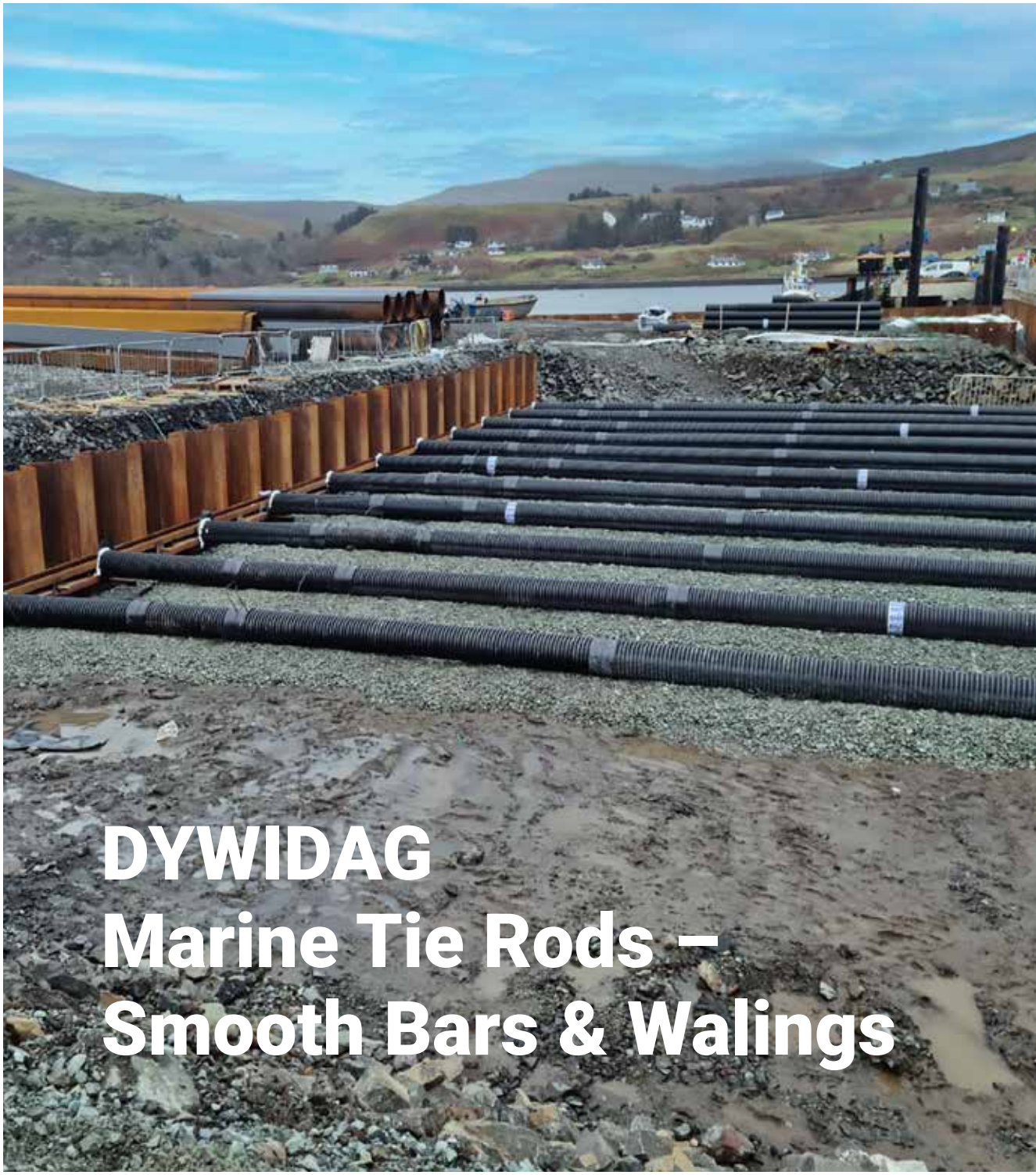
DYWIDAG



DYWIDAG Marine Tie Rods – Smooth Bars & Walings

dywidag.com

PORT OF DUISBURG
CREDIT HÜLSKENS-WASSERBAU AND SSAB JV, ASF TIE RODS

We make infrastructure safer, stronger, and smarter.

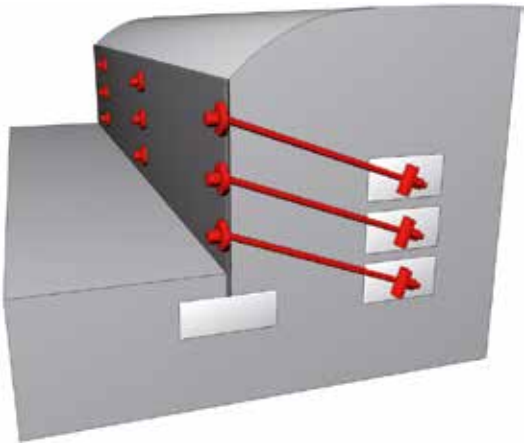
Contents

General Information

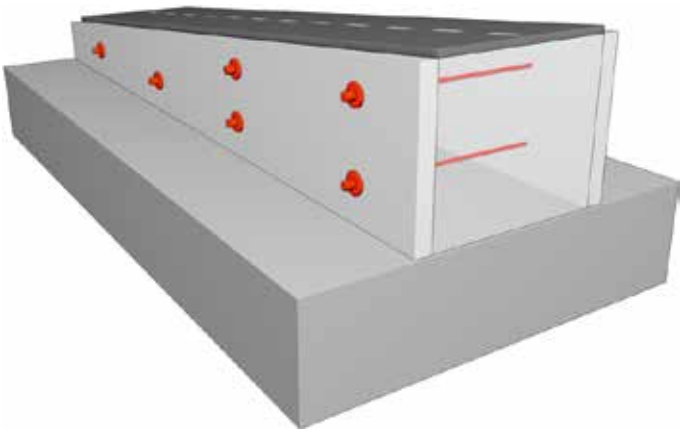
Deep vertical shoring systems for marine structures such as sheet pile walls often require additional anchors which support a specific layer of the shoring wall. These anchors are also referred to as tie rods. They transfer the supportive forces at the connection with the sheet pile wall via tension loads either to a dead man anchorage or to the other shoring wall side in the case of wharf sheet pile boxes. Typically, the horizontal reaction forces are transferred from the sheet pile walls first to a waling beam and then from the waling system to the tie rods. This setup leads to a more distributed load transfer and an additional stiffening and alignment of the sheet pile wall compared to a solution in which the tie rods are directly connected to the sheet pile wall.

Fields of Applications

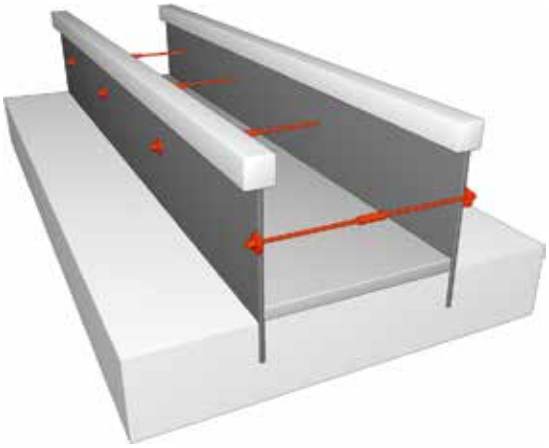
Tie Back Retaining Wall with Dead Man



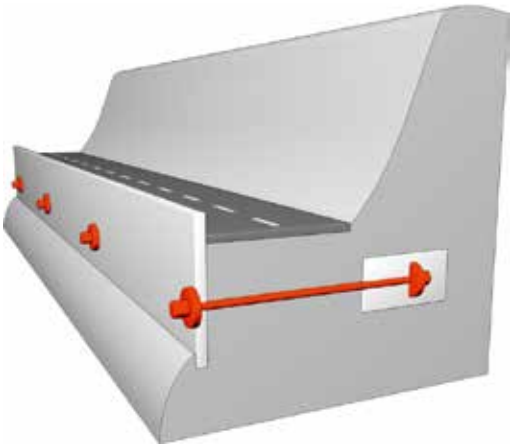
Bracing for Grade Separation



Tie Rods for Sheet Pile Constructed Wharf



Roadway Embankment Stabilization



Overview of Steel Grades

Steel Grade	Diameter [ØD$_1$]	F_y [N/mm²]	F_{ua} [N/mm²]
355	M39 - M160	355	510
460	M39 - M160	460	640
500	M39 - M160	500	680
720	M39 - M160	720	900

F_y = Characteristic Yield Stress

F_{ua} = Characteristic Failure Stress

Steel Properties

Grade 355

- Typcial structural steel acc. to EN 10025
- Forged materials available in all lengths
- CE marking and declaration possible

Grade 460

- Fine-grained structural steel acc. to EN 10025
- Easy-to-process steel grade limit acc. to EN 1993-5
- Forged materials available in all lengths
- CE marking and declaration possible

Grade 500

- Steel modified from Grade 460
- All further properties as for Grade 460
- Forged materials available in all lengths
- CE marking and declaration possible

Grade 720

- Maximum length up to 12m
- CE marking upon request
- Forged materials available up to 12 m length
- Classic QT steel acc. to DIN EN 10083-1 and quenched and tempered to achieve grade 10.9 acc. to EN ISO 898-1

Thread Creation

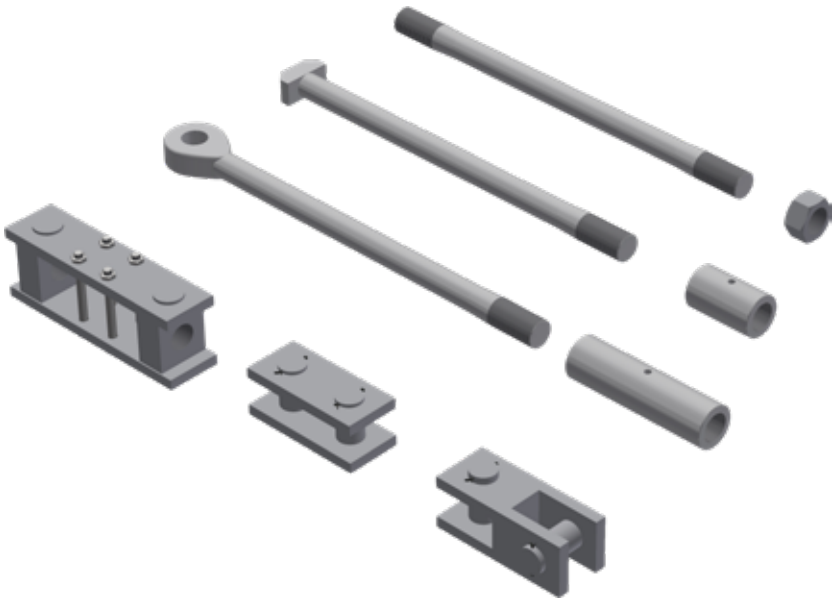
All threads are rolled threads. There is no peeling of the bar surface before the thread rolling process. As a result there are no interruptions to the steel fibres, which leads to an additional strengthening of the surface.

On a solid bar any Thread Length is possible. Both, metric and inch threads can be generated. Especially the inch thread shows on-site benefits such as simpler and faster installation progress.

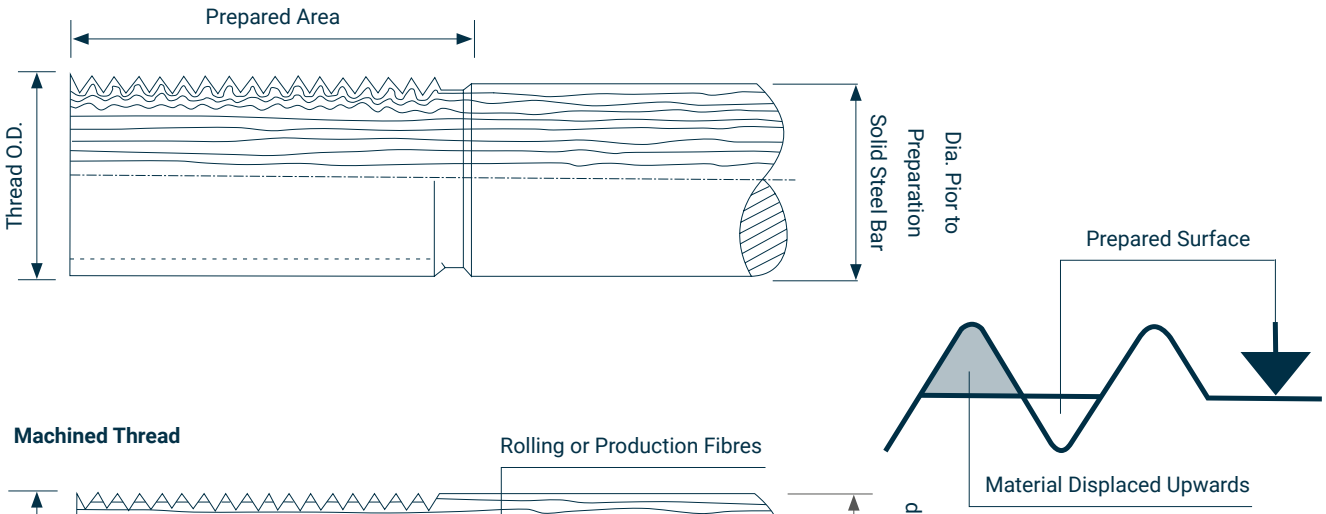
After rolling the thread, the outside diameter of the thread is larger than the diameter of the original steel bar. This leads to a higher load bearing capacity within the thread area compared to a machined thread as this can be seen in the picture below.

