ASDO

TIE BARS FOR MARINE STRUCTURES

Large Diameter Articulated Tie Bars 3" - 6.5" Diameter

US Design with Customary Units

Since 1920

ANKER SCHROEDER

ASDO steel tension members

ASDO TIE BARS FOR MARINE STRUCTURES

Anker Schroeder manufacture large diameter tie bars for retaining structures such as bulkheads, quaywalls, abutments, berths and crane runways. Our tie bars range in diameter from 3" to 7" (M76 to M170) and can be supplied in standard grades 355 & 500 equivalent to 50 & 72 ksi with higher grades available on request. Anker Schroeder tie bars 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 concrete diaphragm walls.

MADE IN GERMANY

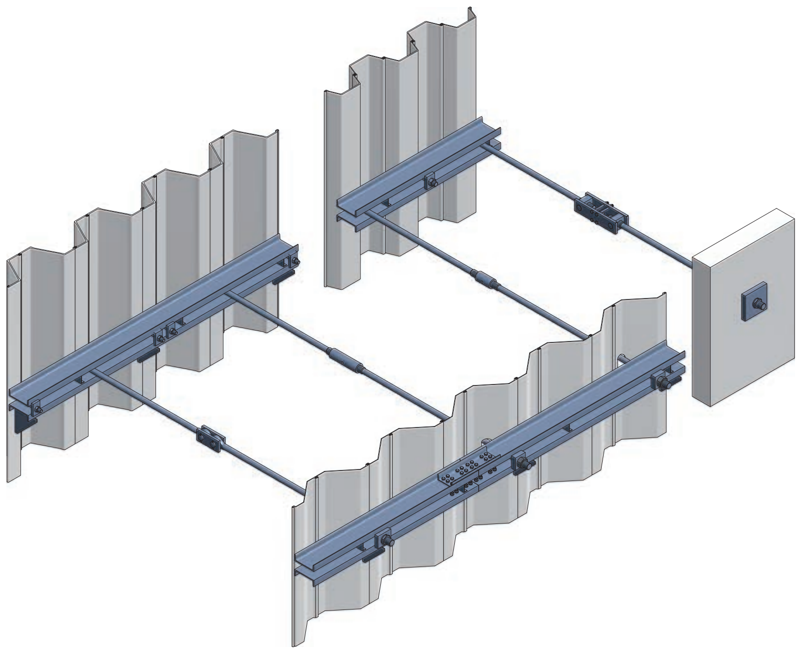
STEEL GRADES

Anker Schroeder offer 2 standard steel grades for tie bars:

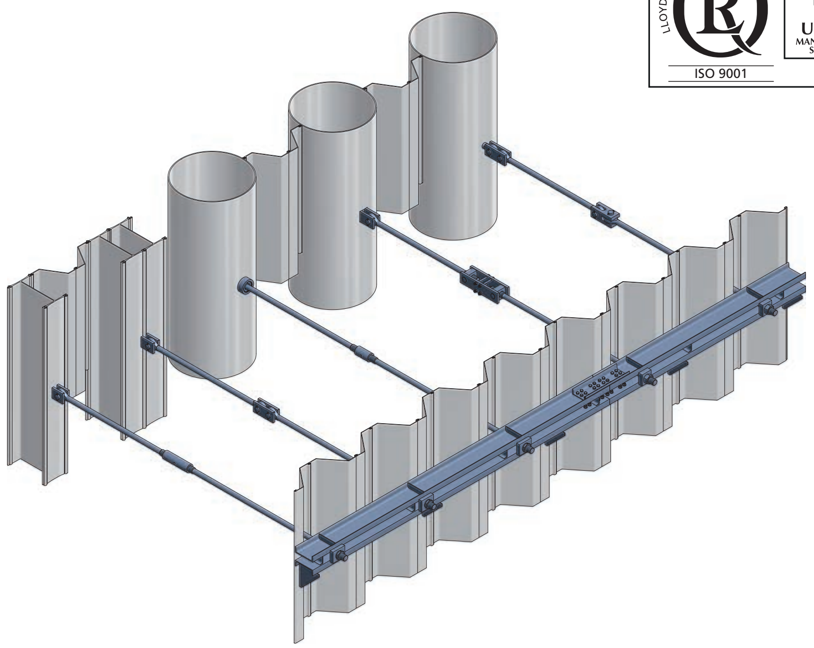
Steel grades	Thread Diameter	Yield Strength	Tensile Strength
ASDO355	2.5" - 6.3" M64 - M165	50 ksi 355 N/mm²	75 ksi 510 N/mm²
ASDO500	2.5" - 6.5" M64 - M170	72 ksi 500 N/mm²	96 ksi 660 N/mm²

other grades are available – please contact our sales team if required

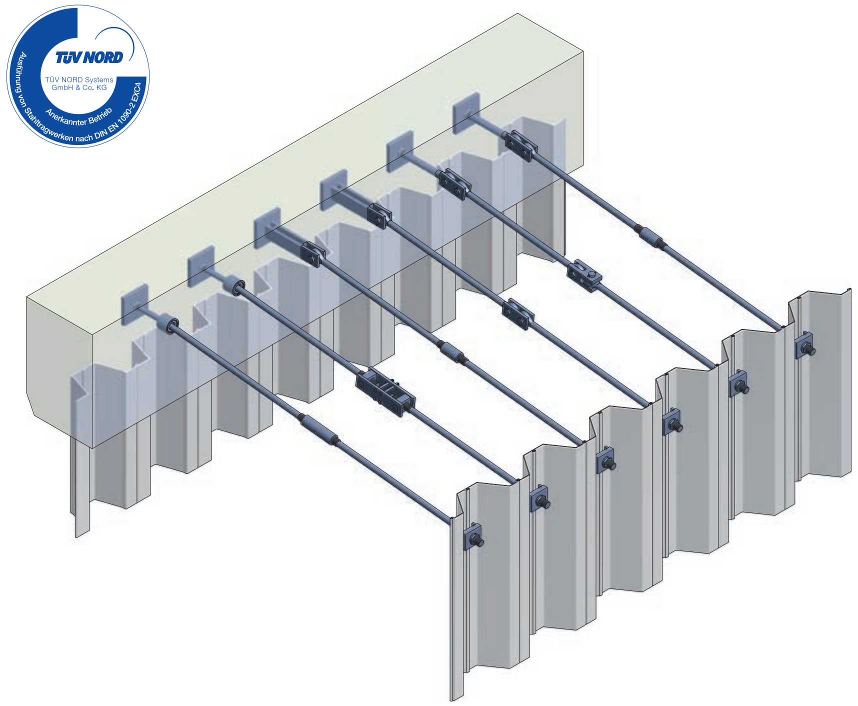
Depending on diameter and length required, Anker Schroeder tie bars are manufactured using selected fine grained steel, high strength low alloy steel or quench and tempered steel. The choice of steel is dependent upon your specific project requirements, but the above minimum properties will be met. All tie bars and components are manufactured to a quality system audited and accredited to ISO 9001 and can be manufactured to meet the requirements of EN1090 and CE marked if required.



Z-pile and U-pile solutions

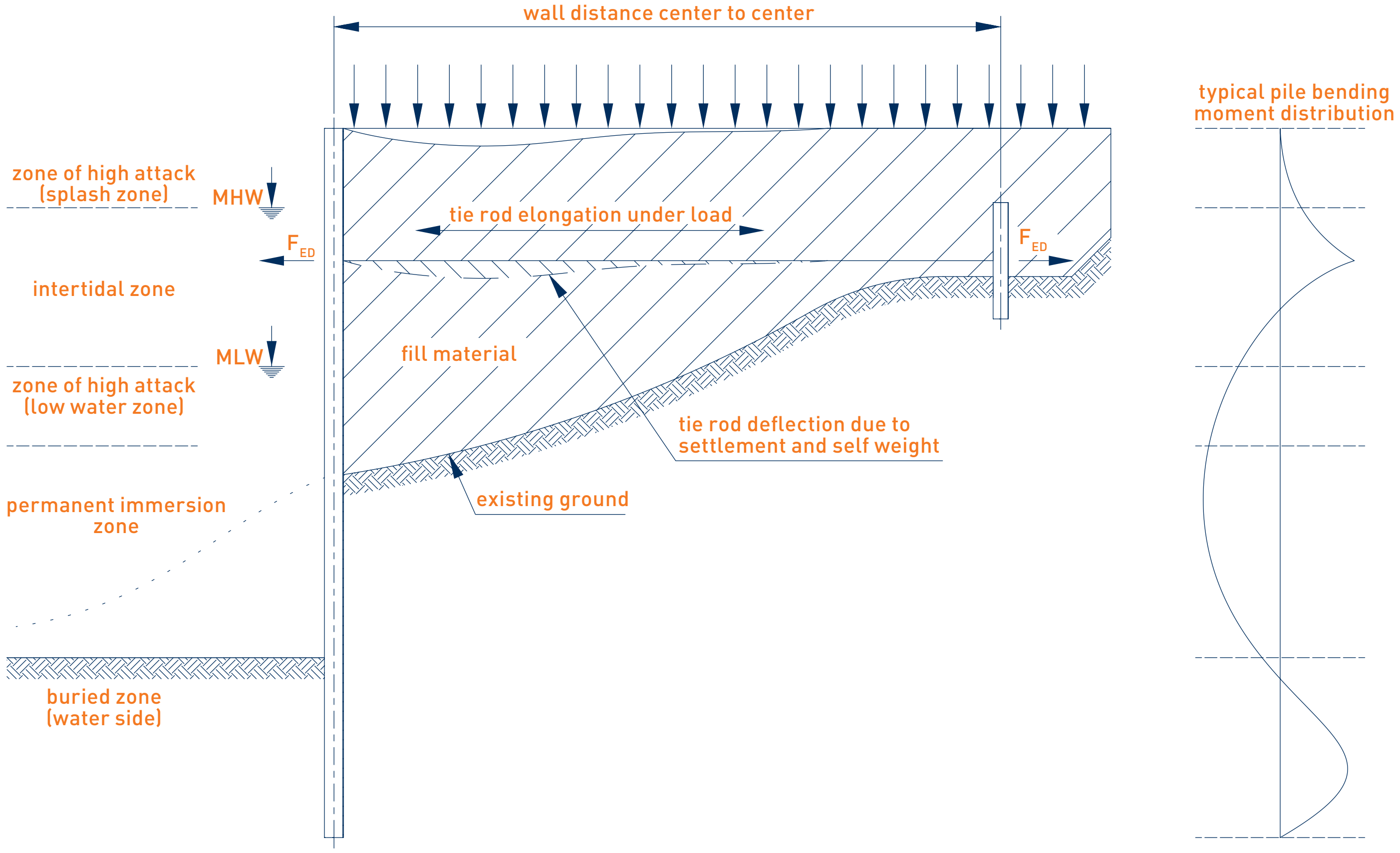


High modulus wall solutions



Concrete wall solutions

ASDO TIE BARS FOR MARINE STRUCTURES



When designing tie bars 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 or capacity is calculated differently between design codes).

Serviceability – the elongation of the tie bars under the serviceability load may be the limiting factor rather than design resistance particularly where large crane loads have to be accommodated. Stiffness of a tie bar is a function of the shaft diameter and subsequently a higher grade steel 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 most easily achieved at a threaded end of the tie bar by means of a hydraulic jack, consideration to the practicality of this should be made at design stage.


Puerto Caucedo, Dominique


Port de Trois-Rivières, Canada

Stressing operation

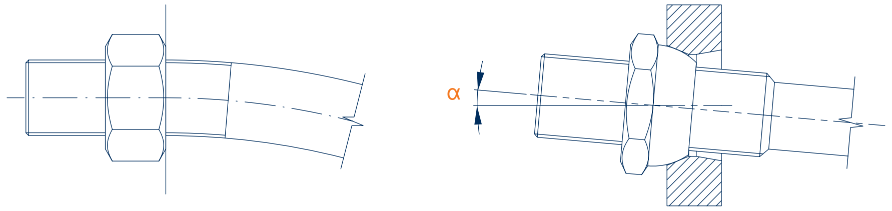
DESIGN CONSIDERATIONS

Settlement – the effect of sag of the tie bar 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 tie bar.

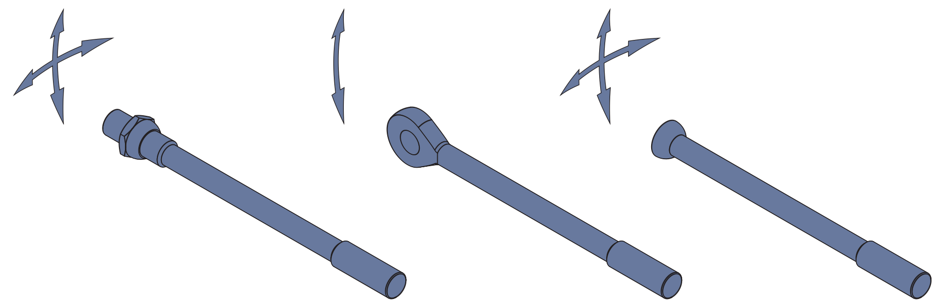
Settlement ducts can also be installed to reduce bending at the connection, however these can be difficult and expensive to install and, if not aligned correctly, will not prevent settlement bending being introduced. If settlement ducts are used articulation at the wall, connection is recommended to 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 tie bars are typically used in aggressive environments and consequently corrosion protection factors influencing effective life must be considered. Consideration of the corrosion protection of the tie bar at design stage and in particular the connection to the front wall is important as the tie bar 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.

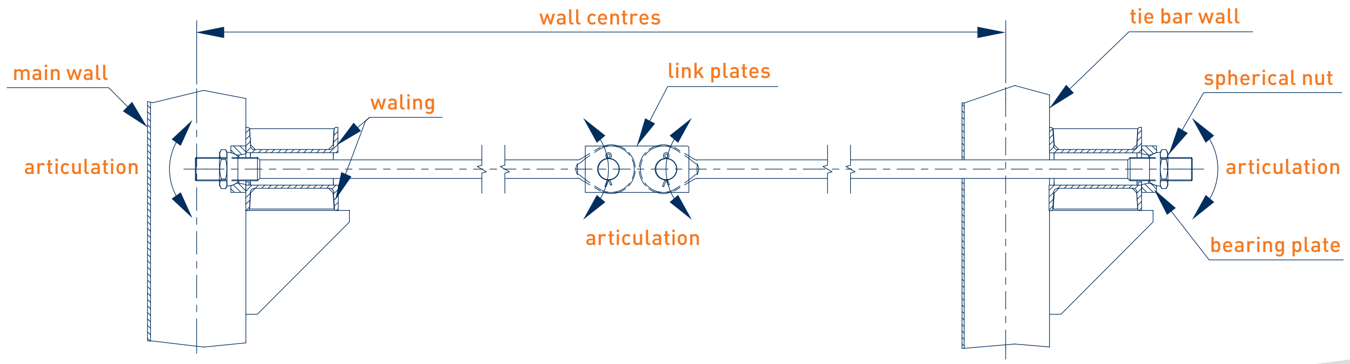


Bending stress induced by settlement or misalignment

Articulation removes bending stress at connection α < 7°



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



TENSILE RESISTANCE OF TIE BARS

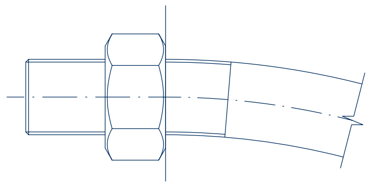
Calculation of the tie bar load capacity depends on the design philosophy and codes of practice being followed. Care should be taken that tie bar loads generated by Allowable Stress Design (ASD) are not used if calculating tie bar capacities using Load & Resistance Factor Design (LRFD) and vice versa.

