



The HZ[®]-M Steel Wall System

New standard
EN 10248 – Part 1&2





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Introduction

The development of the HZ®-M Steel Wall System

The race to build larger vessels for the transport of containers and bulk cargo around the world has resulted in an increase of the draught of major ports, and consequently the need for more heavy-load berthing facilities has arisen. To cope with these deeper structures, conventional steel sheet piles have been replaced with "combined walls" which consist of two complementary elements: a primary element (king pile) and a secondary element (intermediary sheet pile).

Aware of this inescapable evolution in the main application field for the high range of conventional steel sheet piles, "Arbed" (ArcelorMittal since 2007) in Luxembourg started producing the **HZ-ZH** combined wall system in the 1970's. Quickly this system imposed itself as the first choice for the construction of new quay walls in major ports of Germany, Italy, the USA and many emerging economies.

Later in the 1990's, the development of the AZ steel sheet piles led to an improvement of the system: introduction of new HZ king piles that were available in different thicknesses, in combination with these AZ sheet piles as intermediary infill sheet piles. This **HZ/AZ** system encountered a matchless success and is still being used all over the world, in most large ports, in deep excavations, in deep watertight cofferdams, etc. Shipments of the HZ/AZ steel wall system during the last years confirmed this evolution.

At the beginning of the XXI century, trends continued evolving towards larger sea-going vessels. Loads on the future berths were expected to continue to increase. Several new mega-ports were on the planning stage, most existing ports were expanding their capacities. Those investments would have required the execution of a large amount of new quay walls and the deepening of existing ones. New types of applications required larger high-capacity retaining walls.

As a consequence, a shortage of production capacity of the HZ/AZ combined walls was predicted for the long-term. In order to continue to supply state-of-the-art and competitive foundation solutions, the new challenge faced by ArcelorMittal was developing deeper hot rolled HZ sections with thicker flanges, and providing a substantial increase in productivity and production capacity, as well as being more cost-effective. For this development, an incredible amount of parameters and constraints had to be considered by our R&D department.

In 2007, we launched the final research project. Many technical solutions were analysed, then several promising alternatives were investigated in detail in order to select the best choice: **a technically outstanding and proven system** based on existing experience and technology, and **economically a highly competitive solution** compared to existing systems and alternative construction methods and materials.

The HZ®-M Steel Wall concept consists in **hot rolling a wide flange beam, the HZ®-M, with variable thickness of the flange, and subsequently milling a groove into the flanges**, on which a connector is threaded. The finished product is quite similar to the previous HZ/AZ system.

This innovative system requires specialised milling equipment that was engineered and built for this high-precision task. The best suppliers were challenged to design and provide this exclusive milling instrument that would guarantee both a higher production capacity and productivity compared to the existing solution.

An additional advantage is that due to the tight milling tolerances which are achieved, a tighter and better mechanical connection between the flange of the king pile and the hot rolled connectors RH/RZ can be obtained.

Less than one year later, in 2008, ArcelorMittal was proud to supply just-in-time the first HZ®-M in a HZ®-M steel wall system for a huge project in Northern Germany. It proved to be a vast challenge mastered through excellent collaboration between several departments in Luxembourg: R&D, the rolling mill, the technical and the sales departments. The flexibility of the system has been further increased by extending the HZ-M range with the HZ 680M LT section in 2013.

Since 2015, with the introduction of the AZ-800 sections, new infill sheet piles are available which have further improved the competitiveness of the HZ®-M system. In 2019, the HZ 680M LT section was replaced by the new HZ 630M profile, to comply with the demand for stronger combined steel walls with construction height constraints.

We never doubted the success of this system and are confident that our customers will find within our large range of HZ/AZ combinations the most competitive solution for their project.

In 2019, ArcelorMittal has already delivered more than 1 million tonnes of the HZ/AZ system around the world: Brazil, Canada, France, Germany, Italy, Mexico, Nigeria, Poland, Russia, South Africa, The Netherlands, UK and USA, just to mention a few.

Launched in 2021, the **EcoSheetPile™ Plus** label certifies that the steel sheet piles are **produced from 100% recycled steel and 100% certified renewable electricity**.

This is covered by an Environmental Product Declaration (EPD), based on dedicated life-cycle analysis. EcoSheetPile™ Plus is an essential part of ArcelorMittal's **XCarb™ recycled and renewably produced** initiative to reach net zero by 2050.

EcoSheetPile™ Plus

XCarb®
Recycled and renewably
produced

The HZ[®]-M Steel Wall System

The HZ-M Steel Wall System is one of the most preferred solutions for port structures and other deep excavations. It is an HZ/AZ combined wall system that comprises the following elements:

- HZ-M king pile elements, fulfilling two different structural functions: withstand soil and hydrostatic pressures as well as bear vertical loads;
- a pair of AZ sheet piles as an intermediary element that has a soil-retaining and load-transferring function and is generally shorter than the HZ-M king piles;
- special hot rolled connectors (RH, RZD, RZU) connecting infill sheet piles and HZ-M king piles to guarantee a continuous wall.

The general concept of the HZ[®]-M Steel Wall System is based on a stiff king pile with light intermediary sheet piles resulting in an overall safe and cost-effective high capacity retaining structure, with a high stiffness and high bending moment capacity.

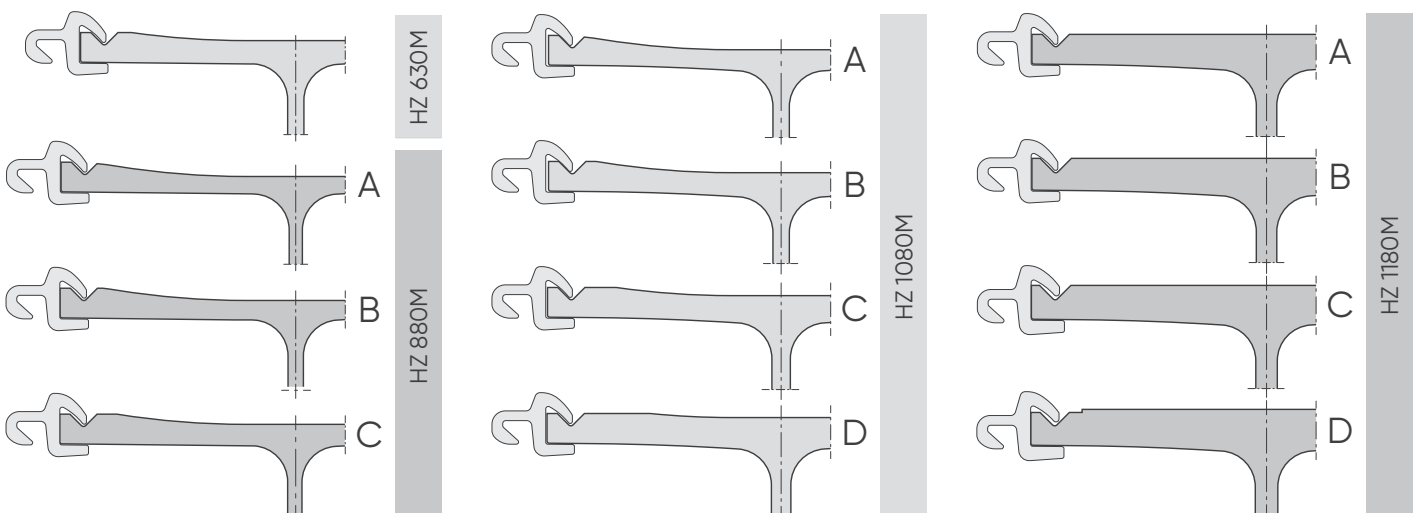
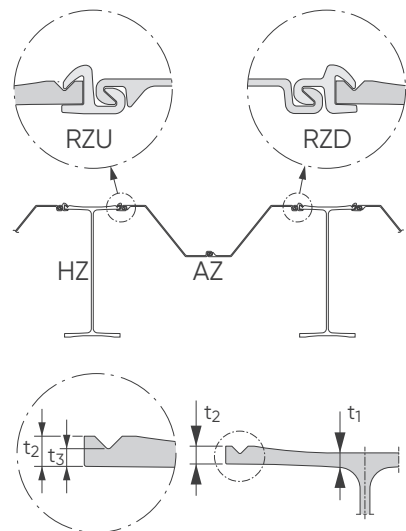
The main advantage of HZ-M king piles is the concave geometry of the flanges of the lighter sections, and the unmatched flange thickness of the heavier king pile sections with up to 40 mm.

To thread the RH/RZ connectors, a groove is milled into the flange. The milling equipment was designed to guarantee very tight tolerances of the groove, which improves interlocking of the connection and ensures sufficient residual steel thickness t_3 . The groove is milled if required; flanges without connectors are not milled.

The connectors are threaded over the mill grooves of the HZ-M pile and partially welded, thus increasing the stiffness and the section modulus of the whole wall. Unlike other combined wall system, the geometry of the connectors ensures a "mechanical connection" between the two elements of the HZ/AZ system and guarantees the continuity of the wall without relying on the welding of the connectors.

Additionally, the HZ/AZ system presents advantages compared to equivalent tube-combiwalls:

- it forms an almost straight wall on the water side/ excavation side;
- the depth of the HZ/AZ system is shallower, which is an advantage in tight situations (for instance, when installing a wall in front of an existing berthing facility);
- less impact of sea water corrosion on lifetime design (only front side flange of the HZ-M is exposed to sea water);
- the mechanical connection of RZ interlocks to the HZ-M beams provide additional safety, e.g. in case of corrosion of the fixation welding;
- the construction of the capping beam is easier and requires less concrete;
- anchoring of the HZ-M is more simple (see specific paragraph on page 47).



Characteristics

Definition of the HZ®-M Steel Wall System

The outstanding feature of the HZ/AZ combined wall system is the extensive collection of possible combinations using the entire AZ sheet pile range (6 solutions for each HZ-M section; AZ range including all rolled-up and rolled-down AZ sections). The combinations are based on the same principle: structural supports comprising 1 or 2 HZ-M king pile sections alternating with intermediary double AZ sheet pile sections, or as alternative without any infill sheet piles.

In this brochure, the tables are restricted to the main infill sheet pile options from our AZ rolling program, but data for other combinations are available on request.

Denomination of the HZ-M Steel Wall System:

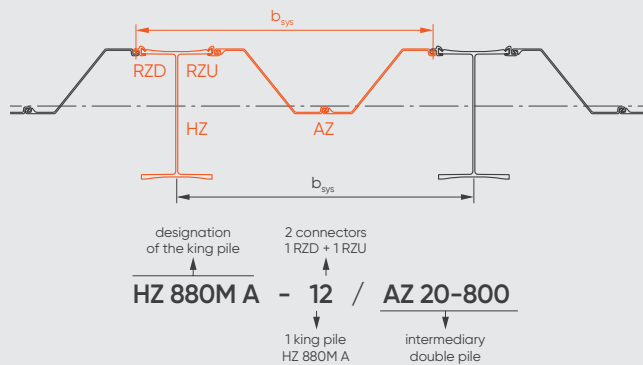
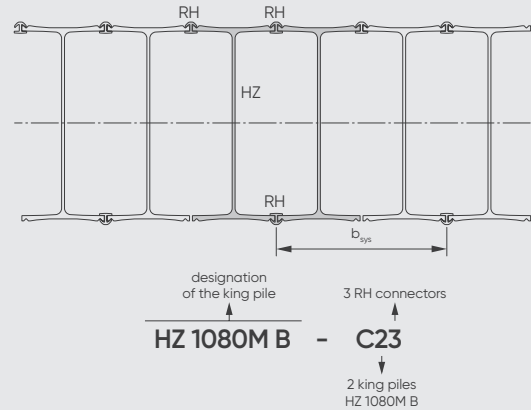
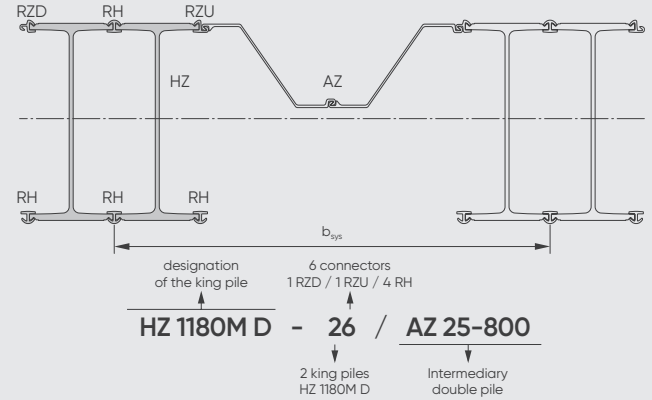
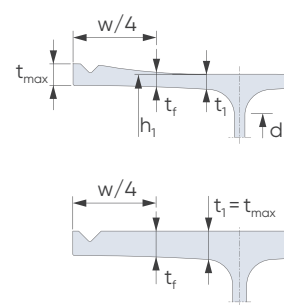
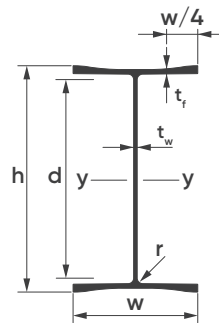


Fig.1. HZ/AZ steel wall system: definitions and designations.

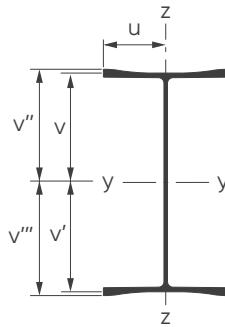


HZ®-M - King piles



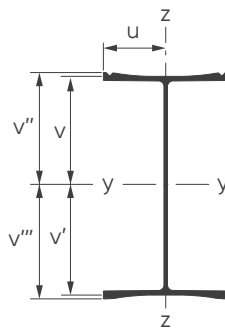
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	mm	mm	mm	mm	mm	mm	mm	mm	mm	cm ²	
HZ 630M	631.4	615.7	510.1	420	22.7	29.0	24.2	16.0	30	116.1	RZD/RZU 16 RH 16
HZ 880M A	831.3	803.4	709.6	458	16.9	29.0	18.9	13.0	30	120.0	RZD/RZU 16 RH 16
HZ 880M B	831.3	807.4	709.6	460	18.9	29.0	20.9	15.0	30	137.2	RZD/RZU 16 RH 16
HZ 880M C	831.3	811.4	709.6	460	20.9	29.0	22.9	15.0	30	139.0	RZD/RZU 16 RH 16
HZ 1080M A	1075.3	1047.4	945.6	454	20.7	29.0	19.6	16.0	30	185.8	RZD/RZU 16 RH 16
HZ 1080M B	1075.3	1053.4	945.6	454	23.7	29.0	22.6	16.0	30	188.3	RZD/RZU 16 RH 16
HZ 1080M C	1075.3	1059.4	945.6	456	26.7	29.0	25.7	18.0	30	211.4	RZD/RZU 16 RH 16
HZ 1080M D	1075.3	1067.4	945.6	457	30.7	30.7	29.7	19.0	30	225.1	RZD/RZU 16 RH 16
HZ 1180M A	1075.4	-	945.6	458	34.7	34.7	31.0	20.0	30	238.9	RZD/RZU 16 RH 16
HZ 1180M B	1079.4	-	945.6	458	36.7	36.7	33.0	20.0	30	240.6	RZD/RZU 16 RH 16
HZ 1180M C	1083.4	-	945.6	459	38.7	38.7	35.0	21.0	30	252.7	RZD/RZU 18 RH 20
HZ 1180M D	1087.4	-	945.6	460	40.7	40.7	37.0	22.0	30	264.9	RZD/RZU 18 RH 20

Solution 100



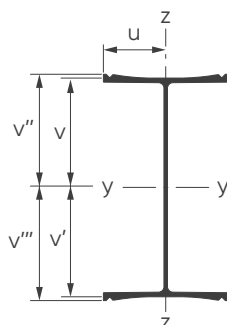
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	mm	mm	mm	mm	mm	cm ²	kg/m	cm ⁴	cm ⁴	cm ⁴	10 ³ cm ⁶	cm ³	cm ³	cm ³	m ² /m	m ² /m
HZ 630M	307.9	307.9	315.7	315.7	210.0	312.0	244.9	220860	34220	598.3	29450	7175	-	1630	0.421	2.430
HZ 880M A	401.7	401.7	415.7	415.7	229.0	299.8	235.3	362700	40000	399.0	60640	9030	-	1745	0.459	2.949
HZ 880M B	403.7	403.7	415.7	415.7	230.0	332.4	260.9	398680	42780	517.7	65270	9875	-	1860	0.461	2.951
HZ 880M C	405.7	405.7	415.7	415.7	230.0	346.9	272.3	422700	44360	597.7	68170	10420	-	1930	0.461	2.950
HZ 1080M A	523.7	523.7	537.7	537.7	227.0	371.8	291.9	699490	39320	547.9	102000	13355	-	1730	0.455	3.403
HZ 1080M B	526.7	526.7	537.7	537.7	227.0	395.2	310.2	764780	42300	685.5	110600	14520	-	1865	0.455	3.403
HZ 1080M C	529.7	529.7	537.7	537.7	228.0	437.2	343.2	843200	44950	904.7	118400	15920	-	1970	0.457	3.405
HZ 1080M D	533.7	533.7	537.7	537.7	228.5	471.2	369.9	919590	46930	1156.9	124900	17230	-	2055	0.457	3.405
HZ 1180M A	537.7	537.7	537.7	537.7	229.0	498.4	391.3	977280	47940	1391.0	128600	18175	-	2095	0.458	3.406
HZ 1180M B	539.7	539.7	539.7	539.7	229.0	516.7	405.6	1030390	51140	1592.0	137800	19090	-	2235	0.458	3.414
HZ 1180M C	541.7	541.7	541.7	541.7	229.5	545.9	428.5	1094540	54720	1860.3	148000	20205	-	2385	0.459	3.423
HZ 1180M D	543.7	543.7	543.7	543.7	230.0	575.1	451.5	1159330	58340	2177.9	158300	21325	-	2535	0.460	3.432

Solution 102



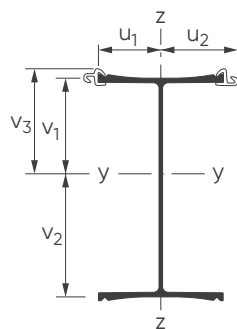
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	mm	mm	mm	mm	mm	cm ²	kg/m	cm ⁴	cm ⁴	cm ⁴	10 ³ cm ⁶	cm ³	cm ³	cm ³	m ² /m	m ² /m
HZ 630M	311.4	304.4	319.2	312.2	210.0	308.6	242.2	217460	33010	569.2	28410	6985	-	1570	0.440	2.430
HZ 880M A	406.1	397.3	420.1	411.3	229.0	296.6	232.8	357280	38650	375.0	58600	8800	-	1690	0.478	2.949
HZ 880M B	408.0	399.4	420.0	411.3	230.0	328.9	258.2	392750	41300	490.1	63000	9625	-	1795	0.481	2.951
HZ 880M C	409.9	401.5	419.8	411.5	230.0	343.4	269.6	416770	42880	570.2	65890	10170	-	1865	0.480	2.950
HZ 1080M A	528.2	519.2	542.2	533.1	227.0	368.7	289.4	690560	38020	525.9	98560	13075	-	1675	0.473	3.403
HZ 1080M B	531.4	522.0	542.4	532.9	227.0	391.7	307.5	754830	40860	656.5	106800	14205	-	1800	0.475	3.403
HZ 1080M C	534.0	525.4	541.9	533.4	228.0	433.7	340.5	833250	43490	876.2	114500	15605	-	1910	0.476	3.405
HZ 1080M D	537.7	529.7	541.6	533.7	228.5	467.7	367.2	909650	45470	1129.1	121000	16920	-	1990	0.477	3.405
HZ 1180M A	541.5	533.9	541.5	533.9	229.0	494.9	388.5	967270	46460	1352.9	124600	17865	-	2030	0.477	3.406
HZ 1180M B	544.5	534.9	544.5	534.9	229.0	512.1	402.0	1017000	49170	1544.3	132400	18675	-	2145	0.481	3.414
HZ 1180M C	546.3	537.1	546.3	537.1	229.5	541.2	424.9	1081070	52740	1817.9	142600	19790	-	2300	0.482	3.423
HZ 1180M D	550.4	537.0	550.4	537.0	230.0	568.1	445.9	1138630	55340	2110.2	150000	20690	-	2405	0.487	3.432

Solution 104



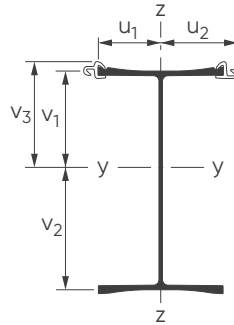
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	mm	mm	mm	mm	mm	cm ²	kg/m	cm ⁴	cm ⁴	cm ⁴	10 ³ cm ⁶	cm ³	cm ³	cm ³	m ² /m	m ² /m
HZ 630M	307.9	307.9	315.7	315.7	210.0	305.1	239.5	214130	31800	543.5	27440	6955	-	1515	0.440	2.449
HZ 880M A	401.7	401.7	415.7	415.7	229.0	293.4	230.3	351980	37300	352.1	56690	8760	-	1630	0.478	2.967
HZ 880M B	403.7	403.7	415.7	415.7	230.0	325.5	255.5	386940	39810	463.4	60880	9585	-	1730	0.481	2.970
HZ 880M C	405.7	405.7	415.7	415.7	230.0	339.9	266.8	410960	41390	543.2	63760	10130	-	1800	0.480	2.970
HZ 1080M A	523.7	523.7	537.7	537.7	227.0	365.6	287.0	681790	36720	500.8	95400	13020	-	1620	0.473	3.421
HZ 1080M B	526.7	526.7	537.7	537.7	227.0	388.3	304.8	745050	39420	629.6	103200	14145	-	1735	0.475	3.423
HZ 1080M C	529.7	529.7	537.7	537.7	228.0	430.3	337.8	823460	42040	849.0	110900	15545	-	1845	0.476	3.424
HZ 1080M D	533.7	533.7	537.7	537.7	228.5	464.3	364.4	899860	44000	1102.0	117300	16860	-	1925	0.477	3.425
HZ 1180M A	537.7	537.7	537.7	537.7	229.0	491.4	385.8	957390	44980	1332.0	120900	17805	-	1965	0.477	3.426
HZ 1180M B	539.7	539.7	539.7	539.7	229.0	507.5	398.4	1003860	47210	1511.8	127500	18600	-	2060	0.481	3.437
HZ 1180M C	541.7	541.7	541.7	541.7	229.5	536.6	421.2	1067820	50760	1780.5	137600	19710	-	2210	0.482	3.446
HZ 1180M D	543.7	543.7	543.7	543.7	230.0	561.0	440.4	1118440	52340	2042.4	142500	20570	-	2275	0.487	3.447

Solution 124



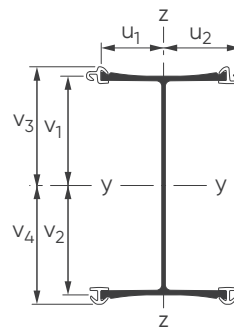
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	mm	mm	mm	mm	mm	cm ²	kg/m	cm ⁴	cm ⁴	cm ⁴	10 ³ cm ⁶	cm ³	cm ³	cm ³	m ² /m	m ² /m
HZ 630M	272.1	343.6	300.3	209.9	263.9	346.2	271.8	247130	52190	702.2	38320	7190	8230	1980	0.582	2.546
HZ 880M A	352.4	451.0	386.8	228.8	282.9	334.5	262.6	410130	61300	503.4	79340	9095	10605	2165	0.621	3.019
HZ 880M B	358.7	448.7	391.1	229.9	283.9	366.6	287.8	445810	64010	614.6	84400	9935	11400	2255	0.624	3.022
HZ 880M C	362.4	449.0	392.8	229.9	283.9	381.0	299.1	470100	65590	695.0	87810	10470	11970	2310	0.624	3.021
HZ 1080M A	470.8	576.6	505.1	226.9	280.9	406.7	319.3	783040	60320	651.8	133500	13580	15500	2150	0.617	3.473
HZ 1080M B	476.6	576.8	507.9	226.9	280.9	429.4	337.0	846900	63020	781.7	142700	14685	16675	2245	0.618	3.474
HZ 1080M C	484.1	575.3	512.4	227.9	281.9	471.4	370.0	926280	65840	998.7	151900	16100	18080	2335	0.619	3.476
HZ 1080M D	491.2	576.3	515.5	228.4	282.4	505.4	396.7	1003330	67900	1252.3	159500	17410	19465	2405	0.620	3.476
HZ 1180M A	497.3	578.1	517.6	228.9	282.9	532.6	418.1	1061330	68980	1495.6	163800	18360	20505	2440	0.621	3.477
HZ 1180M B	500.5	578.9	518.8	228.9	282.9	548.6	430.6	1108050	71210	1677.6	171400	19140	21360	2515	0.622	3.484
HZ 1180M C	500.8	582.6	520.1	229.4	283.4	582.2	457.0	1182510	76990	2024.9	186200	20300	22735	2715	0.635	3.493
HZ 1180M D	504.5	582.9	521.8	229.9	283.9	606.6	476.2	1233510	78680	2290.7	192000	21160	23640	2770	0.641	3.497

Solution 12



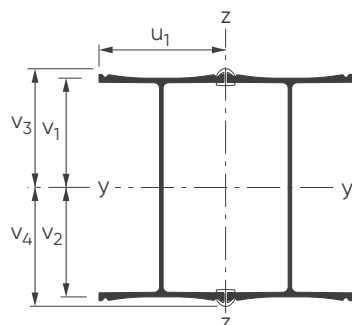
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	v_1	v_2	v_3	u_1	u_2	A	G	I_y	I_z	I_t	I_ω	$W_{el,y}^*$	$W_{el,y}^{**}$	$W_{el,z}$	A_{LW}	A_{LS}
	mm	mm	mm	mm	mm	cm ²	kg/m	cm ⁴	cm ⁴	cm ⁴	10 ³ cm ⁶	cm ³	cm ³	cm ³	m ² /m	m ² /m
HZ 630M	275.5	340.2	303.8	209.9	263.9	349.7	274.5	251260	53400	725.6	40250	7385	8270	2025	0.582	2.527
HZ 880M A	356.7	446.7	391.1	228.8	282.9	337.7	265.1	416790	62650	526.1	83160	9330	10660	2215	0.621	3.001
HZ 880M B	363.0	444.4	395.3	229.9	283.9	370.0	290.5	452960	65490	641.1	88550	10190	11460	2305	0.624	3.002
HZ 880M C	366.5	444.9	396.9	229.9	283.9	384.5	301.8	477210	67070	721.3	91940	10725	12025	2365	0.624	3.002
HZ 1080M A	475.6	571.8	509.9	226.9	280.9	409.8	321.7	793650	61620	674.8	139800	13880	15565	2195	0.617	3.455
HZ 1080M B	481.5	571.9	512.9	226.9	280.9	432.8	339.8	858610	64460	808.1	149600	15015	16740	2295	0.618	3.455
HZ 1080M C	488.5	570.9	516.8	227.9	281.9	474.8	372.8	937820	67290	1025.8	158800	16430	18145	2385	0.619	3.456
HZ 1080M D	495.3	572.1	519.6	228.4	282.4	508.8	399.4	1014760	69370	1279.6	166400	17735	19530	2455	0.620	3.457
HZ 1180M A	501.2	574.2	521.5	228.9	282.9	536.0	420.8	1072760	70460	1522.7	170900	18685	20570	2490	0.621	3.458
HZ 1180M B	505.3	574.1	523.6	228.9	282.9	553.2	434.3	1123200	73180	1717.8	180500	19565	21450	2585	0.622	3.462
HZ 1180M C	505.4	578.0	524.7	229.4	283.4	586.8	460.7	1197860	78970	2068.6	195500	20725	22830	2785	0.635	3.471
HZ 1180M D	511.2	576.2	528.5	229.9	283.9	613.7	481.7	1256780	81670	2358.7	205900	21815	23780	2875	0.641	3.476

Solution 14



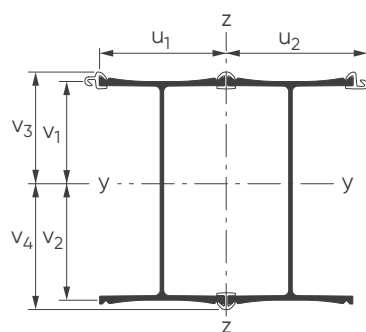
Section	Dimensions						Properties per solution										
	v_1	v_2	v_3	v_4	u_1	u_2	A	G	I_y	I_z	I_t	I_ω	$W_{el,y}^*$	$W_{el,y}^{**}$	$W_{el,z}$	A_{LW}	A_{LS}
	mm	mm	mm	mm	mm	mm	cm ²	kg/m	cm ⁴	cm ⁴	cm ⁴	10 ³ cm ⁶	cm ³	cm ³	cm ³	m ² /m	m ² /m
HZ 630M	307.5	308.3	335.7	336.6	209.9	263.9	386.5	303.4	288850	71250	865.8	62460	9370	8580	2700	0.582	2.808
HZ 880M A	401.1	402.3	435.4	436.8	228.9	282.9	374.8	294.2	484020	83820	656.6	129300	12030	11080	2965	0.621	3.236
HZ 880M B	403.1	404.3	435.5	436.8	229.9	283.9	406.8	319.4	518990	86730	766.1	134700	12835	11885	3055	0.624	3.239
HZ 880M C	405.1	406.3	435.5	436.7	229.9	283.9	421.3	330.7	543000	88310	847.1	138100	13365	12435	3110	0.624	3.239
HZ 1080M A	522.9	524.5	557.2	558.9	226.9	280.9	446.9	350.9	905800	82470	800.8	217700	17270	16205	2935	0.617	3.690
HZ 1080M B	526.0	527.4	557.3	558.9	226.9	280.9	469.6	368.6	969050	85170	930.9	226600	18375	17340	3030	0.618	3.691
HZ 1080M C	529.0	530.4	557.3	558.8	227.9	281.9	511.6	401.6	1047480	88170	1150.2	236400	19750	18745	3130	0.619	3.693
HZ 1080M D	533.1	534.3	557.4	558.8	228.4	282.4	545.6	428.3	1123870	90340	1402.1	244500	21035	20115	3200	0.620	3.693
HZ 1180M A	537.1	538.3	557.4	558.1	228.9	282.9	572.8	449.6	1181400	91500	1649.4	249500	21945	21170	3235	0.621	3.694
HZ 1180M B	539.1	540.3	557.4	558.7	228.9	282.8	588.8	462.2	1227870	93730	1832.0	257000	22725	21975	3315	0.622	3.696
HZ 1180M C	545.9	537.5	565.2	556.8	229.4	283.4	632.7	496.7	1331210	105640	2278.2	292200	24385	23550	3730	0.635	3.730
HZ 1180M D	547.8	539.6	565.1	556.9	229.9	283.9	657.1	515.8	1381830	107440	2534.5	298500	25225	24455	3785	0.641	3.736

Solution 22



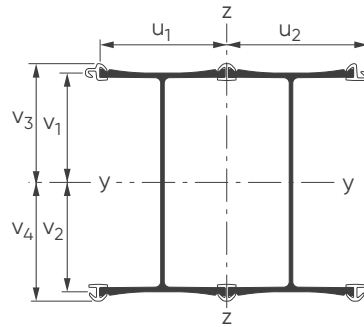
Section	Dimensions					Properties per solution										
	v_1	v_2	v_3	v_4	u_1	A	G	I_y	I_z	I_t	I_ω	$W_{el,y}^*$	$W_{el,y}^{**}$	$W_{el,z}$	A_{LW}	A_{LS}
	mm	mm	mm	mm	mm	cm ²	kg/m	cm ⁴	cm ⁴	cm ⁴	10 ³ cm ⁶	cm ³	cm ³	cm ³	m ² /m	m ² /m
HZ 630M	307.9	307.9	336.2	336.2	427.0	650.4	510.6	465570	351040	238756	70260	15125	13850	8220	0.925	2.934
HZ 880M A	401.7	401.7	436.2	436.2	465.0	627.1	492.3	769720	401560	330960	181100	19160	17650	8635	1.001	3.490
HZ 880M B	403.7	403.7	436.2	436.2	467.0	691.2	542.6	839650	445350	378656	185300	20800	19250	9535	1.007	3.497
HZ 880M C	405.7	405.7	436.2	436.2	467.0	720.1	565.3	887690	464770	387367	208900	21880	20355	9950	1.007	3.496
HZ 1080M A	523.7	523.7	558.1	558.1	461.0	771.4	605.6	1474960	473900	538547	371600	28165	26425	10280	0.993	3.941
HZ 1080M B	526.7	526.7	558.1	558.1	461.0	816.8	641.2	1601480	504130	555020	440200	30405	28695	10935	0.995	3.943
HZ 1080M C	529.7	529.7	558.1	558.1	463.0	900.8	707.1	1758320	559410	625885	468900	33195	31505	12080	0.998	3.946
HZ 1080M D	533.7	533.7	558.1	558.1	464.0	968.8	760.5	1911110	603080	670072	517400	35810	34240	12995	0.999	3.947
HZ 1180M A	537.7	537.7	558.1	558.1	465.0	1023.1	803.2	2026180	637490	709427	540700	37680	36305	13710	1.001	3.949
HZ 1180M B	539.7	539.7	558.1	558.1	465.0	1055.2	828.3	2119120	659790	696179	592500	39265	37970	14190	1.006	3.962
HZ 1180M C	541.7	541.7	561.0	561.0	467.0	1123.7	882.1	2274730	707070	745410	653200	41990	40550	15140	1.011	3.975
HZ 1180M D	543.7	543.7	561.0	561.0	468.0	1172.5	920.4	2375960	740430	781985	672700	43700	42350	15820	1.022	3.983

Solution 24



Section	Dimensions						Properties per solution										
	v_1	v_2	v_3	v_4	u_1	u_2	A	G	I_y	I_z	I_t	I_ω	$W_{el,y}^*$	$W_{el,y}^{**}$	$W_{el,z}$	A_{LW}	A_{LS}
	mm	mm	mm	mm	mm	mm	cm ²	kg/m	cm ⁴	cm ⁴	cm ⁴	10 ³ cm ⁶	cm ³	cm ³	cm ³	m ² /m	m ² /m
HZ 630M	290.0	325.8	318.3	354.1	426.9	480.9	691.5	542.9	500770	430330	253317	95210	15370	14140	8950	1.067	3.031
HZ 880M A	377.0	426.4	411.5	460.8	464.8	518.9	668.2	524.5	831930	495150	331071	240600	19510	18055	9540	1.144	3.542
HZ 880M B	381.2	426.2	413.6	458.7	466.9	520.9	732.3	574.8	902220	539720	378374	244700	21170	19670	10360	1.150	3.548
HZ 880M C	384.0	427.4	414.5	457.8	466.9	520.9	761.2	597.6	950390	559140	392241	271700	22240	20760	10735	1.150	3.548
HZ 1080M A	497.2	550.2	531.7	584.6	460.9	514.9	812.5	637.8	1581890	565930	539125	483600	28755	27060	10990	1.136	3.992
HZ 1080M B	501.6	551.8	533.1	583.2	460.9	514.9	857.9	673.4	1708720	596160	555194	560800	30970	29300	11580	1.138	3.995
HZ 1080M C	506.9	552.5	535.3	581.0	462.9	516.9	941.9	739.4	1866030	652220	625944	591700	33770	32120	12620	1.141	3.998
HZ 1080M D	512.4	555.0	536.8	579.4	463.9	517.9	1009.9	792.8	2019150	696280	670640	644900	36380	34850	13445	1.142	3.999
HZ 1180M A	517.5	557.9	537.9	578.3	464.9	518.9	1064.2	835.4	2134450	731080	717576	670400	38260	36905	14090	1.144	4.001
HZ 1180M B	520.1	559.3	538.5	577.7	464.9	518.9	1096.3	860.6	2227520	753380	719378	726200	39825	38555	14520	1.147	4.009
HZ 1180M C	521.3	562.1	540.6	581.4	466.9	520.9	1169.3	917.9	2394300	810730	745545	805400	42600	41185	15565	1.164	4.022
HZ 1180M D	524.2	563.2	541.5	580.5	467.9	521.9	1218.1	956.2	2495730	844530	783948	828700	44310	42990	16180	1.176	4.032

Solution 26



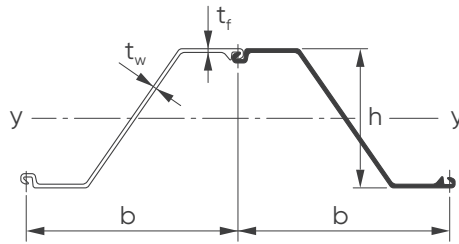
Section	Dimensions						Properties per solution										
	v_1	v_2	v_3	v_4	u_1	u_2	A	G	I_y	I_z	I_t	I_w	$W_{el,y}^*$	$W_{el,y}^{**}$	$W_{el,z}$	A_{LW}	A_{LS}
	mm	mm	mm	mm	mm	mm	cm ²	kg/m	cm ⁴	cm ⁴	cm ⁴	10 ³ cm ⁶	cm ³	cm ³	cm ³	m ² /m	m ² /m
HZ 630M	307.6	308.1	336.0	336.4	426.9	480.9	731.8	574.5	540280	506260	253467	129710	17535	16060	10530	1.067	3.292
HZ 880M A	401.4	402.0	435.8	436.5	464.9	518.9	708.5	556.1	901760	584930	331236	324481	22430	20660	11275	1.144	3.759
HZ 880M B	403.4	404.0	435.8	436.5	466.9	520.9	772.5	606.4	971700	630270	378596	325708	24050	22265	12100	1.150	3.766
HZ 880M C	405.4	406.0	435.9	436.5	466.9	520.9	801.5	629.2	1019730	649680	392302	356525	25115	23365	12475	1.150	3.765
HZ 1080M A	523.3	524.1	557.7	558.5	460.9	514.9	852.8	669.4	1698970	654200	545166	633900	32415	30420	12705	1.136	4.209
HZ 1080M B	526.3	527.1	557.7	558.5	460.9	514.9	898.1	705.0	1825490	684420	555301	719800	34635	32685	13295	1.138	4.212
HZ 1080M C	529.4	530.1	557.8	558.5	462.9	516.9	982.1	771.0	1982330	741240	626147	749200	37400	35495	14340	1.141	4.215
HZ 1080M D	533.4	534.0	557.8	558.5	463.9	517.9	1050.1	824.4	2135120	785680	670660	805600	39980	38235	15170	1.142	4.216
HZ 1180M A	537.4	538.0	557.8	558.4	464.9	518.9	1104.5	867.0	2250190	820860	716260	830900	41825	40295	15820	1.144	4.217
HZ 1180M B	539.4	540.0	557.8	558.4	464.9	518.8	1136.5	892.2	2343130	843160	719557	891800	43390	41960	16250	1.147	4.221
HZ 1180M C	543.9	539.5	563.2	558.8	466.9	520.9	1219.8	957.5	2538170	924710	746792	1022600	46665	45070	17755	1.164	4.259
HZ 1180M D	545.8	541.6	563.1	558.9	467.9	521.9	1268.6	995.9	2639410	959080	783756	1042400	48360	46875	18380	1.176	4.271

Note: Alternative solutions are available on request.

