ASDO

ANCHORS FOR MARINE STRUCTURES

M64 – M170 Tie rods for retaining structures

CE

Since 1920

100 1920–2020 years steel tradition

ANKER SCHROEDER

ASDO steel tension members

ASDO ANCHORS FOR MARINE STRUCTURES

Anker Schroeder manufacture anchors for retaining structures such as quay walls, abutments, berths and crane runways. Our anchors range in diameter from M64 to M170 and can be supplied in grades 500 & 700.
Anker Schroeder anchors are manufactured from round steel bar with forged or threaded ends that allow a variety of connections to be made to sheet piles, tubes, H-piles, combi-walls and diaphragm walls.

MADE IN GERMANY

STEEL GRADES

Anker Schroeder offer 2 standard steel grades for tie bars:

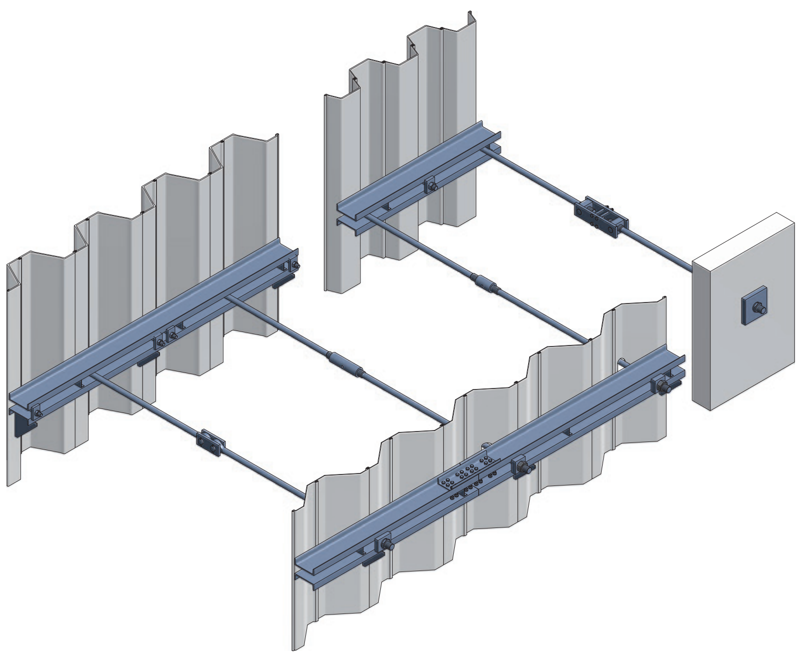
	Diameter	f_y N/mm²	f_{ua} N/mm²
ASDO500	M64 - M165	500	660
ASDO700	M64 - M170	700	900

The choice of steel grade depends on a number of factors, whilst the higher strength steel will always produce the lightest weight anchor this may not be suitable for stiffness requirements, onsite welding or lead-times. Other grades of steel are available please contact Anker Schroeder to discuss further.

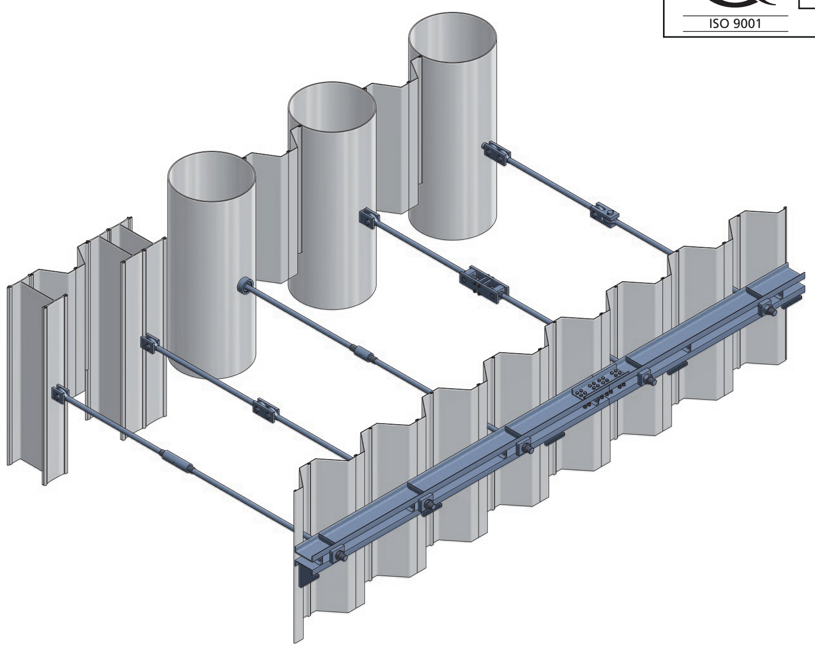
Depending on diameter and length required Anker Schroeder tie bars are manufactured using selected fine grained steel, high strength low alloy steel or quench and tempered steel. The choice of steel is dependent upon your specific project requirements but the above minimum properties will be met. All tie bars and components are manufactured to a quality system audited and accredited to ISO 9001 and meet the requirements of EN 1090 and can be supplied CE marked (a legal requirement for supply into the European market).

ISO 9001 | UKAS MANAGEMENT SYSTEMS 001

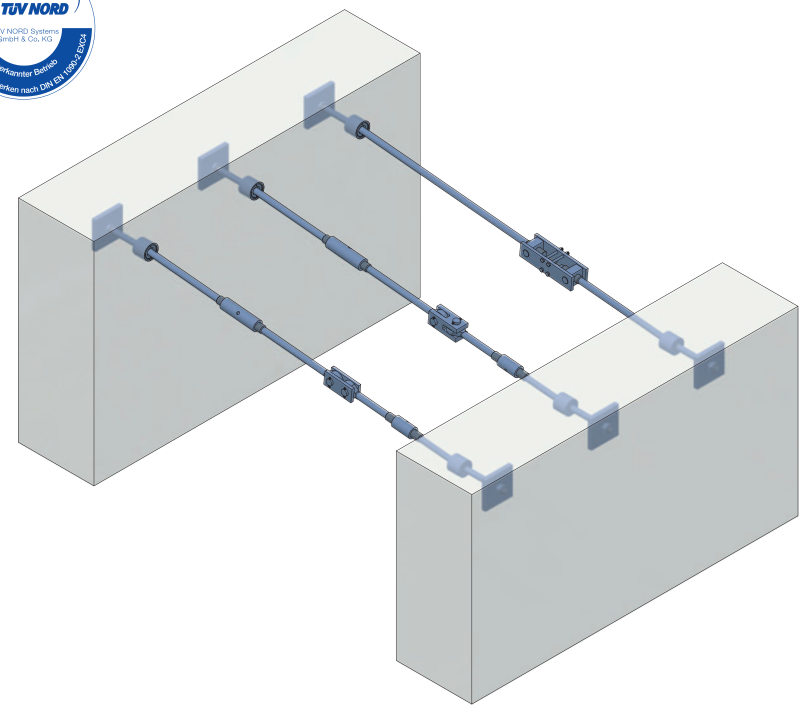
TÜV NORD



Z-pile and U-pile solutions

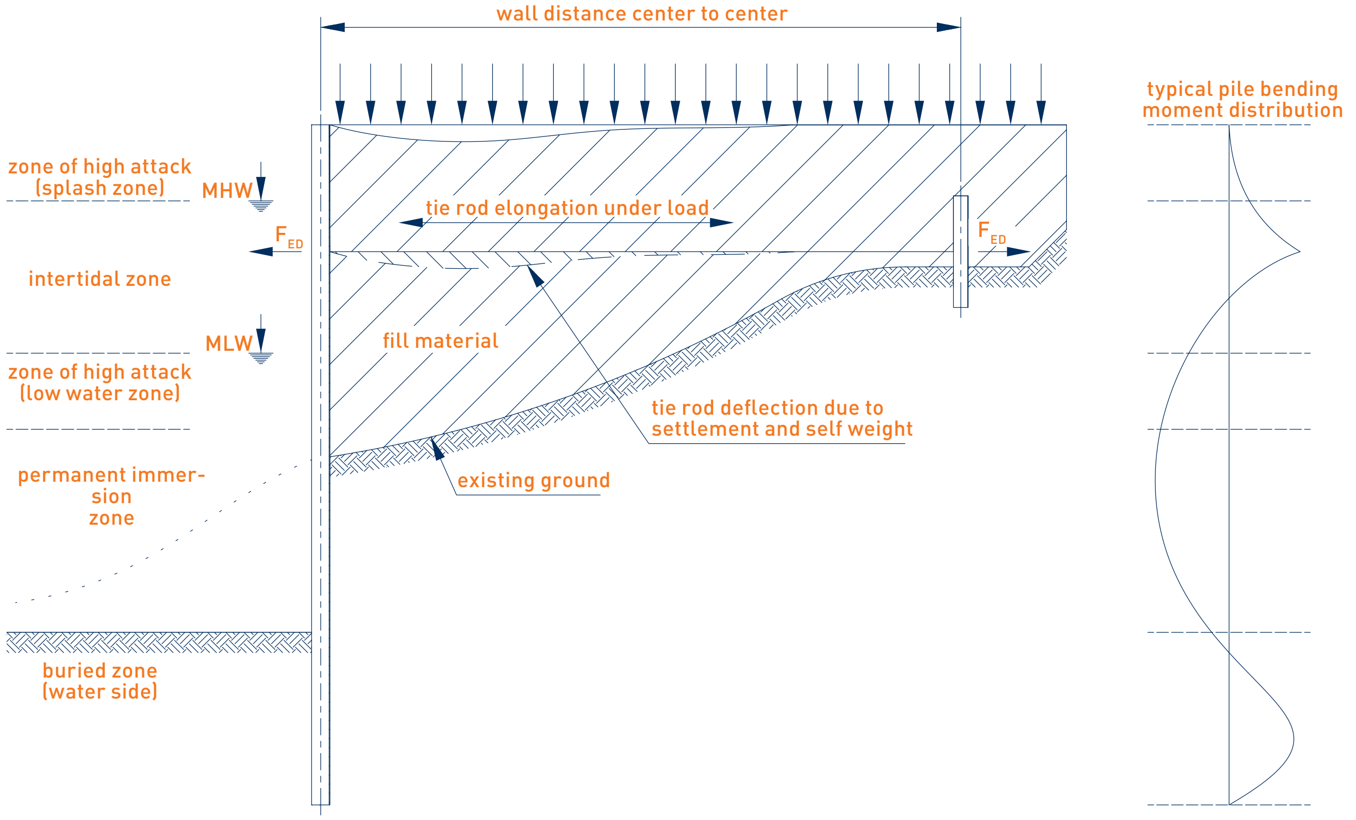


Steel combi-wall solutions



Concrete wall solutions

ASDO ANCHORS FOR MARINE STRUCTURES



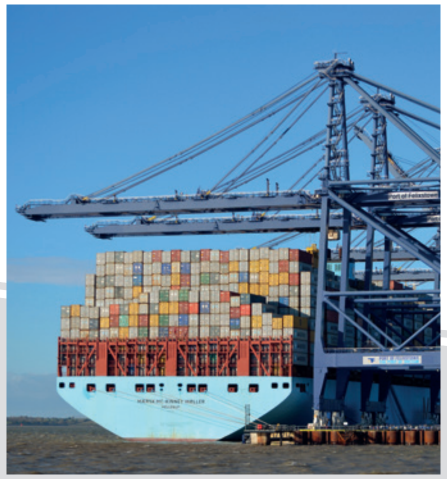
When designing anchors for retaining walls the following should be considered:

Design Resistance – the anchorage should be designed to provide sufficient design resistance to satisfy the design load required (note the design resistance is calculated differently between design codes).

Steel Grade – there are various steel grades available today, some with very high strengths. Care should be taken when selecting a steel as grades with a nominal yield stress greater than 800N/mm² are not permitted according to clause 7.2.2 EN 1993-5. Steels with nominal yields greater than 500N/mm² should be further assessed for durability according clause 3.7 EN 1993-5 - please contact our technical department for more information.

Serviceability – the elongation of the anchors under the serviceability load may be the limiting factor rather than design resistance particularly where large crane loads have to be accommodated. Stiffness of an anchor is a function of the shaft diameter and subsequently a higher grade tie bar (e.g. ASDO700) may not be the most suitable. Movement under imposed loads may be reduced in many cases by pre-loading the anchors at the time of installation to develop the passive resistance of the ground.

Pre-loading of the anchor is easily achieved at a threaded end of the anchor by means of a hydraulic jack, consideration to the practicality of this should be made at design stage.



Felixstowe Docks, UK

Port de Trois-Rivières, Canada

Stressing operation

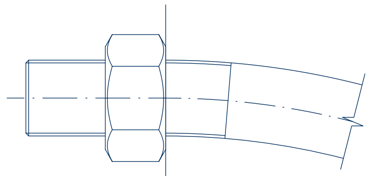
DESIGN CONSIDERATIONS

Settlement – the effect of sag of the anchor and forced deflection due to settlement of fill may induce significant bending stresses at a fixed anchorage and increase the tensile stress in the tie rod locally. Shear stresses may also be induced into the thread if a tie rod is displaced when the fill settles causing compound stresses which must be allowed for in the detailed design. This can often be overcome by provision of articulated joints at connections to the wall.

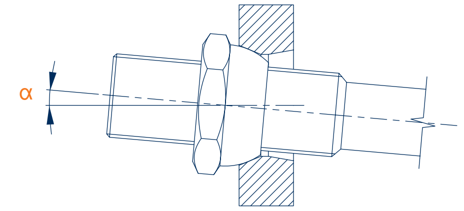
Whether a connection is articulated or fixed will affect the design resistance of the tie bar. If connections are fixed then a greater thread size must be used to accommodate any bending introduced to the anchor.