Design codes also differ between countries – broadly, projects in Europe must be designed to Eurocodes (EN1993-5) whilst projects in North America to various codes and guidance such as United States Army Corps Of Engineers (USACE) EM1110-2-2504 (Chapters 5 & 6).

For information the two design approaches and codes are explained briefly below, but engineers should take care that the correct approach is selected for their particular project and local design regulations.

DESIGN RESISTANCE OF TIE BARS EFFECT OF SETTLEMENT

Most design codes recognise that for typical marine structure tie bars there is a high risk that bars can be subjected to bending at the stiff connection point to the sheet pile wall as settlement of fill occurs. This is particularly important as this is generally the location of the threaded portion of the tie bar which is inherently the weaker part of the system.

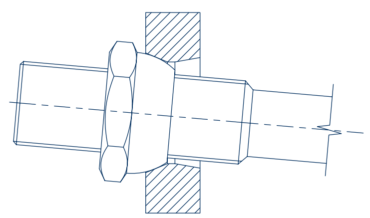


For 'fixed' connections thread capacity reduced by 40% for Eurocode and by 60% for USACE

Eurocodes give guidance as to whether the load capacity of the threaded part of a tie bar should be reduced based on the connection type to the wall- whether it is fixed' or 'articulated' (ie allowed to rotate to reduce bending)

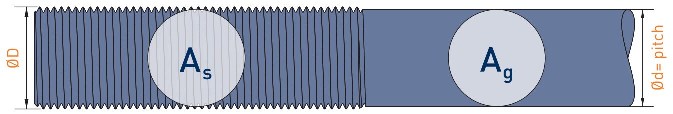
Typically the full tensile design capacity of the thread is reduced by applying a thread factor kt of 0.6 (ie the capacity is reduced by 40%). This is similar to USACE guidance (EM1110-2-2504 Ch. 6, eq. 6.13), which states that the allowable stress in a thread should be calculated as f_t = 0.4 x yield stress of the bar.

EN1993-5 gives further guidance in stating that if "the structural detailing of the location where the anchor rod is joined to the wall is such that bending moments are avoided at that location" the thread factor can be reduced to 0.9. Typically in practice the 0.6 factor is kept along with articulation as a conservative approach.

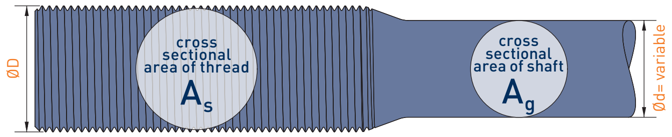


For 'articulated' connections thread capacity reduced by 10%

Deadman tie bars are generally long members (typically > 60 ft) and the requirement to increase the thread size to allow for possible additional loads at the wall can result in an inefficient tie bar design. For traditional threaded bars, the shaft must be a minimum of the pitch diameter of the thread to be formed (eg 3 ¾" for a 4" rolled thread) this is fixed and cannot be changed and hence must be the same along the whole length. However the increase in section size is only required at the ends of the bar and so the additional steel along the majority of the length (shaft) is often not economic.



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



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

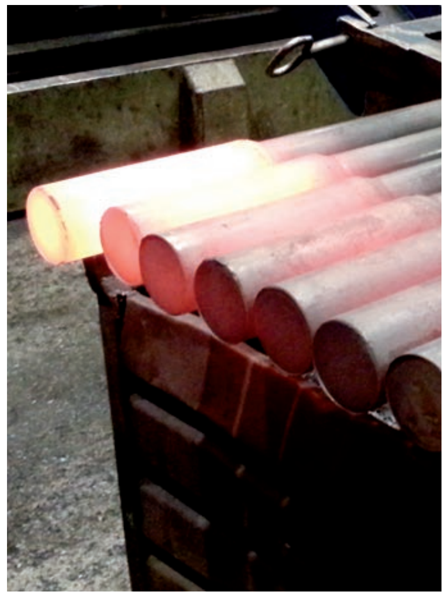
Upset forged thread advantage – stress area of thread > stress area of shaft

With upset forging only the ends of the tie bar are increased in section as shown above. Anker Schroeder have developed a range of high strength bars with upset forged threads that allow a variety of thread diameters to shaft diameters. Upset forging allows threads to be increased in size with little additional weight being added to the tie bar. By increasing the diameter bending stresses can be minimised and sacrificial steel can be easily added to the threaded portion, often the most vulnerable part of a tie bar.

Only upset forged threads ensure that the shaft is the weakest part of a tie bar 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.

Suggested LRFD Design Resistance (based on Eurocode EN1993-5)	Suggested ASD Design Capacity
Design resistance is lesser of:	**Design tensile capacity is lesser of:**
Shaft tensile resistance	**Shaft tensile capacity**
$= A_g \times f_y \times \phi_{ty}$, or	$= A_g \times f_y / \Omega_{ty}$, or
Thread tensile resistance	**Thread tensile capacity**
$= k_t \times f_{ua} \times A_S \times \phi_{tu}$	$= k_t \times f_{ua} \times A_S / \Omega_{tu}$
A_s = tensile stress area of thread A_g = gross cross sectional area of tie bar ϕ_{ty} = resistance factor on yield (typically 0.95) ϕ_{tu} = resistance factor on tensile capacity (typically 0.8) Resistance factors taken from AASHTO Bridge Design Specifications 6.5.4.2 f_y = yield strength of tie bar material	f_{ua} = tensile strength of tie bar material Ω_{ty} = safety factor on yield (typically 1.67) Ω_{tu} = safety factor on tensile capacity (typically 2) k_t = a reduction factor (typically 0.6 but can be 0.9 where structural detailing eliminates bending at the connection)
Note : All factors to be verified by the project engineer before use.	

Anker Schroeder recommended calculation methods are shown above for calculating the load capacity of a deadman tie bar – this method has been used in determining the load capacity values in table 2 on pages 8 & 9.



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 tie bars, this allows the ends 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.

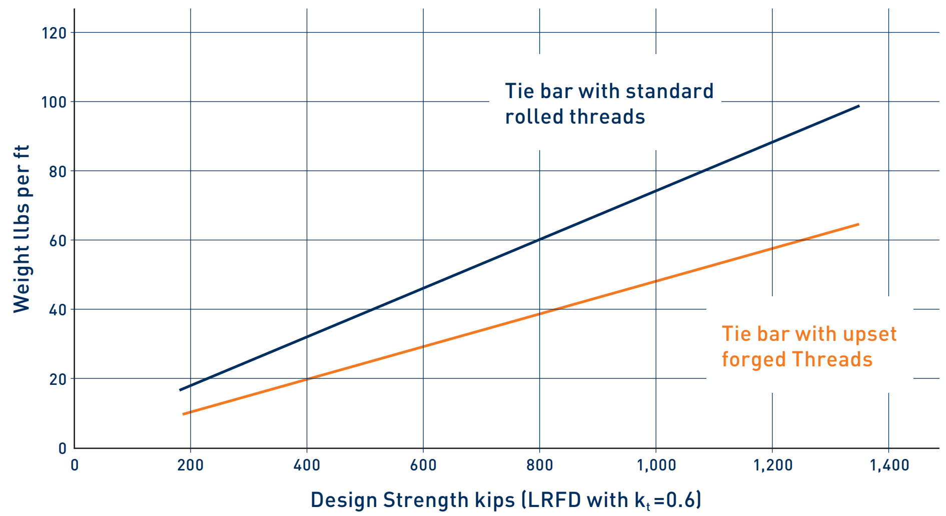
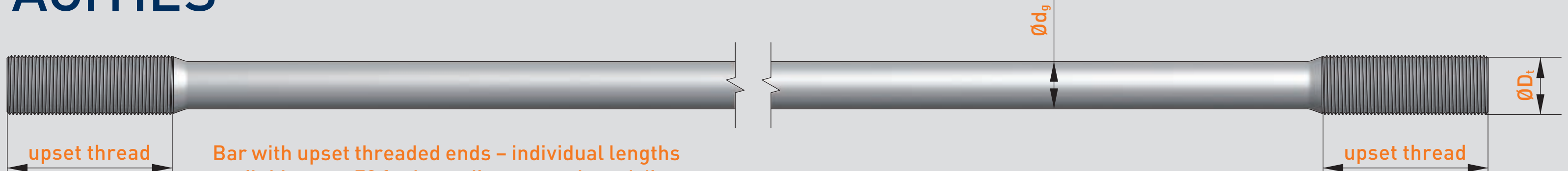


Chart showing the weight per metre advantage for upset forged tie bars compared to standard threaded tie bars.

ASDO TIE BAR DESIGN CAPACITIES



Bar with upset threaded ends – individual lengths available up to 70 ft, depending on grade and diameter (turnbuckles/couplers used for longer lengths).

Table 2 – Tie Bars with upset forged threads

Nominal upset thread diameter	$ØD_t$	mm / in	64 / 2.5	68 / 2.7	72 / 2.8	76 / 3.0	80 / 3.1	85 / 3.3	90 / 3.5	95 / 3.7	100 / 3.9	105 / 4.1	110 / 4.3	115 / 4.5	120 / 4.7	125 / 4.9	130 / 5.1	135 / 5.3	140 / 5.5	145 / 5.7	150 / 5.9	155 / 6.1	160 / 6.3	165 / 6.5	170 / 6.7	$ØD_t$
Thread tensile stress area	A_s	in²	4.15	4.74	5.36	6.03	6.73	7.67	8.67	9.72	10.84	12.02	13.26	14.56	15.92	17.35	18.83	20.37	21.98	23.65	25.37	27.16	29.01	30.92	32.89	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	
Shaft diameters available	All grades	in	1.9 - 2.2	2 - 2.4	2 - 2.5	2.2 - 2.7	2.4 - 2.8	2.5 - 3	2.7 - 3.1	2.8 - 3.4	3 - 3.5	3.1 - 3.7	3.3 - 3.9	3.3 - 4.1	3.7 - 4.3	3.7 - 4.5	3.9 - 4.7	4.1 - 4.9	4.1 - 5.1	4.3 - 5.3	4.5 - 5.5	4.7 - 5.7	4.9 - 5.9	4.9 - 6.1	5.1 - 6.3	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	

ASDO355 – Design Information

ASDO355, $k_t = 0.6$

ASDO code		ASDO355 -	M64/48	M68/52	M72/56	M76/60	M80/64	M85/68	M90/72	M95/75	M100/80	M105/85	M110/90	M115/90	M120/95	M125/100	M130/105	M135/110	M140/115	M145/115	M150/120	M155/125	M160/130	M165+	
Optimum shaft diameter	$Ød_g$	in	1.9	2.0	2.2	2.4	2.5	2.7	2.8	3.0	3.1	3.3	3.5	3.5	3.7	3.9	4.1	4.3	4.5	4.5	4.7	4.9	5.1	larger diameters at request	$Ød_g$
		mm	48	52	56	60	64	68	72	76	80	85	90	90	95	100	105	110	115	115	120	125	130		
Shaft gross area	A_g	in²	2.8	3.3	3.8	4.4	5.0	5.6	6.3	7.0	7.8	8.8	9.9	9.9	11.0	12.2	13.4	14.7	16.1	16.1	17.5	19.0	20.6		A_g
		mm²	1,810	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	10,387	10,387	11,310	12,272	13,273		
Shaft yield capacity	F_y	kips	144	169	197	226	257	290	325	362	401	453	508	508	566	627	691	758	829	829	903	979	1.059		F_y
		kN	642	754	874	1,004	1,142	1,289	1,445	1,610	1,784	2,014	2,258	2,258	2,516	2,788	3,074	3,374	3,687	3,687	4,015	4,357	4,712		
Shaft ultimate capacity	F_{ua}	kips	207	243	282	324	369	416	467	520	576	651	729	729	813	900	993	1.090	1.191	1.191	1.297	1.407	1.522		F_{ua}
		kN	923	1,083	1,256	1,442	1,641	1,852	2,076	2,314	2,564	2,894	3,244	3,244	3,615	4,006	4,416	4,847	5,297	5,297	5,768	6,259	6,769		
LFRD design resistance	$F_{t,Rd}$	kips	137	161	187	214	239	272	308	344	381	427	471	482	537	595	656	721	780	788	857	930	1.006		$F_{t,Rd}$
		kN	610	716	831	952	1,063	1,211	1,369	1,530	1,695	1,899	2,094	2,145	2,391	2,649	2,920	3,205	3,471	3,503	3,814	4,139	4,476		
ASD design strength	$F_{t,Sd}$	kips	86	101	118	134	149	170	192	216	240	267	294	304	339	375	414	452	488	496	540	586	634		$F_{t,Sd}$
		kN	385	451	524	595	665	757	855	960	1,069	1,187	1,309	1,352	1,507	1,670	1,841	2,011	2,170	2,208	2,404	2,609	2,822		

ASDO355, $k_t = 0.9$

ASDO code		ASDO355 -	M64/56	M68/60	M72/64	M76/68	M80/72	M85/75	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+	
Optimum shaft diameter	$Ød_g$	in	2.2	2.4	2.5	2.7	2.8	3.0	3.1	3.3	3.5	3.7	3.9	4.1	4.3	4.5	4.7	4.9	5.1	5.3	5.5	5.7	5.9	larger diameters at request	$Ød_g$
		mm	56	60	64	68	72	76	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150		
Shaft gross area	A_g	in²	3.8	4.4	5.0	5.6	6.3	7.0	7.8	8.8	9.9	11.0	12.2	13.4	14.7	16.1	17.5	19.0	20.6	22.2	23.9	25.6	27.4		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		
Shaft yield capacity	F_y	kips	197	226	257	290	325	362	401	453	508	566	627	691	758	829	903	979	1,059	1,142	1,229	1,318	1,410		F_y
		kN	874	1,004	1,142	1,289	1,445	1,610	1,784	2,014	2,258	2,516	2,788	3,074	3,374	3,687	4,015	4,357	4,712	5,081	5,465	5,862	6,273		
Shaft ultimate capacity	F_{ua}	kips	282	324	369	416	467	520	576	651	729	813	900	993	1,090	1,191	1,297	1,407	1,522	1,641	1,765	1,893	2,026		F_{ua}
		kN	1,256	1,442	1,641	1,852	2,076	2,314	2,564	2,894	3,244	3,615	4,006	4,416	4,847	5,297	5,768	6,259	6,769	7,300	7,851	8,422	9,012		
LFRD design resistance	$F_{t,Rd}$	kips	187	214	244	275	309	344	381	430	482	537	595	656	721	788	857	930	1,006	1,085	1,167	1,252	1,340		$F_{t,Rd}$
		kN	831	954	1,085	1,225	1,373	1,530	1,695	1,914	2,145	2,391	2,649	2,920	3,205	3,503	3,814	4,139	4,476	4,827	5,192	5,569	5,960		
ASD design strength	$F_{t,Sd}$	kips	118	135	154	174	195	217	240	271	304	339	375	414	454	496	540	586	634	684	736	789	844		$F_{t,Rd}$
		kN	524	601	684	772	865	964	1,069	1,206	1,352	1,507	1,670	1,841	2,020	2,208	2,404	2,609	2,822	3,043	3,272	3,510	3,757		