Combined wall, combination 24



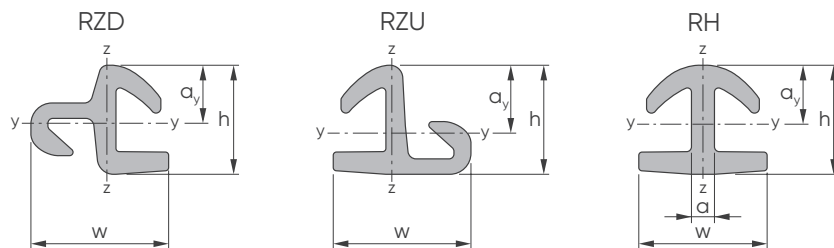
AZ® - Intermediary piles



Section

	Dimensions				Properties per double pile					
	h	b	t _f	t _w	A	G	I _y	W _{el,y}	i _y	A _{LW}
	mm	mm	mm	mm	cm ²	kg/m	cm ⁴	cm ³	cm	m ² /m
AZ 20-800	450	800	9.5	9.5	225.6	177.1	72070	3205	17.87	2.08
AZ 20-800-10/10	451	800	10.0	10.0	235.6	184.9	75070	3335	17.85	2.08
AZ 25-800	475	800	12.5	10.0	261.3	205.1	95060	4005	19.07	2.11
AZ 13-770	344	770	9.0	9.0	193.8	152.1	34440	2000	13.33	1.85
AZ 14-770-10/10	345	770	10.0	10.0	211.2	165.8	37330	2165	13.30	1.85
AZ 28-750	509	750	12.0	10.0	256.8	201.6	107310	4215	20.44	2.11
AZ 30-750	510	750	13.0	11.0	277.1	217.5	115000	4510	20.37	2.11
AZ 32-750	511	750	14.0	12.0	297.4	233.5	122710	4805	20.31	2.11
AZ 13-700	315	700	9.5	9.5	188.5	148.0	28750	1825	12.35	1.71
AZ 13-700-10/10	316	700	10.0	10.0	196.6	154.3	29910	1895	12.33	1.71
AZ 18-700	420	700	9.0	9.0	194.9	153.0	52920	2520	16.47	1.86
AZ 20-700	421	700	10.0	10.0	212.8	167.0	57340	2725	16.42	1.86
AZ 26-700	460	700	12.2	12.2	262.1	205.7	83610	3635	17.86	1.93
AZ 18-10/10	381	630	10.0	10.0	198.1	155.5	44790	2355	15.04	1.71
AZ 26	427	630	13.0	12.2	249.2	195.6	69940	3280	16.75	1.78

Connectors



Section

	Dimensions				Properties							
	h	w	a	a _y	A	G	I _y	I _z	W _{el,y}	W _{el,z}	A _{LW}	A _{LS}
	mm	mm	mm	mm	cm ²	kg/m	cm ⁴	cm ⁴	cm ³	cm ³	m ² /m	m ² /m
RZD 16	61.8	80.5	-	31.5	20.7	16.2	57	94	18	22	0.12	0.06
RZU 16	61.8	80.5	-	38.3	20.4	16.0	68	94	18	22	0.08	0.10
RH 16	61.8	68.2	12.2	32.5	20.1	15.8	83	54	25	16	0.10	0.09
RZD 18	67.3	85.0	-	35.9	23.0	18.0	78	110	22	25	0.12	0.07
RZU 18	67.3	85.0	-	42.1	22.6	17.8	92	110	22	25	0.09	0.10
RH 20	67.3	79.2	14.2	36.5	25.2	19.8	122	88	33	22	0.11	0.10

Note: For suitable combinations of connectors and HZ®-M king piles, see page 4.

Delivery conditions

Tolerances

Standard EN 10248-2:2024

	HZ®-M	AZ®
Mass ¹⁾	± 5 %	± 5 %
Length (L)	± 200 mm	± 200 mm
Thicknesses (t_f, t_w) ²⁾	$t_f, t_w > 12.5 \text{ mm}$: + 2.5 mm / - 1.5 mm	$t_f, t_w \leq 8.5 \text{ mm}$: ± 0.5 mm $t_f, t_w > 8.5 \text{ mm}$: ± 6 %
Height (h)	$h > 500 \text{ mm}$: ± 7 mm	$h \geq 300 \text{ mm}$: ± 7 mm
Width single pile (w)	± 2 % w	± 2 % w
Width double piles (w)	-	± 3 % w
Straightness (S)	0.2 % L	0.2 % L
Squareness of ends of profiles (p)	single pile: 4% h single pile: 2% w	single pile: 2% w double pile: 1% w
Misalignment of the head of double sheet piles (q)	20 mm	20 mm

¹⁾ Of one piece

²⁾ Positive tolerances for AZ defined by ArcelorMittal as per Option 2, Clause 13 of EN 10248-2:2024.

Maximum rolling length³⁾

HZ	33 m
AZ	31 m
RZD / RZU / RH	24 m

Section	EN 10248-1:2023								ASTM	
	S 240 GP	S 270 GP	S 320 GP	S 355 GP	S 390 GP	S 430 GP	S 460 GP	S 500 GP	A 572	A 690
HZ	✓ ⁴⁾	✓	✓	✓	✓	✓	✓	✖	✓	✓
AZ	✓ ⁴⁾	✓	✓	✓	✓	✓	✓	✖	✓	✓ ⁴⁾
RH / RZD / RZU	✖	✖	✖	✖	✖	✖	✓	✖	✖	✓

³⁾ Longer sections may be supplied. Please contact us.

⁴⁾ Please contact us as some limitations may apply.

✓ Available
✖ On request
✖ Currently unavailable

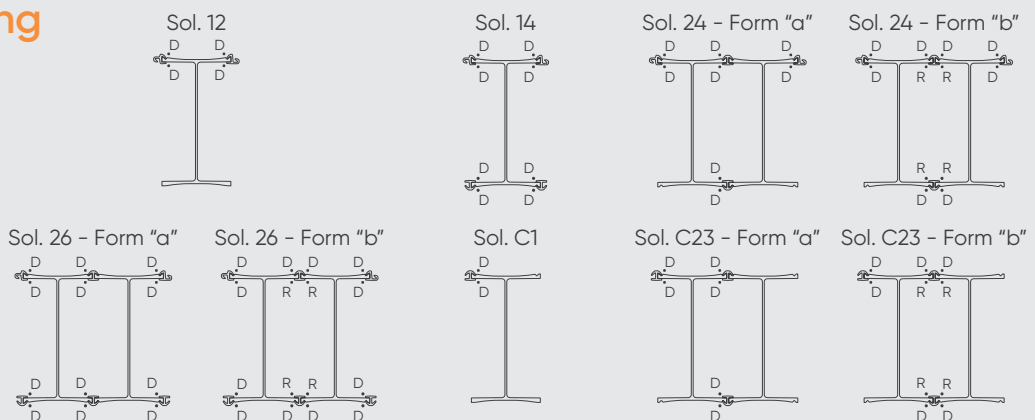
Steel grades

Steel grade EN 10248-1:2023	Min. yield strength	Min. tensile strength	Min. elongation	Minimum impact energy KV ₂	
	R _{eH}	R _m	L ₀ = 5.65 √s ₀	Testing temperature	Joules
	MPa	MPa	%	°C	J
S 240 GP	240	340	26	20	27
S 270 GP	270	410	24	20	27
S 320 GP	320	440	23	20	27
S 355 GP	355	480	22	0	27
S 390 GP	390	490	20	0	27
S 430 GP	430	510	19	0	27
S 460 GP	460	530	17	0	27
S 500 GP	500	580	15	0	27

Contact us for enquiries on S 500 GP steel grade.

All the components of the HZ-M Steel Wall System are available in **ASTM A 690** steel grade. **ASTM A 690** with higher yield strength on request.

Standard welding configurations



D discontinuous weld, $a = 6 \text{ mm}$: 10% of length (100 mm/m) over whole connector length and 500 mm continuous weld at top and toe of connector

R continuous weld, $a = 6 \text{ mm}$: 500 mm at the top and toe of connector

In **Form "a"** the HZ-M king piles can be driven separately if necessary (for instance, in hard driving conditions).

Form "b" is the standard delivery form: the HZ-M king piles are welded together and can only be driven in one piece as a box pile. If hard driving conditions are predicted, the length of the discontinuous weld "D" should be increased. Please contact our technical department for more details.

Characteristics of combinations according to the global safety design approach

Section	Properties per meter of wall ¹⁾							Per system		
	A	I _y	W _{ely} [*]	W _{ely} ^{**}	G _{60%}	G _{80%}	G _{100%}	A _{LW}	A _{LS}	b _{sys}
	cm ² /m	cm ⁴ /m	cm ³ /m	cm ³ /m	kg/m ²	kg/m ²	kg/m ²	m ² /m	m ² /m	m
Combination HZ ... M - 12 / AZ 20-800										
HZ 630M	275.2	154710	4550	5090	176	196	216	2.661	4.606	2.090
HZ 880M A	264.7	229730	5145	5875	168	188	208	2.700	5.080	2.127
HZ 880M B	279.6	246490	5545	6235	180	200	220	2.703	5.082	2.127
HZ 880M C	286.4	257880	5795	6500	186	205	225	2.703	5.081	2.127
HZ 1080M A	299.2	407590	7130	7995	195	215	235	2.696	5.534	2.127
HZ 1080M B	310.0	438170	7660	8545	204	224	243	2.697	5.534	2.127
HZ 1080M C	329.5	475020	8320	9190	219	239	259	2.699	5.536	2.127
HZ 1080M D	345.3	510970	8930	9835	232	251	271	2.699	5.536	2.127
HZ 1180M A	357.9	537990	9370	10315	242	261	281	2.700	5.537	2.127
HZ 1180M B	366.0	561690	9785	10725	248	268	287	2.702	5.541	2.127
HZ 1180M C	381.6	596490	10320	11370	260	280	300	2.714	5.550	2.127
HZ 1180M D	394.0	623870	10830	11805	269	289	309	2.720	5.555	2.127
Combination HZ ... M - 14 / AZ 20-800										
HZ 630M	292.8	172690	5600	5130	184	207	230	2.661	4.887	2.090
HZ 880M A	282.1	261320	6495	5985	176	199	221	2.700	5.315	2.127
HZ 880M B	296.9	277490	6865	6355	188	210	233	2.703	5.318	2.127
HZ 880M C	303.7	288770	7110	6610	193	216	238	2.703	5.318	2.127
HZ 1080M A	316.6	460390	8780	8240	203	226	249	2.696	5.769	2.127
HZ 1080M B	327.3	490170	9295	8770	212	234	257	2.697	5.771	2.127
HZ 1080M C	346.8	526600	9930	9425	227	250	272	2.699	5.772	2.127
HZ 1080M D	362.6	562270	10525	10065	239	262	285	2.699	5.773	2.127
HZ 1180M A	375.2	589040	10945	10555	249	272	295	2.700	5.773	2.127
HZ 1180M B	382.7	610870	11305	10935	255	278	300	2.702	5.775	2.127
HZ 1180M C	403.1	659130	12075	11660	269	293	316	2.714	5.809	2.127
HZ 1180M D	414.4	682580	12460	12080	278	302	325	2.720	5.815	2.127
Combination HZ ... M - 24 / AZ 20-800										
HZ 630M	363.4	226960	6965	6410	252	269	285	3.146	5.111	2.524
HZ 880M A	343.8	347690	8155	7545	238	254	270	3.224	5.621	2.598
HZ 880M B	367.8	374150	8780	8155	257	273	289	3.230	5.628	2.598
HZ 880M C	379.0	392650	9190	8575	265	281	297	3.229	5.627	2.598
HZ 1080M A	400.5	638100	11600	10915	282	298	314	3.215	6.072	2.598
HZ 1080M B	418.0	687030	12450	11780	296	312	328	3.218	6.074	2.598
HZ 1080M C	449.7	746570	13510	12850	321	337	353	3.221	6.077	2.598
HZ 1080M D	475.6	804940	14505	13890	341	357	373	3.222	6.078	2.598
HZ 1180M A	496.1	848660	15210	14675	357	373	389	3.223	6.080	2.598
HZ 1180M B	508.4	884460	15815	15310	367	383	399	3.227	6.089	2.598
HZ 1180M C	535.7	947150	16850	16290	388	404	421	3.243	6.102	2.598
HZ 1180M D	554.0	985340	17495	16975	402	419	435	3.256	6.111	2.598
Combination HZ ... M - 26 / AZ 20-800										
HZ 630M	379.3	242610	7875	7210	260	279	298	3.146	5.372	2.524
HZ 880M A	359.3	374550	9315	8580	245	263	282	3.224	5.839	2.598
HZ 880M B	383.3	400830	9920	9185	264	282	301	3.230	5.845	2.598
HZ 880M C	394.4	419280	10325	9605	273	291	310	3.229	5.844	2.598
HZ 1080M A	416.0	683270	13035	12235	289	308	327	3.215	6.289	2.598
HZ 1080M B	433.5	732080	13890	13110	303	322	340	3.218	6.291	2.598
HZ 1080M C	465.2	791370	14930	14170	328	347	365	3.221	6.294	2.598
HZ 1080M D	491.0	849570	15910	15215	348	367	385	3.222	6.295	2.598
HZ 1180M A	511.6	893180	16600	15995	365	383	402	3.223	6.297	2.598
HZ 1180M B	523.9	928920	17200	16635	374	393	411	3.227	6.300	2.598
HZ 1180M C	555.1	1002400	18430	17800	397	416	436	3.243	6.338	2.598
HZ 1180M D	573.4	1040470	19065	18480	411	431	450	3.256	6.350	2.598

¹⁾ Values taking the intermediary sheet piles into account.

Section

Properties per meter of wall¹⁾

Per system

A	I _y	W _{ely} *	W _{ely} **	G _{60%}	G _{80%}	G _{100%}	A _{LW}	A _{LS}	b _{sys}
cm ² /m	cm ⁴ /m	cm ³ /m	cm ³ /m	kg/m ²	kg/m ²	kg/m ²	m ² /m	m ² /m	m

Combination HZ ... M - 12 / AZ 25-800

HZ 630M	292.3	165710	4870	5455	184	207	229	2.696	4.641	2.090
HZ 880M A	281.5	240530	5385	6150	176	199	221	2.735	5.114	2.127
HZ 880M B	296.4	257290	5790	6510	188	210	233	2.738	5.116	2.127
HZ 880M C	303.2	268670	6040	6770	193	216	238	2.737	5.116	2.127
HZ 1080M A	316.0	418410	7315	8205	203	226	248	2.730	5.569	2.127
HZ 1080M B	326.8	449000	7850	8755	212	234	257	2.732	5.569	2.127
HZ 1080M C	346.3	485830	8510	9400	227	249	272	2.733	5.570	2.127
HZ 1080M D	362.1	521780	9120	10045	240	262	284	2.734	5.571	2.127
HZ 1180M A	374.7	548790	9560	10525	250	272	294	2.734	5.572	2.127
HZ 1180M B	382.8	572490	9970	10935	256	278	300	2.736	5.576	2.127
HZ 1180M C	398.4	607290	10505	11575	267	290	313	2.749	5.584	2.127
HZ 1180M D	410.8	634670	11015	12010	277	300	322	2.755	5.589	2.127

Combination HZ ... M - 14 / AZ 25-800

HZ 630M	309.9	183690	5960	5455	192	218	243	2.696	4.922	2.090
HZ 880M A	298.9	272120	6765	6230	184	209	235	2.735	5.350	2.127
HZ 880M B	313.7	288290	7130	6600	196	221	246	2.738	5.353	2.127
HZ 880M C	320.5	299560	7375	6860	201	226	252	2.737	5.352	2.127
HZ 1080M A	333.4	471210	8985	8430	211	236	262	2.730	5.804	2.127
HZ 1080M B	344.1	501000	9500	8965	219	245	270	2.732	5.805	2.127
HZ 1080M C	363.6	537410	10135	9615	235	260	285	2.733	5.807	2.127
HZ 1080M D	379.4	573070	10725	10255	247	273	298	2.734	5.807	2.127
HZ 1180M A	392.0	599840	11145	10750	257	282	308	2.734	5.808	2.127
HZ 1180M B	399.5	621680	11505	11125	263	288	314	2.736	5.810	2.127
HZ 1180M C	419.9	669920	12270	11850	277	303	330	2.749	5.843	2.127
HZ 1180M D	431.2	693380	12660	12270	286	312	338	2.755	5.850	2.127

Combination HZ ... M - 24 / AZ 25-800

HZ 630M	377.5	236070	7245	6665	259	278	296	3.180	5.145	2.524
HZ 880M A	357.5	356530	8360	7735	244	262	281	3.258	5.656	2.598
HZ 880M B	381.6	382980	8985	8350	263	281	300	3.264	5.662	2.598
HZ 880M C	392.7	401480	9395	8770	272	290	308	3.264	5.662	2.598
HZ 1080M A	414.3	646970	11760	11065	289	307	325	3.250	6.106	2.598
HZ 1080M B	431.8	695900	12610	11935	302	321	339	3.252	6.109	2.598
HZ 1080M C	463.5	755430	13670	13005	327	346	364	3.255	6.112	2.598
HZ 1080M D	489.3	813780	14665	14045	348	366	384	3.256	6.113	2.598
HZ 1180M A	509.8	857500	15370	14825	364	382	400	3.258	6.114	2.598
HZ 1180M B	522.1	893300	15970	15460	373	392	410	3.261	6.123	2.598
HZ 1180M C	549.4	955970	17010	16445	394	413	431	3.278	6.136	2.598
HZ 1180M D	567.7	994160	17650	17125	409	427	446	3.290	6.146	2.598

Combination HZ ... M - 26 / AZ 25-800

HZ 630M	393.5	251720	8170	7485	266	288	309	3.180	5.406	2.524
HZ 880M A	373.0	383390	9535	8785	251	272	293	3.258	5.873	2.598
HZ 880M B	397.0	409660	10140	9385	270	291	312	3.264	5.879	2.598
HZ 880M C	408.1	428110	10545	9810	279	300	320	3.264	5.879	2.598
HZ 1080M A	429.8	692140	13205	12390	296	317	337	3.250	6.323	2.598
HZ 1080M B	447.3	740950	14060	13265	310	330	351	3.252	6.326	2.598
HZ 1080M C	479.0	800230	15095	14330	335	355	376	3.255	6.329	2.598
HZ 1080M D	504.8	858420	16075	15370	355	376	396	3.256	6.330	2.598
HZ 1180M A	525.3	902020	16765	16155	371	392	412	3.258	6.331	2.598
HZ 1180M B	537.6	937760	17365	16795	381	401	422	3.261	6.335	2.598
HZ 1180M C	568.8	1011230	18595	17955	403	425	446	3.278	6.372	2.598
HZ 1180M D	587.1	1049300	19225	18635	418	439	461	3.290	6.385	2.598

¹⁾ Values taking the intermediary sheet piles into account.

Characteristics of combinations according to the global safety design approach

Section	Properties per meter of wall ¹⁾							Per system		
	A	I _y	W _{ely} [*]	W _{ely} ^{**}	G _{60%}	G _{80%}	G _{100%}	A _{LW}	A _{LS}	b _{sys}
	cm ² /m	cm ⁴ /m	cm ³ /m	cm ³ /m	kg/m ²	kg/m ²	kg/m ²	m ² /m	m ² /m	m
Combination HZ ... M - 12 / AZ 13-770										
HZ 630M	267.7	140740	4135	4635	174	192	210	2.427	4.372	2.030
HZ 880M A	257.0	218200	4885	5580	166	184	202	2.466	4.846	2.067
HZ 880M B	272.4	235460	5300	5955	178	196	214	2.469	4.847	2.067
HZ 880M C	279.4	247170	5555	6230	184	201	219	2.469	4.847	2.067
HZ 1080M A	292.4	401210	7015	7870	194	212	230	2.462	5.300	2.067
HZ 1080M B	303.6	432680	7565	8435	203	220	238	2.463	5.300	2.067
HZ 1080M C	323.6	470600	8245	9105	218	236	254	2.464	5.301	2.067
HZ 1080M D	339.9	507590	8870	9770	231	249	267	2.465	5.302	2.067
HZ 1180M A	352.9	535400	9325	10265	241	259	277	2.466	5.303	2.067
HZ 1180M B	361.2	559790	9750	10690	248	266	284	2.467	5.307	2.067
HZ 1180M C	377.3	595600	10305	11350	260	278	296	2.480	5.316	2.067
HZ 1180M D	390.1	623780	10825	11800	270	288	306	2.486	5.321	2.067
Combination HZ ... M - 14 / AZ 13-770										
HZ 630M	285.8	159260	5165	4730	182	203	224	2.427	4.653	2.030
HZ 880M A	274.9	250710	6230	5740	174	195	216	2.466	5.081	2.067
HZ 880M B	290.2	267360	6615	6120	186	207	228	2.469	5.084	2.067
HZ 880M C	297.1	278960	6865	6385	192	212	233	2.469	5.084	2.067
HZ 1080M A	310.4	455540	8685	8150	202	223	244	2.462	5.535	2.067
HZ 1080M B	321.4	486190	9220	8700	210	231	252	2.463	5.536	2.067
HZ 1080M C	341.4	523680	9875	9370	226	247	268	2.464	5.538	2.067
HZ 1080M D	357.7	560380	10490	10030	239	260	281	2.465	5.538	2.067
HZ 1180M A	370.7	587930	10920	10535	249	270	291	2.466	5.539	2.067
HZ 1180M B	378.4	610400	11300	10925	255	276	297	2.467	5.541	2.067
HZ 1180M C	399.5	660050	12090	11680	270	292	314	2.480	5.575	2.067
HZ 1180M D	411.1	684190	12490	12110	279	301	323	2.486	5.581	2.067
Combination HZ ... M - 24 / AZ 13-770										
HZ 630M	359.3	217210	6665	6135	252	267	282	2.912	4.876	2.464
HZ 880M A	339.4	341090	8000	7400	237	252	266	2.989	5.387	2.538
HZ 880M B	364.0	368180	8640	8025	257	271	286	2.995	5.393	2.538
HZ 880M C	375.4	387120	9060	8455	266	280	295	2.995	5.393	2.538
HZ 1080M A	397.4	638360	11605	10920	283	297	312	2.981	5.837	2.538
HZ 1080M B	415.4	688450	12475	11805	297	311	326	2.983	5.840	2.538
HZ 1080M C	447.8	749400	13565	12900	322	337	352	2.986	5.843	2.538
HZ 1080M D	474.3	809140	14580	13965	343	358	372	2.987	5.844	2.538
HZ 1180M A	495.3	853890	15305	14765	360	374	389	2.989	5.846	2.538
HZ 1180M B	507.9	890540	15920	15415	370	384	399	2.992	5.854	2.538
HZ 1180M C	535.8	954690	16985	16420	391	406	421	3.009	5.867	2.538
HZ 1180M D	554.6	993780	17645	17120	406	421	435	3.021	5.877	2.538
Combination HZ ... M - 26 / AZ 13-770										
HZ 630M	375.6	233250	7570	6935	260	277	295	2.912	5.138	2.464
HZ 880M A	355.2	368580	9170	8445	245	262	279	2.989	5.604	2.538
HZ 880M B	379.8	395490	9790	9060	264	281	298	2.995	5.611	2.538
HZ 880M C	391.2	414380	10205	9495	273	290	307	2.995	5.610	2.538
HZ 1080M A	413.3	684600	13060	12255	290	307	324	2.981	6.054	2.538
HZ 1080M B	431.2	734570	13935	13150	304	321	339	2.983	6.057	2.538
HZ 1080M C	463.7	795260	15005	14240	330	347	364	2.986	6.060	2.538
HZ 1080M D	490.1	854830	16005	15305	351	368	385	2.987	6.061	2.538
HZ 1180M A	511.1	899460	16720	16105	367	384	401	2.989	6.062	2.538
HZ 1180M B	523.7	936050	17335	16760	377	394	411	2.992	6.066	2.538
HZ 1180M C	555.6	1011250	18595	17955	400	418	436	3.009	6.104	2.538
HZ 1180M D	574.4	1050210	19240	18650	415	433	451	3.021	6.116	2.538

¹⁾ Values taking the intermediary sheet piles into account.

Section

Properties per meter of wall¹⁾

Per system

A	I _y	W _{ely} *	W _{ely} **	G _{60%}	G _{80%}	G _{100%}	A _{LW}	A _{LS}	b _{sys}
cm ² /m	cm ⁴ /m	cm ³ /m	cm ³ /m	kg/m ²	kg/m ²	kg/m ²	m ² /m	m ² /m	m

Combination HZ ... M - 12 / AZ 28-750

HZ 630M	304.8	180190	5295	5930	192	216	239	2.693	4.638	1.990
HZ 880M A	293.2	258430	5785	6610	184	207	230	2.732	5.112	2.027
HZ 880M B	308.8	276000	6210	6980	196	219	242	2.735	5.114	2.027
HZ 880M C	315.9	287940	6470	7255	202	225	248	2.735	5.113	2.027
HZ 1080M A	329.4	445140	7785	8730	212	235	259	2.728	5.566	2.027
HZ 1080M B	340.7	477230	8345	9305	221	244	267	2.729	5.566	2.027
HZ 1080M C	361.1	515860	9035	9980	237	260	283	2.730	5.567	2.027
HZ 1080M D	377.7	553560	9675	10655	250	273	297	2.731	5.568	2.027
HZ 1180M A	390.9	581890	10135	11155	261	284	307	2.732	5.569	2.027
HZ 1180M B	399.4	606760	10570	11590	267	290	314	2.733	5.573	2.027
HZ 1180M C	415.8	643260	11130	12260	280	303	326	2.746	5.582	2.027
HZ 1180M D	428.8	671960	11665	12715	290	313	337	2.752	5.587	2.027

Combination HZ ... M - 14 / AZ 28-750

HZ 630M	323.2	199080	6460	5915	200	227	254	2.693	4.919	1.990
HZ 880M A	311.4	291580	7245	6675	192	218	244	2.732	5.347	2.027
HZ 880M B	326.9	308520	7630	7065	204	230	257	2.735	5.350	2.027
HZ 880M C	334.0	320350	7885	7335	210	236	262	2.735	5.350	2.027
HZ 1080M A	347.7	500550	9545	8955	220	247	273	2.728	5.801	2.027
HZ 1080M B	358.9	531800	10085	9515	229	256	282	2.729	5.802	2.027
HZ 1080M C	379.3	569980	10745	10200	245	272	298	2.730	5.804	2.027
HZ 1080M D	395.9	607390	11365	10870	258	285	311	2.731	5.804	2.027
HZ 1180M A	409.1	635460	11805	11385	269	295	321	2.732	5.805	2.027
HZ 1180M B	417.0	658370	12185	11785	275	301	327	2.733	5.807	2.027
HZ 1180M C	438.4	708980	12985	12545	290	317	344	2.746	5.841	2.027
HZ 1180M D	450.2	733570	13390	12980	299	326	353	2.752	5.847	2.027

Combination HZ ... M - 24 / AZ 28-750

HZ 630M	391.2	250860	7700	7085	269	288	307	3.178	5.142	2.424
HZ 880M A	370.0	375690	8810	8155	253	272	290	3.255	5.653	2.498
HZ 880M B	395.0	403170	9460	8790	273	291	310	3.262	5.659	2.498
HZ 880M C	406.6	422410	9885	9225	282	300	319	3.261	5.659	2.498
HZ 1080M A	429.1	677850	12320	11595	299	318	337	3.247	6.103	2.498
HZ 1080M B	447.3	728740	13205	12495	314	332	351	3.249	6.106	2.498
HZ 1080M C	480.2	790600	14310	13610	340	358	377	3.252	6.109	2.498
HZ 1080M D	507.1	851270	15340	14690	361	379	398	3.253	6.110	2.498
HZ 1180M A	528.4	896710	16075	15505	377	396	415	3.255	6.112	2.498
HZ 1180M B	541.2	933930	16700	16165	387	406	425	3.258	6.121	2.498
HZ 1180M C	569.5	999040	17775	17185	409	428	447	3.275	6.134	2.498
HZ 1180M D	588.6	1038720	18440	17895	424	443	462	3.287	6.143	2.498

Combination HZ ... M - 26 / AZ 28-750

HZ 630M	407.8	267160	8670	7940	276	298	320	3.178	5.404	2.424
HZ 880M A	386.1	403630	10040	9245	261	282	303	3.255	5.870	2.498
HZ 880M B	411.1	430910	10665	9875	280	301	323	3.262	5.877	2.498
HZ 880M C	422.6	450100	11085	10310	289	311	332	3.261	5.876	2.498
HZ 1080M A	445.3	724830	13830	12980	307	328	350	3.247	6.321	2.498
HZ 1080M B	463.5	775600	14715	13885	321	343	364	3.249	6.323	2.498
HZ 1080M C	496.4	837200	15795	14990	347	368	390	3.252	6.326	2.498
HZ 1080M D	523.2	897690	16810	16075	368	389	411	3.253	6.327	2.498
HZ 1180M A	544.5	943000	17530	16885	385	406	427	3.255	6.329	2.498
HZ 1180M B	557.3	980180	18150	17555	395	416	438	3.258	6.332	2.498
HZ 1180M C	589.7	1056500	19425	18760	419	441	463	3.275	6.370	2.498
HZ 1180M D	608.7	1096060	20080	19465	434	456	478	3.287	6.382	2.498

¹⁾ Values taking the intermediary sheet piles into account.

Characteristics of combinations according to the global safety design approach

Section	Properties per meter of wall ¹⁾							Per system		
	A	I _y	W _{ely} [*]	W _{ely} ^{**}	G _{60%}	G _{80%}	G _{100%}	A _{LW}	A _{LS}	b _{sys}
	cm ² /m	cm ⁴ /m	cm ³ /m	cm ³ /m	kg/m ²	kg/m ²	kg/m ²	m ² /m	m ² /m	m
Combination HZ ... M - 12 / AZ 13-700-10/10										
HZ 630M	289.0	148770	4375	4900	187	207	227	2.293	4.238	1.890
HZ 880M A	277.1	231690	5185	5925	179	198	218	2.332	4.712	1.927
HZ 880M B	293.6	250190	5630	6330	192	211	230	2.335	4.713	1.927
HZ 880M C	301.1	262760	5905	6620	198	217	236	2.335	4.713	1.927
HZ 1080M A	315.2	428050	7485	8395	209	228	247	2.328	5.166	1.927
HZ 1080M B	327.1	461810	8075	9005	218	237	257	2.329	5.166	1.927
HZ 1080M C	348.6	502460	8800	9720	235	254	274	2.330	5.167	1.927
HZ 1080M D	366.1	542120	9475	10435	249	268	287	2.331	5.168	1.927
HZ 1180M A	380.0	571930	9960	10965	260	279	298	2.332	5.169	1.927
HZ 1180M B	388.9	598090	10420	11420	267	286	305	2.333	5.173	1.927
HZ 1180M C	406.1	636480	11010	12130	279	299	319	2.346	5.182	1.927
HZ 1180M D	419.8	666680	11570	12615	290	310	330	2.352	5.187	1.927
Combination HZ ... M - 14 / AZ 13-700-10/10										
HZ 630M	308.5	168660	5470	5010	196	219	242	2.293	4.519	1.890
HZ 880M A	296.4	266560	6625	6105	187	210	233	2.332	4.947	1.927
HZ 880M B	312.7	284400	7035	6510	200	223	245	2.335	4.950	1.927
HZ 880M C	320.2	296850	7305	6795	206	229	251	2.335	4.950	1.927
HZ 1080M A	334.5	486340	9275	8700	217	240	263	2.328	5.401	1.927
HZ 1080M B	346.3	519210	9845	9290	226	249	272	2.329	5.402	1.927
HZ 1080M C	367.7	559390	10545	10010	243	266	289	2.330	5.404	1.927
HZ 1080M D	385.2	598750	11205	10715	257	280	302	2.331	5.404	1.927
HZ 1180M A	399.1	628280	11670	11255	268	291	313	2.332	5.405	1.927
HZ 1180M B	407.4	652380	12075	11675	275	297	320	2.333	5.407	1.927
HZ 1180M C	429.9	705610	12925	12485	290	314	337	2.346	5.441	1.927
HZ 1180M D	442.3	731470	13355	12945	300	323	347	2.352	5.447	1.927
Combination HZ ... M - 24 / AZ 13-700-10/10										
HZ 630M	382.2	228350	7010	6450	268	284	300	2.778	4.742	2.324
HZ 880M A	360.3	359100	8420	7790	252	267	283	2.855	5.253	2.398
HZ 880M B	386.4	387740	9095	8455	272	288	303	2.861	5.259	2.398
HZ 880M C	398.4	407780	9540	8905	282	297	313	2.861	5.259	2.398
HZ 1080M A	421.9	673830	12250	11525	300	316	331	2.847	5.703	2.398
HZ 1080M B	440.8	726850	13175	12465	315	330	346	2.849	5.706	2.398
HZ 1080M C	475.2	791300	14320	13620	342	357	373	2.852	5.709	2.398
HZ 1080M D	503.1	854490	15395	14750	364	379	395	2.853	5.710	2.398
HZ 1180M A	525.4	901820	16165	15595	381	397	412	2.855	5.712	2.398
HZ 1180M B	538.7	940600	16815	16280	392	407	423	2.858	5.720	2.398
HZ 1180M C	568.2	1008410	17940	17345	414	430	446	2.875	5.733	2.398
HZ 1180M D	588.0	1049720	18635	18080	430	446	462	2.887	5.743	2.398
Combination HZ ... M - 26 / AZ 13-700-10/10										
HZ 630M	399.5	245350	7965	7295	276	295	314	2.778	5.003	2.324
HZ 880M A	377.1	388200	9655	8895	260	278	296	2.855	5.470	2.398
HZ 880M B	403.1	416640	10315	9545	280	298	316	2.861	5.477	2.398
HZ 880M C	415.2	436620	10755	10005	290	308	326	2.861	5.476	2.398
HZ 1080M A	438.7	722780	13790	12940	308	326	344	2.847	5.920	2.398
HZ 1080M B	457.7	775670	14715	13890	323	341	359	2.849	5.923	2.398
HZ 1080M C	492.0	839830	15845	15040	350	368	386	2.852	5.926	2.398
HZ 1080M D	519.9	902850	16905	16165	372	390	408	2.853	5.927	2.398
HZ 1180M A	542.1	950040	17660	17015	389	407	426	2.855	5.928	2.398
HZ 1180M B	555.5	988770	18310	17705	400	418	436	2.858	5.932	2.398
HZ 1180M C	589.2	1068250	19640	18970	424	443	462	2.875	5.970	2.398
HZ 1180M D	609.0	1109440	20325	19700	440	459	478	2.887	5.982	2.398

¹⁾ Values taking the intermediary sheet piles into account.

Section

Properties per meter of wall¹⁾

Per system

A	I _y	W _{ely} [*]	W _{ely} ^{**}	G _{60%}	G _{80%}	G _{100%}	A _{LW}	A _{LS}	b _{sys}
cm ² /m	cm ⁴ /m	cm ³ /m	cm ³ /m	kg/m ²	kg/m ²	kg/m ²	m ² /m	m ² /m	m

Combination HZ ... M - 12 / AZ 20-700

HZ 630M	297.6	163280	4800	5375	191	213	234	2.438	4.383	1.890
HZ 880M A	285.5	245920	5505	6290	183	203	224	2.477	4.856	1.927
HZ 880M B	302.0	264400	5950	6690	196	216	237	2.480	4.858	1.927
HZ 880M C	309.5	276970	6225	6980	202	222	243	2.479	4.858	1.927
HZ 1080M A	323.6	442300	7735	8675	213	233	254	2.472	5.311	1.927
HZ 1080M B	335.6	476070	8325	9285	222	243	263	2.474	5.311	1.927
HZ 1080M C	357.0	516700	9050	10000	239	260	280	2.475	5.312	1.927
HZ 1080M D	374.5	556360	9725	10710	253	273	294	2.476	5.313	1.927
HZ 1180M A	388.4	586150	10210	11240	264	284	305	2.476	5.314	1.927
HZ 1180M B	397.3	612320	10665	11695	271	291	312	2.478	5.318	1.927
HZ 1180M C	414.5	650700	11260	12400	283	304	325	2.491	5.327	1.927
HZ 1180M D	428.2	680890	11820	12885	294	315	336	2.497	5.332	1.927

Combination HZ ... M - 14 / AZ 20-700

HZ 630M	317.1	183170	5940	5440	200	224	249	2.438	4.664	1.890
HZ 880M A	304.8	280790	6980	6430	191	215	239	2.477	5.092	1.927
HZ 880M B	321.0	298620	7385	6835	204	228	252	2.480	5.095	1.927
HZ 880M C	328.5	311060	7655	7120	210	234	258	2.479	5.095	1.927
HZ 1080M A	342.9	500590	9545	8955	221	245	269	2.472	5.546	1.927
HZ 1080M B	354.7	533470	10115	9545	230	254	278	2.474	5.547	1.927
HZ 1080M C	376.1	573630	10815	10265	247	271	295	2.475	5.549	1.927
HZ 1080M D	393.6	612980	11470	10970	261	285	309	2.476	5.549	1.927
HZ 1180M A	407.5	642500	11935	11510	272	296	320	2.476	5.550	1.927
HZ 1180M B	415.8	666600	12340	11930	278	302	326	2.478	5.552	1.927
HZ 1180M C	438.3	719830	13185	12735	294	319	344	2.491	5.585	1.927
HZ 1180M D	450.7	745680	13615	13195	304	329	354	2.497	5.592	1.927

Combination HZ ... M - 24 / AZ 20-700

HZ 630M	389.1	240150	7370	6780	271	288	305	2.923	4.887	2.324
HZ 880M A	367.1	370530	8690	8040	255	272	288	3.000	5.398	2.398
HZ 880M B	393.1	399150	9365	8700	275	292	309	3.006	5.404	2.398
HZ 880M C	405.2	419190	9810	9155	285	301	318	3.006	5.404	2.398
HZ 1080M A	428.6	685300	12455	11725	303	320	336	2.992	5.848	2.398
HZ 1080M B	447.6	738320	13380	12660	318	335	351	2.994	5.851	2.398
HZ 1080M C	481.9	802740	14530	13820	345	362	378	2.997	5.854	2.398
HZ 1080M D	509.9	865930	15605	14945	367	384	400	2.998	5.855	2.398
HZ 1180M A	532.1	913250	16370	15790	384	401	418	3.000	5.856	2.398
HZ 1180M B	545.4	952020	17020	16480	395	412	428	3.003	5.865	2.398
HZ 1180M C	574.9	1019820	18145	17540	418	434	451	3.020	5.878	2.398
HZ 1180M D	594.7	1061120	18840	18280	433	450	467	3.032	5.888	2.398

Combination HZ ... M - 26 / AZ 20-700

HZ 630M	406.5	257150	8345	7645	279	299	319	2.923	5.148	2.324
HZ 880M A	383.9	399620	9940	9155	263	282	301	3.000	5.615	2.398
HZ 880M B	409.9	428050	10595	9805	283	303	322	3.006	5.621	2.398
HZ 880M C	421.9	448030	11035	10265	293	312	331	3.006	5.621	2.398
HZ 1080M A	445.5	734240	14010	13145	311	330	350	2.992	6.065	2.398
HZ 1080M B	464.4	787140	14935	14095	326	345	365	2.994	6.068	2.398
HZ 1080M C	498.7	851280	16060	15245	353	372	391	2.997	6.071	2.398
HZ 1080M D	526.7	914290	17120	16370	375	394	413	2.998	6.072	2.398
HZ 1180M A	548.9	961470	17870	17215	392	412	431	3.000	6.073	2.398
HZ 1180M B	562.2	1000190	18520	17910	403	422	441	3.003	6.077	2.398
HZ 1180M C	595.9	1079660	19850	19170	427	448	468	3.020	6.115	2.398
HZ 1180M D	615.7	1120840	20535	19905	443	463	483	3.032	6.127	2.398

¹⁾ Values taking the intermediary sheet piles into account.

