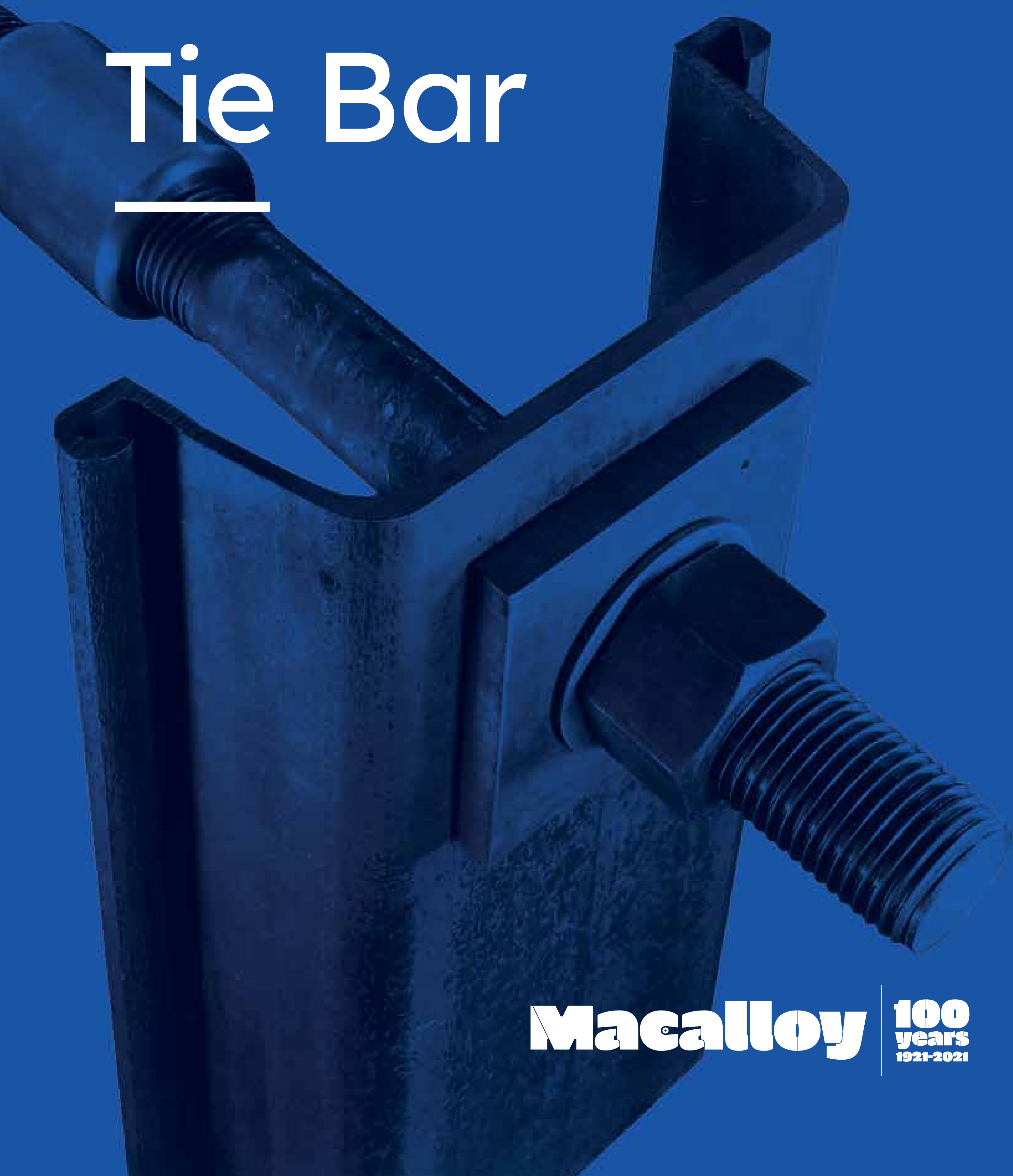
Products & Services

# Marine Tie Bar



Macalloy

100 years 1921-2021

# Macalloy Ltd has been the leader in the design, manufacture and supply of threaded bar systems since the 1940’s. and have supplied the sheet piling tie bar market for over 60 years.


We leverage this experience to develop solutions for all tying applications, now offering Macalloy tie bars in larger diameters and with upset threads. This catalogue offers an overview of the most popular elements in our product range, reflecting the latest advancements. Macalloy is committed to meeting customer needs any bespoke design can be developed to your specifications.

Offering various grades of threaded bar, modern anchorages solutions utilise connecting elements and fixings that including upset threads, in any length up to M160, tables for upset threads as per EN 1993-5. Our technical department is always available to assist you.

Expanding material stocks and facilities allowed Macalloy to offer larger diameters to meet the market demands, the choice and design of anchorage depend on structural requirements.