Settlement ducts can also be installed to reduce bending at the connection however these can be difficult and expensive to install and, if not aligned correctly, will not prevent settlement bending being introduced. If settlement ducts are used articulation at the wall connection is recommended to prevent bending due to the self weight of the bar as the duct moves. Further corrosion protection systems (such as wrapping) are essential particularly where there is a possibility of the duct acting as a conduit for seawater. Please contact our technical department for more information.

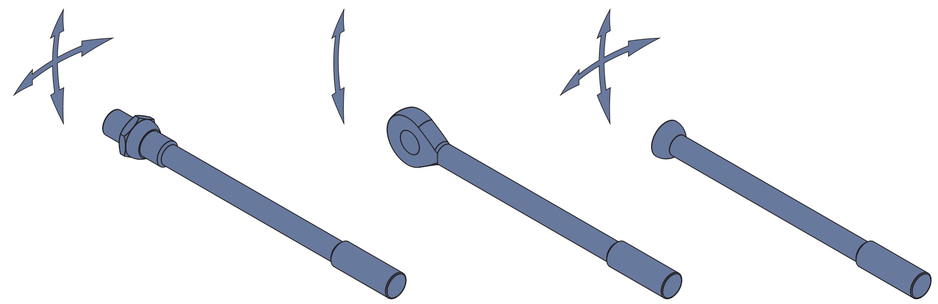
Corrosion protection system
Anchor ties are typically used in aggressive environments and consequently corrosion protection factors influencing effective life must be considered. Consideration of the corrosion protection of the anchors at design stage and in particular the connection to the front wall is important as the anchor is typically subjected to the most aggressive environment at this point. Options include sacrificial steel, protective tape or coating systems. In most cases sacrificial steel provides the more economic and robust form of corrosion protection – see page 24 for more detail.



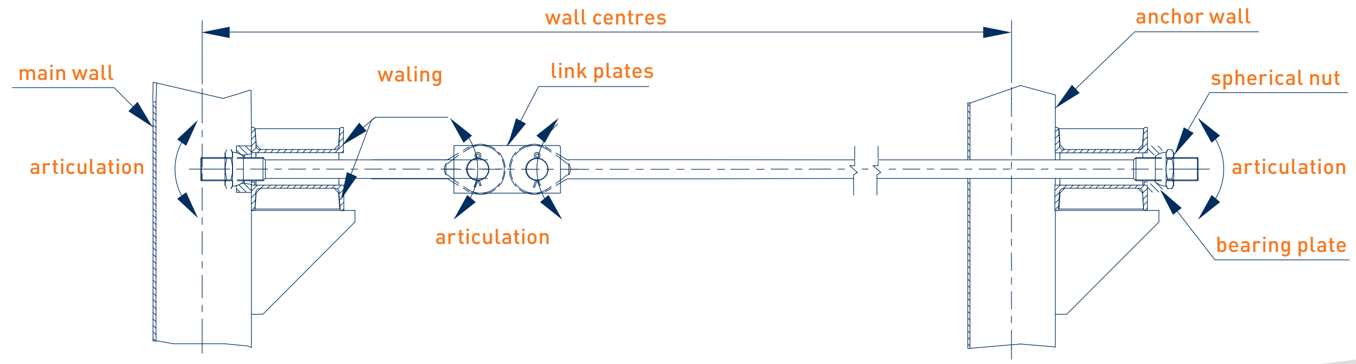
Bending stress induced by settlement or misalignment



Articulation removes bending stress at connection α < 7°



Typical articulated end solutions by Anker Schroeder: Thread and spherical nut | Forged eye | Forged spherical end



ANKER SCHROEDER
ASDO steel tension members

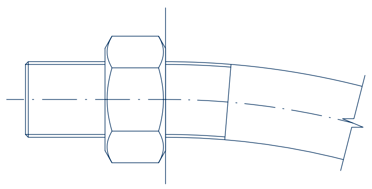
TENSILE RESISTANCE OF TIE BARS

As per Eurocode EN 1993-5 and corresponding parts of IS-9527-Part-III

In accordance with both EN 1993-5 and IS 9527 the tensile resistance $F_{t,Rd}$ of an anchor is calculated as the lesser of the tensile resistance of the thread, $F_{tt,Rd}$ or the tensile resistance of the shaft, $F_{tg,Rd}$ at any time during the life of the structure.

$$F_{t,Rd} = \text{lesser of: } \begin{cases} F_{tg,Rd} = A_g \times f_y / \gamma_{M0} \\ F_{tt,Rd} = k_t \times f_{ua} \times A_S / \gamma_{M2} \end{cases}$$

$F_{t,Rd} = T_d$ = design resistance (EN 1997-5 & IS 800 respectively)
A_s = tensile stress area of thread
A_g = gross cross sectional area of anchor
f_y = yield strength of anchor material
f_{ua} = tensile strength of anchor material
k_t = a reduction factor allowing for combined bending and tension in the thread (typically 0.6 where bending at the connection must be considered and 0.9 where structural detailing eliminates bending at the connection)
$\gamma_{M0} = \gamma_{m0}$ = partial factors accord. EN 1993 & IS 800 (typically 1.0 & 1.1 respectively)
$\gamma_{M2} = \gamma_{ml}$ = partial factors accord. EN1993 & IS 800 (typically 1.25)



Bending stress in thread induced by settlement or misalignment

It is important to note that the thread capacity of an anchor is reduced by the factor k_t. According to EN 1993-5 this is to allow for additional stresses that may be introduced due to settlement of fill or installation in less than ideal conditions.

In accordance with many EN 1993-5 National Annexes a conservative k_t value of 0.6 should be used unless structural detailing at the connection eliminates any possible bending when 0.9 can be used. However fully eliminating bending can be difficult, sometimes settlement ducts are used (and are mentioned in IS 9527-3, clause 8.5.d.2) but typical site conditions hinder proper installation of these as well as failing to provide restraint to the bending introduced by the self weight of the anchor as the duct moves with the fill.

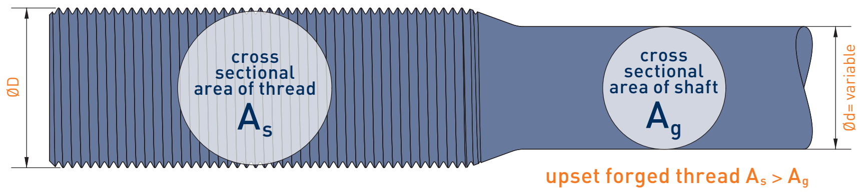
Alignment of anchors, especially for diaphragm walls, is also difficult along with accurate prediction of settlement.

Therefore Anker Schroeder recommend that a k_t factor of k_t 0.6 is used in combination with articulated connections, this can also have benefits for corrosion resistance as the larger thread gives greater durability without increasing overall weight – see page 24.

It is for this reason Anker Schroeder have developed a full range of upset forged ends for tie bars. Upset forging allows threads to be increased in size with little additional weight being added to the anchor. By increasing the thread diameter bending stresses can be minimised and sacrificial steel can be easily added to the threaded portion, often the most vulnerable part of an anchor.

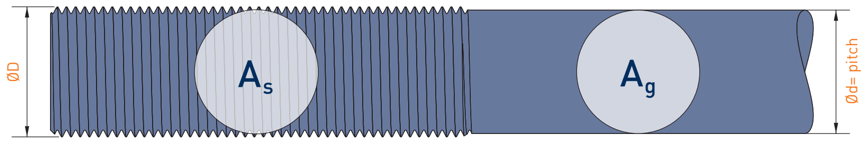
Only upset forged threads ensure that the shaft is the weakest part of a tiebar anchor. This has benefits as, in the unfortunate event of structural failure, the shaft will realise it's full elongation capacity giving greater warning of serviceability failure of the pile wall.

Upset threads can also have benefit for seismic design giving greater safety factor to connections and ensuring maximum elongation takes place along the whole tie rod length during a seismic event.

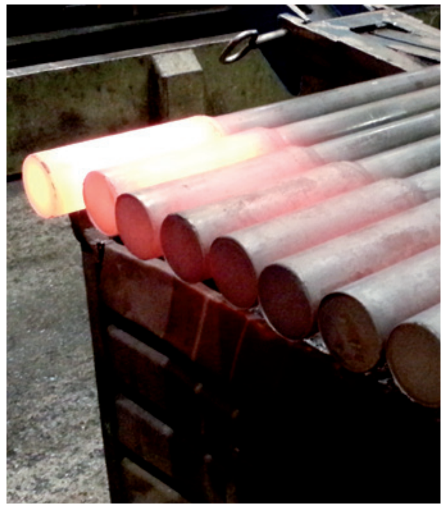


upset forged thread $A_s > A_g$
variable ratio A_s/A_g

Upset forged thread advantage – stress area of thread > stress area of shaft



standard rolled thread $A_s = A_g$
fixed ratio A_s/A_g



Upset forged ends

Upset forging
Unlike traditional forging in which a parent metal is heated and forged into a smaller dimension upset forging is a process by which parent metal is increased in sectional area. In the case of anchors this allows the ends of a bar to be increased in section and threads cut or rolled onto the forged cylinder. The same process can also be used to form articulated ends such as eyes or spherical ends.

Before threading

After threading

Upset forged Treads

Note - thread area > shaft area ensuring yield always occurs in shaft allowing maximum extension.

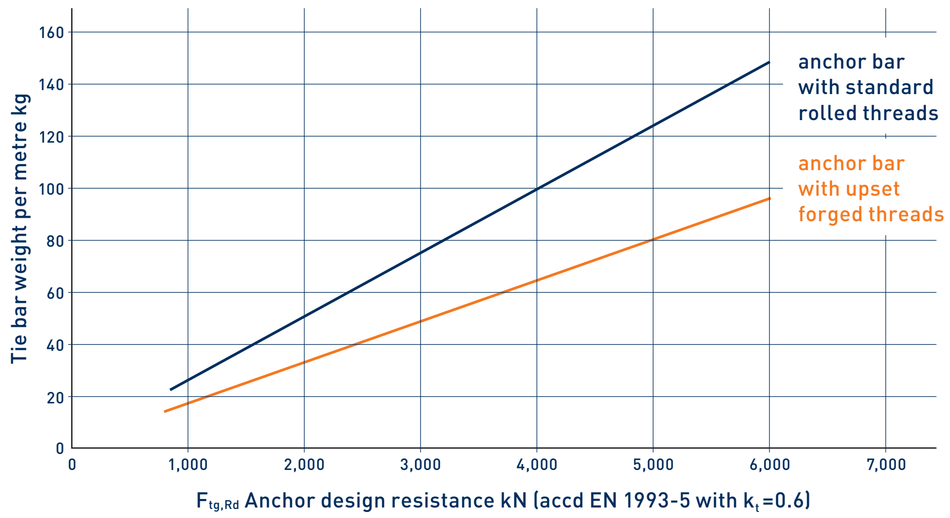


Chart showing the weight per metre advantage for upset forged anchors compared to standard threaded anchors.

ASDO ANCHOR DESIGN CAPACITIES

ASDO

PRODUCT DATA

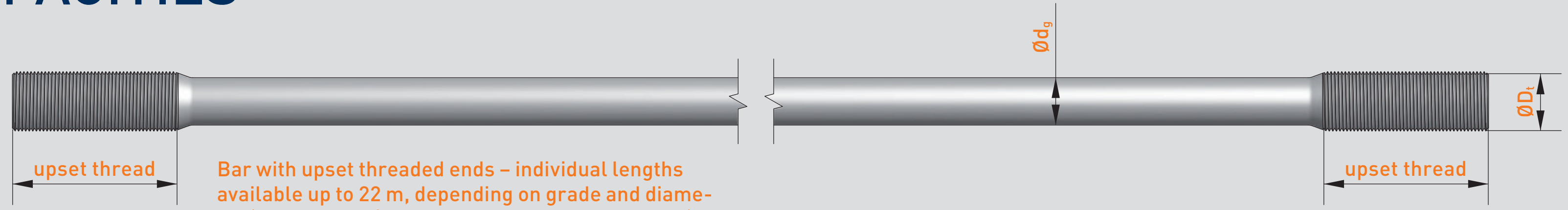


Table 2 – Design tensile resistance of ASDO upset forged threaded tie rods

Nominal upset thread diameter	$ØD_t$	Metric	64	68	72	76	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160	165	170	$ØD_t$
Thread tensile stress area	A_s	mm²	2,676	3,055	3,460	3,889	4,344	4,948	5,591	6,273	6,995	7,755	8,556	9,395	10,274	11,191	12,149	13,145	14,181	15,256	16,370	17,524	18,716	19,948	21,220	A_s
Shaft diameters available*	All grades	mm	48-56	52-60	52-64	56-68	60-72	64-76	68-80	72-86	76-90	80-95	85-100	85-105	95-110	95-115	100-120	105-125	105-130	110-135	115-140	120-145	125-150	125-155	130-160	All grades