ASDO500 – Design Information

ASDO500, $k_t = 0.6$

ASDO 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+	
Optimum shaft diameter	$Ød_g$	in	1.9	2.0	2.0	2.2	2.4	2.5	2.7	2.8	3.0	3.1	3.3	3.5	3.5	3.7	3.9	4.1	4.3	4.3	4.5	4.7	4.9	5.1	larger diameters at request	$Ød_g$
		mm	48	52	52	56	60	64	68	72	76	80	85	90	90	95	100	105	110	110	115	120	125	130		
Shaft gross area	A_g	in²	2.8	3.3	3.3	3.8	4.4	5.0	5.6	6.3	7.0	7.8	8.8	9.9	9.9	11.0	12.2	13.4	14.7	14.7	16.1	17.5	19.0	20.6		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		
Shaft yield capacity	F_y	kips	203	239	239	277	318	362	408	458	510	565	638	715	715	797	883	973	1,068	1,068	1,168	1,271	1,379	1,492		F_y
		kN	905	1,062	1,062	1,232	1,414	1,608	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		
Shaft ultimate capacity	F_{ua}	kips	268	315	315	365	420	477	539	604	673	746	842	944	944	1,052	1,165	1,285	1,410	1,410	1,541	1,678	1,821	1,969		F_{ua}
		kN	1,194	1,402	1,402	1,626	1,866	2,123	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		
LFRD design resistance	$F_{t,Rd}$	kips	191	218	227	263	302	344	388	435	484	537	606	669	679	757	839	925	1,010	1,015	1,109	1,208	1,310	1,417		$F_{t,Rd}$
		kN	848	968	1,009	1,170	1,343	1,528	1,725	1,934	2,155	2,388	2,695	2,976	3,022	3,367	3,731	4,113	4,492	4,514	4,934	5,372	5,829	6,305		
ASD design strength	$F_{t,Sd}$	kips	119	136	143	166	190	217	244	274	305	338	381	418	428	477	529	583	631	640	699	761	826	888		$F_{t,Rd}$
		kN	530	605	636	737	847	963	1,087	1,219	1,358	1,505	1,694	1,860	1,905	2,122	2,351	2,593	2,808	2,845	3,110	3,386	3,674	3,950		

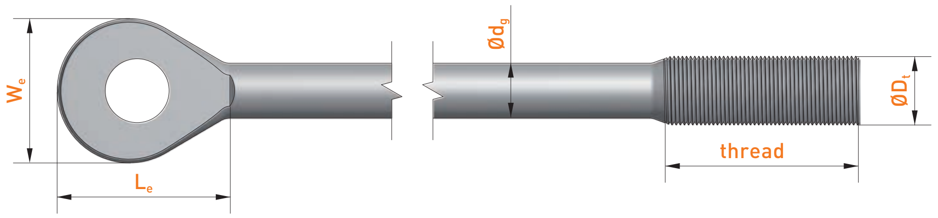
ASDO500, $k_t = 0.9$

Tie bar 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+	
Optimum shaft diameter	$Ød_g$	in	2.2	2.4	2.5	2.7	2.8	3.0	3.1	3.3	3.5	3.7	3.9	4.1	4.3	4.5	4.7	4.9	5.1	5.3	5.5	5.7	5.9	6.1	larger diameters at request	$Ød_g$
		mm	56	60	64	68	72	76	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155		
Shaft gross area	A_g	in²	3.8	4.4	5.0	5.6	6.3	7.0	7.8	8.8	9.9	11.0	12.2	13.4	14.7	16.1	17.5	19.0	20.6	22.2	23.9	25.6	27.4	29.2		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		
Shaft yield capacity	F_y	kips	277	318	362	408	458	510	565	638	715	797	883	973	1,068	1,168	1,271	1,379	1,492	1,609	1,730	1,856	1,986	2,121		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		
Shaft ultimate capacity	F_{ua}	kips	365	420	477	539	604	673	746	842	944	1,052	1,165	1,285	1,410	1,541	1,678	1,821	1,969	2,124	2,284	2,450	2,622	2,800		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		
LFRD design resistance	$F_{t,Rd}$	kips	263	302	344	388	435	484	537	606	679	757	839	925	1,015	1,109	1,208	1,310	1,417	1,528	1,644	1,763	1,887	2,015		$F_{t,Rd}$
		kN	1,170	1,343	1,528	1,725	1,934	2,155	2,388	2,695	3,022	3,367	3,731	4,113	4,514	4,934	5,372	5,829	6,305	6,799	7,312	7,844	8,394	8,963		
ASD design strength	$F_{t,Sd}$	kips	166	190	217	244	274	305	338	382	428	477	529	583	640	699	761	826	893	963	1,036	1,111	1,189	1,270		$F_{t,Rd}$
		kN	737	847	963	1,087	1,219	1,358	1,505	1,699	1,905	2,122	2,351	2,593	2,845	3,110	3,386	3,674	3,974	4,286	4,609	4,944	5,291	5,649		

Note: Above load capacities are based on the calculation methods and typical factors shown on page 6. All assumptions and factors should be checked by the project engineer before use.

ANKER SCHROEDER
ASDO steel tension members

ASDO TIE BAR DESIGN CAPACITIES



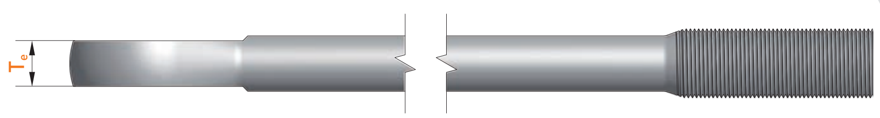
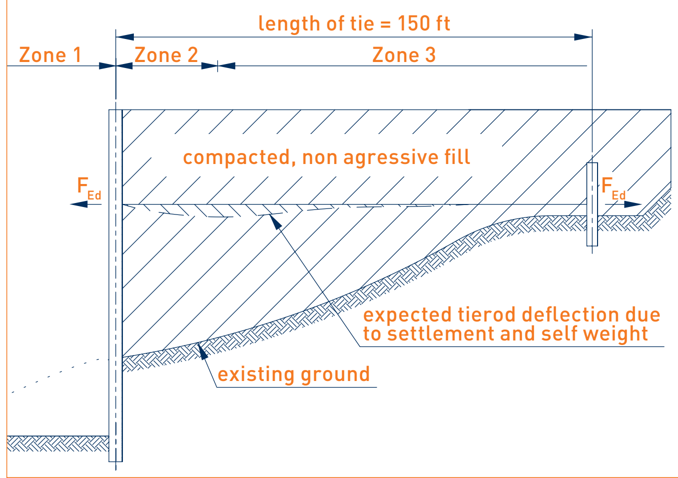


Table 3 – Forged eye (all grades)

Nominal shaft diameter	$Ød_g$	(in) mm	(1.9) 48	(2.0) 52	(2.2) 56	(2.4) 60	(2.5) 64	(2.7) 68	(2.8) 72	(3.0) 76	(3.1) 80	(3.3) 85
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
Eye thickness	T_e	in (mm)	1.7 (42)	1.9 (47)	2.0 (50)	2.0 (50)	2.2 (55)	2.4 (60)	2.4 (60)	2.5 (63)	2.6 (66)	2.8 (72)
Eye length	L_e	in (mm)	6.4 (162)	7.0 (177)	8.0 (204)	8.1 (207)	8.4 (214)	8.9 (227)	8.9 (227)	9.8 (248)	10.3 (262)	11.4 (289)
Eye width	W_e	in (mm)	4.9 (125)	5.3 (135)	6.1 (155)	6.1 (155)	6.5 (165)	7.1 (180)	7.1 (180)	7.5 (190)	8.3 (210)	9.1 (230)
Pin diameter (ASDO500)		in (mm)	2.0 (50)	2.2 (55)	2.4 (60)	2.4 (60)	2.5 (64)	2.8 (72)	2.8 (72)	3.0 (75)	3.1 (80)	3.3 (85)

Nominal shaft diameter	(3.5) 90	(3.7) 95	(3.9) 100	(4.1) 105	(4.3) 110	(4.5) 115	(4.7) 120	(4.9) 125	(5.1) 130	$Ød_g$
Eye ref	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	3.0 (75)	3.1 (80)	3.3 (85)	3.5 (90)	3.7 (95)	3.9 (100)	4.1 (105)	4.5 (115)	4.7 (120)	T_e
Eye length	12.3 (312)	13.1 (332)	13.4 (340)	14.0 (357)	14.5 (370)	15.0 (382)	16.2 (412)	17.3 (440)	18.1 (460)	L_e
Eye width	9.4 (240)	10.0 (255)	10.6 (270)	10.8 (275)	11.4 (290)	11.8 (300)	12.2 (310)	13.0 (330)	13.4 (340)	W_e
Pin diameter (ASDO500)	3.5 (90)	3.7 (95)	3.9 (100)	3.9 (100)	4.3 (110)	4.5 (115)	4.7 (120)	4.7 (120)	5.1 (130)	

Design example (ASD method)



Design criteria:
Design ultimate load for tie bar = 290 kips

Tie bar length = 150 ft (determined by geotechnical analysis)

Tie bar extension limit = 4"

Design life structure = 50 years

Thread notch factor - use recommended value k_t = 0.6

Size selection
Minimum Tie bar size required

From table 2 grade ASDO500, k_t = 0.6 select M100/76 tie bar

Design Capacity = 305 kips › 290 kips ∴ OK

Thread = M100 (3.9" stress area, A_S = 10.84 in²)
Shaft = 3" (76 mm) diameter (stress area Ag = 7 in²)
f_y = 72 k, f_{ua} = 96 ksi

Note: USACE recommend that the capacity of threads are reduced to allow for the effect of bending in the tie bar, Euro codes further recommend 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 – this may require a detailed settlement analysis).

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 kt 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
Elongation under axial working load

Working load = 290 kips

$$\text{Stress in shaft} = \frac{290 \times 10^3}{7} = 41.4 \text{ ksi}$$

$$\text{Elongation} = \frac{41.4 \times 150 \text{ ft}}{29 \times 10^6} = 2.57" < 4" \therefore \text{OK}$$

Where elastic modulus = 29 mpsi

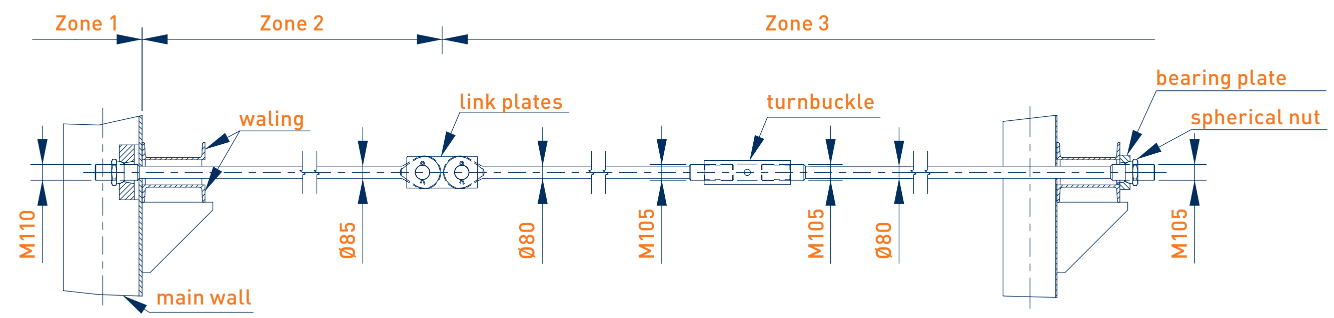
Hint - if the elongation is too great, try a larger diameter of a lesser grade.

We are happy to assist in selecting the correct thread and shaft combination along with suitable connection details – please contact our sales or technical department at sales@asdo.de. The ASDO tie bar system has been used successfully for many of the world's major port constructions, including:

- London Gateway Port (UK)
- Port Autonome Le Havre (France)
- Pecem Port (Brazil)
- Fairview Prince Rupert (Canada)
- Manila Container Port (Philippines)
- Liverpool 2 (UK)
- Accaba Container Port (Jordan)
- Port of Jacksonville (USA)
- Port Jorf Lasfar (Morocco)
- Port de Trois-Rivières (Canada)
- Kingston Port (Jamaica)
- Puerta Caucedo, (Dom. Republic)

Consider 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 EN1993-5 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 tie bar 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	Tie bar connection	Splash zone, aggressive	0.148" (3.75 mm) (from table 4.2 EN1993-5)	4.23" (107.5 mm)	3.28" (83.5 mm)	M110 (4.3")	3.3" (85 mm)
2	Immediately behind wall	Non-aggressive compacted fill, possibility of seawater entering through connection to front wall	0.08" (2 mm) (assumed)	-	3.14" (80 mm)	-	3.3" (85 mm same bar as zone 1)
3	Remainder of tie bar	Non-aggressive compacted fill	0.047" (1.2 mm from table 4.1 EN1993-5, compaction reduction ignored for conservatism)	4.03" (102.4 mm)	3.09" (78.4 mm)	M105 (4.1")	3.15" (80 mm)

Final specification
As a minimum the following information is required in order to specify the tie bars correctly.