## Quality

As you would expect from a company as experienced as Macalloy, all our products and systems follow strict quality guidelines. We adhere to procedures as laid down in BS EN ISO 9001.

## Safe Working Loads

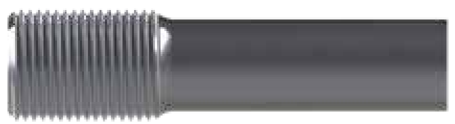
For constant loads, structural safety of anchor walls, waling’s, capping beams, and end plates must be designed in accordance with Eurocode 3, Part 5. It is based on limit state design rather than the factor of safety method.

## Threads

All bars are supplied with standard metric threads to BS3643. A wide range of compatible end connections have been developed to complement the bars, all of which are designed to match the bar capacity.

## Upset Thread

Upset threads are formed to increase the cross-sectional area of the thread to ensure that the design resistance of the shaft and the threaded section are comparable. In addition to standard round steel tie rods with threads at both ends, anchors with upset eyes are available for specific connections. Upset forging allows for larger threads with minimal added weight, ensuring the shaft remains the weakest part. In case of failure, this design provides greater warning of serviceability issues.



## Standard Fittings

Standard tie bar assemblies include a nut, washer, and plate tailored to bearing conditions at each end. For length adjustment and slack removal, a central turnbuckle with right and left-hand threads is available. If adjustment isn’t needed, a full-strength coupler can be used.

## Components

Articulated or pin joints address tie bar sag and forced deflection from fill settlement, which can increase local tensile stress and induce shear stress. These joints should be placed close to the pile and can include LH/RH thread adjustment like a turnbuckle.

## Washers

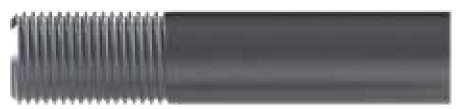
Taper or spherical seating washers are used when the tie bar’s axis isn’t perpendicular to its seating. Profiled anchor blocks are available for tie bars exiting the pile at an angle, such as at a corner.

## Plates

Plates transmit loads, with dimensions depending on the marine tie bar design. Washer plates are for tie bars anchored within sheet pile pans, bearing plates for loads transmitted through walings, and anchorage plates for distributing loads to concrete walls or blocks.

## Bar Length

Tie bars are supplied in 11.8-meter lengths. Longer tendons can be connected using couplers, turnbuckles, link plates, or hinged turnbuckles.



## Steel Grades

Our anchors, ranging from M68 to M160 in diameter, Tie Bars are available in grades 460, 550, 650, and 750. Higher strength steel offers lighter anchors but may not meet all requirements. For details on other available grades, contact Macalloy

| Steel Grade | TB460 | TB550 | TB650 | TB750 |
|---|---|---|---|---|
| Characteristic yield stress ($N/mm^2$) | 460 | 550 | 650 | 750 |
| Characteristic Failure Stress ($N/mm^2$) | 610 | 750 | 850 | 950 |
| Minimum Elongation | 19% | 18% | 15% | 13% |

Macalloy Tie bar has the following mechanical properties. If there is a higher requirement for the impact absorption energy of 27 Joules at -40°C or -60°C it can be achieved.

## Ultimate Limit State

| Symbol | Description |
|---|---|
| $F_{t,Rd}$ | Design tensile resistance of anchor thread |
| $F_{tg,Rd}$ | Design tensile resistance of anchor shaft |
| $F_{yt,Rd}$ | Design resistance at yield stress / 0.2% proof stress of anchor thread |
| $F_{yg,Rd}$ | Design resistance at yield stress / 0.2% proof stress of anchor shaft |
| $K_t$ | Notch Factor |
| $F_{ua}$ | Tensile strength of anchor |
| $F_y$ | Yield stress of anchor |
| $A_s$ | Stressed cross-sectional area, thread |
| $A_g$ | Gross cross-sectional area, shaft |
| $\gamma_{M2}$ | Partial safety factor for anchor shaft stressed up to failure |
| $\gamma_{M0}$ | Partial safety factor for anchor shaft |

The thread capacity of an anchor is reduced by the factor $k_t$ to account for additional stresses from fill settlement or less-than-ideal installation conditions, as per EN1993-5

According to many EN1993-5 National Annexes, use a conservative $k_t$ value of 0.6 unless structural detailing eliminates bending, in which case 0.9 can be used.

