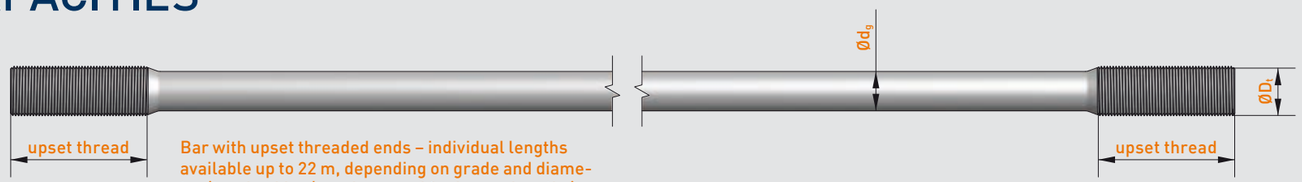
ASDO ANCHOR DESIGN CAPACITIES



Bar with upset threaded ends – individual lengths available up to 22 m, depending on grade and diameter (turnbuckles/couplers used for longer lengths).

Table 2 – Anchors with upset forged threads

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$_s$	mm^2	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

ASD0355 – Tensile resistance (EN1993-5)

ASD0355

k_t = 0.6	Anchor code		ASD0355 -	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$_g$	mm	48	52	56	60	64	68	72	75	80	85	90	90	95	100	105	110	115	115	120	125	130		Ød$_g$
	Shaft gross area	A$_g$	mm^2	1,810	2,124	2,463	2,827	3,217	3,632	4,072	4,418	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	larger diameters at request	A$_g$
	Shaft yield capacity	F$_y$	kN	642	754	874	1,004	1,142	1,289	1,445	1,568	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		F$_y$
	Shaft ultimate capacity	F$_{ua}$	kN	923	1,083	1,256	1,442	1,641	1,852	2,076	2,253	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		F$_{ua}$
	Tensile resistance	F$_{t,Rd}$	kN	642	748	847	952	1,063	1,211	1,369	1,536	1,712	1,899	2,094	2,258	2,515	2,740	2,974	3,218	3,471	3,687	4,007	4,290	4,582		F$_{t,Rd}$

k_t = 0.9	Anchor code		ASD0355 -	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$_g$	mm	56	60	64	68	72	75	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150		Ød$_g$
	Shaft gross area	A$_g$	mm^2	2,463	2,827	3,217	3,632	4,072	4,418	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	larger diameters at request	A$_g$
	Shaft yield capacity	F$_y$	kN	874	1,004	1,142	1,289	1,445	1,568	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		F$_y$
	Shaft ultimate capacity	F$_{ua}$	kN	1,256	1,442	1,641	1,852	2,076	2,253	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		F$_{ua}$
	Tensile resistance	F$_{t,Rd}$	kN	847	952	1,063	1,211	1,369	1,536	1,712	1,899	2,258	2,515	2,740	2,974	3,218	3,687	4,007	4,290	4,582	4,883	5,465	5,846	6,186		F$_{t,Rd}$

ASD0460 – Tensile resistance (EN1993-5)

ASD0460

k_t = 0.6	Anchor code		ASD0460 -	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	M145/115	M150/115	M155/120	M160/125	M165/130	M170+	
	Optimum shaft diameter	Ød$_g$	mm	48	52	52	56	60	64	68	72	76	80	85	90	90	95	100	105	110	115	115	120	125	130		Ød$_g$
	Shaft gross area	A$_g$	mm^2	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	10,387	10,387	11,310	12,272	13,273	larger diameters at request	A$_g$
	Shaft yield capacity	F$_y$	kN	832	977	977	1,133	1,301	1,480	1,671	1,873	2,087	2,312	2,610	2,926	2,926	3,261	3,613	3,983	4,372	4,778	4,778	5,202	5,645	6,106		F$_y$
	Shaft ultimate capacity	F$_{ua}$	kN	1,104	1,295	1,295	1,502	1,725	1,962	2,215	2,484	2,767	3,066	3,461	3,881	3,881	4,324	4,791	5,282	5,797	6,336	6,336	6,899	7,486	8,097		F$_{ua}$
	Tensile resistance	F$_{t,Rd}$	kN	784	895	977	1,133	1,272	1,449	1,637	1,837	2,048	2,271	2,505	2,751	2,926	3,261	3,557	3,849	4,152	4,467	4,778	5,131	5,480	5,841		F$_{t,Rd}$

k_t = 0.9	Anchor code		ASD0460 -	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$_g$	mm	56	60	64	68	72	76	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155		Ød$_g$
	Shaft gross area	A$_g$	mm^2	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	larger diameters at request	A$_g$
	Shaft yield capacity	F$_y$	kN	1,133	1,301	1,480	1,671	1,873	2,087	2,312	2,610	2,926	3,261	3,613	3,983	4,372	4,778	5,202	5,645	6,106	6,584	7,081	7,596	8,129	8,680		F$_y$
	Shaft ultimate capacity	F$_{ua}$	kN	1,502	1,725	1,962	2,215	2,484	2,767	3,066	3,461	3,881	4,324	4,791	5,282	5,797	6,336	6,899	7,486	8,097	8,731	9,390	10,073	10,780	11,510		F$_{ua}$
	Tensile resistance	F$_{t,Rd}$	kN	1,133	1,272	1,449	1,637	1,837	2,048	2,271	2,505	2,926	3,261	3,557	3,849	4,152	4,778	5,131	5,480	5,841	6,584	6,992	7,399	7,817	8,680		F$_{t,Rd}$

