ArcelorMittal Sheet Piling

ArcelorMittal

The HZ®-M Steel Wall System

New standard
EN 10248 - Part 1 & 2

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Port of Poole, UK

Contents

Introduction 2

Characteristics 4

- Definition of the HZ®-M Steel Wall System 4
- HZ-M - King Piles 4
- AZ - Intermediary piles 10
- Connectors 10
- Delivery conditions 11
- Standard welding configurations 11
- Characteristics of combinations (global safety approach) 12
- Characteristics of combinations (EN 1993-5 approach) 20
- Characteristics of combinations C 1 and C 23 28

Designing an HZ-M Steel Wall System 30

- Steel stress verification (global safety approach) 30
- Steel stress verification (EN 1993-5 approach) 31
- Practical aspects 32
- Durability 33
- Resistance to water pressure 34
- Cross-sectional classification of HZ-M (EN 1993) 37
- Conventions and symbols 39

Construction of HZ-M combined walls 40

- Installation procedure 40
- HZ-M specific tie-back solution 47

References 48

Annex 1: Design example according to EN 1993-5 49

Annex 2: HZ-M | Static moment & Plastic section modulus 57

Annex 3: Combinations sorted by ascending elastic section modulus 58

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.

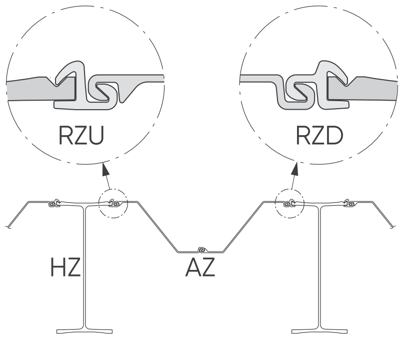
The main advantage of HZ-M king piles is the concave geometry of the flanges of the lighter sections, and the unmatched flange thickness of the heavier king pile sections with up to 40 mm.

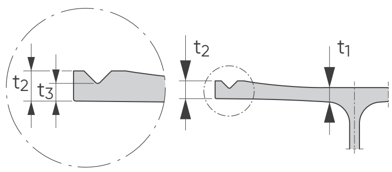
To thread the RH/RZ connectors, a groove is milled into the flange. The milling equipment was designed to guarantee very tight tolerances of the groove, which improves interlocking of the connection and ensures sufficient residual steel thickness t_3. The groove is milled if required; flanges without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

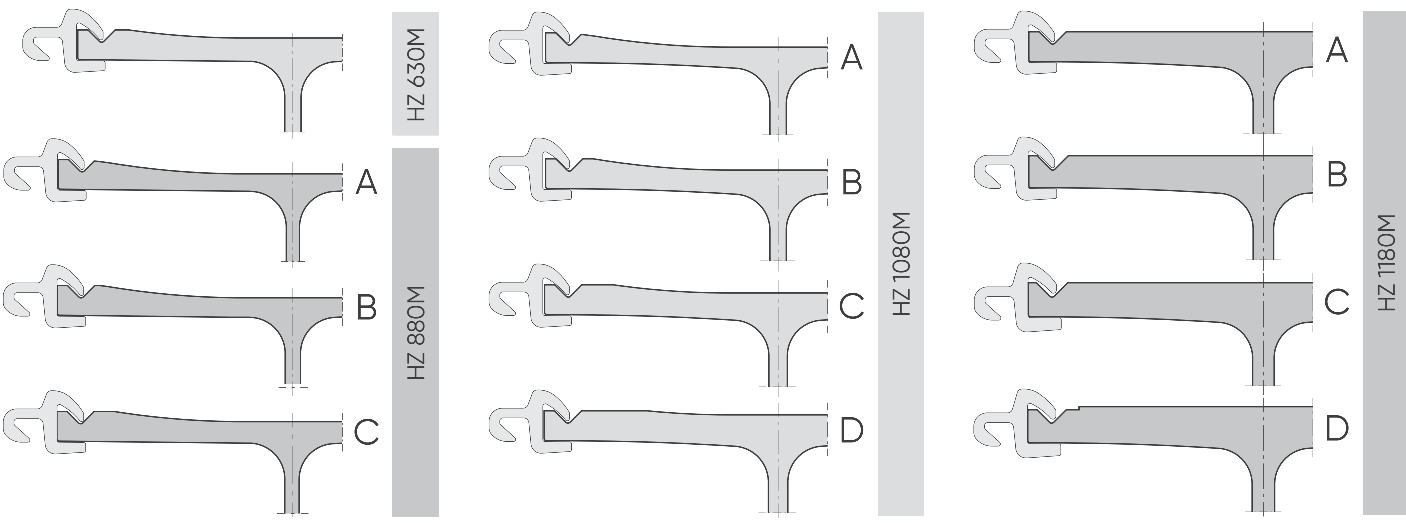
The connectors are threaded over the mill grooves of the HZ-M pile and partially welded, thus increasing the stiffness and the section modulus of the whole wall. Unlike other combined wall system, the geometry of the connectors ensures a "mechanical connection" between the two elements of the HZ/AZ system 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).





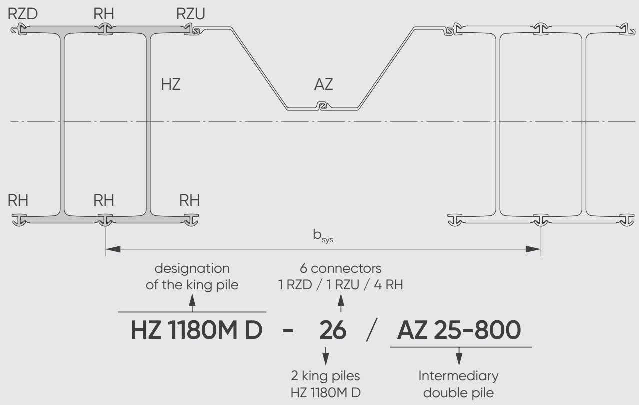


Characteristics

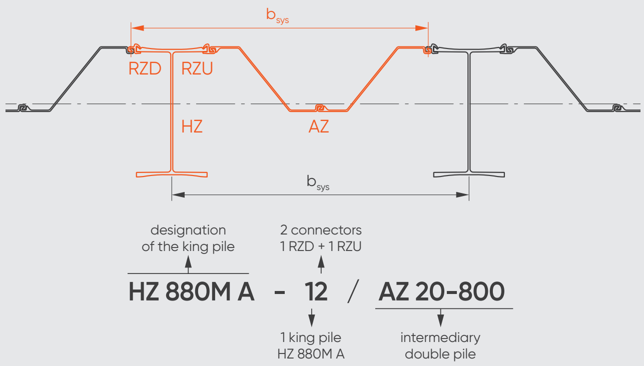
Definition of the HZ®-M Steel Wall System

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:



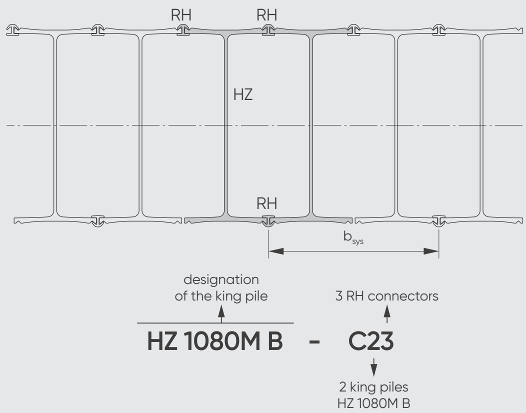
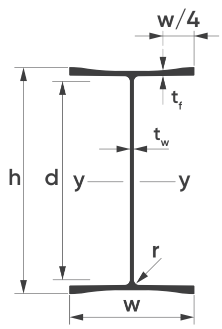
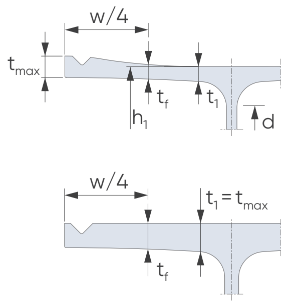


Fig.1. HZ/AZ steel wall system: definitions and designations.

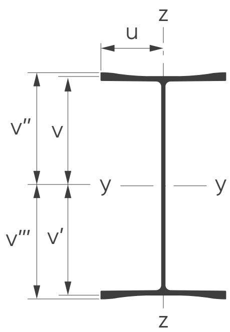
HZ®-M - King piles





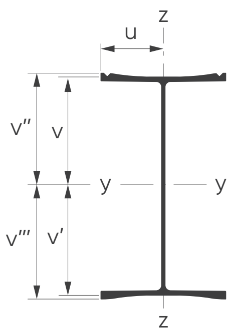
Section	h	h_1	d	w	t_1	t_{max}	t_f	t_w	r	A_v	Suitable connectors	
	mm	mm	mm	mm	mm	mm	mm	mm	mm	cm²		
HZ 630M	631.4	615.7	510.1	420	22.7	29.0	24.2	16.0	30	116.1	RZD/RZU 16	RH 16
HZ 880M A	831.3	803.4	709.6	458	16.9	29.0	18.9	13.0	30	120.0	RZD/RZU 16	RH 16
HZ 880M B	831.3	807.4	709.6	460	18.9	29.0	20.9	15.0	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



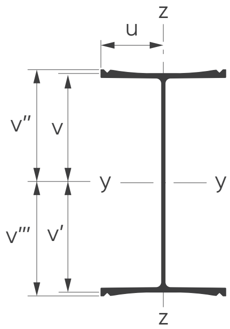
Section	Dimensions					Properties per solution										
	v	v'	v''	v'''	u	A	G	I_y	I_z	I_t	I_ω	$W_{el,y}$ *	$W_{el,y}$ **	$W_{el,z}$	A_{LW}	A_{LS}
	mm	mm	mm	mm	mm	cm²	kg/m	cm⁴	cm⁴	cm⁴	10³cm⁶	cm³	cm³	cm³	m²/m	m²/m
HZ 630M	307.9	307.9	315.7	315.7	210.0	312.0	**244.9**	220860	34220	598.3	29450	**7175**	-	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



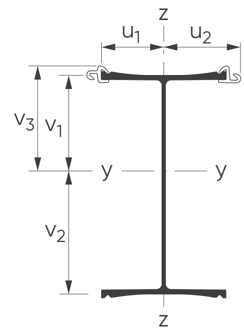
Section	Dimensions					Properties per solution										
	v	v'	v''	v'''	u	A	G	I_y	I_z	I_t	I_ω	$W_{el,y}$ *	$W_{el,y}$ **	$W_{el,z}$	A_{LW}	A_{LS}
	mm	mm	mm	mm	mm	cm²	kg/m	cm⁴	cm⁴	cm⁴	10³cm⁶	cm³	cm³	cm³	m²/m	m²/m
HZ 630M	311.4	304.4	319.2	312.2	210.0	308.6	**242.2**	217460	33010	569.2	28410	**6985**	-	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



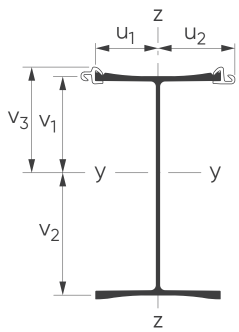
Section	Dimensions					Properties per solution										
	v	v'	v''	v'''	u	A	G	I_y	I_z	I_t	I_ω	$W_{el,y}$ *	$W_{el,y}$ **	$W_{el,z}$	A_{LW}	A_{LS}
	mm	mm	mm	mm	mm	cm²	kg/m	cm⁴	cm⁴	cm⁴	10³cm⁶	cm³	cm³	cm³	m²/m	m²/m
HZ 630M	307.9	307.9	315.7	315.7	210.0	305.1	**239.5**	214130	31800	543.5	27440	**6955**	-	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



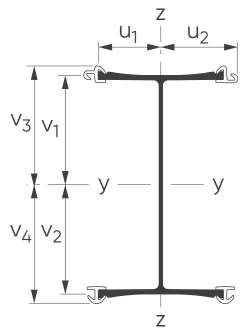
Section	Dimensions					Properties per solution										
	v_1	v_2	v_3	u_1	u_2	A	G	I_y	I_z	I_t	I_ω	$W_{el,y}$ *	$W_{el,y}$ **	$W_{el,z}$	A_{LW}	A_{LS}
	mm	mm	mm	mm	mm	cm²	kg/m	cm⁴	cm⁴	cm⁴	10³cm⁶	cm³	cm³	cm³	m²/m	m²/m
HZ 630M	272.1	343.6	300.3	209.9	263.9	346.2	**271.8**	247130	52190	702.2	38320	**7190**	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



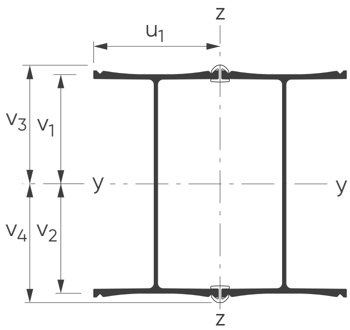
Section	Dimensions					Properties per solution										
	v_1	v_2	v_3	u_1	u_2	A	G	I_y	I_z	I_t	I_ω	$W_{el,y}$ *	$W_{el,y}$ **	$W_{el,z}$	A_{LW}	A_{LS}
	mm	mm	mm	mm	mm	cm^2	kg/m	cm^4	cm^4	cm^4	10^3cm^6	cm^3	cm^3	cm^3	m^2/m	m^2/m
HZ 630M	275.5	340.2	303.8	209.9	263.9	349.7	**274.5**	251260	53400	725.6	40250	**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



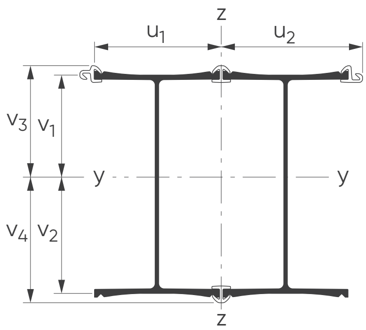
Section	Dimensions						Properties per solution										
	v_1	v_2	v_3	v_4	u_1	u_2	A	G	I_y	I_z	I_t	I_ω	$W_{el,y}$ *	$W_{el,y}$ **	$W_{el,z}$	A_{LW}	A_{LS}
	mm	mm	mm	mm	mm	mm	cm^2	kg/m	cm^4	cm^4	cm^4	10^3cm^6	cm^3	cm^3	cm^3	m^2/m	m^2/m
HZ 630M	307.5	308.3	335.7	336.6	209.9	263.9	386.5	**303.4**	288850	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



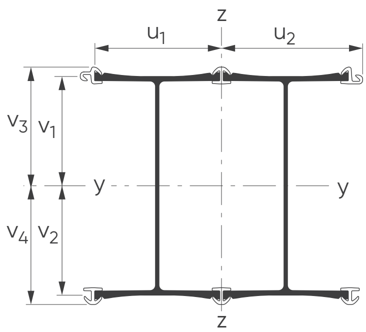
Section	Dimensions					Properties per solution										
	v_1	v_2	v_3	v_4	u_1	A	G	I_y	I_z	I_t	I_ω	$W_{el,y}$ *	$W_{el,y}$ **	$W_{el,z}$	A_{LW}	A_{LS}
	mm	mm	mm	mm	mm	cm²	kg/m	cm⁴	cm⁴	cm⁴	10³cm⁶	cm³	cm³	cm³	m²/m	m²/m
HZ 630M	307.9	307.9	336.2	336.2	427.0	650.4	**510.6**	465570	351040	238756	70260	**15125**	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	cm²	kg/m	cm⁴	cm⁴	cm⁴	10³cm⁶	cm³	cm³	cm³	m²/m	m²/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

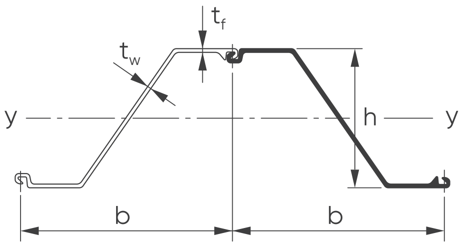


Section	Dimensions						Properties per solution										
	v_1	v_2	v_3	v_4	u_1	u_2	A	G	I_y	I_z	I_t	I_ω	$W_{el,y}$ *	$W_{el,y}$ **	$W_{el,z}$	A_{LW}	A_{LS}
	mm	mm	mm	mm	mm	mm	cm^2	kg/m	cm^4	cm^4	cm^4	10^3cm^6	cm^3	cm^3	cm^3	m^2/m	m^2/m
HZ 630M	307.6	308.1	336.0	336.4	426.9	480.9	731.8	**574.5**	540280	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.