| Formula | Characteristic |
|---|---|
| $F_{t,Rd} = \min(F_{tt,Rd}\,;\,F_{yt,Rd})$ | Design resistance, thread: |
| $F_{tt,Rd} = k_t{*}F_{ua}{*}A_s/\gamma_{M2}$ | Failure in thread: |
| $F_{yt,Rd} = F_y{*}A_s/\gamma_{M0}$ | Yield stress, thread: |
| $F_{g,Rd} = \min(F_{tg,Rd}\,;\,F_{yg,Rd})$ | Design resistance, shaft: |
| $F_{tg,Rd} = A_g{*}F_{ua}/\gamma_{M2}$ | Failure in shaft: |
| $F_{yg,Rd} = F_y{*}A_g/\gamma_{M0}$ | Yield stress, shaft: |
| $F_{u,Rd} = \min(F_{t,Rd}\,;\,F_{g,Rd})$ | Design resistance, anchor: |

According to EN1993-5, the design resistance of the anchor $F_{u,Rd}$ is the lesser value between the thread's design resistance $F_{t,Rd}$ and the shaft's design resistance $F_{g,Rd}$.

## Corrosion Protection

Steel sheet piles are used in many aggressive environments and consequently corrosion protection or factors influencing effective life must be considered. Several options are available to the designer. Consider sacrificial steel, protective tape, or coating systems, with sacrificial steel often being the most cost-effective and durable. Corrosion protection for anchors should be prioritized at the design stage, especially at the connection to the front wall, where anchors are most exposed to aggressive conditions and prone to failure.

## Sacrificial Corrosion

Sacrificial Corrosion is the most practical and robust corrosion protection. The anchor shaft and thread are increased in diameter to account for steel loss over the structure's lifespan, eliminating the need for additional coatings. Tables 4-1 and 4-2 of EN1993-5 provide corrosion allowances for steel sheet piles, and these rates are commonly applied to tie bars as well.

| Required design working life | 5 Years | 25 Years | 50 Years | 75 Years | 100 Years |
|---|---|---|---|---|---|
| Non-compacted and non-aggressive fills (clay, slate, sand, silt) | 0.18 | 0.7 | 1.2 | 1.7 | 2.2 |

Note: For compacted fills the EN1993-5 allows the corrosion rate to be halved.

| Required design working life | 5 Years | 25 Years | 50 Years | 75 Years | 100Years |
|---|---|---|---|---|---|
| Freshwater (river, canal, ...) in the region of the waterline | 0.15 | 0.55 | 0.9 | 1.15 | 1.4 |
| Severely polluted freshwater (wastewater, industrial wastewater) in the region of the waterline | 0.3 | 1.3 | 2.3 | 3.3 | 4.3 |
| Seawater in a temperate climate in the region of the waterline (low water and splash water zones) | 0.55 | 1.9 | 3.75 | 5.6 | 7.5 |
| Seawater in a temperature climate in the underwater or tidal zones. | 0.25 | 0.9 | 1.75 | 2.6 | 3.5 |

Note: At design stage, sacrificial corrosion allowance in the fill can be determined separately to the sacrificial corrosion allowance at the head.

## Protective Tape

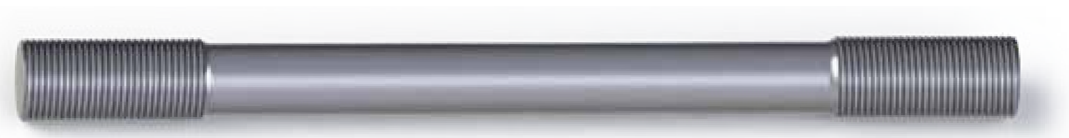
A common form of corrosion protection is to wrap the bar with a protective barrier containing oxygen scavengers, Macalloy can supply factory-wrapped bars with the Denso range of products that uses petrolatum tape to protect anchors, but connections must be wrapped on-site, which can significantly extend installation time.

## Coating Systems

Anchors can be coated with any client-specified system needed to withstand the demanding environment, several options are available, such as paint systems, galvanising or zinc epoxy primer. The threads can only receive a nominal zinc coating when hot-dip galvanized or painted with zinc epoxy primer, therefore further protection may still be required on completion of the installation.

## Protection of the Anchor Head

Adequate protection should be provided to the anchor head detail, as it is often situated in challenging site conditions. The anchor head, particularly vulnerable, can only be fully protected after installation.