Characteristics of combinations according to the global safety design approach

Section	Properties per meter of wall ¹⁾						Per system			
	A	I _y	W _{ely} [*]	W _{ely} ^{**}	G _{60%}	G _{80%}	G _{100%}	A _{LW}	A _{LS}	b _{sys}
	cm ² /m	cm ⁴ /m	cm ³ /m	cm ³ /m	kg/m ²	kg/m ²	kg/m ²	m ² /m	m ² /m	m

Combination HZ ... M - 12 / AZ 26-700

HZ 630M	323.7	177180	5210	5835	204	229	254	2.512	4.457	1.890
HZ 880M A	311.1	259540	5810	6635	195	220	244	2.551	4.931	1.927
HZ 880M B	327.5	278020	6255	7030	208	232	257	2.554	4.933	1.927
HZ 880M C	335.0	290580	6530	7320	214	238	263	2.554	4.932	1.927
HZ 1080M A	349.2	455960	7975	8945	225	249	274	2.547	5.385	1.927
HZ 1080M B	361.2	489720	8565	9550	234	259	284	2.548	5.385	1.927
HZ 1080M C	382.6	530340	9290	10260	251	276	300	2.549	5.387	1.927
HZ 1080M D	400.1	569990	9960	10970	265	289	314	2.550	5.387	1.927
HZ 1180M A	414.0	599780	10445	11500	276	300	325	2.551	5.388	1.927
HZ 1180M B	422.9	625940	10905	11955	283	307	332	2.552	5.392	1.927
HZ 1180M C	440.1	664320	11495	12660	295	320	345	2.565	5.401	1.927
HZ 1180M D	453.7	694500	12055	13140	306	331	356	2.571	5.406	1.927

Combination HZ ... M - 14 / AZ 26-700

HZ 630M	343.1	197070	6395	5855	212	241	269	2.512	4.738	1.890
HZ 880M A	330.3	294410	7320	6740	203	231	259	2.551	5.166	1.927
HZ 880M B	346.6	312230	7725	7150	216	244	272	2.554	5.169	1.927
HZ 880M C	354.1	324670	7990	7435	222	250	278	2.554	5.169	1.927
HZ 1080M A	368.5	514240	9805	9200	233	261	289	2.547	5.620	1.927
HZ 1080M B	380.3	547120	10375	9790	242	271	299	2.548	5.621	1.927
HZ 1080M C	401.7	587270	11075	10510	259	287	315	2.549	5.623	1.927
HZ 1080M D	419.1	626610	11725	11215	273	301	329	2.550	5.624	1.927
HZ 1180M A	433.0	656130	12190	11755	284	312	340	2.551	5.624	1.927
HZ 1180M B	441.3	680230	12590	12175	291	318	346	2.552	5.626	1.927
HZ 1180M C	463.8	733450	13435	12975	306	335	364	2.565	5.660	1.927
HZ 1180M D	476.2	759290	13860	13435	316	345	374	2.571	5.666	1.927

Combination HZ ... M - 24 / AZ 26-700

HZ 630M	410.3	251450	7720	7100	281	302	322	2.997	4.961	2.324
HZ 880M A	387.6	381470	8945	8280	265	284	304	3.074	5.472	2.398
HZ 880M B	413.6	410080	9620	8940	285	305	325	3.081	5.479	2.398
HZ 880M C	425.7	430120	10065	9395	295	314	334	3.080	5.478	2.398
HZ 1080M A	449.2	696280	12655	11910	313	333	353	3.066	5.923	2.398
HZ 1080M B	468.2	749300	13580	12850	328	348	368	3.068	5.925	2.398
HZ 1080M C	502.5	813710	14725	14005	355	375	394	3.072	5.928	2.398
HZ 1080M D	530.4	876880	15800	15135	377	397	416	3.073	5.929	2.398
HZ 1180M A	552.6	924190	16565	15980	394	414	434	3.074	5.931	2.398
HZ 1180M B	566.0	962970	17215	16670	405	424	444	3.077	5.940	2.398
HZ 1180M C	595.4	1030740	18340	17730	427	447	467	3.094	5.953	2.398
HZ 1180M D	615.2	1072040	19035	18465	443	463	483	3.107	5.962	2.398

Combination HZ ... M - 26 / AZ 26-700

HZ 630M	427.7	268460	8715	7980	289	313	336	2.997	5.223	2.324
HZ 880M A	404.4	410570	10210	9405	273	295	317	3.074	5.690	2.398
HZ 880M B	430.4	438980	10865	10055	293	315	338	3.081	5.696	2.398
HZ 880M C	442.4	458960	11305	10515	302	325	347	3.080	5.695	2.398
HZ 1080M A	466.1	745230	14220	13345	321	343	366	3.066	6.140	2.398
HZ 1080M B	485.0	798120	15140	14290	336	358	381	3.068	6.142	2.398
HZ 1080M C	519.3	862240	16265	15440	363	385	408	3.072	6.145	2.398
HZ 1080M D	547.2	925240	17325	16570	385	407	430	3.073	6.146	2.398
HZ 1180M A	569.4	972410	18075	17415	402	425	447	3.074	6.148	2.398
HZ 1180M B	582.7	1011140	18725	18105	413	435	457	3.077	6.151	2.398
HZ 1180M C	616.4	1090590	20050	19365	437	460	484	3.094	6.189	2.398
HZ 1180M D	636.2	1131760	20735	20100	453	476	499	3.107	6.201	2.398

¹⁾ Values taking the intermediary sheet piles into account.

Section

Properties per meter of wall¹⁾

Per system

A	I _y	W _{ely} *	W _{ely} **	G _{60%}	G _{80%}	G _{100%}	A _{LW}	A _{LS}	b _{sys}
cm ² /m	cm ⁴ /m	cm ³ /m	cm ³ /m	kg/m ²	kg/m ²	kg/m ²	m ² /m	m ² /m	m

Combination HZ ... M - 12 / AZ 26

HZ 630M	342.2	183550	5395	6045	217	243	269	2.365	4.310	1.750
HZ 880M A	328.2	272220	6095	6960	207	232	258	2.403	4.783	1.787
HZ 880M B	345.9	292120	6575	7390	221	246	272	2.406	4.785	1.787
HZ 880M C	354.0	305670	6870	7700	227	252	278	2.406	4.785	1.787
HZ 1080M A	369.4	484080	8465	9495	239	264	290	2.399	5.238	1.787
HZ 1080M B	382.3	520490	9100	10150	249	275	300	2.400	5.237	1.787
HZ 1080M C	405.4	564250	9885	10920	267	293	318	2.402	5.239	1.787
HZ 1080M D	424.2	606990	10610	11685	282	307	333	2.402	5.239	1.787
HZ 1180M A	439.2	639100	11130	12255	294	319	345	2.403	5.240	1.787
HZ 1180M B	448.8	667310	11625	12745	301	327	352	2.405	5.244	1.787
HZ 1180M C	467.3	708660	12260	13505	315	341	367	2.418	5.253	1.787
HZ 1180M D	482.0	741180	12865	14025	327	353	378	2.424	5.258	1.787

Combination HZ ... M - 14 / AZ 26

HZ 630M	363.2	205020	6650	6090	226	255	285	2.365	4.590	1.750
HZ 880M A	349.0	309820	7700	7095	216	245	274	2.403	5.018	1.787
HZ 880M B	366.5	329010	8140	7535	230	259	288	2.406	5.022	1.787
HZ 880M C	374.6	342430	8430	7840	236	265	294	2.406	5.021	1.787
HZ 1080M A	390.2	546940	10430	9785	248	277	306	2.399	5.473	1.787
HZ 1080M B	402.9	582400	11040	10420	258	287	316	2.400	5.474	1.787
HZ 1080M C	426.0	625650	11795	11195	276	305	334	2.402	5.475	1.787
HZ 1080M D	444.8	668050	12505	11955	291	320	349	2.402	5.476	1.787
HZ 1180M A	459.7	699860	13000	12540	303	332	361	2.403	5.477	1.787
HZ 1180M B	468.7	725850	13435	12990	310	339	368	2.405	5.478	1.787
HZ 1180M C	492.9	783200	14345	13855	326	357	387	2.418	5.512	1.787
HZ 1180M D	506.3	811040	14805	14355	337	367	397	2.424	5.518	1.787

Combination HZ ... M - 24 / AZ 26

HZ 630M	430.7	261310	8020	7380	296	317	338	2.849	4.814	2.184
HZ 880M A	405.9	399060	9360	8660	278	298	319	2.927	5.325	2.258
HZ 880M B	433.5	429400	10075	9360	300	320	340	2.933	5.331	2.258
HZ 880M C	446.3	450680	10545	9845	310	330	350	2.932	5.330	2.258
HZ 1080M A	471.5	733500	13330	12545	330	350	370	2.919	5.775	2.258
HZ 1080M B	491.6	789810	14315	13545	345	366	386	2.921	5.777	2.258
HZ 1080M C	528.0	858140	15530	14770	374	394	414	2.924	5.780	2.258
HZ 1080M D	557.6	925200	16670	15970	397	418	438	2.925	5.781	2.258
HZ 1180M A	581.2	975400	17485	16865	416	436	456	2.926	5.783	2.258
HZ 1180M B	595.3	1016570	18175	17595	427	447	467	2.930	5.792	2.258
HZ 1180M C	626.5	1088440	19365	18725	451	471	492	2.947	5.805	2.258
HZ 1180M D	647.5	1132240	20100	19505	467	488	508	2.959	5.815	2.258

Combination HZ ... M - 26 / AZ 26

HZ 630M	449.2	279410	9070	8305	305	329	353	2.849	5.075	2.184
HZ 880M A	423.7	429960	10695	9850	287	310	333	2.927	5.542	2.258
HZ 880M B	451.3	460090	11390	10540	308	331	354	2.933	5.548	2.258
HZ 880M C	464.1	481300	11855	11025	318	341	364	2.932	5.548	2.258
HZ 1080M A	489.3	785490	14985	14065	338	361	384	2.919	5.992	2.258
HZ 1080M B	509.5	841670	15970	15070	354	377	400	2.921	5.994	2.258
HZ 1080M C	545.8	909690	17160	16290	382	405	428	2.924	5.997	2.258
HZ 1080M D	575.4	976550	18285	17485	406	429	452	2.925	5.998	2.258
HZ 1180M A	599.0	1026600	19080	18385	424	447	470	2.926	6.000	2.258
HZ 1180M B	613.2	1067730	19775	19120	435	458	481	2.930	6.003	2.258
HZ 1180M C	648.8	1151990	21180	20455	461	485	509	2.947	6.041	2.258
HZ 1180M D	669.8	1195650	21905	21235	478	502	526	2.959	6.054	2.258

¹⁾ Values taking the intermediary sheet piles into account.

Characteristics of combinations according to EN 1993-5 design approach

Section	Properties per meter of wall ¹⁾							Per system		
	A	I _y	W _{ely} [*]	W _{ely} ^{**}	G _{60%}	G _{80%}	G _{100%}	A _{LW}	A _{LS}	b _{sys}
	cm ² /m	cm ⁴ /m	cm ³ /m	cm ³ /m	kg/m ²	kg/m ²	kg/m ²	m ² /m	m ² /m	m
Combination HZ ... M - 12 / AZ 20-800										
HZ 630M	167.4	120225	3535	3960	176	196	216	2.661	4.606	2.090
HZ 880M A	158.8	195955	4390	5015	168	188	208	2.700	5.080	2.127
HZ 880M B	174.0	212960	4795	5390	180	200	220	2.703	5.082	2.127
HZ 880M C	180.8	224360	5045	5655	186	205	225	2.703	5.081	2.127
HZ 1080M A	192.7	373135	6530	7320	195	215	235	2.696	5.534	2.127
HZ 1080M B	203.5	403675	7060	7875	204	224	243	2.697	5.534	2.127
HZ 1080M C	223.3	440915	7725	8535	219	239	259	2.699	5.536	2.127
HZ 1080M D	239.3	477090	8340	9185	232	251	271	2.699	5.536	2.127
HZ 1180M A	252.0	504355	8785	9675	242	261	281	2.700	5.537	2.127
HZ 1180M B	260.1	528070	9200	10085	248	268	287	2.702	5.541	2.127
HZ 1180M C	275.9	563170	9745	10735	260	280	300	2.714	5.550	2.127
HZ 1180M D	288.6	590870	10260	11185	269	289	309	2.720	5.555	2.127
Combination HZ ... M - 14 / AZ 20-800										
HZ 630M	185.0	138210	4485	4110	184	207	230	2.661	4.887	2.090
HZ 880M A	176.3	227560	5660	5210	176	199	221	2.700	5.315	2.127
HZ 880M B	191.3	244005	6035	5590	188	210	233	2.703	5.318	2.127
HZ 880M C	198.1	255290	6285	5850	193	216	238	2.703	5.318	2.127
HZ 1080M A	210.2	425860	8120	7620	203	226	249	2.696	5.769	2.127
HZ 1080M B	220.8	455595	8640	8155	212	234	257	2.697	5.771	2.127
HZ 1080M C	240.6	492470	9290	8815	227	250	272	2.699	5.772	2.127
HZ 1080M D	256.6	528385	9890	9460	239	262	285	2.699	5.773	2.127
HZ 1180M A	269.3	555435	10320	9955	249	272	295	2.700	5.773	2.127
HZ 1180M B	276.9	577280	10685	10335	255	278	300	2.702	5.775	2.127
HZ 1180M C	297.5	625865	11465	11075	269	293	316	2.714	5.809	2.127
HZ 1180M D	309.0	649665	11860	11500	278	302	325	2.720	5.815	2.127
Combination HZ ... M - 24 / AZ 20-800										
HZ 630M	274.0	198405	6090	5605	252	269	285	3.146	5.111	2.524
HZ 880M A	257.2	320220	7510	6950	238	254	270	3.224	5.621	2.598
HZ 880M B	281.9	347275	8150	7575	257	273	289	3.230	5.628	2.598
HZ 880M C	293.0	365820	8565	7995	265	281	297	3.229	5.627	2.598
HZ 1080M A	312.8	608890	11070	10420	282	298	314	3.215	6.072	2.598
HZ 1080M B	330.3	657710	11925	11280	296	312	328	3.218	6.074	2.598
HZ 1080M C	362.6	718260	13000	12365	321	337	353	3.221	6.077	2.598
HZ 1080M D	388.8	777195	14005	13415	341	357	373	3.222	6.078	2.598
HZ 1180M A	409.7	821575	14730	14210	357	373	389	3.223	6.080	2.598
HZ 1180M B	422.0	857400	15330	14845	367	383	399	3.227	6.089	2.598
HZ 1180M C	450.1	921595	16400	15855	388	404	421	3.243	6.102	2.598
HZ 1180M D	468.9	960640	17060	16550	402	419	435	3.256	6.111	2.598
Combination HZ ... M - 26 / AZ 20-800										
HZ 630M	290.0	214060	6950	6365	260	279	298	3.146	5.372	2.524
HZ 880M A	272.8	347100	8635	7955	245	263	282	3.224	5.839	2.598
HZ 880M B	297.4	374020	9260	8575	264	282	301	3.230	5.845	2.598
HZ 880M C	308.6	392510	9670	8995	273	291	310	3.229	5.844	2.598
HZ 1080M A	328.3	653955	12480	11710	289	308	327	3.215	6.289	2.598
HZ 1080M B	345.7	702655	13335	12585	303	322	340	3.218	6.291	2.598
HZ 1080M C	378.1	763025	14400	13665	328	347	365	3.221	6.294	2.598
HZ 1080M D	404.2	821835	15390	14720	348	367	385	3.222	6.295	2.598
HZ 1180M A	425.2	866125	16100	15515	365	383	402	3.223	6.297	2.598
HZ 1180M B	437.5	901900	16705	16155	374	393	411	3.227	6.300	2.598
HZ 1180M C	469.6	976975	17965	17350	397	416	436	3.243	6.338	2.598
HZ 1180M D	488.3	1015940	18615	18045	411	431	450	3.256	6.350	2.598

¹⁾ Values of A, I_y, W_{ely}^{*} & W_{ely}^{**} not taking the intermediary sheet piles into account.

Section

Properties per meter of wall¹⁾

Per system

A	I _y	W _{ely} *	W _{ely} **	G _{60%}	G _{80%}	G _{100%}	A _{LW}	A _{LS}	b _{sys}
cm ² /m	cm ⁴ /m	cm ³ /m	cm ³ /m	kg/m ²	kg/m ²	kg/m ²	m ² /m	m ² /m	m

Combination HZ ... M - 12 / AZ 25-800

HZ 630M	167.4	120225	3535	3960	184	207	229	2.696	4.641	2.090
HZ 880M A	158.8	195955	4390	5015	176	199	221	2.735	5.114	2.127
HZ 880M B	174.0	212960	4795	5390	188	210	233	2.738	5.116	2.127
HZ 880M C	180.8	224360	5045	5655	193	216	238	2.737	5.116	2.127
HZ 1080M A	192.7	373135	6530	7320	203	226	248	2.730	5.569	2.127
HZ 1080M B	203.5	403675	7060	7875	212	234	257	2.732	5.569	2.127
HZ 1080M C	223.3	440915	7725	8535	227	249	272	2.733	5.570	2.127
HZ 1080M D	239.3	477090	8340	9185	240	262	284	2.734	5.571	2.127
HZ 1180M A	252.0	504355	8785	9675	250	272	294	2.734	5.572	2.127
HZ 1180M B	260.1	528070	9200	10085	256	278	300	2.736	5.576	2.127
HZ 1180M C	275.9	563170	9745	10735	267	290	313	2.749	5.584	2.127
HZ 1180M D	288.6	590870	10260	11185	277	300	322	2.755	5.589	2.127

Combination HZ ... M - 14 / AZ 25-800

HZ 630M	185.0	138210	4485	4110	192	218	243	2.696	4.922	2.090
HZ 880M A	176.3	227560	5660	5210	184	209	235	2.735	5.350	2.127
HZ 880M B	191.3	244005	6035	5590	196	221	246	2.738	5.353	2.127
HZ 880M C	198.1	255290	6285	5850	201	226	252	2.737	5.352	2.127
HZ 1080M A	210.2	425860	8120	7620	211	236	262	2.730	5.804	2.127
HZ 1080M B	220.8	455595	8640	8155	219	245	270	2.732	5.805	2.127
HZ 1080M C	240.6	492470	9290	8815	235	260	285	2.733	5.807	2.127
HZ 1080M D	256.6	528385	9890	9460	247	273	298	2.734	5.807	2.127
HZ 1180M A	269.3	555435	10320	9955	257	282	308	2.734	5.808	2.127
HZ 1180M B	276.9	577280	10685	10335	263	288	314	2.736	5.810	2.127
HZ 1180M C	297.5	625865	11465	11075	277	303	330	2.749	5.843	2.127
HZ 1180M D	309.0	649665	11860	11500	286	312	338	2.755	5.850	2.127

Combination HZ ... M - 24 / AZ 25-800

HZ 630M	274.0	198405	6090	5605	259	278	296	3.180	5.145	2.524
HZ 880M A	257.2	320220	7510	6950	244	262	281	3.258	5.656	2.598
HZ 880M B	281.9	347275	8150	7575	263	281	300	3.264	5.662	2.598
HZ 880M C	293.0	365820	8565	7995	272	290	308	3.264	5.662	2.598
HZ 1080M A	312.8	608890	11070	10420	289	307	325	3.250	6.106	2.598
HZ 1080M B	330.3	657710	11925	11280	302	321	339	3.252	6.109	2.598
HZ 1080M C	362.6	718260	13000	12365	327	346	364	3.255	6.112	2.598
HZ 1080M D	388.8	777195	14005	13415	348	366	384	3.256	6.113	2.598
HZ 1180M A	409.7	821575	14730	14210	364	382	400	3.258	6.114	2.598
HZ 1180M B	422.0	857400	15330	14845	373	392	410	3.261	6.123	2.598
HZ 1180M C	450.1	921595	16400	15855	394	413	431	3.278	6.136	2.598
HZ 1180M D	468.9	960640	17060	16550	409	427	446	3.290	6.146	2.598

Combination HZ ... M - 26 / AZ 25-800

HZ 630M	290.0	214060	6950	6365	266	288	309	3.180	5.406	2.524
HZ 880M A	272.8	347100	8635	7955	251	272	293	3.258	5.873	2.598
HZ 880M B	297.4	374020	9260	8575	270	291	312	3.264	5.879	2.598
HZ 880M C	308.6	392510	9670	8995	279	300	320	3.264	5.879	2.598
HZ 1080M A	328.3	653955	12480	11710	296	317	337	3.250	6.323	2.598
HZ 1080M B	345.7	702655	13335	12585	310	330	351	3.252	6.326	2.598
HZ 1080M C	378.1	763025	14400	13665	335	355	376	3.255	6.329	2.598
HZ 1080M D	404.2	821835	15390	14720	355	376	396	3.256	6.330	2.598
HZ 1180M A	425.2	866125	16100	15515	371	392	412	3.258	6.331	2.598
HZ 1180M B	437.5	901900	16705	16155	381	401	422	3.261	6.335	2.598
HZ 1180M C	469.6	976975	17965	17350	403	425	446	3.278	6.372	2.598
HZ 1180M D	488.3	1015940	18615	18045	418	439	461	3.290	6.385	2.598

¹⁾ Values of A, I_y, W_{ely}* & W_{ely}** not taking the intermediary sheet piles into account.

Characteristics of combinations according to EN 1993-5 design approach

Section	Properties per meter of wall ¹⁾							Per system		
	A	I _y	W _{ely} [*]	W _{ely} ^{**}	G _{60%}	G _{80%}	G _{100%}	A _{LW}	A _{LS}	b _{sys}
	cm ² /m	cm ⁴ /m	cm ³ /m	cm ³ /m	kg/m ²	kg/m ²	kg/m ²	m ² /m	m ² /m	m
Combination HZ ... M - 12 / AZ 13-770										
HZ 630M	172.3	123775	3640	4075	174	192	210	2.427	4.372	2.030
HZ 880M A	163.4	201645	4515	5160	166	184	202	2.466	4.846	2.067
HZ 880M B	179.1	219140	4930	5545	178	196	214	2.469	4.847	2.067
HZ 880M C	186.1	230875	5190	5820	184	201	219	2.469	4.847	2.067
HZ 1080M A	198.3	383965	6720	7535	194	212	230	2.462	5.300	2.067
HZ 1080M B	209.4	415390	7265	8100	203	220	238	2.463	5.300	2.067
HZ 1080M C	229.8	453715	7950	8780	218	236	254	2.464	5.301	2.067
HZ 1080M D	246.2	490935	8585	9450	231	249	267	2.465	5.302	2.067
HZ 1180M A	259.4	518995	9040	9955	241	259	277	2.466	5.303	2.067
HZ 1180M B	267.7	543400	9470	10380	248	266	284	2.467	5.307	2.067
HZ 1180M C	283.9	579520	10030	11045	260	278	296	2.480	5.316	2.067
HZ 1180M D	297.0	608025	10555	11505	270	288	306	2.486	5.321	2.067
Combination HZ ... M - 14 / AZ 13-770										
HZ 630M	190.4	142295	4620	4230	182	203	224	2.427	4.653	2.030
HZ 880M A	181.4	234170	5825	5365	174	195	216	2.466	5.081	2.067
HZ 880M B	196.9	251085	6210	5750	186	207	228	2.469	5.084	2.067
HZ 880M C	203.9	262700	6470	6020	192	212	233	2.469	5.084	2.067
HZ 1080M A	216.3	438220	8360	7840	202	223	244	2.462	5.535	2.067
HZ 1080M B	227.2	468820	8890	8390	210	231	252	2.463	5.536	2.067
HZ 1080M C	247.6	506765	9555	9070	226	247	268	2.464	5.538	2.067
HZ 1080M D	264.0	543725	10180	9735	239	260	281	2.465	5.538	2.067
HZ 1180M A	277.2	571555	10620	10245	249	270	291	2.466	5.539	2.067
HZ 1180M B	284.9	594035	10995	10635	255	276	297	2.467	5.541	2.067
HZ 1180M C	306.1	644030	11800	11395	270	292	314	2.480	5.575	2.067
HZ 1180M D	318.0	668520	12205	11835	279	301	323	2.486	5.581	2.067
Combination HZ ... M - 24 / AZ 13-770										
HZ 630M	280.7	203235	6240	5740	252	267	282	2.912	4.876	2.464
HZ 880M A	263.3	327790	7690	7115	237	252	266	2.989	5.387	2.538
HZ 880M B	288.6	355485	8345	7755	257	271	286	2.995	5.393	2.538
HZ 880M C	300.0	374465	8765	8180	266	280	295	2.995	5.393	2.538
HZ 1080M A	320.2	623285	11330	10665	283	297	312	2.981	5.837	2.538
HZ 1080M B	338.1	673255	12205	11545	297	311	326	2.983	5.840	2.538
HZ 1080M C	371.2	735240	13310	12660	322	337	352	2.986	5.843	2.538
HZ 1080M D	398.0	795570	14335	13735	343	358	372	2.987	5.844	2.538
HZ 1180M A	419.4	841000	15075	14545	360	374	389	2.989	5.846	2.538
HZ 1180M B	432.0	877670	15695	15195	370	384	399	2.992	5.854	2.538
HZ 1180M C	460.8	943385	16785	16230	391	406	421	3.009	5.867	2.538
HZ 1180M D	480.0	983350	17460	16940	406	421	435	3.021	5.877	2.538
Combination HZ ... M - 26 / AZ 13-770										
HZ 630M	297.0	219270	7120	6520	260	277	295	2.912	5.138	2.464
HZ 880M A	279.2	355305	8840	8145	245	262	279	2.989	5.604	2.538
HZ 880M B	304.4	382865	9480	8775	264	281	298	2.995	5.611	2.538
HZ 880M C	315.8	401785	9900	9210	273	290	307	2.995	5.610	2.538
HZ 1080M A	336.1	669415	12775	11990	290	307	324	2.981	6.054	2.538
HZ 1080M B	353.9	719265	13650	12880	304	321	339	2.983	6.057	2.538
HZ 1080M C	387.0	781060	14740	13990	330	347	364	2.986	6.060	2.538
HZ 1080M D	413.8	841265	15755	15070	351	368	385	2.987	6.061	2.538
HZ 1180M A	435.2	886600	16480	15880	367	384	401	2.989	6.062	2.538
HZ 1180M B	447.8	923220	17100	16535	377	394	411	2.992	6.066	2.538
HZ 1180M C	480.7	1000070	18390	17760	400	418	436	3.009	6.104	2.538
HZ 1180M D	499.9	1039960	19055	18470	415	433	451	3.021	6.116	2.538

¹⁾ Values of A, I_y, W_{ely}^{*} & W_{ely}^{**} not taking the intermediary sheet piles into account.

Section

Properties per meter of wall¹⁾

Per system

A	I _y	W _{ely} *	W _{ely} **	G _{60%}	G _{80%}	G _{100%}	A _{LW}	A _{LS}	b _{sys}
cm ² /m	cm ⁴ /m	cm ³ /m	cm ³ /m	kg/m ²	kg/m ²	kg/m ²	m ² /m	m ² /m	m

Combination HZ ... M - 12 / AZ 28-750

HZ 630M	175.8	126265	3715	4160	192	216	239	2.693	4.638	1.990
HZ 880M A	166.7	205620	4605	5260	184	207	230	2.732	5.112	2.027
HZ 880M B	182.6	223465	5030	5655	196	219	242	2.735	5.114	2.027
HZ 880M C	189.7	235430	5295	5935	202	225	248	2.735	5.113	2.027
HZ 1080M A	202.2	391540	6850	7680	212	235	259	2.728	5.566	2.027
HZ 1080M B	213.6	423590	7410	8260	221	244	267	2.729	5.566	2.027
HZ 1080M C	234.3	462665	8110	8955	237	260	283	2.730	5.567	2.027
HZ 1080M D	251.1	500625	8750	9635	250	273	297	2.731	5.568	2.027
HZ 1180M A	264.5	529240	9220	10150	261	284	307	2.732	5.569	2.027
HZ 1180M B	273.0	554120	9655	10585	267	290	314	2.733	5.573	2.027
HZ 1180M C	289.5	590955	10225	11265	280	303	326	2.746	5.582	2.027
HZ 1180M D	302.8	620020	10765	11735	290	313	337	2.752	5.587	2.027

Combination HZ ... M - 14 / AZ 28-750

HZ 630M	194.3	145155	4710	4315	200	227	254	2.693	4.919	1.990
HZ 880M A	185.0	238790	5935	5470	192	218	244	2.732	5.347	2.027
HZ 880M B	200.7	256040	6335	5865	204	230	257	2.735	5.350	2.027
HZ 880M C	207.9	267885	6595	6135	210	236	262	2.735	5.350	2.027
HZ 1080M A	220.5	446870	8520	7995	220	247	273	2.728	5.801	2.027
HZ 1080M B	231.7	478075	9070	8555	229	256	282	2.729	5.802	2.027
HZ 1080M C	252.4	516765	9745	9250	245	272	298	2.730	5.804	2.027
HZ 1080M D	269.2	554450	10380	9925	258	285	311	2.731	5.804	2.027
HZ 1180M A	282.6	582835	10830	10445	269	295	321	2.732	5.805	2.027
HZ 1180M B	290.5	605760	11215	10845	275	301	327	2.733	5.807	2.027
HZ 1180M C	312.2	656740	12035	11620	290	317	344	2.746	5.841	2.027
HZ 1180M D	324.2	681715	12445	12065	299	326	353	2.752	5.847	2.027

Combination HZ ... M - 24 / AZ 28-750

HZ 630M	285.3	206590	6345	5835	269	288	307	3.178	5.142	2.424
HZ 880M A	267.5	333040	7815	7230	253	272	290	3.255	5.653	2.498
HZ 880M B	293.2	361180	8475	7875	273	291	310	3.262	5.659	2.498
HZ 880M C	304.8	380465	8905	8315	282	300	319	3.261	5.659	2.498
HZ 1080M A	325.3	633265	11515	10835	299	318	337	3.247	6.103	2.498
HZ 1080M B	343.5	684040	12400	11730	314	332	351	3.249	6.106	2.498
HZ 1080M C	377.1	747010	13520	12860	340	358	377	3.252	6.109	2.498
HZ 1080M D	404.3	808310	14565	13955	361	379	398	3.253	6.110	2.498
HZ 1180M A	426.1	854465	15320	14775	377	396	415	3.255	6.112	2.498
HZ 1180M B	438.9	891725	15945	15435	387	406	425	3.258	6.121	2.498
HZ 1180M C	468.1	958490	17055	16490	409	428	447	3.275	6.134	2.498
HZ 1180M D	487.7	999095	17740	17210	424	443	462	3.287	6.143	2.498

Combination HZ ... M - 26 / AZ 28-750

HZ 630M	301.9	222890	7235	6630	276	298	320	3.178	5.404	2.424
HZ 880M A	283.7	360995	8980	8275	261	282	303	3.255	5.870	2.498
HZ 880M B	309.3	388995	9630	8915	280	301	323	3.262	5.877	2.498
HZ 880M C	320.9	408220	10055	9355	289	311	332	3.261	5.876	2.498
HZ 1080M A	341.4	680135	12980	12180	307	328	350	3.247	6.321	2.498
HZ 1080M B	359.6	730785	13870	13085	321	343	364	3.249	6.323	2.498
HZ 1080M C	393.2	793570	14975	14210	347	368	390	3.252	6.326	2.498
HZ 1080M D	420.4	854735	16005	15310	368	389	411	3.253	6.327	2.498
HZ 1180M A	442.2	900800	16745	16135	385	406	427	3.255	6.329	2.498
HZ 1180M B	455.0	938005	17370	16800	395	416	438	3.258	6.332	2.498
HZ 1180M C	488.4	1016085	18685	18045	419	441	463	3.275	6.370	2.498
HZ 1180M D	507.9	1056610	19360	18770	434	456	478	3.287	6.382	2.498

¹⁾ Values of A, I_y, W_{ely}* & W_{ely}** not taking the intermediary sheet piles into account.

Characteristics of combinations according to EN 1993-5 design approach

Section	Properties per meter of wall ¹⁾							Per system		
	A	I _y	W _{ely} [*]	W _{ely} ^{**}	G _{60%}	G _{80%}	G _{100%}	A _{LW}	A _{LS}	b _{sys}
	cm ² /m	cm ⁴ /m	cm ³ /m	cm ³ /m	kg/m ²	kg/m ²	kg/m ²	m ² /m	m ² /m	m
Combination HZ ... M - 12 / AZ 13-700-10/10										
HZ 630M	185.1	132945	3910	4380	187	207	227	2.293	4.238	1.890
HZ 880M A	175.3	216290	4845	5535	179	198	218	2.332	4.712	1.927
HZ 880M B	192.1	235060	5290	5950	192	211	230	2.335	4.713	1.927
HZ 880M C	199.6	247645	5570	6245	198	217	236	2.335	4.713	1.927
HZ 1080M A	212.7	411860	7205	8080	209	228	247	2.328	5.166	1.927
HZ 1080M B	224.6	445570	7795	8690	218	237	257	2.329	5.166	1.927
HZ 1080M C	246.4	486675	8530	9420	235	254	274	2.330	5.167	1.927
HZ 1080M D	264.1	526605	9205	10135	249	268	287	2.331	5.168	1.927
HZ 1180M A	278.2	556700	9700	10675	260	279	298	2.332	5.169	1.927
HZ 1180M B	287.1	582875	10155	11135	267	286	305	2.333	5.173	1.927
HZ 1180M C	304.6	621620	10760	11850	279	299	319	2.346	5.182	1.927
HZ 1180M D	318.5	652200	11325	12345	290	310	330	2.352	5.187	1.927
Combination HZ ... M - 14 / AZ 13-700-10/10										
HZ 630M	204.5	152835	4960	4540	196	219	242	2.293	4.519	1.890
HZ 880M A	194.5	251180	6245	5750	187	210	233	2.332	4.947	1.927
HZ 880M B	211.2	269330	6665	6170	200	223	245	2.335	4.950	1.927
HZ 880M C	218.7	281790	6940	6455	206	229	251	2.335	4.950	1.927
HZ 1080M A	232.0	470060	8965	8410	217	240	263	2.328	5.401	1.927
HZ 1080M B	243.7	502885	9540	9000	226	249	272	2.329	5.402	1.927
HZ 1080M C	265.5	543585	10250	9730	243	266	289	2.330	5.404	1.927
HZ 1080M D	283.2	583225	10920	10440	257	280	302	2.331	5.404	1.927
HZ 1180M A	297.3	613080	11390	10990	268	291	313	2.332	5.405	1.927
HZ 1180M B	305.6	637195	11795	11405	275	297	320	2.333	5.407	1.927
HZ 1180M C	328.4	690820	12655	12225	290	314	337	2.346	5.441	1.927
HZ 1180M D	341.0	717090	13095	12695	300	323	347	2.352	5.447	1.927
Combination HZ ... M - 24 / AZ 13-700-10/10										
HZ 630M	297.6	215480	6615	6085	268	284	300	2.778	4.742	2.324
HZ 880M A	278.7	346930	8140	7530	252	267	283	2.855	5.253	2.398
HZ 880M B	305.4	376240	8830	8205	272	288	303	2.861	5.259	2.398
HZ 880M C	317.5	396330	9275	8660	282	297	313	2.861	5.259	2.398
HZ 1080M A	338.9	659675	11995	11285	300	316	331	2.847	5.703	2.398
HZ 1080M B	357.8	712565	12915	12220	315	330	346	2.849	5.706	2.398
HZ 1080M C	392.8	778165	14085	13395	342	357	373	2.852	5.709	2.398
HZ 1080M D	421.2	842015	15175	14535	364	379	395	2.853	5.710	2.398
HZ 1180M A	443.8	890100	15955	15390	381	397	412	2.855	5.712	2.398
HZ 1180M B	457.2	928910	16610	16080	392	407	423	2.858	5.720	2.398
HZ 1180M C	487.7	998460	17765	17175	414	430	446	2.875	5.733	2.398
HZ 1180M D	508.0	1040755	18480	17930	430	446	462	2.887	5.743	2.398
Combination HZ ... M - 26 / AZ 13-700-10/10										
HZ 630M	314.9	232480	7550	6915	276	295	314	2.778	5.003	2.324
HZ 880M A	295.5	376050	9355	8620	260	278	296	2.855	5.470	2.398
HZ 880M B	322.2	405215	10030	9285	280	298	316	2.861	5.477	2.398
HZ 880M C	334.3	425245	10475	9745	290	308	326	2.861	5.476	2.398
HZ 1080M A	355.7	708495	13520	12690	308	326	344	2.847	5.920	2.398
HZ 1080M B	374.6	761260	14445	13635	323	341	359	2.849	5.923	2.398
HZ 1080M C	409.6	826660	15600	14805	350	368	386	2.852	5.926	2.398
HZ 1080M D	438.0	890380	16675	15945	372	390	408	2.853	5.927	2.398
HZ 1180M A	460.6	938365	17445	16805	389	407	426	2.855	5.928	2.398
HZ 1180M B	474.0	977120	18095	17500	400	418	436	2.858	5.932	2.398
HZ 1180M C	508.7	1058455	19460	18795	424	443	462	2.875	5.970	2.398
HZ 1180M D	529.1	1100675	20170	19550	440	459	478	2.887	5.982	2.398

¹⁾ Values of A, I_y, W_{ely}* & W_{ely}** not taking the intermediary sheet piles into account.