ASD0500 – Tensile resistance (EN1993-5)

ASD0500

k_t = 0.6	Anchor code		ASD0500 -	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$_g$	mm	48	52	52	56	60	64	68	72	76	80	85	90	90	95	100	105	110	110	115	120	125	130		Ød$_g$
	Shaft gross area	A$_g$	mm^2	1,810	2,124	2,124	2,463	2,827	3,117	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	larger diameters at request	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	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$_{t,Rd}$

k_t = 0.9	Anchor code		ASD0500 -	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$_g$	mm	56	60	64	68	72	76	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155		Ød$_g$
	Shaft gross area	A$_g$	mm^2	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	larger diameters at request	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	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$_{t,Rd}$

ASD0700 – Tensile resistance (EN1993-5)

ASD0700

k_t = 0.6	Anchor code		ASD0700 -	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	
	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$_g$	mm^2	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	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$_{t,Rd}$

k_t = 0.9	Anchor code		ASD0700 -	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	
	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$_g$	mm^2	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	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$_{t,Rd}$

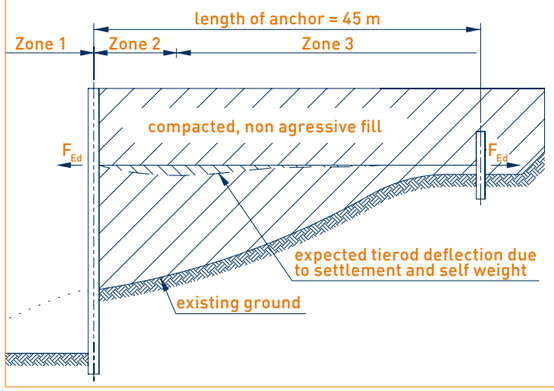
*Note: The above sizes are standardised, other shaft and thread ratios can be adapted to suit your project requirements, e.g. for sacrificial steel requirements or smaller design loads, design resistance calculated as per EN1993-5 with γ_{M0} = 1.0 & γ_{M2} = 1.25 and k_t as noted.

ASDO ANCHOR DESIGN CAPACITIES

Table 3 – Forged eye (all grades)

Nominal shaft diameter	Ød$_a$	mm	48	52	56	60	64	68	72	76	80	85	90	95	100	105	110	115	120	125	130	Ød$_a$
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 (ASD0500)		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

Tie bar length = 45 m (calculated in accordance with EN1997)

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 – Clause 7.2.3 EN1993-5

From table 2 grade ASD0500, k_t = 0.6 select M100/76 anchor

Design tensile resistance $F_{t,Rd}$ = 2,216 kN > 2,200 kN ∴ OK

Thread = M100 (stress area, A_s = 6,995 mm^2)
Shaft = 75 mm diameter (stress area A_g = 4,536 mm^2)
f_y = 500 N/mm^2, f_{ua} = 660 N/mm^2

Note: Clause 7.2.3(4) EN1993-5 states that the design provisions given do not cover the occurrence of bending in the thread. It is recommended by EN1993 & 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).

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
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/m^2

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

Serviceability limit state – Clause 7.2.4 EN1993-5

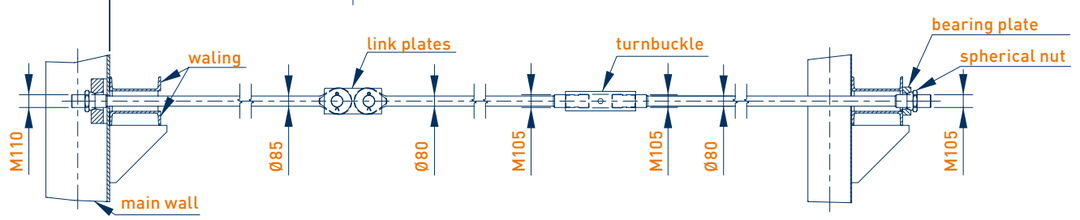
The required additional check for serviceability in this example is already implied in the resistance check $F_{Rd} < F_{Ed}$ as a k_t factor of 0.6 has been used, however it is performed here for information.

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

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

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 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 EN1993-5)	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 EN1993-5, 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 ASD0500 - 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 EN1993-5)
f_y = 500 N/mm^2
f_{ua} = 660 N/mm^2
Corrosion protection = sacrificial steel to all bars and components as indicated