| Nominal Diameter | $ØD_t$ | Metric | M68 | M72 | M76 | M85 | M90 | M95 | M100 | M105 | M110 | M115 | M125 | M130 | M135 | M140 | M150 | M155 | M160 | M165 | M170 | M175 | M180 | M185 | M195 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stressed Area, Thread | $A_s$ | mm² | 3055 | 3460 | 3889 | 4948 | 5591 | 6273 | 6995 | 7755 | 8555 | 9395 | 11191 | 12148 | 13145 | 14181 | 16370 | 17523 | 18716 | 19948 | 21219 | 22530 | 23880 | 25269 | 28165 |
| Shaft Diameter | d | mm | 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | 95 | 100 | 105 | 110 | 115 | 120 | 125 | 130 | 135 | 140 | 145 | 150 | 155 | 160 | 165 |
| Area, Shaft | $A_g$ | mm² | 2376 | 2827 | 3318 | 3848 | 4418 | 5027 | 5675 | 6362 | 7088 | 7854 | 8659 | 9503 | 10387 | 11310 | 12272 | 13273 | 14314 | 15394 | 16513 | 17671 | 18869 | 20106 | 21382 |

| Grade 460 - Anchor Force to EN1993-5 | | | | M68 | M72 | M76 | M85 | M90 | M95 | M100 | M105 | M110 | M115 | M125 | M130 | M135 | M140 | M150 | M155 | M160 | M165 | M170 | M175 | M180 | M185 | M195 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Design Resistance, Shaft | $F_{g,Rd}$ | kN | 1093 | 1301 | 1526 | 1770 | 2032 | 2312 | 2610 | 2926 | 3261 | 3613 | 3983 | 4372 | 4778 | 5202 | 5645 | 6106 | 6584 | 7081 | 7596 | 8129 | 8680 | 9249 | 9836 |
| $k_t$=0.6 | Design Resistance, Thread | $F_{t,Rd}$ | kN | 895 | 1013 | 1139 | 1449 | 1637 | 1837 | 2048 | 2271 | 2505 | 2751 | 3277 | 3557 | 3849 | 4152 | 4793 | 5131 | 5480 | 5841 | 6213 | 6597 | 6992 | 7399 | 8247 |
| | Permissible Design Resistance | $F_{u,Rd}$ | kN | 895 | 1013 | 1139 | 1449 | 1637 | 1837 | 2048 | 2271 | 2505 | 2751 | 3277 | 3557 | 3849 | 4152 | 4793 | 5131 | 5480 | 5841 | 6213 | 6597 | 6992 | 7399 | 8247 |
| | Design Resistance, Shaft | $F_{g,Rd}$ | kN | 1093 | 1301 | 1526 | 1770 | 2032 | 2312 | 2610 | 2926 | 3261 | 3613 | 3983 | 4372 | 4778 | 5202 | 5645 | 6106 | 6584 | 7081 | 7596 | 8129 | 8680 | 9249 | 9836 |
| $k_t$=0.9 | Design Resistance, Thread | $F_{t,Rd}$ | kN | 1342 | 1519 | 1708 | 2173 | 2455 | 2755 | 3072 | 3406 | 3758 | 4126 | 4915 | 5336 | 5773 | 6228 | 7190 | 7696 | 8220 | 8761 | 9320 | 9895 | 10488 | 11098 | 12370 |
| | Permissible Design Resistance | $F_{u,Rd}$ | kN | 1093 | 1301 | 1526 | 1770 | 2032 | 2312 | 2610 | 2926 | 3261 | 3613 | 3983 | 4372 | 4778 | 5202 | 5645 | 6106 | 6584 | 7081 | 7596 | 8129 | 8680 | 9249 | 9836 |

| Grade 550 - Anchor Force to EN1993-5 | | | | M68 | M72 | M76 | M85 | M90 | M95 | M100 | M105 | M110 | M115 | M125 | M130 | M135 | M140 | M150 | M155 | M160 | M165 | M170 | M175 | M180 | M185 | M195 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Design Resistance, Shaft | $F_{g,Rd}$ | kN | 1307 | 1555 | 1825 | 2117 | 2430 | 2765 | 3121 | 3499 | 3899 | 4320 | 4762 | 5227 | 5713 | 6220 | 6750 | 7300 | 7873 | 8467 | 9082 | 9719 | 10378 | 11058 | 11760 |
| $k_t$=0.6 | Design Resistance, Thread | $F_{t,Rd}$ | kN | 1100 | 1245 | 1400 | 1781 | 2013 | 2258 | 2518 | 2792 | 3080 | 3382 | 4029 | 4373 | 4732 | 5105 | 5893 | 6308 | 6738 | 7181 | 7639 | 8111 | 8597 | 9097 | 10139 |
| | Permissible Design Resistance | $F_{u,Rd}$ | kN | 1100 | 1245 | 1400 | 1781 | 2013 | 2258 | 2518 | 2792 | 3080 | 3382 | 4029 | 4373 | 4732 | 5105 | 5893 | 6308 | 6738 | 7181 | 7639 | 8111 | 8597 | 9097 | 10139 |
| | Design Resistance, Shaft | $F_{g,Rd}$ | kN | 1307 | 1555 | 1825 | 2117 | 2430 | 2765 | 3121 | 3499 | 3899 | 4320 | 4762 | 5227 | 5713 | 6220 | 6750 | 7300 | 7873 | 8467 | 9082 | 9719 | 10378 | 11058 | 11760 |
| $k_t$=0.9 | Design Resistance, Thread | $F_{t,Rd}$ | kN | 1650 | 1868 | 2100 | 2672 | 3019 | 3387 | 3777 | 4188 | 4620 | 5073 | 6043 | 6560 | 7098 | 7658 | 8840 | 9463 | 10107 | 10772 | 11459 | 12166 | 12895 | 13645 | 15209 |
| | Permissible Design Resistance | $F_{u,Rd}$ | kN | 1307 | 1555 | 1825 | 2117 | 2430 | 2765 | 3121 | 3499 | 3899 | 4320 | 4762 | 5227 | 5713 | 6220 | 6750 | 7300 | 7873 | 8467 | 9082 | 9719 | 10378 | 11058 | 11760 |