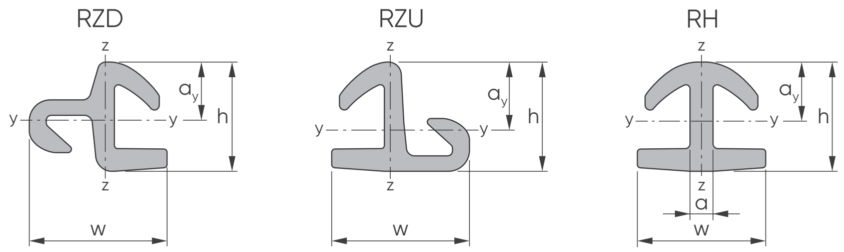
Combined wall, combination 24

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 mm: + 2.5 mm / - 1.5 mm	t_f, t_w ≤ 8.5 mm: ± 0.5 mm t_f,t_w > 8.5 mm: ± 6 %
Height (h)	h > 500 mm: ± 7 mm	h ≥ 300 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
Misalignement 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 length[3]

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

[3] Longer sections may be supplied. Please contact us.

Section \ Steel grade	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
	EN 10248-1:2023								ASTM	
HZ	✓[4]	✓	✓	✓	✓	✓	✓	❖	✓	✓
AZ	✓[4]	✓	✓	✓	✓	✓	✓	❖	✓	✓[4]
RH / RZD / RZU	×	×	×	×	×	❖	✓	❖	×	✓

[4] Please contact us as some limitations may apply.

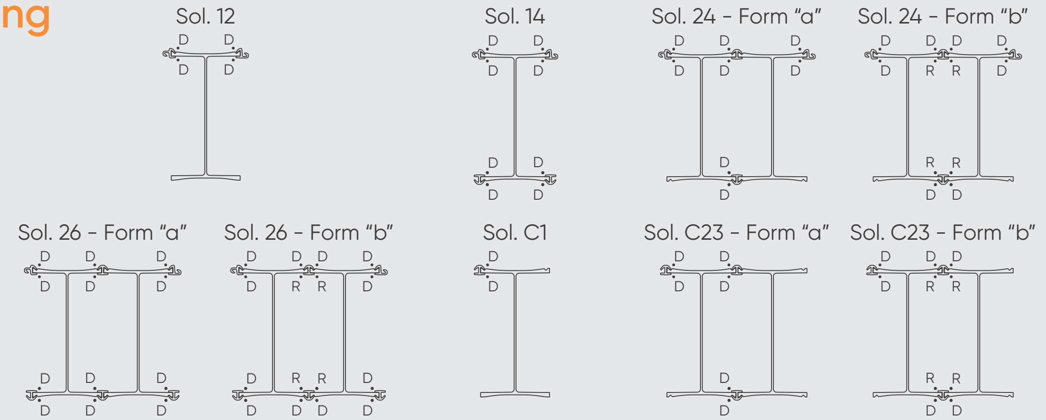
✓ Available
❖ On request
× Currently unavailable

Steel grades

Steel grade EN 10248-1:2023	Min. yield strength R_{eH}	Min. tensile strength R_m	Min. elongation $L_0 = 5.65\ \sqrt{S_0}$	Minimum impact energy KV_2 Testing temperature	Minimum impact energy KV_2 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 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 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	$W_{el,y}$ *	$W_{el,y}$ **	$G_{60\%}$	$G_{80\%}$	$G_{100\%}$	A_{LW}	A_{LS}	b_{sys}
	cm²/m	cm⁴/m	cm³/m	cm³/m	kg/m²	kg/m²	kg/m²	m²/m	m²/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.

Characteristics of combinations according to the global safety design approach

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

Section	Properties per meter of wall[1]							Per system		
	A	I_y	$W_{el,y}$ *	$W_{el,y}$ **	$G_{60\%}$	$G_{80\%}$	$G_{100\%}$	A_{LW}	A_{LS}	b_{sys}
	cm²/m	cm⁴/m	cm³/m	cm³/m	kg/m²	kg/m²	kg/m²	m²/m	m²/m	m
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

Section	Properties per meter of wall[1]							Per system		
	A	I_y	$W_{el,y}$ *	$W_{el,y}$ **	$G_{60\%}$	$G_{80\%}$	$G_{100\%}$	A_{LW}	A_{LS}	b_{sys}
	cm²/m	cm⁴/m	cm³/m	cm³/m	kg/m²	kg/m²	kg/m²	m²/m	m²/m	m
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

Section	Properties per meter of wall[1]							Per system		
	A	I_y	$W_{el,y}$ *	$W_{el,y}$ **	$G_{60\%}$	$G_{80\%}$	$G_{100\%}$	A_{LW}	A_{LS}	b_{sys}
	cm²/m	cm⁴/m	cm³/m	cm³/m	kg/m²	kg/m²	kg/m²	m²/m	m²/m	m
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

Section	Properties per meter of wall[1]							Per system		
	A	I_y	$W_{el,y}$ *	$W_{el,y}$ **	$G_{60\%}$	$G_{80\%}$	$G_{100\%}$	A_{LW}	A_{LS}	b_{sys}
	cm²/m	cm⁴/m	cm³/m	cm³/m	kg/m²	kg/m²	kg/m²	m²/m	m²/m	m
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	$W_{el,y}$ *	$W_{el,y}$ **	$G_{60\%}$	$G_{80\%}$	$G_{100\%}$	A_{LW}	A_{LS}	b_{sys}
	cm²/m	cm⁴/m	cm³/m	cm³/m	kg/m²	kg/m²	kg/m²	m²/m	m²/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.

Characteristics of combinations according to the global safety design approach

Section	Properties per meter of wall[1]							Per system		
	A	I_y	$W_{el,y}$ *	$W_{el,y}$ **	$G_{60\%}$	$G_{80\%}$	$G_{100\%}$	A_{LW}	A_{LS}	b_{sys}
	cm²/m	cm⁴/m	cm³/m	cm³/m	kg/m²	kg/m²	kg/m²	m²/m	m²/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	$W_{el,y}$ *	$W_{el,y}$ **	$G_{60\%}$	$G_{80\%}$	$G_{100\%}$	A_{LW}	A_{LS}	b_{sys}
	cm²/m	cm⁴/m	cm³/m	cm³/m	kg/m²	kg/m²	kg/m²	m²/m	m²/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.

Characteristics of combinations according to the global safety design approach

Section	Properties per meter of wall[1]							Per system		
	A	I_y	$W_{el,y}$ *	$W_{el,y}$ **	$G_{60\%}$	$G_{80\%}$	$G_{100\%}$	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	$W_{el,y}$ *	$W_{el,y}$ **	$G_{60\%}$	$G_{80\%}$	$G_{100\%}$	A_{LW}	A_{LS}	b_{sys}
	cm²/m	cm⁴/m	cm³/m	cm³/m	kg/m²	kg/m²	kg/m²	m²/m	m²/m	m

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

Section	A (cm²/m)	I_y (cm⁴/m)	$W_{el,y}$ * (cm³/m)	$W_{el,y}$ ** (cm³/m)	$G_{60\%}$ (kg/m²)	$G_{80\%}$ (kg/m²)	$G_{100\%}$ (kg/m²)	A_{LW} (m²/m)	A_{LS} (m²/m)	b_{sys} (m)
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

Section	A (cm²/m)	I_y (cm⁴/m)	$W_{el,y}$ * (cm³/m)	$W_{el,y}$ ** (cm³/m)	$G_{60\%}$ (kg/m²)	$G_{80\%}$ (kg/m²)	$G_{100\%}$ (kg/m²)	A_{LW} (m²/m)	A_{LS} (m²/m)	b_{sys} (m)
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

Section	A (cm²/m)	I_y (cm⁴/m)	$W_{el,y}$ * (cm³/m)	$W_{el,y}$ ** (cm³/m)	$G_{60\%}$ (kg/m²)	$G_{80\%}$ (kg/m²)	$G_{100\%}$ (kg/m²)	A_{LW} (m²/m)	A_{LS} (m²/m)	b_{sys} (m)
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

Section	A (cm²/m)	I_y (cm⁴/m)	$W_{el,y}$ * (cm³/m)	$W_{el,y}$ ** (cm³/m)	$G_{60\%}$ (kg/m²)	$G_{80\%}$ (kg/m²)	$G_{100\%}$ (kg/m²)	A_{LW} (m²/m)	A_{LS} (m²/m)	b_{sys} (m)
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.

Characteristics of combinations according to the global safety design approach

Section	Properties per meter of wall[1]							Per system		
	A	I_y	$W_{el,y}$ *	$W_{el,y}$ **	$G_{60\%}$	$G_{80\%}$	$G_{100\%}$	A_{LW}	A_{LS}	b_{sys}
	cm²/m	cm⁴/m	cm³/m	cm³/m	kg/m²	kg/m²	kg/m²	m²/m	m²/m	m

Combination HZ ... M – 12 / AZ 26

Section	A	Iy	Wel,y *	Wel,y **	G60%	G80%	G100%	ALW	ALS	bsys
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

Section	A	Iy	Wel,y *	Wel,y **	G60%	G80%	G100%	ALW	ALS	bsys
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

Section	A	Iy	Wel,y *	Wel,y **	G60%	G80%	G100%	ALW	ALS	bsys
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

Section	A	Iy	Wel,y *	Wel,y **	G60%	G80%	G100%	ALW	ALS	bsys
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	$W_{el,y}$*	$W_{el,y}$**	$G_{60\%}$	$G_{80\%}$	$G_{100\%}$	A_{LW}	A_{LS}	b_{sys}
	cm²/m	cm⁴/m	cm³/m	cm³/m	kg/m²	kg/m²	kg/m²	m²/m	m²/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, $W_{el,y}$* & $W_{el,y}$** 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	$W_{el,y}$*	$W_{el,y}$**	$G_{60\%}$	$G_{80\%}$	$G_{100\%}$	A_{LW}	A_{LS}	b_{sys}
	cm²/m	cm⁴/m	cm³/m	cm³/m	kg/m²	kg/m²	kg/m²	m²/m	m²/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, $W_{el,y}$* & $W_{el,y}$** 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	$W_{el,y}$*	$W_{el,y}$**	$G_{60\%}$	$G_{80\%}$	$G_{100\%}$	A_{LW}	A_{LS}	b_{sys}
	cm²/m	cm⁴/m	cm³/m	cm³/m	kg/m²	kg/m²	kg/m²	m²/m	m²/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, $W_{el,y}$* & $W_{el,y}$** 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	$W_{el,y}$*	$W_{el,y}$**	$G_{60\%}$	$G_{80\%}$	$G_{100\%}$	A_{LW}	A_{LS}	b_{sys}
	cm²/m	cm⁴/m	cm³/m	cm³/m	kg/m²	kg/m²	kg/m²	m²/m	m²/m	m

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

Section	A cm²/m	I_y cm⁴/m	$W_{el,y}$* cm³/m	$W_{el,y}$** cm³/m	$G_{60\%}$ kg/m²	$G_{80\%}$ kg/m²	$G_{100\%}$ kg/m²	A_{LW} m²/m	A_{LS} m²/m	b_{sys} m
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

Section	A cm²/m	I_y cm⁴/m	$W_{el,y}$* cm³/m	$W_{el,y}$** cm³/m	$G_{60\%}$ kg/m²	$G_{80\%}$ kg/m²	$G_{100\%}$ kg/m²	A_{LW} m²/m	A_{LS} m²/m	b_{sys} m
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

Section	A cm²/m	I_y cm⁴/m	$W_{el,y}$* cm³/m	$W_{el,y}$** cm³/m	$G_{60\%}$ kg/m²	$G_{80\%}$ kg/m²	$G_{100\%}$ kg/m²	A_{LW} m²/m	A_{LS} m²/m	b_{sys} m
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

Section	A cm²/m	I_y cm⁴/m	$W_{el,y}$* cm³/m	$W_{el,y}$** cm³/m	$G_{60\%}$ kg/m²	$G_{80\%}$ kg/m²	$G_{100\%}$ kg/m²	A_{LW} m²/m	A_{LS} m²/m	b_{sys} m
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, $W_{el,y}$* & $W_{el,y}$** 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	$W_{el,y}$*	$W_{el,y}$**	$G_{60\%}$	$G_{80\%}$	$G_{100\%}$	A_{LW}	A_{LS}	b_{sys}
	cm²/m	cm⁴/m	cm³/m	cm³/m	kg/m²	kg/m²	kg/m²	m²/m	m²/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, $W_{el,y}$* & $W_{el,y}$** 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	$W_{el,y}$*	$W_{el,y}$**	$G_{60\%}$	$G_{80\%}$	$G_{100\%}$	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, $W_{el,y}$* & $W_{el,y}$** 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	$W_{el,y}$*	$W_{el,y}$**	$G_{60\%}$	$G_{80\%}$	$G_{100\%}$	A_{LW}	A_{LS}	b_{sys}
	cm²/m	cm⁴/m	cm³/m	cm³/m	kg/m²	kg/m²	kg/m²	m²/m	m²/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, $W_{el,y}$* & $W_{el,y}$** not taking the intermediary sheet piles into account.

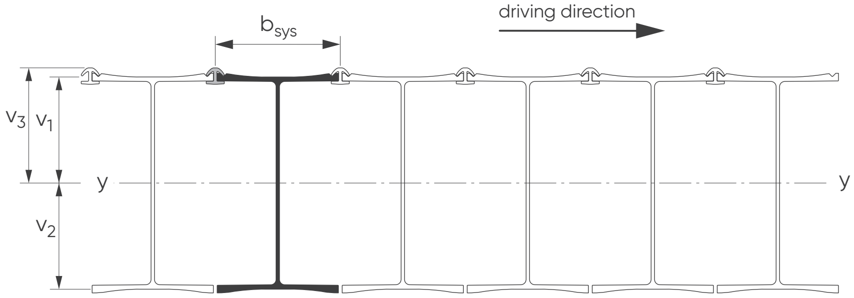
Characteristics of combinations according to EN 1993-5 design approach

Section	Properties per meter of wall[1]							Per system		
	A	I_y	$W_{el,y}$*	$W_{el,y}$**	$G_{60\%}$	$G_{80\%}$	$G_{100\%}$	A_{LW}	A_{LS}	b_{sys}
	cm²/m	cm⁴/m	cm³/m	cm³/m	kg/m²	kg/m²	kg/m²	m²/m	m²/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

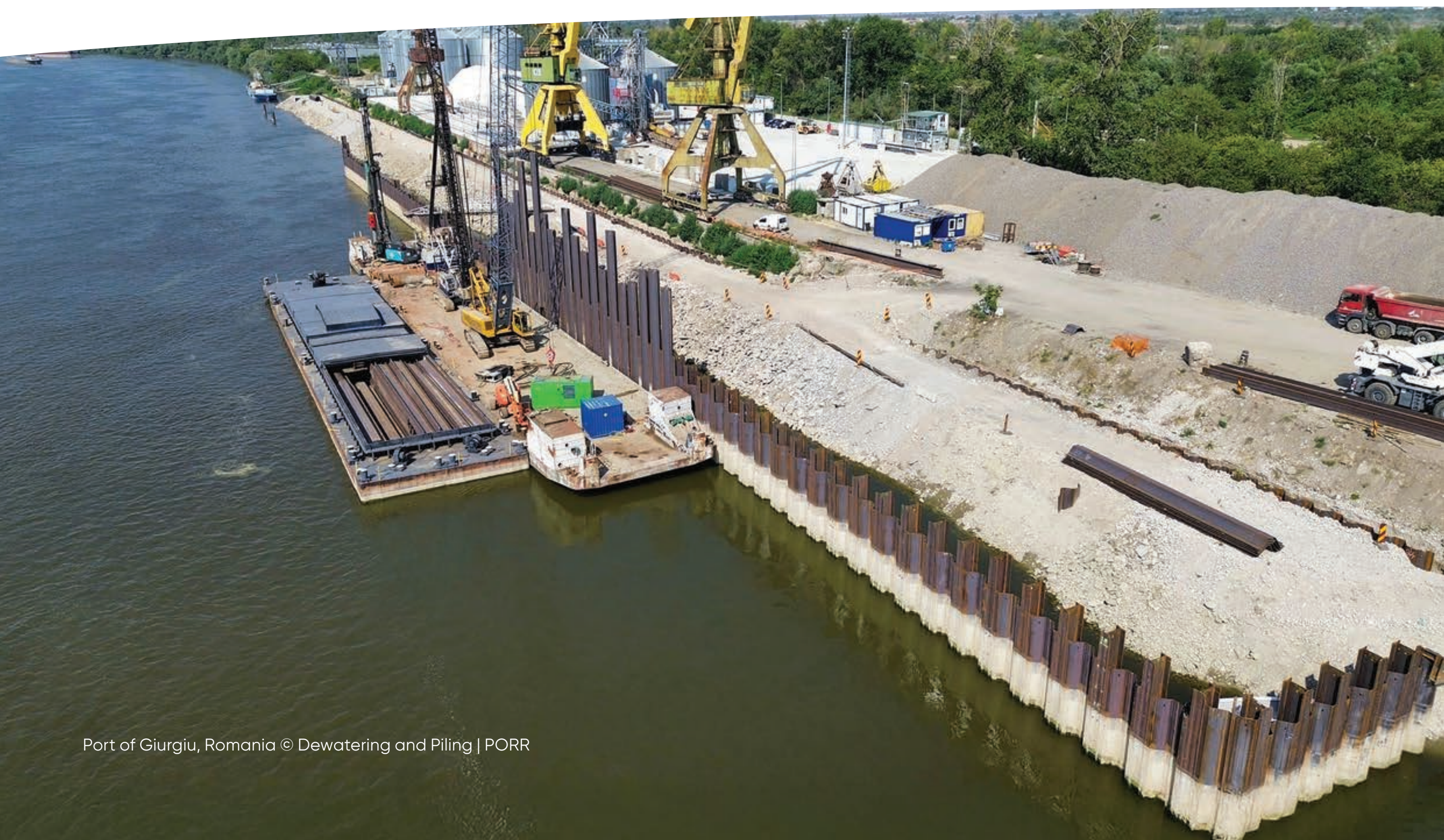
[1] Values of A, I_y, $W_{el,y}$* & $W_{el,y}$** not taking the intermediary sheet piles into account.