ASDO500 – Tensile resistance

ASDO500	Anchor code		ASDO500 -	M64/48	M68/52	M72/52	M76/56	M80/60	M85/64	M90/68	M95/72	M100/76	M105/80	M110/85	M115/90	M120/90	M125/95	M130/100	M135/105	M140/110	M145/110	M150/115	M155/120	M160/125	M165/130	M170+	
$k_t = 0.6$	Optimum shaft diameter	$Ød_g$	mm	48	52	52	56	60	64	68	72	76	80	85	90	90	95	100	105	110	110	115	120	125	130	larger diameters at request	$Ød_g$
	Shaft gross area	A_g	mm²	1,810	2,124	2,124	2,463	2,827	3,217	3,632	4,072	4,536	5,027	5,675	6,362	6,362	7,088	7,854	8,659	9,503	9,503	10,387	11,310	12,272	13,273		A_g
	Shaft yield capacity	F_y	kN	905	1,062	1,062	1,232	1,414	1,559	1,816	2,036	2,268	2,513	2,837	3,181	3,181	3,544	3,927	4,330	4,752	4,752	5,193	5,655	6,136	6,637		F_y
	Shaft ultimate capacity	F_{ua}	kN	1,194	1,402	1,402	1,626	1,866	2,057	2,397	2,687	2,994	3,318	3,745	4,199	4,199	4,678	5,184	5,715	6,272	6,272	6,855	7,464	8,099	8,760		F_{ua}
	Tensile resistance to EN 1993-5	$F_{t,Rd}$	kN	848	968	1,062	1,232	1,376	1,559	1,771	1,987	2,216	2,457	2,710	2,976	3,181	3,544	3,849	4,164	4,492	4,752	5,186	5,551	5,929	6,320		$F_{t,Rd}$
	Tensile resistance to IS 800	T_d	kN	823	965	965	1,120	1,285	1,462	1,651	1,851	2,062	2,285	2,579	2,892	2,892	3,222	3,570	3,936	4,320	4,320	4,721	5,141	5,578	6,033		T_d
	Anchor code		ASDO500 -	M64/56	M68/60	M72/64	M76/68	M80/72	M85/76	M90/80	M95/85	M100/90	M105/95	M110/100	M115/105	M120/110	M125/115	M130/120	M135/125	M140/130	M145/135	M150/140	M155/145	M160/150	M165/155	M170+	
$k_t = 0.9$	Optimum shaft diameter	$Ød_g$	mm	56	60	64	68	72	76	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155	larger diameters at request	$Ød_g$
	Shaft gross area	A_g	mm²	2,463	2,827	3,217	3,632	4,072	4,536	5,027	5,675	6,362	7,088	7,854	8,659	9,503	10,387	11,310	12,272	13,273	14,314	15,394	16,513	17,671	18,869		A_g
	Shaft yield capacity	F_y	kN	1,232	1,414	1,608	1,816	2,036	2,268	2,513	2,837	3,181	3,544	3,927	4,330	4,752	5,193	5,655	6,136	6,637	7,157	7,697	8,256	8,836	9,435		F_y
	Shaft ultimate capacity	F_{ua}	kN	1,626	1,866	2,123	2,397	2,687	2,994	3,318	3,745	4,199	4,678	5,184	5,715	6,272	6,855	7,464	8,099	8,760	9,447	10,160	10,899	11,663	12,454		F_{ua}
	Tensile resistance to EN 1993-5	$F_{t,Rd}$	kN	1,232	1,376	1,567	1,771	1,987	2,216	2,457	2,710	3,181	3,544	3,849	4,164	4,752	5,186	5,551	5,929	6,320	7,138	7,565	8,005	8,836	9,400		$F_{t,Rd}$
	Tensile resistance to IS 800	T_d	kN	1,120	1,285	1,462	1,651	1,851	2,062	2,285	2,579	2,892	3,222	3,570	3,936	4,320	4,721	5,141	5,578	6,033	6,506	6,997	7,506	8,032	8,577		T_d

ASDO700 – Tensile resistance

ASDO700	Anchor code		ASDO700 -	M64/48	M68/52	M72/52	M76/56	M80/60	M85/64	M90/68	M95/72	M100/76	M105/80	M110/85	M115/85	M120/90	M125/95	M130/100	M135/105	M140/105	M145/110	M150/115	M155/120	M160/125	M165/125	M170/130	
$k_t = 0.6$	Optimum shaft diameter	$Ød_g$	mm	48	52	52	56	60	64	68	72	76	80	85	85	90	95	100	105	105	110	115	120	125	125	130	$Ød_g$
	Shaft gross area	A_g	mm²	1,810	2,124	2,124	2,463	2,827	3,217	3,632	4,072	4,536	5,027	5,675	5,675	6,362	7,088	7,854	8,659	8,659	9,503	10,387	11,310	12,272	12,272	13,273	A_g
	Shaft yield capacity	F_y	kN	1,267	1,487	1,487	1,724	1,979	2,252	2,542	2,850	3,176	3,519	3,972	3,972	4,453	4,962	5,498	6,061	6,061	6,652	7,271	7,917	8,590	8,590	9,291	F_y
	Shaft ultimate capacity	F_{ua}	kN	1,629	1,911	1,911	2,217	2,545	2,895	3,269	3,664	4,083	4,524	5,107	5,107	5,726	6,379	7,069	7,793	7,793	8,553	9,348	10,179	11,045	11,045	11,946	F_{ua}
	Tensile resistance to EN 1993-5	$F_{t,Rd}$	kN	1,156	1,320	1,487	1,680	1,877	2,137	2,415	2,710	3,022	3,350	3,696	3,972	4,438	4,835	5,248	5,679	6,061	6,590	7,072	7,570	8,085	8,590	9,167	$F_{t,Rd}$
	Tensile resistance to IS 800	T_d	kN	1,152	1,320	1,351	1,567	1,799	2,047	2,311	2,591	2,887	3,199	3,611	3,611	4,048	4,511	4,998	5,510	5,510	6,048	6,610	7,197	7,809	7,809	8,447	T_d
	Anchor code		ASDO700 -	M64/56	M68/60	M72/64	M76/68	M80/72	M85/76	M90/80	M95/85	M100/90	M105/95	M110/100	M115/105	M120/110	M125/115	M130/120	M135/125	M140/130	M145/135	M150/140	M155/145	M160/150	M165/155	M170/160	
$k_t = 0.9$	Optimum shaft diameter	$Ød_g$	mm	56	60	64	68	72	76	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160	$Ød_g$
	Shaft gross area	A_g	mm²	2,463	2,827	3,217	3,632	4,072	4,536	5,027	5,675	6,362	7,088	7,854	8,659	9,503	10,387	11,310	12,272	13,273	14,314	15,394	16,513	17,671	18,869	20,106	A_g
	Shaft yield capacity	F_y	kN	1,724	1,979	2,252	2,542	2,850	3,176	3,519	3,972	4,453	4,962	5,498	6,061	6,652	7,271	7,917	8,590	9,291	10,020	10,776	11,559	12,370	13,208	14,074	F_y
	Shaft ultimate capacity	F_{ua}	kN	2,217	2,545	2,895	3,269	3,664	4,083	4,524	5,107	5,726	6,379	7,069	7,793	8,553	9,348	10,179	11,045	11,946	12,882	13,854	14,862	15,904	16,982	18,096	F_{ua}
	Tensile resistance to EN 1993-5	$F_{t,Rd}$	kN	1,680	1,877	2,137	2,415	2,710	3,022	3,350	3,972	4,438	4,835	5,248	6,061	6,590	7,072	7,570	8,590	9,167	9,733	10,316	11,533	12,167	12,818	13,486	$F_{t,Rd}$
	Tensile resistance to IS 800	T_d	kN	1,567	1,799	2,047	2,311	2,591	2,887	3,199	3,611	4,048	4,511	4,998	5,510	6,048	6,610	7,197	7,809	8,447	9,109	9,796	10,508	11,245	12,008	12,795	T_d

*Note: The above sizes are standardised, other shaft and thread ratios can be adapted to suit your project requirements, e.g. for sacrificial steel requirements or smaller design loads, design resistance calculated as per the calculation notes below.

Calculation notes

Area

Tensile thread area A_s based on pitch diameter according ISO Metric threads
Shaft area A_g based on gross area of shaft

Note : Indian Standards conservatively use the net root area of threads for area calculations. Please contact our technical department if you require this data.

Bar mechanical properties

Shaft Yield Capacity $F_y = A_g \times f_y$ (see page 3 for minimum yield stress of material)
Shaft Ultimate Capacity $F_{ua} = A_g \times f_{ua}$ (see page 3 for minimum tensile stress of material)

Note : the above are actual minimum mechanical properties of the material and no partial or safety factors are applied.

Design tensile resistance to EN 1993-5

Calculated as detailed on page 6 with following partial factors
$\gamma_{M0} = 1.0$ (EN recommended partial factor for resistance of cross-sections)
$\gamma_{M2} = 1.25$ (EN recommended partial factor for resistance of cross-sections in tension to fracture)

Design tensile resistance to Indian Standards IS 800 and IS 9527

The design methodology for tension members is stated in IS 800 (see section 6) and is the same as Eurocode methodology in EN 1993-1-1. For the particular installation situation IS 9527-3 gives further guidance for sheet pile walls and section 8.2 suggests that where vertical loading of tie bars may occur (e.g. due to settlement) loads should be increased by 20%. This increase in loads along the whole tie rod can lead to inefficient design as generally settlement will affect the connection to the wall causing bending at this point (see page 5 & 6). The Eurocodes allow for this effect at the connections by introduction of the 'k_t' factor and this has been adopted here to harmonise IS & EN design methods.

However, it is important to note that Indian Design standards recommend different partial factors in design. The above design IS resistances are calculated with the following partial factors
$\gamma_{M0} = 1.1$ (IS recommended partial factor for resistance governed by yielding)
$\gamma_{m1} = 1.25$ (IS recommended partial factor for resistance governed by ultimate stress)

Note : Calculations are based on the stress areas of thread (A_s) not root area (A_n)

ANKER SCHROEDER
ASDO steel tension members

ASDO ANCHOR DESIGN CAPACITIES

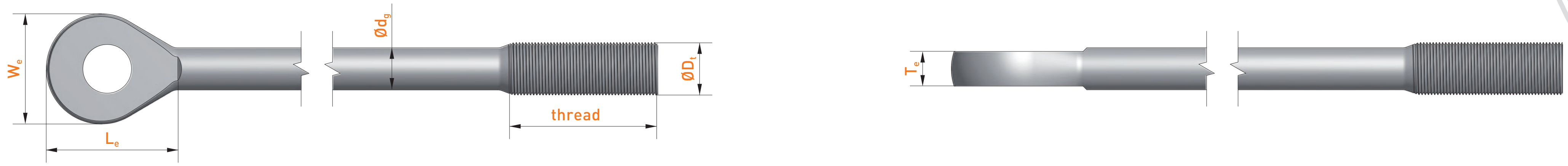
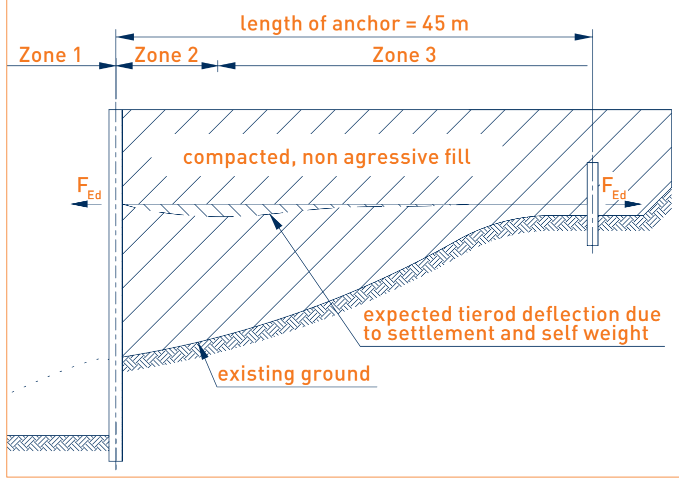


Table 3 – Forged eye (all grades)

Nominal shaft diameter	$Ød_g$	mm	48	52	56	60	64	68	72	76	80	85	90	95	100	105	110	115	120	125	130	$Ød_g$
Eye ref		inches	2 1/2	2 3/4	3	3	3 1/4	3 1/2	3 1/2	3 3/4	4	4 1/4	4 1/2	4 3/4	5	5 1/4	5 1/2	5 3/4	6	6 1/4	6 1/2	
Eye thickness	T_e	mm	42	47	50	50	55	60	60	63	66	72	75	80	85	90	95	100	105	115	120	T_e
Eye length	L_e	mm	162	177	204	207	214	227	227	248	262	289	312	332	340	357	370	382	412	440	460	L_e
Eye width	W_e	mm	125	135	155	155	165	180	180	190	210	230	240	255	270	275	290	300	310	330	340	W_e
Pin diameter		mm	50	55	60	60	64	72	72	75	80	85	90	95	100	100	110	115	120	125	130	

Design example



Design criteria:
Design ultimate load for anchor, F_{Ed} = 2,200 kN (i.e. tie rod must resist this load)

Tie bar length = 45 m (calculated in accordance with EN 1997 or **IS 9527-3** as appropriate)

Serviceability characteristic load, $F_{t,ser}$ = 1,600 kN

Tie bar extension limit = 100 mm

Design life structure = 50 years

Thread notch factor - use recommended value k_t = 0.6 (see EN1993-5 National UK Annex)

Size selection

Minimum Anchor size required

From table 2 grade ASDO500, k_t = 0.6 select tie rod with design tensile load capacity nearest above ULS load

Code	EN 1993-5	IS 9527
Design ULS F_{Ed}	2,200 kN	
Selected size (from table 2)	M100/76	M105/80
Design Tensile Resistance	2,216 kN	2,285 kN
Check > 2,200 kN	OK	OK

Note: Clause 7.2.3(4) EN 1993-5 states that the design provisions given do not cover the occurrence of bending in the thread. It is recommended by EN 1993 & EAU that connections to the wall be articulated to provide sufficient rotation tolerance (further articulation at points of maximum bending along the bar should also be considered) it is recommended that designs to **IS 9527** follow the same principles.