| Grade 650 - Anchor Force to EN1993-5 | | | | M68 | M72 | M76 | M85 | M90 | M95 | M100 | M105 | M110 | M115 | M125 | M130 | M135 | M140 | M150 | M155 | M160 | M165 | M170 | M175 | M180 | M185 | M195 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Design Resistance, Shaft | $F_{g,Rd}$ | kN | 1544 | 1838 | 2157 | 2501 | 2872 | 3267 | 3688 | 4135 | 4607 | 5105 | 5628 | 6177 | 6751 | 7351 | 7977 | 8628 | 9304 | 10006 | 10733 | 11486 | 12265 | 13069 | 13899 |
| $k_t$=0.6 | Design Resistance, Thread | $F_{t,Rd}$ | kN | 1247 | 1412 | 1587 | 2019 | 2281 | 2559 | 2854 | 3164 | 3491 | 3833 | 4566 | 4957 | 5363 | 5786 | 6679 | 7150 | 7636 | 8139 | 8658 | 9192 | 9743 | 10310 | 11491 |
| | Permissible Design Resistance | $F_{u,Rd}$ | kN | 1247 | 1412 | 1587 | 2019 | 2281 | 2559 | 2854 | 3164 | 3491 | 3833 | 4566 | 4957 | 5363 | 5786 | 6679 | 7150 | 7636 | 8139 | 8658 | 9192 | 9743 | 10310 | 11491 |
| | Design Resistance, Shaft | $F_{g,Rd}$ | kN | 1544 | 1838 | 2157 | 2501 | 2872 | 3267 | 3688 | 4135 | 4607 | 5105 | 5628 | 6177 | 6751 | 7351 | 7977 | 8628 | 9304 | 10006 | 10733 | 11486 | 12265 | 13069 | 13899 |
| $k_t$=0.9 | Design Resistance, Thread | $F_{t,Rd}$ | kN | 1870 | 2117 | 2380 | 3028 | 3422 | 3839 | 4281 | 4746 | 5236 | 5750 | 6849 | 7435 | 8045 | 8679 | 10018 | 10724 | 11454 | 12208 | 12986 | 13788 | 14615 | 15465 | 17237 |
| | Permissible Design Resistance | $F_{u,Rd}$ | kN | 1544 | 1838 | 2157 | 2501 | 2872 | 3267 | 3688 | 4135 | 4607 | 5105 | 5628 | 6177 | 6751 | 7351 | 7977 | 8628 | 9304 | 10006 | 10733 | 11486 | 12265 | 13069 | 13899 |

| Grade 750 - Anchor Force to EN1993-5 | | | | M68 | M72 | M76 | M85 | M90 | M95 | M100 | M105 | M110 | M115 | M125 | M130 | M135 | M140 | M150 | M155 | M160 | M165 | M170 | M175 | M180 | M185 | M195 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Design Resistance, Shaft | $F_{g,Rd}$ | kN | 1782 | 2121 | 2489 | 2886 | 3313 | 3770 | 4256 | 4771 | 5316 | 5890 | 6494 | 7127 | 7790 | 8482 | 9204 | 9955 | 10735 | 11545 | 12385 | 13254 | 14152 | 15080 | 16037 |
| $k_t$=0.6 | Design Resistance, Thread | $F_{t,Rd}$ | kN | 1393 | 1578 | 1773 | 2256 | 2549 | 2860 | 3190 | 3536 | 3901 | 4284 | 5103 | 5540 | 5994 | 6466 | 7465 | 7991 | 8535 | 9096 | 9676 | 10274 | 10889 | 11523 | 12843 |
| | Permissible Design Resistance | $F_{u,Rd}$ | kN | 1393 | 1578 | 1773 | 2256 | 2549 | 2860 | 3190 | 3536 | 3901 | 4284 | 5103 | 5540 | 5994 | 6466 | 7465 | 7991 | 8535 | 9096 | 9676 | 10274 | 10889 | 11523 | 12843 |
| | Design Resistance, Shaft | $F_{g,Rd}$ | kN | 1782 | 2121 | 2489 | 2886 | 3313 | 3770 | 4256 | 4771 | 5316 | 5890 | 6494 | 7127 | 7790 | 8482 | 9204 | 9955 | 10735 | 11545 | 12385 | 13254 | 14152 | 15080 | 16037 |
| $k_t$=0.9 | Design Resistance, Thread | $F_{t,Rd}$ | kN | 2090 | 2366 | 2660 | 3384 | 3824 | 4291 | 4784 | 5305 | 5852 | 6426 | 7655 | 8310 | 8991 | 9700 | 11197 | 11986 | 12802 | 13645 | 14514 | 15411 | 16334 | 17284 | 19265 |
| | Permissible Design Resistance | $F_{u,Rd}$ | kN | 1782 | 2121 | 2489 | 2886 | 3313 | 3770 | 4256 | 4771 | 5316 | 5890 | 6494 | 7127 | 7790 | 8482 | 9204 | 9955 | 10735 | 11545 | 12385 | 13254 | 14152 | 15080 | 16037 |