Key Advantages of Rolled Threads

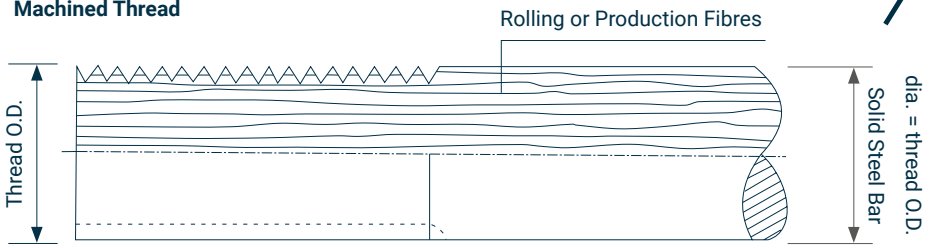
- Rolled threads lead to a better profile accuracy than machined threads.
- By rolling the thread, the steels gets coldformed. This increases the strength of the steel at the roots and flanks of the thread.
- Compared to machined threads, fibres within the steel matrix are not interrupted in case of rolled or hot rolled threads.
- Rolled threads lead to a better dynamic load behavior than machined threads
- Nuts, couplers and turnbuckles typically have machined threads since these load bearing parts (internal threads) are always subject to lower stress levels compared to the corresponding external thread of the tie rod part.



Rolled Thread



Machined Thread



UIG HARBOUR

ULS Tie Rod Design According to DIN EN 1993-5

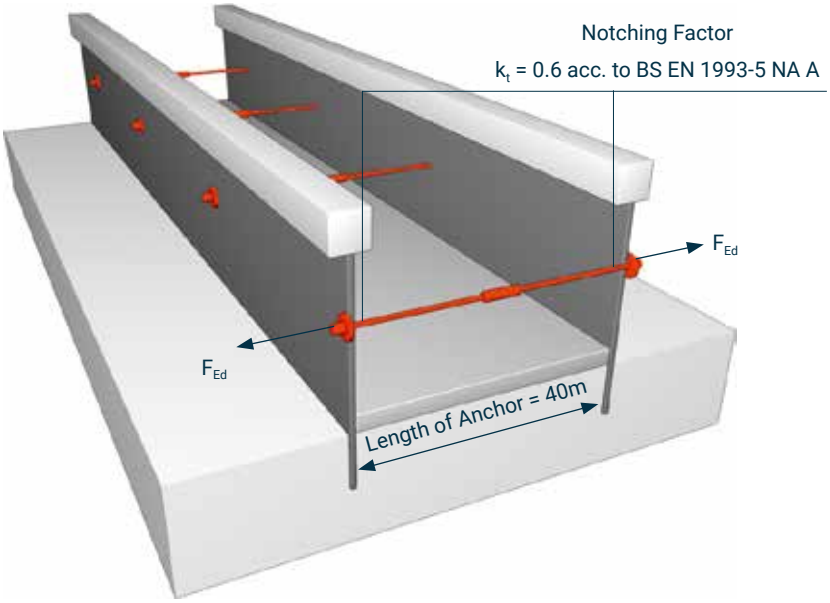
Symbol	Description
$F_{tt,Rd}$	Design tensile resistance of anchor thread
$F_{tg,Rd}$	Design tensile resistance of anchor shaft
$F_{yt,Rd}$	Design resistance at yield stress / 0.2% proof stress of anchor thread
$F_{yg,Rd}$	Design resistance at yield stress / 0.2% proof stress of anchor shaft
k_t	Notch factor
f_{ua}	Tensile strength of anchor
f_y	Yield stress of anchor
A_s	Stressed cross-sectional area, thread
A_g	Gross cross-sectional area, shaft
Y_{M2}	= 1.25 (Partial safety factor for anchor shaft stressed up to failure, EN 1993-5, 7.2.3)
Y_{M0}	= 1.00 (Partial safety factor for anchor shaft, EN 1993-5, 7.2.3)
$Y_{Mt,ser}$	= 1.10 (Partial safety factor SLS verification, EN 1993-5, 7.2.4)

Characteristic	Formula
Design Resistance, Thread	$F_{t,Rd} = \min(F_{tt,Rd} ; F_{yt,Rd})$
Failure in Thread	$F_{tt,Rd} = k_t * f_{ua} * A_s / Y_{M2}$
Yield Stress, Thread	$F_{yt,Rd} = f_y * A_s / Y_{M0}$
Design Resistance, Shaft	$F_{g,Rd} = \min(F_{tg,Rd} ; F_{yg,Rd})$
Failure in Shaft	$F_{tg,Rd} = A_g * f_{ua} / Y_{M2}$
Yield Stress, Shaft	$F_{yg,Rd} = f_y * A_g / Y_{M0}$

Design Example

Design Conditions

- Ultimate Limit State (ULS) load for tie rod
  - F_{Ed} = 2,500[kN]
- Serviceability Limit State (SLS) load
  - $F_{t,ser}$ = 1,600[kN]
- Tie bar length
  - 40m
- Tie bar elongation limit (SLS)
  - 80[mm]
- Design life of structure
  - 50 years
- Notching factor in thread area – use recommended value k_t = 0.6 (see BS EN 1993-5 NA A1)



Tie Rod Type Selection

The required minimum anchor size depends on the design tensile resistance $F_{t,Rd}$ = min($F_{tt,Rd}$; $F_{yt,Rd}$) according to EN 1993-5, 7.2.3 The used partial safety factor for the design level are given in the formulation above. The UK decision for the values of the thread notch factor, given in BS EN 1993-5, NA Table A1 Subclause 7.2.3 (2) are:

- The recommended value for kt is kt = 0.6". This is motivated for cases where possible bending in the anchor as an effect of actions is not made explicit.
- Only in cases where 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 recommended value for k_t may be chosen as k_t = 0.9".Based on the design resistance values of tie rods with rolled threads, tie rod type M105/81 is chosen to fit directly the design tensile resistance conditions in the Ultimate Limit State.
- Thread
  - M105 (stress area A_S: 7,755[mm²])
- Shaft
  - 81[mm] (stress area A_g: 5,153[mm²])
- Yield Stress of the Anchor
  - f_y = 500[N/mm²]
- Tensile Strength of Anchor
  - f_{ua} = 680[N/mm²]

Serviceability Limit State (SLS) Check acc. to EN 1993-5, 7.2.4

Elongation under SLS loading condition.

1. Stress in shaft, σt = $F_{t,ser}/A_g$ = 1,600 * 10^3/5,153 = 310[N/mm²]

2. Elongation = σt * Length/E-Modul = 310 * 400/2,100 = 59[mm] < 80[mm]
   Note: If the elongation is exceeding the limit of 80[mm], try a larger diameter of a less grade.

3. Yield Stress, Thread = $F_{yt,Rd}$ = f_y * min(A_S;A_g)/$\gamma_{Mt,ser}$ = 500 * 7,755/(1.1 * 10^3) = 3,525[kN] > 1,600[kN] = $F_{t,ser}$

Ultimate Limit State (ULS) check acc. to EN 1993-5, 7.2.3

1. Design tensile resistance = $F_{t,Rd}$ = 2,531[kN] > 2,500[kN] = F_{Ed}

Case studies

PROJECT
Stonehaven Piers Reconstruction

CLIENT
Aberdeenshire Council

LOCATION
Stonehaven

YEAR / DURATION
2022/6 months

FORM OF CONTRACT
NEC4 ECC Option C

Project Profile – Stonehaven, Aberdeenshire

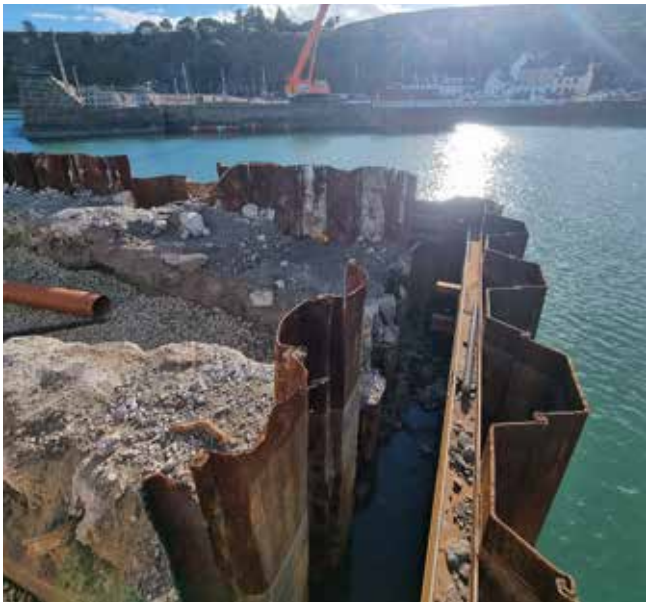
Working on behalf of Aberdeenshire Council, our valued installer TMS Ltd were appointed as Principal Contractor to reconstruction three new pier heads in Stonehaven Harbour Aberdeenshire. The three new pier heads encapsulated the existing Net Pier, South Pier and Fish Jetty structures that had been considered to have reached the end of their serviceable life and at risk of failure if their condition were allowed to continue to degrade.

Project Scope:

Installation of DYWIDAG Marine Ties to sheet piled wall system to support the berthing face retaining wall. DYWIDAG Tie rods were specified in varying lengths to provide 6 no longitudinal Tie Rods from dead-man's anchors at the existing old quay wall, to terminate through the back Waling's of the new quay wall.

S355 grade Gusseted angled plates were designed & manufactured by DYWIDAG and installed by TMS to provide anchorage for the inner corner bracing Ties, installed within the inner pan of the newly constructed sheet piled quay wall. A 1100 kN Jack was utilized to stress the Tie Bars before locking nuts were installed.

The piling works was undertaken using a Movax and impact hammer piling equipment on a 45t excavator supported by cranes. The piles were installed both from barge, but then moving to the pier deck following structural assessment. The supporting cranes were also based on the piers to assist the pitching of the 12m long sheet piles.



A modular barge and tugboat were used during the busy tourist months to transport most of the plant and equipment between the piers as some were inaccessible for deliveries with articulated lorries. Due to the age and uncertainty over the existing piers structural integrity; vibration and tilt monitoring systems were set up to ensure there was no movement on the piers during the loading and piling works. These were attached onto the existing piers during the works and were set with trigger warnings that would alert the construction team if movement occurred. The existing concrete decks and some masonry were demolished, and reinforced concrete capping beams and slabs constructed. By using a bolted cantilevered falsework system on the seaward side of the sheet piles, TMS were able to cast the capping beams safely over water. A boom gate system, used to create a sanctuary harbour between two piers during storms had to be replaced. An existing underwater concrete cill was removed, and a new cill, guides and boom gates were fabricated and installed.

PROJECT
AV Dawson NSSB1 Repair

CLIENT
AV Dawson Ports

LOCATION
Port of Middlesbrough, Middlesbrough

YEAR / DURATION
2020/21 - 8 months

FORM OF CONTRACT
NEC3 Option C

Description of Project:
TMS Maritime Ltd were appointed by the Port of Middlesbrough an AV Dawson Facility, to carry out the replacement of the failed section of Quay Wall. Due to increasing dredge depth and quay loading, the existing sheet piled quay wall had suffered partial failure, replacement was needed urgently to prevent collapse and allow for future operational loading on the quay side. DYWIDAG Marine Tie Bars were specified through the design process to be installed through the newly constructed CHS piled quay wall.

The full scope of the project included installing a temporary cofferdam around the extent of the working area, filled to stabilise the existing quay wall. Demolition of existing reinforced concrete capping beam using diamond wire sawing and mechanical breaking and the extraction of 35 linear metres of continuous sheet piles, each 28m long.

TMS Installed 70No 508mm diameter CHS piles to support a new concrete slab quay area together with 28No 1067mm, 30mtr long sheet piles clutched together to make a new continuous berthing face.

DYWIDAG Marine Ties and sub-anchors were installed to the new wall system to support the berthing face retaining wall. The Tie Rods were fixed from 'dead-man's' anchors to the final connections through the CHS Piles.

Grade S355 Gusseted plates were designed & manufactured by DYWIDAG and a unique 'key hole' locking plate was required in various locations along the Quay Wall through the CHS piles.