Further checks may be required for combined bending and axial load checks in both the thread and shaft due to settlement of the fill. The use of upset threads and a k_t factor of 0.6 will give greater capacity in the areas of likely bending giving a greater safety factor. For the above example the tie bar arrangement in the figure opposite can be made.

Serviceability check (shown for M100/76 tie rod only)

Elongation under axial characteristic loading

$F_{t,ser}$ = 1,600 kN

$$\text{Stress in shaft} = \frac{1{,}600 \times 10^3}{4{,}536} = 353 \text{ N/mm}^2$$

$$\text{Elongation} = \frac{353 \times 45{,}000}{210 \times 10^3} = 76 \text{ mm} < 100 \text{ mm} \therefore \text{OK}$$

Where elastic modulus = 210 kN/m²

Hint – if the elongation is too great try a larger diameter of a lesser grade.

Serviceability limit state – Clause 7.2.4 EN 1993-5

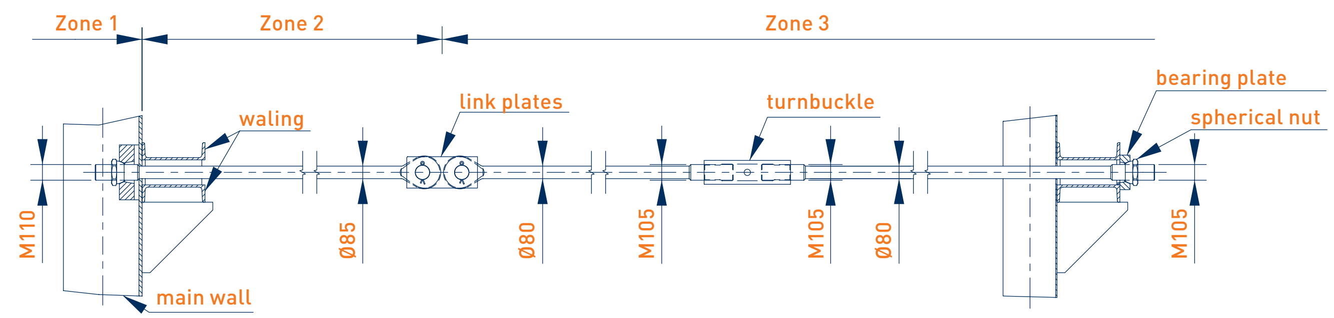
The required additional check for serviceability in this example is already implied in the resistance check $F_{Rd} < F_{Ed}$ as a k_t factor of 0.6 has been used, however it is performed here for information.

$$F_{t,ser} \le \frac{f_y A_s}{\gamma M_{t,ser}}$$ where A_s is the lesser of shaft area or thread area

$$1{,}600 \text{ kN} \le \frac{500 \times 4{,}536}{1.1 \times 10^3} \le 2{,}062 \text{ kN} \therefore \text{OK}$$

Corrosion resistance – for robustness and simplicity in handling and installation use sacrificial steel. The tie bar is split into zones as per the diagram below. The corrosion rate assumed for each zone depends on local conditions, or the guidance given in EN 1993-5 can be considered. The rates given below are for example only.

Each zone is considered in turn and the expected corrosion rate added to the minimum size, as per the table below. Note the corrosion rate assumed for zone one can be reduced considerably by placing the anchor connection head behind the sheet pile pan as shown on page 12 and detail Z page 20.



Zone	Description	Environment	Corrosion allowance	Min. size including corrosion allowance		Nearest standard size	
				Thread	shaft	Thread	shaft
1	Anchor head	Splash zone, aggressive	3.75 mm (from table 4.2 EN 1993-5)	107.5	83.5 mm	M110	85 mm
2	Immediately behind wall	Non-aggressive compacted fill, possibility of seawater entering through connection to front wall	2.0 mm (assumed)	-	80 mm	-	85 mm (same bar as zone 1)
3	Remainder of tie bar	Non-aggressive compacted fill	1.2 mm (from table 4.1 EN 1993-5, compaction reduction ignored for conservatism)	102.4	78.4 mm	M105	80 mm

Final specification

As a minimum the following information is required in order to specify the anchors correctly.

Anchors:

Grade ASDO500 - M110/85, M105/80 with articulated connections, turnbuckles and length as indicated on drawing
Minimum design resistance, $F_{t,Rd}$ = 2,200 kN (after corrosion losses)
k_t = 0.6 (in accordance with EN 1993-5)
f_y = 500 N/mm²
f_{ua} = 660 N/mm²
Corrosion protection = sacrificial steel to all bars and components as indicated

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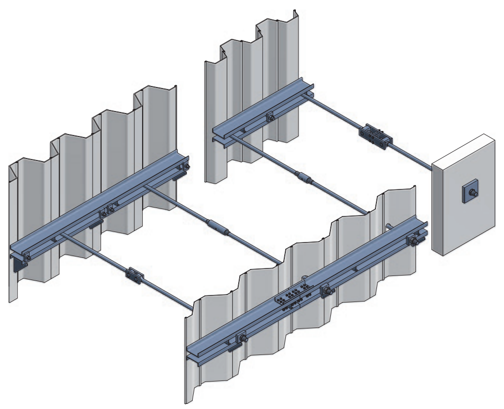
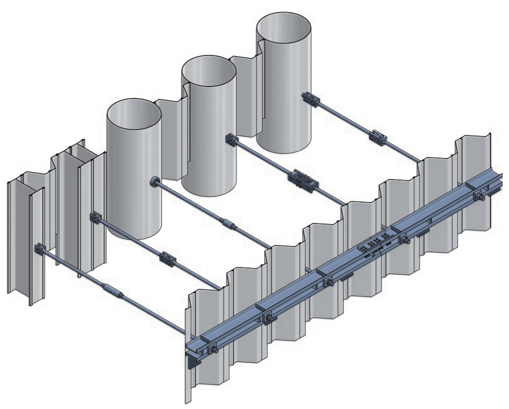
ASDO steel tension members

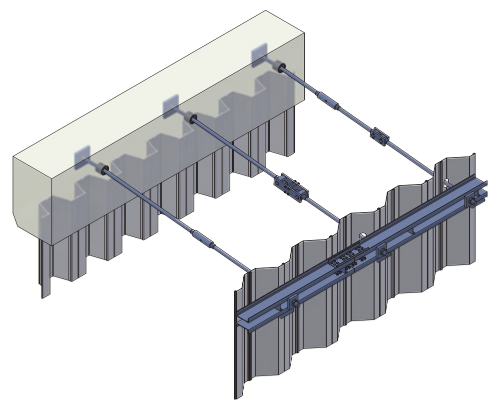
TYPICAL ARTICULATED WALL CONNECTIONS



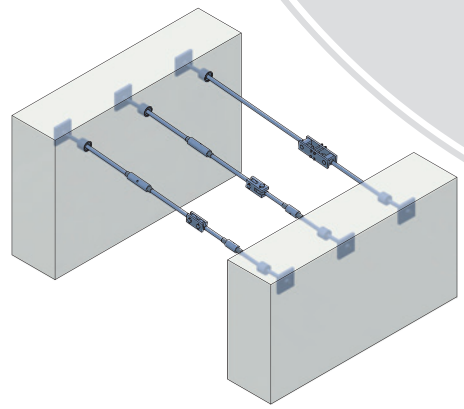
Sheet pile walls



Combi-pile walls

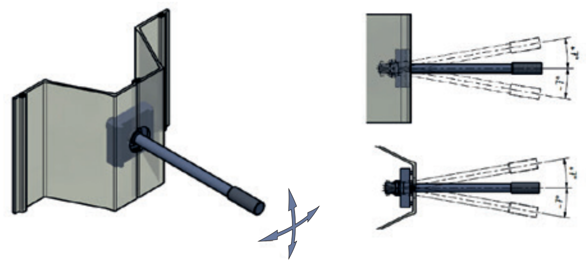


Steel walls with concrete capping beams

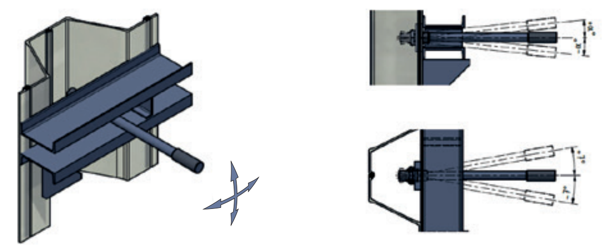


Concrete diaphragm walls

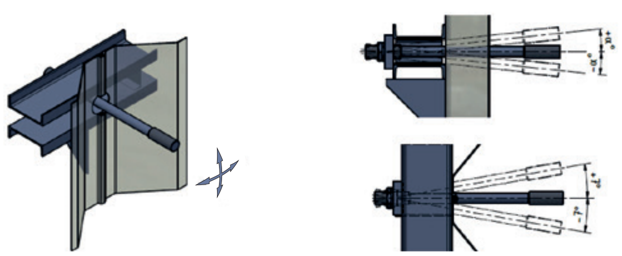
Sheet pile & waling connections
Forces are transferred from the sheet pile to the anchor bar through waling sections that run the length of the wall. At the front wall these are normally placed behind the wall (i.e. earth side) and at the anchor wall the non-bearing side.



Spherical nut & plate direct to sheet pile

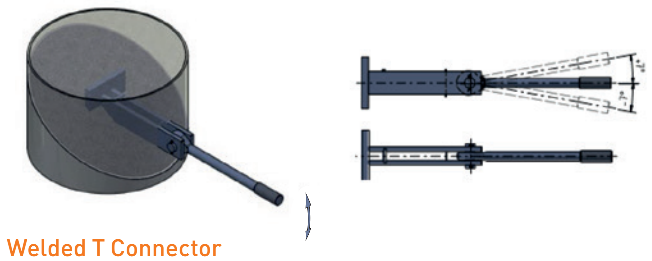


Spherical nut & plate direct to waling (front wall)

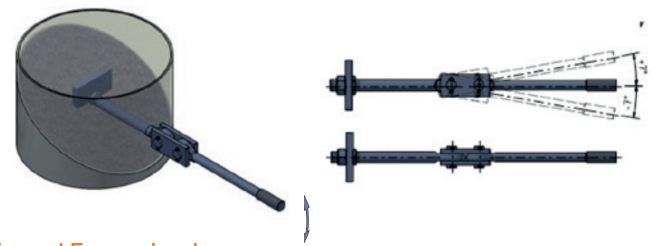


Spherical nut & plate direct to waling (anchor wall)

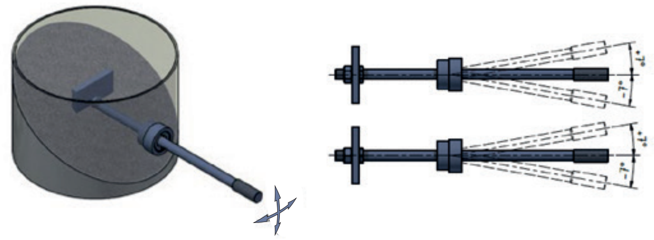
Tube and H Pile connections
Anchor forces are generally high and articulated connections are recommended to minimize bending at the connection. Tube connections can be provided that allows movement in the vertical direction or in all directions.



Welded T Connector



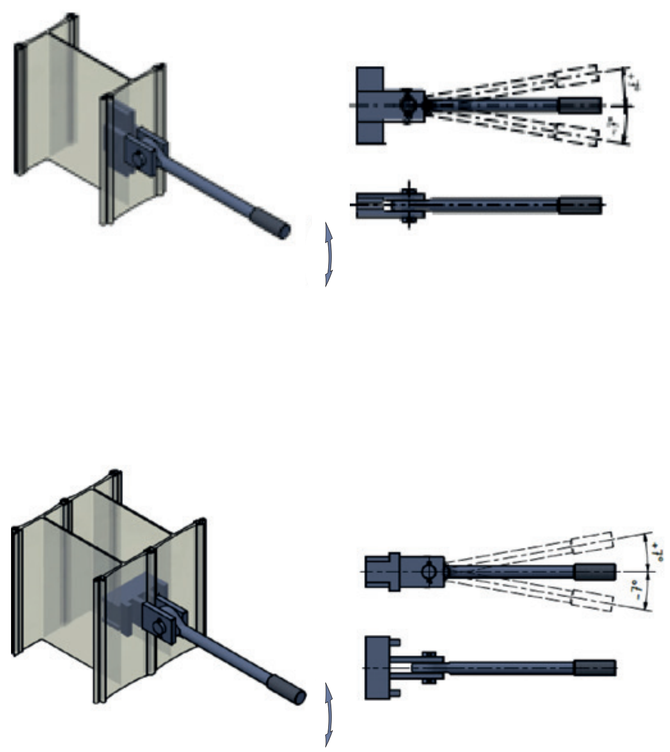
Forged Eye anchor bar



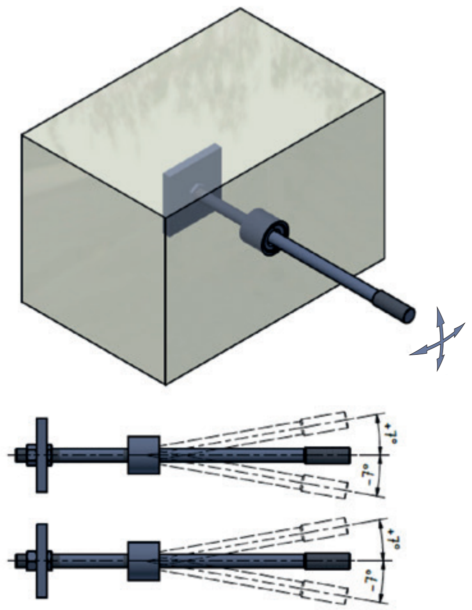
Spherical Connector

Concrete wall connections
Alignment between the front wall and anchor wall connection points is critical. The ASDO articulated spherical connections allow easy casting into the wall without difficult interruption to formwork and allow easy connection once the wall has cured. Articulated joints are strongly recommended to aid installation.

