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.

### Table 6: Physical Parameters

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Nominal Bar Diameter -mm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>Bars</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sectional Area</td>
<td>mm²</td>
<td>322</td>
</tr>
<tr>
<td>Mass per metre</td>
<td>kg</td>
<td>2.57</td>
</tr>
<tr>
<td>Metre run of bar per tonne</td>
<td>mm²</td>
<td>404</td>
</tr>
<tr>
<td>Characteristic failing load</td>
<td>kN</td>
<td>314</td>
</tr>
<tr>
<td>Prestress at 70% characteristic</td>
<td>kN</td>
<td>220</td>
</tr>
</tbody>
</table>

#### Flat Nuts

**Nut reference**

- FSE20
- FN25
- FN26.5
- FN32
- FN36
- FN40
- FN50
- FN75

**Length**

- mm | 25  | 34.5 | 38.5 | 43 | 48 | 53 | 73.5 | 100 |

**Outside diameter**

- mm | 50  | 60  | 65  | 70 | 75 | 90 | 105  | 135 |

**Thickness**

- mm | 5   | 5   | 5   | 5  | 5  | 5  | 5    | -   |

#### Flat Washers

**Washer reference**

- FSW20
- 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**

- FSC20
- 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   | 75   | 95  | 120 | -   | -   | -    |

#### End Plates

**Plate reference**

- FSP20
- FPP25
- FPP26.5
- FPP32
- FPP36
- FPP40
- FPP50
- FPP75

**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 | 65  | 80   | 40   | 40 | 50  | 60  | 60   | 70   |

**Larger Diameter Ducts May Be Required Locally To Accommodate Couplers.**

#### Ducts

**Recommended Duct ID**

- mm | 30  | 38  | 40  | 48  | 54  | 60  | 75   | 109  |

#### Threads

**Pitch**

- mm | 2.5 | 6   | 6   | 6   | 8   | 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 accommodate a coupler †† Dimension for stainless grade differ contact Macalloy for details**

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**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

---

Larger diameter ducts may be required locally to accommodate couplers.
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**Table 7  Reinforcement details**

<table>
<thead>
<tr>
<th>Macalloy dia. mm</th>
<th>HELIX</th>
<th>LINKS</th>
<th>RECOMMENDED DUCT INSIDE DIAMETER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bar A</td>
<td>Pitch mm</td>
<td>OD</td>
</tr>
<tr>
<td>25</td>
<td>12 20</td>
<td>40 175</td>
<td>4</td>
</tr>
<tr>
<td>26.5</td>
<td>12 20</td>
<td>40 180</td>
<td>4</td>
</tr>
<tr>
<td>32</td>
<td>12 20</td>
<td>40 190</td>
<td>5</td>
</tr>
<tr>
<td>36</td>
<td>12 20</td>
<td>40 210</td>
<td>6</td>
</tr>
<tr>
<td>40</td>
<td>12 20</td>
<td>40 240</td>
<td>7</td>
</tr>
<tr>
<td>50</td>
<td>12 20</td>
<td>40 300</td>
<td>8</td>
</tr>
<tr>
<td>75</td>
<td>16 30</td>
<td>50 450</td>
<td>8</td>
</tr>
</tbody>
</table>

**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.
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**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.

**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.
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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