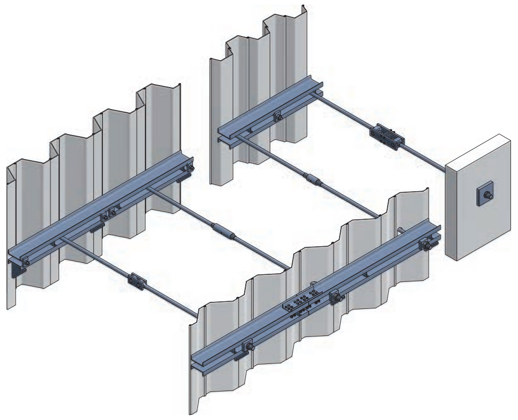
Tie bars:

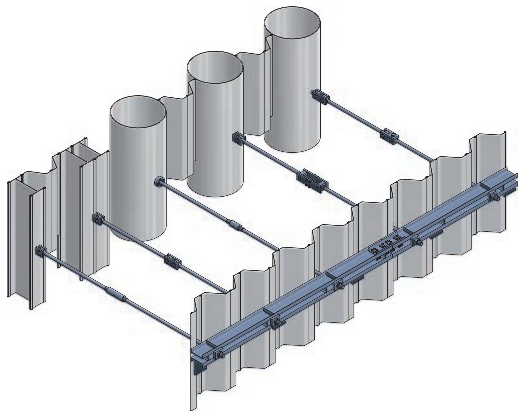
Grade ASDO500 - M110/85, M105/80 with articulated connections, turnbuckles and length as indicated on drawing
Minimum ASD design capacity = 290 kips (after corrosion losses)
k_t = 0.6
Yield strength = 72 ksi (500 N/mm²)
Tensile strength = 96 ksi (660 N/mm²)
Corrosion protection = sacrificial steel to all bars and components as indicated

TYPICAL CONNECTIONS

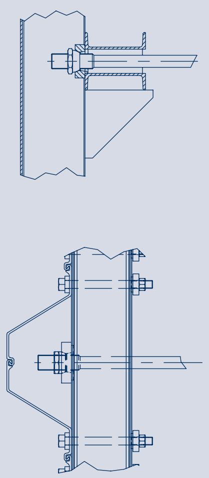
Connections to sheet piles
Forces are transferred from the sheet pile to the tie bar through waling sections that run the length of the wall. At the front wall these are normally placed behind the wall (i.e. earth side) and at the tie bar wall the non-bearing side.

Connections to high modulus piles
Tie bar forces are generally high and articulated connections and recommended to minimize bending at the connection. Articulation can be provided that allows movement in the vertical direction or in all directions.

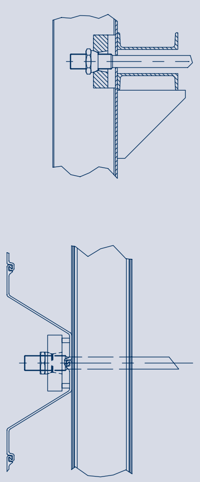




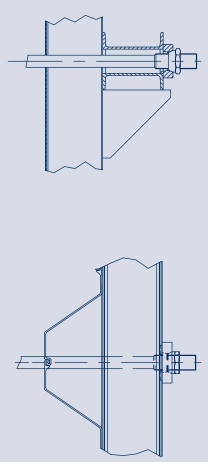
Steel Z-pile with spherical nut (articulated)



Tie bar connection to inside of pile pan
Sheet pile loads are transferred to the waling via waling bolts, then to the tie bar by a spherical bearing plate and nut. The connection is placed inside the pan giving greater corrosion protection.

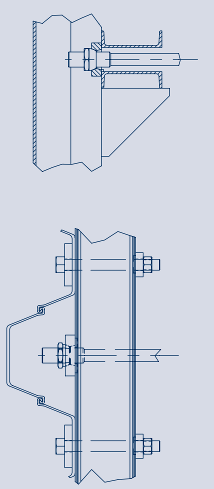


Tie bar connection to outside of pile pan
Sheet pile loads are transferred directly to the tie bar. This has the advantage that less waling bolts are required, but the tie bar connection is placed outside the wall in the aggressive corrosion zone.

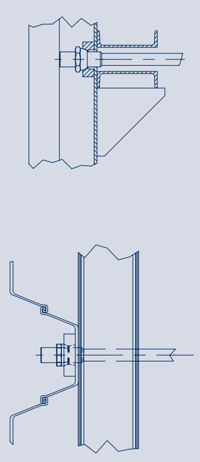


Tie bar wall connection
Tie bar forces are transferred directly to the tie bar wall via the waling. Generally waling bolts are not required.

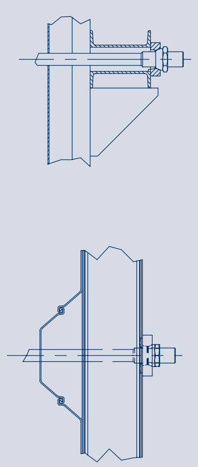
Steel U-pile with spherical nut (articulated)



Tie bar connection to inside of pile pan
Sheet pile loads are transferred to the waling via waling bolts, then to the tie bar by a spherical bearing plate and nut. The connection is placed inside the pan giving greater corrosion protection.

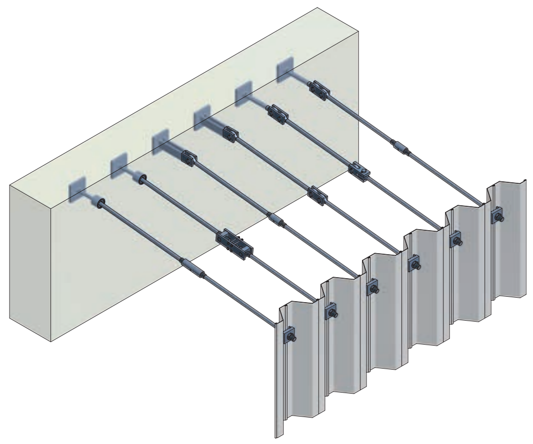


Tie bar connection to outside of pile pan
Sheet pile loads are transferred directly to the tie bar. This has the advantage that less waling bolts are required, but the tie bar connection is placed outside the wall in the aggressive corrosion zone.

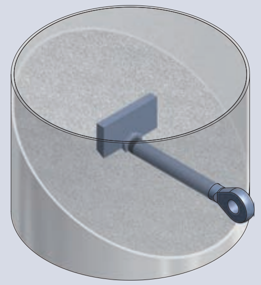


Tie bar wall connection
Tie bar forces are transferred directly to the tie bar wall via the waling. Generally waling bolts are not required.

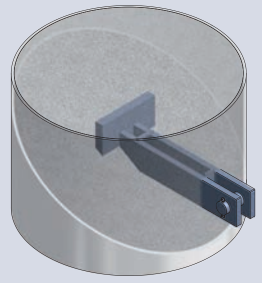
Connections to concrete walls
Alignment between the front wall and tie bar wall connection points is critical. Simple articulated connections allow easy casting into the wall without difficult interruption to formwork and allow easy connection once the wall has cured. Articulated joints are strongly recommended to aid installation.



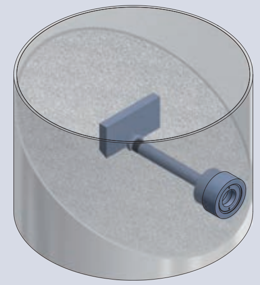
Combi & diaphragm wall connections (articulated)



Combi wall – cast-in forged eye
A forged eye bar is cast into the tube transferring forces to the centre of the tube. The anchor bars are attached to the cast-in bar via link plates allowing articulation in the vertical direction.

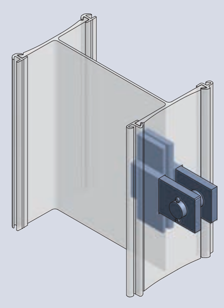


Combi wall cast-in T-Plate
A fabricated T-Plate is cast into the tube transferring forces to the centre of the tube. Forged eye anchor bars are attached to the T-connector via a pin allowing articulation in the vertical direction. See table 7 for more detail.

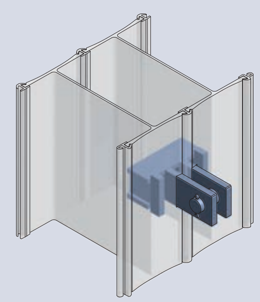


Combi & D-wall cast-in spherical box
A machined ´spherical box is cast into the tube transferring forces to the centre of the tube. Forged spherical anchor bars are connected to the box allowing articulation in both the vertical & horizontal directions.

HZ-M-pile connections (articulated)



HZ-M wall tension plates
Machined and factory welded tension plates are placed either side of the HZ-M web and passed through burnt holes in the flange. Forces are transferred from the transition radius of the HZ-M to the forged eye anchor bar through a pin connection and articulation in the vertical plane is possible. See table 6 for more detail.



Double HZ-M wall tension beam
A factory welded tension beam is placed bearing on HZ-M flanges close to the web and tension plates passed through burnt holes in the flange. Forces are transferred to the anchor bar through a pin connection and articulation in the vertical plane is possible.

ASDO

PRODUCT DATA

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

Nominal thread diameter			(in) mm	(2.5) 64	(2.7) 68	(2.8) 72	(3.0) 76	(3.1) 80	(3.3) 85	(3.5) 90	(3.7) 95	(3.9) 100	(4.1) 105	(4.3) 110	(4.5) 115	(4.7) 120	(4.9) 125	(5.1) 130	(5.3) 135	(5.5) 140	(5.7) 145	(5.9) 150	(6.1) 155	(6.3) 160	
Spherical plate against waling	Width	w_{PW}	in (mm)	6.3 (160)	6.3 (160)	7.1 (180)	7.1 (180)	7.1 (180)	7.9 (200)	7.9 (200)	7.9 (200)	7.9 (200)	8.7 (220)	8.7 (220)	9.1 (230)	9.4 (240)	9.8 (250)	10.2 (260)	10.6 (270)	11.0 (280)	11.4 (290)	11.4 (290)	12.2 (310)	12.2 (310)	w_{PW}
	Breadth	b_{PW}	in (mm)	7.9 (200)	8.3 (210)	9.1 (230)	9.1 (230)	9.4 (240)	9.8 (250)	10.2 (260)	10.6 (270)	10.6 (270)	11.0 (280)	11.8 (300)	11.8 (300)	11.8 (300)	13.0 (330)	13.0 (330)	13.4 (340)	13.8 (350)	14.6 (370)	14.6 (370)	15.4 (390)	15.4 (390)	b_{PW}
	Thickness	t_{PW}	in (mm)	1.2 (30)	1.2 (30)	1.4 (35)	1.6 (40)	1.6 (40)	2.0 (50)	2.2 (55)	2.2 (55)	2.6 (65)	2.8 (70)	2.8 (70)	3.1 (80)	3.1 (80)	3.5 (90)	3.7 (95)	3.9 (100)	3.9 (100)	4.3 (110)	4.7 (120)	4.7 (120)	5.1 (130)	t_{PW}
	Max. dist. between waling[2]	W_{dist}	in (mm)	3.9 (100)	3.9 (100)	4.7 (120)	4.7 (120)	4.7 (120)	5.5 (140)	5.5 (140)	5.5 (140)	5.5 (140)	6.3 (160)	6.3 (160)	6.3 (160)	6.3 (160)	7.1 (180)	7.1 (180)	7.1 (180)	7.1 (180)	7.9 (200)	7.9 (200)	7.9 (200)	7.9 (200)	W_{dist}

Nominal thread diameter			(in) mm	(2.5) 64	(2.7) 68	(2.8) 72	(3.0) 76	(3.1) 80	(3.3) 85	(3.5) 90	(3.7) 95	(3.9) 100	(4.1) 105	(4.3) 110	(4.5) 115	(4.7) 120	(4.9) 125	(5.1) 130	(5.3) 135	(5.5) 140	(5.7) 145	(5.9) 150	(6.1) 155	(6.3) 160	
Standard plate against waling	Width	w_{PU}	in (mm)	6.3 (160)	6.3 (160)	7.1 (180)	7.1 (180)	7.1 (180)	7.9 (200)	7.9 (200)	7.9 (200)	7.9 (200)	8.7 (220)	8.7 (220)	8.7 (220)	8.7 (220)	9.4 (240)	9.4 (240)	9.4 (240)	9.4 (240)	10.2 (260)	10.2 (260)	10.2 (260)	10.2 (260)	w_{PU}
	Breadth	b_{PU}	in (mm)	6.7 (170)	7.1 (180)	7.9 (200)	7.9 (200)	7.9 (200)	8.3 (210)	8.3 (210)	8.7 (220)	8.7 (220)	9.1 (230)	9.4 (240)	9.4 (240)	9.4 (240)	10.2 (260)	10.6 (270)	10.6 (270)	11.0 (280)	11.4 (290)	11.8 (300)	12.2 (310)	12.2 (310)	b_{PU}
	Thickness	t_{PU}	in (mm)	1.2 (30)	1.2 (30)	1.4 (35)	1.6 (40)	1.6 (40)	2.0 (50)	2.2 (55)	2.2 (55)	2.6 (65)	2.8 (70)	2.8 (70)	3.1 (80)	3.1 (80)	3.5 (90)	3.7 (95)	3.9 (100)	3.9 (100)	4.3 (110)	4.7 (120)	4.7 (120)	5.1 (130)	t_{PU}
	Max. dist. between waling[2]	W_{dist}	in (mm)	3.9 (100)	3.9 (100)	4.7 (120)	4.7 (120)	4.7 (120)	5.5 (140)	5.5 (140)	5.5 (140)	5.5 (140)	6.3 (160)	6.3 (160)	6.3 (160)	6.3 (160)	7.1 (180)	7.1 (180)	7.1 (180)	7.1 (180)	7.9 (200)	7.9 (200)	7.9 (200)	7.9 (200)	W_{dist}

Nominal thread diameter			(in) mm	(2.5) 64	(2.7) 68	(2.8) 72	(3.0) 76	(3.1) 80	(3.3) 85	(3.5) 90	(3.7) 95	(3.9) 100	(4.1) 105	(4.3) 110	(4.5) 115	(4.7) 120	(4.9) 125	(5.1) 130	(5.3) 135	(5.5) 140	(5.7) 145	(5.9) 150	(6.1) 155	(6.3) 160	
Spherical plate against concrete	Width	w_{PC}	in (mm)	8.7 (220)	9.4 (240)	9.8 (250)	10.2 (260)	11.4 (290)	11.8 (300)	13.0 (330)	13.4 (340)	13.8 (350)	14.2 (360)	15.4 (390)	16.1 (410)	16.5 (420)	17.7 (450)	18.1 (460)	19.3 (490)	19.7 (500)	20.5 (520)	21.3 (540)	21.7 (550)	22.8 (580)	w_{PC}
	Breadth	b_{PC}	in (mm)	8.7 (220)	9.4 (240)	9.8 (250)	10.2 (260)	11.4 (290)	11.8 (300)	13.0 (330)	13.4 (340)	13.8 (350)	14.2 (360)	15.4 (390)	16.1 (410)	16.5 (420)	17.7 (450)	18.1 (460)	19.3 (490)	19.7 (500)	20.5 (520)	21.3 (540)	21.7 (550)	22.8 (580)	b_{PC}
	Thickness	t_{PC}	in (mm)	1.2 (30)	1.4 (35)	1.4 (35)	1.4 (35)	1.4 (35)	1.6 (40)	1.6 (40)	1.8 (45)	2.0 (50)	2.0 (50)	2.2 (55)	2.2 (55)	2.4 (60)	2.4 (60)	2.6 (65)	2.6 (65)	2.8 (70)	2.8 (70)	3.0 (75)	3.1 (80)	3.1 (80)	t_{PC}