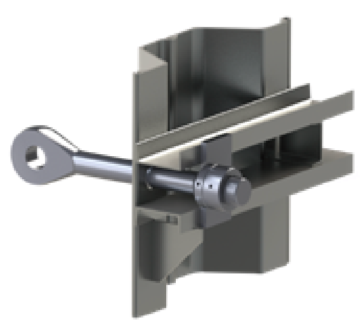
## Link Plates, Hinged Turnbuckles and Cardan Joints

Forged eyes and link plates offer the most economical articulated joint and the simplest connection for site conditions.

Hinge turnbuckles create a joint for both tensioning and articulated connections, enables length adjustment and articulation in one plane.

Link Plates or Articulated Turnbuckles are available to counter the effect of tie bar sag and forced deflection due to settlement fill.

The cardan joint enables bars with forged eyes to articulate in both vertical and horizontal planes. Removing the forced deflection due to site requirements significantly reduceing the tensile stress in the tie bar locally.



## U and Z Pile Anchor Wall connection

Round steel tie rods are a cost-effective anchoring solution for sheet pile walls. Typically, horizontal reaction forces are first transferred from the sheet pile walls to a waling beam and then to the tie rods, providing more distributed load transfer and added stiffening compared to direct tie rod connections

Anchor spacing is determined by the sheet pile wall's system width.

Typically, waling sections are positioned on the non-bearing side at the anchor wall

## Combi Wall Connection

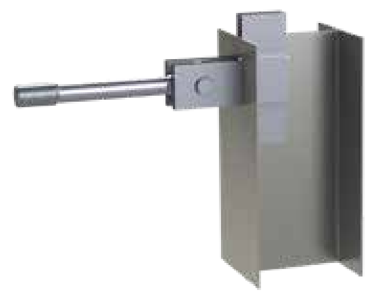
Connections to combined sheet piling with tubular piles are typically made using T-connections that pass through the pile wall and are introduced from above.

Anchor forces on high modulus piles are usually high, so articulated connections such as a link plate are recommended to permit vertical articulation.

## HZ-M Wall tension plates

Tension plates are positioned on either side of the HZ-M web, forces transfer from the HZ-wall to the forged eye anchor bar via a pin connection