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	$W_{el,y}$*	$W_{el,y}$**	A_{LW}	A_{LS}	b_{sys}
	mm	mm	mm	cm²/m	kg/m²	cm⁴/m	cm³/m	cm³/m	m²/m	m²/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



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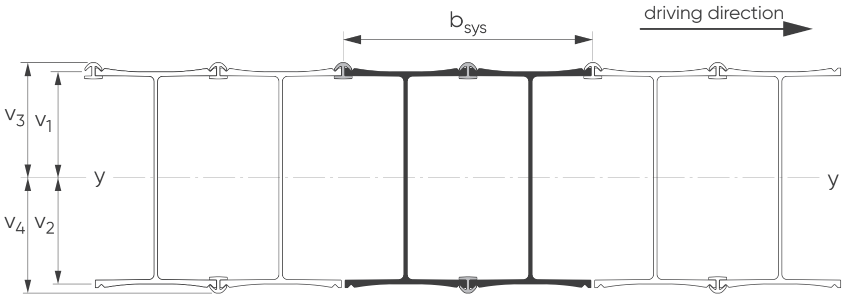
Combination C 23



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	cm²/m	kg/m²	cm⁴/m	cm³/m	cm³/m	m²/m	m²/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

Port of Giurgiu, Romania © Dewatering and Piling | PORR

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:

$$\sigma_{\text{HZ}} = \frac{M_{\text{HZ}}}{W_{\text{HZ}}} = \left(\frac{1}{W_{\text{HZ}}}\right)\left(\frac{I_{\text{HZ}}}{I_{\text{sys}}} M_{\text{sys}}\right) b_{\text{sys}}$$

$$= \frac{1}{W_{\text{HZ, eq}}} M_{\text{sys}}$$

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

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:
“$W_{HZ,eq}$” is labelled in the tables of this brochure as $W_{el,y}^{*}$.

For the connectors RH / RZD / RZU:

$$\sigma_{\text{RH/RZ}} = \frac{M_{\text{HZ}}}{W_{\text{RH/RZ}}} = \left(\frac{1}{W_{\text{RH/RZ}}}\right)\left(\frac{I_{\text{HZ}}}{I_{\text{sys}}} M_{\text{sys}}\right) b_{\text{sys}}$$

$$= \frac{1}{W_{\text{RH/RZ, eq}}} M_{\text{sys}}$$

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

Note:
“$W_{RH/RZ,eq}$” is labelled in the tables of this brochure as $W_{el,y}^{**}$.

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 A 690, 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 $W_{el,y}^{*}$ and $W_{el,y}^{**}$ 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]).

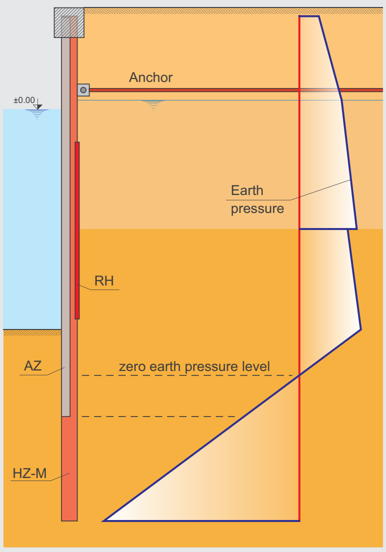


Fig. 2. Optimization of the length of the AZ infill sheet piles.

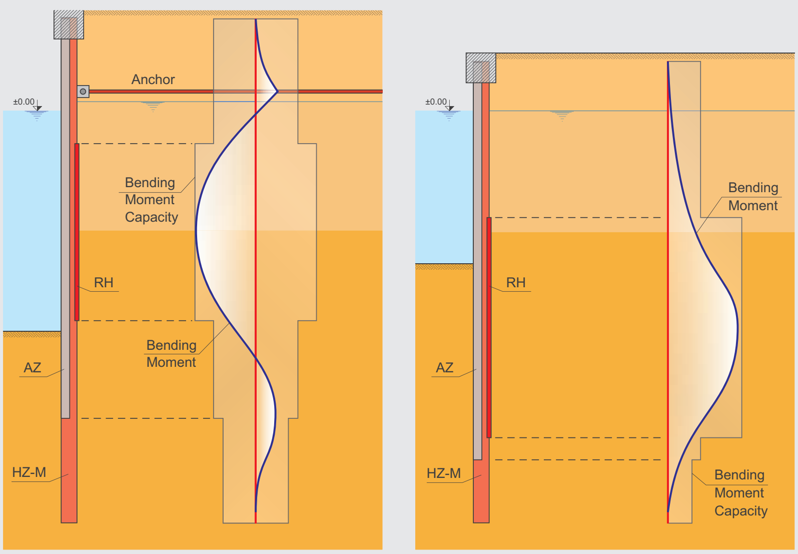


Fig. 3. Optimization of the bending moment capacity with additional RH connectors on the rear flange.

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.

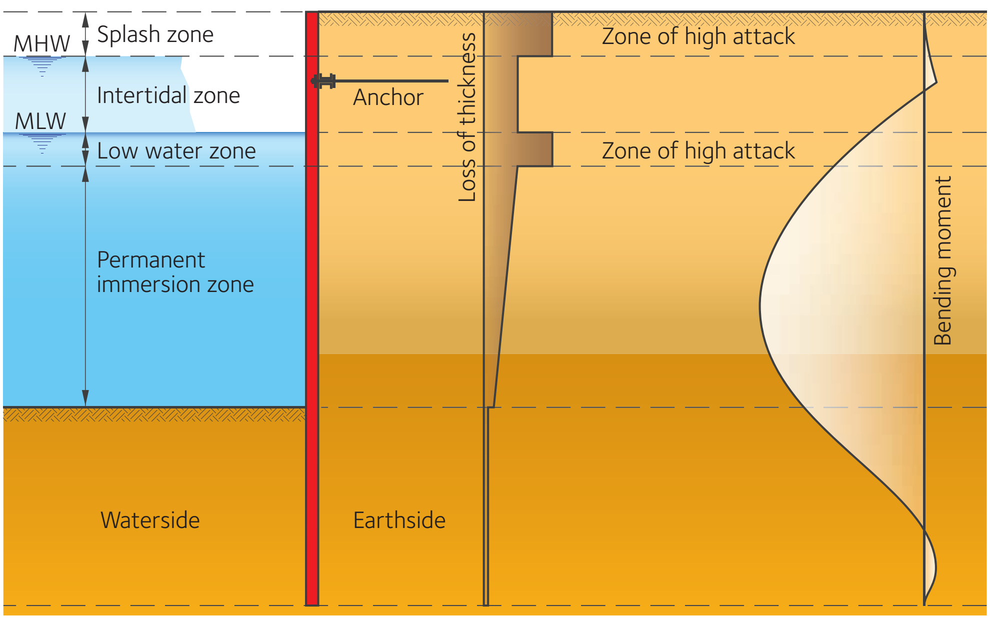
The determination of the residual section properties after corrosion of an HZ-M Steel Wall System is more complex than for standard sheet piles because corrosion is higher on the water side of the wall. Assumptions like proportionality to the initial thickness of the flange are too conservative and may 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.

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.

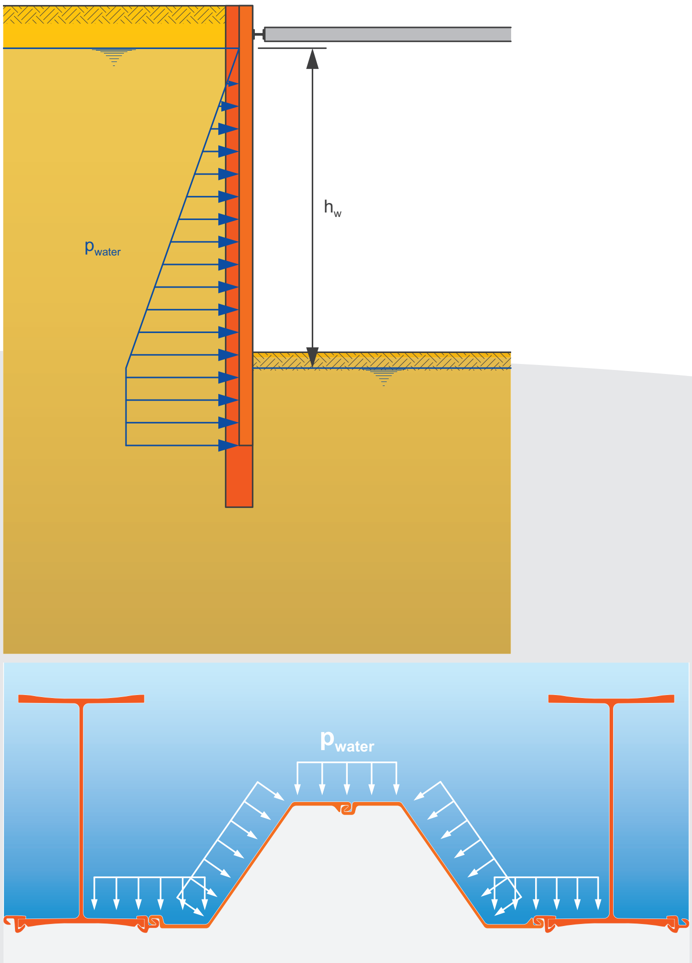


Fig. 4. HZ-M system under water pressure: assumptions.

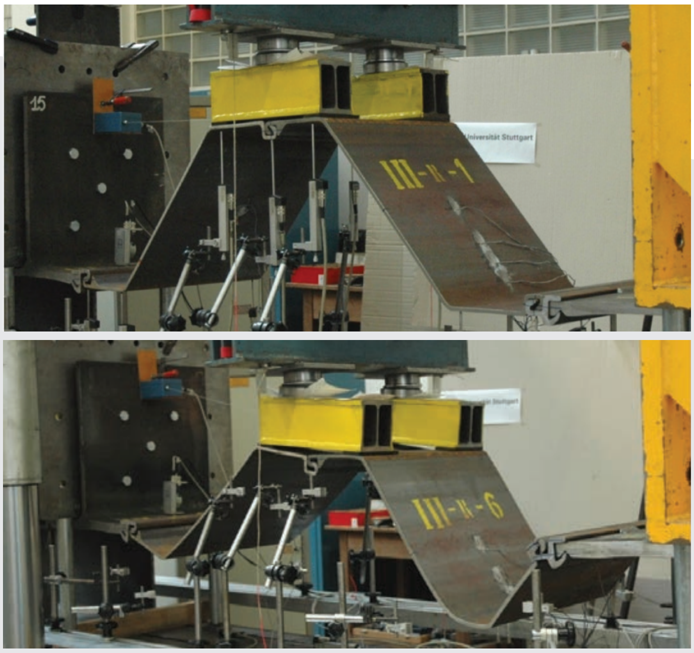


Fig. 5. Mechanical testing of the HZ-M system in the laboratory.

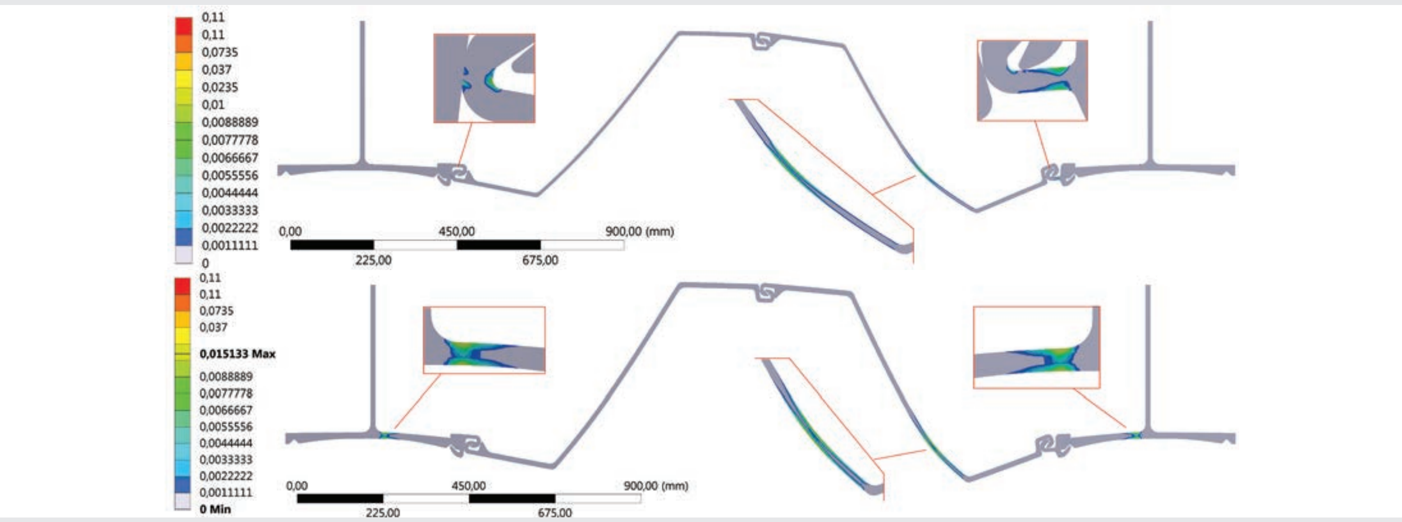


Fig. 6. Numerical simulation of an HZ/AZ combined wall under water pressure.

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 values[1] can be obtained by applying the partial safety factor γ_{M0}. Please refer to EN 1993-5 [1] and the relevant National Annex for γ_{M0} (EN 1993-5 recommends a value of γ_{M0} = 1.0).

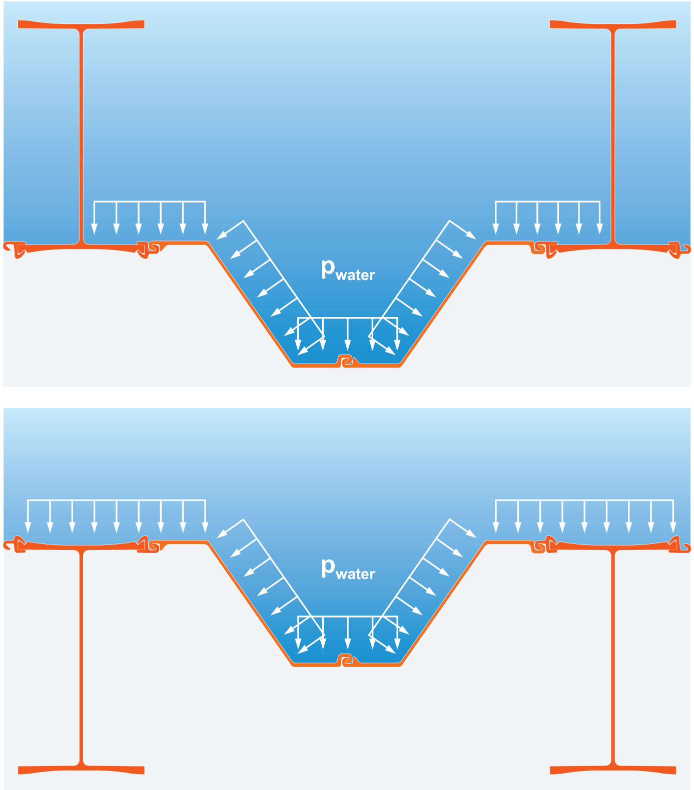


Fig. 7. AZ infill sheet piles under water pressure working in tension.