Nominal thread diameter			(in) mm	(2.5) 64	(2.7) 68	(2.8) 72	(3.0) 76	(3.1) 80	(3.3) 85	(3.5) 90	(3.7) 95	(3.9) 100	(4.1) 105	(4.3) 110	(4.5) 115	(4.7) 120	(4.9) 125	(5.1) 130	(5.3) 135	(5.5) 140	(5.7) 145	(5.9) 150	(6.1) 155	(6.3) 160	
Spherical plate against concrete	Width	w_{PC}	in (mm)	8.7 (220)	9.4 (240)	9.8 (250)	10.2 (260)	11.4 (290)	11.8 (300)	13.0 (330)	13.4 (340)	13.8 (350)	14.2 (360)	15.4 (390)	16.1 (410)	16.5 (420)	17.7 (450)	18.1 (460)	19.3 (490)	19.7 (500)	20.5 (520)	21.3 (540)	21.7 (550)	22.8 (580)	w_{PC}
	Breadth	b_{PC}	in (mm)	8.7 (220)	9.4 (240)	9.8 (250)	10.2 (260)	11.4 (290)	11.8 (300)	13.0 (330)	13.4 (340)	13.8 (350)	14.2 (360)	15.4 (390)	16.1 (410)	16.5 (420)	17.7 (450)	18.1 (460)	19.3 (490)	19.7 (500)	20.5 (520)	21.3 (540)	21.7 (550)	22.8 (580)	b_{PC}
	Thickness	t_{PC}	in (mm)	1.2 (30)	1.4 (35)	1.4 (35)	1.4 (35)	1.4 (35)	1.6 (40)	1.6 (40)	1.8 (45)	2.0 (50)	2.0 (50)	2.2 (55)	2.2 (55)	2.4 (60)	2.4 (60)	2.6 (65)	2.6 (65)	2.8 (70)	2.8 (70)	3.0 (75)	3.1 (80)	3.1 (80)	t_{PC}

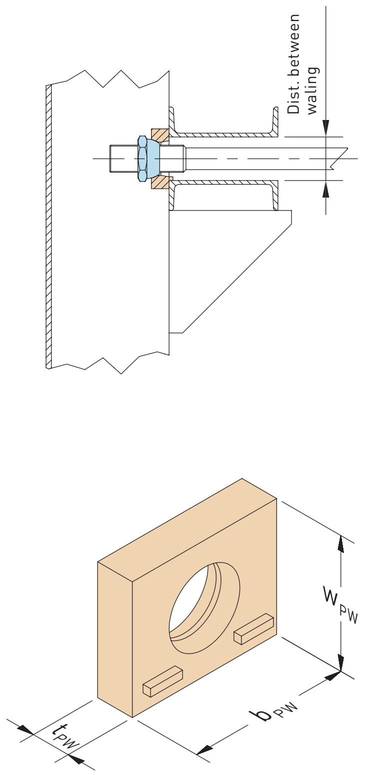
Notes: 1. All plates grade 50 ksi and based on the maximum thread capacity for ASDO500, $k_t = 0.6$. For other grades or where $k_t = 0.9$ different plates are required.*
2. A waling gap greater than this distance will reduce the capacity of the plate.*
3. Concrete grade assumed at C35/45, plate dimensions will change for different grades of concrete.*

***Please contact our technical department for further information.**

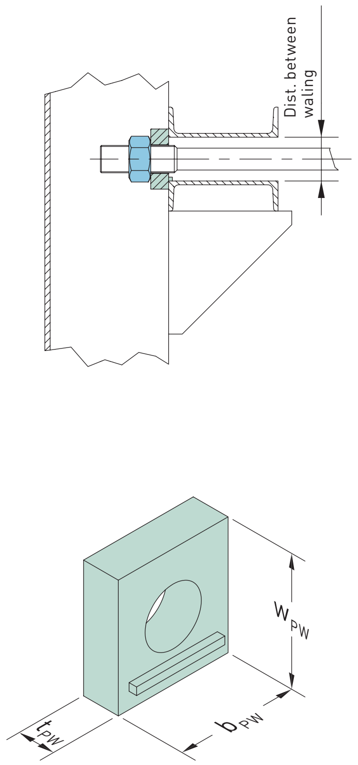
Table 5 – Hexagon and spherical nuts (ASDO500, $k_t = 0.6$)

Nominal thread diameter		(in) mm	(2.5) 64	(2.7) 68	(2.8) 72	(3.0) 76	(3.1) 80	(3.3) 85	(3.5) 90	(3.7) 95	(3.9) 100	(4.1) 105	(4.3) 110	(4.5) 115	(4.7) 120	(4.9) 125	(5.1) 130	(5.3) 135	(5.5) 140	(5.7) 145	(5.9) 150	(6.1) 155	(6.3) 160	
Hexagon Flat Nuts	Across corners	in (mm)	4.2 (106)	4.4 (111)	4.6 (117)	4.8 (123)	5.0 (128)	5.3 (134)	5.7 (145)	5.9 (151)	6.4 (162)	6.8 (173)	7.0 (179)	7.5 (191)	7.7 (196)	8.2 (208)	8.4 (214)	8.6 (219)	9.1 (231)	9.5 (242)	9.5 (242)	10.0 (254)	10.5 (266)	w_{PU}
	Across flats	in (mm)	3.7 (95)	3.9 (100)	4.1 (105)	4.3 (110)	4.5 (115)	4.7 (120)	5.1 (130)	5.3 (135)	5.7 (145)	5.9 (150)	6.1 (155)	6.5 (165)	6.7 (170)	7.1 (180)	7.3 (185)	7.5 (190)	7.9 (200)	8.3 (210)	8.3 (210)	8.7 (220)	9.1 (230)	b_{PU}
Spherical Nuts	Across corners	in (mm)	4.2 (106)	4.4 (111)	4.6 (117)	4.8 (123)	5.0 (128)	5.3 (134)	5.7 (145)	5.9 (151)	6.4 (162)	7.7 (196)	8.2 (208)	8.6 (219)	8.9 (225)	9.3 (237)	9.5 (242)	10.0 (254)	10.5 (266)	10.7 (271)	11.1 (283)	11.6 (294)	11.8 (300)	t_{PU}
	Across flats	in (mm)	3.7 (95)	3.9 (100)	4.1 (105)	4.3 (110)	4.5 (115)	4.7 (120)	5.1 (130)	5.3 (135)	5.7 (145)	6.7 (170)	7.1 (180)	7.5 (190)	7.7 (195)	8.1 (205)	8.3 (210)	8.7 (220)	9.1 (230)	9.3 (235)	9.6 (245)	10.0 (255)	10.2 (260)	W_{dist}
	Depth	in (mm)	2.0 (51)	2.1 (54)	2.3 (58)	2.4 (61)	2.5 (64)	2.7 (68)	2.8 (72)	3.0 (76)	3.1 (80)	4.3 (110)	4.3 (110)	4.7 (120)	4.7 (120)	5.1 (130)	5.1 (130)	5.5 (140)	5.5 (140)	5.9 (150)	5.9 (150)	6.3 (160)	6.3 (160)	

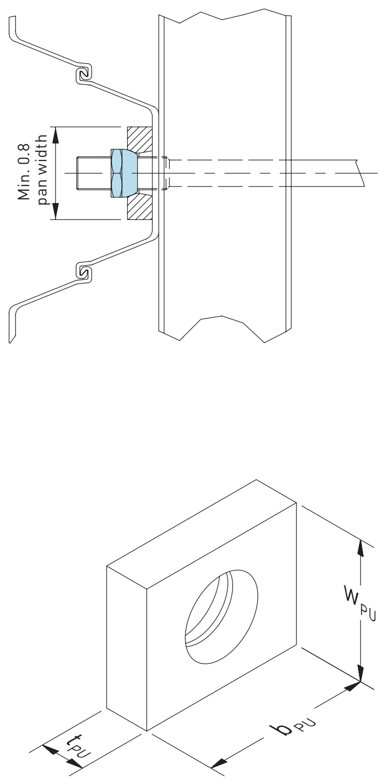
Standard bearing plates



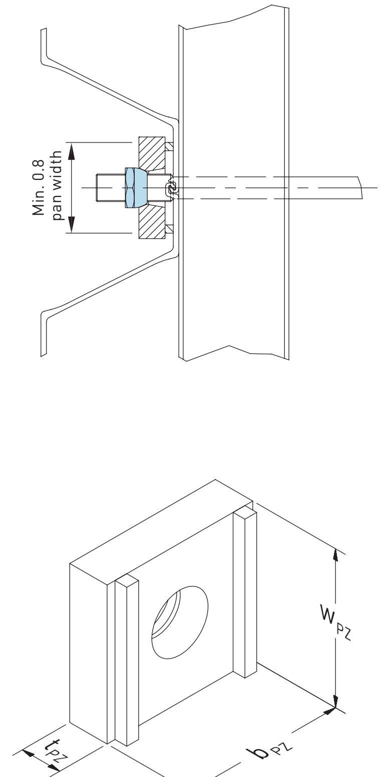
Spherical plate against waling



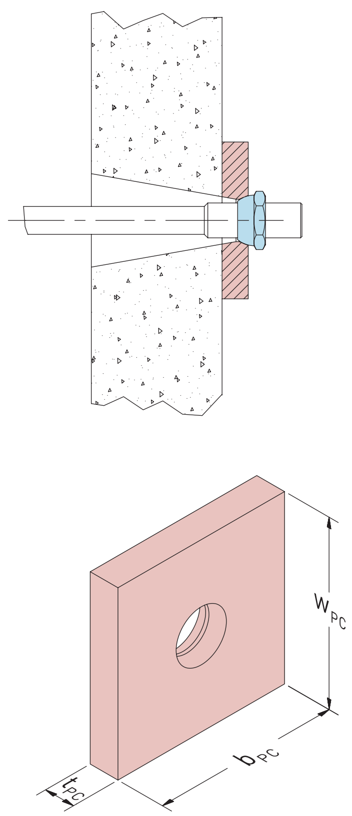
Standard plate against waling



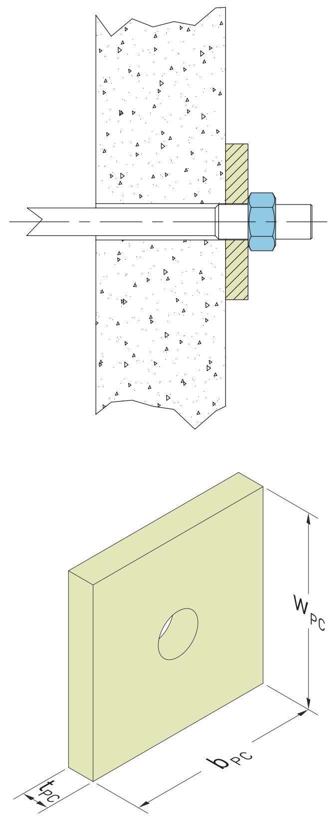
Spherical / standard plate against U-pile (contact Anker Schroeder for dimensions)



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

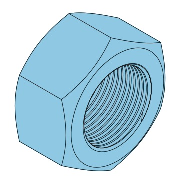


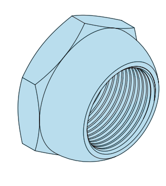
Spherical plate against concrete



Standard plate against concrete

Hexagon and spherical nuts


Hexagon


Spherical

ANKER SCHROEDER
ASDO steel tension members

CONNECTIONS

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

Nominal Shaft diameter		(in) mm	(1.9) 48	(2.0) 52	(2.2) 56	(2.4) 60	(2.5) 64	(2.7) 68	(2.8) 72	(3.0) 76	(3.1) 80	(3.3) 85	(3.5) 90	(3.7) 95	(3.9) 100	(4.1) 105	(4.3) 110	(4.5) 115	(4.7) 120	(4.9) 125	(5.1) 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}	in (mm)	5.1 (130)	5.7 (145)	6.3 (160)	6.7 (170)	6.7 (170)	7.5 (190)	7.5 (190)	7.7 (195)	8.9 (225)	9.6 (245)	10.6 (270)	11.2 (285)	11.4 (290)	11.8 (300)	12.6 (320)	13.0 (330)	13.6 (345)	14.4 (365)	14.6 (370)	b_{TP}
Tension plates thickness	t_{TP}	in (mm)	1.2 (30)	1.2 (30)	1.2 (30)	1.2 (30)	1.4 (35)	1.6 (40)	1.6 (40)	1.6 (40)	1.6 (40)	1.6 (40)	1.6 (40)	1.8 (45)	2.0 (50)	2.0 (50)	2.2 (55)	2.4 (60)	2.4 (60)	2.4 (60)	2.6 (65)	t_{TP}
Bearing plates breadth	b_{PP}	in (mm)	4.3 (110)	4.5 (115)	5.1 (130)	5.5 (140)	5.5 (140)	6.1 (155)	6.7 (170)	7.5 (190)	7.5 (190)	8.1 (205)	9.4 (240)	9.8 (250)	10.4 (265)	10.4 (265)	11.4 (290)	12.2 (310)	13.0 (330)	13.8 (350)	14.6 (370)	b_{PP}
Bearing plates thickness	l_{PP}*	in (mm)	0.6 (15)	0.8 (20)	1.0 (25)	1.0 (25)	1.0 (25)	1.0 (25)	1.0 (25)	1.2 (30)	1.2 (30)	1.2 (30)	1.4 (35)	1.4 (35)	1.4 (35)	1.4 (35)	1.6 (40)	1.6 (40)	1.6 (40)	1.6 (40)	1.6 (40)	l_{PP}*
Bearing plates length		in (mm)	15.7 (400)	15.7 (400)	15.7 (400)	17.3 (440)	18.5 (470)	20.9 (530)	22.4 (570)	21.7 (550)	24.0 (610)	26.4 (670)	27.6 (700)	29.9 (760)	31.9 (810)	33.9 (860)	34.6 (880)	37.0 (940)	39.0 (990)	41.7 (1,060)	43.7 (1,110)	
Pin diameter		in (mm)	2.0 (50)	2.2 (55)	2.4 (60)	2.4 (60)	2.5 (64)	2.8 (72)	2.8 (72)	3.0 (75)	3.1 (80)	3.3 (85)	3.5 (90)	3.7 (95)	3.9 (100)	3.9 (100)	4.3 (110)	4.5 (115)	4.7 (120)	4.9 (125)	5.1 (130)	