Steel H pile connections



Concrete connections



Note : angle +α°/-α° dependent on channel spacing

CONNECTIONS

Table 4 – Standard bearing plates (ASDO500, $k_t = 0.6$)

Nominal thread diameter			Metric	64	68	72	76	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160	
Spherical plate against waling	Width	w_{PW}	mm	160	160	180	180	180	200	200	200	210	220	220	230	240	250	260	270	280	290	290	310	310	w_{PW}
	Breadth	b_{PW}	mm	210	220	230	230	240	250	260	270	270	280	300	300	300	330	330	340	350	370	370	390	390	b_{PW}
	Thickness	t_{PW}	mm	30	30	35	40	40	50	55	55	65	70	70	80	80	90	95	100	100	110	120	120	130	t_{PW}
	Max. dist. between waling[2]	W_{dist}	mm	100	100	120	120	120	140	140	140	140	160	160	160	160	180	180	180	180	200	200	200	200	W_{dist}

Nominal thread diameter			Metric	64	68	72	76	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160	
Standard plate against waling	Width	w_{PW}	mm	160	160	180	180	180	200	200	200	200	220	220	220	220	240	240	240	240	260	260	260	260	w_{PU}
	Breadth	b_{PW}	mm	170	180	200	200	200	210	210	220	220	230	240	240	240	260	270	270	280	290	300	310	310	b_{PU}
	Thickness	t_{PW}	mm	30	30	35	40	40	50	55	55	65	70	70	80	80	90	95	100	100	110	120	120	130	t_{PU}
	Max. dist. between waling[2]	W_{dist}	mm	100	100	120	120	120	140	140	140	140	160	160	160	160	180	180	180	180	200	200	200	200	W_{dist}

Nominal thread diameter			Metric	64	68	72	76	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160	
Spherical plate against concrete	Width	w_{PC}	mm	220	240	250	260	290	300	330	340	350	360	390	410	420	450	460	490	500	520	540	550	580	w_{PC}
	Breadth	b_{PC}	mm	220	240	250	260	290	300	330	340	350	360	390	410	420	450	460	490	500	520	540	550	580	b_{PC}
	Thickness	t_{PC}	mm	30	35	35	35	35	40	40	45	50	50	55	55	60	60	65	65	70	70	75	80	80	t_{PC}

Nominal thread diameter			Metric	64	68	72	76	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160	
Standard plate against concrete	Width	w_{PC}	mm	220	240	250	260	280	300	330	340	350	370	390	410	420	450	460	490	500	520	540	550	580	w_{PC}
	Breadth	b_{PC}	mm	220	240	250	260	280	300	330	340	350	370	390	410	420	450	460	490	500	520	540	550	580	b_{PC}
	Thickness	t_{PC}	mm	30	35	35	35	40	40	45	45	50	50	55	55	60	60	65	70	70	70	75	80	80	t_{PC}

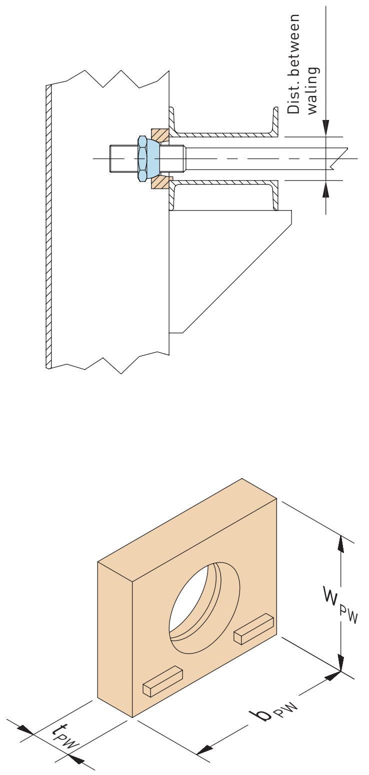
Notes: 1. All plates grade S355 and based on the maximum thread capacity for ASDO500, $k_t = 0.6$. For other grades or where $k_t = 0.9$ different plates are required.*
2. A waling gap greater than this distance will reduce the capacity of the plate.*
3. Concrete grade assumed at C35/45, plate dimensions will change for different grades of concrete.*
***Please contact our technical department for further information.**

Table 5 – Hexagon and spherical nuts (ASDO500, $k_t = 0.6$)

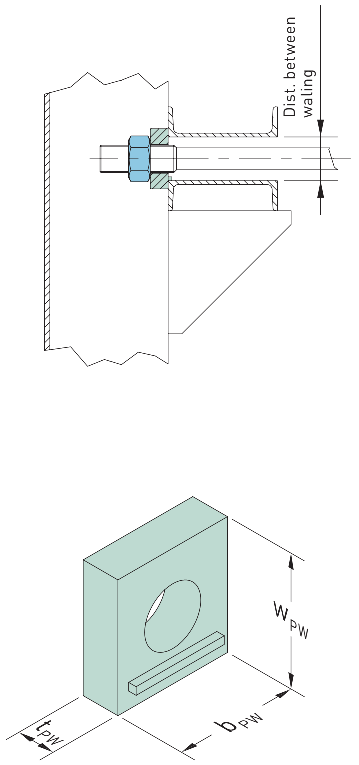
Nominal thread diameter		Metric	64	68	72	76	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160
Hexagon Flat Nuts	Across corners	mm	106	111	117	123	128	134	145	151	162	173	179	191	196	208	214	219	231	242	242	254	266
	Across flats	mm	95	100	105	110	115	120	130	135	145	150	155	165	170	180	185	190	200	210	210	220	230
Spherical Nuts	Across corners	mm	106	111	117	123	128	134	145	151	162	196	208	219	225	237	242	254	266	271	283	294	300
	Across flats	mm	95	100	105	110	115	120	130	135	145	170	180	190	195	205	210	220	230	235	245	255	260
	Depth	mm	51	54	58	61	64	68	72	76	80	107	107	117	117	127	127	137	137	147	147	157	157

Note : All above dimensions are nominal only and subject to change to suit project requirements.

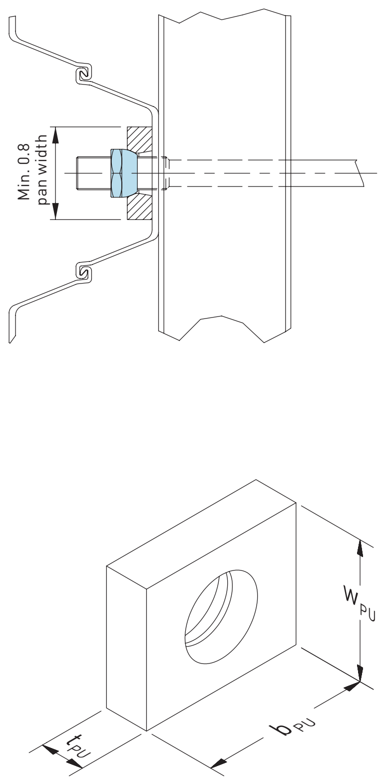
Standard bearing plates



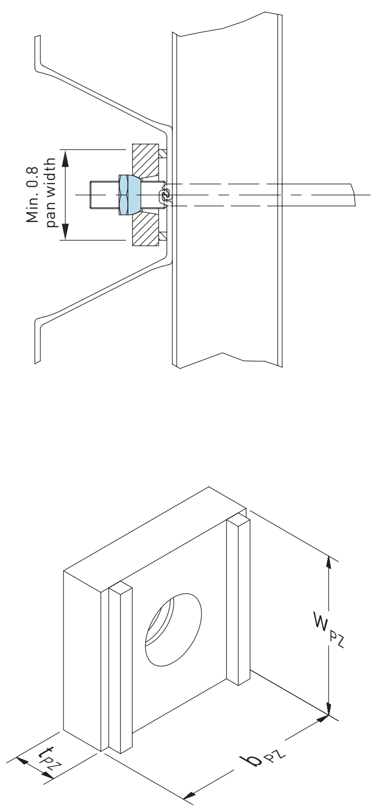
Spherical plate against waling



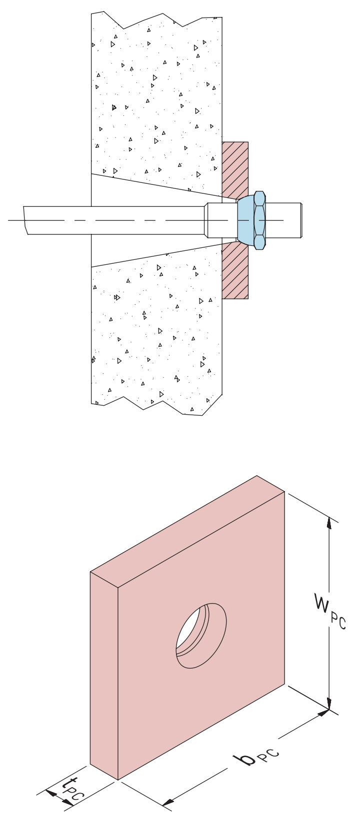
Standard plate against waling



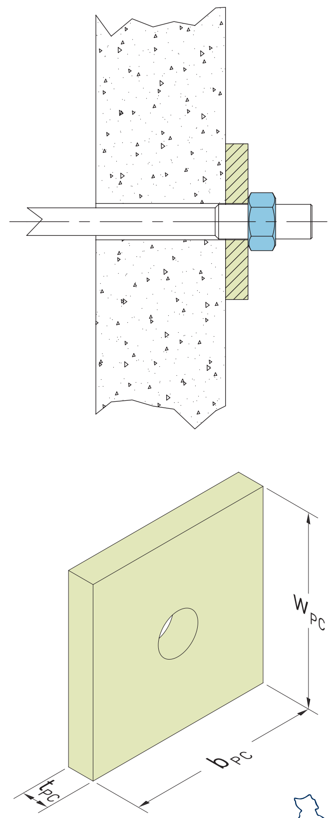
Spherical / standard plate against U-pile (contact Anker Schroeder for dimensions)



Spherical / standard plate against Z-pile (contact Anker Schroeder for dimensions)

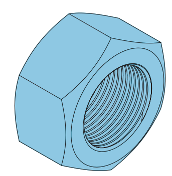


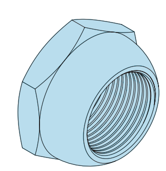
Spherical plate against concrete



Standard plate against concrete

Hexagon and spherical nuts


Hexagon


Spherical

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ASDO steel tension members

CONNECTIONS

Table 6 – T-Plates for HZ-M-piles (ASDO500, $k_t = 0.6$)

Nominal shaft diameter		mm	48	52	56	60	64	68	72	76	80	85	90	95	100	105	110	115	120	125	130	
Eye ref		inches	2 1/2	2 3/4	3	3	3 1/4	3 1/2	3 1/2	3 3/4	4	4 1/4	4 1/2	4 3/4	5	5 1/4	5 1/2	5 3/4	6	6 1/4	6 1/2	
Tension plates breadth	b_{TP}	mm	130	145	160	170	170	190	190	195	225	245	270	285	290	300	320	330	345	365	370	b_{TP}
Tension plates thickness	t_{TP}	mm	30	30	30	30	35	40	40	40	40	40	40	45	50	50	55	60	60	60	65	t_{TP}
Bearing plates breadth	b_{PP}	mm	110	115	140	140	140	170	170	190	190	205	240	250	265	265	290	310	330	350	370	b_{PP}
Bearing plates thickness	t_{PP}	mm	15	20	25	25	25	25	25	30	30	30	35	35	35	35	40	40	40	40	40	t_{PP}
Bearing plates length	l_{PP}*	mm	400	400	440	440	470	550	570	590	610	670	700	760	810	860	880	940	990	1060	1110	l_{PP}*
Pin diameter		mm	50	55	60	60	64	72	72	75	80	85	90	95	100	100	110	115	120	125	130	

*l_{PP} based on a HZM profile quality S240GP with f_y 219 N/mm².

