# Combined wall structures

## Quick design tables

Combined wall is a retaining wall solution when high horizontal or vertical bearing resistance is required. A combined wall combines pipes (primary elements) with intermediate sheet piles (secondary elements). Pre-calculated tables in this manual offer an easy and quick way to select a combined wall structure with adequate resistance for project.

**Applications:**
- harbor quay walls
- structures under combined lateral and vertical loads

# Combined wall with tubular piles

SSAB supplies spirally welded tubular piles from its mill in Oulainen (FI) delivered with EN 10219 certification and ETA approval as bearing piles. Spirally welded piles can be delivered with diameters up to 1220 mm, wall thickness up to 22 mm and length up to 41 m without splice welding. Longer piles can be spliced by welding in factory conditions.

Tubular piles are available in numerous European steel grades. Most used steel grades, their chemical compositions and mechanical properties are presented in Table 1. Steel and coils are produced in SSAB's own steel mill in Raahe (FI). The piles can be coated on request and are provided with connectors upon customer's need. Most often used connector types are E21 and E22. Tubular piles are the main retaining elements of the combined wall, carrying horizontal loads from soil and water pressures and vertical loads from above structures. The intermediate sheet piles can be either U-type or Z-type. Sheet piles transfer horizontal loads to the tubular piles. The tables below give an overview of some of the possible combined wall systems. The tables are valid for E21 connectors.

### Equivalent moment of inertia and elastic section modulus of combined wall

The design of combined walls is based on guidelines given in EN 1993-5 and it's based on functionality of primary and secondary elements:

- The primary elements act as retaining elements against the earth and water pressures and may act as bearing piles for vertical loads.
- The secondary elements only fill the gap between the primary elements and transmit the loads resulting from earth and water pressures to the primary elements.

This leads to following equations:

$$I_{sys} = \frac{I_{primary\ element}}{b_{sys}}$$

$$W_{sys} = \frac{W_{primary\ element}}{b_{sys}}$$

### Design resistances in tables

Design resistances in Tables 2 to 6 are calculated by using following partial factors.

$\gamma_{M0}$ = 1.00
$\gamma_{M1}$ = 1.10 / 1.20

These partial factors are recommended values given in EN 1993-5 for piling and in EN 1993-6 for local buckling. The value 1.2 for $\gamma_{M1}$ is used according to strong recommendation from CEN/TC250 (November 22nd 2024) in situations where the value of relative slenderness $\lambda_x$ is between $\lambda_{x0}$ and $\lambda_{xp}$. If appropriate National Annex has different values for partial factors, the resistance values in tables should be modified accordingly.

### Local buckling of primary piles belonging to cross-section class 4

For primary piles belonging to cross-section class 4 the local buckling resistance has been checked according to EN 1993-1-6. In tables this value is given as primary value. For piles belonging to cross-section class 4 also elastic bending resistance has been given in brackets [ ] as secondary value. Elastic bending resistance can be used if piles meet the requirements given in EN 1993-5 clause 5.5.4(9).

### Effect of intermediate sheet piles for the bending resistance of the combined wall

Since sheet piles only fill the gap between primary elements, only the width of the sheet piles has influence on the resistance of the combined wall. Change of width of sheet piles changes the $b_{sys}$ value. Even if sheet piles to be used have different thicknesses than the ones given in tables, the resistance of the wall remains the same. In such situations only given weight values $G_{60\%}$ and $G_{100\%}$ are changing.

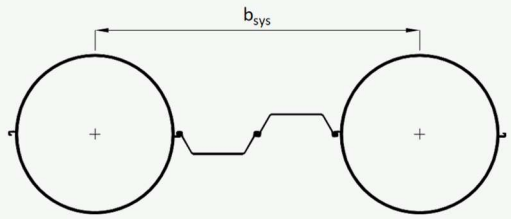
### Calculation tool for retaining walls

SSAB PileWallCalc can be used to calculate the structural resistances of combined walls and other types of retaining walls. The tool allows project specific variations such as changing the connector type and inputting different corrosion allowances.