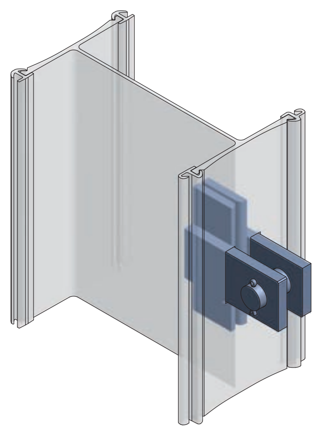
*l_{PP} based on a HZM profile quality S240GP with f_y 219 N/mm²

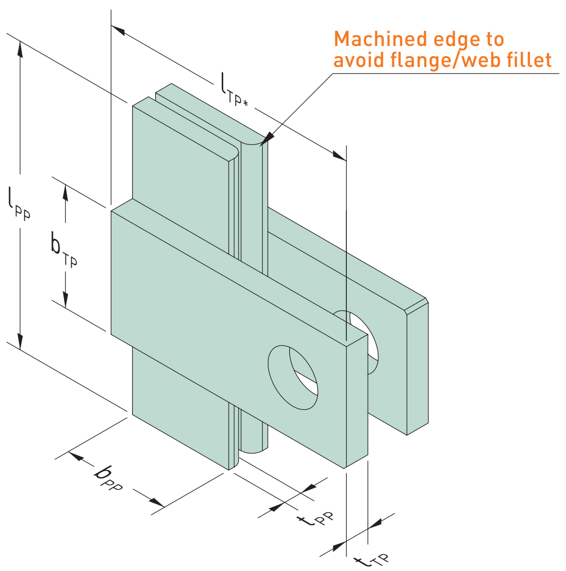
Table 7 – T-Tie bars for combi-walls (ASDO500, $k_t = 0.6$)

Nominal Shaft diameter		(in) mm	(1.9) 48	(2.0) 52	(2.2) 56	(2.4) 60	(2.5) 64	(2.7) 68	(2.8) 72	(3.0) 76	(3.1) 80	(3.3) 85	(3.5) 90	(3.7) 95	(3.9) 100	(4.1) 105	(4.3) 110	(4.5) 115	(4.7) 120	(4.9) 125	(5.1) 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 Plate Width	b_1	in (mm)	5.1 (130)	5.7 (145)	6.3 (160)	6.7 (170)	6.7 (170)	7.5 (190)	7.5 (190)	7.7 (195)	8.9 (225)	9.6 (245)	10.6 (270)	11.2 (285)	11.4 (290)	11.8 (300)	12.6 (320)	13.0 (330)	13.6 (345)	14.4 (365)	14.6 (370)	b_1
Tension Plate thickness	t_1	in (mm)	1.2 (30)	1.2 (30)	1.2 (30)	1.2 (30)	1.4 (35)	1.6 (40)	1.6 (40)	1.6 (40)	1.6 (40)	1.6 (40)	1.6 (40)	1.8 (45)	2.0 (50)	2.0 (50)	2.2 (55)	2.4 (60)	2.4 (60)	2.4 (60)	2.6 (65)	t_1
Bearing plate height & width*	l_2 x b_2	in (mm)	9.1 (230)	9.8 (250)	10.6 (270)	11.4 (290)	12.2 (310)	13.0 (330)	13.4 (340)	14.2 (360)	15.0 (380)	15.7 (400)	16.9 (430)	18.1 (460)	18.9 (480)	19.3 (490)	20.9 (530)	21.7 (550)	22.4 (570)	23.2 (590)	24.0 (610)	l_2 x b_2
bearing plate thickness	t_2	in (mm)	1.4 (35)	1.6 (40)	1.8 (45)	1.8 (45)	2.0 (50)	2.0 (50)	2.2 (55)	2.2 (55)	2.4 (60)	2.6 (65)	2.8 (70)	2.8 (70)	3.0 (75)	3.0 (75)	3.1 (80)	3.5 (90)	3.5 (90)	3.7 (95)	3.7 (95)	t_2
Pin diameter		in (mm)	2.0 (50)	2.2 (55)	2.4 (60)	2.4 (60)	2.5 (64)	2.8 (72)	2.8 (72)	3.0 (75)	3.1 (80)	3.3 (85)	3.5 (90)	3.7 (95)	3.9 (100)	3.9 (100)	4.3 (110)	4.5 (115)	4.7 (120)	4.7 (120)	5.1 (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 50 ksi and based on maximum thread capacity for ASDO500, k_t = 0.6. For other grades and k_t = 0.9 contact our technical team.

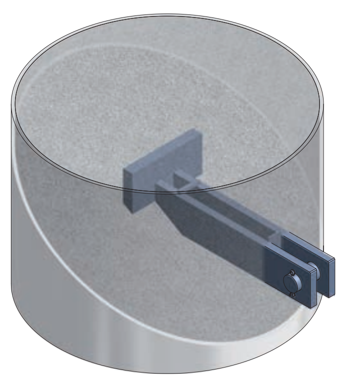
T-Plates for HZ-piles

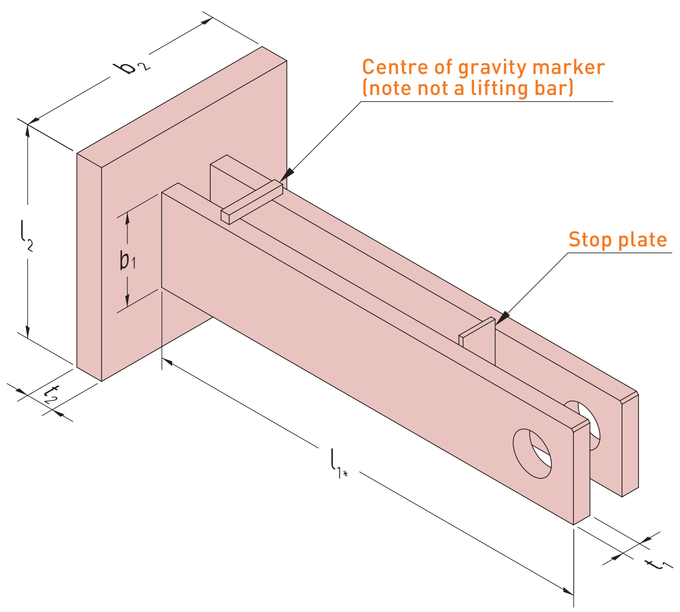




*l_{TP} depending on H-pile and nominal size

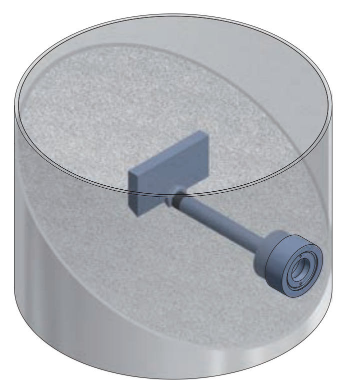
T-Tie bars for combi-walls

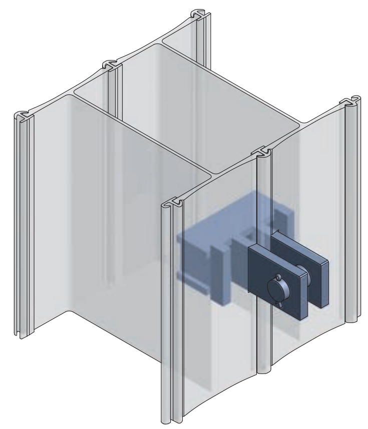




*l_1 depending on tube diameter and nominal size

Other connectors





CONNECTIONS

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

Nominal thread diameter		(in) mm	(2.5) 64	(2.7) 68	(2.8) 72	(3.0) 76	(3.1) 80	(3.3) 85	(3.5) 90	(3.7) 95	(3.9) 100	(4.1) 105	(4.3) 110	(4.5) 115	(4.7) 120	(4.9) 125	(5.1) 130	(5.3) 135	(5.5) 140	(5.7) 145	(5.9) 150	(6.1) 155	(6.3) 160	(6.5) 165	
Diameter	$ØD_t$ & $ØD_{cp}$	in (mm)	3.7 (95)	4.0 (102)	4.0 (102)	4.3 (108)	4.5 (114)	4.8 (121)	5.0 (127)	5.2 (133)	5.7 (146)	6.0 (152)	6.3 (159)	6.5 (165)	6.7 (171)	7.0 (178)	7.5 (191)	7.5 (191)	8.0 (203)	8.0 (203)	8.5 (216)	8.5 (216)	9.0 (229)	9.5 (241)	$ØD_t$ & $ØD_{cp}$
Standard turnbuckle length	L_t	in (mm)	11.0 (280)	11.4 (290)	11.6 (295)	12.0 (305)	12.2 (310)	12.6 (320)	13.0 (330)	13.4 (340)	13.8 (350)	14.2 (360)	14.6 (370)	15.0 (380)	15.7 (400)	16.1 (410)	16.5 (420)	16.9 (430)	17.3 (440)	17.7 (450)	18.1 (460)	18.7 (475)	19.1 (485)	19.5 (495)	L_t
Standard turnbuckle adjustment	+/-	in (mm)	2.0 (50)	2.0 (50)	2.0 (50)	2.0 (50)	2.0 (50)	2.0 (50)	2.0 (50)	2.0 (50)	2.0 (50)	2.0 (50)	2.0 (50)	2.0 (50)	2.0 (50)	2.0 (50)	2.0 (50)	2.0 (50)	2.0 (50)	2.0 (50)	2.0 (50)	2.0 (50)	2.0 (50)	2.0 (50)	+/-
Long turnbuckle length	L_t	in (mm)	18.9 (480)	19.3 (490)	19.5 (495)	19.9 (505)	20.1 (510)	20.5 (520)	20.9 (530)	21.3 (540)	21.7 (550)	22.0 (560)	22.4 (570)	22.8 (580)	23.6 (600)	24.0 (610)	24.4 (620)	24.8 (630)	25.2 (640)	25.6 (650)	26.0 (660)	26.6 (675)	27.0 (685)	27.4 (695)	L_t
Long turnbuckle adjustment	+/-	in (mm)	5.9 (150)	5.9 (150)	5.9 (150)	5.9 (150)	5.9 (150)	5.9 (150)	5.9 (150)	5.9 (150)	5.9 (150)	5.9 (150)	5.9 (150)	5.9 (150)	5.9 (150)	5.9 (150)	5.9 (150)	5.9 (150)	5.9 (150)	5.9 (150)	5.9 (150)	5.9 (150)	5.9 (150)	5.9 (150)	+/-
Coupler length	L_{cp}	in (mm)	5.1 (130)	5.5 (140)	5.7 (145)	6.1 (155)	8.9 (225)	9.3 (235)	9.6 (245)	10.0 (255)	10.8 (275)	11.2 (285)	11.6 (295)	12.0 (305)	12.6 (320)	13.0 (330)	13.4 (340)	13.8 (350)	14.2 (360)	14.6 (370)	15.0 (380)	15.6 (395)	15.9 (405)	16.3 (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		(in) mm	(2.5) 64	(2.7) 68	(2.8) 72	(3.0) 76	(3.1) 80	(3.3) 85	(3.5) 90	(3.7) 95	(3.9) 100	(4.1) 105	(4.3) 110	(4.5) 115	(4.7) 120	(4.9) 125	(5.1) 130	(5.3) 135	(5.5) 140	(5.7) 145	(5.9) 150	(6.1) 155	(6.3) 160	(6.5) 165	
Length	L_{AT}	in (mm)	19.7 (500)	20.1 (510)	21.3 (540)	25.6 (650)	26.4 (670)	26.8 (680)	27.2 (690)	28.3 (720)	29.9 (760)	31.1 (790)	31.9 (810)	33.5 (850)	34.3 (870)	35.8 (910)	35.4 (900)	37.0 (940)	37.0 (940)	38.2 (970)	38.2 (970)	39.8 (1,010)	40.6 (1,030)	41.3 (1,050)	L_{AT}
Adjustment	+/-	in (mm)	3.9 (100)	3.9 (100)	3.9 (100)	3.9 (100)	3.9 (100)	3.9 (100)	3.9 (100)	3.9 (100)	3.9 (100)	3.9 (100)	3.9 (100)	3.9 (100)	3.9 (100)	3.9 (100)	3.9 (100)	3.9 (100)	3.9 (100)	3.9 (100)	3.9 (100)	3.9 (100)	3.9 (100)	3.9 (100)	+/-
Width	W_{AT}	in (mm)	6.9 (175)	7.1 (180)	7.3 (185)	7.5 (190)	7.7 (195)	8.5 (215)	9.3 (235)	9.4 (240)	10.0 (255)	10.2 (260)	10.4 (265)	10.8 (275)	11.0 (280)	12.0 (305)	12.6 (320)	12.8 (325)	13.8 (350)	14.2 (360)	14.6 (370)	15.0 (380)	15.0 (380)	16.3 (415)	W_{AT}
Height	H_{AT}	in (mm)	5.5 (140)	6.1 (155)	6.5 (165)	6.9 (175)	7.5 (190)	7.7 (195)	7.9 (200)	8.5 (215)	9.4 (240)	10.2 (260)	10.6 (270)	11.6 (295)	12.0 (305)	12.8 (325)	12.6 (320)	13.6 (345)	13.4 (340)	14.4 (365)	14.4 (365)	15.4 (390)	15.7 (400)	16.1 (410)	H_{AT}

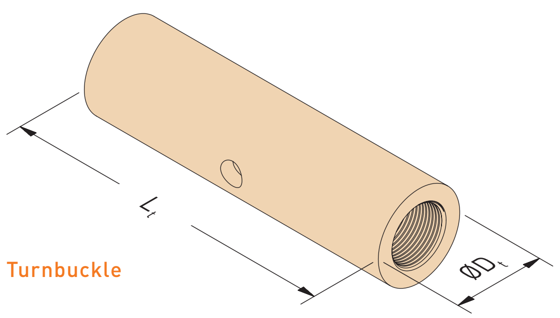
Table 10 – Link plates (ASDO500, k_t = 0.6)