Section

Properties per meter of wall¹⁾

Per system

A	I _y	W _{ely} *	W _{ely} **	G _{60%}	G _{80%}	G _{100%}	A _{LW}	A _{LS}	b _{sys}
cm ² /m	cm ⁴ /m	cm ³ /m	cm ³ /m	kg/m ²	kg/m ²	kg/m ²	m ² /m	m ² /m	m

Combination HZ ... M - 12 / AZ 20-700

HZ 630M	185.1	132945	3910	4380	191	213	234	2.438	4.383	1.890
HZ 880M A	175.3	216290	4845	5535	183	203	224	2.477	4.856	1.927
HZ 880M B	192.1	235060	5290	5950	196	216	237	2.480	4.858	1.927
HZ 880M C	199.6	247645	5570	6245	202	222	243	2.479	4.858	1.927
HZ 1080M A	212.7	411860	7205	8080	213	233	254	2.472	5.311	1.927
HZ 1080M B	224.6	445570	7795	8690	222	243	263	2.474	5.311	1.927
HZ 1080M C	246.4	486675	8530	9420	239	260	280	2.475	5.312	1.927
HZ 1080M D	264.1	526605	9205	10135	253	273	294	2.476	5.313	1.927
HZ 1180M A	278.2	556700	9700	10675	264	284	305	2.476	5.314	1.927
HZ 1180M B	287.1	582875	10155	11135	271	291	312	2.478	5.318	1.927
HZ 1180M C	304.6	621620	10760	11850	283	304	325	2.491	5.327	1.927
HZ 1180M D	318.5	652200	11325	12345	294	315	336	2.497	5.332	1.927

Combination HZ ... M - 14 / AZ 20-700

HZ 630M	204.5	152835	4960	4540	200	224	249	2.438	4.664	1.890
HZ 880M A	194.5	251180	6245	5750	191	215	239	2.477	5.092	1.927
HZ 880M B	211.2	269330	6665	6170	204	228	252	2.480	5.095	1.927
HZ 880M C	218.7	281790	6940	6455	210	234	258	2.479	5.095	1.927
HZ 1080M A	232.0	470060	8965	8410	221	245	269	2.472	5.546	1.927
HZ 1080M B	243.7	502885	9540	9000	230	254	278	2.474	5.547	1.927
HZ 1080M C	265.5	543585	10250	9730	247	271	295	2.475	5.549	1.927
HZ 1080M D	283.2	583225	10920	10440	261	285	309	2.476	5.549	1.927
HZ 1180M A	297.3	613080	11390	10990	272	296	320	2.476	5.550	1.927
HZ 1180M B	305.6	637195	11795	11405	278	302	326	2.478	5.552	1.927
HZ 1180M C	328.4	690820	12655	12225	294	319	344	2.491	5.585	1.927
HZ 1180M D	341.0	717090	13095	12695	304	329	354	2.497	5.592	1.927

Combination HZ ... M - 24 / AZ 20-700

HZ 630M	297.6	215480	6615	6085	271	288	305	2.923	4.887	2.324
HZ 880M A	278.7	346930	8140	7530	255	272	288	3.000	5.398	2.398
HZ 880M B	305.4	376240	8830	8205	275	292	309	3.006	5.404	2.398
HZ 880M C	317.5	396330	9275	8660	285	301	318	3.006	5.404	2.398
HZ 1080M A	338.9	659675	11995	11285	303	320	336	2.992	5.848	2.398
HZ 1080M B	357.8	712565	12915	12220	318	335	351	2.994	5.851	2.398
HZ 1080M C	392.8	778165	14085	13395	345	362	378	2.997	5.854	2.398
HZ 1080M D	421.2	842015	15175	14535	367	384	400	2.998	5.855	2.398
HZ 1180M A	443.8	890100	15955	15390	384	401	418	3.000	5.856	2.398
HZ 1180M B	457.2	928910	16610	16080	395	412	428	3.003	5.865	2.398
HZ 1180M C	487.7	998460	17765	17175	418	434	451	3.020	5.878	2.398
HZ 1180M D	508.0	1040755	18480	17930	433	450	467	3.032	5.888	2.398

Combination HZ ... M - 26 / AZ 20-700

HZ 630M	314.9	232480	7550	6915	279	299	319	2.923	5.148	2.324
HZ 880M A	295.5	376050	9355	8620	263	282	301	3.000	5.615	2.398
HZ 880M B	322.2	405215	10030	9285	283	303	322	3.006	5.621	2.398
HZ 880M C	334.3	425245	10475	9745	293	312	331	3.006	5.621	2.398
HZ 1080M A	355.7	708495	13520	12690	311	330	350	2.992	6.065	2.398
HZ 1080M B	374.6	761260	14445	13635	326	345	365	2.994	6.068	2.398
HZ 1080M C	409.6	826660	15600	14805	353	372	391	2.997	6.071	2.398
HZ 1080M D	438.0	890380	16675	15945	375	394	413	2.998	6.072	2.398
HZ 1180M A	460.6	938365	17445	16805	392	412	431	3.000	6.073	2.398
HZ 1180M B	474.0	977120	18095	17500	403	422	441	3.003	6.077	2.398
HZ 1180M C	508.7	1058455	19460	18795	427	448	468	3.020	6.115	2.398
HZ 1180M D	529.1	1100675	20170	19550	443	463	483	3.032	6.127	2.398

¹⁾ Values of A, I_y, W_{ely}* & W_{ely}** not taking the intermediary sheet piles into account.

Characteristics of combinations according to EN 1993-5 design approach

Section	Properties per meter of wall ¹⁾						Per system			
	A	I _y	W _{ely} [*]	W _{ely} ^{**}	G _{60%}	G _{80%}	G _{100%}	A _{LW}	A _{LS}	b _{sys}
	cm ² /m	cm ⁴ /m	cm ³ /m	cm ³ /m	kg/m ²	kg/m ²	kg/m ²	m ² /m	m ² /m	m

Combination HZ ... M - 12 / AZ 26-700

HZ 630M	185.1	132945	3910	4380	204	229	254	2.512	4.457	1.890
HZ 880M A	175.3	216290	4845	5535	195	220	244	2.551	4.931	1.927
HZ 880M B	192.1	235060	5290	5950	208	232	257	2.554	4.933	1.927
HZ 880M C	199.6	247645	5570	6245	214	238	263	2.554	4.932	1.927
HZ 1080M A	212.7	411860	7205	8080	225	249	274	2.547	5.385	1.927
HZ 1080M B	224.6	445570	7795	8690	234	259	284	2.548	5.385	1.927
HZ 1080M C	246.4	486675	8530	9420	251	276	300	2.549	5.387	1.927
HZ 1080M D	264.1	526605	9205	10135	265	289	314	2.550	5.387	1.927
HZ 1180M A	278.2	556700	9700	10675	276	300	325	2.551	5.388	1.927
HZ 1180M B	287.1	582875	10155	11135	283	307	332	2.552	5.392	1.927
HZ 1180M C	304.6	621620	10760	11850	295	320	345	2.565	5.401	1.927
HZ 1180M D	318.5	652200	11325	12345	306	331	356	2.571	5.406	1.927

Combination HZ ... M - 14 / AZ 26-700

HZ 630M	204.5	152835	4960	4540	212	241	269	2.512	4.738	1.890
HZ 880M A	194.5	251180	6245	5750	203	231	259	2.551	5.166	1.927
HZ 880M B	211.2	269330	6665	6170	216	244	272	2.554	5.169	1.927
HZ 880M C	218.7	281790	6940	6455	222	250	278	2.554	5.169	1.927
HZ 1080M A	232.0	470060	8965	8410	233	261	289	2.547	5.620	1.927
HZ 1080M B	243.7	502885	9540	9000	242	271	299	2.548	5.621	1.927
HZ 1080M C	265.5	543585	10250	9730	259	287	315	2.549	5.623	1.927
HZ 1080M D	283.2	583225	10920	10440	273	301	329	2.550	5.624	1.927
HZ 1180M A	297.3	613080	11390	10990	284	312	340	2.551	5.624	1.927
HZ 1180M B	305.6	637195	11795	11405	291	318	346	2.552	5.626	1.927
HZ 1180M C	328.4	690820	12655	12225	306	335	364	2.565	5.660	1.927
HZ 1180M D	341.0	717090	13095	12695	316	345	374	2.571	5.666	1.927

Combination HZ ... M - 24 / AZ 26-700

HZ 630M	297.6	215480	6615	6085	281	302	322	2.997	4.961	2.324
HZ 880M A	278.7	346930	8140	7530	265	284	304	3.074	5.472	2.398
HZ 880M B	305.4	376240	8830	8205	285	305	325	3.081	5.479	2.398
HZ 880M C	317.5	396330	9275	8660	295	314	334	3.080	5.478	2.398
HZ 1080M A	338.9	659675	11995	11285	313	333	353	3.066	5.923	2.398
HZ 1080M B	357.8	712565	12915	12220	328	348	368	3.068	5.925	2.398
HZ 1080M C	392.8	778165	14085	13395	355	375	394	3.072	5.928	2.398
HZ 1080M D	421.2	842015	15175	14535	377	397	416	3.073	5.929	2.398
HZ 1180M A	443.8	890100	15955	15390	394	414	434	3.074	5.931	2.398
HZ 1180M B	457.2	928910	16610	16080	405	424	444	3.077	5.940	2.398
HZ 1180M C	487.7	998460	17765	17175	427	447	467	3.094	5.953	2.398
HZ 1180M D	508.0	1040755	18480	17930	443	463	483	3.107	5.962	2.398

Combination HZ ... M - 26 / AZ 26-700

HZ 630M	314.9	232480	7550	6915	289	313	336	2.997	5.223	2.324
HZ 880M A	295.5	376050	9355	8620	273	295	317	3.074	5.690	2.398
HZ 880M B	322.2	405215	10030	9285	293	315	338	3.081	5.696	2.398
HZ 880M C	334.3	425245	10475	9745	302	325	347	3.080	5.695	2.398
HZ 1080M A	355.7	708495	13520	12690	321	343	366	3.066	6.140	2.398
HZ 1080M B	374.6	761260	14445	13635	336	358	381	3.068	6.142	2.398
HZ 1080M C	409.6	826660	15600	14805	363	385	408	3.072	6.145	2.398
HZ 1080M D	438.0	890380	16675	15945	385	407	430	3.073	6.146	2.398
HZ 1180M A	460.6	938365	17445	16805	402	425	447	3.074	6.148	2.398
HZ 1180M B	474.0	977120	18095	17500	413	435	457	3.077	6.151	2.398
HZ 1180M C	508.7	1058455	19460	18795	437	460	484	3.094	6.189	2.398
HZ 1180M D	529.1	1100675	20170	19550	453	476	499	3.107	6.201	2.398

¹⁾ Values of A, I_y, W_{ely}^{*} & W_{ely}^{**} not taking the intermediary sheet piles into account.

Section

Properties per meter of wall¹⁾

Per system

A	I _y	W _{ely} *	W _{ely} **	G _{60%}	G _{80%}	G _{100%}	A _{LW}	A _{LS}	b _{sys}
cm ² /m	cm ⁴ /m	cm ³ /m	cm ³ /m	kg/m ²	kg/m ²	kg/m ²	m ² /m	m ² /m	m

Combination HZ ... M - 12 / AZ 26

HZ 630M	199.9	143580	4220	4730	217	243	269	2.365	4.310	1.750
HZ 880M A	189.0	233235	5225	5970	207	232	258	2.403	4.783	1.787
HZ 880M B	207.1	253480	5705	6415	221	246	272	2.406	4.785	1.787
HZ 880M C	215.2	267050	6005	6730	227	252	278	2.406	4.785	1.787
HZ 1080M A	229.4	444125	7770	8715	239	264	290	2.399	5.238	1.787
HZ 1080M B	242.2	480480	8405	9370	249	275	300	2.400	5.237	1.787
HZ 1080M C	265.7	524805	9195	10155	267	293	318	2.402	5.239	1.787
HZ 1080M D	284.8	567860	9925	10930	282	307	333	2.402	5.239	1.787
HZ 1180M A	300.0	600315	10460	11515	294	319	345	2.403	5.240	1.787
HZ 1180M B	309.6	628540	10950	12005	301	327	352	2.405	5.244	1.787
HZ 1180M C	328.4	670320	11600	12780	315	341	367	2.418	5.253	1.787
HZ 1180M D	343.5	703295	12210	13310	327	353	378	2.424	5.258	1.787

Combination HZ ... M - 14 / AZ 26

HZ 630M	220.9	165060	5355	4905	226	255	285	2.365	4.590	1.750
HZ 880M A	209.8	270860	6735	6205	216	245	274	2.403	5.018	1.787
HZ 880M B	227.7	290430	7185	6655	230	259	288	2.406	5.022	1.787
HZ 880M C	235.8	303865	7480	6960	236	265	294	2.406	5.021	1.787
HZ 1080M A	250.1	506885	9665	9070	248	277	306	2.399	5.473	1.787
HZ 1080M B	262.8	542280	10285	9705	258	287	316	2.400	5.474	1.787
HZ 1080M C	286.3	586170	11055	10490	276	305	334	2.402	5.475	1.787
HZ 1080M D	305.4	628915	11775	11260	291	320	349	2.402	5.476	1.787
HZ 1180M A	320.6	661110	12285	11850	303	332	361	2.403	5.477	1.787
HZ 1180M B	329.5	687115	12720	12300	310	339	368	2.405	5.478	1.787
HZ 1180M C	354.1	744945	13650	13180	326	357	387	2.418	5.512	1.787
HZ 1180M D	367.8	773270	14120	13685	337	367	397	2.424	5.518	1.787

Combination HZ ... M - 24 / AZ 26

HZ 630M	316.7	229295	7040	6475	296	317	338	2.849	4.814	2.184
HZ 880M A	296.0	368440	8645	8000	278	298	319	2.927	5.325	2.258
HZ 880M B	324.4	399570	9380	8715	300	320	340	2.933	5.331	2.258
HZ 880M C	337.2	420900	9850	9195	310	330	350	2.932	5.330	2.258
HZ 1080M A	359.9	700575	12735	11985	330	350	370	2.919	5.775	2.258
HZ 1080M B	380.0	756745	13720	12980	345	366	386	2.921	5.777	2.258
HZ 1080M C	417.2	826410	14960	14225	374	394	414	2.924	5.780	2.258
HZ 1080M D	447.3	894225	16115	15435	397	418	438	2.925	5.781	2.258
HZ 1180M A	471.4	945285	16945	16345	416	436	456	2.926	5.783	2.258
HZ 1180M B	485.6	986505	17640	17075	427	447	467	2.930	5.792	2.258
HZ 1180M C	517.9	1060365	18870	18240	451	471	492	2.947	5.805	2.258
HZ 1180M D	539.5	1105285	19625	19040	467	488	508	2.959	5.815	2.258

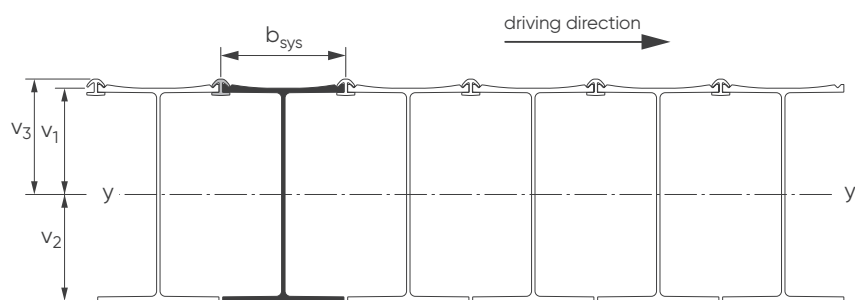
Combination HZ ... M - 26 / AZ 26

HZ 630M	335.1	247385	8030	7355	305	329	353	2.849	5.075	2.184
HZ 880M A	313.8	399365	9935	9150	287	310	333	2.927	5.542	2.258
HZ 880M B	342.2	430340	10655	9865	308	331	354	2.933	5.548	2.258
HZ 880M C	355.0	451610	11125	10350	318	341	364	2.932	5.548	2.258
HZ 1080M A	377.7	752425	14360	13475	338	361	384	2.919	5.992	2.258
HZ 1080M B	397.8	808455	15340	14480	354	377	400	2.921	5.994	2.258
HZ 1080M C	435.0	877915	16565	15720	382	405	428	2.924	5.997	2.258
HZ 1080M D	465.1	945585	17710	16935	406	429	452	2.925	5.998	2.258
HZ 1180M A	489.2	996545	18525	17850	424	447	470	2.926	6.000	2.258
HZ 1180M B	503.4	1037705	19220	18585	435	458	481	2.930	6.003	2.258
HZ 1180M C	540.3	1124080	20670	19965	461	485	509	2.947	6.041	2.258
HZ 1180M D	561.9	1168915	21420	20760	478	502	526	2.959	6.054	2.258

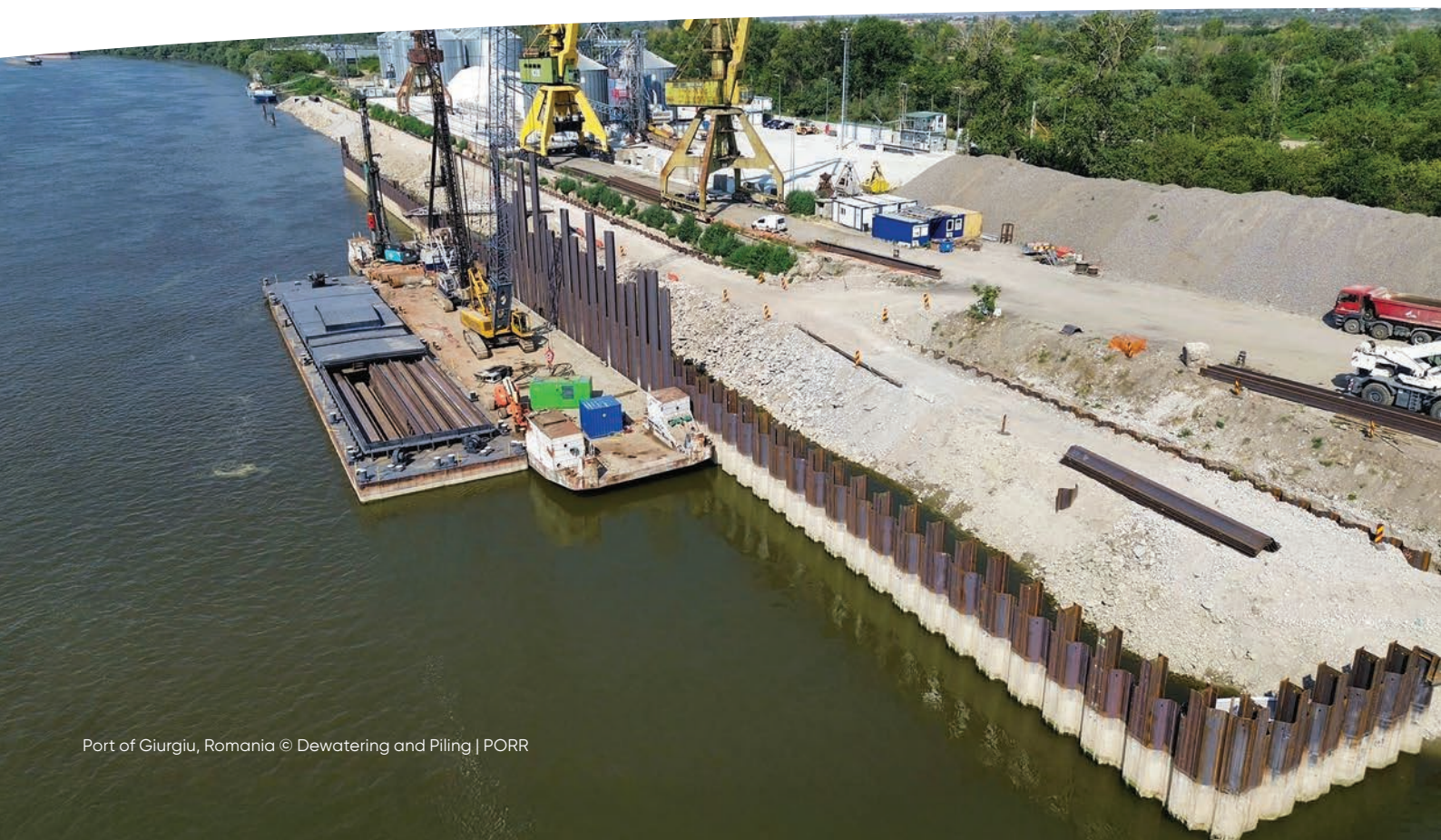
¹⁾ Values of A, I_y, W_{ely}* & W_{ely}** not taking the intermediary sheet piles into account.

Characteristics of combinations C 1 and C 23

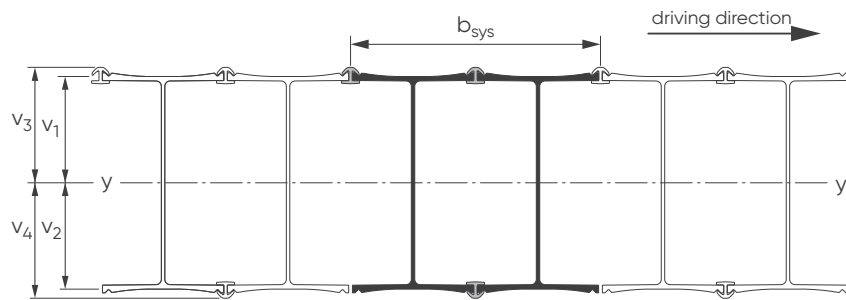
Combination C 1



Section	Dimensions			Properties per meter of wall					Per system		
	v_1	v_2	v_3	A	G	I_y	W_{ely}^*	W_{ely}^{**}	A_{LW}	A_{LS}	b_{sys}
	mm	mm	mm	cm ² /m	kg/m ²	cm ⁴ /m	cm ³ /m	cm ³ /m	m ² /m	m ² /m	m
HZ 630M	292.6	323.2	320.9	757.3	594.5	542340	16780	16900	0.513	2.500	0.434
HZ 880M A	380.2	423.2	414.6	671.0	526.8	823630	19460	19865	0.551	2.984	0.475
HZ 880M B	384.5	422.9	417.0	736.4	578.1	895380	21175	21475	0.554	2.986	0.475
HZ 880M C	387.3	424.1	417.7	766.9	602.0	946160	22310	22650	0.554	2.986	0.475
HZ 1080M A	500.8	546.6	535.2	830.8	652.2	1590360	29095	29715	0.547	3.439	0.470
HZ 1080M B	505.5	547.9	536.9	880.0	690.8	1728110	31540	32185	0.548	3.438	0.470
HZ 1080M C	510.5	548.9	538.9	965.7	758.0	1887970	34395	35035	0.549	3.440	0.470
HZ 1080M D	515.8	551.6	540.2	1035.8	813.1	2046410	37100	37880	0.550	3.440	0.470
HZ 1180M A	520.8	554.6	541.2	1091.2	856.6	2164320	39025	39990	0.551	3.441	0.475
HZ 1180M B	524.5	554.9	542.9	1127.6	885.2	2270310	40910	41820	0.553	3.447	0.475
HZ 1180M C	522.7	560.7	542.0	1192.6	936.2	2418290	43130	44615	0.558	3.465	0.475
HZ 1180M D	527.8	559.6	545.1	1246.5	978.5	2535560	45310	46515	0.564	3.472	0.475



Combination C 23



Section	Dimensions				Properties per meter of wall					Per system		
	v_1	v_2	v_3	v_4	A	G	I_y	$W_{el,y}^*$	$W_{el,y}^{**}$	A_{LW}	A_{LS}	b_{sys}
	mm	mm	mm	mm	cm ² /m	kg/m ²	cm ⁴ /m	cm ³ /m	cm ³ /m	m ² /m	m ² /m	m
HZ 630M	298.7	317.0	327.1	345.3	772.5	606.4	557210	17580	16135	0.998	2.992	0.868
HZ 880M A	389.1	414.3	423.6	448.7	685.6	538.2	849130	20500	18925	1.074	3.526	0.950
HZ 880M B	392.3	415.1	424.7	447.6	750.3	589.0	919420	22150	20540	1.081	3.532	0.950
HZ 880M C	394.7	416.7	425.2	447.1	780.8	613.0	970120	23285	21695	1.080	3.531	0.950
HZ 1080M A	510.3	537.1	544.8	571.5	845.7	663.8	1633800	30420	28590	1.066	3.976	0.940
HZ 1080M B	514.1	539.3	545.5	570.8	894.1	701.9	1769060	32800	30995	1.068	3.978	0.940
HZ 1080M C	518.2	541.2	546.6	569.6	979.7	769.1	1928510	35635	33855	1.072	3.981	0.940
HZ 1080M D	523.0	544.4	547.4	568.8	1049.8	824.1	2086700	38330	36685	1.073	3.982	0.940
HZ 1180M A	527.6	547.8	548.0	568.3	1105.1	867.5	2204240	40235	38790	1.074	3.984	0.950
HZ 1180M B	529.9	549.5	548.3	568.0	1139.1	894.2	2302720	41905	40545	1.078	3.995	0.950
HZ 1180M C	530.2	553.2	549.5	572.5	1209.4	949.4	2466050	44575	43075	1.087	4.017	0.950
HZ 1180M D	532.6	554.7	549.9	572.0	1258.2	987.7	2567270	46280	44880	1.099	4.025	0.950



Designing an HZ®-M Steel Wall System

There are two recognized approaches for designing a combined HZ/AZ sheet pile system: the Global Safety Approach and the Eurocode-compliant Partial Safety Factor Approach. While they follow different design philosophies, one applying overall safety margins, the other using differentiated limit state checks, both methods ensure a robust and safe design when

correctly applied. The Eurocode approach should be adopted to meet regulatory standards for projects in Europe.

This chapter presents both approaches, allowing engineers to choose the most suitable framework for their project.

Steel stress verification (global safety approach)

The design of a combined wall is similar to that of all standard sheet pile walls, but calculating the section properties of a combined HZ/AZ system is undertaken differently to conventional sheet piling.

The combined wall is a combination of different elements with the underlying assumption that the bending moments along the wall are distributed to the different elements proportionally to their stiffness.

Consequently:

- moment of inertia of one HZ/AZ system (one HZ®-M and one pair of AZ):

$$I_{\text{sys}} = I_{\text{HZ}} + I_{\text{AZ}}$$

- moment of inertia of the HZ/AZ system per meter of wall:

$$I_{\text{sys/m}} = \frac{I_{\text{HZ}} + I_{\text{AZ}}}{b_{\text{sys}}}$$

Hence, following formulas allow calculating the bending moment distribution to each single component.

Assuming that M_{sys} is the bending moment per meter of wall based on the geotechnical design:

- bending moment transmitted to the HZ-M king pile (including the connectors):

$$M_{\text{HZ}} = \left(\frac{I_{\text{HZ}}}{I_{\text{sys}}} M_{\text{sys}} \right) b_{\text{sys}}$$

- bending moment transmitted to the intermediary AZ sheet pile:

$$M_{\text{AZ}} = \left(\frac{I_{\text{AZ}}}{I_{\text{sys}}} M_{\text{sys}} \right) b_{\text{sys}}$$

If only the effect of the bending moments is considered, steel stresses can be determined with the basic formula:

$$\sigma = \frac{M}{W}$$

For the HZ-M king piles:

$$\begin{aligned} \sigma_{\text{HZ}} &= \frac{M_{\text{HZ}}}{W_{\text{HZ}}} = \left(\frac{1}{W_{\text{HZ}}} \right) \left(\frac{I_{\text{HZ}}}{I_{\text{sys}}} M_{\text{sys}} \right) b_{\text{sys}} \\ &= \frac{1}{W_{\text{HZ, eq}}} M_{\text{sys}} \end{aligned}$$

where $W_{\text{HZ, eq}} = \frac{I_{\text{sys}}}{b_{\text{sys}} \max(v_1, v_2)}$

is the "equivalent section modulus" of the HZ-M king pile. This approach simplifies the task of the designer by using exclusively M_{sys} (no need to decompose M_{sys}).

Note:

" $W_{\text{HZ, eq}}$ " is labelled in the tables of this brochure as W_{ely}^* .

For the connectors RH / RZD / RZU:

$$\begin{aligned} \sigma_{\text{RH/RZ}} &= \frac{M_{\text{HZ}}}{W_{\text{RH/RZ}}} = \left(\frac{1}{W_{\text{RH/RZ}}} \right) \left(\frac{I_{\text{HZ}}}{I_{\text{sys}}} M_{\text{sys}} \right) b_{\text{sys}} \\ &= \frac{1}{W_{\text{RH/RZ, eq}}} M_{\text{sys}} \end{aligned}$$

where $W_{\text{RH/RZ, eq}} = \frac{I_{\text{sys}}}{b_{\text{sys}} \max(v_3, v_4)}$

Note:

" $W_{\text{RH/RZ, eq}}$ " is labelled in the tables of this brochure as W_{ely}^{**} .

For the AZ infill sheet piles:

$$\sigma_{AZ} = \frac{M_{AZ}}{W_{AZ}} = \frac{\frac{I_{AZ}}{I_{sys}} M_{sys} b_{sys}}{W_{AZ}}$$

Based on the above formulas, the verification of the allowable stresses is straightforward:

$$\sigma_{allowable} = \frac{f_y}{S_F}$$

The steel stresses of each component must be checked individually:

$$\sigma_{HZ} \leq \sigma_{allowable, HZ}$$

$$\sigma_{RH/RZ} \leq \sigma_{allowable, RH/RZ}$$

$$\sigma_{AZ} \leq \sigma_{allowable, AZ}$$

Notes:

- the yield stress of each component may be different. As a rule of thumb, stresses within the infill sheet piles are most often relatively small, allowing the use of a low steel grade for the AZ sections. This improves the cost efficiency of the system. However, driveability issues may trigger the choice of a higher steel grade than required by the design calculations.
- the yield strength of the connectors shall be equal or higher than that of the HZ-M, except for the combination 12. Hence, connectors are available exclusively with a yield strength of 460 MPa.
- the full range of HZ-M system are also available in ASTM A690, with yield strengths of 345 MPa and above.

The HZ-M king piles are capable of transferring high vertical loads to the subsoil. In such cases, stress analysis should include vertical loads and additional bending moments induced by deflection. Vertical loads can also originate from battered anchor piles, struts, etc.

The basic formula changes to:

$$\sigma = \frac{M}{W_x} + \frac{N \cdot e}{W_x} + \frac{N}{A_{HZ}}$$

To summarize, the designer can calculate in an easy way the stresses in the different components of the HZ-M by using the bending moment M_{sys} of the combined wall and the two "equivalent" section moduli W_{ely}^* and W_{ely}^{**} which are shown in the tables on pages 12 to 19 of this brochure.

Steel stress verification (EN 1993-5 approach)

In Europe, the design of steel sheet pile walls has to be compliant with the Eurocodes. Please refer to EN 1993-5 [1] for the complete design method. Eurocodes are based on partial safety factors that are applied to the resistances (EN 1993-5) and the actions (geotechnical design based on EN 1997-1 [2]). Contrary to the global safety approach, the Eurocode approach does not take into account the intermediate sheet piles to determine the sectional properties of the system. The relevant cross sectional area, the section moduli and the moment of inertia can be found in the tables on pages 20 to 27 of this brochure. Recommendations and advice for efficient design of combined steel walls according to the Eurocodes can be found in [3] and [12]. A detailed design example can be found in Annex 1 of this brochure.



Practical aspects

The contribution of the infill sheet piles is relatively small for certain combinations so that in some cases, the designer neglects the contribution of the moment of inertia of the infill sheet piles. This is a safe-sided approach but might be over conservative in some cases.

Savings can be achieved by shortening the length of the intermediary sheet piles. In the ground, where there is earth support and embedment, the length of the intermediary sheet piles can be considerably optimized. In the infill role, the intermediary sheet pile is only required to resist active earth pressures down to the zero earth pressure level. For safety reasons, its length is extended below this level by at least 1 – 2 m (Figure 2). If the embedment of the infill sheet pile is quite small, special care must be taken during construction to make sure that the piles are driven to the design level. For cantilever walls, the maximum bending moment occurs in the embedded portion of the piles. Therefore, the length of the infill sheet piles must be checked. Furthermore, if groundwater pressures are high, the risk of seepage beneath the toe should be analysed when optimizing the length of the intermediary sheet piles.

The HZ-M king pile spacing should be limited so that full continuous earth resistance is safeguarded. When determining pile spacing, arching effects of the soil may be considered. If these properties are negligible (e.g. in soft mud or where groundwater pressure is high), the transverse load capacity of the intermediary sheet piles needs to be checked. Additionally, the development of the earth resistance in front of the wall may have to be checked. Experience shows that for the standard

HZ/AZ combinations, this 3D effect on the passive resistance can be taken into account, and the design of the combined wall can be done as a continuous retaining wall. More detailed information can be found in Chapter 8.1.2.8 of the EAU 2020 [3]. The section modulus of the HZ-M king piles can be adapted to the resultant bending moment by adding RH connectors to the rear flanges. As a result, a lighter section can be selected and simply strengthened locally, where maximum bending occurs (Figure 3).

The HZ-M wall system, with which all ArcelorMittal AZ sections can be used as intermediary sheet piles, offers maximum flexibility in terms of design. Heavier AZ sections can also be selected to enhance corrosion resistance or enhance driving behaviour. Generally speaking, the range of suitable sheet piles varies from 1 200 cm³/m to 3 200 cm³/m.

Driveability is an additional key factor that should be analysed when choosing the infill sheet piles. In normal driving conditions, infill sheet piles above 20 m should have a section modulus above 2 000 cm³/m.

Local standards or regulations may call for specific features of the infill sheet piles. For instance, in some countries infill sheet piles used in marine structures shall have a minimum thickness of 10 – 12 mm.

Note:

The appropriate design approach should be adopted to meet the local regulatory standards of the project (e.g. contribution of the infill sheet piles to bending resistance [1]).

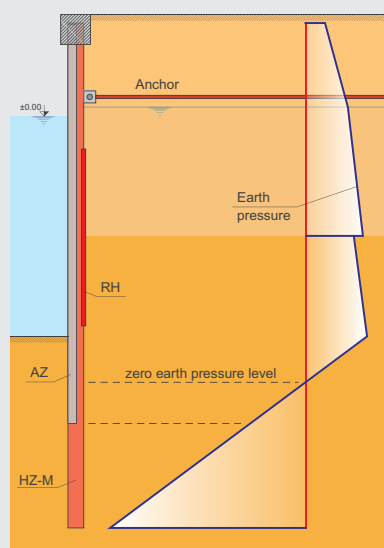


Fig. 2. Optimization of the length of the AZ infill sheet piles.

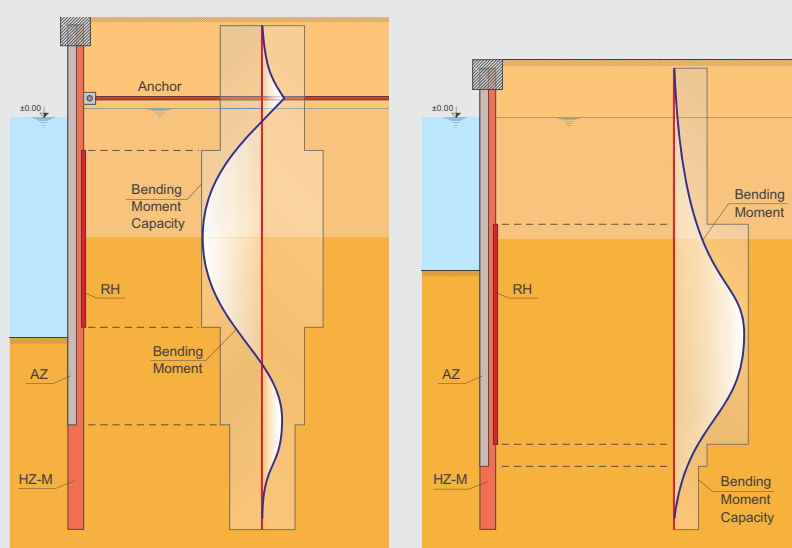


Fig. 3. Optimization of the bending moment capacity with additional RH connectors on the rear flange.



Port of Cagliari, Italy © RCM

Durability

Generally, when designing temporary structures, corrosion does not have to be considered. For permanent structures, however, corrosion impact has to be analyzed for the service life. The loss of steel has an influence on the design of structures executed in marine environments. Atmospheric corrosion is quite small, and in most natural soils, steel resists quite well to the phenomenon of corrosion.

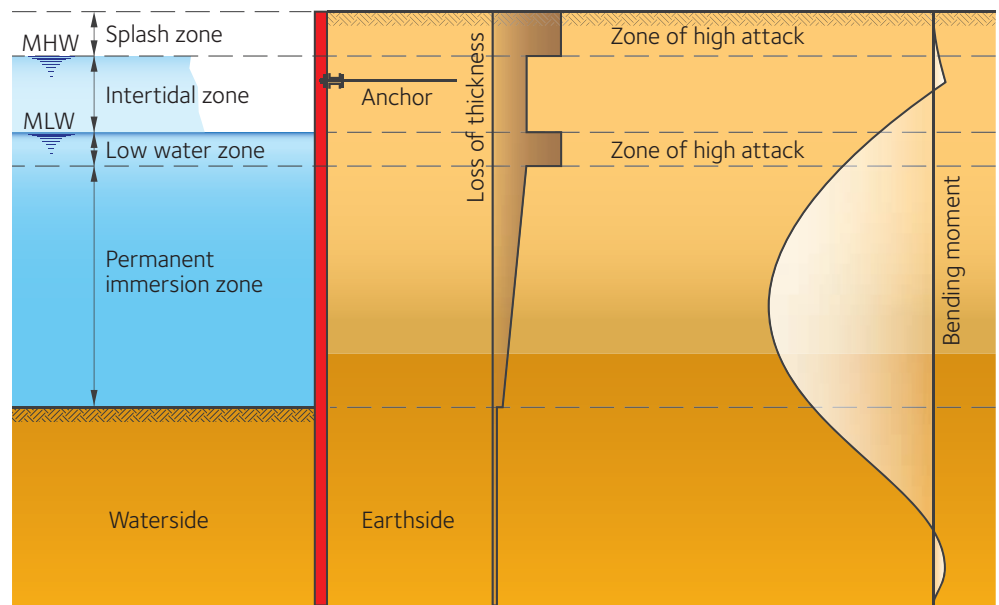
The determination of the residual section properties after corrosion of an HZ-M Steel Wall System is more complex than for standard sheet piles because corrosion is higher on the water side of the wall. Assumptions like proportionality to the initial thickness of the flange are too conservative and may lead to uneconomic solutions. Our technical department can provide additional support, if you need an assessment of the residual section properties.

Additional protection methods of the steel include surface coatings, cathodic protection (only in the zone which is permanently in contact with water), concrete capping beams, etc.

ArcelorMittal has developed a new steel grade **AMLoCor®** that is more resistant to corrosion in the "Permanent Immersion Zone" and in the "Low Water Zone". In the near future, all the elements of the HZ-M system will be available in AMLoCor steel grade with different yield strengths.

ArcelorMittal's technical department can assist with any queries.