TMS were appointed as Principal Contractor to complete the works on the River Tees, utilising their specialist maritime experience and in-house piling capabilities. They have used DYWIDAG Tie's on many projects over the years and find our 'cut & couple 'system invaluable when it comes to those slight modifications which are required on projects like this.

Working closely with both Temporary and Permanent works Designers they were able to create a full land-based methodology utilising a 280t crane to support the works. By eliminating expensive marine jack-up barges, working from the quay side the collaboratively planned scheme was able to be delivered within the Clients tight budget.

DYWIDAG were able to input with an initiative design solution for the plate anchorage between the Tie Rods and the CHS Piles. TMS were commended by the client for this solution and cost saving engineering practise.

Tie Rod Types

Nominal Diameter	ØD$_1$	Metric	M39	M42	M45	M48	M52	M56	M60	M64	M68	M72	M76
Area, Core Diameter	A_s	[mm²]	976	1,121	1,306	1,473	1,758	2,030	2,362	2,676	3,055	3,460	3,889
Shaft Diameter	d	[mm]	36	39	42	45	38	41	44	47	50	54	57
Area, Shaft	A_g	[mm²]	1,017	1,194	1,385	1,590	1,134	1,320	1,521	1,735	1,963	2,290	2,552

Grade 355 – Anchor Force to EAU 2014, k_t 0.55			M39	M42	M45	M48	M52	M56	M60	M64	M68	M72	M76
Design Resistance, Shaft	$F_{g,Rd}$	[kN]	328	385	447	513	366	426	491	560	634	739	824
Design Resistance, Thread	$F_{t,Rd}$	[kN]	205	235	275	309	371	428	500	565	648	736	830
Permissible Design Resistance	$F_{u,Rd}$	[kN]	205	235	275	309	366	426	491	560	634	739	824

Grade 460 – Anchor Force to EAU 2014, k_t 0.55			M39	M42	M45	M48	M52	M56	M60	M64	M68	M72	M76
Design Resistance, Shaft	$F_{g,Rd}$	[kN]	425	499	579	665	474	552	636	726	821	958	1,067
Design Resistance, Thread	$F_{t,Rd}$	[kN]	257	294	345	387	465	537	627	709	813	924	1,042
Permissible Design Resistance	$F_{u,Rd}$	[kN]	257	294	345	387	465	537	627	709	813	924	1,042

Grade 500 – Anchor Force to EAU 2014, k_t 0.55			M39	M42	M45	M48	M52	M56	M60	M64	M68	M72	M76
Design Resistance, Shaft	$F_{g,Rd}$	[kN]	462	542	629	723	516	600	691	789	892	1,041	1,160
Design Resistance, Thread	$F_{t,Rd}$	[kN]	273	313	366	412	494	570	666	754	864	982	1,107
Permissible Design Resistance	$F_{u,Rd}$	[kN]	273	313	366	412	494	570	666	754	864	982	1,107

ASF EYE ANCHOR BARS

M80	M85	M90	M95	M100	M105	M110	M115	M120	M125	M130	M135	M140	M145	M150	M155	M160
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
60	64	68	73	77	81	85	89	93	97	101	105	109	113	118	123	127
2,827	3,217	3,632	4,185	4,657	5,153	5,675	6,221	6,793	7,390	8,012	8,659	9,331	10,029	10,936	11,882	12,668

M80	M85	M90	M95	M100	M105	M110	M115	M120	M125	M130	M135	M140	M145	M150	M155	M160
912	1,038	1,172	1,351	1,503	1,663	1,831	2,008	2,192	2,385	2,586	2,795	3,011	3,237	3,529	3,835	4,088
930	1,062	1,204	1,354	1,512	1,680	1,857	2,042	2,236	2,439	2,651	2,871	3,101	3,339	3,586	3,842	4,106
912	1,038	1,172	1,351	1,503	1,663	1,831	2,008	2,192	2,385	2,586	2,795	3,011	3,237	3,529	3,835	4,088

M80	M85	M90	M95	M100	M105	M110	M115	M120	M125	M130	M135	M140	M145	M150	M155	M160
1,182	1,345	1,519	1,750	1,947	2,155	2,373	2,602	2,841	3,090	3,350	3,621	3,902	4,194	4,573	4,969	5,297
1,167	1,333	1,510	1,699	1,898	2,108	2,330	2,562	2,806	3,061	3,326	3,603	3,891	4,190	4,500	4,821	5,153
1,167	1,333	1,510	1,699	1,898	2,108	2,330	2,562	2,806	3,061	3,326	3,603	3,891	4,190	4,500	4,821	5,153

M80	M85	M90	M95	M100	M105	M110	M115	M120	M125	M130	M135	M140	M145	M150	M155	M160
1,285	1,462	1,651	1,902	2,117	2,342	2,579	2,828	3,088	3,359	3,642	3,936	4,242	4,559	4,971	5,401	5,758
1,240	1,416	1,605	1,805	2,017	2,240	2,476	2,723	2,981	3,252	3,534	3,828	4,134	4,452	4,781	5,122	5,475
1,240	1,416	1,605	1,805	2,017	2,240	2,476	2,723	2,981	3,252	3,534	3,828	4,134	4,452	4,781	5,122	5,475

PIER HEAD, STONEHAVEN

Tie Rods with Upset and Rolled Threads acc. to DIN EN 1993-5

Nominal Diameter	$ØD_1$	Metric	M39	M42	M45	M48	M52	M56	M60	M64	M68	M72	M76
Stressed Area, Thread	A_s	[mm²]	976	1,121	1,306	1,473	1,758	2,030	2,362	2,676	3,055	3,460	3,889
Shaft Diameter	d	[mm]	36	39	42	45	38-39	41-42	44-46	47-50	50-54	54-58	57-62

Grade 355 – Anchor Force to EN 1993-5, k_t 0.6			M39	M42	M45	M48	M52	M56	M60	M64	M68	M72	M76
Shaft Diameter	d	[mm]	36	39	42	45	38	41	44	47	50	54	57
Area, Shaft	A_g	[mm²]	1,018	1,195	1,385	1,590	1,134	1,320	1,521	1,735	1,963	2,290	2,552
Design Resistance, Shaft	$F_{g,Rd}$	[kN]	361	424	492	565	403	469	540	616	697	813	906
Design Resistance, Thread	$F_{t,Rd}$	[kN]	239	274	320	361	430	497	578	655	748	847	952
Permissible Design Resistance	$F_{u,Rd}$	[kN]	239	274	320	361	403	469	540	616	697	813	906

Grade 355 – Anchor Force to EN 1993-5, k_t 0.9			M39	M42	M45	M48	M52	M56	M60	M64	M68	M72	M76
Shaft Diameter	d	[mm]	36	39	42	45	39	42	46	50	54	58	62
Area, Shaft	A_g	[mm²]	1,018	1,195	1,385	1,590	1,195	1,385	1,662	1,963	2,290	2,642	3,019
Design Resistance, Shaft	$F_{g,Rd}$	[kN]	361	424	492	565	424	492	590	697	813	938	1,072
Design Resistance, Thread	$F_{t,Rd}$	[kN]	346	398	464	523	624	721	839	950	1,085	1,228	1,381
Permissible Design Resistance	$F_{u,Rd}$	[kN]	346	398	464	523	424	492	590	697	813	938	1,072

Grade 460 – Anchor Force to EN 1993-5, k_t 0.6			M39	M42	M45	M48	M52	M56	M60	M64	M68	M72	M76
Shaft Diameter	d	[mm]	36	39	42	45	38	41	44	47	50	54	57
Area, Shaft	A_g	[mm²]	1,018	1,195	1,385	1,590	1,134	1,320	1,521	1,735	1,963	2,290	2,552
Design Resistance, Shaft	$F_{g,Rd}$	[kN]	468	550	637	732	522	607	699	798	903	1,054	1,174
Design Resistance, Thread	$F_{t,Rd}$	[kN]	300	344	401	453	540	624	726	822	938	1,063	1,195
Permissible Design Resistance	$F_{u,Rd}$	[kN]	300	344	401	453	522	607	699	798	903	1,054	1,174

Grade 460 – Anchor Force to EN 1993-5, k_t 0.9			M39	M42	M45	M48	M52	M56	M60	M64	M68	M72	M76
Shaft Diameter	d	[mm]	36	39	42	45	39	42	46	50	54	58	62
Area, Shaft	A_g	[mm²]	1,018	1,195	1,385	1,590	1,195	1,385	1,662	1,963	2,290	2,642	3,019
Design Resistance, Shaft	$F_{g,Rd}$	[kN]	468	550	637	732	550	637	764	903	1,054	1,215	1,389
Design Resistance, Thread	$F_{t,Rd}$	[kN]	449	516	601	678	809	934	1,087	1,231	1,405	1,592	1,789
Permissible Design Resistance	$F_{u,Rd}$	[kN]	449	516	601	678	550	637	764	903	1,054	1,215	1,389

Grade 500 – Anchor Force to EN 1993-5, k_t 0.6			M39	M42	M45	M48	M52	M56	M60	M64	M68	M72	M76
Shaft Diameter	d	[mm]	36	39	42	45	38	41	44	47	50	54	57
Area, Shaft	A_g	[mm²]	1,018	1,195	1,385	1,590	1,134	1,320	1,521	1,735	1,963	2,290	2,552
Design Resistance, Shaft	$F_{g,Rd}$	[kN]	509	597	693	795	567	660	760	867	982	1,145	1,276
Design Resistance, Thread	$F_{t,Rd}$	[kN]	319	366	426	481	574	663	771	873	997	1,129	1,269
Permissible Design Resistance	$F_{u,Rd}$	[kN]	319	366	426	481	567	660	760	867	982	1,129	1,269

Grade 500 – Anchor Force to EN 1993-5, k_t 0.9			M39	M42	M45	M48	M52	M56	M60	M64	M68	M72	M76
Shaft Diameter	d	[mm]	36	39	42	45	39	42	46	50	54	58	62
Area, Shaft	A_g	[mm²]	1,018	1,195	1,385	1,590	1,195	1,385	1,662	1,963	2,290	2,642	3,019
Design Resistance, Shaft	$F_{g,Rd}$	[kN]	509	597	693	795	597	693	831	982	1,145	1,321	1,510
Design Resistance, Thread	$F_{t,Rd}$	[kN]	478	549	639	721	861	994	1,156	1,310	1,496	1,694	1,904
Permissible Design Resistance	$F_{u,Rd}$	[kN]	478	549	639	721	597	693	831	982	1,145	1,321	1,510

M80	M85	M90	M95	M100	M105	M110	M115	M120	M125	M130	M135	M140	M145	M150	M155	M160
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
60-66	64-71	68-75	73-80	77-85	81-90	85-95	89-100	93-105	97-110	100-115	105-120	110-125	115-130	120-135	125-140	130-145

M80	M85	M90	M95	M100	M105	M110	M115	M120	M125	M130	M135	M140	M145	M150	M155	M160
60	64	68	73	77	81	85	89	93	97	100	105	110	115	120	125	130
2,827	3,217	3,632	4,185	4,657	5,153	5,675	6,221	6,793	7,390	7,854	8,659	9,503	10,387	11,310	12,272	13,273
1,004	1,142	1,289	1,486	1,653	1,829	2,014	2,209	2,411	2,623	2,788	3,074	3,374	3,687	4,015	4,357	4,712
1,063	1,211	1,369	1,536	1,712	1,898	2,095	2,300	2,515	2,740	2,974	3,218	3,472	3,735	4,007	4,290	4,582
1,004	1,142	1,289	1,486	1,653	1,829	2,014	2,209	2,411	2,623	2,788	3,074	3,374	3,687	4,007	4,290	4,582

M80	M85	M90	M95	M100	M105	M110	M115	M120	M125	M130	M135	M140	M145	M150	M155	M160
66	71	75	80	85	90	95	100	105	110	115	120	125	130	135	140	145
3,421	3,959	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
1,215	1,406	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
1,542	1,757	1,985	2,227	2,483	2,753	3,037	3,335	3,647	3,973	4,313	4,666	5,034	5,416	5,811	6,221	6,644
1,215	1,406	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

M80	M85	M90	M95	M100	M105	M110	M115	M120	M125	M130	M135	M140	M145	M150	M155	M160
60	64	68	73	77	81	85	89	93	97	100	105	110	115	120	125	130
2,827	3,217	3,632	4,185	4,657	5,153	5,675	6,221	6,793	7,390	7,854	8,659	9,503	10,387	11,310	12,272	13,273
1,301	1,480	1,671	1,925	2,142	2,370	2,610	2,862	3,125	3,399	3,613	3,983	4,372	4,778	5,202	5,645	6,106
1,334	1,520	1,718	1,927	2,149	2,382	2,628	2,886	3,156	3,438	3,732	4,038	4,356	4,687	5,029	5,383	5,750
1,301	1,480	1,671	1,925	2,142	2,370	2,610	2,862	3,125	3,399	3,613	3,983	4,356	4,687	5,029	5,383	5,750