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 ± 5° for rotation and ± 100mm 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.

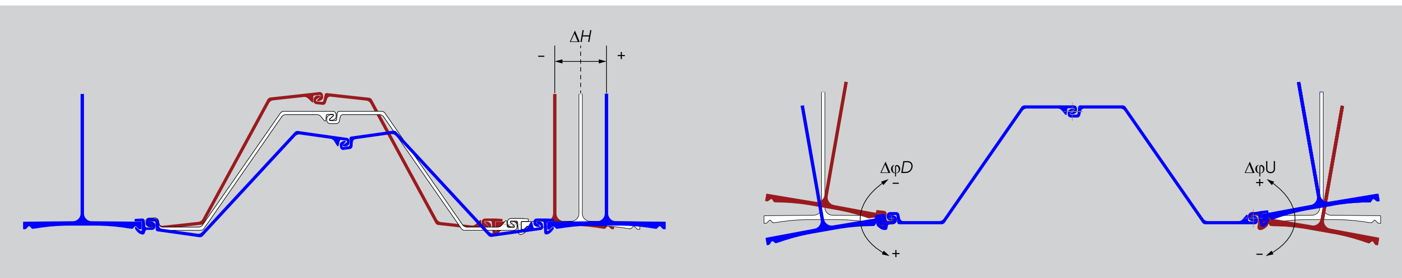


Fig. 8. Considered driving imperfections (± 5° for rotation and ± 100 mm for horizontal displacement).

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					
HZ-M steel grade	S 430 GP			S 460 GP			S 430 GP			S 460 GP			S 430 GP			S 460 GP		
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 bending[1)]

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}.

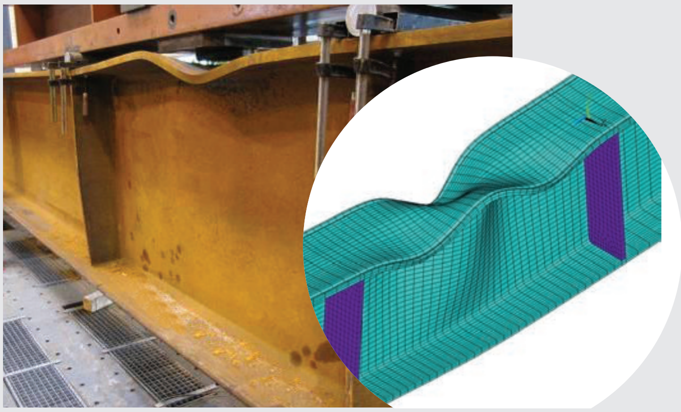
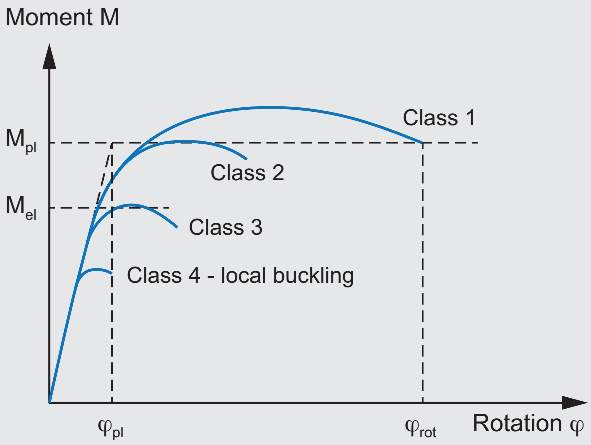
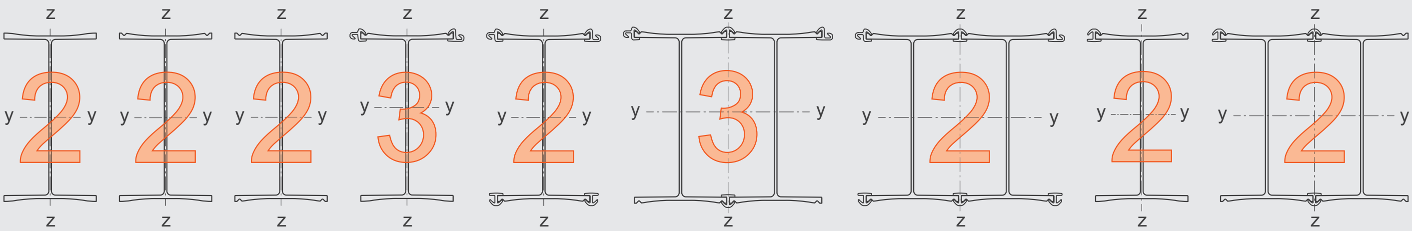


Fig. 9. Comparison between 4 point bending test and FEA simulation.





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 GP[2)].

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).

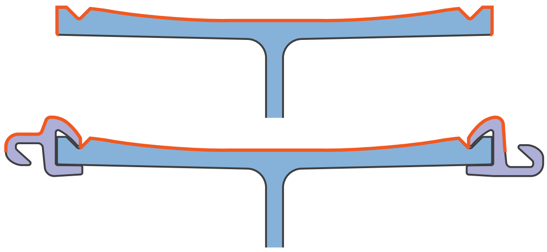


Fig. 11. Corrosion assumption: loss of steel thickness on outer flange.

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 flange[1].

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.

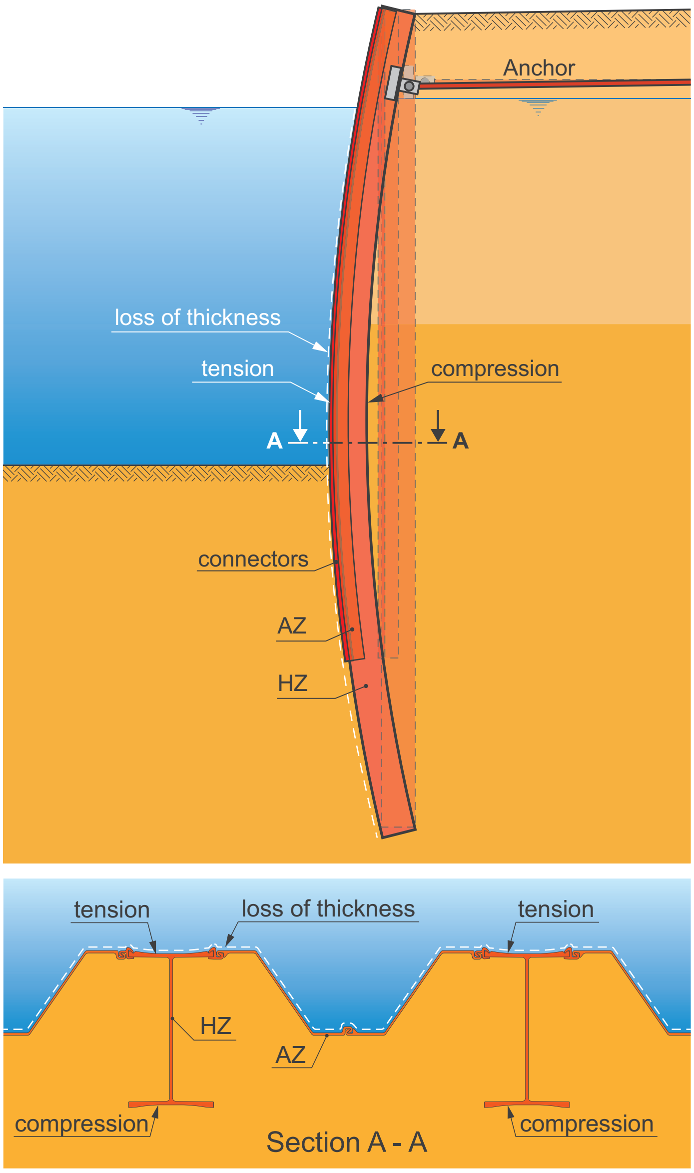


Fig. 13. Common configuration of an HZ/AZ combined wall system (typical cross section).

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 configurations[2], 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).

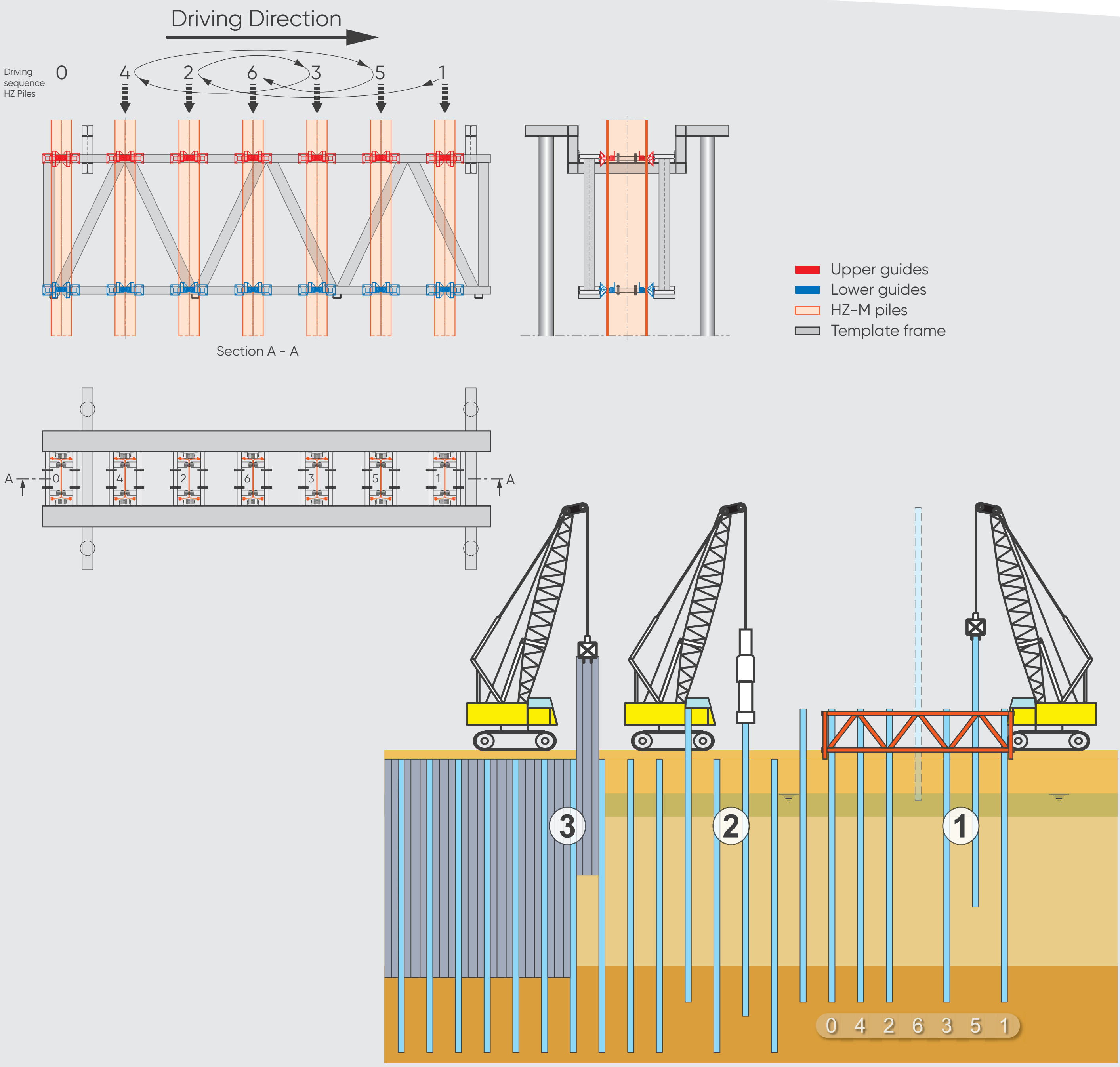


Fig. 14. Installation procedure: driving template and "Pilgrim's step" driving sequence.

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].

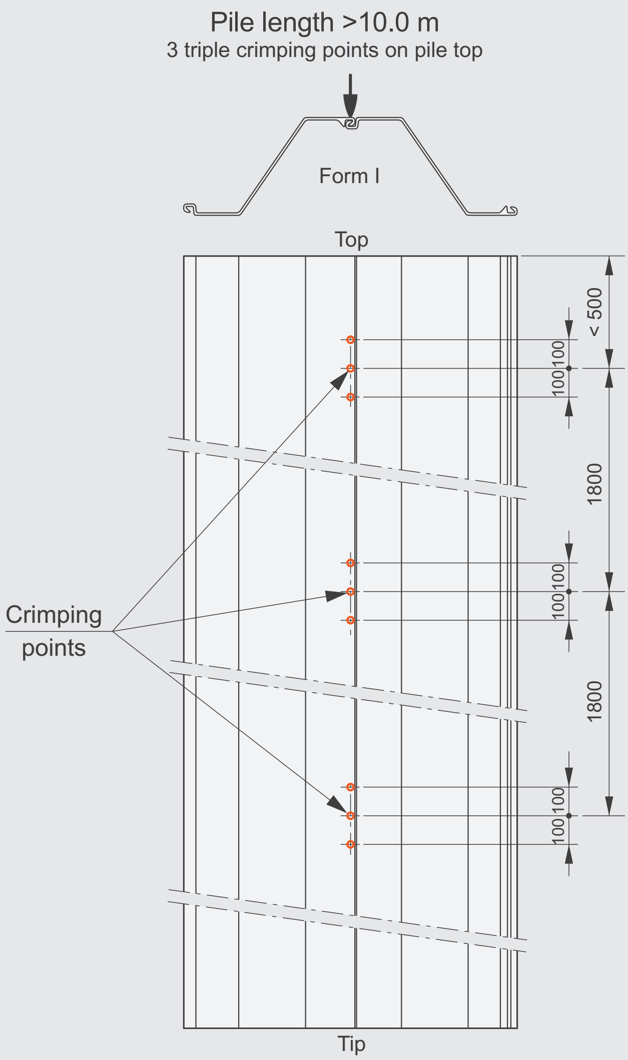


Fig. 15. Special crimping pattern for AZ infill sheet piles and crimping at the rolling mill.

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.

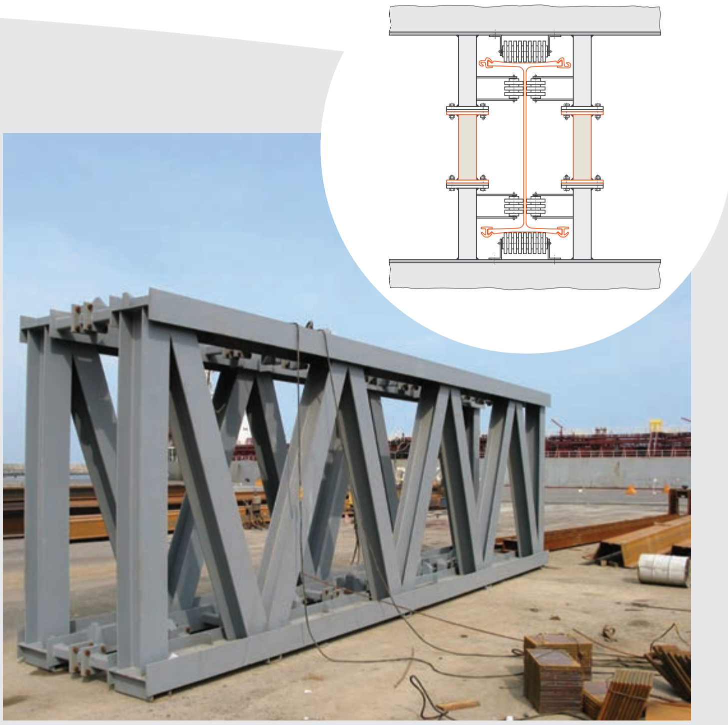


Fig. 17. Template and detail of guide.

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.