Example for typical loss of thickness due to corrosion and moment distribution for anchored sheet pile wall in marine environment:



Resistance to water pressure

The HZ-M system can be submitted to high hydraulic pressures, for instance, when used to build a cofferdam in the middle of a river. The performance of the system under water pressure depends on the chosen combination of HZ-M king pile and AZ infill sheet pile and their respective steel grades. This chapter aims to provide sufficient information to select the optimal HZ/AZ combination for this particular loading case.

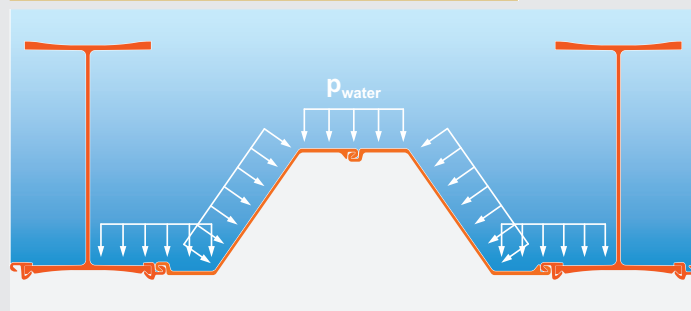
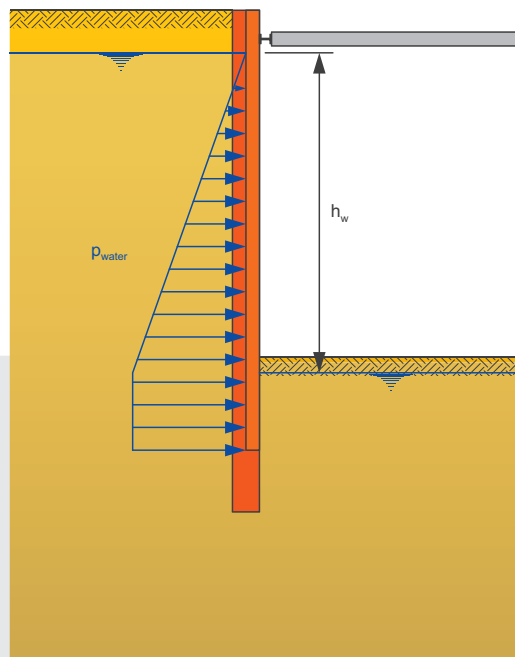


Fig. 4. HZ-M system under water pressure: assumptions.

Subsequent to former test series with sheet pile sections AZ 13, AZ 18 and AZ 26, a large number of mechanical laboratory testing and finite element simulations were performed for the series AZ-700, AZ-750, AZ-770 and AZ-800 at the Institute of Structural Design of the University of Stuttgart (Germany), to determine the resistance of the HZ-M system to hydraulic pressure. The mechanical tests used several hydraulic jacks applying progressive loads on the upper corners of the AZ piles (Figure 5). Back-calculation of these tests allowed for calibration of a 2D FE model, considering conservative plane stress values, consistent with the 50 cm test samples.

The results confirm the excellent behaviour of the HZ-M Steel Wall System, which can resist water head differences up to 13 m for the AZ-700 profiles, and up to 10 m for the AZ-800 profiles. Declutching of the interlocks did not occur in any test, which confirms the outstanding reliability of the connectors and the "Larssen" interlocks of the AZ sheet piles.

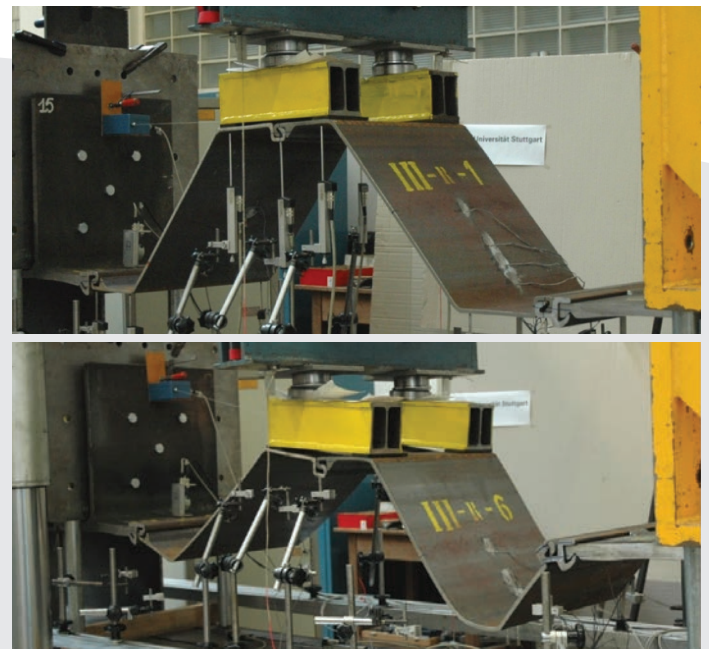


Fig. 5. Mechanical testing of the HZ-M system in the laboratory.

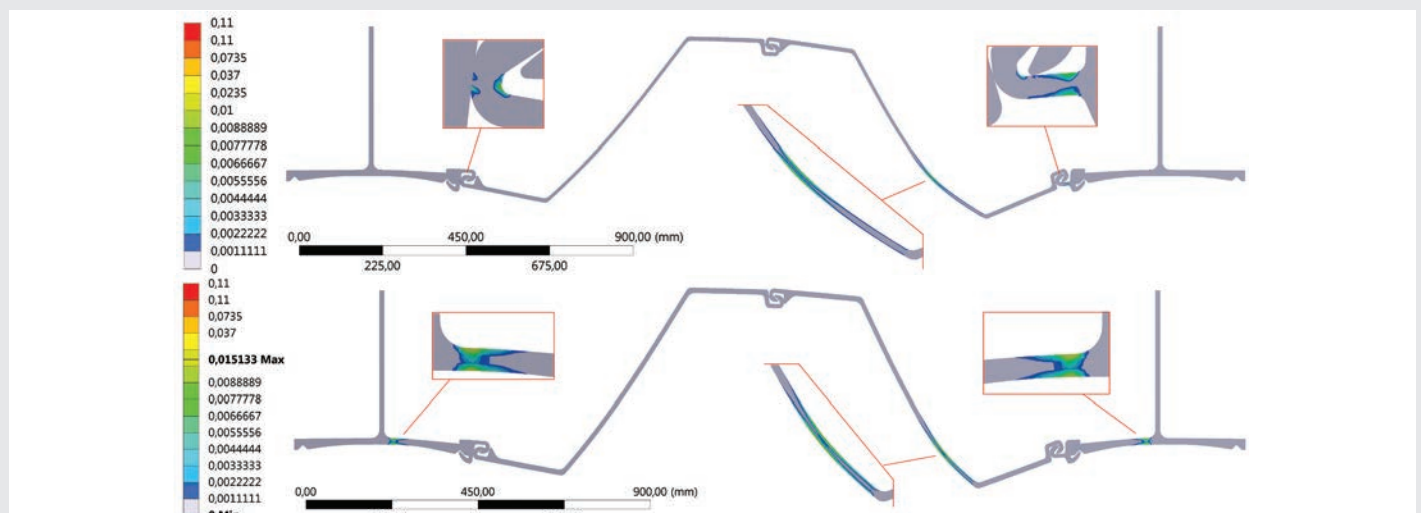


Fig. 6. Numerical simulation of an HZ/AZ combined wall under water pressure.

Characteristic values for maximum water pressures $p_{max,k}$ of the different AZ series (AZ-700, AZ-770, AZ-750 and AZ-800) result from a statistical evaluation of numerical test results from FEA, which have been validated to experimental test results ([10], [11]).

The required safety factors according to Eurocode EN 1993-1-5, Annex C [7], are included in the characteristic values. The characteristic values of the water pressure are listed in the following table, and are valid for the following:

- steel grades
 - > HZ-M S 430 GP & above $f_y \geq 430$ MPa
 - > RZD/RZU S 460 GP $f_y \geq 460$ MPa
 - > AZ S 240 GP, S 355 GP & S 430 GP
- the structure is submitted to pure water pressure.
Eventual additional earth pressures are not considered.

The table is subdivided in three combinations of HZ-M king piles:

- HZ 880M A, S 430 GP & S 460 GP
- HZ 880M B, S 430 GP & S 460 GP
- HZ 880M C, HZ 1080M & HZ 1180M, S 430 GP & S 460 GP

Design values¹⁾ can be obtained by applying the partial safety factor γ_{MO} . Please refer to EN 1993-5 [1] and the relevant National Annex for γ_{MO} (EN 1993-5 recommends a value of $\gamma_{MO} = 1.0$).

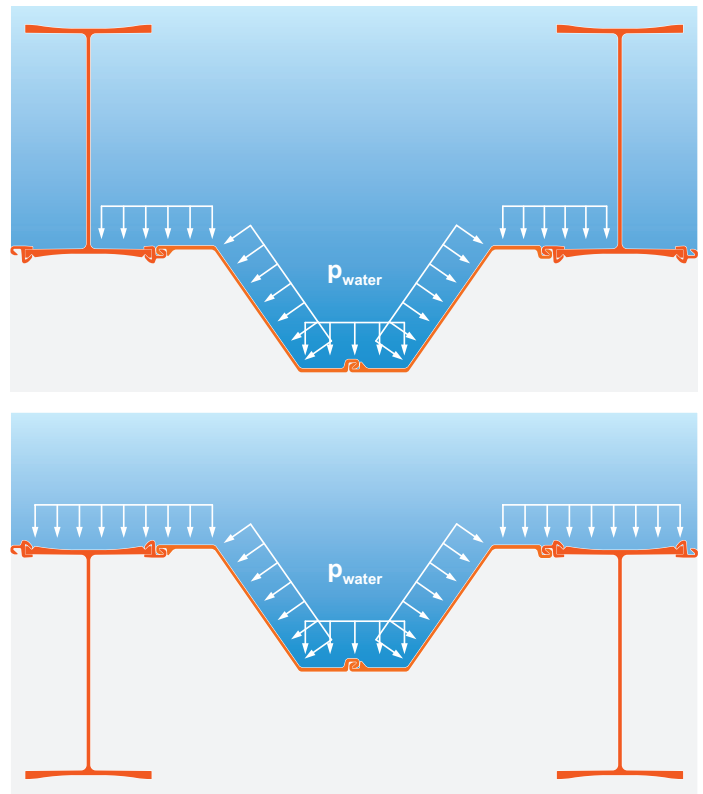


Fig. 7. AZ infill sheet piles under water pressure working in tension.

Impact of driving imperfections :

The impact of driving imperfections of the HZ-M combined wall on the resistance to water pressure was investigated. The range of imperfections considered was $\pm 5^\circ$ for rotation and ± 100 mm for horizontal displacement (Figure 8).

The study conducted showed a **reduction limited to 20%** in the water pressure resistance for the range of imperfections and the

profiles considered (AZ 18-10/10, AZ 26, AZ 18-700, AZ 20-700, AZ 26-700, AZ 20-800, AZ 22-800, AZ 25-800, AZ 27-800, AZ 30-750, AZ 32-750).

For further information, please contact ArcelorMittal Sheet Piling.

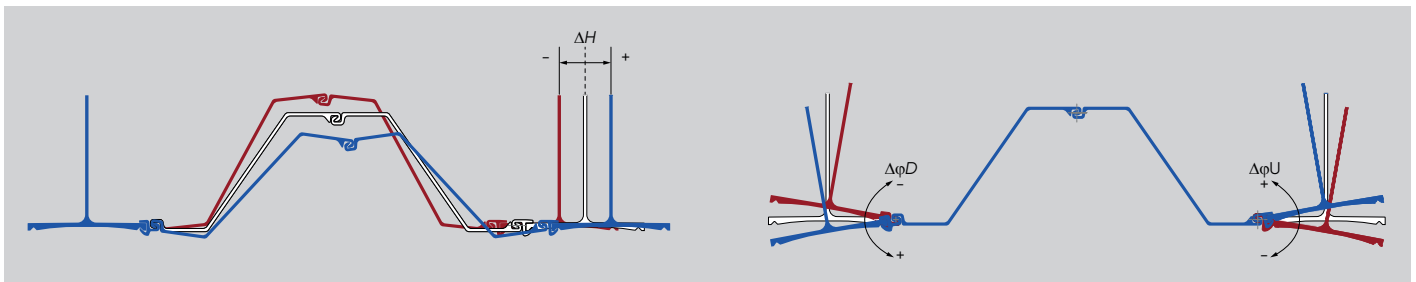


Fig. 8. Considered driving imperfections ($\pm 5^\circ$ for rotation and ± 100 mm for horizontal displacement).

Notes:

- As a rule of thumb, the resistance of AZ infill sheet piles increases with the yield strength.
- Failure can occur in the AZ infill sheet piles or in the flange of the HZ-M king pile, and consequently the minimum value of both resistances is chosen. Failure of the flange of the lighter HZ 880M series under high pressure governs the resistance in a few cases. **Bold values** in the table correspond to a failure within the HZ-M flange. For the HZ 630M, please contact our technical department.
- It is to be noted that driving tolerances and material thickness losses due to corrosion may have an impact on the water pressure resistance of the infill sheet piles and are not covered by the tabled values.

¹⁾ This procedure is only valid for a "Limit State" design approach as described in European Eurocodes. If the design of the sheet pile structure is based on an "Allowable Stress Design" (ASD) approach, the calculation using characteristic values of the table must be considered with an appropriate global safety factor based on local standards and design rules.

King pile	HZ 880M A						HZ 880M B						HZ 880M C / HZ 1080 M / HZ 1180 M					
	S 430 GP			S 460 GP			S 430 GP			S 460 GP			S 430 GP			S 460 GP		
	S 240 GP	S 355 GP	S 430 GP	S 240 GP	S 355 GP	S 430 GP	S 240 GP	S 355 GP	S 430 GP	S 240 GP	S 355 GP	S 430 GP	S 240 GP	S 355 GP	S 430 GP	S 240 GP	S 355 GP	S 430 GP
AZ steel grade																		
AZ steel grade	S 240 GP	S 355 GP	S 430 GP	S 240 GP	S 355 GP	S 430 GP	S 240 GP	S 355 GP	S 430 GP	S 240 GP	S 355 GP	S 430 GP	S 240 GP	S 355 GP	S 430 GP	S 240 GP	S 355 GP	S 430 GP
AZ infill sheet	Characteristic values of water pressure p _{max,k} (kPa)																	
AZ 18-10/10	71.6	89.6	93.7	74.6	93.4	97.7	76.6	95.9	100.3	79.1	98.9	103.5	77.1	96.5	100.9	79.3	99.2	103.8
AZ 26	85.6	107.2	112.1	90.1	112.8	118.0	99.8	124.9	130.7	104.7	131.1	137.1	107.4	134.4	140.6	110.2	137.9	144.3
AZ 12-770	35.1	51.9	57.6	35.1	51.9	57.6	35.1	51.9	57.6	35.1	51.9	57.6	35.1	51.9	57.6	35.1	51.9	57.6
AZ 13-770	38.5	57.0	63.0	38.5	57.0	63.0	38.5	57.0	63.0	38.5	57.0	63.0	38.5	57.0	63.0	38.5	57.0	63.0
AZ 14-770	42.0	62.1	68.3	42.0	62.1	68.3	42.0	62.1	68.3	42.0	62.1	68.3	42.0	62.1	68.3	42.0	62.1	68.3
AZ 14-770-10/10	45.4	67.1	73.6	45.4	67.1	73.6	45.4	67.1	73.6	45.4	67.1	73.6	45.4	67.1	73.6	45.4	67.1	73.6
AZ 12-700	46.5	68.8	77.4	46.5	68.8	77.4	46.5	68.8	77.4	46.5	68.8	77.4	46.5	68.8	77.4	46.5	68.8	77.4
AZ 13-700	52.7	77.9	88.2	52.7	77.9	88.2	52.7	77.9	88.2	52.7	77.9	88.2	52.7	77.9	88.2	52.7	77.9	88.2
AZ 13-700-10/10	55.7	82.4	92.4	55.7	82.4	93.5	55.7	82.4	92.4	55.7	82.4	93.5	55.7	82.4	93.5	55.7	82.4	93.5
AZ 14-700	58.8	87.0	92.4	58.8	87.0	98.3	58.8	87.0	92.4	58.8	87.0	98.3	58.8	87.0	98.9	58.8	87.0	98.9
AZ 17-700	41.3	61.1	67.4	41.3	61.1	67.4	41.3	61.1	67.4	41.3	61.1	67.4	41.3	61.1	67.4	41.3	61.1	67.4
AZ 18-700	45.0	66.6	73.7	45.0	66.6	73.7	45.0	66.6	73.7	45.0	66.6	73.7	45.0	66.6	73.7	45.0	66.6	73.7
AZ 19-700	48.7	72.1	79.9	48.7	72.1	79.9	48.7	72.1	79.9	48.7	72.1	79.9	48.7	72.1	79.9	48.7	72.1	79.9
AZ 20-700	52.5	77.6	86.2	52.5	77.6	86.2	52.5	77.6	86.2	52.5	77.6	86.2	52.5	77.6	86.2	52.5	77.6	86.2
AZ 24-700	70.4	88.1	92.2	73.8	92.4	96.6	78.8	98.6	103.1	80.4	100.6	105.2	79.5	99.5	104.1	81.0	101.4	106.1
AZ 26-700	74.8	93.7	98.0	78.4	98.2	102.7	86.6	108.4	113.4	89.3	111.8	117.0	89.2	111.6	116.8	90.8	113.6	118.8
AZ 28-700	79.5	99.5	104.1	83.1	104.0	108.8	91.8	114.9	120.2	95.9	120.0	125.5	98.7	123.6	129.3	100.9	126.2	132.1
AZ 18-800	35.7	50.2	55.8	36.8	51.6	57.4	36.3	51.1	56.8	37.1	52.3	58.1	36.5	51.8	57.6	37.3	53.0	58.9
AZ 20-800	41.8	56.4	62.6	43.0	58.0	64.4	42.4	57.5	63.8	43.4	58.8	65.3	42.6	57.7	64.1	43.6	59.0	65.5
AZ 22-800	48.5	62.5	69.5	49.9	64.3	71.5	49.2	63.8	70.9	50.4	65.3	72.5	49.5	63.5	70.5	50.6	64.9	72.1
AZ 23-800	43.4	54.4	60.0	44.7	55.8	61.6	44.1	54.7	60.4	45.1	56.0	61.8	44.3	55.4	61.1	45.3	56.8	62.7
AZ 25-800	49.6	60.9	67.3	51.1	62.7	69.3	49.8	62.3	68.8	51.0	63.8	70.4	50.0	62.6	69.2	51.1	64.1	70.7
AZ 27-800	55.8	67.7	73.2	57.4	69.6	76.0	56.6	69.8	77.1	57.9	71.4	78.9	56.9	69.8	77.0	58.2	71.4	78.8
AZ 28-750	52.7	67.7	75.0	54.2	69.8	77.3	53.5	68.7	76.1	54.7	70.3	77.9	53.8	68.6	76.0	55.0	70.2	77.7
AZ 30-750	60.2	75.6	80.8	61.9	77.8	84.3	61.1	78.2	86.6	62.5	80.0	88.6	61.4	78.6	87.1	62.8	80.3	88.9
AZ 32-750	68.1	81.0	86.4	70.1	84.3	89.8	69.1	87.6	97.0	70.7	89.6	99.2	69.5	88.3	97.8	71.1	90.3	100.0

Cross-sectional classification of HZ[®]-M (EN 1993)

Standard case in pure bending¹⁾

The design of steel sheet piles according to the European standards (EN 1993) requires the cross-sectional classification of profiles. The standard provides tables for the classification of the most common sections, like tubes, angles, H-beams, but does not deal with special sections like HZ-M with welded connectors on the extremities of the flanges, or sections with specific geometries as curved flanges with an increasing thickness towards its "free" ends.

This is why a realistic classification was prepared to take into account the real geometry and the bending moment distribution for the HZ/AZ system.

A class 2 section may be designed using the plastic section modulus W_{pl} whereas for a class 3 section the designer only uses the elastic section modulus W_{el} . For a class 4 section, local buckling occurs before reaching the elastic bending moment capacity M_{el} .

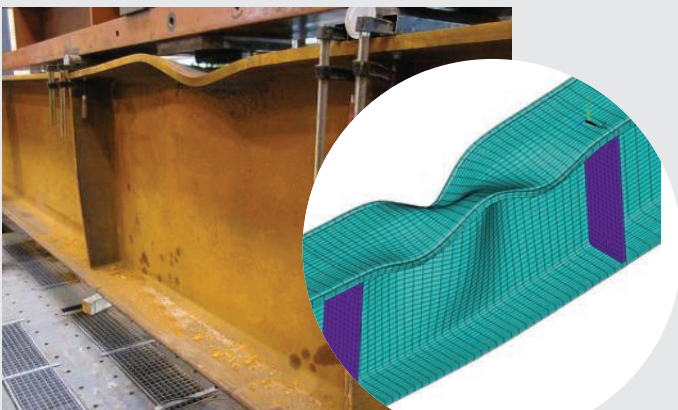
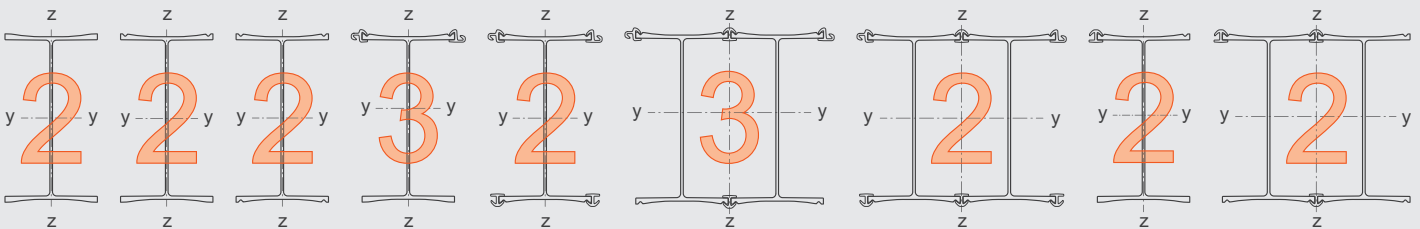
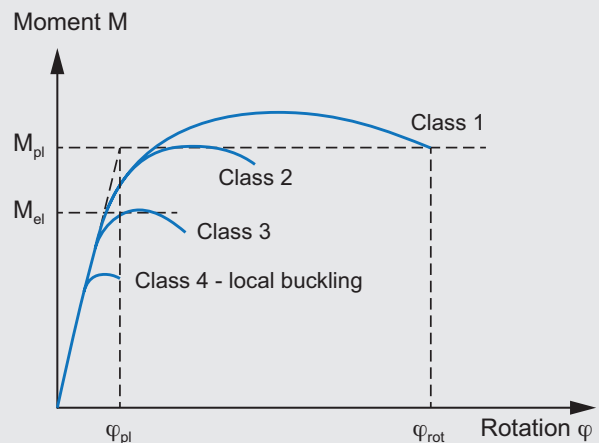


Fig. 9. Comparison between 4 point bending test and FEA simulation.



Cross section classes of HZ-M solutions, valid for the whole HZ-M range with nominal geometries and for steel grades from S 240 GP to S 460 GP.

Fig. 10. Cross section classes for the HZ-M solutions.

In collaboration with the RWTH Aachen University, an experimental campaign on "4 points bending tests" (Figure 9), backed by numerical simulation using a finite element model developed by RWTH, has been performed [8].

The cross section's classes of HZ-M resulting from this campaign are summarized in Figure 10 and are valid for the whole HZ-M range and steel grades from S 240 GP to S 460 GP²⁾.

From a safe-sided approach, all sections can be classified as cross-section class 2, for steel grades ranging from S 240 GP to S 460 GP, except for the solutions 12 and 24 (with connectors on the tensile flange or the compression flange) which are classified as class 3.

¹⁾ In case of a combination of bending moments and significant compression loads, the design of the HZ-M section will generally be governed by the web slenderness (see formulas in EN 1993), except in the case of corrosion of flanges and web.

²⁾ For sheet pile applications, all HZ 1180M may be classified in class 1 with verification of the rotation capacity by appropriate calculation methods. Otherwise a class 2 should be chosen.

Influence of the loss of steel thickness of the flange

The corrosion phenomenon and its influence on the cross sectional classification was investigated. A parametric study [9] was carried out with the finite element model developed by RWTH considering a loss of steel thickness on one flange (outer face) up to 8 mm (see Figure 11).

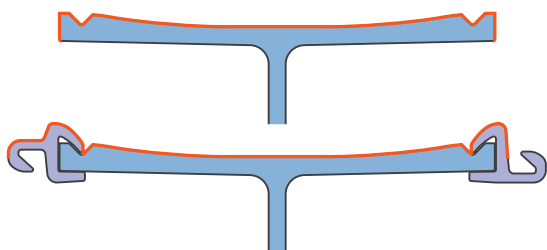


Fig. 11. Corrosion assumption: loss of steel thickness on outer flange.

The worst case was considered in this numerical study: the connectors are on the tension flange, and the flange thickness reduction is at the compression flange¹⁾.

Typically, connectors and corrosion occur on the tension flange, and the cross section class can be chosen from the following table.

Section	Classification for loss of steel thickness 0 – 8 mm
HZ 880M A	3
HZ 880M B	3
HZ 880M C	3
HZ 1080M A	3
HZ 1080M B	3
HZ 1080M C	2
HZ 1080M D	2
HZ 1180M A	2
HZ 1180M B	2
HZ 1180M C	2
HZ 1180M D	2

Cross section classes with connectors on the tension flange and corrosion on the tension flange, valid for all HZ-M solutions, up to S 460 GP steel grade.

Fig. 12. Cross section classes for corroded HZ-M solutions.

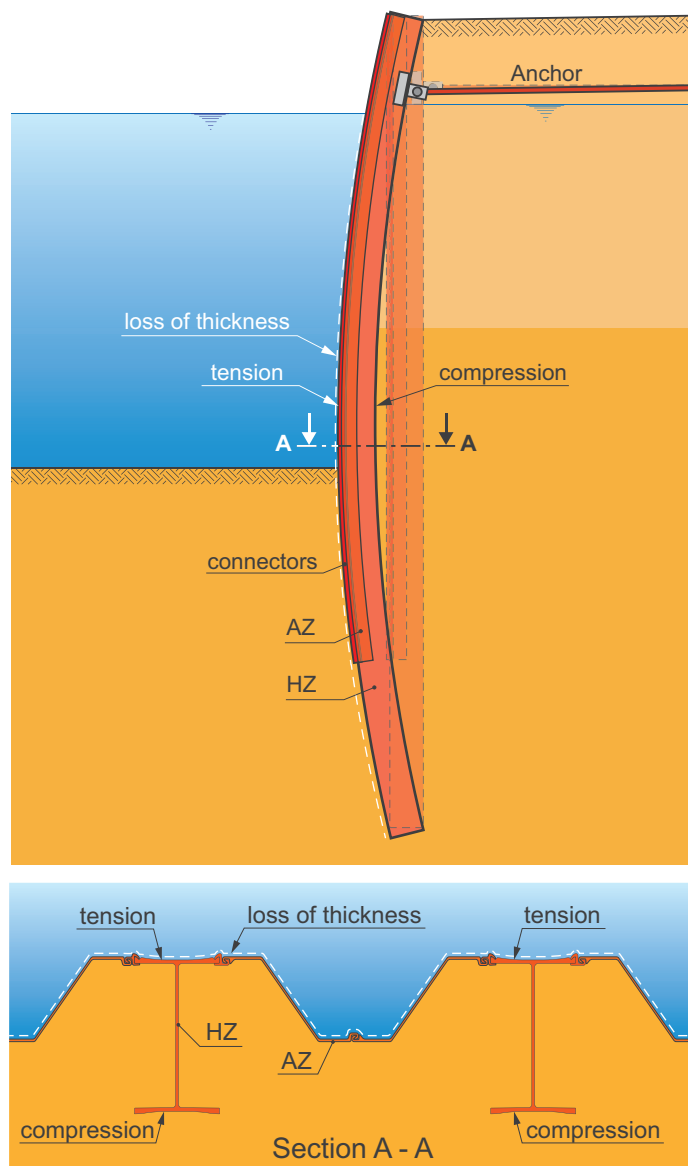


Fig. 13. Common configuration of an HZ/AZ combined wall system (typical cross section).

General conclusions

Combining the results from both research projects, the classification of the cross sections for the HZ-M king pile in pure bending can be summarized as follows:

- **Without corrosion**
all the HZ-M king piles can be classified as class 2 (except solutions 12 and 24 : class 3)
- **With corrosion**
for the most common configurations²⁾, the effect of the corrosion on the HZ-M classification is very limited.
All the HZ-M solutions can be calculated in class 2 or 3 for up to 8 mm of loss of steel according to the table and the sketch above (Figure 12 & 13).

Above conclusions are valid for the whole HZ-M range from HZ 880M A to HZ 1180M D and steel grades S 240 GP up to S 460 GP. Please contact the technical department for the HZ 630M.

Remark: The classification of the HZ-M king piles in pure bending is allowable for king piles subject to combined bending and normal force as long as no interaction between bending and normal force needs to be considered in member design (EN 1993-5, 5.2.3). Classification of king piles subject to higher normal forces may combine classification of the flange according to the tests of HZ-M in pure bending and classification of the web according to EN 1993-1-1.

¹⁾ "Solution 12" was chosen for all investigations as it is the most critical configuration (safe sided approach).

²⁾ Please contact our technical department in case the connectors are on the tension flange and corrosion occurs on the compression flange.

Conventions and symbols

b	nominal width of the AZ element
b_{sys}	width of one system (HZ/AZ combination)
d	depth of straight portion of web
e	eccentricity
f_y	yield strength of the steel
h_i	height (depth) of the section
i_y	radius of gyration about the y-y axis. $i_y = \sqrt{I_y/A}$
$p_{max,k}$	characteristic value of water pressure
p_{water}	water pressure
r	inner radius of the HZ-M profile, between web and flange
t_f	thickness of the flange / thickness of the HZ-M flange at a distance $w/4$ from the edge
t_1	thickness for flange bending
t_2	thickness at the edge of the flange
t_3	thickness in the groove
t_{max}	maximum flange thickness
t_w	thickness of the web
v_1, v_2, u_1	distance of the neutral axis to the extreme fibre of the HZ-M flanges
v_3, v_4, u_2	distance of the neutral axis to the extreme fibre of the connector RH/RZ
w	nominal width of HZ-M element
A	cross sectional area
A_v	shear area
A_{HZ}	cross sectional area of the HZ-M king pile
A_{LS}	coating area on the soil side (back), excluding the inside of the interlocks, per element or system width, per unit length
A_{LW}	coating area on the water side (front), excluding the inside of the interlocks, per element or system width, per unit length
G	mass of the element / solution (with length RH/RZ = length HZ) per unit length
$G_{60\%}$	mass of the combination with length of the infill sheet piles AZ = 60% of the length of the HZ-M king piles

$G_{80\%}$	mass of the combination with length of the infill sheet piles AZ = 80% of the length of the HZ-M king piles
$G_{100\%}$	mass of the combination with length of the infill sheet piles AZ = 100% of the length of the HZ-M king piles
I_{AZ}	moment of inertia of one pair of AZ sheet pile
I_{HZ}	moment of inertia of one HZ-M king pile
I_{sys}	moment of inertia of one system (HZ/AZ combination)
$I_{sys/m}$	moment of inertia of the wall per m of wall
I_y	moment of inertia about the main neutral axis y-y
I_t	torsional constant
I_ω	warping constant
I_z	moment of inertia about the neutral axis z-z (weak axis)
M_{AZ}	bending moment transmitted to the intermediary AZ sheet pile
M_{HZ}	bending moment transmitted to the HZ-M king pile
M_{sys}	maximum bending moment per m of wall based on a design
N	vertical load
S_F	global safety factor applicable to steel
S_y	static moment of the HZ-M
W_{AZ}	section modulus of a pair of AZ
$W_{el,y}^*$	equivalent elastic section modulus of the combination related to the extreme fiber of the flange of the HZ-M
$W_{el,y}^{**}$	equivalent elastic section modulus of the combination related to the extreme fiber of the connector RH/RZ
$W_{el,z}$	elastic section modulus of the element related to neutral axis z-z (weak axis)
$W_{HZ,eq.} = W_{el,y}^*$	
$W_{pl,y}$	plastic section modulus of the HZ-M
$W_{RH/RZ,eq.} = W_{el,y}^{**}$	
σ_{AZ}	steel stresses in the intermediary AZ sheet pile
σ_{HZ}	steel stresses in the HZ-M king pile

Construction of HZ-M combined walls

Installation procedure

The HZ-M Steel Wall System can be installed on land or from water in a similar way. The key element for state-of-the-art installation is pile guiding. The guide can be a 2-level template frame or a leader mast attached to the pile driving machine.

First, the template frame is placed and secured to avoid any shifting during driving. Then a number of HZ-M king piles are pitched in the template. Afterwards, the king piles are driven into the ground (Figure 14 - Step 1), starting preferably with a vibratory hammer, adopting the "Pilgrim's step" driving sequence.

Depending on the soil conditions, the application and the geometry of the final structure, a second driving phase with a sufficiently powered impact hammer may be required (Figure 14 - Step 2): driving to final depth resumes after the removal of the driving template.

Generally, intermediary sheet piles are pitched and driven after the installation of the HZ-M piles is completed (Figure 14 - Step 3).

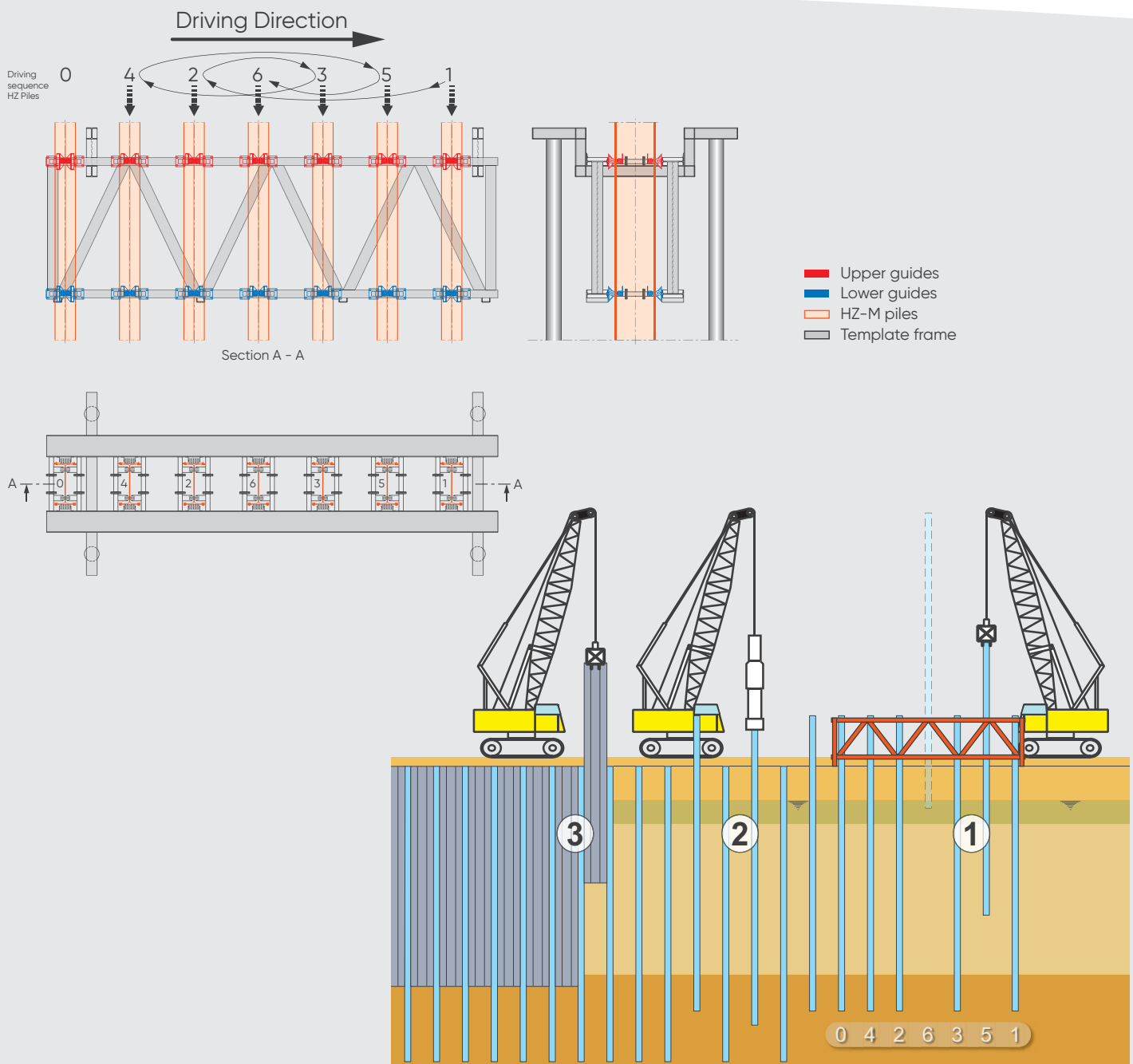


Fig. 14. Installation procedure: driving template and "Pilgrim's step" driving sequence.

In case of difficult geotechnical conditions, the following may be necessary:

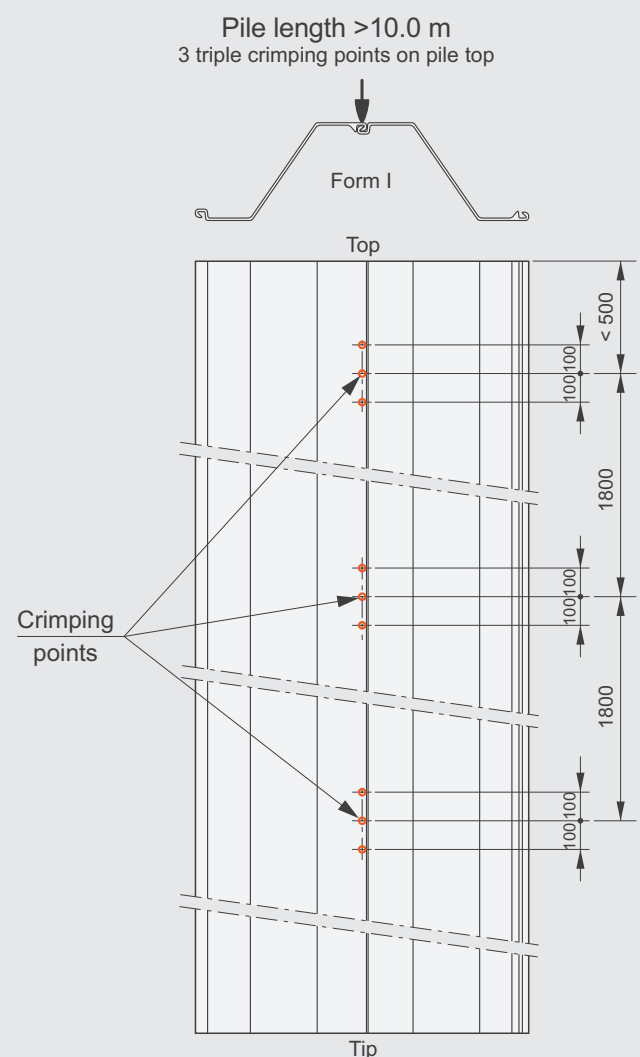
- Driving operation in stages: driving of king piles with vibratory hammer until refusal, then it can be opted for an impact hammer to reach final installation depth. The use of an impact hammer allows for an assessment of the final bearing capacity.
- Pre-drilling after placing the HZ-M piles may be considered to avoid damages of the infill sheet piles.
- In case vibrations on surrounding structures shall be avoided, placing of the HZ-M piles in a slurry trench may be considered.