M80	M85	M90	M95	M100	M105	M110	M115	M120	M125	M130	M135	M140	M145	M150	M155	M160
66	71	75	80	85	90	95	100	105	110	115	120	125	130	135	140	145
3,421	3,959	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
1,574	1,821	2,032	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
1,998	2,276	2,572	2,886	3,218	3,567	3,936	4,322	4,726	5,148	5,589	6,047	6,523	7,018	7,530	8,061	8,609
1,574	1,821	2,032	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

M80	M85	M90	M95	M100	M105	M110	M115	M120	M125	M130	M135	M140	M145	M150	M155	M160
60	64	68	73	77	81	85	89	93	97	100	105	110	115	120	125	130
2,827	3,217	3,632	4,185	4,657	5,153	5,675	6,221	6,793	7,390	7,854	8,659	9,503	10,387	11,310	12,272	13,273
1,414	1,608	1,816	2,093	2,328	2,576	2,837	3,111	3,396	3,695	3,927	4,330	4,752	5,193	5,655	6,136	6,637
1,418	1,615	1,825	2,048	2,283	2,531	2,793	3,067	3,353	3,653	3,965	4,291	4,629	4,980	5,343	5,720	6,109
1,414	1,608	1,816	2,048	2,283	2,531	2,793	3,067	3,353	3,653	3,927	4,291	4,629	4,980	5,343	5,720	6,109

M80	M85	M90	M95	M100	M105	M110	M115	M120	M125	M130	M135	M140	M145	M150	M155	M160
66	71	75	80	85	90	95	100	105	110	115	120	125	130	135	140	145
3,421	3,959	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
1,711	1,980	2,209	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
2,127	2,423	2,737	3,071	3,425	3,797	4,189	4,600	5,030	5,479	5,948	6,436	6,943	7,469	8,015	8,580	9,163
1,711	1,980	2,209	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

Tie Rods with Rolled Threads acc. to DIN EN 1993-5 k_t 0.9

Nominal Diameter	$ØD_1$	Metric	M39	M42	M45	M48	M52	M56	M60	M64	M68	M72	M76
Stressed Area, Thread	A_s	[mm²]	976	1,121	1,306	1,473	1,758	2,030	2,362	2,676	3,055	3,460	3,889
Shaft Diameter	d	[mm]	36	39	42	45	49	52	56	60	64	68	72
Area, Shaft	A_g	[mm²]	1,018	1,195	1,385	1,590	1,847	2,124	2,463	2,827	3,217	3,632	4,072

Grade 355 – Anchor Force to EN 1993-5, k_t 0.9			M39	M42	M45	M48	M52	M56	M60	M64	M68	M72	M76
Design Resistance, Shaft	$F_{g,Rd}$	[kN]	361	424	492	565	656	754	874	1,004	1,142	1,289	1,445
Design Resistance, Thread	$F_{t,Rd}$	[kN]	346	397	463	522	624	720	838	949	1,084	1,228	1,380
Max. Design Resistance	$F_{u,Rd}$	[kN]	346	397	463	522	624	720	838	949	1,084	1,228	1,380

Grade 460 – Anchor Force to EN 1993-5, k_t 0.9			M39	M42	M45	M48	M52	M56	M60	M64	M68	M72	M76
Design Resistance, Shaft	$F_{g,Rd}$	[kN]	468	550	637	732	850	977	1,133	1,301	1,480	1,671	1,873
Design Resistance, Thread	$F_{t,Rd}$	[kN]	448	515	600	677	808	933	1,086	1,230	1,405	1,591	1,788
Max. Design Resistance	$F_{u,Rd}$	[kN]	448	515	600	677	808	933	1,086	1,230	1,405	1,591	1,788

Grade 500 – Anchor Force to EN 1993-5, k_t 0.9			M39	M42	M45	M48	M52	M56	M60	M64	M68	M72	M76
Design Resistance, Shaft	$F_{g,Rd}$	[kN]	509	597	693	795	924	1,062	1,232	1,414	1,608	1,816	2,036
Design Resistance, Thread	$F_{t,Rd}$	[kN]	477	548	639	721	860	993	1,156	1,310	1,495	1,694	1,904
Max. Design Resistance	$F_{u,Rd}$	[kN]	477	548	639	721	860	993	1,156	1,310	1,495	1,694	1,904

Grade 720 – Anchor Force to EN 1993-5, k_t 0.9			M39	M42	M45	M48	M52	M56	M60	M64	M68	M72	M76
Design Resistance, Shaft	$F_{g,Rd}$	[kN]	733	860	998	1,145	1,330	1,529	1,773	2,036	2,316	2,615	2,931
Design Resistance, Thread	$F_{t,Rd}$	[kN]	632	726	846	954	1,139	1,315	1,530	1,734	1,979	2,242	2,520
Max. Design Resistance	$F_{u,Rd}$	[kN]	632	726	846	954	1,139	1,315	1,530	1,734	1,979	2,242	2,520

M80	M85	M90	M95	M100	M105	M110	M115	M120	M125	M130	M135	M140	M145	M150	M155	M160
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
76	81	86	91	96	101	106	111	116	121	126	131	136	141	146	151	156
4,536	5,153	5,809	6,504	7,238	8,012	8,825	9,677	10,568	11,499	12,469	13,478	14,527	15,615	16,742	17,908	19,113

M80	M85	M90	M95	M100	M105	M110	M115	M120	M125	M130	M135	M140	M145	M150	M155	M160
1,610	1,829	2,062	2,309	2,570	2,844	3,133	3,435	3,752	4,082	4,426	4,785	5,157	5,543	5,943	6,357	6,785
1,542	1,756	1,984	2,226	2,483	2,753	3,037	3,335	3,647	3,972	4,312	4,666	5,034	5,415	5,811	6,220	6,644
1,542	1,756	1,984	2,226	2,483	2,753	3,037	3,335	3,647	3,972	4,312	4,666	5,034	5,415	5,811	6,220	6,644

M80	M85	M90	M95	M100	M105	M110	M115	M120	M125	M130	M135	M140	M145	M150	M155	M160
2,087	2,370	2,672	2,992	3,330	3,685	4,059	4,451	4,861	5,290	5,736	6,200	6,682	7,183	7,701	8,238	8,792
1,998	2,276	2,571	2,885	3,217	3,567	3,935	4,321	4,726	5,147	5,588	6,046	6,523	7,017	7,530	8,060	8,609
1,998	2,276	2,571	2,885	3,217	3,567	3,935	4,321	4,726	5,147	5,588	6,046	6,523	7,017	7,530	8,060	8,609

M80	M85	M90	M95	M100	M105	M110	M115	M120	M125	M130	M135	M140	M145	M150	M155	M160
2,268	2,576	2,904	3,252	3,619	4,006	4,412	4,838	5,284	5,750	6,234	6,739	7,263	7,807	8,371	8,954	9,557
2,126	2,422	2,737	3,071	3,424	3,797	4,189	4,599	5,030	5,479	5,948	6,435	6,943	7,469	8,014	8,579	9,163
2,126	2,422	2,737	3,071	3,424	3,797	4,189	4,599	5,030	5,479	5,948	6,435	6,943	7,469	8,014	8,579	9,163

M80	M85	M90	M95	M100	M105	M110	M115	M120	M125	M130	M135	M140	M145	M150	M155	M160
3,266	3,710	4,182	4,683	5,212	5,769	6,354	6,967	7,609	8,279	8,978	9,704	10,459	11,242	12,054	12,894	13,762
2,814	3,206	3,622	4,064	4,532	5,025	5,544	6,087	6,657	7,251	7,872	8,517	9,189	9,885	10,607	11,355	12,128
2,814	3,206	3,622	4,064	4,532	5,025	5,544	6,087	6,657	7,251	7,872	8,517	9,189	9,885	10,607	11,355	12,128

Eye Rods k_t 0.6

Grade 355 – Anchor Force to DIN EN 1993-5			A150 M39	A175 M42	A200 M48	A225 M60	A250 M64	A275 M68	A300A M72	A300B M76	A325 M80
Shaft Diameter	d	[mm]	36	39	42	45	48	52	56	60	64
Eye Thickness	c	[mm]	25	30	33	39	42	47	50	50	55
Eye Length	La	[mm]	86	106	127	135	147	166	190	190	210
Eye Width	a	[mm]	72	85	105	110	125	135	155	155	165
Pin, Diameter	d0	[mm]	30	33	36	40	47	52	56	56	62

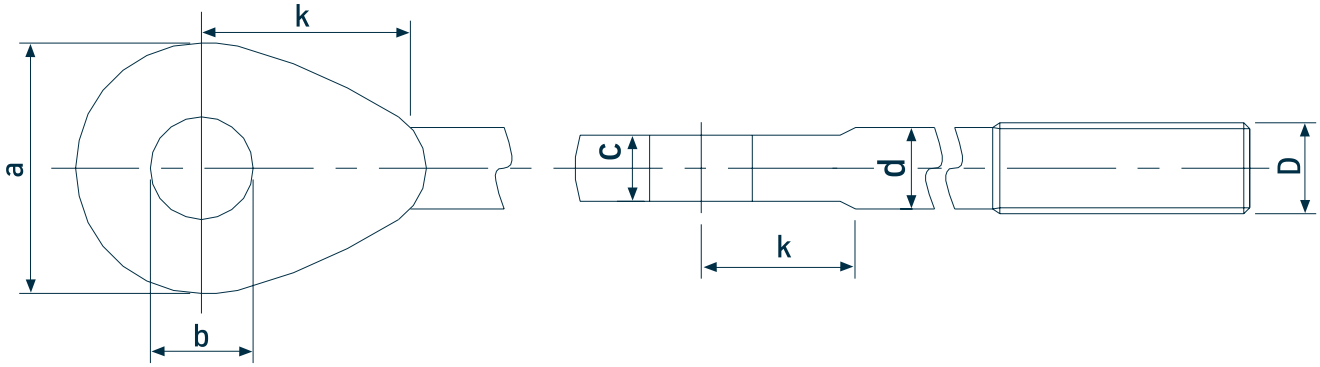
Grade 500 – Anchor Force to DIN EN 1993-5			A150 M39	A175 M42	A200 M48	A225 M60	A250 M64	A275 M68	A300A M72	A300B M76	A325 M80
Shaft Diameter	d	[mm]	36	39	42	45	48	52	56	60	64
Eye Thickness	c	[mm]	25	30	33	39	42	47	50	50	55
Eye Length	La	[mm]	86	106	127	135	147	166	190	190	210
Eye Width	a	[mm]	72	85	105	110	125	135	155	155	165
Pin, Diameter	d0	[mm]	30	33	36	41	47	52	56	56	62

Grade 720 – Anchor Force to DIN EN 1993-5			A150 M39	A175 M42	A200 M48	A225 M60	A250 M64	A275 M68	A300A M72	A300B M76	A325 M80
Shaft Diameter	d	[mm]	36	39	42	45	48	52	56	60	64
Eye Thickness	c	[mm]	25	30	33	39	42	47	50	50	55
Eye Length	La	[mm]	86	106	127	135	147	166	190	190	210
Eye Width	a	[mm]	72	85	105	110	125	135	155	155	165
Pin, Diameter	d0	[mm]	30	33	40	44	50	55	61	61	66

A350	A375A	A375B	A400	A425	A450	A475	A500	A525	A550	A575	A600	A625	A650
M85	M90	M95	M100	M105	M115	M120	M125	M130	M135	M145	M150	M155	M160
68	72	75	80	85	90	95	100	105	110	115	120	125	130
60	63	63	66	72	75	80	85	90	95	100	105	115	120
220	235	235	253	290	300	323	340	350	365	373	380	439	459
180	190	190	210	230	240	255	270	275	290	300	310	330	340
68	70	70	76	80	85	90	95	100	100	105	110	115	120

A350	A375A	A375B	A400	A425	A450	A475	A500	A525	A550	A575	A600	A625	A650
M85	M90	M95	M100	M105	M115	M120	M125	M130	M135	M145	M150	M155	M160
68	72	75	80	85	90	95	100	105	110	115	120	125	130
60	63	63	66	72	75	80	85	90	95	100	105	115	120
220	235	235	253	290	300	323	340	350	365	373	380	439	459
180	190	190	210	230	240	255	270	275	290	300	310	330	340
68	70	70	76	80	85	90	95	100	105	110	115	120	125

A350	A375A	A375B	A400	A425	A450	A475	A500	A525	A550	A575	A600	A625	A650
M85	M90	M95	M100	M105	M115	M120	M125	M130	M135	M145	M150	M155	M160
68	72	75	80	85	90	95	100	105	110	115	120	125	130
60	63	63	66	72	75	80	85	90	95	100	105	115	120
220	235	235	253	290	300	323	340	350	365	373	380	439	459
180	190	190	210	230	240	255	270	275	290	300	310	330	340
72	76	76	85	90	95	100	105	110	110	115	125	130	135