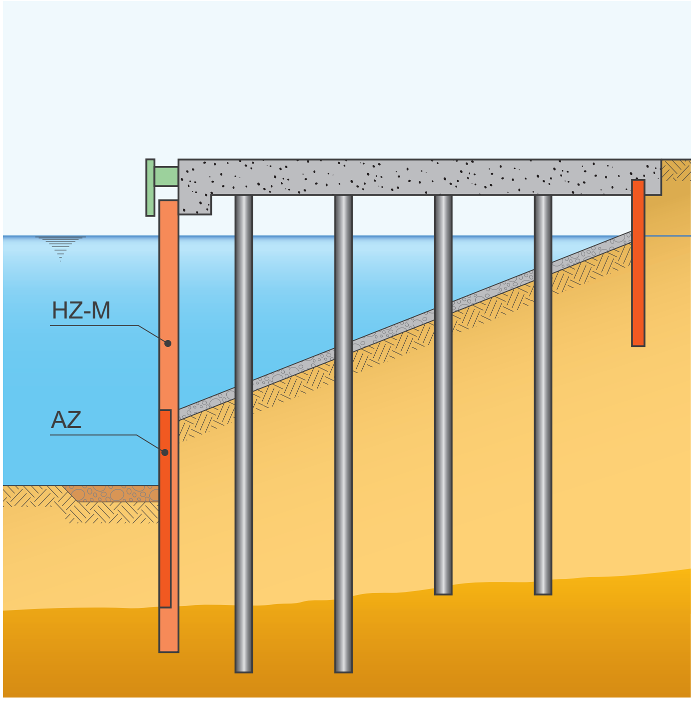


Fig. 19. Installation of AZ below water level with a follower on a vibratory hammer.

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.

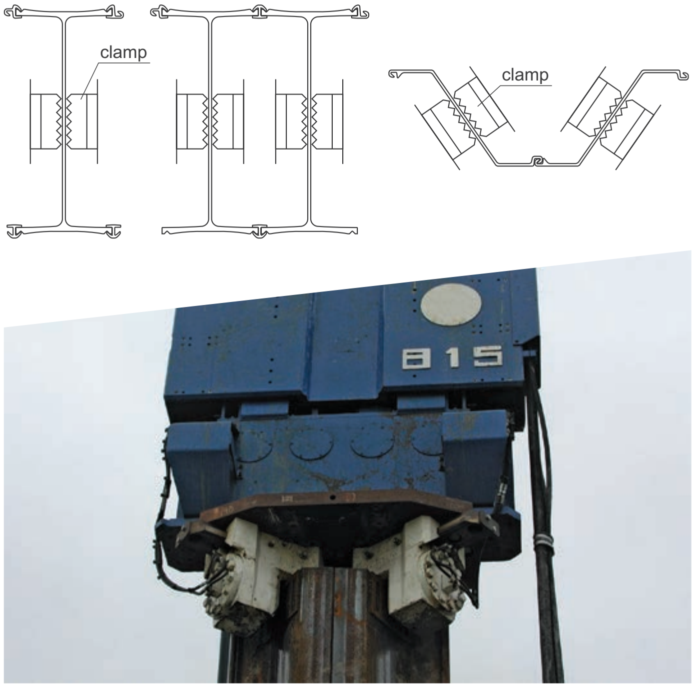


Fig. 20. Double clamps for a vibratory hammer.

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

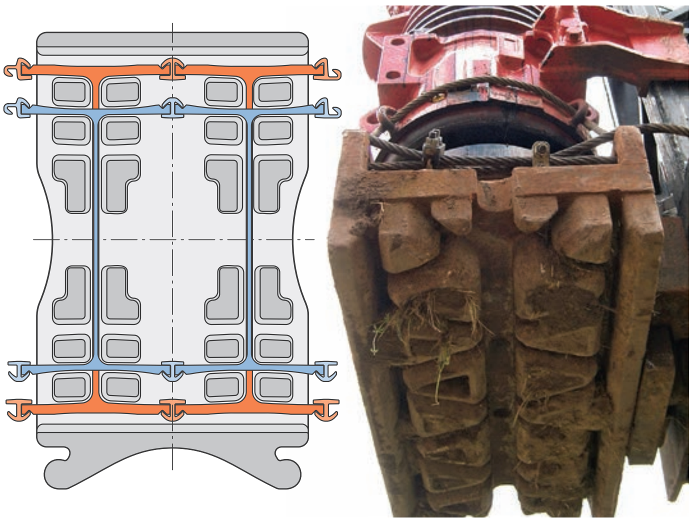


Fig. 21. Impact hammer driving cap.

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:

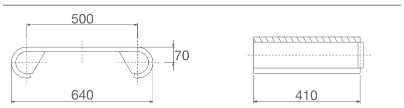
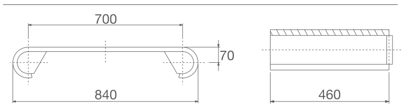
- check for obstructions in the soil. This can be done, for example, by extracting the intermediary sheet pile and re-driving it outside the interlocks.
- verify that the spacing and the positioning of the king piles is correct. This can be done, for example, by means of an inclinometer. A tube of the 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.

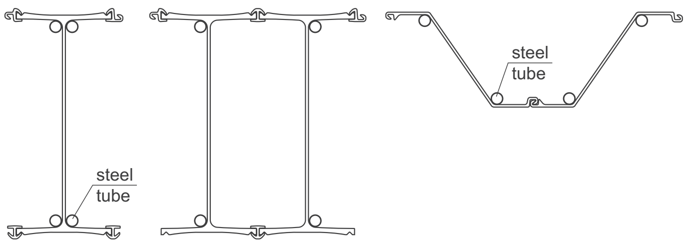


Fig. 22. Water jetting.

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.

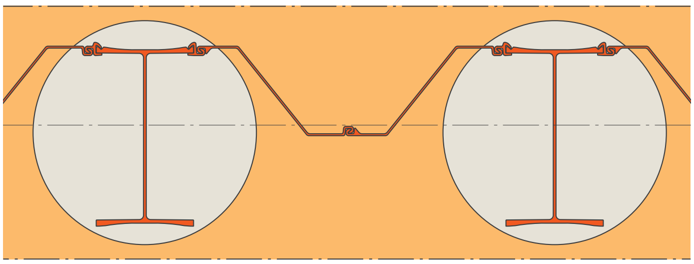


Fig. 23. Pre-drilling / augering for king piles.

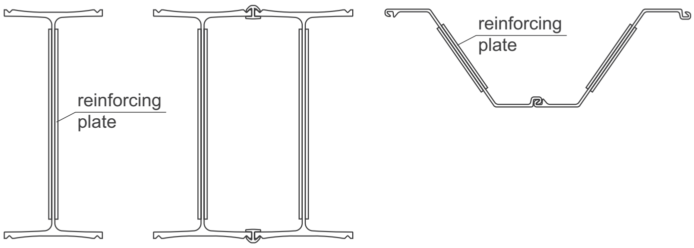
Fig. 24. Reinforcing of the tip of the pile with steel plates / shoes welded on the king pile toe.

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.

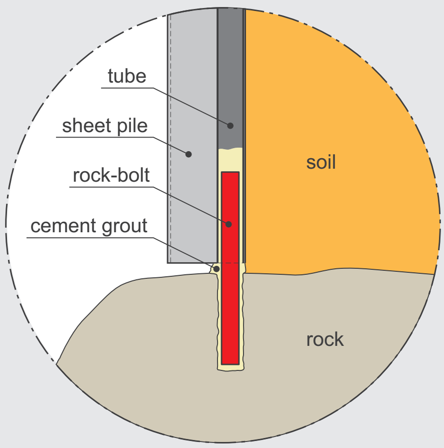


Fig. 25. Concept of a rock-bolt.

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.

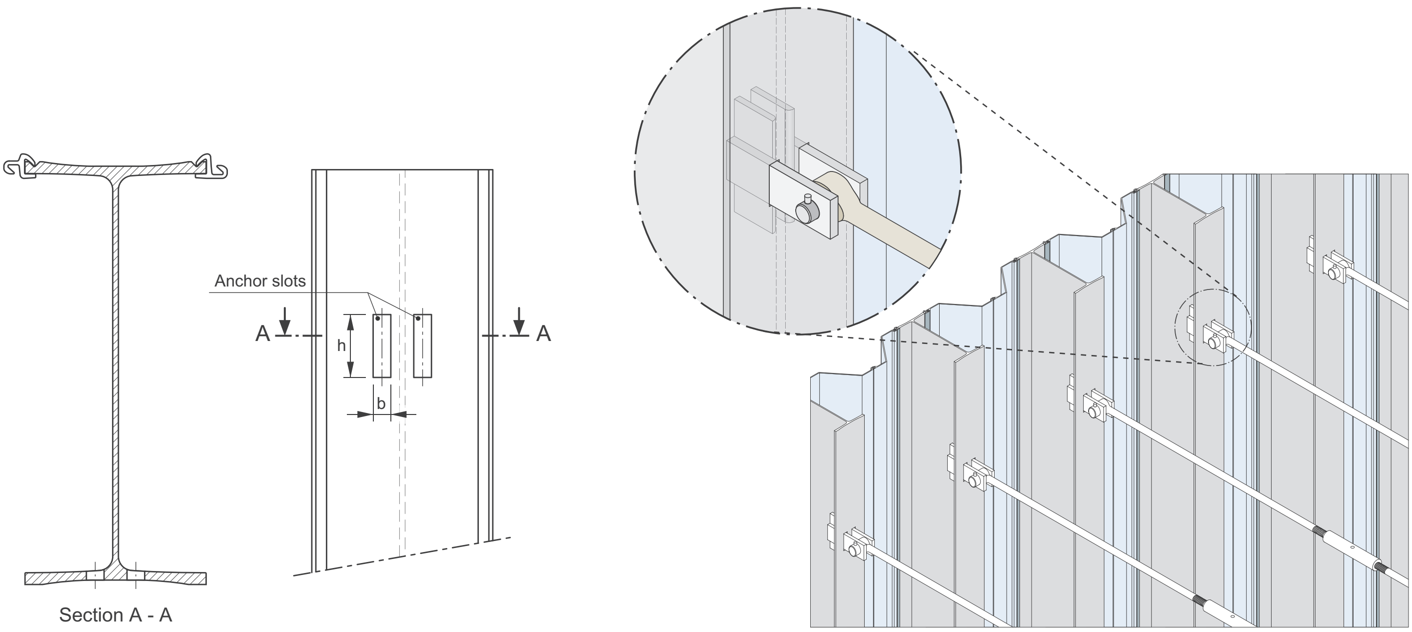


Fig. 26. Special tie-rod connection with T-connector for the HZ-M.

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

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

References

[1] EN 1993-5: Eurocode 3. Design of steel structures - Part 5: Piling. CEN.

[2] EN 1997-1: Eurocode 7. Geotechnical design - Part 1: General rules. CEN.

[3] EAU 2020. Recommendations of the Committee for Waterfront Structures Harbours and Waterways. Ernst und Sohn.

[4] EN 10248-1: 2023 - Hot-rolled steel sheet piles - Part 1: Technical delivery conditions. CEN.

[5] EN 10248-2: 2024 - Hot-rolled steel sheet piles - Part 2: Tolerances on shape and dimensions. CEN.

[6] EN 1990: Eurocode: Basis of structural design. CEN.

[7] EN 1993-1-5: Eurocode 3: Design of steel structures - Part 1-5: Plated structural elements.

[8] Cross sectional classification of ArcelorMittal HZ range. RWTH Aachen. 2012.

[9] Cross sectional classification taking into account corrosion of ArcelorMittal HZ range. RWTH Aachen. 2012.

[10] Ulrike Kuhlmann and Adrian Just, Final Report – Expert Statement – Combined HZ-M/AZ Pile Walls Loaded with Water Pressure. Evaluation of Additional Tests and Statistical Re-evaluation of the Characteristic Resistance Values, Institute of Structural Design, University of Stuttgart, Germany, March 2019.

[11] Ulrike Kuhlmann and Alexander Enders, Final Report – Investigations on combined sheet pile walls (HZ/AZ system) under water pressure loading.Test back-calculation of experimental investigations with five AZ/HZ combinations in reverse setup position (b), Institute of Structural Design, University of Stuttgart, Germany, May 2019.

[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

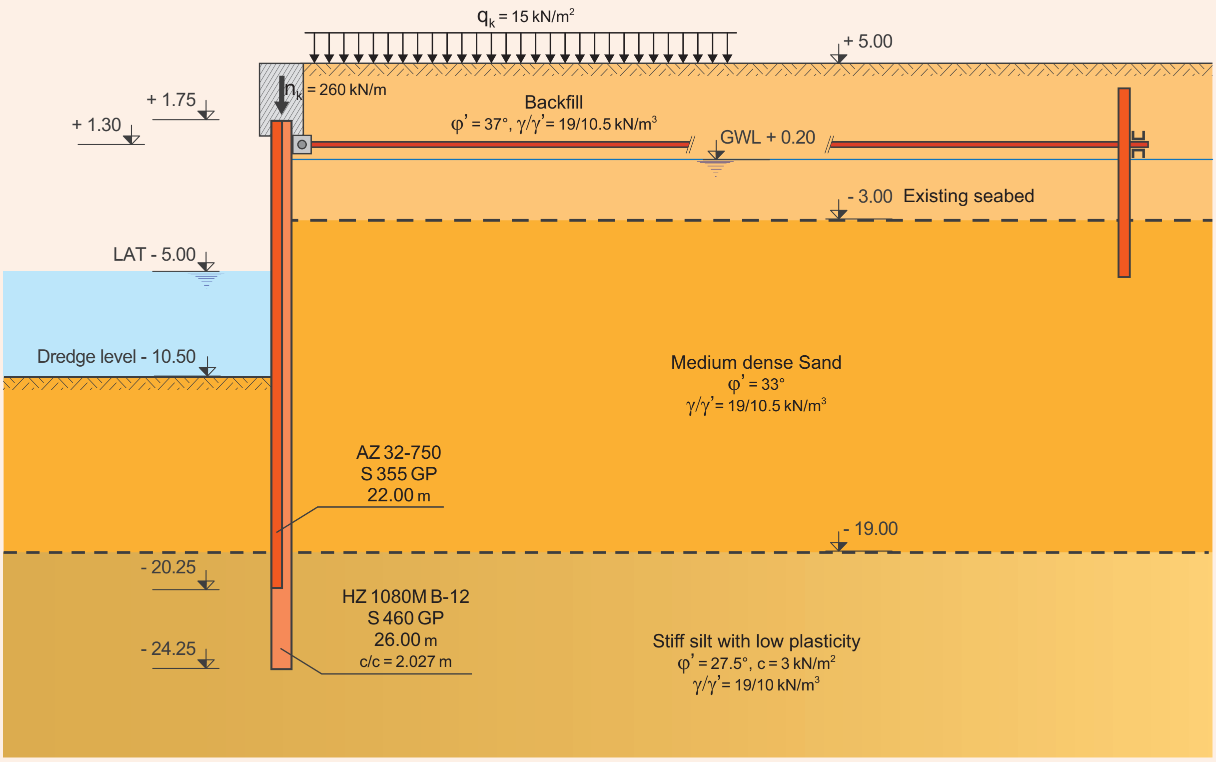


Fig. A1: Cross section of the quay wall.