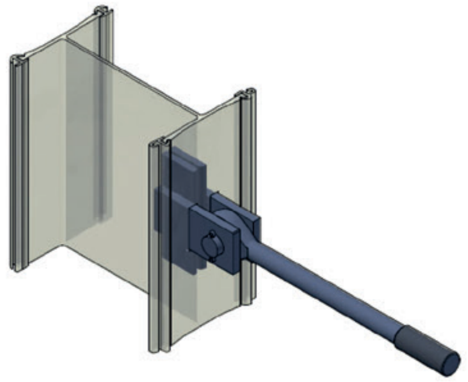
Table 7 – T-Anchors for combi-walls (ASDO500, $k_t = 0.6$)

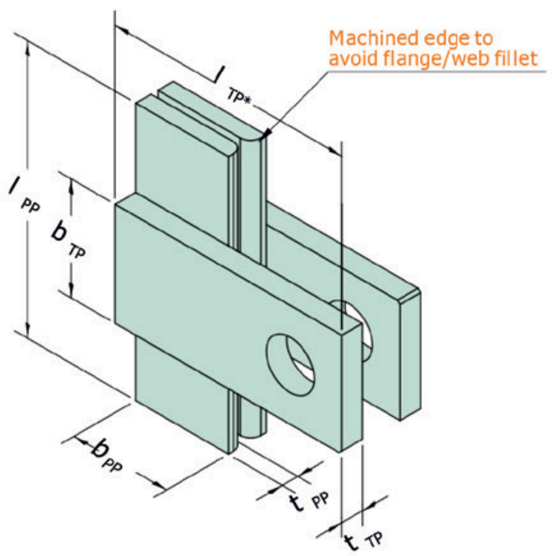
Nominal shaft diameter		mm	48	52	56	60	64	68	72	76	80	85	90	95	100	105	110	115	120	125	130	
Eye ref		inches	2 1/2	2 3/4	3	3	3 1/4	3 1/2	3 1/2	3 3/4	4	4 1/4	4 1/2	4 3/4	5	5 1/4	5 1/2	5 3/4	6	6 1/4	6 1/2	
Tension plates width	b_1	mm	130	145	160	170	170	190	190	195	225	245	270	285	290	300	320	330	345	365	370	b_1
Tension plates thickness	t_1	mm	30	30	30	30	35	40	40	40	40	40	40	45	50	50	55	60	60	60	65	t_1
Bearing plates height & width*	$l_2 \times b_2$	mm	230	250	270	290	310	330	340	360	380	400	430	460	480	490	530	550	570	590	610	$l_2 \times b_2$
Bearing plates thickness	t_2	mm	35	40	45	45	50	50	55	55	60	65	70	70	75	75	80	90	90	95	95	t_2
Pin diameter		mm	50	55	60	60	64	72	72	75	80	85	90	95	100	100	110	115	120	125	130	

Note concrete grade assumed at C35/45, plate dimensions will change for different grades – please contact our technical department for information.
All plates grade S355 and based on maximum thread capacity for ASDO500, $k_t = 0.6$. For other grades and $k_t = 0.9$ contact our technical team.

Note : All above dimensions are nominal only and subject to change to suit project requirements.

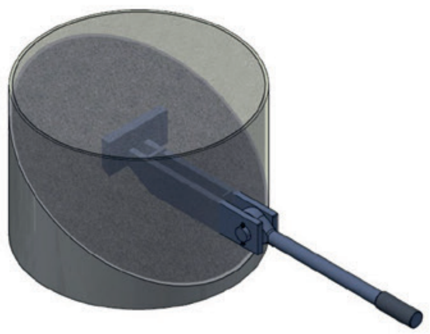
T-Plates for HZ-piles

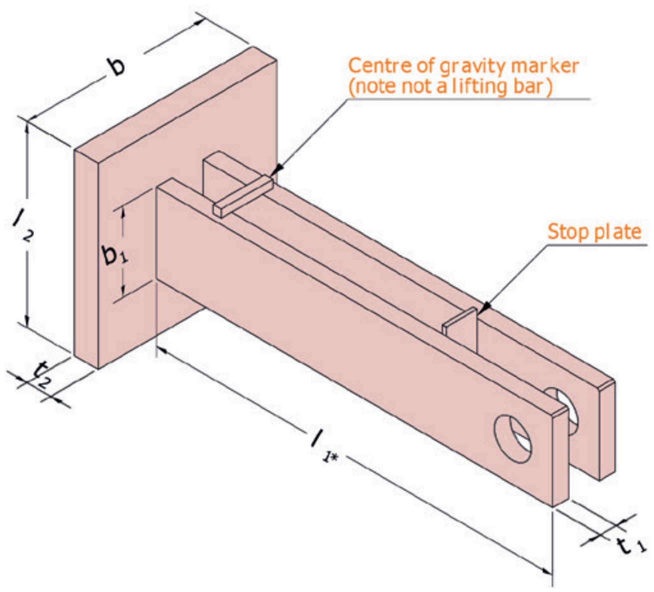




*l_{TP} depending on H-pile and nominal size

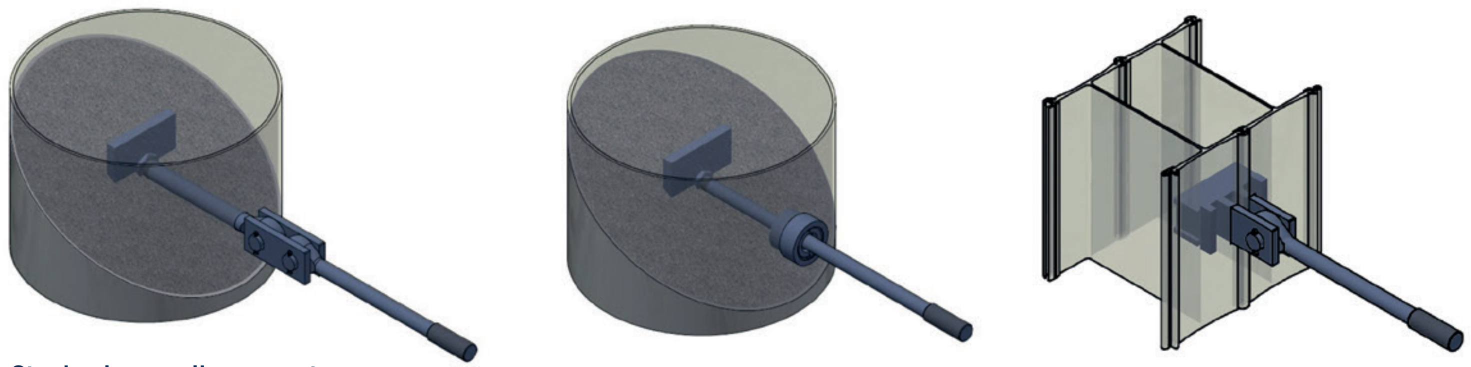
T-Anchors for combi-walls



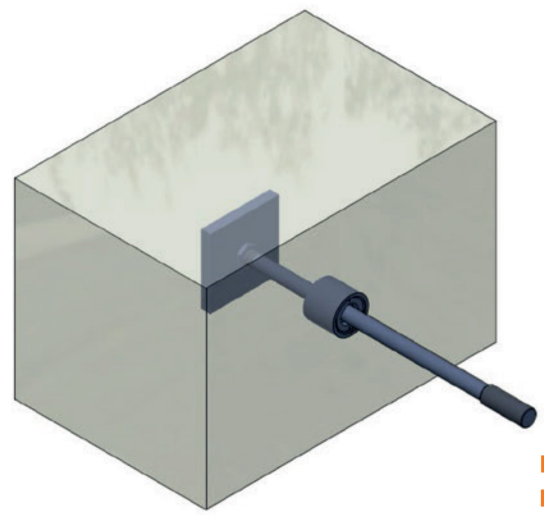


*l_1 depending on tube diameter and nominal size

Other connectors



Steel primary pile connectors



Concrete spherical connector

Exploded detail of spherical connector

For further detail of the above connectors please contact our technical department

CONNECTIONS

Table 8 – Turnbuckle & coupler (ASDO500, $k_t = 0.6$)

Nominal thread diameter		Metric	64	68	72	76	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160	165	
Diameter	ØD_t & ØD_{cp}	mm	95	102	102	108	114	121	127	133	146	152	159	165	168	178	191	191	203	203	216	216	229	241	ØD_t & ØD_{cp}
Standard turnbuckle length	L_t	mm	280	290	295	305	310	320	330	340	350	360	370	380	400	410	420	430	440	450	460	475	485	495	L_t
Standard turnbuckle adjustment	+/-	mm	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	+/-
Long turnbuckle length	L_t	mm	480	490	495	505	510	520	530	540	550	560	570	580	600	610	620	630	640	650	660	675	685	695	L_t
Long turnbuckle adjustment	+/-	mm	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	150	+/-
Coupler length	L_{cp}	mm	130	140	145	155	225	235	245	255	275	285	295	305	320	330	340	350	360	370	380	395	405	415	L_{cp}

Turnbuckles with longer adjustment are possible - please contact our sales department for more information.

Table 9 – Articulated turnbuckle (ASDO500, $k_t = 0.6$)

Nominal thread diameter		Metric	64	68	72	76	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160	165	
Length	L_{AT}	mm	500	510	540	650	670	680	690	720	760	790	810	850	870	910	900	940	940	970	970	1010	1030	1050	L_{AT}
Adjustment	+/-	mm	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	+/-
Width	W_{AT}	mm	175	180	185	190	195	215	235	240	255	260	265	275	280	305	320	325	350	360	370	380	380	415	W_{AT}
Height	H_{AT}	mm	140	155	165	175	190	195	200	215	240	260	270	295	305	325	320	345	340	365	365	390	400	410	H_{AT}

Table 10 – Link plates (ASDO500, $k_t = 0.6$)

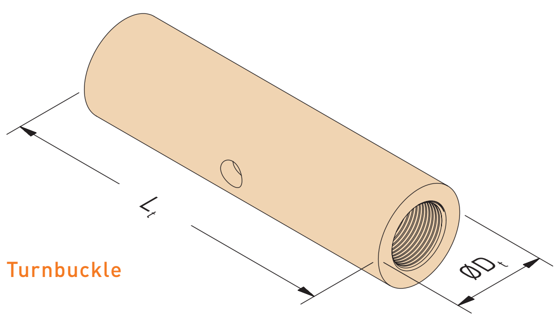
Nominal shaft diameter	Ød_s	mm	48	52	56	60	64	68	72	76	80	85	90	95	100	105	110	115	120	125	130	Ød_s
Eye ref		inches	2 1/2	2 3/4	3	3	3 1/4	3 1/2	3 1/2	3 3/4	4	4 1/4	4 1/2	4 3/4	5	5 1/4	5 1/2	5 3/4	6	6 1/4	6 1/2	
Thickness	W_{LP}	mm	30	30	30	30	35	40	40	40	40	40	40	45	50	50	55	60	60	60	65	W_{LP}
Length	L_{LP}	mm	300	335	390	390	405	440	440	475	510	570	625	660	675	705	730	750	795	840	860	L_{LP}
Height	h_{LP}	mm	130	145	160	170	170	190	190	195	225	245	270	285	290	300	320	330	345	365	370	h_{LP}
Pin diameter		mm	50	55	60	60	64	72	72	75	80	85	90	95	100	100	110	115	120	125	130	

Table 11 – Cardan joint (ASDO500, $k_t = 0.6$)

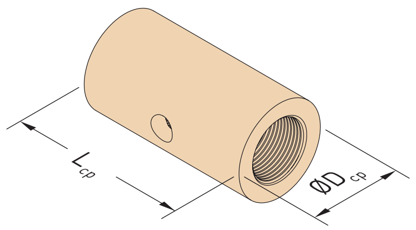
Nominal shaft diameter	Ød_s	mm	48	52	56	60	64	68	72	76	80	85	90	95	100	105	110	115	120	125	130	Ød_s
Eye ref		inches	2 1/2	2 3/4	3	3	3 1/4	3 1/2	3 1/2	3 3/4	4	4 1/4	4 1/2	4 3/4	5	5 1/4	5 1/2	5 3/4	6	6 1/4	6 1/2	
Length	L_{CJ}	mm	330	360	410	410	440	480	480	500	540	570	610	660	680	700	750	780	810	870	910	L_{CJ}
Width	W_{CJ}	mm	120	130	140	140	150	170	170	180	190	200	210	220	240	250	260	270	280	290	300	W_{CJ}
Height	h_{CJ}	mm	120	130	140	140	150	170	170	180	190	200	210	220	240	250	260	270	280	290	300	h_{CJ}
Pin diameter		mm	50	55	60	60	64	72	72	75	80	85	90	95	100	100	110	115	120	120	130	

All plates grade S355 and based on maximum thread capacity for ASDO500, $k_t = 0.6$. For other grades and $k_t = 0.9$ contact our technical team.

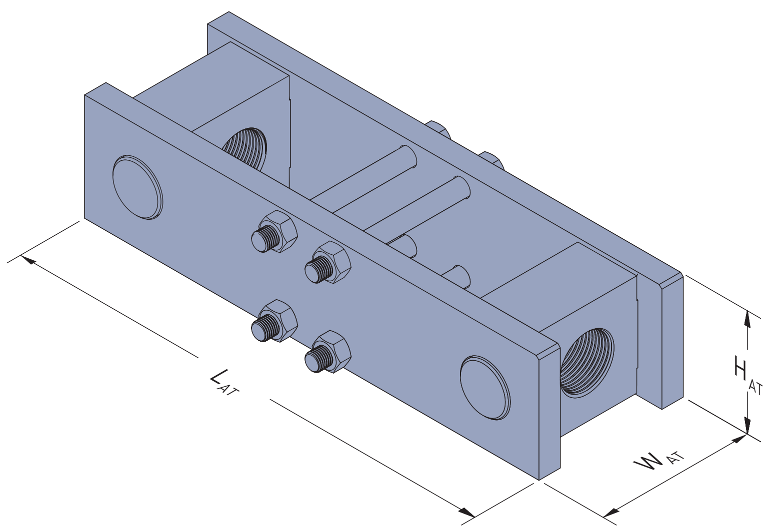
Note : All above dimensions are nominal only and subject to change to suit project requirements.