**Table 1. Standard steel grades of SSAB's steel piles.**

| | Carbon equivalent | Chemical composition, max. | | | | Mechanical properties | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Impact strength | |
| Steel grade | CEV max. [%] | C [%] | Mn [%] | P [%] | S [%] | $f_y$ min [MPa] | $f_u$ [MPa] | $A_5$ min [%] | T * [°C] | KV min [J] |
| **S355J2H** | 0.45 | 0.22 | 1.6 | 0.03 | 0.03 | 355 | 470-630 | 20 | -20 | 27 |
| **S440J2H** | 0.45 | 0.16 | 1.6 | 0.02 | 0.02 | 440 | 490-630 | 17 | -20 | 27 |
| **S460MH** | 0.46 | 0.16 | 1.7 | 0.035 | 0.03 | 460 | 530-720 | 17 | -20 | 40 |
| **S550J2H** | 0.47 | 0.12 | 1.9 | 0.02 | 0.02 | 550 | 605-760 | 14 | -20 | 27 |

**Table 2. Combined walls with double U sheet piles as secondary elements, width of single sheet pile 600 mm.**




$b_{sys}$: System width
$G_{60\%}$: Length of sheet piles is 60 % of length of king piles
$G_{100\%}$: Length of sheet piles is 100 % of length of king piles
$I_{sys}$: Moment of inertia of combined wall
$W_{sys,pl}$: Plastic section modulus of combined wall
$W_{sys,el}$: Elastic section modulus of combined wall
$M_{Rd}$: Design value of bending moment resistance with specified steel grade