Results of the computation

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

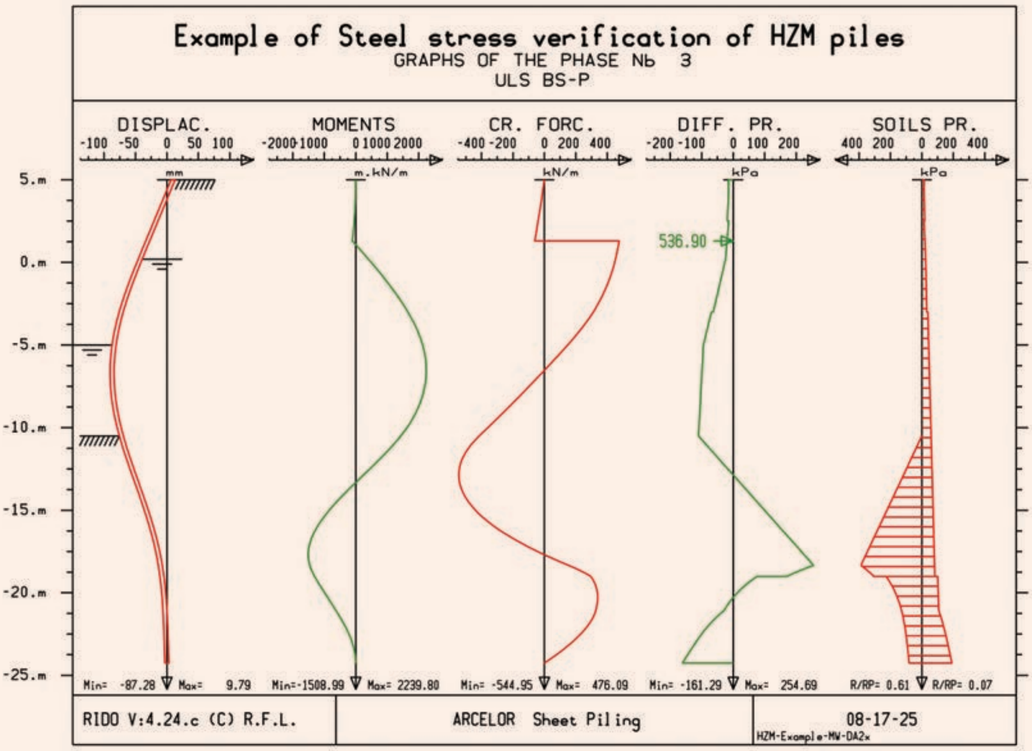


Fig. A2: Internal forces of the cross sections

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 γ_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 γ_Q = 1.50 for variable actions by multiplying the effects of actions with γ_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 N/mm²

(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 N/mm²
Height of the section:	h = 511 mm
Width of the double pile:	$2*b$ = 1500 mm
Thickness of the flange	t_f = 14.0 mm
Thickness of the web:	t_w = 12.0 mm
Inclination of the web:	α = 58.9°

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 beforehands 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:

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

ok

Pressure difference acting on the sheet pile:

$$p_k \leq 40\ kN/m^2 \quad \rightarrow \quad p_k = 52\ kN/m^2 > 40\ kN/m^2$$

does not meet requirements

Maximum clearance between the primary elements:

$$B \leq 1.50\ m \quad \rightarrow \quad B = 1.50\ m \leq 1.50\ m$$

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:

$$\Delta h = 5.20\ m \quad \rightarrow \quad p_k = 5.2 * 10.0 = 52\ kN/m^2$$

Partial factor: γ_G = 1.35 [*1]

Design water pressure on the intermediate pile:

$$p_{Ed} = p_k * \gamma_G = 70.2\ kPa$$

[*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:

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

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

$$p_{Ed} \leq p_{max} / \gamma_{M0}$$

$$\mathbf{70.2\ kN/m^2 \leq 90.3/1.0\ kN/m^2}$$

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

$c/t = 189/22.6 = 8.36 < 14 * \epsilon = 10.01$ → Class 3

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

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.

$$t = min \begin{cases} t_l \\ t_f \end{cases} = 22.6\ mm$$

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

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

$\alpha = 0.5 + N_{Ed}/(2*d*t_w*f_y)$ and $d = c = 945.6\ mm$

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

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

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

$59.1 > 51.9$ → section class 3 or 4

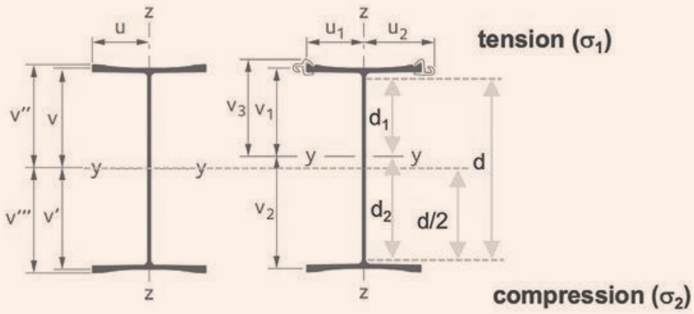


Fig. A3.

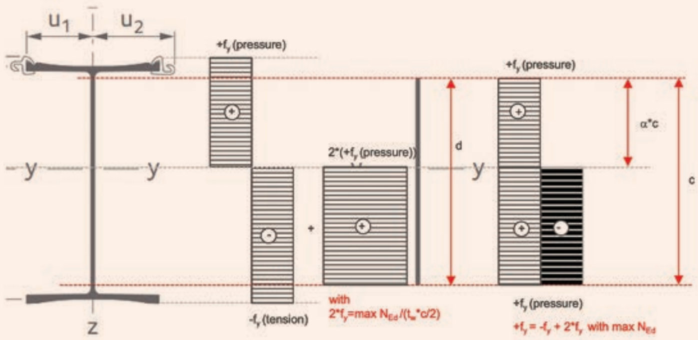


Fig. A4. Plastic steel stress distribution (class 2)

for section class 3

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

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

$\sigma_1 = -287\ N/mm^2$

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

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

$\sigma_2 = +388\ N/mm^2$

with $N_{Ed} = 791\ kN$ (pressure) and $maxM_{y,Ed} = 6129\ kNm$

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

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

$d_1 = d - d_2 = 945.6 - 518 = 427.6\ mm$

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

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

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

→ 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**

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

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

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.

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

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

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

$t_w = 16\ mm$

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

$\gamma_{M0} = 1.0$

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

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

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.

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

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

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

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

$W_{el,y}$ = 15015 cm³ and A = 432.8 cm²

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

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

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: $p_{Ed} = 70.2\ kN/m^2$

Structural model:

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

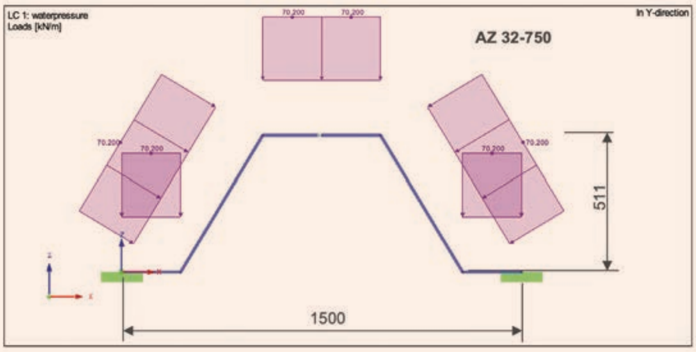


Fig. A5.

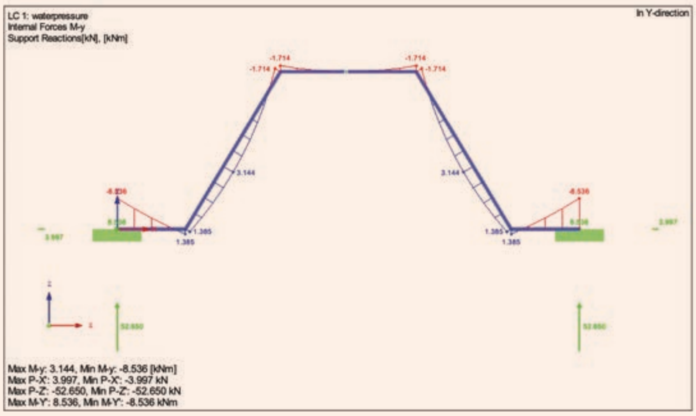


Fig. A6.

Support forces:

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

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

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

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.

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

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

with $d = (w - s)/2 - r$
(Distance between the tip of the flange and the beginning of the fillet)

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

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

Determination of the resistance to local plate bending:

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

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

$N_{Rd} = t * f_y / \gamma_{M0}$ with $t = t_1 = 23.7$ mm

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

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

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

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

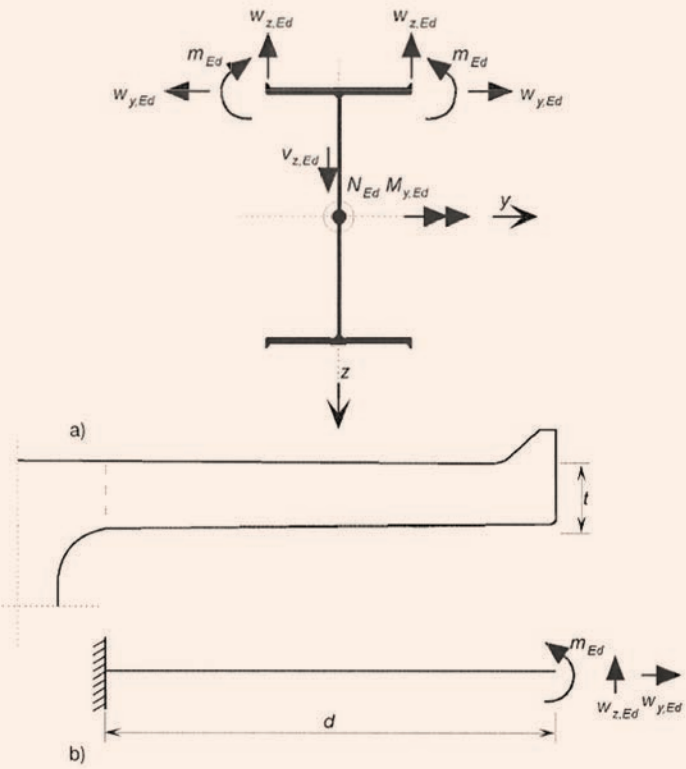


Fig. A7.

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)

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

with $h_w = d + 2*r$ = 945.6+2*30 = 1005.6 mm

$t_w = s$ = 16 mm

η = 1.00

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

ϵ = 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)

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

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)

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

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

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

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

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 $\tau_{cr} = k_\tau * \sigma_E$ 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:

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

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

$$\chi_w = 0.83/1.02 = \mathbf{0.81}$$

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

and:

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

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

Maximal shear force at EL. -12.89 m: V_{Ed} = 1491 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)

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

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

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):

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

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

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 mm < 40 mm

and S460GP = S460

and buckling around the strong axis (y-y)

→ Buckling curve: a_0 → α = 0.13

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

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

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 χ_{LT} = 1.0, and without buckling around the weak axis.

$$\frac{N_{Ed}}{\chi_y * N_{Rk} / \gamma_{M1}} + k_{yy} * \frac{M_{y,Ed}}{\chi_{LT} * M_{y,Rk} / \gamma_{M1}} \leq 1.0$$

$$\frac{N_{Ed}}{\chi_z * N_{Rk} / \gamma_{M1}} + k_{zy} * \frac{M_{y,Ed}}{\chi_{LT} * M_{y,Rk} / \gamma_{M1}} \leq 1.0$$

with γ_{M1} = 1.10 and χ_z = 1.0 and χ_{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

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

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

$$-1 < -0.67 < 0$$

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

$$0 < 0.07 < 1$$

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

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

$$k_{yy} = C_{my} * \left(1 + 0.6 * \bar{\lambda} * \frac{N_{Ed}}{\chi_y * N_{Rk} / \gamma_{M1}}\right) \leq C_{my} * \left(1 + 0.6 * \frac{N_{Ed}}{\chi_y * N_{Rk} / \gamma_{M1}}\right)$$

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

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

k_{yy} = <u>0.94</u> < 0.95 and $k_{zy} = 0.8 * k_{yy}$ = 0.752

Formula (6.62) of EN 1993-1-1, with $k_{zy} < k_{yy}$ and χ_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).

$$\frac{N_{Ed}}{\chi_y * N_{Rk} / \gamma_{M1}} + k_{yy} * \frac{M_{y,Ed}}{\chi_{LT} * M_{y,Rk} / \gamma_{M1}} \leq 1.0$$

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

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

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

and $N_{Ed} = 791\ kN$

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

$$\mathbf{0.05 + 0.94 * 0.98 = 0.97 < 1.0}$$

Annex 2:
HZ-M | Static moment & Plastic section modulus

Section	$W_{el,y}$	S_y	$W_{pl,y}$	$W_{el,y}$	S_y	$W_{pl,y}$	$W_{el,y}$	S_y	$W_{pl,y}$
	cm^3	cm^3	cm^3	cm^3	cm^3	cm^3	cm^3	cm^3	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 $W_{pl,y}$ 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

$W_{el,y}$ *	$G_{100\%}$	Section	Combination
cm³/m	kg/m²		
4135	210	HZ 630M	12/AZ 13-770
4180	217	HZ 630M	12/AZ 14-770-10/10
4355	224	HZ 630M	12/AZ 13-700
4375	227	HZ 630M	12/AZ 13-700-10/10
4550	216	HZ 630M	12/AZ 20-800
4590	220	HZ 630M	12/AZ 20-800-10/10
4730	226	HZ 630M	12/AZ 18-700
4800	234	HZ 630M	12/AZ 20-700
4870	229	HZ 630M	12/AZ 25-800
4885	202	HZ 880M A	12/AZ 13-770
4915	208	HZ 880M A	12/AZ 14-770-10/10
4975	246	HZ 630M	12/AZ 18-10/10
5145	208	HZ 880M A	12/AZ 20-800
5165	224	HZ 630M	14/AZ 13-770
5175	211	HZ 880M A	12/AZ 20-800-10/10
5175	214	HZ 880M A	12/AZ 13-700
5185	218	HZ 880M A	12/AZ 13-700-10/10
5210	231	HZ 630M	14/AZ 14-770-10/10
5210	254	HZ 630M	12/AZ 26-700
5295	239	HZ 630M	12/AZ 28-750
5300	214	HZ 880M B	12/AZ 13-770
5330	220	HZ 880M B	12/AZ 14-770-10/10
5385	221	HZ 880M A	12/AZ 25-800
5395	269	HZ 630M	12/AZ 26
5410	247	HZ 630M	12/AZ 30-750
5450	239	HZ 630M	14/AZ 13-700
5455	217	HZ 880M A	12/AZ 18-700
5470	242	HZ 630M	14/AZ 13-700-10/10
5505	224	HZ 880M A	12/AZ 20-700
5525	255	HZ 630M	12/AZ 32-750
5545	220	HZ 880M B	12/AZ 20-800
5555	219	HZ 880M C	12/AZ 13-770
5580	223	HZ 880M B	12/AZ 20-800-10/10
5585	226	HZ 880M C	12/AZ 14-770-10/10
5600	230	HZ 630M	14/AZ 20-800
5615	227	HZ 880M B	12/AZ 13-700
5630	230	HZ 880M B	12/AZ 13-700-10/10
5650	234	HZ 630M	14/AZ 20-800-10/10
5780	235	HZ 880M A	12/AZ 18-10/10
5785	230	HZ 880M A	12/AZ 28-750
5790	233	HZ 880M B	12/AZ 25-800
5795	225	HZ 880M C	12/AZ 20-800
5810	244	HZ 880M A	12/AZ 26-700
5830	229	HZ 880M C	12/AZ 20-800-10/10
5865	241	HZ 630M	14/AZ 18-700
5870	238	HZ 880M A	12/AZ 30-750
5895	233	HZ 880M C	12/AZ 13-700
5900	230	HZ 880M B	12/AZ 18-700
5905	236	HZ 880M C	12/AZ 13-700-10/10
5940	249	HZ 630M	14/AZ 20-700
5950	237	HZ 880M B	12/AZ 20-700
5955	246	HZ 880M A	12/AZ 32-750
5960	243	HZ 630M	14/AZ 25-800
6040	238	HZ 880M C	12/AZ 25-800
6095	258	HZ 880M A	12/AZ 26
6175	236	HZ 880M C	12/AZ 18-700
6185	262	HZ 630M	14/AZ 18-10/10
6210	242	HZ 880M B	12/AZ 28-750
6225	243	HZ 880M C	12/AZ 20-700
6230	216	HZ 880M A	14/AZ 13-770
6255	249	HZ 880M B	12/AZ 18-10/10
6255	257	HZ 880M B	12/AZ 26-700
6265	222	HZ 880M A	14/AZ 14-770-10/10
6295	250	HZ 880M B	12/AZ 30-750
6380	258	HZ 880M B	12/AZ 32-750
6395	269	HZ 630M	14/AZ 26-700
6460	254	HZ 630M	14/AZ 28-750
6470	248	HZ 880M C	12/AZ 28-750
6495	221	HZ 880M A	14/AZ 20-800
6530	225	HZ 880M A	14/AZ 20-800-10/10
6530	263	HZ 880M C	12/AZ 26-700
6555	256	HZ 880M C	12/AZ 18-10/10
6555	256	HZ 880M C	12/AZ 30-750
6575	272	HZ 880M B	12/AZ 26
6585	262	HZ 630M	14/AZ 30-750
6610	229	HZ 880M A	14/AZ 13-700
6615	228	HZ 880M B	14/AZ 13-770
6625	233	HZ 880M A	14/AZ 13-700-10/10
6645	264	HZ 880M C	12/AZ 32-750
6650	234	HZ 880M B	14/AZ 14-770-10/10
6650	285	HZ 630M	14/AZ 26
6670	282	HZ 630M	24/AZ 13-770
6705	288	HZ 630M	24/AZ 14-770-10/10
6710	270	HZ 630M	14/AZ 32-750
6765	235	HZ 880M A	14/AZ 25-800
6865	233	HZ 880M B	14/AZ 20-800
6865	233	HZ 880M C	14/AZ 13-770
6870	278	HZ 880M C	12/AZ 26
6900	237	HZ 880M B	14/AZ 20-800-10/10
6900	240	HZ 880M C	14/AZ 14-770-10/10
6920	232	HZ 880M A	14/AZ 18-700
6965	285	HZ 630M	24/AZ 20-800
6980	239	HZ 880M A	14/AZ 20-700
6995	297	HZ 630M	24/AZ 13-700
7005	288	HZ 630M	24/AZ 20-800-10/10
7010	300	HZ 630M	24/AZ 13-700-10/10
7015	230	HZ 1080M A	12/AZ 13-770
7020	242	HZ 880M B	14/AZ 13-700
7035	245	HZ 880M B	14/AZ 13-700-10/10
7040	236	HZ 1080M A	12/AZ 14-770-10/10
7110	238	HZ 880M C	14/AZ 20-800
7130	235	HZ 1080M A	12/AZ 20-800
7130	246	HZ 880M B	14/AZ 25-800
7140	242	HZ 880M C	14/AZ 20-800-10/10
7150	239	HZ 1080M A	12/AZ 20-800-10/10
7245	244	HZ 880M A	14/AZ 28-750
7245	296	HZ 630M	24/AZ 25-800
7290	248	HZ 880M C	14/AZ 13-700
7305	251	HZ 880M C	14/AZ 13-700-10/10
7315	248	HZ 1080M A	12/AZ 25-800
7315	299	HZ 630M	24/AZ 18-700
7320	259	HZ 880M A	14/AZ 26-700
7330	245	HZ 880M B	14/AZ 18-700
7340	252	HZ 880M A	14/AZ 30-750
7350	252	HZ 880M A	14/AZ 18-10/10
7370	305	HZ 630M	24/AZ 20-700
7375	252	HZ 880M C	14/AZ 25-800
7385	252	HZ 880M B	14/AZ 20-700
7435	260	HZ 880M A	14/AZ 32-750
7475	244	HZ 1080M A	12/AZ 13-700
7485	247	HZ 1080M A	12/AZ 13-700-10/10
7565	238	HZ 1080M B	12/AZ 13-770
7570	295	HZ 630M	26/AZ 13-770
7590	245	HZ 1080M B	12/AZ 14-770-10/10
7600	251	HZ 880M C	14/AZ 18-700
7610	300	HZ 630M	26/AZ 14-770-10/10
7630	257	HZ 880M B	14/AZ 28-750
7655	258	HZ 880M C	14/AZ 20-700
7660	243	HZ 1080M B	12/AZ 20-800
7670	320	HZ 630M	24/AZ 18-10/10
7685	247	HZ 1080M B	12/AZ 20-800-10/10
7695	247	HZ 1080M A	12/AZ 18-700