Nominal shaft diameter	$Ød_g$	(in) mm	(1.9) 48	(2.0) 52	(2.2) 56	(2.4) 60	(2.5) 64	(2.7) 68	(2.8) 72	(3.0) 76	(3.1) 80	(3.3) 85	(3.5) 90	(3.7) 95	(3.9) 100	(4.1) 105	(4.3) 110	(4.5) 115	(4.7) 120	(4.9) 125	(5.1) 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	
Thickness	W_{LP}	in (mm)	1.2 (30)	1.2 (30)	1.2 (30)	1.2 (30)	1.4 (35)	1.6 (40)	1.6 (40)	1.6 (40)	1.6 (40)	1.6 (40)	1.6 (40)	1.8 (45)	2.0 (50)	2.0 (50)	2.2 (55)	2.4 (60)	2.4 (60)	2.4 (60)	2.6 (65)	W_{LP}
Length	L_{LP}	in (mm)	11.8 (300)	13.2 (335)	15.4 (390)	15.4 (390)	15.9 (405)	17.3 (440)	17.3 (440)	18.7 (475)	20.1 (510)	22.4 (570)	24.6 (625)	26.0 (660)	26.6 (675)	27.8 (705)	28.7 (730)	29.5 (750)	31.3 (795)	33.1 (840)	33.9 (860)	L_{LP}
Height	h_{LP}	in (mm)	5.1 (130)	5.7 (145)	6.3 (160)	6.7 (170)	6.7 (170)	7.5 (190)	7.5 (190)	7.7 (195)	8.9 (225)	9.6 (245)	10.6 (270)	11.2 (285)	11.4 (290)	11.8 (300)	12.6 (320)	13.0 (330)	13.6 (345)	14.4 (365)	14.6 (370)	h_{LP}
Pin diameter		in (mm)	2.0 (50)	2.2 (55)	2.4 (60)	2.4 (60)	2.5 (64)	2.8 (72)	2.8 (72)	3.0 (75)	3.1 (80)	3.3 (85)	3.5 (90)	3.7 (95)	3.9 (100)	3.9 (100)	4.3 (110)	4.5 (115)	4.7 (120)	4.7 (120)	5.1 (130)	

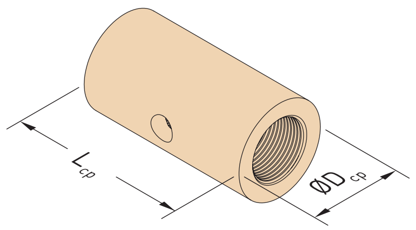
Table 11 – Cardan joint (ASDO500, k_t = 0.6)

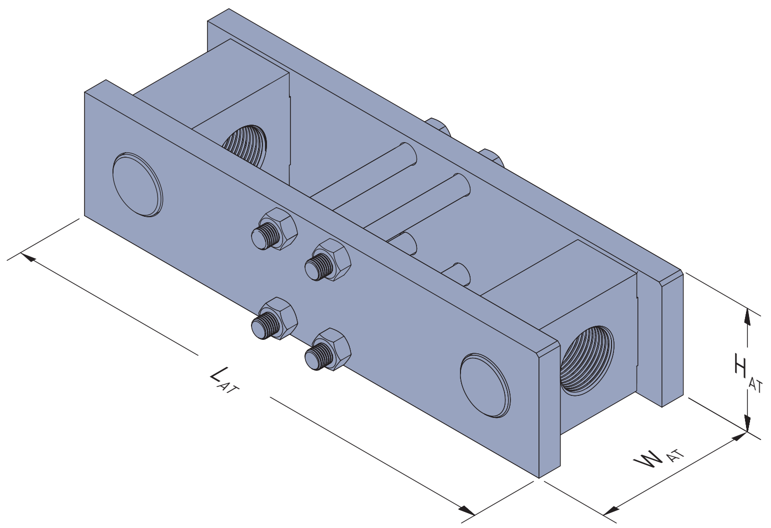
Nominal shaft diameter	$Ød_g$	(in) mm	(1.9) 48	(2.0) 52	(2.2) 56	(2.4) 60	(2.5) 64	(2.7) 68	(2.8) 72	(3.0) 76	(3.1) 80	(3.3) 85	(3.5) 90	(3.7) 95	(3.9) 100	(4.1) 105	(4.3) 110	(4.5) 115	(4.7) 120	(4.9) 125	(5.1) 130	
Eye ref		inches	2 1/2	2 3/4	3	3	3 1/4	3 1/2	3 1/2	3 3/4	4	4 1/4	4 1/2	4 3/4	5	5 1/4	5 1/2	5 3/4	6	6 1/4	6 1/2	
Length	L_{CJ}	in (mm)	13.0 (330)	14.2 (360)	16.1 (410)	16.1 (410)	17.3 (440)	18.9 (480)	18.9 (480)	19.7 (500)	21.3 (540)	22.4 (570)	24.0 (610)	26.0 (660)	26.8 (680)	27.6 (700)	29.5 (750)	30.7 (780)	31.9 (810)	34.3 (870)	35.8 (910)	L_{CJ}
Width	W_{CJ}	in (mm)	4.7 (120)	5.1 (130)	5.5 (140)	5.5 (140)	5.9 (150)	6.7 (170)	6.7 (170)	7.1 (180)	7.5 (190)	7.9 (200)	8.3 (210)	8.7 (220)	9.4 (240)	9.8 (250)	10.2 (260)	10.6 (270)	11.0 (280)	11.4 (290)	11.8 (300)	W_{CJ}
Height	h_{CJ}	in (mm)	4.7 (120)	5.1 (130)	5.5 (140)	5.5 (140)	5.9 (150)	6.7 (170)	6.7 (170)	7.1 (180)	7.5 (190)	7.9 (200)	8.3 (210)	8.7 (220)	9.4 (240)	9.8 (250)	10.2 (260)	10.6 (270)	11.0 (280)	11.4 (290)	11.8 (300)	h_{CJ}
Pin diameter		in (mm)	2.0 (50)	2.2 (55)	2.4 (60)	2.4 (60)	2.5 (64)	2.8 (72)	2.8 (72)	3.0 (75)	3.1 (80)	3.3 (85)	3.5 (90)	3.7 (95)	3.9 (100)	3.9 (100)	4.3 (110)	4.5 (115)	4.7 (120)	4.7 (120)	5.1 (130)	

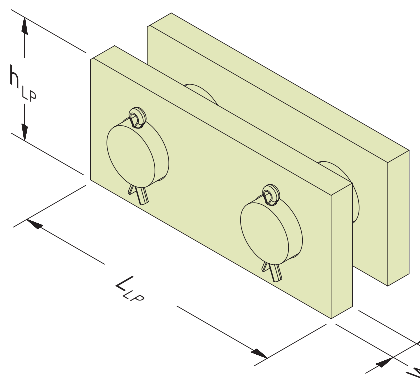
All plates grade 50 ksi and based on maximum thread capacity for ASDO500, k_t = 0.6. For other grades and k_t = 0.9 contact our technical team.

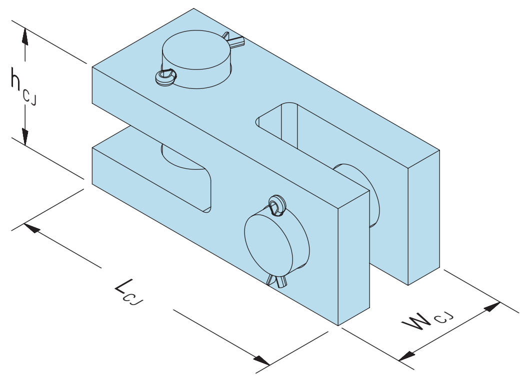


Turnbuckle









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.

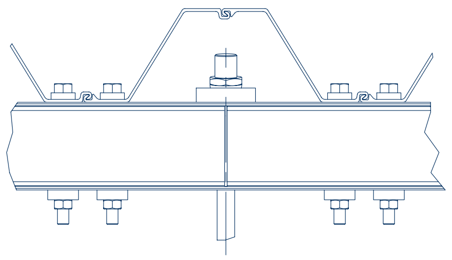
Link plates
Together with forged eyes link plates provide the most economic articulated joint and the simplest connection to achieve in site conditions.

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

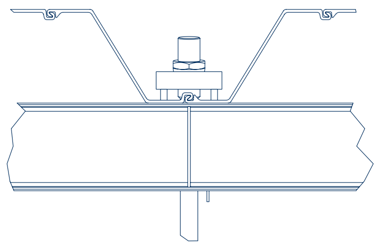
WALINGS

DESIGN CONSIDERATIONS

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.

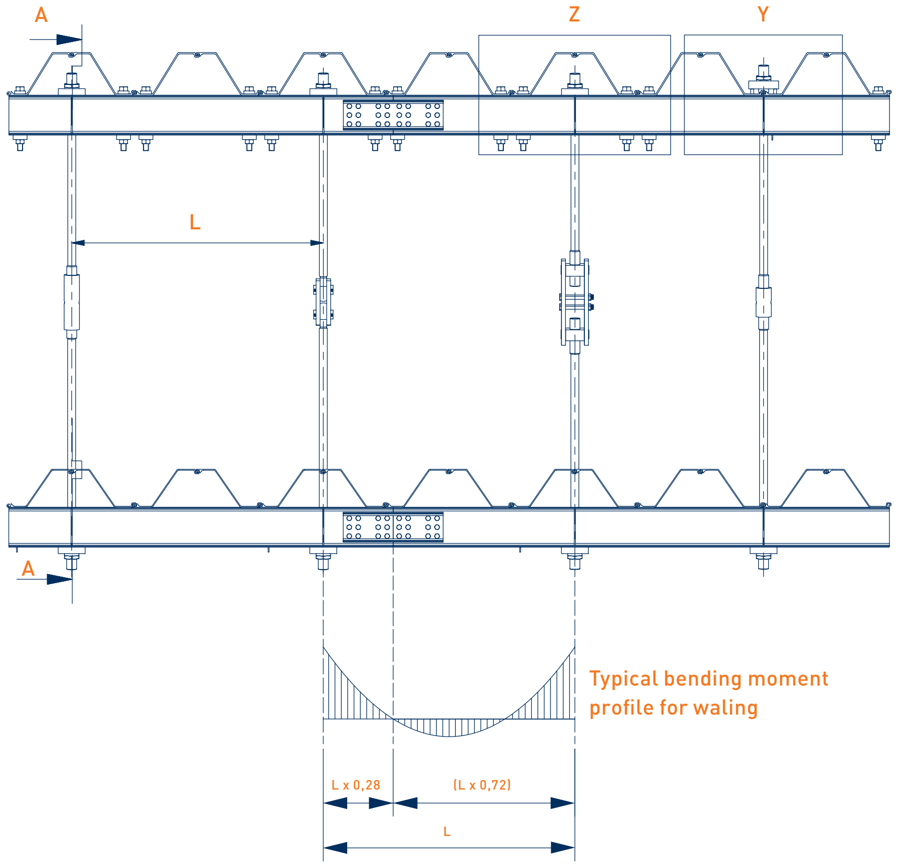


Detail Z
Tie bar connection inside sheet pile pan for additional corrosion protection

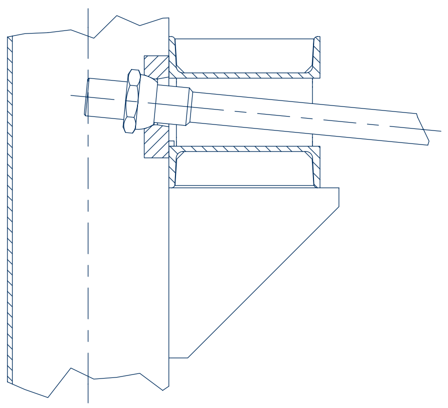


Detail Y
Tie bar connection outside sheet pile

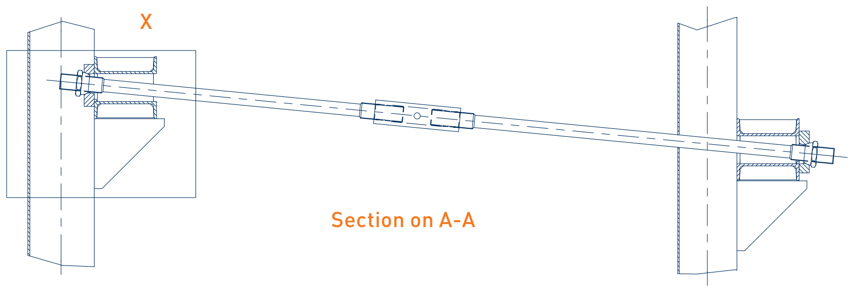
Note: The combination of tie bar head connections to the outside and inside of the sheet pan is shown for example only and would not normally be used in practice.



Typical bending moment profile for waling



Detail X



Section on A-A

Tie bar 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 tie 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.

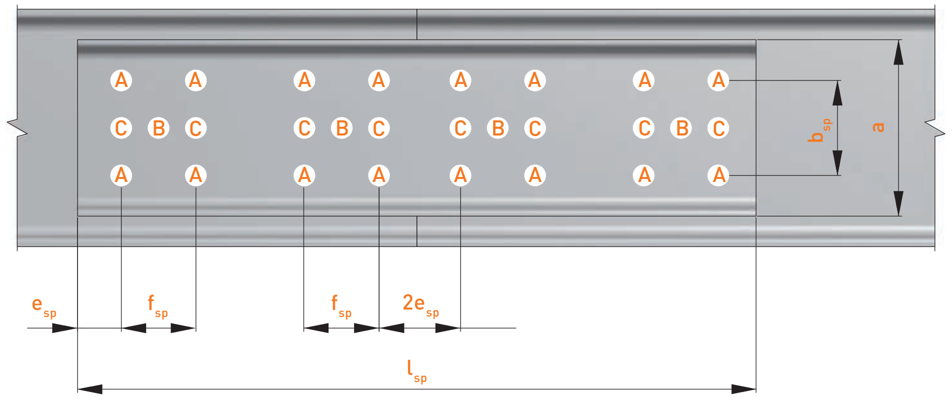
For design purposes the waling can be considered as continuous with allowance being made for end spans. Although the waling is then statically indeterminate, it is usual to adopt a simplified approach where the bending moment is assumed to be $wL^2/10$, being the calculated load to be supplied by the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

When checking the anchorage system for the loss of a single tie bar, 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 tie bars 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 tie bars.

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 and high shear loads should be made.