| Primary elements | | | Secondary elements = Double VL603 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pile | $d$ | $t$ | $b_{sys}$ | $G_{60\%}$ | $G_{100\%}$ | $I_{sys}$ | $W_{sys,pl}$ | $W_{sys,el}$ | $M_{Rd,S355}$ | $M_{Rd,S440}$ | $M_{Rd,S460}$ | $M_{Rd,S550}$ |
| | [mm] | [mm] | [m] | [kg/m$^2$] | [kg/m$^2$] | [cm$^4$/m] | [cm$^3$/m] | [cm$^3$/m] | [kNm/m] * | [kNm/m] * | [kNm/m] * | [kNm/m] * |
| **RR400** | 406.4 | 10 | 1.652 | 110 | 144 | 14 812 | 951 | 729 | 338 | 321 | 335 | 333 [401] |
| | | 12.5 | 1.652 | 125 | 159 | 18 174 | 1 174 | 894 | 417 | 517 | 540 | 492 |
| **RR450** | 457.0 | 10 | 1.703 | 114 | 148 | 20 606 | 1 173 | 902 | 417 | 397 | 415 | 410 [496] |
| | | 12.5 | 1.703 | 130 | 163 | 25 335 | 1 451 | 1 109 | 515 | 638 | 510 | 610 |
| **RR500** | 508.0 | 10 | 1.754 | 118 | 150 | 27 663 | 1 414 | 1 089 | 387 | 397 [479] | 414 [501] | 493 [599] |
| | | 12.5 | 1.754 | 135 | 167 | 34 068 | 1 750 | 1 341 | 621 | 590 | 617 | 612 [738] |
| | | 14.2 | 1.754 | 147 | 179 | 38 312 | 1 975 | 1 508 | 701 | 869 | 694 | 830 |
| | | 16 ** | 1.754 | 159 | 191 | 42 708 | 2 209 | 1 681 | 784 | 972 | 1 016 | |
| **RR550** | 559.0 | 10 | 1.805 | 122 | 153 | 36 012 | 1 670 | 1 288 | 457 | 468 [567] | 489 [593] | 580 [709] |
| | | 12.5 | 1.805 | 140 | 171 | 44 411 | 2 069 | 1 589 | 734 | 699 | 731 | 723 [874] |
| | | 14.2 | 1.805 | 153 | 184 | 49 989 | 2 336 | 1 789 | 829 | 787 | 823 | 816 [984] |
| | | 16 ** | 1.805 | 166 | 197 | 55 780 | 2 614 | 1 996 | 928 | 1 150 | 1 203 | |
| **RR600** | 610.0 | 10 | 1.856 | 125 | 156 | 45 715 | 1 940 | 1 499 | 440 [532] | 542 [659] | 566 [689] | 671 [824] |
| | | 12.5 | 1.856 | 145 | 175 | 56 441 | 2 405 | 1 851 | 657 | 675 [814] | 705 [851] | 839 [1018] |
| | | 14.2 | 1.856 | 158 | 188 | 63 580 | 2 716 | 2 085 | 964 | 917 | 959 | 950 [1147] |
| | | 16 | 1.856 | 172 | 202 | 71 003 | 3 042 | 2 328 | 1 080 | 1 024 | 1 071 | 1 280 |
| | | 18 | 1.856 | 187 | 218 | 79 090 | 3 400 | 2 593 | 1 207 | 1 496 | 1 564 | 1 426 |
| **RR650** | 660.0 | 10 | 1.906 | 128 | 158 | 56 595 | 2 217 | 1 715 | 502 [609] | 617 [755] | 644 [789] | 762 [943] |
| | | 12.5 | 1.906 | 149 | 179 | 69 940 | 2 750 | 2 119 | 752 | 771 [933] | 805 [975] | 958 [1166] |
| | | 14.2 | 1.906 | 163 | 193 | 78 837 | 3 108 | 2 389 | 848 | 1 051 | 911 [1099] | 1086 [1314] |
| | | 16 | 1.906 | 178 | 207 | 88 101 | 3 482 | 2 670 | 1 236 | 1 175 | 1 228 | 1217 [1468] |
| | | 18 | 1.906 | 194 | 223 | 98 210 | 3 893 | 2 976 | 1 382 | 1 713 | 1 369 | 1 637 |
| **RR700** | 711.0 | 10 | 1.957 | 132 | 160 | 69 137 | 2 511 | 1 945 | 567 [690] | 696 [856] | 726 [895] | 857 [1070] |
| | | 12.5 | 1.957 | 153 | 182 | 85 510 | 3 117 | 2 405 | 854 | 873 [1058] | 911 [1106] | 1082 [1323] |
| | | 14.2 | 1.957 | 168 | 197 | 96 441 | 3 523 | 2 713 | 963 | 989 [1194] | 1033 [1248] | 1229 [1492] |
| | | 16 | 1.957 | 183 | 212 | 107 838 | 3 950 | 3 033 | 1 402 | 1 335 | 1 395 | 1381 [1668] |
| | | 18 | 1.957 | 200 | 229 | 120 291 | 4 418 | 3 384 | 1 568 | 1 489 | 1 557 | 1544 [1861] |
| | | 20 | 1.957 | 217 | 246 | 132 525 | 4 881 | 3 728 | 1 733 | 2 148 | 2 245 | |

* = Design value of bending moment resistance ($M_{pl}$ for cross-section classes 1 and 2, $M_{el}$ for cross-section class 3 and value with local buckling considered in cross-section class 4) (in cross-section class 4 $M_{el}$ is shown in brackets [ ] for situations where the requirements given in EN 1993-5 clause 5.5.4(9) are fulfilled)
** = Diameter - wall thickness combination not in normal production, check availability from SSAB sales
*** = Wall thickness not in normal production, check availability from SSAB sales