$W_{el,y}$* cm³/m	$G_{100\%}$ kg/m²	Section	Combination
7700	274	HZ 880M A	14/AZ 26
7700	307	HZ 630M	24/AZ 28-750
7720	322	HZ 630M	24/AZ 26-700
7725	264	HZ 880M B	14/AZ 30-750
7725	272	HZ 880M B	14/AZ 26-700
7735	254	HZ 1080M A	12/AZ 20-700
7785	259	HZ 1080M A	12/AZ 28-750
7790	265	HZ 880M B	14/AZ 18-10/10
7800	314	HZ 630M	24/AZ 30-750
7820	272	HZ 880M B	14/AZ 32-750
7850	257	HZ 1080M B	12/AZ 25-800
7850	266	HZ 1080M A	12/AZ 30-750
7875	298	HZ 630M	26/AZ 20-800
7885	262	HZ 880M C	14/AZ 28-750
7895	320	HZ 630M	24/AZ 32-750
7915	274	HZ 1080M A	12/AZ 32-750
7915	301	HZ 630M	26/AZ 20-800-10/10
7950	311	HZ 630M	26/AZ 13-700
7965	314	HZ 630M	26/AZ 13-700-10/10
7975	274	HZ 1080M A	12/AZ 26-700
7980	270	HZ 880M C	14/AZ 30-750
7990	278	HZ 880M C	14/AZ 26-700
8000	266	HZ 880M A	24/AZ 13-770
8020	338	HZ 630M	24/AZ 26
8025	272	HZ 880M A	24/AZ 14-770-10/10
8065	254	HZ 1080M B	12/AZ 13-700
8070	278	HZ 880M C	14/AZ 32-750
8075	257	HZ 1080M B	12/AZ 13-700-10/10
8085	272	HZ 880M C	14/AZ 18-10/10
8140	288	HZ 880M B	14/AZ 26
8155	270	HZ 880M A	24/AZ 20-800
8170	309	HZ 630M	26/AZ 25-800
8180	273	HZ 880M A	24/AZ 20-800-10/10
8220	268	HZ 1080M A	12/AZ 18-10/10
8245	254	HZ 1080M C	12/AZ 13-770
8270	261	HZ 1080M C	12/AZ 14-770-10/10
8285	256	HZ 1080M B	12/AZ 18-700
8285	313	HZ 630M	26/AZ 18-700
8320	259	HZ 1080M C	12/AZ 20-800
8325	263	HZ 1080M B	12/AZ 20-700
8345	262	HZ 1080M C	12/AZ 20-800-10/10
8345	267	HZ 1080M B	12/AZ 28-750
8345	319	HZ 630M	26/AZ 20-700
8360	281	HZ 880M A	24/AZ 25-800

$W_{el,y}$* cm³/m	$G_{100\%}$ kg/m²	Section	Combination
8410	275	HZ 1080M B	12/AZ 30-750
8410	280	HZ 880M A	24/AZ 13-700
8420	283	HZ 880M A	24/AZ 13-700-10/10
8430	294	HZ 880M C	14/AZ 26
8465	290	HZ 1080M A	12/AZ 26
8480	283	HZ 1080M B	12/AZ 32-750
8510	272	HZ 1080M C	12/AZ 25-800
8565	284	HZ 1080M B	12/AZ 26-700
8640	286	HZ 880M B	24/AZ 13-770
8645	282	HZ 880M A	24/AZ 18-700
8665	291	HZ 880M B	24/AZ 14-770-10/10
8670	320	HZ 630M	26/AZ 28-750
8685	244	HZ 1080M A	14/AZ 13-770
8690	288	HZ 880M A	24/AZ 20-700
8695	334	HZ 630M	26/AZ 18-10/10
8710	250	HZ 1080M A	14/AZ 14-770-10/10
8715	336	HZ 630M	26/AZ 26-700
8775	327	HZ 630M	26/AZ 30-750
8780	249	HZ 1080M A	14/AZ 20-800
8780	289	HZ 880M B	24/AZ 20-800
8790	270	HZ 1080M C	12/AZ 13-700
8800	274	HZ 1080M C	12/AZ 13-700-10/10
8805	252	HZ 1080M A	14/AZ 20-800-10/10
8805	292	HZ 880M B	24/AZ 20-800-10/10
8810	290	HZ 880M A	24/AZ 28-750
8855	278	HZ 1080M B	12/AZ 18-10/10
8870	267	HZ 1080M D	12/AZ 13-770
8880	333	HZ 630M	26/AZ 32-750
8885	297	HZ 880M A	24/AZ 30-750
8895	273	HZ 1080M D	12/AZ 14-770-10/10
8930	271	HZ 1080M D	12/AZ 20-800
8945	304	HZ 880M A	24/AZ 26-700
8955	275	HZ 1080M D	12/AZ 20-800-10/10
8955	303	HZ 880M A	24/AZ 32-750
8985	262	HZ 1080M A	14/AZ 25-800
8985	300	HZ 880M B	24/AZ 25-800
9010	273	HZ 1080M C	12/AZ 18-700
9035	283	HZ 1080M C	12/AZ 28-750
9050	280	HZ 1080M C	12/AZ 20-700
9060	295	HZ 880M C	24/AZ 13-770
9070	353	HZ 630M	26/AZ 26
9085	300	HZ 880M C	24/AZ 14-770-10/10
9085	301	HZ 880M B	24/AZ 13-700
9095	303	HZ 880M B	24/AZ 13-700-10/10

$W_{el,y}$* cm³/m	$G_{100\%}$ kg/m²	Section	Combination
9100	300	HZ 1080M B	12/AZ 26
9100	301	HZ 880M A	24/AZ 18-10/10
9105	291	HZ 1080M C	12/AZ 30-750
9120	284	HZ 1080M D	12/AZ 25-800
9170	279	HZ 880M A	26/AZ 13-770
9170	299	HZ 1080M C	12/AZ 32-750
9190	297	HZ 880M C	24/AZ 20-800
9195	284	HZ 880M A	26/AZ 14-770-10/10
9215	301	HZ 880M C	24/AZ 20-800-10/10
9220	252	HZ 1080M B	14/AZ 13-770
9245	259	HZ 1080M B	14/AZ 14-770-10/10
9260	259	HZ 1080M A	14/AZ 13-700
9275	263	HZ 1080M A	14/AZ 13-700-10/10
9290	300	HZ 1080M C	12/AZ 26-700
9295	257	HZ 1080M B	14/AZ 20-800
9315	282	HZ 880M A	26/AZ 20-800
9320	261	HZ 1080M B	14/AZ 20-800-10/10
9320	303	HZ 880M B	24/AZ 18-700
9325	277	HZ 1180M A	12/AZ 13-770
9345	285	HZ 880M A	26/AZ 20-800-10/10
9350	284	HZ 1180M A	12/AZ 14-770-10/10
9360	319	HZ 880M A	24/AZ 26
9365	309	HZ 880M B	24/AZ 20-700
9370	281	HZ 1180M A	12/AZ 20-800
9395	285	HZ 1180M A	12/AZ 20-800-10/10
9395	308	HZ 880M C	24/AZ 25-800
9460	310	HZ 880M B	24/AZ 28-750
9465	284	HZ 1080M D	12/AZ 13-700
9475	287	HZ 1080M D	12/AZ 13-700-10/10
9500	262	HZ 1080M A	14/AZ 18-700
9500	270	HZ 1080M B	14/AZ 25-800
9530	310	HZ 880M C	24/AZ 13-700
9530	316	HZ 880M B	24/AZ 30-750
9535	293	HZ 880M A	26/AZ 25-800
9540	313	HZ 880M C	24/AZ 13-700-10/10
9545	269	HZ 1080M A	14/AZ 20-700
9545	273	HZ 1080M A	14/AZ 28-750
9560	294	HZ 1180M A	12/AZ 25-800
9605	323	HZ 880M B	24/AZ 32-750
9615	281	HZ 1080M A	14/AZ 30-750
9620	325	HZ 880M B	24/AZ 26-700
9635	296	HZ 1080M C	12/AZ 18-10/10
9645	293	HZ 880M A	26/AZ 13-700
9655	296	HZ 880M A	26/AZ 13-700-10/10

$W_{el,y}$*	$G_{100\%}$	Section	Combination
cm³/m	kg/m²		
9675	297	HZ 1080M D	12/AZ 28-750
9685	287	HZ 1080M D	12/AZ 18-700
9690	289	HZ 1080M A	14/AZ 32-750
9725	294	HZ 1080M D	12/AZ 20-700
9740	304	HZ 1080M D	12/AZ 30-750
9750	284	HZ 1180M B	12/AZ 13-770
9765	312	HZ 880M C	24/AZ 18-700
9775	290	HZ 1180M B	12/AZ 14-770-10/10
9785	287	HZ 1180M B	12/AZ 20-800
9790	298	HZ 880M B	26/AZ 13-770
9805	289	HZ 1080M A	14/AZ 26-700
9810	291	HZ 1180M B	12/AZ 20-800-10/10
9810	312	HZ 1080M D	12/AZ 32-750
9810	318	HZ 880M C	24/AZ 20-700
9815	304	HZ 880M B	26/AZ 14-770-10/10
9815	323	HZ 880M B	24/AZ 18-10/10
9835	269	HZ 1080M B	14/AZ 13-700
9845	272	HZ 1080M B	14/AZ 13-700-10/10
9875	268	HZ 1080M C	14/AZ 13-770
9885	318	HZ 1080M C	12/AZ 26
9885	319	HZ 880M C	24/AZ 28-750
9895	295	HZ 880M A	26/AZ 18-700
9900	275	HZ 1080M C	14/AZ 14-770-10/10
9920	301	HZ 880M B	26/AZ 20-800
9930	272	HZ 1080M C	14/AZ 20-800
9940	301	HZ 880M A	26/AZ 20-700
9950	295	HZ 1180M A	12/AZ 13-700
9950	304	HZ 880M B	26/AZ 20-800-10/10
9955	276	HZ 1080M C	14/AZ 20-800-10/10
9955	326	HZ 880M C	24/AZ 30-750
9960	298	HZ 1180M A	12/AZ 13-700-10/10
9960	314	HZ 1080M D	12/AZ 26-700
9970	300	HZ 1180M B	12/AZ 25-800
10030	332	HZ 880M C	24/AZ 32-750
10040	303	HZ 880M A	26/AZ 28-750
10065	334	HZ 880M C	24/AZ 26-700
10070	271	HZ 1080M B	14/AZ 18-700
10075	340	HZ 880M B	24/AZ 26
10085	282	HZ 1080M B	14/AZ 28-750
10115	278	HZ 1080M B	14/AZ 20-700
10115	309	HZ 880M A	26/AZ 30-750
10135	285	HZ 1080M C	14/AZ 25-800
10135	307	HZ 1180M A	12/AZ 28-750
10140	312	HZ 880M B	26/AZ 25-800
10155	290	HZ 1080M B	14/AZ 30-750
10160	284	HZ 1080M A	14/AZ 18-10/10
10170	298	HZ 1180M A	12/AZ 18-700
10195	316	HZ 880M A	26/AZ 32-750
10200	315	HZ 1180M A	12/AZ 30-750
10205	307	HZ 880M C	26/AZ 13-770
10210	305	HZ 1180M A	12/AZ 20-700
10210	317	HZ 880M A	26/AZ 26-700

$W_{el,y}$*	$G_{100\%}$	Section	Combination
cm³/m	kg/m²		
10225	297	HZ 1080M B	14/AZ 32-750
10235	312	HZ 880M C	26/AZ 14-770-10/10
10265	323	HZ 1180M A	12/AZ 32-750
10285	333	HZ 880M C	24/AZ 18-10/10
10300	314	HZ 880M B	26/AZ 13-700
10305	296	HZ 1180M C	12/AZ 13-770
10315	316	HZ 880M B	26/AZ 13-700-10/10
10320	300	HZ 1180M C	12/AZ 20-800
10325	310	HZ 880M C	26/AZ 20-800
10330	303	HZ 1180M C	12/AZ 14-770-10/10
10345	303	HZ 1180M C	12/AZ 20-800-10/10
10355	313	HZ 880M C	26/AZ 20-800-10/10
10365	311	HZ 1080M D	12/AZ 18-10/10
10375	299	HZ 1080M B	14/AZ 26-700
10410	302	HZ 1180M B	12/AZ 13-700
10420	305	HZ 1180M B	12/AZ 13-700-10/10
10420	315	HZ 880M A	26/AZ 18-10/10
10430	306	HZ 1080M A	14/AZ 26
10445	325	HZ 1180M A	12/AZ 26-700
10490	281	HZ 1080M D	14/AZ 13-770
10505	313	HZ 1180M C	12/AZ 25-800
10515	287	HZ 1080M D	14/AZ 14-770-10/10
10525	285	HZ 1080M D	14/AZ 20-800
10535	285	HZ 1080M C	14/AZ 13-700
10545	289	HZ 1080M C	14/AZ 13-700-10/10
10545	320	HZ 880M C	26/AZ 25-800
10545	350	HZ 880M C	24/AZ 26
10550	288	HZ 1080M D	14/AZ 20-800-10/10
10550	316	HZ 880M B	26/AZ 18-700
10570	314	HZ 1180M B	12/AZ 28-750
10595	322	HZ 880M B	26/AZ 20-700
10610	333	HZ 1080M D	12/AZ 26
10625	305	HZ 1180M B	12/AZ 18-700
10635	321	HZ 1180M B	12/AZ 30-750
10665	312	HZ 1180M B	12/AZ 20-700
10665	323	HZ 880M B	26/AZ 28-750
10695	333	HZ 880M A	26/AZ 26
10700	329	HZ 1180M B	12/AZ 32-750
10725	298	HZ 1080M D	14/AZ 25-800
10740	323	HZ 880M C	26/AZ 13-700
10740	329	HZ 880M B	26/AZ 30-750
10745	298	HZ 1080M C	14/AZ 28-750
10755	326	HZ 880M C	26/AZ 13-700-10/10
10770	288	HZ 1080M C	14/AZ 18-700
10775	294	HZ 1080M B	14/AZ 18-10/10
10815	295	HZ 1080M C	14/AZ 20-700
10820	306	HZ 1080M C	14/AZ 30-750
10820	335	HZ 880M B	26/AZ 32-750
10825	306	HZ 1180M D	12/AZ 13-770
10830	309	HZ 1180M D	12/AZ 20-800
10850	313	HZ 1180M D	12/AZ 14-770-10/10
10850	313	HZ 1180M D	12/AZ 20-800-10/10