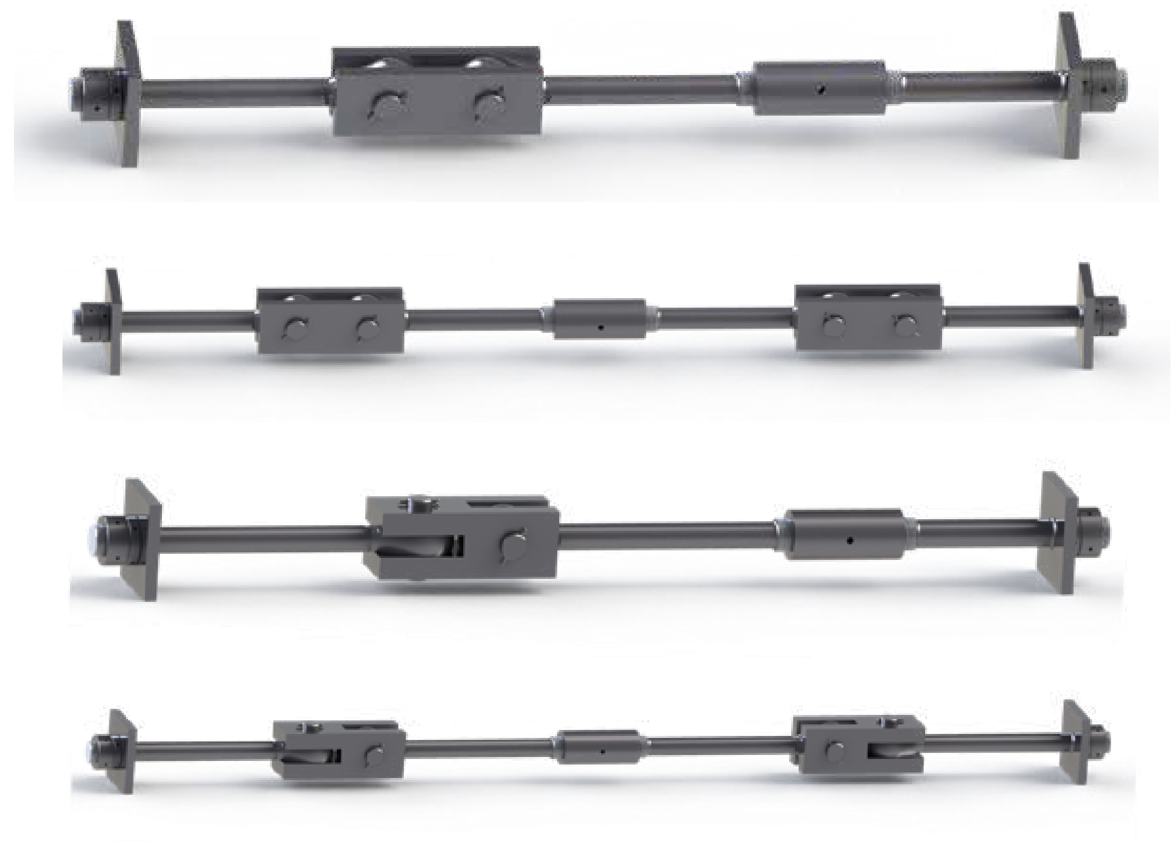
For expected settlement, the anchor connection should be hinged to permit vertical movement and prevent bending stresses at threaded joints.



## Concrete Wall Connection

Anchor forces are transferred directly to the concrete wall via the plate. Proper alignment between the front wall and anchor wall connection points is crucial.

A simple end plate connection is commonly used. when the anchor is laid in filled ground and settlement is likely an additional hinged connection joint is necessary.



Link Plates are ideal for special connections and expected settlements.

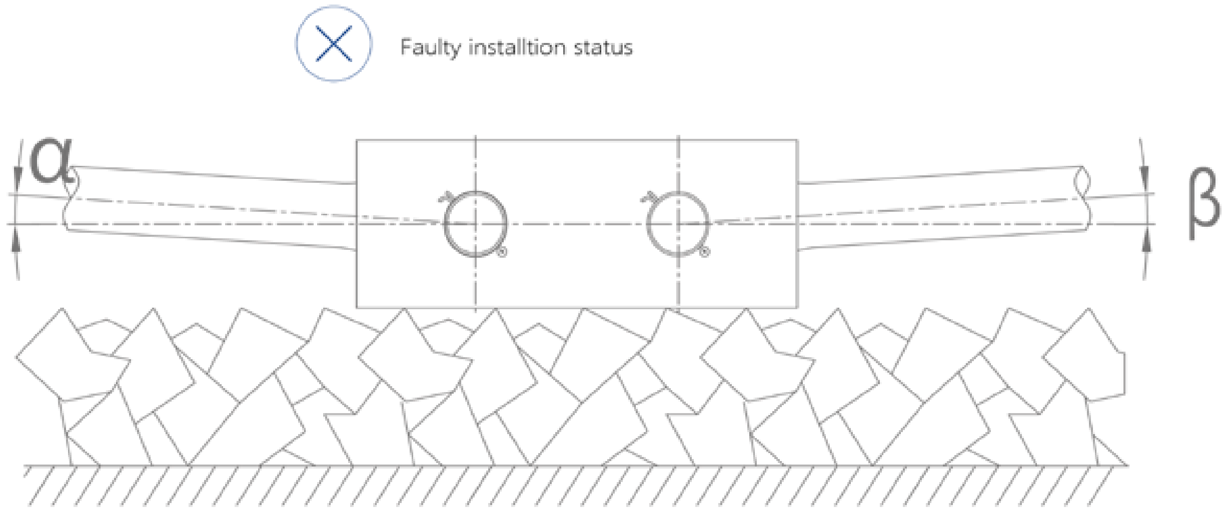



Fig. 2 The shaft and unidirectional hinge are directly placed on the ground, and shaft is tilted