Tie Rod Connection Elements

Turnbuckles for Tie Rods

Grade 355 to EAU with k_t 0.55 | Grade 355 Anchor with k_t 0.6 in S355

Nominal Diameter	$ØD_1$	Metric	M39	M42	M45	M48	M52	M56	M60	M64	M68	M72	M76
Length	a	[mm]	350	400	400	450	450	450	500	500	500	500	550
Outside Diameter	b	[mm]	63.5	70	73	76.1	82.5	82.5	88.9	101.6	101.6	108	114.3
Thread Length	c	[mm]	40	45	45	50	55	60	60	65	70	75	80
Undercut	e	[mm]	42	45	48	51	55	59	63	67	71	75	79
Hole Diameter	f	[mm]	25	25	25	25	25	25	25	25	25	25	25
Weight		[kg]	5.4	7.7	8.1	9.7	11.4	10.2	13.3	19.2	17.6	20.0	24.7

Grade 460/500 to EAU with k_t 0.55 |
Grade 460/500 Anchor with k_t 0.6 in S355 | Tie Rods Grade 355 to Grade 500 with k_t 0.9 in S355 in 20MnV6

Nominal Diameter	$ØD_1$	Metric	M39	M42	M45	M48	M52	M56	M60	M64	M68	M72	M76
Length	a	[mm]	350	400	400	450	450	450	500	500	500	500	550
Outside Diameter	b	[mm]	73	76.1	82.5	82.5	88.9	101.6	101.6	108	114.3	121	127
Thread Length	c	[mm]	40	45	45	50	55	60	60	65	70	75	80
Undercut	e	[mm]	42	45	48	51	55	59	63	67	71	75	79
Hole Diameter	f	[mm]	25	25	25	25	25	25	25	25	25	25	25
Weight		[kg]	8.2	9.9	11.8	12.5	14.4	19.9	20.7	23.3	26.0	29.2	35.1

Grade 720 on request

Couplers for Tie Rods

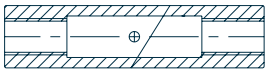
Grade 355 to EAU with k_t 0.55 | Grade 355 Anchor with k_t 0.6 in S355

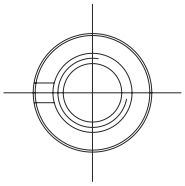
Nominal Diameter	$ØD_1$	Metric	M39	M42	M45	M48	M52	M56	M60	M64	M68	M72	M76
Length	a	[mm]	120	130	140	150	150	170	180	180	190	200	210
Outside Diameter	b	[mm]	63.5	70	73	76.1	82.5	82.5	88.9	101.6	101.6	108	114.3
Hole Diameter	f	[mm]	25	25	25	25	25	25	25	25	25	25	25
Weight		[kg]	1.9	2.5	2.9	3.2	3.8	3.8	4.8	6.9	6.7	8.0	9.4

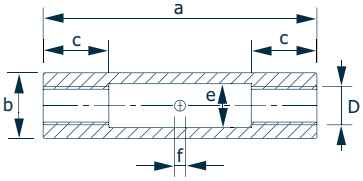
Grade 460/ 500 to EAU with k_t 0.55 |
Grade 460/500 Anchor with k_t 0.6 in S355 | Tie Rods Grade 355 to Grade 500 with k_t 0.9 in 20MnV6

Nominal Diameter	$ØD_1$	Metric	M39	M42	M45	M48	M52	M56	M60	M64	M68	M72	M76
Length	a	[mm]	120	130	140	150	150	170	180	180	190	200	210
Outside Diameter	b	[mm]	73	76.1	82.5	82.5	88.9	101.6	101.6	108	114.3	121	127
Hole Diameter	f	[mm]	25	25	25	25	25	25	25	25	25	25	25
Weight		[kg]	2.8	3.2	4.1	4.2	4.8	7.5	7.5	8.4	9.9	11.7	13.4

Grade 720 on request

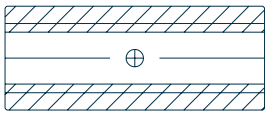


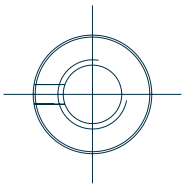


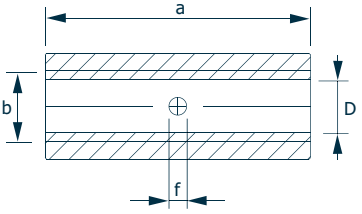


M80	M85	M90	M95	M100	M105	M110	M115	M120	M125	M130	M135	M140	M145	M150	M155	M160
550	550	550	550	550	550	550	550	550	550	550	550	550	550	550	550	550
114.3	121	127	133	139.7	152.4	152.4	159	165.1	177.8	177.8	191	193.7	203	216	216	219.1
80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160
83	88	93	98	103	108	113	118	123	128	133	138	143	148	153	158	163
25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
22.6	25.1	27.2	29.4	32.3	41.4	37.7	40.9	43.6	54.2	49.9	61.9	60.8	68.4	81.9	76.7	76.0

M80	M85	M90	M95	M100	M105	M110	M115	M120	M125	M130	M135	M140	M145	M150	M155	M160
550	550	550	550	550	550	550	550	550	550	550	550	550	550	550	550	550
133	139.7	141.3	152.4	159	168.3	177.8	191	193.7	203	203	219.1	219.1	229	229	244.5	244.5
80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160
83	88	93	98	103	108	113	118	123	128	133	138	143	148	153	158	163
25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
38.3	41.7	40.2	48.2	51.8	58.7	66.2	78.9	78.4	86.8	82.4	101.0	96.3	106.5	101.5	121.2	115.9







M80	M85	M90	M95	M100	M105	M110	M115	M120	M125	M130	M135	M140	M145	M150	M155	M160
225	240	250	260	260	260	260	260	260	260	260	270	280	290	300	310	320
114.3	121	127	133	139.7	152.4	152.4	159	165.1	177.8	177.8	191	193.7	203	216	216	219.1
25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
9.2	11.0	12.4	13.9	15.3	19.6	17.8	19.3	20.6	25.6	23.6	30.4	30.9	36.1	44.7	43.3	44.2

M80	M85	M90	M95	M100	M105	M110	M115	M120	M125	M130	M135	M140	M145	M150	M155	M160
225	240	250	260	275	285	295	305	320	330	340	350	360	370	380	390	400
133	139.7	141.3	152.4	159	168.3	177.8	191	193.7	203	203	219.1	219.1	229	229	244.5	244.5
25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
15.7	18.2	18.3	22.8	25.9	30.4	35.5	43.7	45.6	52.1	51.0	64.3	63.0	71.7	70.1	86.0	84.3

Hinged Turnbuckles for Tie Rods

Grade 355 to EAU with k_t 0.55 and SF355 Anchor with k_t 0.6 in S355

Nominal Diameter	ØD$_1$	Metric	M39	M42	M45	M48	M52	M56	M60	M64	M68	M72	M76
Length (Plate)	a	[mm]	510	530	540	545	555	570	615	630	640	650	765
Height (Plate)	b	[mm]	90	90	100	110	110	130	130	140	150	160	170
Thickness (Plate)	c	[mm]	15	15	20	20	20	20	25	25	25	25	30
Hole Spacing (Plate)	e	[mm]	400	410	410	410	410	410	450	450	450	450	550
Height (Nut)	f	[mm]	40	45	45	50	55	60	60	65	70	75	80
Width (Nut between Plates)	g	[mm]	60	65	70	75	80	85	90	95	100	105	110
Width (Nut and Plates)	h	[mm]	100	110	120	130	130	140	150	160	160	170	180
Weight		[kg]	10.8	11.2	17.0	18.8	19.2	23.3	31.4	34.6	37.7	40.8	61.3

Grade 460/500 to EAU with k_t 0.55, Grade 460/500 with k_t 0.6 and Grade 355 to Grade 500 with k_t 0.9 in S355

Nominal Diameter	ØD$_1$	Metric	M39	M42	M45	M48	M52	M56	M60	M64	M68	M72	M76
Length (Plate)	a	[mm]	530	545	560	570	580	595	645	655	670	685	795
Height (Plate)	b	[mm]	100	110	120	130	130	150	150	160	170	180	190
Thickness (Plate)	c	[mm]	20	20	25	25	25	30	30	35	35	35	40
Hole Spacing (Plate)	e	[mm]	400	410	410	410	410	410	450	450	450	450	550
Height (Nut)	f	[mm]	40	45	45	50	55	60	60	65	70	75	80
Width (Nut between Plates)	g	[mm]	60	65	70	75	80	85	90	95	100	105	110
Width (Nut and Plates)	h	[mm]	110	120	130	140	140	160	160	180	180	190	200
Weight		[kg]	16.6	18,8	26,4	29,1	29,6	42,0	45,6	57,6	62,6	67,8	94,9

Grade 720 on request

Hexagonal Nuts*

Grade 355 to Grade 500 in S355 | Grade 720 in Class 10

Nominal Diameter	ØD$_1$	Metric	M39	M42	M45	M48	M52	M56	M60	M64	M68	M72	M76
Width across flats	s	[mm]	60	65	70	75	80	85	90	95	100	105	110
Width across corners	a	[mm]	66	72	78	83	89	94	100	106	112	117	123
Height	m	[mm]	31	34	36	38	42	45	48	51	54	58	61
Weight		[kg]	0.5	1	0.8	1	1.2	1.4	2	2	2	2.6	3

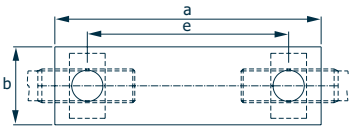
- Dimensions to ISO 4032, class 5/8/10.
  Constructional differences possible when using S355 as nut grade. Please contact our engineering department for information.

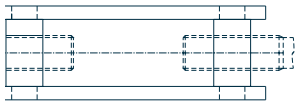
Domed Nuts*

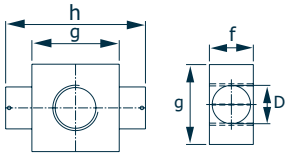
Grade 355 to Grade 500 in S355 | Grade 720 in class 10

Nominal Diameter	ØD$_1$	Metric	M39	M42	M45	M48	M52	M56	M60	M64	M68	M72	M76
Width Across Flats	s	[mm]	60	65	70	75	80	85	90	95	100	105	110
Width Across Corners	a	[mm]	66	72	78	83	89	94	100	106	112	117	123
Height	m	[mm]	31	34	36	38	42	45	48	51	54	58	61
Weight		[kg]	0.5	1	0.8	1	1.2	1.4	2	2	2	2.6	3

- Dimensions to ISO 4032, class 5/8/10.
  Constructional differences possible when using S355 as nut grade.
  Please contact our engineering department for information.

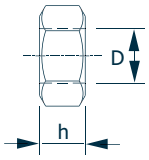


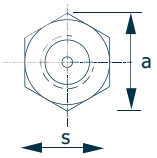




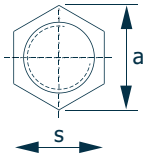
M80	M85	M90	M95	M100	M105	M110	M115	M120	M125	M130	M135	M140	M145	M150	M155	M160
775	790	840	860	865	875	880	880	900	900	915	935	945	960	975	990	1,005
180	190	200	210	220	230	240	250	270	280	290	300	310	320	330	350	360
30	30	35	35	40	40	40	40	45	45	50	50	50	55	55	60	60
550	550	590	590	580	580	570	560	560	550	550	550	550	550	550	550	550
80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160
115	120	130	135	145	150	155	165	170	180	185	190	200	210	210	220	230
190	190	210	220	240	240	250	260	270	280	300	300	310	330	330	350	360
65.7	70.7	92.3	99.2	119.5	126.4	132.6	138.2	171.7	178.0	208.3	220.2	230.0	265.3	277.8	326.4	340.8

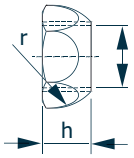
M80	M85	M90	M95	M100	M105	M110	M115	M120	M125	M130	M135	M140	M145	M150	M155	M160
810	860	880	900	910	925	930	935	955	960	980	995	1,010	1,025	1,045	1,060	1,080
200	240	230	240	260	270	280	290	310	320	340	350	360	370	390	400	420
40	45	45	50	55	55	60	60	65	65	70	70	75	75	80	80	85
550	550	590	590	580	580	570	560	560	550	550	550	550	550	550	550	550
80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160
115	120	130	135	145	150	155	165	170	180	185	190	200	210	210	220	230
210	220	230	250	270	270	290	300	310	320	340	340	360	370	380	390	410
101.7	145.8	143.0	169.6	204.3	215.7	245.3	255.4	302.1	313.5	366.2	382.7	428.1	446.6	511.9	532.5	605.3