$W_{el,y}$*	$G_{100\%}$	Section	Combination
cm³/m	kg/m²		
10865	338	HZ 880M B	26/AZ 26-700
10885	322	HZ 1180M A	12/AZ 18-10/10
10890	313	HZ 1080M C	14/AZ 32-750
10905	332	HZ 1180M B	12/AZ 26-700
10920	291	HZ 1180M A	14/AZ 13-770
10945	295	HZ 1180M A	14/AZ 20-800
10950	298	HZ 1180M A	14/AZ 14-770-10/10
10970	298	HZ 1180M A	14/AZ 20-800-10/10
10990	325	HZ 880M C	26/AZ 18-700
11000	316	HZ 1180M C	12/AZ 13-700
11010	319	HZ 1180M C	12/AZ 13-700-10/10
11015	322	HZ 1180M D	12/AZ 25-800
11035	331	HZ 880M C	26/AZ 20-700
11040	316	HZ 1080M B	14/AZ 26
11075	315	HZ 1080M C	14/AZ 26-700
11085	332	HZ 880M C	26/AZ 28-750
11115	337	HZ 880M B	26/AZ 18-10/10
11130	326	HZ 1180M C	12/AZ 28-750
11130	345	HZ 1180M A	12/AZ 26
11145	308	HZ 1180M A	14/AZ 25-800
11160	338	HZ 880M C	26/AZ 30-750
11195	299	HZ 1080M D	14/AZ 13-700
11195	334	HZ 1180M C	12/AZ 30-750
11205	302	HZ 1080M D	14/AZ 13-700-10/10
11220	318	HZ 1180M C	12/AZ 18-700
11240	344	HZ 880M C	26/AZ 32-750
11260	325	HZ 1180M C	12/AZ 20-700
11260	342	HZ 1180M C	12/AZ 32-750
11300	297	HZ 1180M B	14/AZ 13-770
11305	300	HZ 1180M B	14/AZ 20-800
11305	347	HZ 880M C	26/AZ 26-700
11325	304	HZ 1180M B	14/AZ 14-770-10/10
11330	304	HZ 1180M B	14/AZ 20-800-10/10
11365	311	HZ 1080M D	14/AZ 28-750
11380	330	HZ 1180M B	12/AZ 18-10/10
11390	354	HZ 880M B	26/AZ 26
11430	302	HZ 1080M D	14/AZ 18-700
11440	319	HZ 1080M D	14/AZ 30-750
11470	309	HZ 1080M D	14/AZ 20-700
11495	345	HZ 1180M C	12/AZ 26-700
11505	314	HZ 1180M B	14/AZ 25-800
11510	326	HZ 1080M D	14/AZ 32-750
11530	312	HZ 1080M C	14/AZ 18-10/10
11560	326	HZ 1180M D	12/AZ 13-700
11570	330	HZ 1180M D	12/AZ 13-700-10/10
11580	347	HZ 880M C	26/AZ 18-10/10
11600	314	HZ 1080M A	24/AZ 20-800
11605	312	HZ 1080M A	24/AZ 13-770
11620	317	HZ 1080M A	24/AZ 20-800-10/10
11625	317	HZ 1080M A	24/AZ 14-770-10/10
11625	352	HZ 1180M B	12/AZ 26
11660	310	HZ 1180M A	14/AZ 13-700

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

$W_{el,y}$*	$G_{100\%}$	Section	Combination
cm³/m	kg/m²		
15795	390	HZ 1080M C	26/AZ 28-750
15800	416	HZ 1080M D	24/AZ 26-700
15815	399	HZ 1180M B	24/AZ 20-800
15835	384	HZ 1080M C	26/AZ 13-700
15835	402	HZ 1180M B	24/AZ 20-800-10/10
15845	386	HZ 1080M C	26/AZ 13-700-10/10
15855	396	HZ 1080M C	26/AZ 30-750
15910	385	HZ 1080M D	26/AZ 20-800
15910	402	HZ 1080M C	26/AZ 32-750
15920	399	HZ 1180M B	24/AZ 13-770
15930	388	HZ 1080M D	26/AZ 20-800-10/10
15940	404	HZ 1180M B	24/AZ 14-770-10/10
15970	400	HZ 1080M B	26/AZ 26
15970	410	HZ 1180M B	24/AZ 25-800
16005	385	HZ 1080M D	26/AZ 13-770
16025	386	HZ 1080M C	26/AZ 18-700
16030	390	HZ 1080M D	26/AZ 14-770-10/10
16060	391	HZ 1080M C	26/AZ 20-700
16075	396	HZ 1080M D	26/AZ 25-800
16075	415	HZ 1180M A	24/AZ 28-750
16130	421	HZ 1180M A	24/AZ 30-750
16155	410	HZ 1180M A	24/AZ 13-700
16165	412	HZ 1180M A	24/AZ 13-700-10/10
16185	428	HZ 1180M A	24/AZ 32-750
16265	408	HZ 1080M C	26/AZ 26-700
16335	412	HZ 1180M A	24/AZ 18-700
16370	418	HZ 1180M A	24/AZ 20-700
16470	420	HZ 1080M D	24/AZ 18-10/10
16565	434	HZ 1180M A	24/AZ 26-700
16600	402	HZ 1180M A	26/AZ 20-800
16625	405	HZ 1180M A	26/AZ 20-800-10/10
16670	438	HZ 1080M D	24/AZ 26
16700	425	HZ 1180M B	24/AZ 28-750
16720	401	HZ 1180M A	26/AZ 13-770
16740	407	HZ 1180M A	26/AZ 14-770-10/10
16755	431	HZ 1180M B	24/AZ 30-750
16765	412	HZ 1180M A	26/AZ 25-800
16810	411	HZ 1080M D	26/AZ 28-750
16810	420	HZ 1180M B	24/AZ 13-700
16810	438	HZ 1180M B	24/AZ 32-750
16815	423	HZ 1180M B	24/AZ 13-700-10/10
16850	421	HZ 1180M C	24/AZ 20-800
16865	417	HZ 1080M D	26/AZ 30-750
16870	424	HZ 1180M C	24/AZ 20-800-10/10
16895	405	HZ 1080M D	26/AZ 13-700
16905	408	HZ 1080M D	26/AZ 13-700-10/10
16925	423	HZ 1080M D	26/AZ 32-750
16950	411	HZ 1080M C	26/AZ 18-10/10
16985	421	HZ 1180M C	24/AZ 13-770
16990	422	HZ 1180M B	24/AZ 18-700
17005	426	HZ 1180M C	24/AZ 14-770-10/10
17010	431	HZ 1180M C	24/AZ 25-800
17020	428	HZ 1180M B	24/AZ 20-700
17085	408	HZ 1080M D	26/AZ 18-700
17120	413	HZ 1080M D	26/AZ 20-700
17160	428	HZ 1080M C	26/AZ 26
17200	411	HZ 1180M B	26/AZ 20-800
17215	444	HZ 1180M B	24/AZ 26-700
17225	414	HZ 1180M B	26/AZ 20-800-10/10
17285	439	HZ 1180M A	24/AZ 18-10/10
17325	430	HZ 1080M D	26/AZ 26-700
17335	411	HZ 1180M B	26/AZ 13-770
17355	417	HZ 1180M B	26/AZ 14-770-10/10
17365	422	HZ 1180M B	26/AZ 25-800
17485	456	HZ 1180M A	24/AZ 26
17495	435	HZ 1180M D	24/AZ 20-800
17515	438	HZ 1180M D	24/AZ 20-800-10/10
17530	427	HZ 1180M A	26/AZ 28-750
17585	434	HZ 1180M A	26/AZ 30-750
17640	440	HZ 1180M A	26/AZ 32-750
17645	435	HZ 1180M D	24/AZ 13-770
17650	423	HZ 1180M A	26/AZ 13-700
17650	446	HZ 1180M D	24/AZ 25-800
17660	426	HZ 1180M A	26/AZ 13-700-10/10
17665	441	HZ 1180M D	24/AZ 14-770-10/10
17775	447	HZ 1180M C	24/AZ 28-750
17830	453	HZ 1180M C	24/AZ 30-750
17835	425	HZ 1180M A	26/AZ 18-700
17870	431	HZ 1180M A	26/AZ 20-700
17885	460	HZ 1180M C	24/AZ 32-750
17935	443	HZ 1180M C	24/AZ 13-700
17940	446	HZ 1180M C	24/AZ 13-700-10/10
17975	450	HZ 1180M B	24/AZ 18-10/10
18075	447	HZ 1180M A	26/AZ 26-700
18080	434	HZ 1080M D	26/AZ 18-10/10
18110	445	HZ 1180M C	24/AZ 18-700
18145	451	HZ 1180M C	24/AZ 20-700
18150	438	HZ 1180M B	26/AZ 28-750
18175	467	HZ 1180M B	24/AZ 26
18210	444	HZ 1180M B	26/AZ 30-750
18265	450	HZ 1180M B	26/AZ 32-750
18285	452	HZ 1080M D	26/AZ 26
18300	433	HZ 1180M B	26/AZ 13-700
18310	436	HZ 1180M B	26/AZ 13-700-10/10
18340	467	HZ 1180M C	24/AZ 26-700
18430	436	HZ 1180M C	26/AZ 20-800
18440	462	HZ 1180M D	24/AZ 28-750
18450	439	HZ 1180M C	26/AZ 20-800-10/10
18490	435	HZ 1180M B	26/AZ 18-700
18495	468	HZ 1180M D	24/AZ 30-750
18520	441	HZ 1180M B	26/AZ 20-700
18550	475	HZ 1180M D	24/AZ 32-750
18590	446	HZ 1180M C	26/AZ 25-800
18595	436	HZ 1180M C	26/AZ 13-770
18615	442	HZ 1180M C	26/AZ 14-770-10/10
18630	459	HZ 1180M D	24/AZ 13-700
18635	462	HZ 1180M D	24/AZ 13-700-10/10
18725	457	HZ 1180M B	26/AZ 26-700
18805	461	HZ 1180M D	24/AZ 18-700
18840	467	HZ 1180M D	24/AZ 20-700
18875	452	HZ 1180M A	26/AZ 18-10/10
19035	483	HZ 1180M D	24/AZ 26-700
19065	450	HZ 1180M D	26/AZ 20-800
19080	470	HZ 1180M A	26/AZ 26
19085	453	HZ 1180M D	26/AZ 20-800-10/10
19170	474	HZ 1180M C	24/AZ 18-10/10
19225	461	HZ 1180M D	26/AZ 25-800
19240	451	HZ 1180M D	26/AZ 13-770
19260	456	HZ 1180M D	26/AZ 14-770-10/10
19365	492	HZ 1180M C	24/AZ 26
19425	463	HZ 1180M C	26/AZ 28-750
19480	469	HZ 1180M C	26/AZ 30-750
19540	476	HZ 1180M C	26/AZ 32-750
19565	464	HZ 1180M B	26/AZ 18-10/10
19630	460	HZ 1180M C	26/AZ 13-700
19640	462	HZ 1180M C	26/AZ 13-700-10/10
19775	481	HZ 1180M B	26/AZ 26
19815	462	HZ 1180M C	26/AZ 18-700
19850	468	HZ 1180M C	26/AZ 20-700
19905	491	HZ 1180M D	24/AZ 18-10/10
20050	484	HZ 1180M C	26/AZ 26-700
20080	478	HZ 1180M D	26/AZ 28-750
20100	508	HZ 1180M D	24/AZ 26
20135	484	HZ 1180M D	26/AZ 30-750
20195	491	HZ 1180M D	26/AZ 32-750
20320	475	HZ 1180M D	26/AZ 13-700
20325	478	HZ 1180M D	26/AZ 13-700-10/10
20500	477	HZ 1180M D	26/AZ 18-700
20535	483	HZ 1180M D	26/AZ 20-700
20735	499	HZ 1180M D	26/AZ 26-700
20975	492	HZ 1180M C	26/AZ 18-10/10
21180	509	HZ 1180M C	26/AZ 26
21705	508	HZ 1180M D	26/AZ 18-10/10
21905	526	HZ 1180M D	26/AZ 26


EBSARY

Trademarks
ArcelorMittal is the owner of following trademark applications or registered trademarks:
"AS 500", "AU", "AZ", "GU", "HZ", "PU", "AMLoCor", "AKILA", "Seline", "Beltan", "ROXAN", "Arcoseal", "XCarb", "EcoSheetPile".
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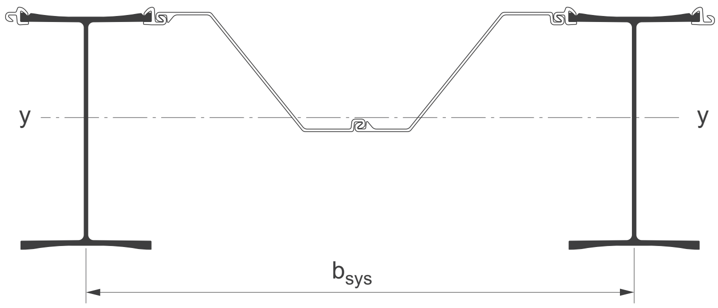
Combination 12



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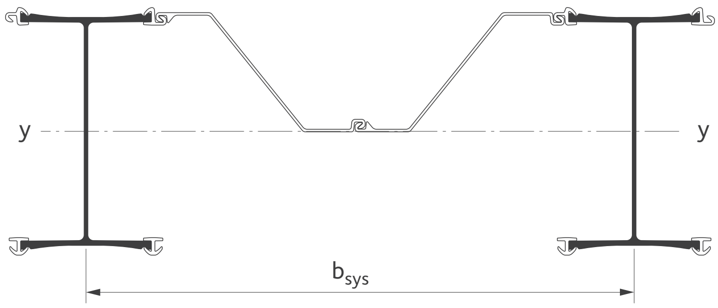

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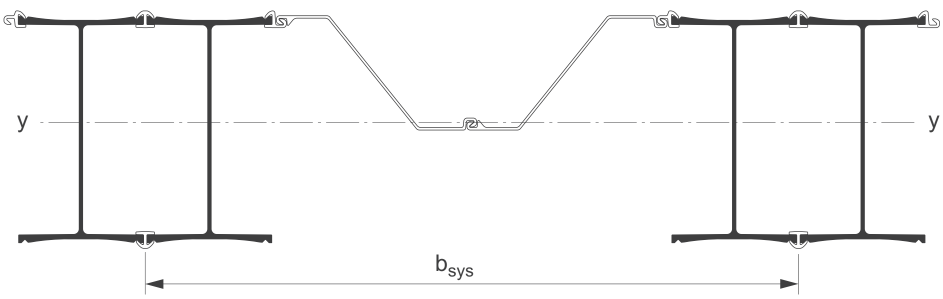

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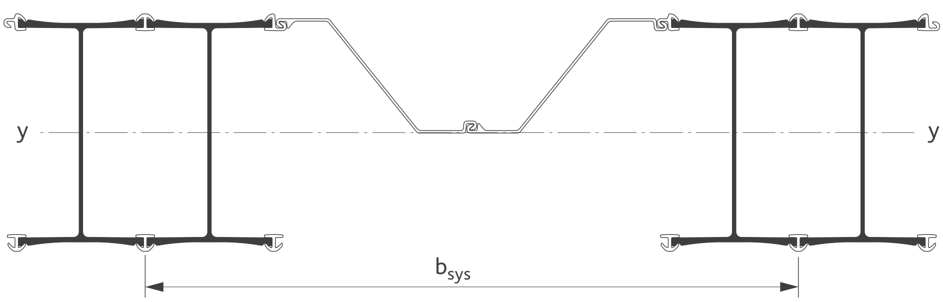

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