WALINGS AND SPLICE CONNECTIONS



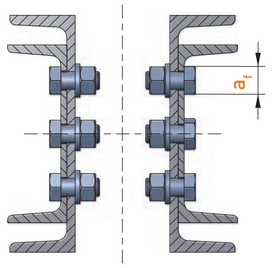
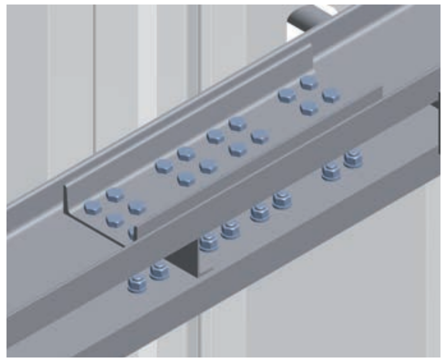


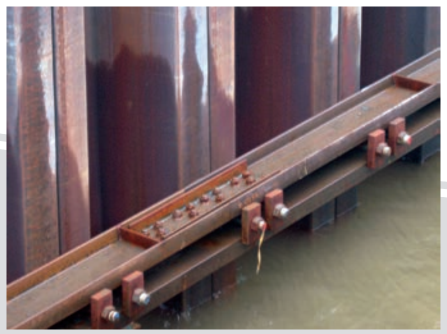
Table 12 – Waling splice connections

Walings		Splice connections							
Section (European)	Section Modulus in³ (cm³)	Section	l_{sp} in (mm)	hole pattern	b_{sp} in (mm)	e_{sp} in (mm)	f_{sp} in (mm)	Bolts (DIN 7990)	Hex across flat in (mm)
UPN180	18.3 (300)	UPN140	22.0 (560)	A	2.4 (60)	1.6 (40)	2.4 (60)	32 x M20 x 45 mm lg	1.2 (30)
UPN200	23.3 (382)	UPN140	25.2 (640)	A	2.4 (60)	1.6 (40)	2.4 (60)	32 x M20 x 45 mm lg	1.2 (30)
UPN220	29.9 (490)	UPN160	26.8 (680)	A	3.1 (80)	1.6 (40)	2.4 (60)	32 x M20 x 45 mm lg	1.2 (30)
UPN240	36.6 (600)	UPN180	29.1 (740)	A	3.5 (90)	2.0 (50)	3.0 (75)	32 x M24 x 50 mm lg	1.4 (36)
UPN260	45.3 (742)	UPN200	31.5 (800)	A	4.3 (110)	2.0 (50)	3.0 (75)	32 x M24 x 50 mm lg	1.4 (36)
UPN280	54.7 (896)	UPN220	33.1 (840)	AB	4.7 (120)	2.0 (50)	3.5 (90)	40 x M24 x 55 mm lg	1.4 (36)
UPN300	65.3 (1,070)	UPN220	36.2 (920)	AB	4.7 (120)	2.0 (50)	3.5 (90)	40 x M24 x 55 mm lg	1.4 (36)
UPN320	82.9 (1,358)	UPN240	39.4 (1,000)	AB	5.1 (130)	2.4 (60)	4.3 (110)	40 x M30 x 65 mm lg	1.8 (46)
UPN350	89.6 (1,468)	UPN260	39.4 (1,000)	AB	5.5 (140)	2.4 (60)	4.3 (110)	40 x M30 x 65 mm lg	1.8 (46)
UPN380	101.2 (1,658)	UPN300	39.4 (1,000)	AC	7.1 (180)	2.4 (60)	3.5 (90)	48 x M30 x 65 mm lg	1.8 (46)
UPN400	124.5 (2,040)	UPN300	39.4 (1,000)	AC	7.1 (180)	2.4 (60)	3.5 (90)	48 x M30 x 65 mm lg	1.8 (46)

The above sizes are the most common used – other sections can be provided on request.



Waling splice detail



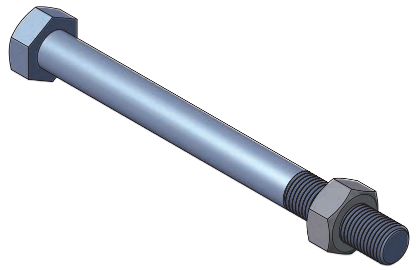
Port, Reykjavik

For longer lengths, walings can be joined by splice sections. These should be located at a distance of 0.28 of the tie bar spacing from an tie bar location as this will be close to the position of minimum bending moment in the waling. 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 tie bar 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 tie bar walls are used, similar walings to those at the retaining wall are required. These are always placed behind the tie bar 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

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.



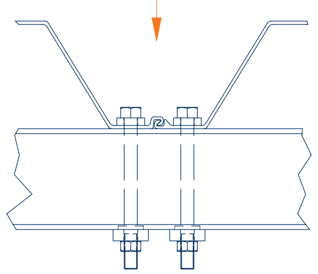
Waling bolt with forged head and hexagon nut.

Table 13 – Waling Bolts

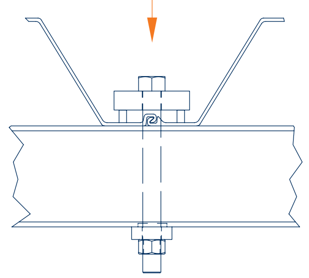
Thread	Thread pitch P	Stress area A_{sp}	Width Across Flats*	Grade ASDO	Load Capacity (based on calculation page 6)	
Metric (in)	mm	in² (mm²)	in (mm)		kips (kN)	kips (kN)
36 (1.4)	4.0	1.3 (817)	2.2 (55)	355	45.0 (200)	28.1 (125)
				500	58.2 (259)	36.4 (162)
42 (1.7)	4.5	1.7 (1,121)	2.6 (65)	355	61.6 (274)	38.6 (171)
				500	79.8 (355)	49.9 (222)
45 (1.8)	4.5	2.0 (1,306)	2.8 (70)	355	71.9 (320)	44.9 (200)
				500	93.1 (414)	58.1 (259)
48 (1.9)	5.0	2.3 (1,473)	3.0 (75)	355	81.2 (361)	50.7 (225)
				500	105.0 (467)	65.6 (292)
52 (2.0)	5.0	2.7 (1,758)	3.1 (80)	355	96.7 (430)	60.5 (269)
				500	125.2 (557)	78.2 (348)
56 (2.2)	5.5	3.1 (2,030)	3.3 (85)	355	111.7 (497)	69.8 (311)
				500	144.6 (643)	90.4 (402)
60 (2.4)	5.5	3.7 (2,362)	3.5 (90)	355	129.9 (578)	81.2 (361)
				500	168.2 (748)	105.1 (468)
64 (2.5)	6.0	4.1 (2,676)	3.7 (95)	355	147.2 (655)	92.0 (409)
				500	190.6 (848)	119.1 (530)

*can be increased to allow for sacrificial corrosion

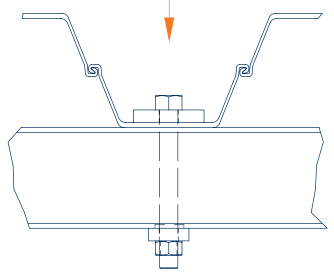
Forged head of waling bolt placed to outside of sheet pile for increased corrosion resistance



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 tie bars at design stage and of particular importance is the connection to the front wall as the tie bar is typically subjected to the most aggressive environment at this point and this is the most common area of failure for an anchorage.

Tables 4-1 & 4-2 of EN1993-5 give guidance to corrosion allowances for steel sheet piles, it is accepted practice to use these same rates for tie bars.

Corrosion protection for tie bars can be provided in several ways.

Sacrificial steel
Anker Schroeder consider sacrificial steel to be the most practical and robust corrosion protection. The tie bar 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 tie bar 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 3" (76 mm)

Thread diameter required M100 (4")

Sacrificial corrosion allowance in fill 0.047" (1.2 mm)

Sacrificial corrosion allowance at head 0.148" (3.75 mm)

Tie bar shaft size required = 3.28" (83.5 mm) (nearest standard size = 3.3" (85 mm)) and thread size M110. (4.3").

Therefore use ASDO500 M110/85.

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

Table 14 – Corrosion allowances for steel tie bars

EN1993-5 Table 4-1 – Recommended value for the loss of steel thickness due to corrosion in soils with or without groundwater

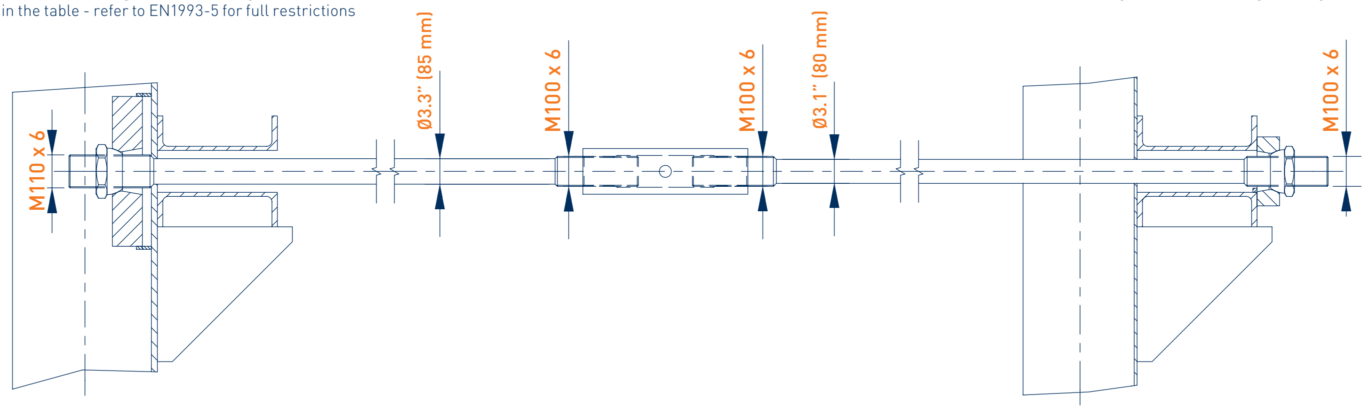
Required design working life		5 years	25 years	50 years	75 years	100 years
Non-compacted and non-aggressive fills (clay, schist, sand, silt ...)	in (mm)	0.007 (0.18)	0.028 (0.70)	0.047 (1.20)	0.067 (1.70)	0.087 (2.20)

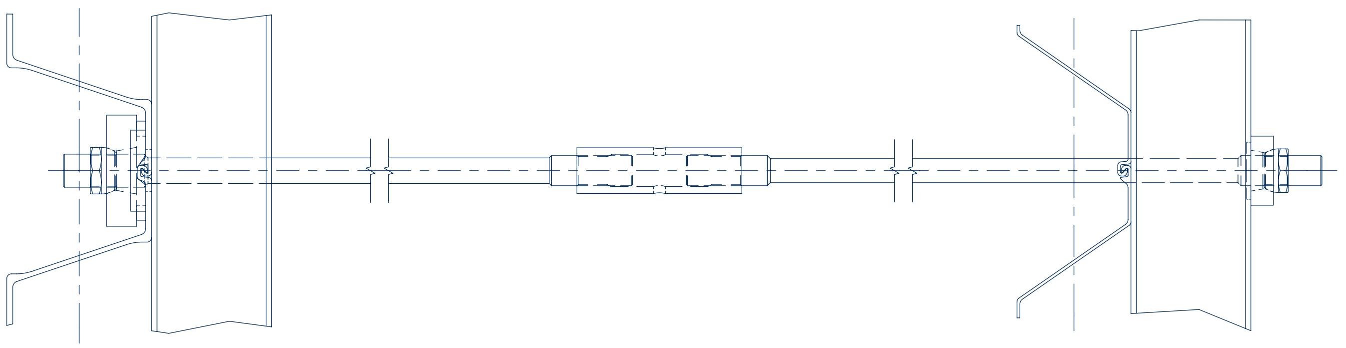
Note: For compacted fills EN1993-5 allows the corrosion rates above to be halved

EN1993-5 Table 4-2 – Recommended value for the loss of steel thickness (mm) due to corrosion in fresh water or sea 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)	in (mm)	0.006 (0.15)	0.022 (0.55)	0.035 (0.90)	0.045 (1.15)	0.055 (1.40)
Very polluted fresh water (sewage, industrial effluent ...) in the zone of high attack (water line)	in (mm)	0.012 (0.30)	0.051 (1.30)	0.091 (2.30)	0.13 (3.30)	0.169 (4.30)
Sea Water in temperate climate in the zone of high attack (low water and splash zones)	in (mm)	0.022 (0.55)	0.074 (1.90)	0.148 (3.75)	0.22 (5.60)	0.295 (7.50)
Sea Water in temperate climate in the zone of permanent immersion or in the intertidal zone	in (mm)	0.01 (0.25)	0.035 (0.90)	0.069 (1.75)	0.102 (2.60)	0.138 (3.50)

Note: The values given are only for guidance. Local conditions should be considered because they may affect the actual corrosion rate, which can be lower or higher than the average value given in the table - refer to EN1993-5 for full restrictions





DESIGN CONSIDERATIONS

Wrapping systems
The most commonly used wrapping system is to cover the tie bars 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 tie bar head can only be fully protected once installed and this is often difficult to achieve in site conditions.

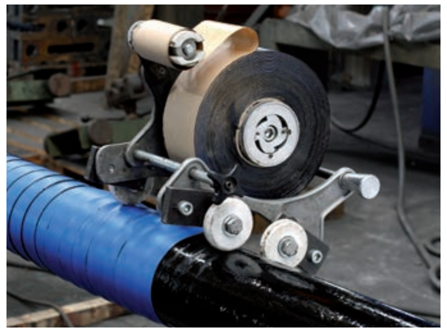
It is important to ensure that protection to connections and the tie bar head are correctly performed during installation, any damaged or unprotected areas must be repaired before backfilling.

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
Tie bars 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 tie bar. To discuss these issues further, please contact our technical department.


Factory wrapping of tie bars


Storage of wrapped tie bars

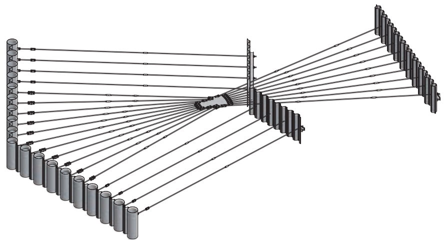

Site wrapping of connections

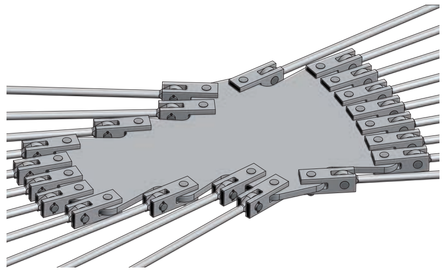

Galvanized T-plates


Galvanized tie bars


Painted tie bar

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





SITE INFORMATION

Storage of tie bars
Tie bars 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 tie bars are delivered in sections of typically 12 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.

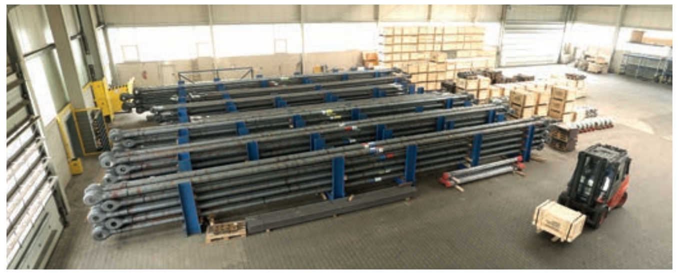
Installation
Tie bars should be installed as close as possible to the line of force that they will experience during service. Account should be taken of the additional forces that will be introduced to the bar by settlement of the fill, particularly bending at the wall connection.

Long tie bars should be lifted by use of a stiff lifting beam with supports at approximately every 13-20 ft (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 4,500 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

GENERAL INFORMATION

ASDO Stainless Architectural tie bars

Diameter ½" to 2 ¼"
M12 to M56

ASDO Structural Architectural tie bars

Diameter ½" to 6.3"
M12 to M160

ASDO Micro Piles

Diameters up to 6.3" and working loads > 675 kips
M160 - 3,000 kN

ASDO Forged Shackles

Working load capacities up to 1,650 tons

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.

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