M80	M85	M90	M95	M100	M105	M110	M115	M120	M125	M130	M135	M140	M145	M150	M155	M160
115	120	130	135	145	150	155	165	170	180	185	190	200	210	210	220	230
128	134	145	151	162	168	173	185	190	202	207	212	224	235	235	245	255
64	68	72	76	80	84	88	92	96	100	104	108	112	116	120	124	128
3.4	3.9	4.9	5.6	6.8	7.5	8.2	10.1	11.7	13	13.8	15.2	17.5	20.7	20	23.1	26.5





M80	M85	M90	M95	M100	M105	M110	M115	M120	M125	M130	M135	M140	M145	M150	M155	M160
115	120	130	135	145	150	155	165	170	180	185	190	200	210	210	220	230
128	134	145	151	162	168	173	185	190	202	207	212	224	235	235	245	255
64	68	72	76	80	84	88	92	96	100	104	108	112	116	120	124	128
3.4	3.9	4.9	5.6	6.8	8	8.2	10.1	11.7	13	13.8	15.2	17.5	20.7	20	23	27

Shackle Joint for Tie Rods

Grade 355

Nominal Diameter	$ØD_1$	Metric	A150	A175	A200	A225	A250	A275	A300A	A300B	A325
Length (Plate)	a	[mm]	195	220	255	270	310	340	380	380	405
Height (Plate)	b	[mm]	80	90	100	110	130	140	150	150	160
Thickness (Plate)	c	[mm]	15	15	20	20	25	25	25	30	30
Hole Spacing (Plate)	e	[mm]	90	105	130	135	150	165	190	190	200
Diameter (Pin)	g	[mm]	30	33	36	40	47	52	56	56	62
Length (Pin)	k	[mm]	90	95	110	120	135	140	145	160	160
Weight		[kg]	4.3	5.5	9.1	10.8	18	21.6	25.9	30.5	35.1

Grade 500

Nominal Diameter	$ØD_1$	Metric	A150	A175	A200	A225	A250	A275	A300A	A300B	A325
Length (Plate)	a	[mm]	195	220	255	275	310	340	380	380	405
Height (Plate)	b	[mm]	80	90	100	110	130	140	150	150	160
Thickness (Plate)	c	[mm]	15	20	20	25	25	30	30	35	35
Hole Spacing (Plate)	e	[mm]	90	105	130	135	150	165	190	190	200
Diameter (Pin)	g	[mm]	30	33	36	41	47	52	56	56	62
Length (Pin)	k	[mm]	90	105	110	130	135	150	155	170	170
Weight		[kg]	4.3	7	9.1	13.4	18	25.3	30.4	35	40.1

Grade 720 on request

Rocker Plate for Tie Rods

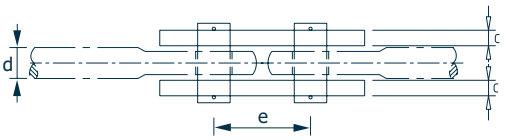
Grade 355 to EAU with kt 0.55 and Grade 355 Anchor with kt 0.6 in S355

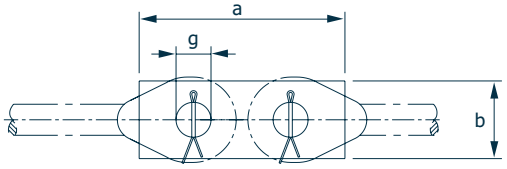
Nominal Diameter	$ØD_1$	Metric	M39	M42	M45	M48	M52	M56	M60	M64	M68	M72	M76
Plate Width	b	[mm]	80	90	90	100	100	110	120	120	130	140	140
Plate Height	h	[mm]	70	80	80	90	90	100	110	110	120	120	130
Plate Thickness	t	[mm]	20	30	30	30	30	30	40	40	40	40	40
Rocker	s	[mm]	50	50	50	50	50	50	50	50	50	50	50
Weight		[kg]	1.1	1.8	1.8	2.2	2	2.5	3.8	3.7	4.4	4.5	4.9

Threaded Rocker Plate for Tie Rods

Grade 355 to EAU with kt 0.55 and Grade 355 Anchor with kt 0.6 in S355

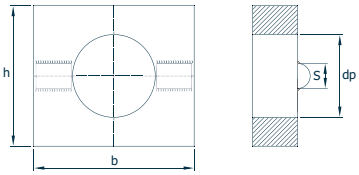
Nominal Diameter	$ØD_1$	Metric	M39	M42	M45	M48	M52	M56	M60	M64	M68	M72	M76
Plate Width	b	[mm]	100	110	110	120	130	150	150	150	160	160	180
Plate Height	h	[mm]	100	110	110	120	130	150	150	150	160	160	180
Plate Thickness	t	[mm]	35	40	40	45	45	50	55	60	65	65	70
Rocker	s	[mm]	50	50	50	50	50	50	50	50	50	50	50
Weight		[kg]	2.9	3.9	3.8	5	5.8	8.6	9.2	9.7	11.9	11.7	16.1



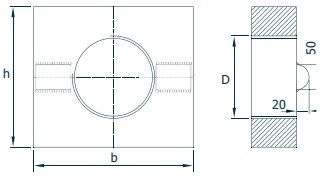


A350	A375A	A375B	A400	A425	A450	A475	A500	A525	A550	A575	A600	A625	A650
445	465	465	505	545	570	605	640	660	680	705	735	775	805
180	180	180	200	210	220	230	250	260	260	270	280	300	310
30	35	35	40	40	40	45	50	50	50	55	55	60	60
220	230	230	255	280	290	310	325	330	350	360	375	400	410
68	70	70	76	80	85	90	95	100	100	105	110	115	120
165	180	185	200	205	215	230	245	250	255	275	280	295	300
43.5	52.4	52.7	71.7	81.4	90.4	111.9	141.3	152.7	157.4	186.2	202.5	246.9	266.3

A350	A375A	A375B	A400	A425	A450	A475	A500	A525	A550	A575	A600	A625	A650
445	465	465	505	545	570	605	640	660	695	720	750	795	820
180	180	180	200	210	220	230	250	260	270	280	300	310	320
40	40	40	45	50	50	55	55	60	60	65	65	70	70
220	230	230	255	280	290	310	325	330	350	360	375	400	410
68	70	70	76	80	85	90	95	100	105	110	115	120	125
185	190	195	210	225	235	250	255	270	275	295	300	315	320
56	58.9	59.2	79.6	99.3	110	133.6	153.8	179.5	197.2	229.6	256.6	301.1	322.2



M80	M85	M90	M95	M100	M105	M110	M115	M120	M125	M130	M135	M140	M145	M150	M155	M160
150	160	180	180	190	200	210	220	230	240	250	260	270	280	290	300	310
130	140	150	150	160	170	180	190	190	200	210	220	230	240	240	250	250
40	50	50	50	50	60	60	60	60	70	70	70	70	80	80	90	90
60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
5.4	7.8	9.6	9.2	10.3	14	15.5	17.1	17.2	21.7	23.7	25.8	28.6	34.4	35.3	42.5	43.5



M80	M85	M90	M95	M100	M105	M110	M115	M120	M125	M130	M135	M140	M145	M150	M155	M160
180	180	200	200	220	220	220	230	240	250	260	280	280	300	300	320	320
180	180	200	200	220	220	220	230	240	250	260	280	280	300	300	320	320
80	80	85	95	100	105	110	115	120	130	140	150	150	150	150	160	160
60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
18.3	17.8	23.7	25.7	33.2	34	34.8	39.7	44.9	52.6	61.1	77.1	75.7	88.3	86.8	106.7	105.1

Universal Joints for Tie Rods

Grade 355 to EAU with k_t 0.55 and Grade 355 Anchor with k_t 0.6 in S355

Nominal Diameter	ØD$_1$	Metric	M39	M42	M45	M48	M52	M56	M60	M64	M68	M72	M76
Length (Plate)	a	[mm]	195	220	235	265	275	290	305	330	350	365	405
Height and Width (Plate)	b	[mm]	90	90	100	110	110	130	130	140	150	160	170
Leg Thickness (Plate)	c	[mm]	14	15	16	17	18	20	21	23	24	25	27
Hole Spacing (Plate)	e	[mm]	105	120	125	150	150	155	160	175	190	190	220
Leg Length (Plate)	f	[mm]	91	103	110	124	129	135	142	154	163	170	189
Diameter (Pin)	g	[mm]	33	35	39	41	43	48	50	55	58	61	65
Length (Pin)	k	[mm]	90	95	100	105	110	120	125	130	140	145	150
Weight		[kg]	5.2	6.2	7.9	10.3	11.3	15.9	17.5	22	26.4	30.7	38.3

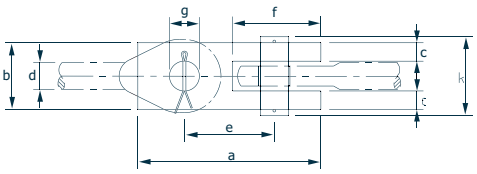
Universal Joints at Waling for Tie Rods

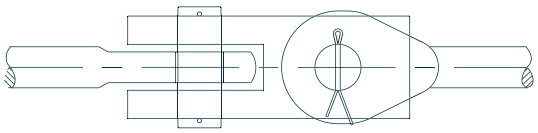
Grade 355 to EAU with k_t 0.55 and Grade 355 Anchor with k_t 0.6 in S355

Nominal Diameter	ØD$_1$	Metric	M39	M42	M45	M48	M52	M56	M60	M64	M68	M72	M76
Length (Plate)	a	[mm]	Length to suit installation conditions										
Height and Width (Plate)	b	[mm]	90	90	100	110	110	130	130	140	150	160	170
Leg Thickness (Plate)	c	[mm]	14	15	16	17	18	20	21	23	24	25	27
Hole Spacing (Plate)	e	[mm]	Length to suit installation conditions										
Leg Length (Plate)	f	[mm]	91	103	110	124	129	135	142	154	163	170	189
Diameter (Pin)	g	[mm]	33	35	39	41	43	48	50	55	58	61	65
Length (Pin)	k	[mm]	90	95	100	105	110	120	125	130	140	145	150

Grade 720 on request.

Length (a) and hole spacing (e) for a universal joint at the waling to suit customer specification or type of installation.





M80	M85	M90	M95	M100	M105	M110	M115	M120	M125	M130	M135	M140	M145	M150	M155	M160
425	435	475	500	545	580	595	615	655	680	705	740	755	785	815	860	890
180	190	200	210	220	230	240	250	270	280	290	300	310	320	330	350	360
28	30	32	34	36	37	39	40	42	44	46	48	50	52	55	57	58
230	230	255	265	295	320	320	330	355	365	380	400	400	415	430	460	470
199	203	222	233	255	272	278	288	307	318	330	346	353	367	380	402	416
68	73	77	82	87	91	95	99	104	108	113	118	122	126	131	136	141
160	165	175	185	195	200	210	215	225	235	245	255	260	270	280	290	300
44.2	51.3	62.3	73.6	88	100.3	113.8	125.7	151.4	171	191.8	217.4	237.8	264.9	299.2	345.4	376.5

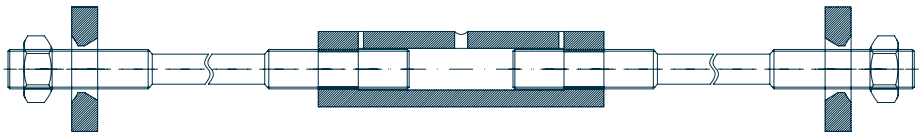
M80	M85	M90	M95	M100	M105	M110	M115	M120	M125	M130	M135	M140	M145	M150	M155	M160
Length to suit installation conditions																
180	190	200	210	220	230	240	250	270	280	290	300	310	320	330	350	360
28	30	32	34	36	37	39	40	42	44	46	48	50	52	55	57	58
Length to suit installation conditions																
199	203	222	233	255	272	278	288	307	318	330	346	353	367	380	402	416
68	73	77	82	87	91	95	99	104	108	113	118	122	126	131	136	141
160	165	175	185	195	200	210	215	225	235	245	255	260	270	280	290	300

Typical Complete Tie Rod Systems

Compensate for Shallow Angles of up to max. 5°

Components

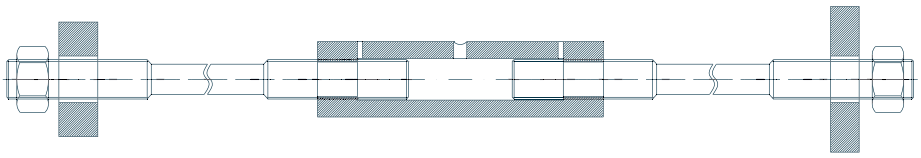
- Spherical Collar Nut
- End Plate with Spherical Recess
- Anchor Thread–Thread
- Turnbuckle
- Anchor Thread–Thread
- End plate with Spherical Recess
- Spherical Collar Nut