It is recommended to use partially crimped pairs of AZ sheet piles: this specific crimping of the interlocks increases the stiffness at the top of the sheet pile and facilitates the installation process (Figure 15). At the bottom, the AZ sheet piles are still “flexible” enough to accommodate the driving tolerances of the king piles. For wide AZ- piles, the use of double clamps is recommended to achieve the best installation performance.

More detailed information about installation of combined walls can be found in Chapter 8.1.5 of the EAU 2020 [3].



Fig. 15. Special crimping pattern for AZ infill sheet piles and crimping at the rolling mill.



Installation methods

It is essential that king piles are driven in the correct position as per driving plan. Greatest possible accuracy has to be guaranteed on verticality or prescribed batter. Two different methods can be used.

Method 1: Template with two guide levels

A rigid template with two guide levels is used in this method. The template has openings for the theoretical position of the king piles (Figure 16). The vertical distance between the two levels should be 25% of the pile length, but in any case not less than 3 m.

The template should be placed as close to the ground as possible. On land, the template can rest on the ground, but it should be secured firmly against shifting. It is advisable to support the template on separate piles. When driving in water, the template should be supported on auxiliary piles just above the water level.

Depending on the design, templates usually have space for 5 to 9 king piles (Figure 14). These primary piles are driven using a free-hanging vibrator or an impact hammer, the vibrator being the most commonly used equipment. Inside the template, a proper HZ-M guiding system (Figure 17) should be designed to avoid damage to the coating on the sheet piles if applicable (for example, by using guiding rolls).

After all the piles in one template are driven, the template is removed and repositioned. The last driven pile will serve as an anchor pile to guarantee the correct new position of the template. This will ensure proper alignment and distance between the next driven king piles. It may also serve as a support pile.

Later on, the intermediary sheet piles can be installed with the same driving equipment, or by a second pile driving team. For this operation, no template is necessary.



Fig. 16. Driving templates and their support.

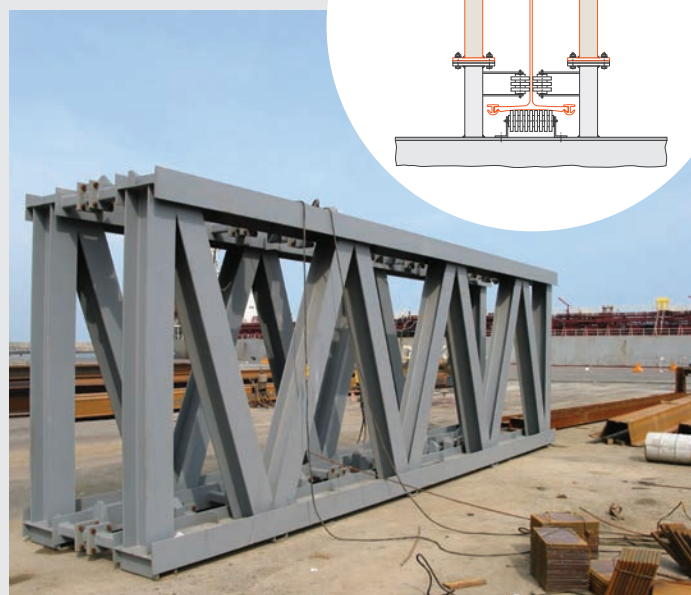


Fig. 17. Template and detail of guide.



Fig. 18. Template with a single level and piling equipment guided on a fixed leader.

Method 2: Fixed leader system

The king piles are driven using piling equipment guided by a fixed leader (Figure 18). The specified verticality or inclination must be achieved by the leader and the correct positioning through a simple horizontal driving frame. When piling in water, the latter is secured above the water level on auxiliary piles. In all other cases, it is set down on the driving planum and fixed in its position.

Underwater installation

The rehabilitation of an existing deck-on-piles (Figure 19) or a gravity structure may be done with an underwater cantilever or anchored sheet pile wall installed in front of the existing structure. The installation of such a wall is more complex, but the procedure is similar to the driving methods described before. There is a need for a guiding system and the driving sequence follows the same principles, but the different phases have to be adapted to the local environment and tidal fluctuations. The driving equipment should be able to work under water, otherwise a vibratory hammer fitted with a "follower" (extension) can be used (Figure 19).

Additional recommendations

It is important to constantly check the position of the king piles and their verticality during the installation process. It should be as close as possible to the theoretical position. The intermediary sheet piles should be designed in the way, that they can compensate for installation tolerances of the king piles and their position without damage. The tolerance compensation can result from interlock rotation (only for AZ-piles), elastic deformation and plastic deformation.

In order to ensure an efficient and damage-free installation of AZ-type intermediary sheet piles, the distance between two adjacent king piles, at any position over the height of the infill sheet pile, should not exceed 200 mm and, in any case, the distance shall be less than the unfolded width of the intermediary sheet pile. In addition, compatibility with the rotation capacity of the interlocks should be considered. Producer information must be observed.

In case prescribed tolerances are not achieved, the king piles should be extracted and re-driven, or compatibility of the achieved driving tolerances should be proven. In special cases, the contractor can fabricate a special pile which takes into account the existing driving imperfection. It is to be noted that driving tolerances may have an impact on the water pressure resistance of the infill sheet piles and need to be accounted for in the design.

Under certain conditions, more specific attention to the choice of the intermediary sections is recommended. Please contact our Technical Department for further information.

Generally, tolerances shall be agreed upon before the project starts.

Filling the interlocks of the free RZ connectors before installation with foam, Beltan®Plus or grease will significantly reduce the interlock resistance thus facilitates the pile driving. In case of non-cohesive soils, this procedure is strongly recommended as it prevents soil compacting inside of the interlocks.

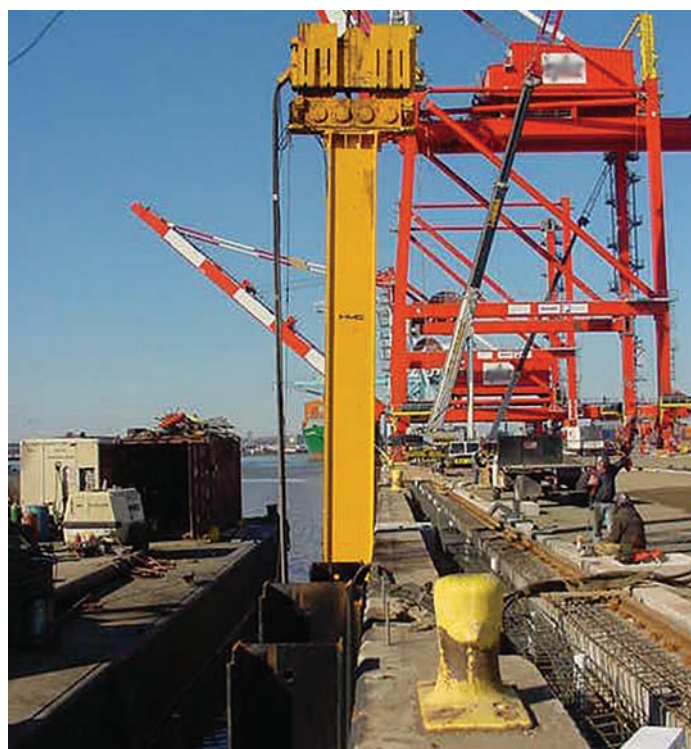
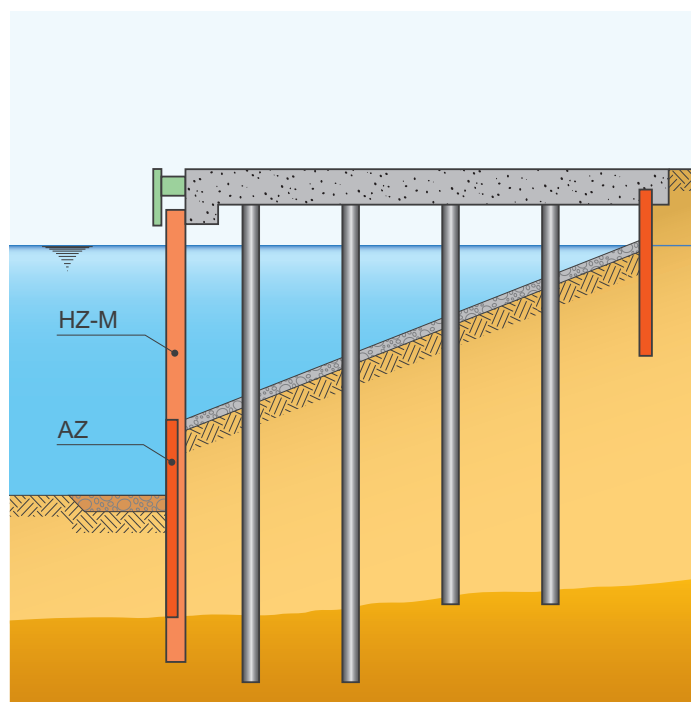


Fig. 19. Installation of AZ below water level with a follower on a vibratory hammer.

Driving equipment

State-of-the-art driving technology allows for the use of impact or vibratory equipment to drive king piles and intermediary sheet piles. Vibratory equipment should be preferred whenever possible. A combination of the two methods can be used for the driving of the king piles: the king piles are first driven using vibration techniques. The final depth is reached with an impact hammer, also to allow for a first assessment of the bearing capacity.

Intermediary sheet piles are generally installed with vibratory hammers. Vibratory hammers should be fitted with adequate clamps to ensure a correct energy transfer to the pile during the driving process. It is recommended to use double clamps for HZ-M box piles. For intermediary AZ sheet piles, single or double clamps can be considered (Figure 20). It is advisable to choose a vibrator with sufficient power reserve to allow for good driving speed and penetration, as well as to prevent damaging the interlocks through overheating. Vibratory hammers with variable moment are preferable. The different types of impact hammers are free-fall hammers, diesel hammers, and hydraulic hammers.

A driving cap must be used with free-fall or diesel hammers (Figure 21). In the case of an hydraulic hammer, the manufacturer can provide special driving plates which fit the geometry of the pile head. Note that impact hammers should be powerful enough to avoid local deformation of the pile heads.

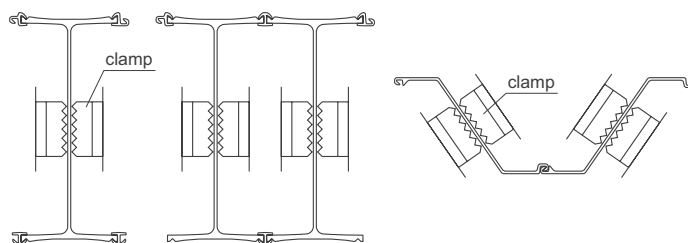


Fig. 20. Double clamps for a vibratory hammer.

Position of section HZ 880M / 1080M / 1180M as solution 26

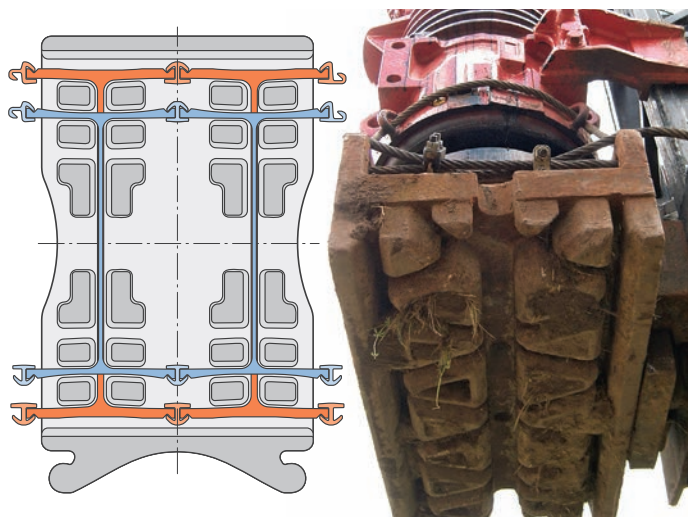


Fig. 21. Impact hammer driving cap.

If driving of the intermediary sheet piles shows no progress, is impossible or can only be achieved through excessive driving energy, the following is advised:

- check for obstructions in the soil. This can be done, for example, by extracting the intermediary sheet pile and re-driving it outside the interlocks.
- verify that the spacing and the positioning of the king piles is correct. This can be done, for example, by means of an inclinometer. A tube of the same diameter as the inclinometer is fitted with a corresponding connector and jetted down on the interlocks at the back flange of the king pile. The measurements taken by the inclinometer will give information on the actual position of the king pile at the relevant depths. In case the spacing between the king piles does not comply with the driving tolerances requirements, the king piles must be extracted and re-driven.

It is strongly advised to avoid forcing the driving of an intermediary sheet pile, as this might lead to interlock damage.

Sheet pile sections and corresponding driving caps

Arrangement	Single pile	Double pile
Driving caps	HS 8-11	HD 6-11
HZ®-M sections		
HZ 630M	✓ ¹⁾	✓ ¹⁾
HZ 880M	✓	✓
HZ 1080M	✓	✓
HZ 1180M	✓	✓

¹⁾ On request.

Dimensions of relevant sliding guides	Designation	Corresponding driving caps
	500/90	HS 8-11
	700/90	HD 6-11

Driving aids

Whenever difficult driving is expected due to unfavourable geotechnical conditions, auxiliary techniques can help to smooth the progress of driving:

- water jetting: mainly in compact granular or slightly cohesive soils
- pre-drilling
- reinforcing the pile toe
- blasting
- installation in slurry trench.

Water jetting in compact granular or slightly cohesive soil

Water jetting tubes attached to the intermediary sheet piles might facilitate the driving. A pressure of approximately 10 - 20 bars yields good results through minimizing the friction along the sheet pile surface and reducing toe resistance. Installation time, necessary driving energy, and vibrations are drastically reduced.

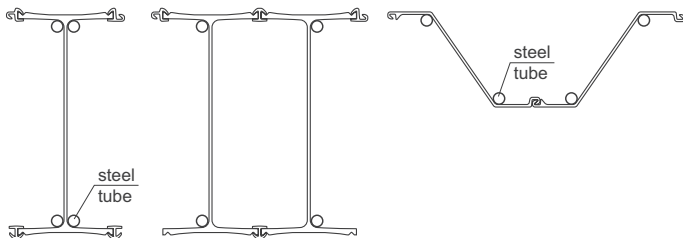


Fig. 22. Water jetting.

Pre-drilling / Augering

Pre-drilling or augering is often used when sheet piles are to be driven into compact sands or stiff clays. The aim is to loosen the soil, in some cases even soil replacement can be foreseen, so that driving can be performed with standard piling equipment.

Pre-drilling can also be used when the combined wall has to penetrate rock layers. In this case, only the HZ-M king piles are driven into the drilled space in the soil layer (Figure 23).

Generally, pre-drilling is done only for the intermediary piles. The drilling diameter can be chosen in the range of 30%-40% of the sheet pile width.

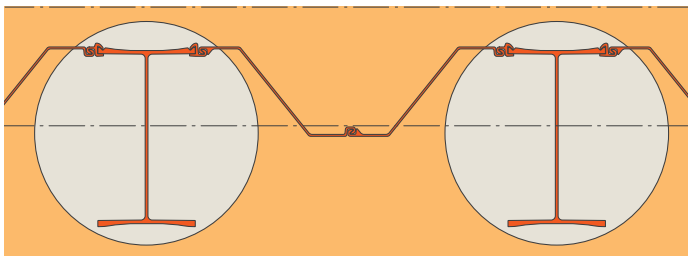


Fig. 23. Pre-drilling / augering for king piles.





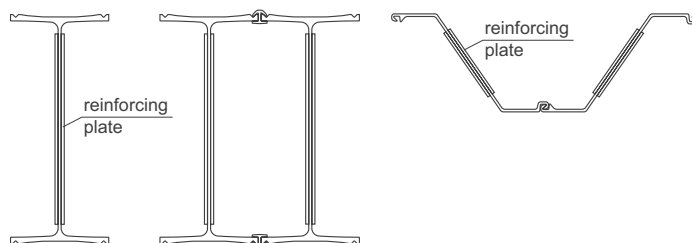
Fig. 24. Reinforcing of the tip of the pile with steel plates / shoes welded on the king pile toe.

Reinforcing of the pile toe

Piles can be strengthened by welding steel plates at the tip of the pile. This is used predominantly in cohesive soils with the aim of reducing skin friction (Figure 24).

Alternatively, the whole toe of the pile can be equipped with special cast elements also called "tip points" or "pile shoes". This allows the pile to penetrate into rock, up to a few meters (for instance in sandstone or mudstone), without damage.

For the HZ-M king piles, a special toe-cutting can be foreseen to concentrate the driving energy at the toe of the pile and cut through the hard soil layers (Figure 24). For AZ piles, simple plates can be sufficient as reinforcement.



Rock bolting / Toe pinning into a rock layer

If the rock layer is higher than the required embedment depth of the combined wall, then the bottom of the wall can be secured by dowelling the king pile to the underlying rock (toe-pin, see Figure 25). Please consult the specific brochure for more information.

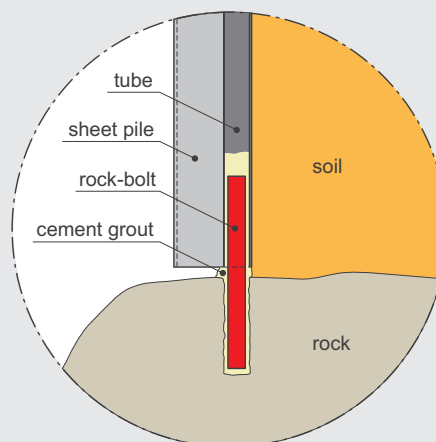


Fig. 25. Concept of a rock-bolt.

HZ[®]-M specific tie-back solution

Anchoring an HZ/AZ combined wall system can be simple and efficient: a tie-rod links each HZ-M pile or HZ-M box pile to a steel sheet pile anchor wall or isolated sheet pile panels – a particularly economical solution.

Because each king pile is anchored, a traditional waler system can be avoided. The tie-rod is simply linked to the HZ-M pile through two T-connectors and a pin. T-connectors are threaded through slots cut on jobsite in the rear flange of the HZ-M pile after driving. Loads are thereby applied close to the web.

HZ-M sections can be delivered with precut anchor slots on request, although this is not best practice as it is difficult to achieve the exact elevation of the slots due to driving tolerances. The figure below shows the slots cut in the HZ-M king pile. The dimensions "h" and "b" vary with the tie rod diameter.

Conventional anchoring, incorporating a waler system, is an alternative. The HZ-M system can also be anchored with battered steel HP-piles or with grouted anchors.

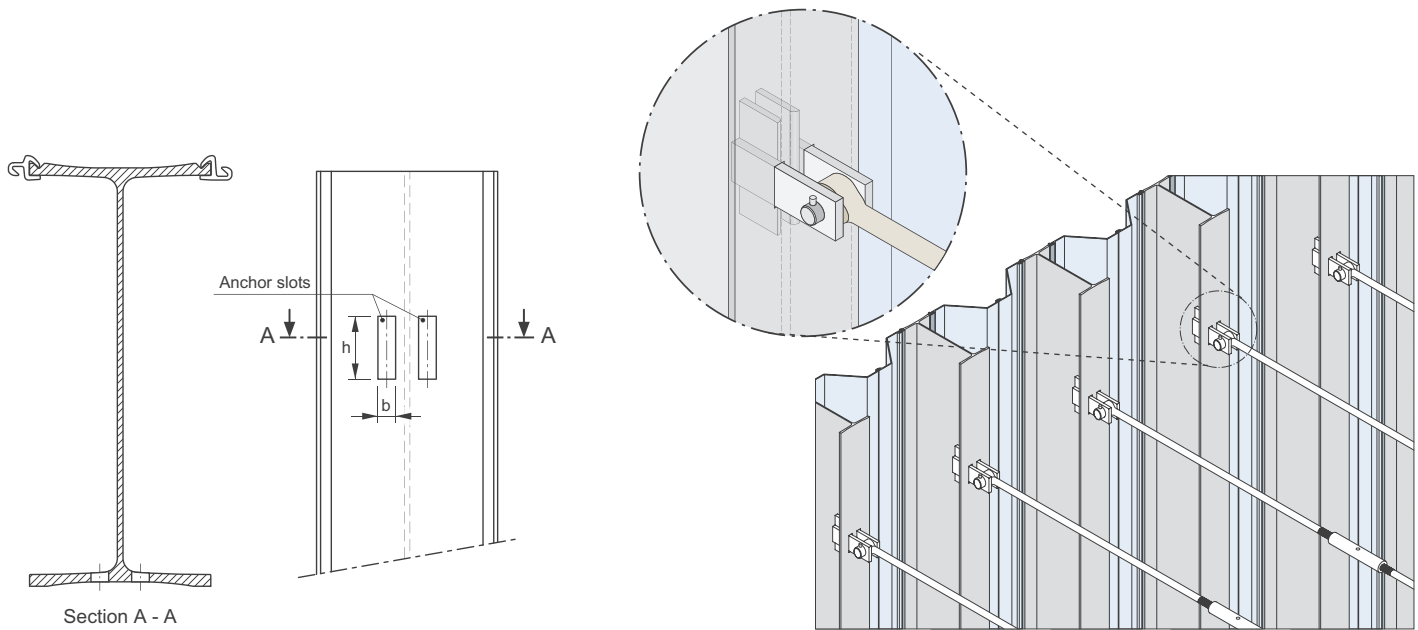


Fig. 26. Special tie-rod connection with T-connector for the HZ-M.



Fig. 27. Installation of the T-connectors at the job-site.



Fig. 28. Conventional anchor solution with tie-rods, walers,...

References

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- [3] EAU 2020. Recommendations of the Committee for Waterfront Structures Harbours and Waterways. Ernst und Sohn.
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- [6] EN 1990: Eurocode: Basis of structural design. CEN.
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- [12] U. Kuhlmann, J. Grabe, B. Froschmeier, C. Schallück, A. Just: Entwicklung von effizienten Dimensionierungsgrundlagen für die Tragbohlen von kombinierten Stahlspundwänden. Forschung für die Praxis P 813. Forschungsvereinigung Stahlanwendung e.V. (FOSTA), Verlag und Vertriebsgesellschaft mbH, Düsseldorf, 2012.

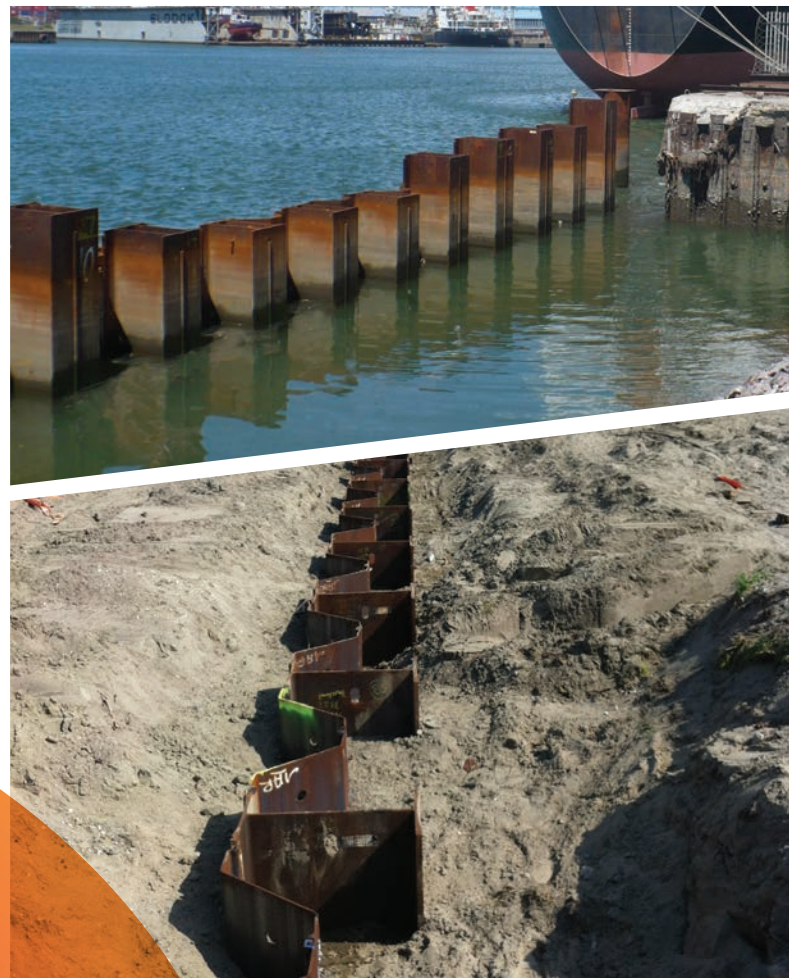
Notes:

The nominal width of a combination b_{sys} has been rounded to a mean value valid for the whole range of a combination. However, the nominal width of the “solutions” has been taken into account for the determination of the section properties. For installation purposes, the nominal system width of the combination “ b_{sys} ” should be used.

All the data in the tables in this flyer has been determined with a CAD software. The main section properties have been rounded. Section properties determined in a different way may differ slightly.

Mass of HZ/AZ combinations: $G_{60\%}$, $G_{80\%}$ & $G_{100\%}$ assume that the length of the connectors RZD/RZU and the RH on the back flange (Sol. 14 and Sol. 26) are the same as the length of the infill sheet piles AZ. The RH connecting two HZ-M king piles (Sol. 24 and Sol. 26) have the same length as the HZ-M king piles.

Rounding of the mass of single elements of the combined system leads in some cases to slight discrepancies in the mass of the combinations / solutions.



Annex 1:

Design example according to EN 1993-5

Introduction

For the countries participating in the Eurocode, the combined sheet pile wall must be verified according to EN 1993-5, paragraph 5.5. EN 1993-5, like all standards in the 1993 series, is based on EN 1993-1-1. Therefore, the stability verifications for the HZ-M pile, as part of the combined sheet pile wall, must be based on EN 1993-1-1, too.

Since the deformation of retaining structures is determined by the soil also, stability verifications based exclusively on EN 1993-1-1 would lead to uneconomical results or, in the worst case, would not be possible. Therefore, since the introduction of the Eurocode, numerous research projects have attempted to adapt the verification methods for retaining structures on the deformation performance and load-bearing behavior of piles embedded in the soil and to publish simplified procedures.

The following design example is based on EN 1993-5 and the requirements of EAU 2020 [3] for eliminating the lateral-torsional buckling analysis. It is valid for combined steel sheet pile walls with I-shaped supporting piles that are completely backfilled with at least medium dense, non-cohesive soils or cohesive soils with at least a stiff consistency.

Considered codes and technical guidelines

The verification is done for the ultimate limit state STR.

Because only the steel stress and stability verification of the combined HZ-M sheet pile wall should be presented in this example, hence the limit state STR, further limit states required according to Eurocode are not investigated.

Determination of the internal forces for the persistent and transient design situation according to EN 1997-1, approach 2

$$A 1 + M1 + R2$$

with the partial factors according to EN 1997-1 Annex A.3 table A.3

$$\gamma_G = 1.35$$

$$\gamma_Q = 1.50$$

Steel stress and buckling verification according to EN 1993-5 in combination with EN 1993-1-1 and EN 1993-1-5

with the partial factors according to EN 1993-5

paragraph 5.1.1: $\gamma_{M0} = 1.00$

$$\gamma_{M1} = 1.10$$

Section and Results

Section

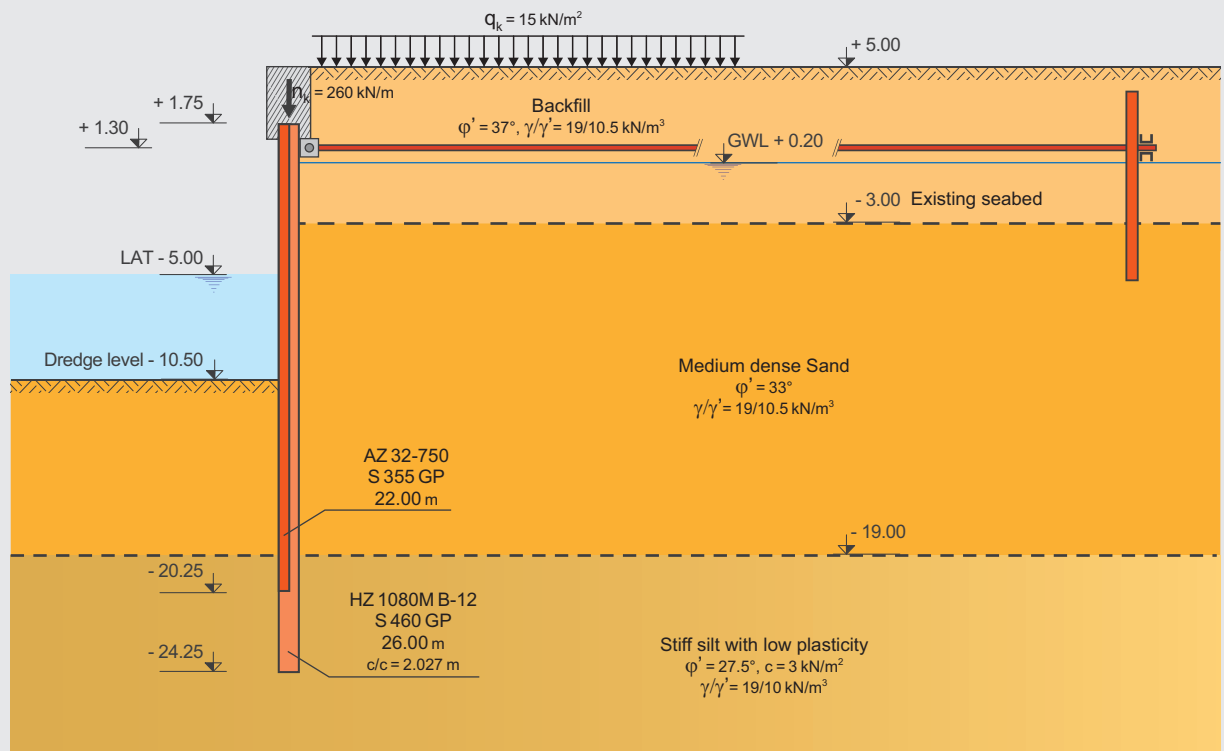


Fig. A1: Cross section of the quay wall.

Results of the computation

The characteristic internal forces are calculated with the specialised software RIDO, based on the subgrade reaction modulus.

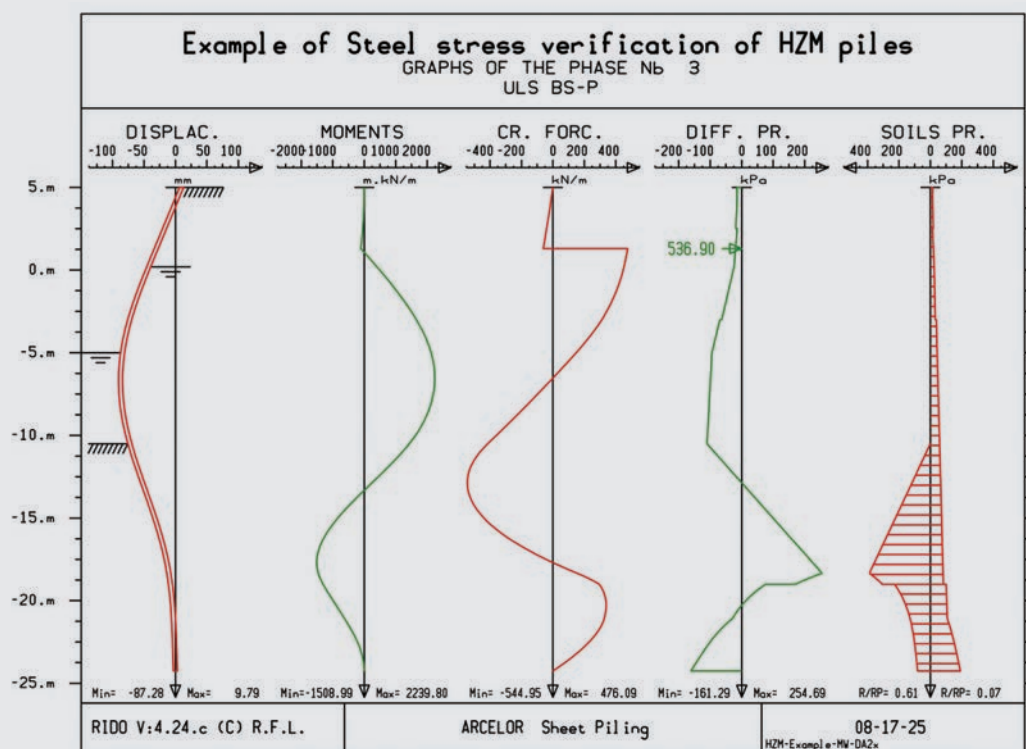


Fig. A2: Internal forces of the cross sections

The steel stress and buckling verification will be performed in the ultimate limit state STR. For this purpose, the characteristic internal forces (Figure A2) are multiplied by the partial safety factor $\gamma_G = 1.35$ for permanent actions.

(The variable load q_k has been multiplied by the factor $1.5/1.35 = 1.11$ during the computation with the software RIDO, to obtain a total safety factor of $\gamma_G = 1.50$ for variable actions by multiplying the effects of actions with $\gamma_G = 1.35$)

Width of one system: $c/c = 2.027$ m (HZ 1080M B-12/AZ 32-750)

Elevation	Bending moment		Shear force		Normal force	
	Per meter of wall	Per pile	Per meter of wall	Per pile	Per meter of wall	Per pile
EL.	$m_{y,Ed}$	$M_{y,Ed}$	v_{Ed}	V_{Ed}	n_{Ed}	N_{Ed}
[m]	[kNm/m]	[kNm]	[kN/m]	[kN]	[kN/m]	[kN]
					390.00	791
+1.30	-146.34	- 297	642.72	1303		
-6.55	3023.73	6129	0	0		
-10.50	1930.80	3914	-560.37	-1136		
-12.89	0	0	-735.68	-1491		
-17.67	-2037.14	-4129	0	0		

Section properties

Section:	HZ 1080M B-12/AZ 32-750	S 460 GP/S 355 GP	c/c = 2.027 m
----------	-------------------------	-------------------	---------------

King pile: **HZ 1080M B-12 S 460 GP** → **Solution: 12**

Yield strength: $f_y = 460 \text{ N/mm}^2$

(Required section properties are given in this catalogue and are not listed separately.)

Intermediate pile: **AZ 32-750 S 355 GP**

Yield strength: $f_y = 355 \text{ N/mm}^2$

Height of the section: $h = 511 \text{ mm}$

Width of the double pile: $2 \cdot b = 1500 \text{ mm}$

Thickness of the flange: $t_f = 14.0 \text{ mm}$

Thickness of the web: $t_w = 12.0 \text{ mm}$

Inclination of the web: $\alpha = 58.9^\circ$

Structural analysis for ultimate limit state (STR)

General considerations

Arching effects in the soil are taken into account

According to EN 1993-5, Paragraph 5.5.2 (2), arching effects in the soil, and therefore the redistribution of earth pressure to the stiffer load-bearing elements, hence the HZ-M piles, may be considered.

Driving imperfections are not taken into account

According to EN 1993-5, Paragraph 5.5.1 (4), it must be agreed beforehand whether and to what extent driving imperfections are to be taken into account.

The lateral-torsional buckling verification is not required because the king piles of the combined wall are completely embedded in medium-dense sand and embedded in stiff silt.
According to EAU 2020, Paragraph 8.2.7 (1), the lateral-torsional buckling verification can be omitted for a combined wall that is fully backfilled with at least medium-dense, non-cohesive soil or with cohesive soil with at least a stiff consistency.

Verification of the intermediate piles

In case the following conditions are met, according to EN 1993-5 5.5.2 (7) sheet piles as secondary elements (= intermediate piles) must not be verified.

Thickness of the pile:

$$\min \begin{Bmatrix} t_w \\ t_f \end{Bmatrix} = t_{\min} \geq 10 \text{ mm} \rightarrow t_w = 12 \text{ mm} > 10 \text{ mm}$$

ok

Pressure difference acting on the sheet pile:

$$p_k \leq 40 \text{ kN/m}^2 \rightarrow p_k = 52 \text{ kN/m}^2 > 40 \text{ kN/m}^2$$

does not meet requirements

Maximum clearance between the primary elements:

$$B \leq 1.50 \text{ m} \rightarrow B = 1.50 \text{ m} \leq 1.50 \text{ m}$$

ok

→ Verification of the intermediate pile is required according to EN 1993-5 5.5.2 (7)

Loads

Because arching effects can be considered, the intermediate piles are loaded exclusively by water pressure.

Water pressure on the pile:

$$\Delta h = 5.20 \text{ m} \rightarrow p_k = 5.2 \cdot 10.0 = 52 \text{ kN/m}^2$$

Partial factor: $\gamma_G = 1.35^{*1}$

Design water pressure on the intermediate pile:

$$p_{Ed} = p_k \cdot \gamma_G = 70.2 \text{ kPa}$$

*1: The partial factor can be stated by the national annex. E.g. in Germany a reduced factor of $\gamma_{G,red} = 1.20$ (acc. to EAU 2020 Tab. 1.1) can be considered in case the structure meets the requirements of the paragraph 8.2.13 of the EAU 2020.

Verification

As long as arching effects in the soil can be assumed and only water pressure acts on the sheet piles, the verification can be carried out using the table at page 36 of this brochure.

The table provides characteristic limit values for the maximum pressure on the intermediate pile depending on the sheet pile profile, HZ-M beam and steel grade.

If arching effects in the soil cannot be assumed, the design can be carried out according to the method described in EN 1993-5 5.5.2 (3) and to the Figure 5-9 in that chapter.

Characteristic, allowable value:

$$\text{HZ 1080M in S 460 GP with AZ 32-750 in S 355 GP} \\ \rightarrow p_{\max,k} = 90.3 \text{ kN/m}^2 \text{ and } \gamma_{M0} = 1.0$$

Pressure on the intermediate pile: $p_{Ed} = 70.2 \text{ kN/m}^2$

$$p_{Ed} \leq p_{\max} / \gamma_{M0} \\ 70.2 \text{ kN/m}^2 \leq 90.3 / 1.0 \text{ kN/m}^2$$

Verification of the king piles

General considerations

The verification is done according to EN 1993-5 Annex D.1

In case the water pressure on the combined wall exceeds 50 kN/m², the load-bearing capacity of the king pile must be reduced, according to EN 1993-5 5.5.4 (2), due to the interaction between bending moments, axial forces, and local plate bending. Therefore, local flange bending must be verified. The simplified method according to Annex D.1 is suitable for this purpose.