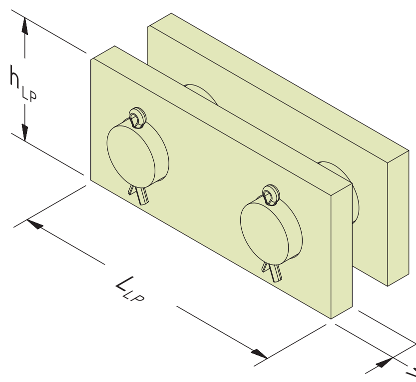
Turnbuckle



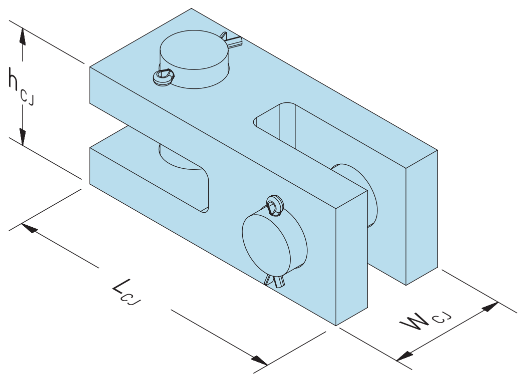
Coupler
Couplers and turnbuckles are used to connect bars to make longer lengths. A turnbuckle can be used for length adjustment.



Articulated turnbuckle
An adjustable turnbuckle allows length adjustment and articulation in one plane.



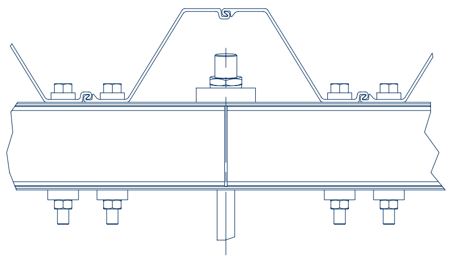
Link plates
Together with forged eyes link plates provide the most economic articulated joint and the simplest connection to achieve in site conditions.



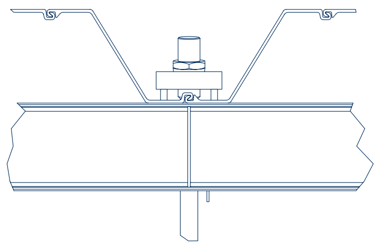
Cardan joint
The cardan joint allows bars with forged eyes to articulate in both vertical and horizontal planes.

WALINGS

Anker Schroeder can supply complete waling systems to suit a variety of wall configurations. Waling usually comprises of two rolled steel channel sections placed back to back and spaced to allow the tie rods to pass between the channels. This spacing must allow for the diameter of the tie rod and the thickness of any protective material applied to the rod and take into account any additional space required if the tie rods are inclined and need to pass between the walings at an angle.

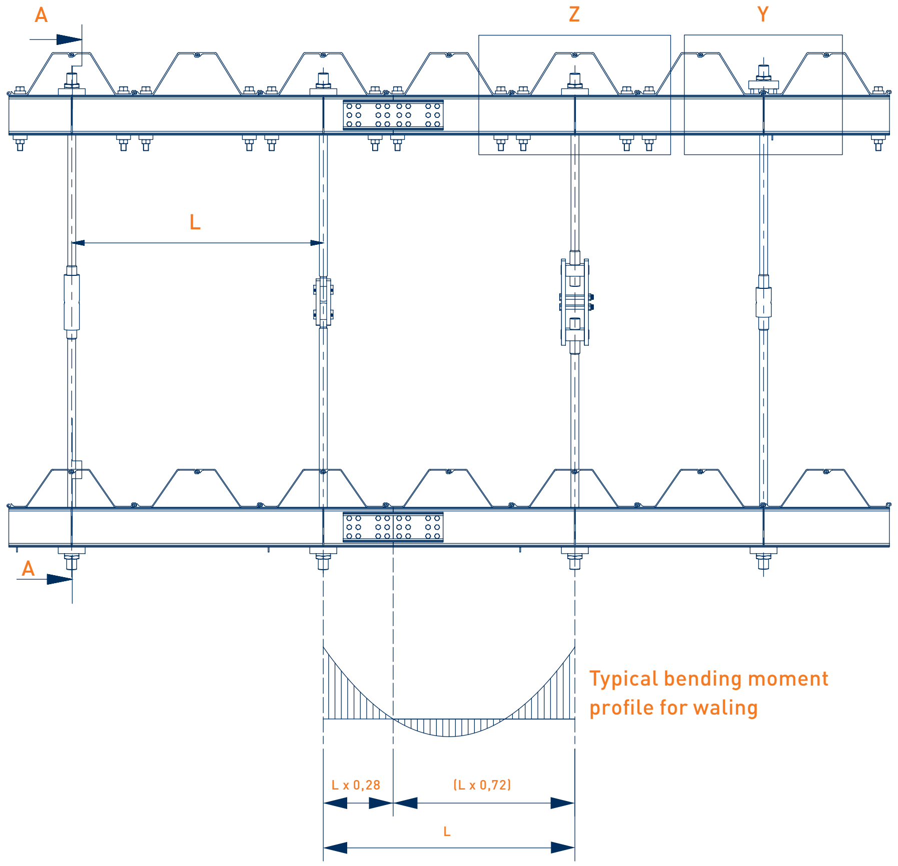


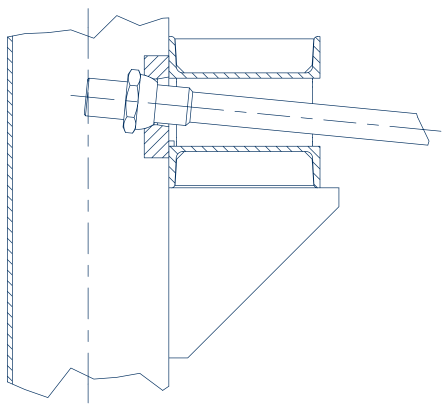
Detail Z
Tie bar connection inside sheet pile pan for additional corrosion protection



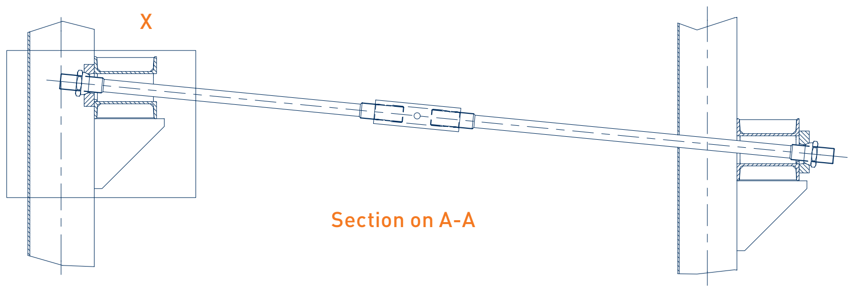
Detail Y
Tie bar connection outside sheet pile

Note: The combination of anchor head connections to the outside and inside of the sheet pan is shown for example only and would not normally be used in practice.





Detail X



Section on A-A

Anchor connections to a sheet pile wall can be made in two ways – outside the wall or inside as shown opposite. Generally walings placed inside the retaining wall are preferred both for aesthetic reasons and, in the case of a wall in tidal or fluctuating water level conditions, to prevent damage to the waling by floating craft or vice versa.

Placing the waling inside the wall also allows the anchor bar to be connected inside the wall within the pan of a sheet pile. This greatly increases the corrosion protection to the main tie bar connection, see detail Z.

When the waling is placed behind the front wall, it is necessary to use waling bolts and plates at every point of contact between the piles and the waling to ensure load is transferred fully to the waling.

Anker Schroeder supply a complete range of waling bolts to suit project applications. Bolt heads are forged on to the bar and if these are placed on the outside of the wall provide greater corrosion protection than exposed threads such as hexagon nut connections.

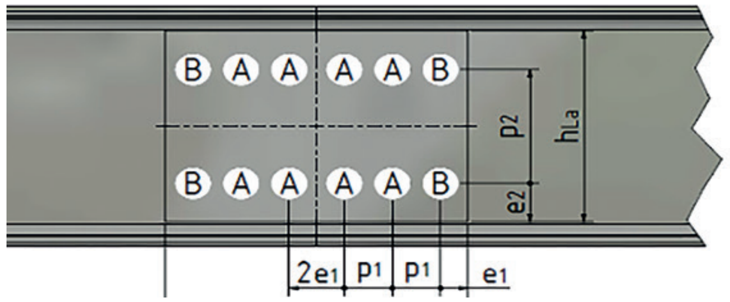
For design purposes the waling can be considered as continuous with allowance being made for end spans. Although the waling is then statically indeterminate, it is usual to adopt a simplified approach where the bending moment is assumed to be $wL^2/10$, being the calculated load to be supplied by the anchorage system acting as a uniformly distributed load and L is the span between anchors.

When checking the anchorage system for the loss of a single anchor, the load in the anchorage system is assessed on the basis of the requirements for a serviceability limit state analysis with no allowance made for overdig at excavation level. The resulting bending moments and tie forces are considered to be ultimate values and are applied over a length of waling of 2L.

In this extreme condition, it can be demonstrated that, with the exception of the anchors at either end of the external spans, the bending moment in a continuous waling resulting from the loss of any tie rod will not exceed $0.3\ wL^2$ where w is the support load calculated for this condition expressed as a UDL and, for simplicity, L is the original span between anchors.

Typical waling sizes and grades along with theoretical bending capacities are given in table 12. It is intended that these values are used for estimation only and provide an initial assessment to which waling section may be suitable. For complete assessment of structural requirements a more rigorous analysis taking into account factors such as torsion, axial loading, vertical loading and high shear loads should be made.

WALINGS AND SPLICE CONNECTIONS



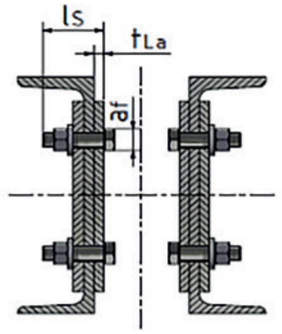
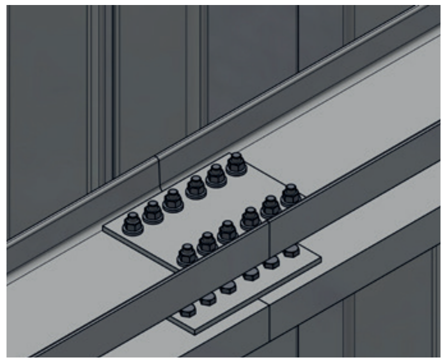
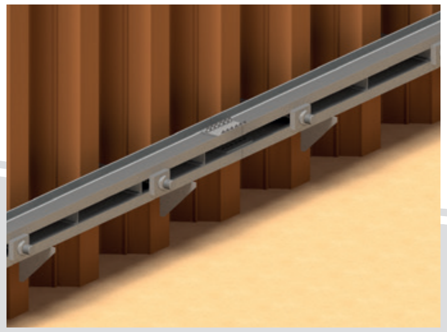


Table 12 – Waling splice connections

Walings beam	Splice plates			Splice bolts				Bolt hole detail				
Section profile	Width h_{La}	thickness l_{La}	lenght l_{La}	Number ∑n	Size Metric	Length l_s	Hex across flats, a_f	Pattern	Spacing e_1	e_2	p_1	p_2
UPN 160	110	10	200	8	M 16	60	24	A	25	25	50	60
UPN 180	140	10	200	8	M 16	60	24	A	25	30	50	80
UPN 200	140	12	260	8	M 20	75	30	A	35	30	60	80
UPN 220	160	12	270	8	M 20	75	30	A	35	40	65	80
UPN 240	180	10	260	8	M 20	70	30	A	35	35	60	110
UPN 260	200	10	270	8	M 20	70	30	A	35	40	65	120
UPN 280	200	10	260	8	M 22	75	30	A	35	35	60	130
UPN 300	220	10	300	8	M 22	75	30	A	40	45	70	130
UPN 320	240	15	270	8	M 24	95	36	A	35	40	65	160
UPN 350	280	15	270	8	M 24	95	36	A	35	45	65	190
UPN 380	300	12	400	12	M 24	90	36	A+B	35	70	65	160
UPN 400	320	14	440	12	M 24	90	36	A+B	40	65	70	190

all dimensions in mm
1. The above section sizes are suggestions only, other waling detail can be supplied on request.
2. All sections and plates based on Grade S355J2 to EN 10025-2
3. Splice details above are not moment connections, ie for use at locations at zero bending moment only (see page 20)
4. All bolts are grade 8.8 to ISO 898


Waling splice detail


Typical waling detail

For longer lengths, walings can be joined by splice sections. These should be located at a distance of 0.28 of the anchor spacing from an anchor location as this will be close to the position of minimum bending moment in the waling (nb this should also be checked for the load case of one tie bar failing in which the anchor spacing will double). The walings should be ordered 100 mm longer than the theoretical dimensions to allow for any creep which may develop in the wall as the piles are driven. Splice connections can be welded or bolted, if bolted only one end of the waling length is drilled for splicing to match the splice hole pattern. The other end is supplied plain for cutting and drilling on site, after the actual length required has been determined. Where inclined ties are used, the vertical component of the anchor load must not be overlooked and provision must be made to support the waling, usually in the form of brackets or welded connections. Where sheet pile anchor walls are used, similar walings to those at the retaining wall are required. These are always placed behind the anchor piles and consequently no waling bolts are required. Where higher waling loads are found, e.g. for combi-walls, Anker Schroeder can offer walings fabricated from higher inertia sections, e.g. H sections – please contact our sales department for more information.

Where walings form part of the permanent structure they can be supplied with protective coatings or often more economical a sacrificial steel allowance made. If coatings are supplied then further coatings are recommended on site after installation.

WALING BOLTS

PRODUCT DATA

Waling bolts are made from the same grades of steel as ASDO355 & ASDO500. Bolts can be made with forged hexagon heads or threaded each end, lengths are made to order. Standard hexagon nuts are provided.