Dead Man

Components

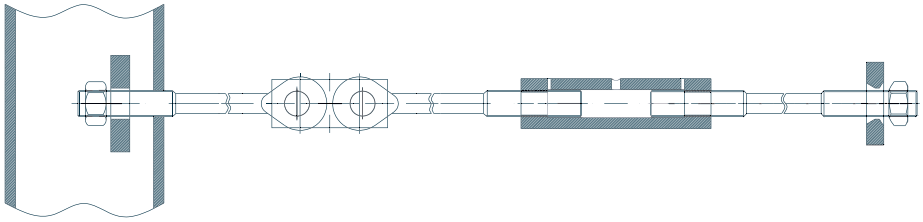
- Nut
- Rear Plate
- Anchor Thread–Thread
- Turnbuckle
- Anchor Thread–Thread
- Rear Plate
- Nut



Combined Sheet Piling with Tubular Piles

Components

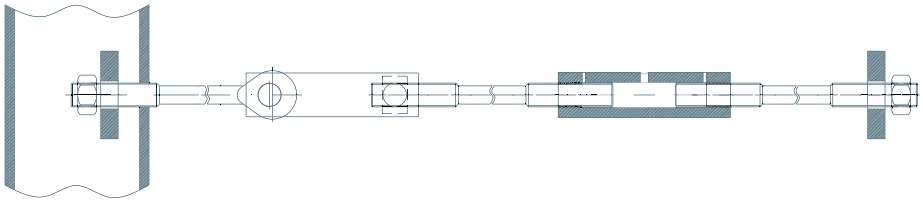
- Tube
- Plate
- Nut
- Eye Rod
- Shackle Joint
- Eye Rod
- Turnbuckle
- Anchor Thread–Thread
- End Plate with Spherical Recess
- Spherical Collar Nut



Combined Sheet Piling when using Grade 720

Components

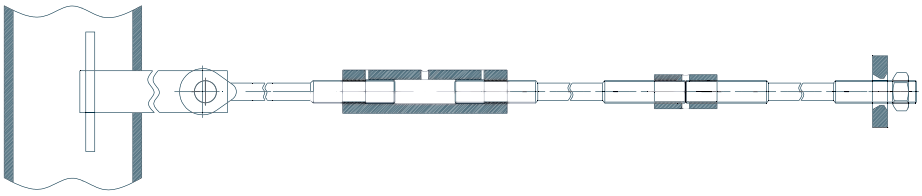
- Tube
- Plate
- Nut
- Eye Rod
- Shackle Joint Turnbuckle
- Anchor Thread–Thread
- Turnbuckle
- Anchor Thread–Thread
- Plate
- Nut



Anchors Connected to Tubular Piles

Components

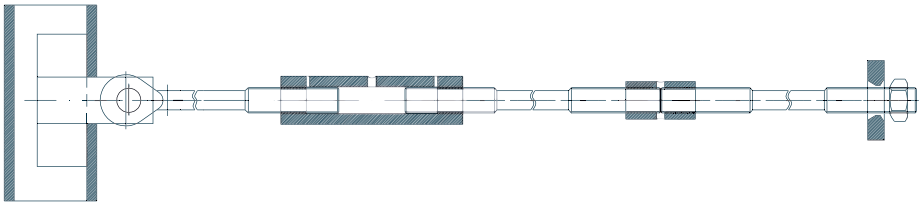
- Tube
- T-Connection
- Eye Rod
- Turnbuckle
- Anchor Thread–Thread
- Coupler
- Anchor Thread–Thread
- End Plate with Spherical Recess
- Spherical Collar Nut



Heavy-Duty Walls with Steel Sections

Components

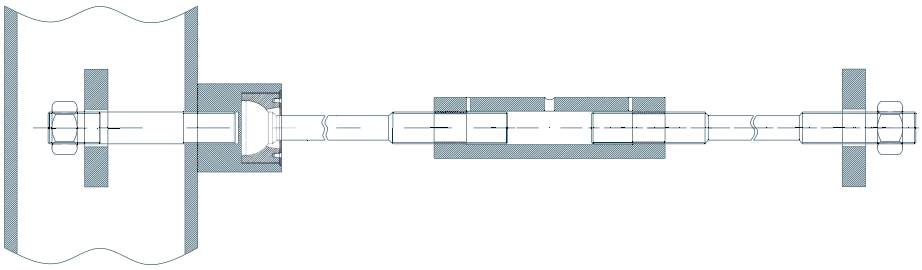
- HZ Section
- T-Connection
- Eye Rod
- Turnbuckle
- Anchor Thread–Thread
- Coupler
- Anchor Thread–Thread
- End Plate with Spherical Recess
- Spherical Collar Nut



Alternative Tubular Pile Connection Option Permitting Rotational Movement in all Directions

Components

- Tube
- Plate
- Nut
- Anchor Thread–Thread
- Ball Fitting
- Anchor with Head for Ball Fitting
- Turnbuckle
- Anchor Thread–Thread
- Plate
- Nut

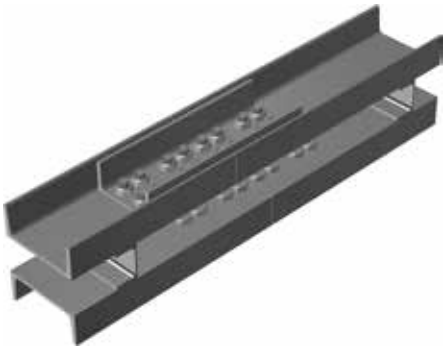


Walings

The waling system function typically is to transfer the loads from the sheet pile wall to the tie rods. Additionally the waling system aligns and stiffens the sheet pile wall. In general the waling system is located inside the main shoring wall. For a waling beam usually two latticed steel channels are used. Common steel profiles therefor are UPE or UNP types but also single LARSSEN or I-sections can be used. The spacing between two waling steel profiles depend on the tie rod diameter as well as the inclination of the tie rods and are generated by the use of additional welded on web plates.

Waling beam segments usually have a length equal to a multiple of the anchor spacing. Splice joints of the waling beams should be positioned in areas of minimum stress. This reduces the splicing costs to a minimum which means that the load capacity of the splicing is just equal to the internal forces which occur at this point of the structure. Our splice joints are prefabricated in a way that only one side of the waling beam has

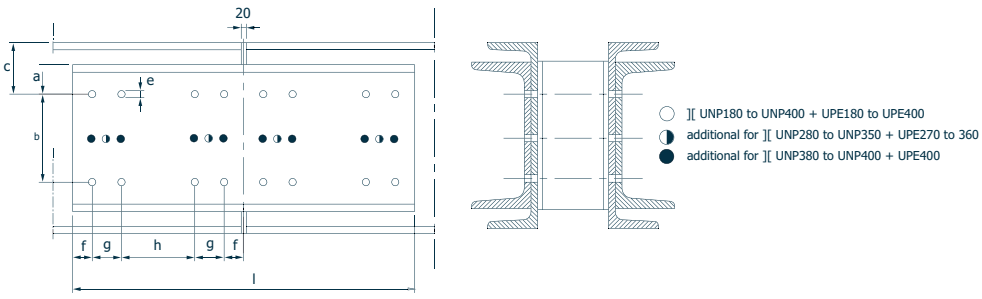
predrilled holes and the other side can be adapted according to the site conditions. Another opportunity is to use welded joint connections where no prefabrication is required.



Waling Splice Joint

][	Waling		Splicing piece][			Dimensions							Bolts, DIN 933			Nut	Washer	Weight
	Wy [kg]/m		][	l	[kg]	a	b	c	e Ø	f	g	h	No.	Size	L	DIN 934	DIN 125	[kg]
	[cm³]			[mm]		[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]				[mm]		
UNP180	300	44	UNP120	560	14.9	37.5	45	67.5	22	40	60	80	32	M20	45	Ø37/ Ø21 x 3	M20	8
UNP200	382	50.6	UNP140	640	20.5	40	60	70	22	40	60	120	32	M20	45	Ø37/ Ø21 x 3	M20	8
UNP220	490	58.8	UNP160	680	25.7	40	80	70	22	40	60	140	32	M20	45	Ø37/ Ø21 x 3	M20	8
UNP240	600	66.4	UNP180	740	32.6	45	90	75	26	50	75	120	32	M24	50	Ø44/ Ø25 x 4	M24	13
UNP260	742	75.8	UNP200	800	40.5	45	110	75	26	50	75	150	32	M24	50	Ø44/ Ø25 x 4	M24	13
UNP280	892	83.8	UNP220	840	49.4	50	120	80	26	50	90	140	40	M24	55	Ø44/ Ø25 x 4	M24	16
UNP300	1,070	92.4	UNP220	920	54.1	50	120	90	26	50	90	180	40	M24	55	Ø44/ Ø25 x 4	M24	16
UNP320	1,360	119	UNP240	1,000	66.4	55	130	95	32	60	110	160	40	M30	65	Ø56/ Ø31 x 4	M30	35
UNP350	1,468	121.2	UNP260	1,000	75.8	60	140	105	32	60	110	160	40	M30	65	Ø56/ Ø31 x 4	M30	35
UNP380	1,660	126.2	UNP300	1,000	92.2	60	180	100	32	60	90	200	48	M30	65	Ø56/ Ø31 x 4	M30	42
UNP400	2,040	143.6	UNP300	1,000	92.2	60	180	110	32	60	90	200	48	M30	65	Ø56/ Ø31 x 4	M30	42
UPE180	301	39.5	UPE120	560	13.6	37.5	45	67.5	22	40	60	80	32	M20	45	Ø37/ Ø21 x 3	M20	8
UPE200	382	45.6	UPE140	640	18.6	40	60	70	22	40	60	120	32	M20	45	Ø37/ Ø21 x 3	M20	8
UPE220	488	53.2	UPE160	680	23.2	40	80	70	22	40	60	140	32	M20	45	Ø37/ Ø21 x 3	M20	8
UPE240	600	60.5	UPE180	740	29.2	45	90	75	26	50	75	120	32	M24	50	Ø44/ Ø25 x 4	M24	13
UPE270	780	70.4	UPE200	840	38.3	45	110	80	26	50	90	140	40	M24	55	Ø44/ Ø25 x 4	M24	16
UPE300	1,043	88.9	UPE220	920	49	50	120	90	26	50	90	180	40	M24	55	Ø44/ Ø25 x 4	M24	16
UPE330	1,335	106.4	UPE240	1,000	60.5	55	130	100	32	60	110	160	40	M30	65	Ø56/ Ø31 x 4	M30	35
UPE360	1,648	122.4	UPE270	1,000	70.4	65	140	110	32	60	110	160	40	M30	65	Ø56/ Ø31 x 4	M30	35
UPE400	2,098	144.4	UPE300	1,000	88.9	60	180	110	32	60	90	200	48	M30	65	Ø56/ Ø31 x 4	M30	42

Steel grade: S235JR / S355

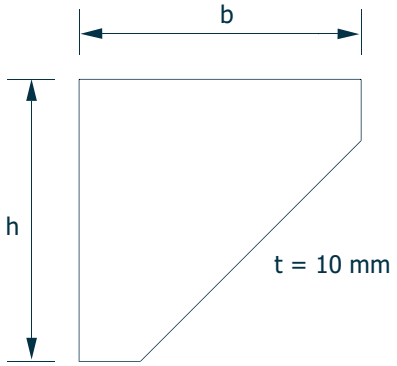


Waling Bracket

Waling Section		][180	][200	][220	][240	][260	][280	][300	][320	][350	][380	][400
h	[mm]	230	250	270	290	310	330	350	370	400	430	450
b	[mm]	230	250	270	290	310	330	350	370	400	430	450
	[kg]	2.89	3.34	3.83	4.35	4.90	5.48	6.09	6.73	7.76	8.85	9.62

Steel grade: S235JR / S355

Other forms made from channel sections are possible.