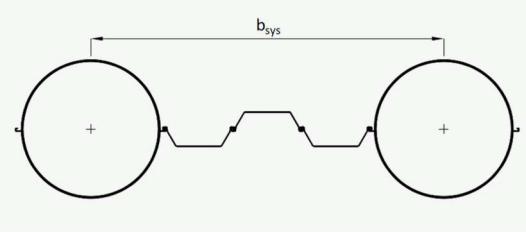
| Primary elements | | | Secondary elements = Double VL603 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pile | $d$ | $t$ | $b_{sys}$ | $G_{60\%}$ | $G_{100\%}$ | $I_{sys}$ | $W_{sys,pl}$ | $W_{sys,el}$ | $M_{Rd,S355}$ | $M_{Rd,S440}$ | $M_{Rd,S460}$ | $M_{Rd,S550}$ |
| | [mm] | [mm] | [m] | [kg/m²] | [kg/m²] | [cm⁴/m] | [cm³/m] | [cm³/m] | [kNm/m] * | [kNm/m] * | [kNm/m] * | [kNm/m] * |
| **RR750** | 762.0 | 10 | 2,008 | 134 | 163 | 83 181 | 2 816 | 2 183 | 634 [775] | 777 [961] | 809 [1004] | 953 [1201] |
| | | 12.5 | 2,008 | 157 | 185 | 102 954 | 3 497 | 2 702 | 793 [959] | 977 [1189] | 1020 [1243] | 1209 [1486] |
| | | 14.2 | 2,008 | 173 | 201 | 116 171 | 3 955 | 3 049 | 1 082 | 1109 [1342] | 1158 [1403] | 1377 [1677] |
| | | 16 | 2,008 | 189 | 217 | 129 967 | 4 435 | 3 411 | 1 211 | 1 501 | 1300 [1569] | 1549 [1876] |
| | | 18 | 2,008 | 207 | 235 | 145 058 | 4 963 | 3 807 | 1 762 | 1 675 | 1 751 | 1735 [2094] |
| | | 20 | 2,008 | 224 | 252 | 159 902 | 5 485 | 4 197 | 1 947 | 1 847 | 1 931 | |
| **RR800** | 813.0 | 10 | 2,059 | 137 | 165 | 98 768 | 3 132 | 2 430 | 702 [863] | 858 [1069] | 894 [1118] | 1049 [1336] |
| | | 12.5 | 2,059 | 161 | 188 | 122 322 | 3 891 | 3 009 | 881 [1068] | 1084 [1324] | 1131 [1384] | 1339 [1655] |
| | | 14.2 | 2,059 | 177 | 204 | 138 084 | 4 401 | 3 397 | 1 206 | 1232 [1495] | 1287 [1563] | 1528 [1868] |
| | | 16 | 2,059 | 194 | 221 | 154 552 | 4 937 | 3 802 | 1 350 | 1385 [1673] | 1447 [1749] | 1721 [2091] |
| | | 18 | 2,059 | 212 | 240 | 172 584 | 5 526 | 4 246 | 1 962 | 1 868 | 1 953 | 1931 [2335] |
| | | 20 | 2,059 | 231 | 258 | 190 340 | 6 110 | 4 682 | 2 169 | 2 060 | 2 154 | |
| | | 21 *** | 2,059 | 240 | 268 | 199 115 | 6 399 | 4 898 | 2 272 | 2 155 | 2 253 | |
| | | 22 *** | 2,059 | 250 | 277 | 207 822 | 6 687 | 5 112 | 2 374 | 2 942 | 2 352 | |
| **RR900** | 914.0 | 10 | 2,160 | 142 | 168 | 134 327 | 3 784 | 2 939 | 841 [1043] | 1022 [1293] | 1063 [1352] | 1240 [1617] |
| | | 12.5 | 2,160 | 168 | 194 | 166 532 | 4 703 | 3 644 | 1061 [1294] | 1301 [1603] | 1357 [1676] | 1600 [2004] |
| | | 14.2 | 2,160 | 185 | 211 | 188 122 | 5 323 | 4 116 | 1206 [1461] | 1484 [1811] | 1549 [1894] | 1833 [2264] |
| | | 16 | 2,160 | 203 | 229 | 210 714 | 5 974 | 4 611 | 1 637 | 1673 [2029] | 1747 [2121] | 2074 [2536] |
| | | 18 | 2,160 | 223 | 249 | 235 493 | 6 691 | 5 153 | 1 829 | 1877 [2267] | 1961 [2370] | 2333 [2834] |