However, Annex D.1 requires a stress design according to EN 1993-1-1 6.2.9.2 and 6.2.10, which refer to elastic stress states, hence a class 3 section must be considered.

Classification of the HZ-M piles according to EN 1993-1-1 5.5

Flange (EN 1993-1-1 table 5.2, Outstand flanges)

The flange is exclusively subject to compression

$$c/t = 189/22.6 = 8.36 < 14 * \epsilon = 10.01 \rightarrow \text{Class 3}$$

$$\text{with } c = (w - 2 * r - s)/2 = (454 - 2 * 30 - 16)/2 = 189 \text{ mm}$$

Because the cross-section of the flange does not exactly match the cross-section specified in EN 1993-1-1 table 5.2, on the safe side, the cross-section class is determined with the thinnest thickness of the flange.

$$t = \min \left\{ \begin{matrix} t_l \\ t_f \end{matrix} \right\} = 22.6 \text{ mm}$$

$$\text{and } \epsilon = \sqrt{235/f_y} = \sqrt{235/460} = 0.715$$

Web (EN 1993-1-1 table 5.2, internal compression parts)

The web is subject to compression and tension.

The allowable ratio c/t for the different section classes is divided in three categories. The category to choose, depends on the part of the length of the web under compression. In case the web is not subject to pure compression or pure bending, hence 50% of the length is under compression, the part under compression could be determined with the formulae below. (The determination is an iterative process where the section class must be assessed and then verified with the ratio c/t)

for section class 2

$$\alpha = 0.5 + N_{Ed} / (2 * d * t_w * f_{y,w}) \quad \text{and } d = c = 945.6 \text{ mm}$$

$$\alpha = 0.5 + 791 / (2 * 945.6 * 16 * 460 / 1000) = 0.56 > 0.50$$

$$c/t \leq \frac{456 * \epsilon}{13 * \alpha - 1}$$

$$945.6/16 \leq \frac{456 * 0.715}{13 * 0.56 - 1}$$

$$59.1 > 51.9 \rightarrow \text{section class 3 or 4}$$

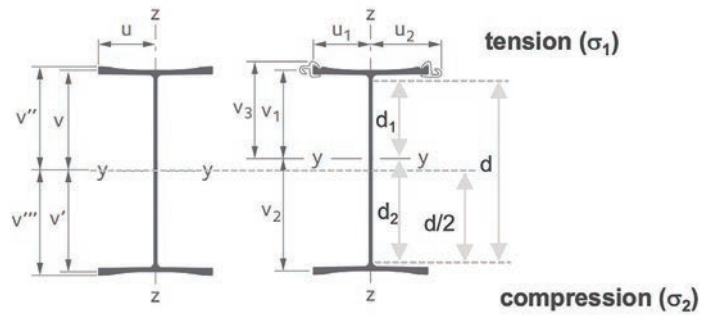


Fig. A3.

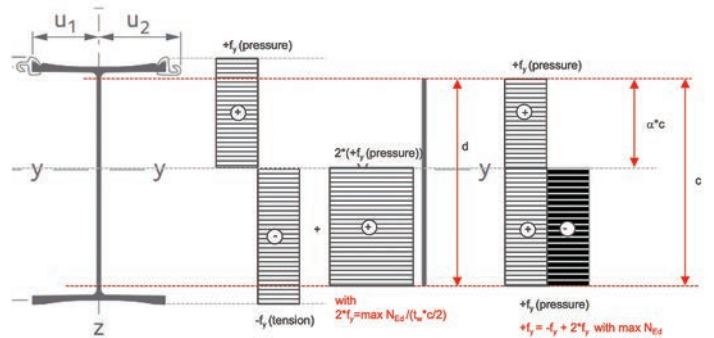


Fig. A4. Plastic steel stress distribution (class 2)

for section class 3

$$\sigma_1 = N_{Ed} / A - M_{y,Ed} / (I_y / d_1) \quad (\text{tension})$$

$$\sigma_1 = 10 * 791 / 432.8 - 1000 * 6129 / (858610 / 42.76)$$

$$\sigma_1 = -287 \text{ N/mm}^2$$

$$\sigma_2 = N_{Ed} / A + M_{y,Ed} / (I_y / d_2) \quad (\text{pressure})$$

$$\sigma_2 = 10 * 791 / 432.8 + 1000 * 6129 / (858610 / 51.8)$$

$$\sigma_2 = +388 \text{ N/mm}^2$$

$$\text{with } N_{Ed} = 791 \text{ kN (pressure)} \quad \text{and } \max M_{y,Ed} = 6129 \text{ kNm}$$

$$\text{and } d_2 = d/2 + (v_2 - v') \quad \text{with } v' = 526.7 \text{ mm of Solution 100}$$

$$d_2 = 945.6/2 + (571.9 - 526.7) = 518 \text{ mm}$$

$$d_1 = d - d_2 = 945.6 - 518 = 427.6 \text{ mm}$$

$$\psi = \sigma_1 / \sigma_2 = -287 / (+388) = -0.74 > -1$$

$$c/t \leq \frac{42 * \epsilon}{0.67 + 0.33 * \psi}$$

$$c/t = 945.6/16 = 59 < \frac{42 * 0.715}{0.67 - 0.33 * 0.74} = 71$$

→ Class 3

For HZ-M piles predominantly subjected to bending, the cross-section class alternatively can be determined using the information given on page 37 and 38 of this brochure. The given cross-section classes are generally more favorable than those determined according to EN 1993-1-1. However, the classification, determined through a series of tests at RWTH Aachen University, refers exclusively to "pure" bending. A significant vertical compressive force would place the web of the HZ-M pile predominantly under compression, resulting in a less favorable class.

Verification of the king pile according to EN 1993-1-1 6.2 and EN 1993-5 Annex D.1.2

Reduction of the yield strength due to water pressure on the combined wall according to EN 1993-5 D.1.2 (2)

Water pressure: 4.0 m < h = 5.20 m ≤ 10 m? Yes

$$4\text{ m} < h = 5.20\text{ m} < 10\text{ m}: f_{y,red} = f_y \left(\frac{16 - \frac{h}{4}}{15} \right)$$

$$f_{y,red} = 460 * \left(\frac{16 - \frac{5.2}{4}}{15} \right) = 450.8\text{ N/mm}^2$$

Steel stress verification of the king pile according to EN 1993-5 Annex D.1.2 (2)

Paragraph D.1.2 (2) of Annex D of EN 1993-5 requires a cross-section analysis according to EN 1993-1-1 6.2.9.2 and 6.2.10 with the reduced yield strength [$f_{y,red}$] determined in D.1.2 (2).

Verification of the shear resistance according to EN 1993-1-1 6.2.6

The shear stress analysis is performed according to EN 1993-1-1 6.2.6 (5) for a Class 3 I-section.

On the safe side, the HZ-M pile is verified at the point of maximum shear force, at EL. -12.89 m. If a stress superposition is required, the pile should be verified for the combined effects of actions at the point of maximum stress.

$$\tau_{Ed} = \frac{V_{Ed}}{h_w * t_w}$$

$$\tau_{Ed} = \frac{1491 * 1000}{1005.6 * 16} = 93 \frac{\text{N}}{\text{mm}^2}$$

with $h_w = d + 2 * r = 945.6 + 2 * 30 = 1005.6\text{ mm}$

$$t_w = 16\text{ mm}$$

$$f_y = f_{y,red} = 450.8\text{ N/mm}^2$$

$$\gamma_{M0} = 1.0$$

$$\frac{\tau_{Ed}}{f_y / (\sqrt{3} * \gamma_{M0})} \leq 1.0$$

$$\frac{93}{450.8 / (\sqrt{3} * 1.0)} = 0.36 \leq 1.0$$

Verification of bending and axial force according to EN 1993-1-1 6.2.9.2

The bending stress analysis is performed according to EN 1993-1-1 6.2.9.2 for a Class 3 cross-section at the point with the highest bending moment, at EL. -6.55 m. The interaction between bending, the associated shear force, and the normal force, to be verified according to EN 1993-1-1 6.2.10, can be neglected, since high bending moments do not overlap with high shear forces at any point in the cross-section.

$$\sigma_{x,Ed} = \frac{M_{y,Ed}}{W_{el,y}} + \frac{N_{Ed}}{A}$$

$$\sigma_{x,Ed} = \frac{6129}{15015} * 1000 + \frac{791}{432.8} * 10$$

$$\sigma_{x,Ed} = 427\text{ MPa}$$

with $M_{y,Ed} = 6129\text{ kNm}$ and $N_{Ed} = 791\text{ kN}$ at EL. -6.55 m

$$W_{el,y} = 15015\text{ cm}^3 \quad \text{and} \quad A = 432.8\text{ cm}^2$$

$$\sigma_{x,Ed} \leq \frac{f_{y,red}}{\gamma_{M0}}$$

$$\rightarrow \sigma_{x,Ed} = 427\text{ N/mm}^2 \leq 450.8 / 1.0\text{ N/mm}^2$$



Verification of the resistance to local plate bending in the flange according to EN 1993-5 annex D.1.2 (3)

Support forces of the infill sheet pile

The support forces are determined according to EN 1993-5 5.5.2 (3) and to the Figure 5-9 in that chapter, with a simplified two-dimensional structural model using the RFEM software from Dlubal.

The support forces will be induced via the connectors into the flange.

Maximal pressure on the infill sheet pile: $p_{Ed} = 70.2 \text{ kN/m}^2$

Structural model:

The geometry for the static system of the infill pile can be found in the general catalogue of ArcelorMittal sheet piling.

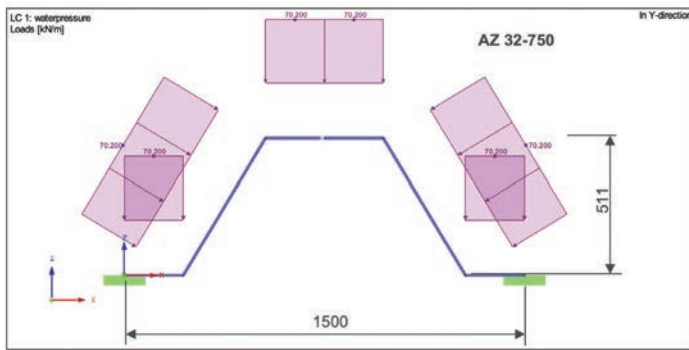


Fig. A5.

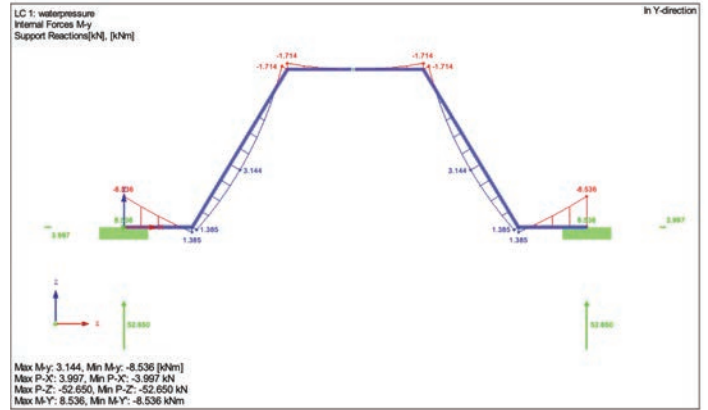


Fig. A6.

Support forces:

$$w_{z,Ed} = 52.62 \text{ kN/m}$$

$$w_{y,Ed} = -4.0 \text{ kN/m}$$

$$m_{Ed} = -8.536 \text{ kNm/m}$$

Determination of the internal forces which cause local plate bending

The internal forces are determined at the beginning of the fillet of the flange using EN 1993-5 formula (D.2) and Figure D.1 from that chapter (reproduced below as Fig. A7) as well as the calculated reaction forces.

$$M_{Ed} = m_{Ed} + w_{z,Ed} * d$$

$$M_{Ed} = |-8.536| + 52.62 * 0.189 = 18.48 \text{ kNm}$$

$$\text{with } d = (w - s) / 2 - r$$

(Distance between the tip of the flange and the beginning of the fillet)

$$d = (454 - 16) / 2 - 30 = 189 \text{ mm}$$

$$N_{Ed} = w_{y,Ed} = |-4.0| \text{ kN/m}.$$

Determination of the resistance to local plate bending:

$$M_{Rd} = 0.2875 * t^2 * f_y / \gamma_{M0}$$

$$M_{Rd} = 0.2875 * 23.7^2 * 1000 * 460 / (1.0 * 1000^2) = 74.3 \text{ kNm/m}$$

$$N_{Rd} = t * f_y / \gamma_{M0} \quad \text{with } t = t_l = 23.7 \text{ mm}$$

$$N_{Rd} = 23.7 * 460 * 1000 / (1.0 * 1000) = 10902 \text{ kN/m}$$

Verification according to the formula (D.1) of EN 1993-5 annex D.1

$$\frac{M_{Ed}}{M_{Rd}} + \left(\frac{N_{Ed}}{N_{Rd}} \right)^2 \leq 1.0$$

$$\frac{18.48}{74.3} + \left(\frac{4.0}{10902} \right)^2 = 0.25 \leq 1.0$$

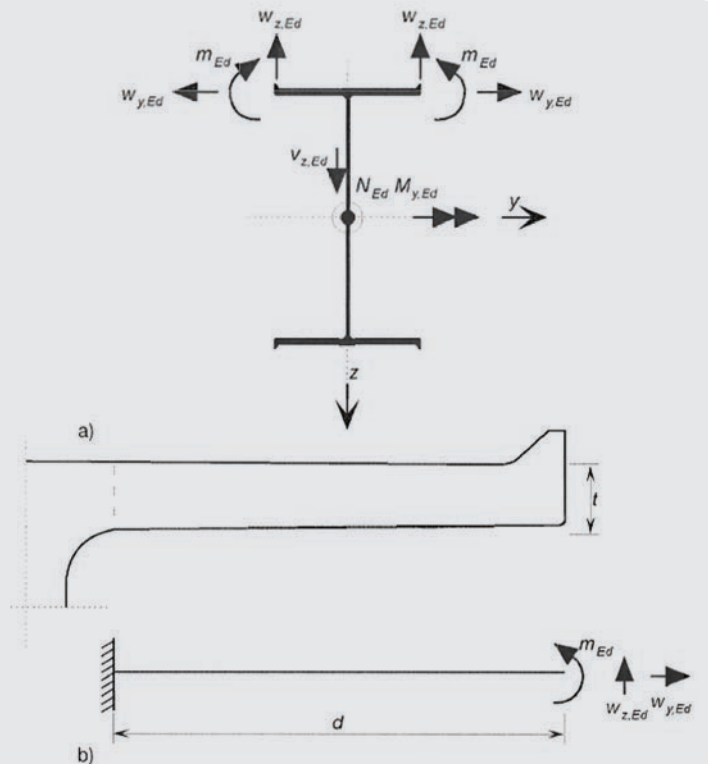


Fig. A7.

Shear stress verification of the web according to EN 1993-1-5 paragraph 5

The shear buckling verification required in EN 1993-5, paragraph D.1.2 (4) for the web of the HZ-M pile according to EN 1993-1-5 is based on the same method as the shear buckling verification according to EN 1993-1-3, the reduced stress method. In the web of the HZ-M pile the percentage of the reduction of the resistance to shear force is the same up to a slenderness of $\bar{\lambda}_w = 1.4$ for HZ-M piles which are stiffened or unstiffened at the support, as well as for piles verified according to EN 1993-1-5 or EN 1993-1-3. However, EN 1993-1-5, paragraph 5.1 (2) requires stiffeners at the support if a shear buckling verification is required.

Since EN 1993-1-3 does not require stiffeners for the same method, for the same web with the same slenderness, it is reasonable not to incorporate them into a web verified according to EN 1993-1-5.

The new generation of the Eurocode will address this issue. According to prEN 1993-5 stiffeners at the support are not required for a web slenderness of $\bar{\lambda}_w < 1.4$ in combination with the factor $\eta = 1.0$.

Verification according to EN 1993-1-5 paragraph 5.1 (2)

$$\frac{h_w}{t_w} \leq 72 \frac{\epsilon}{\eta}$$

$$\text{with } h_w = d + 2 \cdot r = 945.6 + 2 \cdot 30 = 1005.6 \text{ mm}$$

$$t_w = s = 16 \text{ mm}$$

$$\eta = 1.00$$

(According to some national annexes of EN 1993-1-5, $\eta = 1.20$ could also be used. Since the stiffeners at the support are omitted in this example, the less favorable value for the analysis, $\eta = 1.00$, is used.)

$$\epsilon = 0.715$$

$$\frac{1005.6}{16} = 62.85 > 72 \frac{0.715}{1.0} = 51.48$$

→ The resistance to shear buckling should be verified for unstiffened webs according to EN 1993-1-5.

Resistance to shear buckling according to EN 1993-1-5 5.2 (1)

$$V_{b,Rd} = V_{bw,Rd} + V_{bf,Rd} \leq \frac{\eta \cdot f_{yw} \cdot h_w \cdot t}{\sqrt{3} \cdot \gamma_{M1}}$$

The total resistance to shear buckling comprise the resistance of the web [$V_{bw,Rd}$] and of the flange [$V_{bf,Rd}$].

Because the resistance to shear buckling of the web is sufficient for typical combined sheet pile walls with HZ-M piles, only the resistance of the web is determined in this example.

Contribution of the web to the design value of the resistance to shear buckling according to EN 1993-1-5 5.2 (1) formula (5.2)

$$V_{bw,Rd} = \frac{x_w \cdot f_{yw} \cdot h_w \cdot t}{\sqrt{3} \cdot \gamma_{M1}}$$

with the modified slenderness according to EN 1993-1-5 5.3 (3) a) formula (5.5)

$$\bar{\lambda}_w = h_w / (86.4 \cdot t \cdot \epsilon)$$

$$\bar{\lambda}_w = 1005.6 / (86.4 \cdot 16 \cdot 0.715) = 1.02 < 1.40$$

Since formula (5.5) of EN 1993-1-5 gives the same modified slenderness for a pile with stiffeners at the support as with the general formula (5.3) with a critical buckling stress $\tau_{cr} = k_\tau \cdot \sigma_E$ according to EN 1993-1-5 Annex A and an unlimited beam length [a] in relation to a short web height [h_w], i.e. the case that would also apply in EN 1993-1-3, the modified slenderness is determined here with formula (5.5) despite the lack of support stiffeners.

Factor for the contribution of the web to the resistance to shear buckling [χ_w] according to table 5.1 of EN 1993-1-5:

$$0.83 / \eta \leq \bar{\lambda}_w < 1.08$$

$$0.83 / \eta = 0.83 / 1.00 = 0.83 < 1.02 < 1.08 \rightarrow \chi_w = 0.83 / \bar{\lambda}_w$$

$$\chi_w = 0.83 / 1.02 = 0.81$$

$$V_{bw,Rd} = \frac{0.81 \cdot 460 \cdot 1005.6 \cdot 16}{\sqrt{3} \cdot 1.1 \cdot 1000} = 3147 \text{ kN}$$

and:

$$V_{b,Rd} = V_{bw,Rd} + V_{bf,Rd} \leq \frac{\eta \cdot f_{yw} \cdot h_w \cdot t}{\sqrt{3} \cdot \gamma_{M1}}$$

$$V_{b,Rd} = 3147 + V_{bf,Rd} \leq \frac{1.0 \cdot 460 \cdot 1005.6 \cdot 16}{\sqrt{3} \cdot 1000 \cdot 1.1} = 3885 \text{ kN}$$

Maximal shear force at EL. -12.89 m:

$$V_{Ed} = 1491 \text{ kN}$$

$$\frac{V_{Ed}}{V_{b,Rd}} = \frac{1491}{3147} = 0.47 < 0.5$$

→ Interaction bending moment, shear force and axial force can be neglected

Verification of the resistance to buckling according to EN 1993-1-1 6.3.3

EN 1993-5 D.1.2 (5) requires a buckling analysis of the entire system for load-bearing piles according to EN 1993-1-1 6.3.3. The equations (6.61) and (6.62) of paragraph 6.3.3 of EN 1993-1-1 include both the lateral-torsional buckling analysis with the reduction factor [χ_{LT}] as well as the buckling analysis around the major and minor axes of the load-bearing pile with the reduction factors [χ_y] and [χ_z].

Since in this example the load-bearing pile is completely embedded in medium-dense sand and, from EL. -19 m to the toe, in stiff, cohesive soil, the lateral-torsional buckling analysis can be omitted according to EAU 2020 8.2.7 (1). Therefore, the reduction factor [χ_{LT}] is set to 1.0 in equations (6.61) and (6.62).

Because the HZ-M pile is embedded completely in medium dense sand and stiff silt, buckling around the weak axis cannot occur. Hence, the term in equations (6.61) and (6.62), related to bending and buckling around the weak axis, is omitted.

Buckling length according to EN 1993-5 annex D.1.1 (2) and EN 1993-5 5.2.3 (5)

$$L_{cr} = 0.70 * l \quad \text{with } l = +1.30 + |-24.25| = 25.55 \text{ m}$$

$$L_{cr} = 0.70 * 25.55 = 17.89 \text{ m}$$

Numerous methods to determine the buckling lengths exist in the literature, such as the method developed by Ulrike Kuhlmann, Bernadette Leitz, Adrian Just, Jürgen Grabe, and Christoph Schallück at the University of Stuttgart which is presented in the article "Simplified criteria and economic design for king piles in combined steel pile walls according to EN 1993, part 1-1," Verlag Ernst & Sohn, Berlin – Steel Construction 8 (2015), No. 2. Often, those methods help to achieve shorter buckling lengths.

Buckling coefficient according to EN 1993-1-1 6.3.1.2

$$\bar{\lambda} = \sqrt{A * f_y / N_{cr}} = \sqrt{432.8 * 46 / 55602} = 0.60 > 0.20$$

with the elastic critical force for buckling around the strong axis (= y-y axis):

$$N_{cr,y} = \frac{\pi^2 * E * I_y}{L_{cr}^2}$$

$$N_{cr,y} = \frac{\pi^2 * 2.1 * 10^4 * 858610}{1789^2} = 55602 \text{ kN}$$

because : $\bar{\lambda} > 0.20$:

$$\phi = 0.5 * [1 + \alpha * (\bar{\lambda} - 0.20) + \bar{\lambda}^2]$$

with $h/b = h/w = 1075.3/454 = 2.37 > 1.2$

and $t_f = t_{max} = 29 \text{ mm} < 40 \text{ mm}$

and S460GP = S460

and buckling around the strong axis (y-y)

→ Buckling curve: $\alpha_0 \rightarrow \alpha = 0.13$

$$\phi = 0.5 * [1 + 0.13 * (0.60 - 0.20) + 0.60^2] = 0.71$$

$$\chi_y = 1 / (\phi + \sqrt{\phi^2 - \bar{\lambda}^2}) = 1 / (0.71 + \sqrt{0.71^2 - 0.60^2}) = 0.92$$

Buckling verification, EN 1993-1-1 6.3.3

The stability analysis is carried out according to EN 1993-1-1 6.3.3 (4), formulae (6.61) and (6.62), without lateral-torsional buckling, therefore with $\chi_{LT} = 1.0$, and without buckling around the weak axis.

$$\frac{N_{Ed}}{\chi_y * N_{Rk} / \gamma_{MI}} + k_{yy} * \frac{M_{y,Ed}}{\chi_{LT} * M_{y,Rk} / \gamma_{MI}} \leq 1.0$$

$$\frac{N_{Ed}}{\chi_z * N_{Rk} / \gamma_{MI}} + k_{zy} * \frac{M_{y,Ed}}{\chi_{LT} * M_{y,Rk} / \gamma_{MI}} \leq 1.0$$

with $\gamma_{MI} = 1.10$ and $\chi_z = 1.0$ and $\chi_{LT} = 1.0$

and the interaction factors k_{yy} and k_{zy} according to EN 1993-1-1, Annex B, table B.1 for elastic cross-sectional properties, with the equivalent uniform moment factors according to EN 1993-5 Annex B, table B3

$$|M_h| = |-4129| \text{ kNm/m} < |M_s| = 6129 \text{ kNm/m}$$

$$\alpha_h = M_h / M_s = -4129 / 6129 = -0.67$$

$$-1 < -0.67 < 0$$

$$\psi = M_{h1} / M_{h2} = -297 / -4129 = 0.07$$

$$0 < 0.07 < 1$$

$$\rightarrow C_{my} = 0.95 + 0.05 * \alpha_h = 0.95 + 0.05 * (-0.67) = 0.92$$

and EN 1993-1-1, annex B, table B.1 for class 3 sections which are not susceptible to torsional deformations

$$k_{yy} = C_{my} * \left(1 + 0.6 * \bar{\lambda} * \frac{N_{Ed}}{\chi_y * N_{Rk} / \gamma_{MI}} \right) \leq C_{my} * \left(1 + 0.6 * \frac{N_{Ed}}{\chi_y * N_{Rk} / \gamma_{MI}} \right)$$

$$\text{with } \bar{\lambda} = 0.60 \quad \text{and} \quad N_{Rk} = f_y * A = 46 * 432.8 = 19909 \text{ kN/m}$$

$$k_{yy} = 0.92 * \left(1 + 0.6 * 0.60 * \frac{791}{0.92 * 19909 / 1.1} \right) < 0.92 * \left(1 + 0.6 * \frac{791}{0.92 * 19909 / 1.1} \right)$$

$$k_{yy} = 0.94 < 0.95 \quad \text{and} \quad k_{zy} = 0.8 * k_{yy} = 0.752$$

Formula (6.62) of EN 1993-1-1, with $k_{zy} < k_{yy}$ and $\chi_z = 1.0$, is more favorable than formula (6.61) and can therefore be neglected. The stability analysis is performed exclusively with formula (6.61).

$$\frac{N_{Ed}}{\chi_y * N_{Rk} / \gamma_{MI}} + k_{yy} * \frac{M_{y,Ed}}{\chi_{LT} * M_{y,Rk} / \gamma_{MI}} \leq 1.0$$

with the characteristic resistance for bending for a class 3 cross section

$$M_{y,Rk} = f_y * W_{el,y} = 460 * 15015 / 1000 = 6907 \text{ kNm}$$

$$\text{and } M_{Ed} = 6129 \text{ kNm} \quad \text{at EL. -6.55 m}$$

$$\text{and } N_{Ed} = 791 \text{ kN}$$

$$\frac{791}{0.92 * 19909 / 1.1} + 0.94 * \frac{6129}{1.0 * 6907 / 1.1} \leq 1.0$$

$$0.05 + 0.94 * 0.98 = 0.97 < 1.0$$

Annex 2:

HZ-M | Static moment & Plastic section modulus

Section	$W_{el,y}$ cm ³	S_y cm ³	W_{ply} cm ³	$W_{el,y}$ cm ³	S_y cm ³	W_{ply} cm ³	$W_{el,y}$ cm ³	S_y cm ³	W_{ply} cm ³
Sol. 100			Sol. 12			Sol. 26			
HZ 630M	7175	3940	7880	7385	4450	8785	17535	9505	19010
HZ 880M A	9030	4915	9835	9330	5605	11075	22430	12020	24045
HZ 880M B	9875	5415	10830	10190	6105	12100	24050	12995	25985
HZ 880M C	10420	5710	11420	10725	6400	12690	25115	13585	27165
HZ 1080M A	13355	7475	14950	13880	8395	16710	32415	17810	35615
HZ 1080M B	14520	8090	16185	15015	9005	17930	34635	19005	38010
HZ 1080M C	15920	8925	17850	16430	9845	19620	37400	20670	41345
HZ 1080M D	17230	9690	19380	17735	10615	21160	39980	22200	44400
HZ 1180M A	18175	10275	20550	18685	11200	22340	41825	23370	46740
HZ 1180M B	19090	10770	21535	19565	11670	23275	43390	24230	48465
HZ 1180M C	20205	11410	22820	20725	12415	24750	46665	26160	52320
HZ 1180M D	21325	12055	24110	21815	13005	25945	48360	27190	54380
Sol. 102			Sol. 14			Sol. C1			
HZ 630M	6985	3885	7770	9370	5060	10125	7285	4180	8340
HZ 880M A	8800	4850	9700	12030	6425	12845	9185	5245	10460
HZ 880M B	9625	5345	10685	12835	6910	13820	10035	5735	11455
HZ 880M C	10170	5640	11275	13365	7205	14405	10575	6030	12040
HZ 1080M A	13075	7390	14780	17270	9440	18885	13615	7905	15795
HZ 1080M B	14205	8000	16000	18375	10040	20080	14760	8515	17015
HZ 1080M C	15605	8830	17665	19750	10875	21745	16165	9350	18685
HZ 1080M D	16920	9595	19190	21035	11635	23275	17475	10115	20215
HZ 1180M A	17865	10180	20365	21945	12220	24445	18420	10700	21390
HZ 1180M B	18675	10645	21285	22725	12655	25305	19310	11165	22315
HZ 1180M C	19790	11285	22570	24385	13675	27345	20490	11930	23845
HZ 1180M D	20690	11865	23725	25225	14190	28380	21565	12515	25020
Sol. 104			Sol. 24			Sol. C23			
HZ 630M	6955	3830	7665	15370	8860	17655	15260	8570	17130
HZ 880M A	8760	4785	9575	19510	11165	22260	19350	10780	21545
HZ 880M B	9585	5270	10545	21170	12125	24220	20995	11755	23490
HZ 880M C	10130	5565	11135	22240	12735	25400	22070	12345	24670
HZ 1080M A	13020	7310	14615	28755	16705	33370	28475	16195	32375
HZ 1080M B	14145	7905	15815	30970	17905	35765	30700	17390	34770
HZ 1080M C	15545	8740	17480	33770	19575	39110	33495	19060	38105
HZ 1080M D	16860	9505	19010	36380	21105	42170	36105	20585	41165
HZ 1180M A	17805	10090	20180	38260	22280	44515	37980	21755	43505
HZ 1180M B	18600	10520	21040	39825	23140	46240	39555	22620	45230
HZ 1180M C	19710	11160	22325	42600	24800	49550	42345	24295	48580
HZ 1180M D	20570	11675	23355	44310	25830	51615	44055	25330	50640

The plastic section modulus W_{ply} applies only for steel stress verification of "class 1" and "class 2" sections according to EN 1993.

Annex 3:

Combinations sorted by ascending elastic section modulus according to global safety approach

W_{ely}^*	$G_{100\%}$	Section	Combination	W_{ely}^*	$G_{100\%}$	Section	Combination	W_{ely}^*	$G_{100\%}$	Section	Combination
cm ³ /m	kg/m ²			cm ³ /m	kg/m ²			cm ³ /m	kg/m ²		
4135	210	HZ 630M	12/AZ 13-770	5865	241	HZ 630M	14/AZ 18-700	6900	237	HZ 880M B	14/AZ 20-800-10/10
4180	217	HZ 630M	12/AZ 14-770-10/10	5870	238	HZ 880M A	12/AZ 30-750	6900	240	HZ 880M C	14/AZ 14-770-10/10
4355	224	HZ 630M	12/AZ 13-700	5895	233	HZ 880M C	12/AZ 13-700	6920	232	HZ 880M A	14/AZ 18-700
4375	227	HZ 630M	12/AZ 13-700-10/10	5900	230	HZ 880M B	12/AZ 18-700	6965	285	HZ 630M	24/AZ 20-800
4550	216	HZ 630M	12/AZ 20-800	5905	236	HZ 880M C	12/AZ 13-700-10/10	6980	239	HZ 880M A	14/AZ 20-700
4590	220	HZ 630M	12/AZ 20-800-10/10	5940	249	HZ 630M	14/AZ 20-700	6995	297	HZ 630M	24/AZ 13-700
4730	226	HZ 630M	12/AZ 18-700	5950	237	HZ 880M B	12/AZ 20-700	7005	288	HZ 630M	24/AZ 20-800-10/10
4800	234	HZ 630M	12/AZ 20-700	5955	246	HZ 880M A	12/AZ 32-750	7010	300	HZ 630M	24/AZ 13-700-10/10
4870	229	HZ 630M	12/AZ 25-800	5960	243	HZ 630M	14/AZ 25-800	7015	230	HZ 1080M A	12/AZ 13-770
4885	202	HZ 880M A	12/AZ 13-770	6040	238	HZ 880M C	12/AZ 25-800	7020	242	HZ 880M B	14/AZ 13-700
4915	208	HZ 880M A	12/AZ 14-770-10/10	6095	258	HZ 880M A	12/AZ 26	7035	245	HZ 880M B	14/AZ 13-700-10/10
4975	246	HZ 630M	12/AZ 18-10/10	6175	236	HZ 880M C	12/AZ 18-700	7040	236	HZ 1080M A	12/AZ 14-770-10/10
5145	208	HZ 880M A	12/AZ 20-800	6185	262	HZ 630M	14/AZ 18-10/10	7110	238	HZ 880M C	14/AZ 20-800
5165	224	HZ 630M	14/AZ 13-770	6210	242	HZ 880M B	12/AZ 28-750	7130	235	HZ 1080M A	12/AZ 20-800
5175	211	HZ 880M A	12/AZ 20-800-10/10	6225	243	HZ 880M C	12/AZ 20-700	7130	246	HZ 880M B	14/AZ 25-800
5175	214	HZ 880M A	12/AZ 13-700	6230	216	HZ 880M A	14/AZ 13-770	7140	242	HZ 880M C	14/AZ 20-800-10/10
5185	218	HZ 880M A	12/AZ 13-700-10/10	6255	249	HZ 880M B	12/AZ 18-10/10	7150	239	HZ 1080M A	12/AZ 20-800-10/10
5210	231	HZ 630M	14/AZ 14-770-10/10	6255	257	HZ 880M B	12/AZ 26-700	7245	244	HZ 880M A	14/AZ 28-750
5210	254	HZ 630M	12/AZ 26-700	6265	222	HZ 880M A	14/AZ 14-770-10/10	7245	296	HZ 630M	24/AZ 25-800
5295	239	HZ 630M	12/AZ 28-750	6295	250	HZ 880M B	12/AZ 30-750	7290	248	HZ 880M C	14/AZ 13-700
5300	214	HZ 880M B	12/AZ 13-770	6380	258	HZ 880M B	12/AZ 32-750	7305	251	HZ 880M C	14/AZ 13-700-10/10
5330	220	HZ 880M B	12/AZ 14-770-10/10	6395	269	HZ 630M	14/AZ 26-700	7315	248	HZ 1080M A	12/AZ 25-800
5385	221	HZ 880M A	12/AZ 25-800	6460	254	HZ 630M	14/AZ 28-750	7315	299	HZ 630M	24/AZ 18-700
5395	269	HZ 630M	12/AZ 26	6470	248	HZ 880M C	12/AZ 28-750	7320	259	HZ 880M A	14/AZ 26-700
5410	247	HZ 630M	12/AZ 30-750	6495	221	HZ 880M A	14/AZ 20-800	7330	245	HZ 880M B	14/AZ 18-700
5450	239	HZ 630M	14/AZ 13-700	6530	225	HZ 880M A	14/AZ 20-800-10/10	7340	252	HZ 880M A	14/AZ 30-750
5455	217	HZ 880M A	12/AZ 18-700	6530	263	HZ 880M C	12/AZ 26-700	7350	252	HZ 880M A	14/AZ 18-10/10
5470	242	HZ 630M	14/AZ 13-700-10/10	6555	256	HZ 880M C	12/AZ 18-10/10	7370	305	HZ 630M	24/AZ 20-700
5505	224	HZ 880M A	12/AZ 20-700	6555	256	HZ 880M C	12/AZ 30-750	7375	252	HZ 880M C	14/AZ 25-800
5525	255	HZ 630M	12/AZ 32-750	6575	272	HZ 880M B	12/AZ 26	7385	252	HZ 880M B	14/AZ 20-700
5545	220	HZ 880M B	12/AZ 20-800	6585	262	HZ 630M	14/AZ 30-750	7435	260	HZ 880M A	14/AZ 32-750
5555	219	HZ 880M C	12/AZ 13-770	6610	229	HZ 880M A	14/AZ 13-700	7475	244	HZ 1080M A	12/AZ 13-700
5580	223	HZ 880M B	12/AZ 20-800-10/10	6615	228	HZ 880M B	14/AZ 13-770	7485	247	HZ 1080M A	12/AZ 13-700-10/10
5585	226	HZ 880M C	12/AZ 14-770-10/10	6625	233	HZ 880M A	14/AZ 13-700-10/10	7565	238	HZ 1080M B	12/AZ 13-770
5600	230	HZ 630M	14/AZ 20-800	6645	264	HZ 880M C	12/AZ 32-750	7570	295	HZ 630M	26/AZ 13-770
5615	227	HZ 880M B	12/AZ 13-700	6650	234	HZ 880M B	14/AZ 14-770-10/10	7590	245	HZ 1080M B	12/AZ 14-770-10/10
5630	230	HZ 880M B	12/AZ 13-700-10/10	6650	285	HZ 630M	14/AZ 26	7600	251	HZ 880M C	14/AZ 18-700
5650	234	HZ 630M	14/AZ 20-800-10/10	6670	282	HZ 630M	24/AZ 13-770	7610	300	HZ 630M	26/AZ 14-770-10/10
5780	235	HZ 880M A	12/AZ 18-10/10	6705	288	HZ 630M	24/AZ 14-770-10/10	7630	257	HZ 880M B	14/AZ 28-750
5785	230	HZ 880M A	12/AZ 28-750	6710	270	HZ 630M	14/AZ 32-750	7655	258	HZ 880M C	14/AZ 20-700
5790	233	HZ 880M B	12/AZ 25-800	6765	235	HZ 880M A	14/AZ 25-800	7660	243	HZ 1080M B	12/AZ 20-800
5795	225	HZ 880M C	12/AZ 20-800	6865	233	HZ 880M B	14/AZ 20-800	7670	320	HZ 630M	24/AZ 18-10/10
5810	244	HZ 880M A	12/AZ 26-700	6865	233	HZ 880M C	14/AZ 13-770	7685	247	HZ 1080M B	12/AZ 20-800-10/10
5830	229	HZ 880M C	12/AZ 20-800-10/10	6870	278	HZ 880M C	12/AZ 26	7695	247	HZ 1080M A	12/AZ 18-700