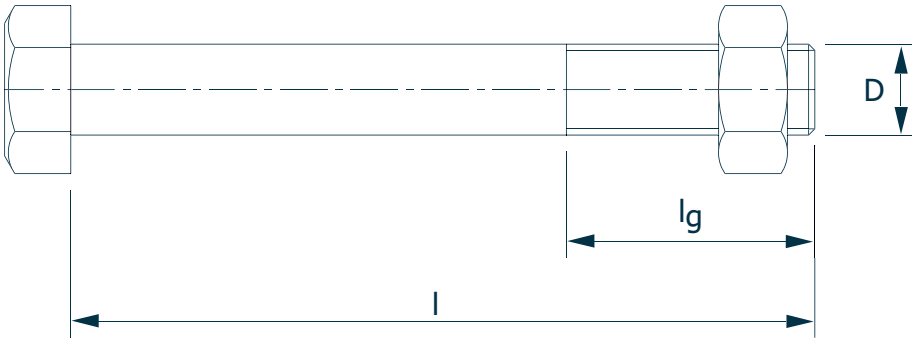
Waling Bolt with Head and Nut

D	Metric	M27	M33	M39	M45	M52	M56	M64	M72	M76	M85	M90
][200	l [mm]	320	320	340	360							
	lg [mm]	85	95	105	115							
	[kg]	1.54	2.50	3.88	5.61							
][220	l [mm]	340	340	360	380	400						
	lg [mm]	85	95	105	115	125						
	[kg]	1.62	2.62	4.05	5.83	8.21						
][240	l [mm]	360	360	380	400	420	420	440	460			
	lg [mm]	85	95	105	115	125	130	135	140			
	[kg]	1.70	2.73	4.22	6.06	8.51	10.06	13.67	18.08			
][260	l [mm]	380	380	400	420	440	440	460	480	500	510	530
	lg [mm]	85	95	105	115	125	130	135	140	145	150	155
	[kg]	1.77	2.85	4.39	6.29	8.80	10.41	14.11	18.65	22.72	28.88	34.24
][280	l [mm]	400	400	420	440	460	460	480	500	520	530	550
	lg [mm]	85	95	105	115	125	130	135	140	145	150	155
	[kg]	1.85	2.97	4.56	6.52	9.10	10.76	14.56	19.23	23.36	29.69	35.16
][300	l [mm]		420	440	460	480	480	500	520	540	550	570
	lg [mm]		95	105	115	125	130	135	140	145	150	155
	[kg]		3.09	4.73	6.75	9.39	11.10	15	19.80	24	30.50	36.07
][320	l [mm]		440	460	480	500	500	520	540	560	570	590
	lg [mm]		95	105	115	125	130	135	140	145	150	155
	[kg]		3.21	4.89	6.97	9.69	11.45	15.44	20.32	24.64	31.31	36.98
][350	l [mm]			490	510	530	530	550	570	590	600	620
	lg [mm]			105	115	125	130	135	140	145	150	155
	[kg]			5.15	7.32	10.13	11.97	16.11	21.22	25.60	32.53	38.35
][380	l [mm]			520	540	560	560	580	600	620	630	650
	lg [mm]			105	115	125	130	135	140	145	150	155
	[kg]			5.40	7.66	10.58	12.49	16.78	22.08	26.56	33.74	39.72
][400	l [mm]			540	560	580	580	600	620	640	650	670
	lg [mm]			105	115	125	130	135	140	145	150	155
	[kg]			5.57	7.89	10.88	12.84	17.22	22.65	27.20	34.58	40.63

Steel grade: S355 / S355J2+N

The weight includes the nut

Also available in Grade 500 / 8.8 / 10.9



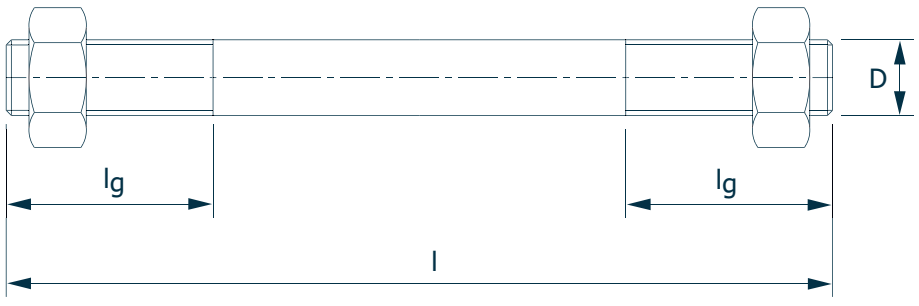
Waling Stud with two Nuts

D	Metric	M27	M33	M39	M45	M52	M56	M64	M72	M76	M85	M90
][200	l [mm]	350	380	400	440							
	lg [mm]	85	95	105	115							
	[kg]	1.65	2.86	4.38	6.42							
][220	l [mm]	380	410	430	460	480						
	lg [mm]	85	95	105	115	125						
	[kg]	1.77	3.03	4.63	6.65	9.31						
][240	l [mm]	390	420	440	470	510	510	530	560	580	600	630
	lg [mm]	85	95	105	115	125	130	135	140	145	150	155
	[kg]	1.81	3.09	4.72	6.76	9.75	11.64	15.57	20.77	24.34	31.88	37.93
][260	l [mm]	410	440	460	490	530	530	550	580	600	620	650
	lg [mm]	85	95	105	115	125	130	135	140	145	150	155
	[kg]	1.88	3.21	4.89	6.99	10.05	11.98	16.01	21.34	24.98	32.68	38.84
][280	l [mm]	430	460	480	510	550	550	570	600	620	640	670
	lg [mm]	85	95	105	115	125	130	135	140	145	150	155
	[kg]	1.96	3.33	5.06	7.22	10.35	12.33	16.96	21.91	25.62	33.49	39.76
][300	l [mm]		480	510	540	570	570	600	620	640	660	690
	lg [mm]		95	105	115	125	130	135	140	145	150	155
	[kg]		3.45	5.31	7.56	10.64	12.68	17.12	22.48	26.26	34.80	40.67
][320	l [mm]			530	560	590	590	620	640	660	680	710
	lg [mm]			105	115	125	130	135	140	145	150	155
	[kg]			5.48	7.79	10.94	13.02	17.57	23.05	26.90	35.11	41.58
][350	l [mm]			550	580	620	620	640	660	680	710	740
	lg [mm]			105	115	125	130	135	140	145	150	155
	[kg]			5.65	8.02	11.38	13.54	18.01	23.62	27.54	36.33	42.95
][380	l [mm]			580	610	650	650	670	680	710	740	770
	lg [mm]			105	115	125	130	135	140	145	150	155
	[kg]			5.90	8.36	11.83	14.06	18.68	24.19	28.50	37.54	44.32
][400	l [mm]			600	630	670	670	690	700	730	760	790
	lg [mm]			105	115	125	130	135	140	145	150	155
	[kg]			6.07	8.59	12.12	14.41	19.12	24.76	29.14	38.35	45.23

Steel grade: S355 / S355J2+N

The weight includes the nut

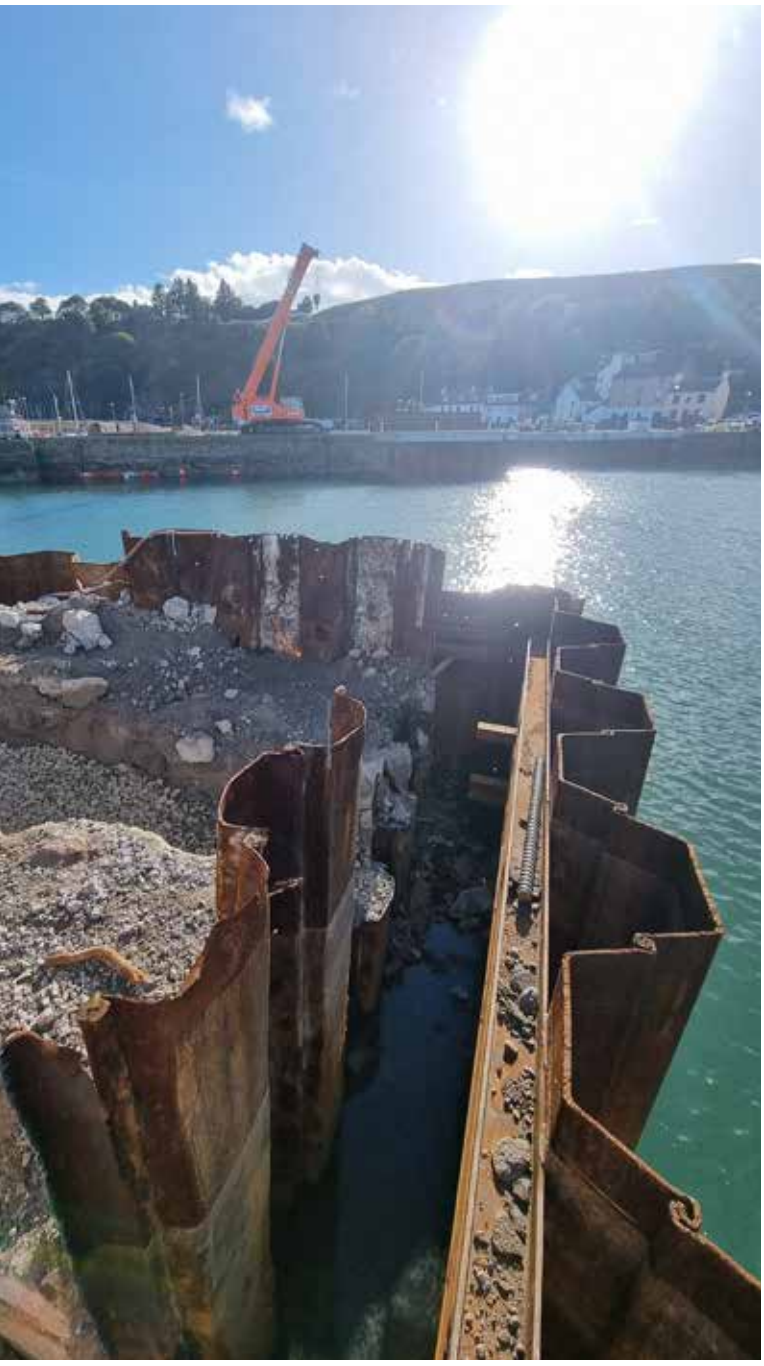
Also available in Grade 500 / 8.8 / 10.9



Appendix

List of Standards and Directives

Standard	Date	Characteristics
DIN 976-1	2002-12	Stud bolts – Part 1: Metric thread
DIN 19703	2014-06	Locks for waterways for inland navigation – Principles for dimensioning and equipment
DIN 1054	2010-12	Subsoil – Verification of the safety of earthworks and foundations – Supplementary rules to DIN EN 1997-1
DIN EN 1090-1	2012-02	Execution of steel structures and aluminium structures Part 1: Requirements for conformity assessment of structural components
DIN EN 1090-2	2011-10	Execution of steel structures and aluminium structures Part 2: Technical requirements for steel structures
DIN 1478	2005-09	Turnbuckles made from steel tubes or round steel bars
DIN EN 1561	2012-01	Founding – Grey cast irons
DIN EN 1563	2012-03	Founding – Spheroidal graphite cast irons
DIN EN 1993-1-1	2010-12	Eurocode 3: Design of steel structures Part 1-1: General rules and rules for buildings
DIN EN 1993-1-1/NA	2010-12	National Annex – Nationally Determined Parameters Eurocode 3: Design of steel structures Part 1-1: General rules and rules for buildings
DIN EN 1993-1-5	2010-12	Eurocode 3: Design of steel structures – Part 1-5: Plated structural elements
DIN EN 1993-1-5/NA	2010-12	National Annex – Nationally Determined Parameters Eurocode 3: Design of steel structures Part 1-5: Plated structural elements
DIN EN 10025-2	2005-04	Hot-rolled products of structural steels Part 2: Technical delivery conditions for non-alloy structural steels
DIN EN 10027-1	2005-10	Designation systems for steels – Part 1: Steel names
DIN EN 10059	2004-02	Hot-rolled square steel bars for general purposes – Dimensions and tolerances on shape and dimensions
DIN EN 10060	2004-02	Hot-rolled round steel bars – Dimensions and tolerances on shape and dimensions
DIN EN 10061	2004-02	Hot-rolled hexagon steel bars – Dimensions and tolerances on shape and dimensions
DIN EN 10279	2000-03	Hot-rolled steel channels – Tolerances on shape, dimensions and mass
DIN 19704-1	2012-05	Hydraulic steel structures – Part 1: Criteria for design and calculation
DIN 19704-2	1998-05	Hydraulic steel structures – Part 2: Design and manufacturing
DIN EN ISO 4016	2011-06	Hexagon head bolts – Product grade C
DIN EN ISO 8062-3	2008-09	Geometrical Product Specifications (GPS) – Dimensional and geometrical tolerances for moulded parts Part 3: General dimensional and geometrical tolerances and machining allowances for castings
DIN EN ISO 9001	2008-12	Quality management systems – Requirements
DIN EN ISO 9013	2003-07	Thermal cutting – Classification of thermal cuts – Geometrical product specification and quality tolerances
EAU2012	2004-12	Recommendations of the Committee for Waterfront Structures, Harbours and Waterways, EAU 2012
BS OHSAS 18001	2007	Occupational health and safety management systems – Requirements
DIN EN ISO 12944-1	1998-07	Paints and varnishes – Corrosion protection of steel structures by protective paint systems Part 2: Classification of environments
DIN EN ISO 3834-2	2006-03	Quality requirements for fusion welding of metallic materials Part 2: Comprehensive quality requirements
DIN EN 1993-5	2009-12	Eurocode 3: Design of steel structures – Part 5: Piling
DIN EN 1997-1	2014-03	Eurocode 7: Geotechnical design – Part 1: General rules
DIN EN 10025-6	2011-04	Hot-rolled products of structural steels – Part 6: Technical delivery conditions for flat products of high yield strength structural steels in the quenched and tempered conditions



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