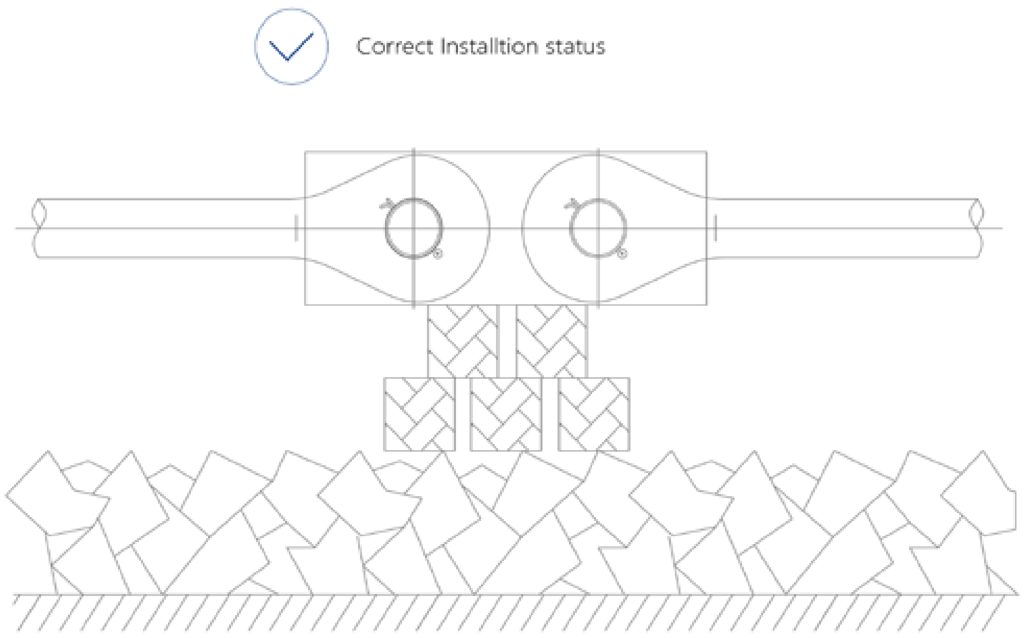



Fig. 3 Timber is placed under shaft and unidirectional hinge,and shaft shall be horizontal

Tie bars are assembled with component bars supported at the correct level, with slack removed by tightening the end nut. Typically, they reach their working load during backfilling, as pile movement induces load into the tie bars.



## Waling Bolts

Macalloy offers waling bolts in various grades to complement its tie bars. Waling bolts, made from the same steel as TB460, can be threaded at both ends, with customizable lengths.

## Supply

Most major projects require rolling raw materials to the specific project diameter, which can be adjusted to the nearest millimetre for the most economical solution.

## Storage

Tie rods and accessories must be stored and handled to prevent deformation, corrosion, heat exposure, bending, or damage. Welding or flame cutting on tie rods and accessories is prohibited without written approval from Macalloy. All components must be protected from heat exposure on site.

## Assembly

Due to shipping restrictions, anchors are typically delivered in sections up to 11.8 m. Sections should be assembled on-site to design lengths to ensure threads are clean and undamaged. All threaded connections must engage at least one thread diameter.

## Installation

Anchors should be installed as close as possible to their expected line of force. Consider additional forces from fill settlement, especially bending at the wall connection. For long anchors, use a stiff lifting beam with supports every 4-6 meters. Settlement ducts can reduce bending but require careful alignment to be effective.

## Prestressing of Anchors

Pre-loading anchors is most efficiently done using a hydraulic jack at the threaded end. This should be considered during the design stage for practicality.

## Site services

Macalloy offers training for assembly, installation, and stressing, for more information, please contact our site services department; siteservices@macalloy.com

While we strive for accuracy, we cannot guarantee the completeness of all details. Customers should verify product suitability for their needs. This data does not constitute a contractual offer. As part of our continuous improvement policy, we may amend details without notice. For current information, please contact our technical department; technical@macalloy.com

## TUAS SOUTH SHIPYARD, SINGAPORE

Tie Rod Type: ø60, ø65, ø80
Tensile Strength: Grade 460
Total QTY: 2250pcs
Total Weight: 1970 ton

## SUONA PORT, EGYPT.

Tie Rod Type: ø90
Tensile Strength: Grade 700
Total Weight: 300 ton

## KARACHI DEEP WATER PORT, PAKISTAN.

Tie Rod Type: ø150, ø140
Tensile Strength: Grade 550
Total QTY: 609pcs
Total Weight: 5500 ton

ETA DANMARK
ETA - 21/0053 Tension Rod Systems
BSEN ISO 9001: 2015

MADE IN SHEFFIELD

Macalloy 100 years 1921-2021

For further information call +44 (0)1909 519200
email sales@macalloy.com or visit macalloy.com
Caxton Way, Dinnington, Sheffield, S25 3QE, U.K.

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