W_{ely}^*	$G_{100\%}$	Section	Combination	W_{ely}^*	$G_{100\%}$	Section	Combination	W_{ely}^*	$G_{100\%}$	Section	Combination
cm ³ /m	kg/m ²			cm ³ /m	kg/m ²			cm ³ /m	kg/m ²		
7700	274	HZ 880M A	14/AZ 26	8410	275	HZ 1080M B	12/AZ 30-750	9100	300	HZ 1080M B	12/AZ 26
7700	307	HZ 630M	24/AZ 28-750	8410	280	HZ 880M A	24/AZ 13-700	9100	301	HZ 880M A	24/AZ 18-10/10
7720	322	HZ 630M	24/AZ 26-700	8420	283	HZ 880M A	24/AZ 13-700-10/10	9105	291	HZ 1080M C	12/AZ 30-750
7725	264	HZ 880M B	14/AZ 30-750	8430	294	HZ 880M C	14/AZ 26	9120	284	HZ 1080M D	12/AZ 25-800
7725	272	HZ 880M B	14/AZ 26-700	8465	290	HZ 1080M A	12/AZ 26	9170	279	HZ 880M A	26/AZ 13-770
7735	254	HZ 1080M A	12/AZ 20-700	8480	283	HZ 1080M B	12/AZ 32-750	9170	299	HZ 1080M C	12/AZ 32-750
7785	259	HZ 1080M A	12/AZ 28-750	8510	272	HZ 1080M C	12/AZ 25-800	9190	297	HZ 880M C	24/AZ 20-800
7790	265	HZ 880M B	14/AZ 18-10/10	8565	284	HZ 1080M B	12/AZ 26-700	9195	284	HZ 880M A	26/AZ 14-770-10/10
7800	314	HZ 630M	24/AZ 30-750	8640	286	HZ 880M B	24/AZ 13-770	9215	301	HZ 880M C	24/AZ 20-800-10/10
7820	272	HZ 880M B	14/AZ 32-750	8645	282	HZ 880M A	24/AZ 18-700	9220	252	HZ 1080M B	14/AZ 13-770
7850	257	HZ 1080M B	12/AZ 25-800	8665	291	HZ 880M B	24/AZ 14-770-10/10	9245	259	HZ 1080M B	14/AZ 14-770-10/10
7850	266	HZ 1080M A	12/AZ 30-750	8670	320	HZ 630M	26/AZ 28-750	9260	259	HZ 1080M A	14/AZ 13-700
7875	298	HZ 630M	26/AZ 20-800	8685	244	HZ 1080M A	14/AZ 13-770	9275	263	HZ 1080M A	14/AZ 13-700-10/10
7885	262	HZ 880M C	14/AZ 28-750	8690	288	HZ 880M A	24/AZ 20-700	9290	300	HZ 1080M C	12/AZ 26-700
7895	320	HZ 630M	24/AZ 32-750	8695	334	HZ 630M	26/AZ 18-10/10	9295	257	HZ 1080M B	14/AZ 20-800
7915	274	HZ 1080M A	12/AZ 32-750	8710	250	HZ 1080M A	14/AZ 14-770-10/10	9315	282	HZ 880M A	26/AZ 20-800
7915	301	HZ 630M	26/AZ 20-800-10/10	8715	336	HZ 630M	26/AZ 26-700	9320	261	HZ 1080M B	14/AZ 20-800-10/10
7950	311	HZ 630M	26/AZ 13-700	8775	327	HZ 630M	26/AZ 30-750	9320	303	HZ 880M B	24/AZ 18-700
7965	314	HZ 630M	26/AZ 13-700-10/10	8780	249	HZ 1080M A	14/AZ 20-800	9325	277	HZ 1180M A	12/AZ 13-770
7975	274	HZ 1080M A	12/AZ 26-700	8780	289	HZ 880M B	24/AZ 20-800	9345	285	HZ 880M A	26/AZ 20-800-10/10
7980	270	HZ 880M C	14/AZ 30-750	8790	270	HZ 1080M C	12/AZ 13-700	9350	284	HZ 1180M A	12/AZ 14-770-10/10
7990	278	HZ 880M C	14/AZ 26-700	8800	274	HZ 1080M C	12/AZ 13-700-10/10	9360	319	HZ 880M A	24/AZ 26
8000	266	HZ 880M A	24/AZ 13-770	8805	252	HZ 1080M A	14/AZ 20-800-10/10	9365	309	HZ 880M B	24/AZ 20-700
8020	338	HZ 630M	24/AZ 26	8805	292	HZ 880M B	24/AZ 20-800-10/10	9370	281	HZ 1180M A	12/AZ 20-800
8025	272	HZ 880M A	24/AZ 14-770-10/10	8810	290	HZ 880M A	24/AZ 28-750	9395	285	HZ 1180M A	12/AZ 20-800-10/10
8065	254	HZ 1080M B	12/AZ 13-700	8855	278	HZ 1080M B	12/AZ 18-10/10	9395	308	HZ 880M C	24/AZ 25-800
8070	278	HZ 880M C	14/AZ 32-750	8870	267	HZ 1080M D	12/AZ 13-770	9460	310	HZ 880M B	24/AZ 28-750
8075	257	HZ 1080M B	12/AZ 13-700-10/10	8880	333	HZ 630M	26/AZ 32-750	9465	284	HZ 1080M D	12/AZ 13-700
8085	272	HZ 880M C	14/AZ 18-10/10	8885	297	HZ 880M A	24/AZ 30-750	9475	287	HZ 1080M D	12/AZ 13-700-10/10
8140	288	HZ 880M B	14/AZ 26	8895	273	HZ 1080M D	12/AZ 14-770-10/10	9500	262	HZ 1080M A	14/AZ 18-700
8155	270	HZ 880M A	24/AZ 20-800	8930	271	HZ 1080M D	12/AZ 20-800	9500	270	HZ 1080M B	14/AZ 25-800
8170	309	HZ 630M	26/AZ 25-800	8945	304	HZ 880M A	24/AZ 26-700	9530	310	HZ 880M C	24/AZ 13-700
8180	273	HZ 880M A	24/AZ 20-800-10/10	8955	275	HZ 1080M D	12/AZ 20-800-10/10	9530	316	HZ 880M B	24/AZ 30-750
8220	268	HZ 1080M A	12/AZ 18-10/10	8955	303	HZ 880M A	24/AZ 32-750	9535	293	HZ 880M A	26/AZ 25-800
8245	254	HZ 1080M C	12/AZ 13-770	8985	262	HZ 1080M A	14/AZ 25-800	9540	313	HZ 880M C	24/AZ 13-700-10/10
8270	261	HZ 1080M C	12/AZ 14-770-10/10	8985	300	HZ 880M B	24/AZ 25-800	9545	269	HZ 1080M A	14/AZ 20-700
8285	256	HZ 1080M B	12/AZ 18-700	9010	273	HZ 1080M C	12/AZ 18-700	9545	273	HZ 1080M A	14/AZ 28-750
8285	313	HZ 630M	26/AZ 18-700	9035	283	HZ 1080M C	12/AZ 28-750	9560	294	HZ 1180M A	12/AZ 25-800
8320	259	HZ 1080M C	12/AZ 20-800	9050	280	HZ 1080M C	12/AZ 20-700	9605	323	HZ 880M B	24/AZ 32-750
8325	263	HZ 1080M B	12/AZ 20-700	9060	295	HZ 880M C	24/AZ 13-770	9615	281	HZ 1080M A	14/AZ 30-750
8345	262	HZ 1080M C	12/AZ 20-800-10/10	9070	353	HZ 630M	26/AZ 26	9620	325	HZ 880M B	24/AZ 26-700
8345	267	HZ 1080M B	12/AZ 28-750	9085	300	HZ 880M C	24/AZ 14-770-10/10	9635	296	HZ 1080M C	12/AZ 18-10/10
8345	319	HZ 630M	26/AZ 20-700	9085	301	HZ 880M B	24/AZ 13-700	9645	293	HZ 880M A	26/AZ 13-700
8360	281	HZ 880M A	24/AZ 25-800	9095	303	HZ 880M B	24/AZ 13-700-10/10	9655	296	HZ 880M A	26/AZ 13-700-10/10

W_{ely}^*	$G_{100\%}$	Section	Combination	W_{ely}^*	$G_{100\%}$	Section	Combination	W_{ely}^*	$G_{100\%}$	Section	Combination
cm ³ /m	kg/m ²			cm ³ /m	kg/m ²			cm ³ /m	kg/m ²		
9675	297	HZ 1080M D	12/AZ 28-750	10225	297	HZ 1080M B	14/AZ 32-750	10865	338	HZ 880M B	26/AZ 26-700
9685	287	HZ 1080M D	12/AZ 18-700	10235	312	HZ 880M C	26/AZ 14-770-10/10	10885	322	HZ 1180M A	12/AZ 18-10/10
9690	289	HZ 1080M A	14/AZ 32-750	10265	323	HZ 1180M A	12/AZ 32-750	10890	313	HZ 1080M C	14/AZ 32-750
9725	294	HZ 1080M D	12/AZ 20-700	10285	333	HZ 880M C	24/AZ 18-10/10	10905	332	HZ 1180M B	12/AZ 26-700
9740	304	HZ 1080M D	12/AZ 30-750	10300	314	HZ 880M B	26/AZ 13-700	10920	291	HZ 1180M A	14/AZ 13-770
9750	284	HZ 1180M B	12/AZ 13-770	10305	296	HZ 1180M C	12/AZ 13-770	10945	295	HZ 1180M A	14/AZ 20-800
9765	312	HZ 880M C	24/AZ 18-700	10315	316	HZ 880M B	26/AZ 13-700-10/10	10950	298	HZ 1180M A	14/AZ 14-770-10/10
9775	290	HZ 1180M B	12/AZ 14-770-10/10	10320	300	HZ 1180M C	12/AZ 20-800	10970	298	HZ 1180M A	14/AZ 20-800-10/10
9785	287	HZ 1180M B	12/AZ 20-800	10325	310	HZ 880M C	26/AZ 20-800	10990	325	HZ 880M C	26/AZ 18-700
9790	298	HZ 880M B	26/AZ 13-770	10330	303	HZ 1180M C	12/AZ 14-770-10/10	11000	316	HZ 1180M C	12/AZ 13-700
9805	289	HZ 1080M A	14/AZ 26-700	10345	303	HZ 1180M C	12/AZ 20-800-10/10	11010	319	HZ 1180M C	12/AZ 13-700-10/10
9810	291	HZ 1180M B	12/AZ 20-800-10/10	10355	313	HZ 880M C	26/AZ 20-800-10/10	11015	322	HZ 1180M D	12/AZ 25-800
9810	312	HZ 1080M D	12/AZ 32-750	10365	311	HZ 1080M D	12/AZ 18-10/10	11035	331	HZ 880M C	26/AZ 20-700
9810	318	HZ 880M C	24/AZ 20-700	10375	299	HZ 1080M B	14/AZ 26-700	11040	316	HZ 1080M B	14/AZ 26
9815	304	HZ 880M B	26/AZ 14-770-10/10	10410	302	HZ 1180M B	12/AZ 13-700	11075	315	HZ 1080M C	14/AZ 26-700
9815	323	HZ 880M B	24/AZ 18-10/10	10420	305	HZ 1180M B	12/AZ 13-700-10/10	11085	332	HZ 880M C	26/AZ 28-750
9835	269	HZ 1080M B	14/AZ 13-700	10420	315	HZ 880M A	26/AZ 18-10/10	11115	337	HZ 880M B	26/AZ 18-10/10
9845	272	HZ 1080M B	14/AZ 13-700-10/10	10430	306	HZ 1080M A	14/AZ 26	11130	326	HZ 1180M C	12/AZ 28-750
9875	268	HZ 1080M C	14/AZ 13-770	10445	325	HZ 1180M A	12/AZ 26-700	11130	345	HZ 1180M A	12/AZ 26
9885	318	HZ 1080M C	12/AZ 26	10490	281	HZ 1080M D	14/AZ 13-770	11145	308	HZ 1180M A	14/AZ 25-800
9885	319	HZ 880M C	24/AZ 28-750	10505	313	HZ 1180M C	12/AZ 25-800	11160	338	HZ 880M C	26/AZ 30-750
9895	295	HZ 880M A	26/AZ 18-700	10515	287	HZ 1080M D	14/AZ 14-770-10/10	11195	299	HZ 1080M D	14/AZ 13-700
9900	275	HZ 1080M C	14/AZ 14-770-10/10	10525	285	HZ 1080M D	14/AZ 20-800	11195	334	HZ 1180M C	12/AZ 30-750
9920	301	HZ 880M B	26/AZ 20-800	10535	285	HZ 1080M C	14/AZ 13-700	11205	302	HZ 1080M D	14/AZ 13-700-10/10
9930	272	HZ 1080M C	14/AZ 20-800	10545	289	HZ 1080M C	14/AZ 13-700-10/10	11220	318	HZ 1180M C	12/AZ 18-700
9940	301	HZ 880M A	26/AZ 20-700	10545	320	HZ 880M C	26/AZ 25-800	11240	344	HZ 880M C	26/AZ 32-750
9950	295	HZ 1180M A	12/AZ 13-700	10545	350	HZ 880M C	24/AZ 26	11260	325	HZ 1180M C	12/AZ 20-700
9950	304	HZ 880M B	26/AZ 20-800-10/10	10550	288	HZ 1080M D	14/AZ 20-800-10/10	11260	342	HZ 1180M C	12/AZ 32-750
9955	276	HZ 1080M C	14/AZ 20-800-10/10	10550	316	HZ 880M B	26/AZ 18-700	11300	297	HZ 1180M B	14/AZ 13-770
9955	326	HZ 880M C	24/AZ 30-750	10570	314	HZ 1180M B	12/AZ 28-750	11305	300	HZ 1180M B	14/AZ 20-800
9960	298	HZ 1180M A	12/AZ 13-700-10/10	10595	322	HZ 880M B	26/AZ 20-700	11305	347	HZ 880M C	26/AZ 26-700
9960	314	HZ 1080M D	12/AZ 26-700	10610	333	HZ 1080M D	12/AZ 26	11325	304	HZ 1180M B	14/AZ 14-770-10/10
9970	300	HZ 1180M B	12/AZ 25-800	10625	305	HZ 1180M B	12/AZ 18-700	11330	304	HZ 1180M B	14/AZ 20-800-10/10
10030	332	HZ 880M C	24/AZ 32-750	10635	321	HZ 1180M B	12/AZ 30-750	11365	311	HZ 1080M D	14/AZ 28-750
10040	303	HZ 880M A	26/AZ 28-750	10665	312	HZ 1180M B	12/AZ 20-700	11380	330	HZ 1180M B	12/AZ 18-10/10
10065	334	HZ 880M C	24/AZ 26-700	10665	323	HZ 880M B	26/AZ 28-750	11390	354	HZ 880M B	26/AZ 26
10070	271	HZ 1080M B	14/AZ 18-700	10695	333	HZ 880M A	26/AZ 26	11430	302	HZ 1080M D	14/AZ 18-700
10075	340	HZ 880M B	24/AZ 26	10700	329	HZ 1180M B	12/AZ 32-750	11440	319	HZ 1080M D	14/AZ 30-750
10085	282	HZ 1080M B	14/AZ 28-750	10725	298	HZ 1080M D	14/AZ 25-800	11470	309	HZ 1080M D	14/AZ 20-700
10115	278	HZ 1080M B	14/AZ 20-700	10740	323	HZ 880M C	26/AZ 13-700	11495	345	HZ 1180M C	12/AZ 26-700
10115	309	HZ 880M A	26/AZ 30-750	10740	329	HZ 880M B	26/AZ 30-750	11505	314	HZ 1180M B	14/AZ 25-800
10135	285	HZ 1080M C	14/AZ 25-800	10745	298	HZ 1080M C	14/AZ 28-750	11510	326	HZ 1080M D	14/AZ 32-750
10135	307	HZ 1180M A	12/AZ 28-750	10755	326	HZ 880M C	26/AZ 13-700-10/10	11530	312	HZ 1080M C	14/AZ 18-10/10
10140	312	HZ 880M B	26/AZ 25-800	10770	288	HZ 1080M C	14/AZ 18-700	11560	326	HZ 1180M D	12/AZ 13-700
10155	290	HZ 1080M B	14/AZ 30-750	10775	294	HZ 1080M B	14/AZ 18-10/10	11570	330	HZ 1180M D	12/AZ 13-700-10/10
10160	284	HZ 1080M A	14/AZ 18-10/10	10815	295	HZ 1080M C	14/AZ 20-700	11580	347	HZ 880M C	26/AZ 18-10/10
10170	298	HZ 1180M A	12/AZ 18-700	10820	306	HZ 1080M C	14/AZ 30-750	11600	314	HZ 1080M A	24/AZ 20-800
10195	316	HZ 880M A	26/AZ 32-750	10820	335	HZ 880M B	26/AZ 32-750	11605	312	HZ 1080M A	24/AZ 13-770
10200	315	HZ 1180M A	12/AZ 30-750	10825	306	HZ 1180M D	12/AZ 13-770	11620	317	HZ 1080M A	24/AZ 20-800-10/10
10205	307	HZ 880M C	26/AZ 13-770	10830	309	HZ 1180M D	12/AZ 20-800	11625	317	HZ 1080M A	24/AZ 14-770-10/10
10210	305	HZ 1180M A	12/AZ 20-700	10850	313	HZ 1180M D	12/AZ 14-770-10/10	11625	352	HZ 1180M B	12/AZ 26
10210	317	HZ 880M A	26/AZ 26-700	10850	313	HZ 1180M D	12/AZ 20-800-10/10	11660	310	HZ 1180M A	14/AZ 13-700

W_{ely}^*	$G_{100\%}$	Section	Combination	W_{ely}^*	$G_{100\%}$	Section	Combination	W_{ely}^*	$G_{100\%}$	Section	Combination
cm ³ /m	kg/m ²			cm ³ /m	kg/m ²			cm ³ /m	kg/m ²		
11665	337	HZ 1180M D	12/AZ 28-750	12660	338	HZ 1180M D	14/AZ 25-800	14010	350	HZ 1080M A	26/AZ 20-700
11670	313	HZ 1180M A	14/AZ 13-700-10/10	12740	338	HZ 1180M A	14/AZ 18-10/10	14060	351	HZ 1080M B	26/AZ 25-800
11725	329	HZ 1080M D	14/AZ 26-700	12865	378	HZ 1180M D	12/AZ 26	14090	365	HZ 1180M C	14/AZ 18-10/10
11730	344	HZ 1180M D	12/AZ 30-750	12915	334	HZ 1180M C	14/AZ 13-700	14110	368	HZ 1080M B	24/AZ 18-10/10
11760	325	HZ 1080M A	24/AZ 25-800	12925	337	HZ 1180M C	14/AZ 13-700-10/10	14220	366	HZ 1080M A	26/AZ 26-700
11780	329	HZ 1180M D	12/AZ 18-700	12985	344	HZ 1180M C	14/AZ 28-750	14310	377	HZ 1080M C	24/AZ 28-750
11795	334	HZ 1080M C	14/AZ 26	13000	361	HZ 1180M A	14/AZ 26	14315	370	HZ 1080M C	24/AZ 13-700
11795	352	HZ 1180M D	12/AZ 32-750	13035	327	HZ 1080M A	26/AZ 20-800	14315	386	HZ 1080M B	24/AZ 26
11805	321	HZ 1180M A	14/AZ 28-750	13055	352	HZ 1180M C	14/AZ 30-750	14320	373	HZ 1080M C	24/AZ 13-700-10/10
11820	336	HZ 1180M D	12/AZ 20-700	13060	324	HZ 1080M A	26/AZ 13-770	14345	387	HZ 1180M C	14/AZ 26
11855	364	HZ 880M C	26/AZ 26	13060	330	HZ 1080M A	26/AZ 20-800-10/10	14365	383	HZ 1080M C	24/AZ 30-750
11875	329	HZ 1180M A	14/AZ 30-750	13085	330	HZ 1080M A	26/AZ 14-770-10/10	14420	390	HZ 1080M C	24/AZ 32-750
11895	313	HZ 1180M A	14/AZ 18-700	13125	360	HZ 1180M C	14/AZ 32-750	14495	372	HZ 1080M C	24/AZ 18-700
11935	320	HZ 1180M A	14/AZ 20-700	13130	352	HZ 1080M A	24/AZ 18-10/10	14505	373	HZ 1080M D	24/AZ 20-800
11945	337	HZ 1180M A	14/AZ 32-750	13145	337	HZ 1180M C	14/AZ 18-700	14525	376	HZ 1080M D	24/AZ 20-800-10/10
12015	344	HZ 1180M C	12/AZ 18-10/10	13165	343	HZ 1080M B	24/AZ 13-700	14530	378	HZ 1080M C	24/AZ 20-700
12055	356	HZ 1180M D	12/AZ 26-700	13175	346	HZ 1180M B	14/AZ 18-10/10	14550	375	HZ 1180M D	14/AZ 18-10/10
12065	317	HZ 1180M B	14/AZ 13-700	13175	346	HZ 1080M B	24/AZ 13-700-10/10	14580	372	HZ 1080M D	24/AZ 13-770
12075	316	HZ 1180M C	14/AZ 20-800	13185	344	HZ 1180M C	14/AZ 20-700	14600	378	HZ 1080M D	24/AZ 14-770-10/10
12075	320	HZ 1180M B	14/AZ 13-700-10/10	13205	337	HZ 1080M A	26/AZ 25-800	14665	384	HZ 1080M D	24/AZ 25-800
12090	314	HZ 1180M C	14/AZ 13-770	13205	351	HZ 1080M B	24/AZ 28-750	14705	357	HZ 1080M B	26/AZ 13-700
12100	320	HZ 1180M C	14/AZ 20-800-10/10	13265	358	HZ 1080M B	24/AZ 30-750	14715	359	HZ 1080M B	26/AZ 13-700-10/10
12115	320	HZ 1180M C	14/AZ 14-770-10/10	13320	364	HZ 1080M B	24/AZ 32-750	14715	364	HZ 1080M B	26/AZ 28-750
12185	327	HZ 1180M B	14/AZ 28-750	13330	370	HZ 1080M A	24/AZ 26	14725	394	HZ 1080M C	24/AZ 26-700
12190	340	HZ 1180M A	14/AZ 26-700	13345	344	HZ 1180M D	14/AZ 13-700	14775	366	HZ 1080M A	26/AZ 18-10/10
12240	327	HZ 1080M D	14/AZ 18-10/10	13345	345	HZ 1080M B	24/AZ 18-700	14775	370	HZ 1080M B	26/AZ 30-750
12240	329	HZ 1080M A	24/AZ 13-700	13355	347	HZ 1180M D	14/AZ 13-700-10/10	14805	397	HZ 1180M D	14/AZ 26
12250	331	HZ 1080M A	24/AZ 13-700-10/10	13380	351	HZ 1080M B	24/AZ 20-700	14830	377	HZ 1080M B	26/AZ 32-750
12255	335	HZ 1180M B	14/AZ 30-750	13390	353	HZ 1180M D	14/AZ 28-750	14900	359	HZ 1080M B	26/AZ 18-700
12260	367	HZ 1180M C	12/AZ 26	13435	364	HZ 1180M C	14/AZ 26-700	14930	365	HZ 1080M C	26/AZ 20-800
12270	330	HZ 1180M C	14/AZ 25-800	13435	368	HZ 1180M B	14/AZ 26	14935	365	HZ 1080M B	26/AZ 20-700
12295	319	HZ 1180M B	14/AZ 18-700	13460	361	HZ 1180M D	14/AZ 30-750	14950	368	HZ 1080M C	26/AZ 20-800-10/10
12320	337	HZ 1080M A	24/AZ 28-750	13510	353	HZ 1080M C	24/AZ 20-800	14985	384	HZ 1080M A	26/AZ 26
12325	343	HZ 1180M B	14/AZ 32-750	13530	369	HZ 1180M D	14/AZ 32-750	15005	364	HZ 1080M C	26/AZ 13-770
12340	326	HZ 1180M B	14/AZ 20-700	13535	356	HZ 1080M C	24/AZ 20-800-10/10	15025	369	HZ 1080M C	26/AZ 14-770-10/10
12375	343	HZ 1080M A	24/AZ 30-750	13565	352	HZ 1080M C	24/AZ 13-770	15095	376	HZ 1080M C	26/AZ 25-800
12425	331	HZ 1080M A	24/AZ 18-700	13570	347	HZ 1180M D	14/AZ 18-700	15140	381	HZ 1080M B	26/AZ 26-700
12435	350	HZ 1080M A	24/AZ 32-750	13580	368	HZ 1080M B	24/AZ 26-700	15210	389	HZ 1180M A	24/AZ 20-800
12450	328	HZ 1080M B	24/AZ 20-800	13585	357	HZ 1080M C	24/AZ 14-770-10/10	15230	392	HZ 1180M A	24/AZ 20-800-10/10
12455	336	HZ 1080M A	24/AZ 20-700	13615	354	HZ 1180M D	14/AZ 20-700	15305	389	HZ 1180M A	24/AZ 13-770
12460	325	HZ 1180M D	14/AZ 20-800	13670	364	HZ 1080M C	24/AZ 25-800	15325	394	HZ 1180M A	24/AZ 14-770-10/10
12470	331	HZ 1080M B	24/AZ 20-800-10/10	13780	342	HZ 1080M A	26/AZ 13-700	15330	397	HZ 1080M C	24/AZ 18-10/10
12475	326	HZ 1080M B	24/AZ 13-770	13790	344	HZ 1080M A	26/AZ 13-700-10/10	15340	398	HZ 1080M D	24/AZ 28-750
12485	329	HZ 1180M D	14/AZ 20-800-10/10	13830	350	HZ 1080M A	26/AZ 28-750	15370	400	HZ 1180M A	24/AZ 25-800
12490	323	HZ 1180M D	14/AZ 13-770	13860	374	HZ 1180M D	14/AZ 26-700	15390	392	HZ 1080M D	24/AZ 13-700
12500	331	HZ 1080M B	24/AZ 14-770-10/10	13890	340	HZ 1080M B	26/AZ 20-800	15395	395	HZ 1080M D	24/AZ 13-700-10/10
12505	349	HZ 1080M D	14/AZ 26	13890	356	HZ 1080M A	26/AZ 30-750	15395	404	HZ 1080M D	24/AZ 30-750
12515	329	HZ 1180M D	14/AZ 14-770-10/10	13910	343	HZ 1080M B	26/AZ 20-800-10/10	15450	411	HZ 1080M D	24/AZ 32-750
12590	346	HZ 1180M B	14/AZ 26-700	13935	339	HZ 1080M B	26/AZ 13-770	15530	414	HZ 1080M C	24/AZ 26
12610	339	HZ 1080M B	24/AZ 25-800	13950	362	HZ 1080M A	26/AZ 32-750	15570	394	HZ 1080M D	24/AZ 18-700
12620	356	HZ 1180M D	12/AZ 18-10/10	13960	344	HZ 1080M B	26/AZ 14-770-10/10	15605	400	HZ 1080M D	24/AZ 20-700
12655	353	HZ 1080M A	24/AZ 26-700	13975	344	HZ 1080M A	26/AZ 18-700	15755	382	HZ 1080M B	26/AZ 18-10/10

$W_{el,y}^*$	$G_{100\%}$	Section	Combination	$W_{el,y}^*$	$G_{100\%}$	Section	Combination	$W_{el,y}^*$	$G_{100\%}$	Section	Combination
cm ³ /m	kg/m ²			cm ³ /m	kg/m ²			cm ³ /m	kg/m ²		
15795	390	HZ 1080M C	26/AZ 28-750	17020	428	HZ 1180M B	24/AZ 20-700	18615	442	HZ 1180M C	26/AZ 14-770-10/10
15800	416	HZ 1080M D	24/AZ 26-700	17085	408	HZ 1080M D	26/AZ 18-700	18630	459	HZ 1180M D	24/AZ 13-700
15815	399	HZ 1180M B	24/AZ 20-800	17120	413	HZ 1080M D	26/AZ 20-700	18635	462	HZ 1180M D	24/AZ 13-700-10/10
15835	384	HZ 1080M C	26/AZ 13-700	17160	428	HZ 1080M C	26/AZ 26	18725	457	HZ 1180M B	26/AZ 26-700
15835	402	HZ 1180M B	24/AZ 20-800-10/10	17200	411	HZ 1180M B	26/AZ 20-800	18805	461	HZ 1180M D	24/AZ 18-700
15845	386	HZ 1080M C	26/AZ 13-700-10/10	17215	444	HZ 1180M B	24/AZ 26-700	18840	467	HZ 1180M D	24/AZ 20-700
15855	396	HZ 1080M C	26/AZ 30-750	17225	414	HZ 1180M B	26/AZ 20-800-10/10	18875	452	HZ 1180M A	26/AZ 18-10/10
15910	385	HZ 1080M D	26/AZ 20-800	17285	439	HZ 1180M A	24/AZ 18-10/10	19035	483	HZ 1180M D	24/AZ 26-700
15910	402	HZ 1080M C	26/AZ 32-750	17325	430	HZ 1080M D	26/AZ 26-700	19065	450	HZ 1180M D	26/AZ 20-800
15920	399	HZ 1180M B	24/AZ 13-770	17335	411	HZ 1180M B	26/AZ 13-770	19080	470	HZ 1180M A	26/AZ 26
15930	388	HZ 1080M D	26/AZ 20-800-10/10	17355	417	HZ 1180M B	26/AZ 14-770-10/10	19085	453	HZ 1180M D	26/AZ 20-800-10/10
15940	404	HZ 1180M B	24/AZ 14-770-10/10	17365	422	HZ 1180M B	26/AZ 25-800	19170	474	HZ 1180M C	24/AZ 18-10/10
15970	400	HZ 1080M B	26/AZ 26	17485	456	HZ 1180M A	24/AZ 26	19225	461	HZ 1180M D	26/AZ 25-800
15970	410	HZ 1180M B	24/AZ 25-800	17495	435	HZ 1180M D	24/AZ 20-800	19240	451	HZ 1180M D	26/AZ 13-770
16005	385	HZ 1080M D	26/AZ 13-770	17515	438	HZ 1180M D	24/AZ 20-800-10/10	19260	456	HZ 1180M D	26/AZ 14-770-10/10
16025	386	HZ 1080M C	26/AZ 18-700	17530	427	HZ 1180M A	26/AZ 28-750	19365	492	HZ 1180M C	24/AZ 26
16030	390	HZ 1080M D	26/AZ 14-770-10/10	17585	434	HZ 1180M A	26/AZ 30-750	19425	463	HZ 1180M C	26/AZ 28-750
16060	391	HZ 1080M C	26/AZ 20-700	17640	440	HZ 1180M A	26/AZ 32-750	19480	469	HZ 1180M C	26/AZ 30-750
16075	396	HZ 1080M D	26/AZ 25-800	17645	435	HZ 1180M D	24/AZ 13-770	19540	476	HZ 1180M C	26/AZ 32-750
16075	415	HZ 1180M A	24/AZ 28-750	17650	423	HZ 1180M A	26/AZ 13-700	19565	464	HZ 1180M B	26/AZ 18-10/10
16130	421	HZ 1180M A	24/AZ 30-750	17650	446	HZ 1180M D	24/AZ 25-800	19630	460	HZ 1180M C	26/AZ 13-700
16155	410	HZ 1180M A	24/AZ 13-700	17660	426	HZ 1180M A	26/AZ 13-700-10/10	19640	462	HZ 1180M C	26/AZ 13-700-10/10
16165	412	HZ 1180M A	24/AZ 13-700-10/10	17665	441	HZ 1180M D	24/AZ 14-770-10/10	19775	481	HZ 1180M B	26/AZ 26
16185	428	HZ 1180M A	24/AZ 32-750	17775	447	HZ 1180M C	24/AZ 28-750	19815	462	HZ 1180M C	26/AZ 18-700
16265	408	HZ 1080M C	26/AZ 26-700	17830	453	HZ 1180M C	24/AZ 30-750	19850	468	HZ 1180M C	26/AZ 20-700
16335	412	HZ 1180M A	24/AZ 18-700	17835	425	HZ 1180M A	26/AZ 18-700	19905	491	HZ 1180M D	24/AZ 18-10/10
16370	418	HZ 1180M A	24/AZ 20-700	17870	431	HZ 1180M A	26/AZ 20-700	20050	484	HZ 1180M C	26/AZ 26-700
16470	420	HZ 1080M D	24/AZ 18-10/10	17885	460	HZ 1180M C	24/AZ 32-750	20080	478	HZ 1180M D	26/AZ 28-750
16565	434	HZ 1180M A	24/AZ 26-700	17935	443	HZ 1180M C	24/AZ 13-700	20100	508	HZ 1180M D	24/AZ 26
16600	402	HZ 1180M A	26/AZ 20-800	17940	446	HZ 1180M C	24/AZ 13-700-10/10	20135	484	HZ 1180M D	26/AZ 30-750
16625	405	HZ 1180M A	26/AZ 20-800-10/10	17975	450	HZ 1180M B	24/AZ 18-10/10	20195	491	HZ 1180M D	26/AZ 32-750
16670	438	HZ 1080M D	24/AZ 26	18075	447	HZ 1180M A	26/AZ 26-700	20320	475	HZ 1180M D	26/AZ 13-700
16700	425	HZ 1180M B	24/AZ 28-750	18080	434	HZ 1080M D	26/AZ 18-10/10	20325	478	HZ 1180M D	26/AZ 13-700-10/10
16720	401	HZ 1180M A	26/AZ 13-770	18110	445	HZ 1180M C	24/AZ 18-700	20500	477	HZ 1180M D	26/AZ 18-700
16740	407	HZ 1180M A	26/AZ 14-770-10/10	18145	451	HZ 1180M C	24/AZ 20-700	20535	483	HZ 1180M D	26/AZ 20-700
16755	431	HZ 1180M B	24/AZ 30-750	18150	438	HZ 1180M B	26/AZ 28-750	20735	499	HZ 1180M D	26/AZ 26-700
16765	412	HZ 1180M A	26/AZ 25-800	18175	467	HZ 1180M B	24/AZ 26	20975	492	HZ 1180M C	26/AZ 18-10/10
16810	411	HZ 1080M D	26/AZ 28-750	18210	444	HZ 1180M B	26/AZ 30-750	21180	509	HZ 1180M C	26/AZ 26
16810	420	HZ 1180M B	24/AZ 13-700	18265	450	HZ 1180M B	26/AZ 32-750	21705	508	HZ 1180M D	26/AZ 18-10/10
16810	438	HZ 1180M B	24/AZ 32-750	18285	452	HZ 1080M D	26/AZ 26	21905	526	HZ 1180M D	26/AZ 26
16815	423	HZ 1180M B	24/AZ 13-700-10/10	18300	433	HZ 1180M B	26/AZ 13-700				
16850	421	HZ 1180M C	24/AZ 20-800	18310	436	HZ 1180M B	26/AZ 13-700-10/10				
16865	417	HZ 1080M D	26/AZ 30-750	18340	467	HZ 1180M C	24/AZ 26-700				
16870	424	HZ 1180M C	24/AZ 20-800-10/10	18430	436	HZ 1180M C	26/AZ 20-800				
16895	405	HZ 1080M D	26/AZ 13-700	18440	462	HZ 1180M D	24/AZ 28-750				
16905	408	HZ 1080M D	26/AZ 13-700-10/10	18450	439	HZ 1180M C	26/AZ 20-800-10/10				
16925	423	HZ 1080M D	26/AZ 32-750	18490	435	HZ 1180M B	26/AZ 18-700				
16950	411	HZ 1080M C	26/AZ 18-10/10	18495	468	HZ 1180M D	24/AZ 30-750				
16985	421	HZ 1180M C	24/AZ 13-770	18520	441	HZ 1180M B	26/AZ 20-700				
16990	422	HZ 1180M B	24/AZ 18-700	18550	475	HZ 1180M D	24/AZ 32-750				
17005	426	HZ 1180M C	24/AZ 14-770-10/10	18590	446	HZ 1180M C	26/AZ 25-800				
17010	431	HZ 1180M C	24/AZ 25-800	18595	436	HZ 1180M C	26/AZ 13-770				





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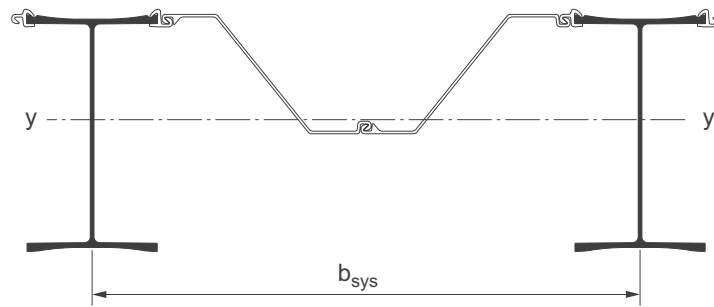
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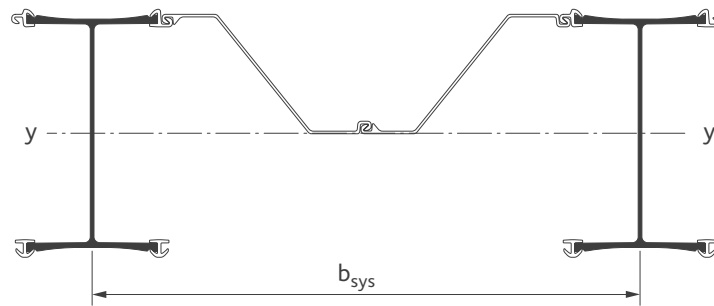
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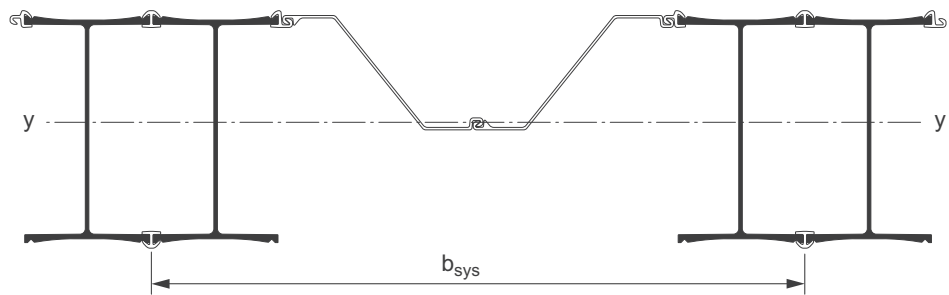
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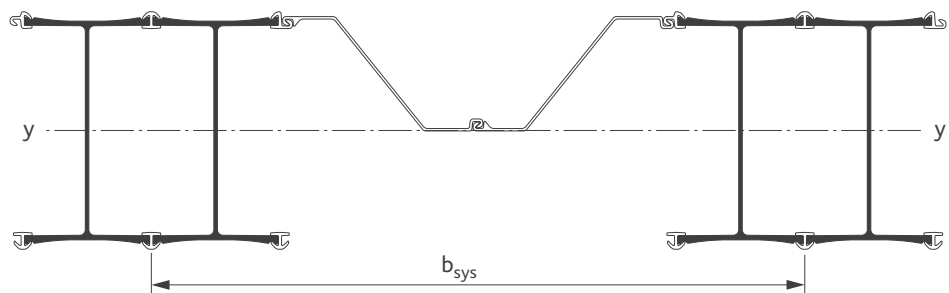
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