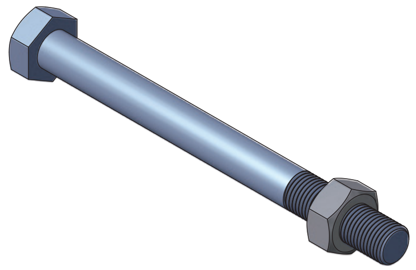
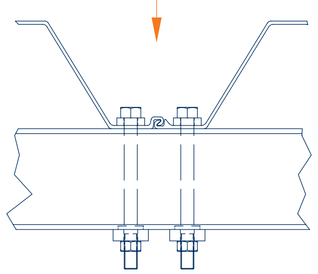

Waling bolt with forged head and hexagon nut.

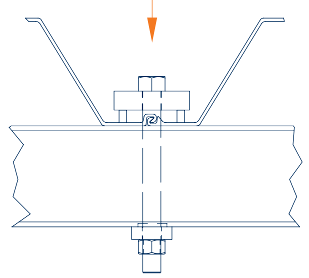
Table 13 – Waling Bolts

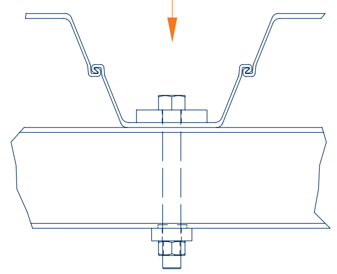
Thread	Thread pitch P	Stress area A_{sp}	Width Across Flats*	Grade ASDO	Tensile Resistance accd. EN1993-5
Metric	mm	mm²	mm		kN
36	4,0	817	55	355	200
				500	259
42	4,5	1.121	65	355	274
				500	355
45	4,5	1.306	70	355	320
				500	414
48	5,0	1.473	75	355	361
				500	467
52	5,0	1.758	80	355	430
				500	557
56	5,5	2.030	85	355	497
				500	643
60	5,5	2.362	90	355	578
				500	748
64	6,0	2.676	95	355	655
				500	848

*Can be increased to allow for sacrificial corrosion

Forged head of waling bolt placed to outside of sheet pile for increased corrosion resistance


Waling bolts to Z-piles


Waling bolts to Z-piles


Waling bolts to U-piles

CORROSION PROTECTION

Marine structures inherently operate in aggressive environments and selection of robust protection systems for tie bars is key to the longevity of a structure. It is very important to consider the corrosion protection of the anchors at design stage and of particular importance is the connection to the front wall as the anchor is typically subjected to the most aggressive environment at this point and this is the most common area of failure for an anchorage. The same guidance is given in **IS 9527** (Part-III)-1983, Clause 8.2.b where it is mentioned that allowance shall be made in the cross-sectional area of ties for corrosion (ie increase the diameter of shaft and thread)

Tables 4-1 & 4-2 of EN 1993-5 give guidance to corrosion allowances for steel sheet piles, it is accepted practice to use these same rates for tie bars.

Corrosion protection for anchors can be provided in several ways.

Sacrificial steel
Anker Schroeder consider sacrificial steel to be the most practical and robust corrosion protection. The anchor shaft and thread size are increased in diameter to allow for corrosion steel loss during the life of the structure. No additional coating is required.

The figure below shows how the threaded part of the anchor in the splash zone has been increased in diameter to allow for the anticipated corrosion loss. This system is robust as no special transport or site considerations are required.

By calculation use Grade ASDO500

Shaft diameter required 76 mm

Thread diameter required M100

Sacrificial corrosion allowance in fill 1.2 mm

Sacrificial corrosion allowance at head 3.75 mm

Anchor shaft size required = 83.5 mm (nearest standard size = 85 mm) and thread size M110.

Therefore use ASDO500 M110/85.

Note: The shaft and thread can be reduced as the corrosion rate decreases (see page 11).

Corrosion allowances for steel anchors

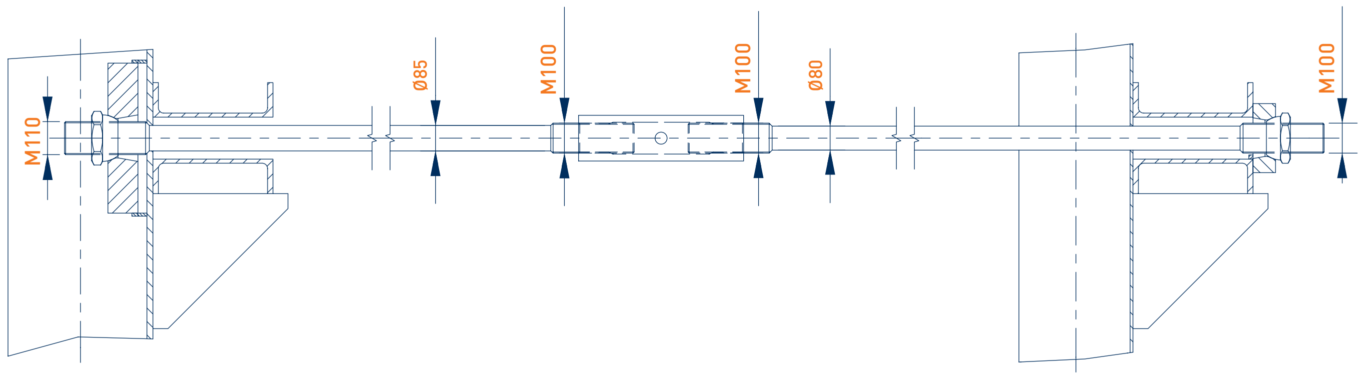
EN 1993-5 Table 4-1 – Recommended value for the loss of steel thickness (mm) due to corrosion in soils with or without groundwater

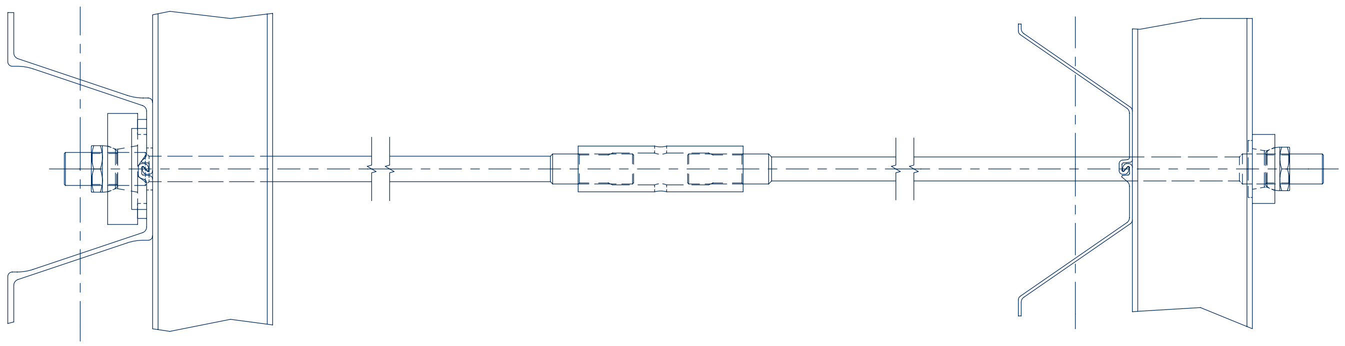
Required design working life	5 years	25 years	50 years	75 years	100 years
Non-compacted and non-aggressive fills (clay, schist, sand, silt ...)	0.18	0.7	1.2	1.7	2.2

Note: For compacted fills EN 1993-5 allows the corrosion rates above to be halved but Anker Schroeder recommend this is ignored for conservatism.

EN 1993-5 Table 4-2 – Recommended value for the loss of steel thickness (mm) due to corrosion in water

Required design working life	5 years	25 years	50 years	75 years	100 years
Common fresh water (river, ship canal ...) in the zone of high attack (water line)	0.15	0.55	0.9	1.15	1.4
Very polluted fresh water (sewage, industrial effluent ...) in the zone of high attack (water line)	0.3	1.3	2.3	3.3	4.3
Sea Water in temperate climate in the zone of high attack (low water and splash zones)	0.55	1.9	3.75	5.6	7.5
Sea Water in temperate climate in the zone of permanent immersion or in the intertidal zone	0.25	0.9	1.75	2.6	3.5





DESIGN CONSIDERATIONS

Wrapping systems
Wrapping systems are sometimes used to cover the anchors in a protective barrier such as petrolatum tape (e.g. Denso).

Anker Schroder can offer factory petrolatum wrapped bar, but it should be remembered, that connections cannot be wrapped until installed on site and can increase installation time considerably.

The vulnerable anchor head can only be fully protected once installed and this is often difficult to achieve in site conditions.

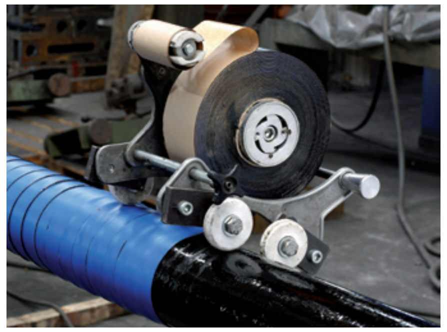
It is important to ensure that protection to connections and the anchor head are correctly performed during installation, any damaged or unprotected areas must be repaired before backfilling.

Galvanising
With the exception of ASDO700 bar Anker Schroeder tie bars and components can be hot dip galvanised to EN ISO 1461 but consideration should be given to threads which are unable to have more than a nominal coating of zinc. Please contact our technical department for further detail.

Painting
Anchors can have any suitable paint system applied as required by the client. Consideration should be given to likely damage that will occur to the paint system during transport and installation as any break in the protective system could lead to pitting corrosion.

Please contact our technical department for further detail.

General Note
Any breaks in the protective system could lead to aggressive pitting corrosion and premature failure of the anchor. It is for these practical reasons that ASDO recommend sacrificial steel as the most cost effective corrosion protection. To discuss these issues further, please contact our technical department.



Factory wrapping of anchors

Storage of wrapped anchors

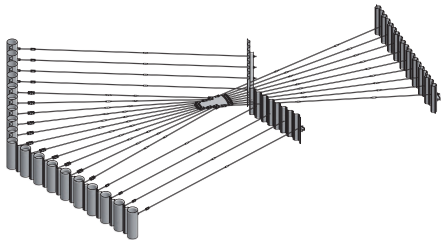
Site wrapping of connections

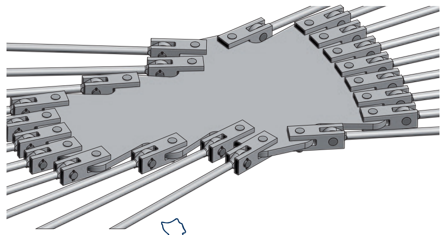
Galvanised T-plates

Galvanised anchors

Painted anchor

Anchorage Fabrications
Anker Schroeder can also supply anchorage distribution units for more complex constructions.





ANKER SCHROEDER
ASDO steel tension members

SITE INFORMATION

Storage of anchors
Tie rods and accessories shall be stored and handled in such a way as to avoid excessive deformation, corrosion, exposure to heat (e.g. flame cutting), bending or damage of any kind being caused on the rods, threaded ends, turnbuckles or nuts.

All threaded parts must be carefully protected from dust, dirt and damage. Clean and check all threads thoroughly before use.

No welding or flame cutting shall be carried out on the tie rods and/or accessories (turnbuckles, couplers, nuts) without written approval of ASDO. All tie bars and accessories should be protected from any exposure to heat processes on site such as welding or flame cutting.

Assembly
Container or road shipping restrictions generally mean that anchors are delivered in sections of typically 12-18 m or less, however Anker Schroeder have direct rail links and convenient access to docks where longer lengths can be shipped – please contact our technical team for further detail. Sections are assembled on site to design lengths. Assembly on a clear hard-standing with roller trestles is recommended. Great care should be taken in ensuring threads are clean and free of dirt and damage prior to assembling. All threaded connections must be made with minimum engagement of at least 1 x diameter of the thread.

Installation
Anchors should be installed as close as possible to the line of force that they will experience during service. Account should be taken of the additional forces that will be introduced to the bar by settlement of the fill, particularly bending at the wall connection.

Long anchors should be lifted by use of a stiff lifting beam with supports at approximately every 4-6 m.

Site services & training
Anker Schroeder are able to offer training for assembly, installation and stressing either at your site or at our factory in Dortmund. Please contact our technical department for more information.



Stock and availability
Anker Schroeder hold over 4,000 tonnes of raw material enabling many projects to be quickly supplied with initial needs. However most major projects will require the bulk of raw material to be rolled to the specific project diameter which can be adapted to the nearest millimetre to ensure the most economical solution. Please contact our sales department to discuss your project requirements.


OTHER PRODUCTS

ASDO Stainless Architectural tie bars

Diameter M12 to M56

ASDO Structural Architectural tie bars

Diameter M12 to M160

This publication provides information and technical details currently used by Anker Schroeder in the manufacture of its products.

Although we have taken great care in the preparation of the data within this publication, we cannot assume responsibility for the completeness and accuracy of all the details given. Each customer should satisfy themselves of the product suitability for their requirements. The publication of this data does not imply a contractual offer.

In line with Anker Schroeder's policy of continuous improvement the company reserves the right to change or amend details. Please contact our technical department for further information or to ensure these details are current.

Sustainability
Steel is the most recycled material in construction. All anchorage material supplied by Anker Schroeder is sourced from reputable steel mills and, where possible, up to 90% of melt is recycled steel. Once a structure has reached the end of it's design life Anker Schroeder Bars are 100% recyclable as scrap material but the economics and environmental impact of extraction from the structure need to be considered.

ASDO

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100 years steel tradition 1920–2020

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