| | | 20 | 2,160 | 243 | 269 | 259 936 | 7 402 | 5 688 | 2 628 | 2 503 | 2 616 | |
| | | 21 *** | 2,160 | 253 | 279 | 272 032 | 7 754 | 5 953 | 2 753 | 2 619 | 2 738 | |
| | | 22 *** | 2,160 | 263 | 289 | 284 045 | 8 106 | 6 215 | 2 877 | 2 735 | 2 859 | |
| **RR1000** | 1016.0 | 12.5 | 2,262 | 174 | 199 | 219 329 | 5 565 | 4 318 | 1248 [1533] | 1525 [1900] | 1589 [1986] | 1865 [2375] |
| | | 14.2 | 2,262 | 192 | 217 | 247 905 | 6 301 | 4 880 | 1423 [1732] | 1746 [2147] | 1821 [2245] | 2148 [2684] |
| | | 16 | 2,262 | 212 | 237 | 277 842 | 7 074 | 5 469 | 1604 [1942] | 1974 [2407] | 2060 [2516] | 2439 [3008] |
| | | 18 | 2,262 | 233 | 258 | 310 722 | 7 927 | 6 117 | 2 171 | 2220 [2691] | 2318 [2814] | 2753 [3364] |
| | | 20 | 2,262 | 255 | 280 | 343 202 | 8 772 | 6 756 | 2 398 | 2461 [2973] | 2571 [3108] | |
| | | 21 *** | 2,262 | 265 | 290 | 359 293 | 9 193 | 7 073 | 2 511 | 2580 [3112] | 2695 [3253] | |
| | | 22 *** | 2,262 | 276 | 301 | 375 286 | 9 611 | 7 388 | 3 412 | 3 251 | 2818 [3398] | |
| **RR1200** | 1220.0 | 12.5 | 2,466 | 185 | 208 | 350 497 | 7 391 | 5 746 | 1630 [2040] | 1975 [2528] | 2053 [2643] | 2385 [3160] |
| | | 14.2 | 2,466 | 206 | 228 | 396 498 | 8 373 | 6 500 | 1870 [2307] | 2280 [2860] | 2374 [2990] | 2778 [3575] |
| | | 16 | 2,466 | 227 | 250 | 444 778 | 9 406 | 7 291 | 2118 [2588] | 2594 [3208] | 2703 [3354] | 3182 [4010] |
| | | 18 | 2,466 | 251 | 274 | 497 909 | 10 547 | 8 162 | 2387 [2898] | 2933 [3591] | 3059 [3755] | 3616 [4489] |
| | | 20 | 2,466 | 274 | 297 | 550 505 | 11 680 | 9 025 | 2650 [3204] | 3264 [3971] | 3407 [4151] | |
| | | 21 *** | 2,466 | 286 | 309 | 576 603 | 12 244 | 9 453 | 3 356 | 3427 [4159] | 3578 [4348] | |
| | | 22 *** | 2,466 | 298 | 321 | 602 568 | 12 805 | 9 878 | 3 507 | 3588 [4346] | 3747 [4544] | |

* = Design value of bending moment resistance ($M_{pl}$ for cross-section classes 1 and 2, $M_{el}$ for cross-section class 3 and value with local buckling considered in cross-section class 4) (in cross-section class 4 $M_{el}$ is shown in brackets [ ] for situations where the requirements given in EN 1993-5 clause 5.5.4(9) are fulfilled)

** = Diameter - wall thickness combination not in normal production, check availability from SSAB sales

*** = Wall thickness not in normal production, check availability from SSAB sales

## Table 3. Combined walls with triple U sheet piles as secondary elements, width of single sheet pile 600 mm.




$b_{sys}$: System width
$G_{60\%}$: Length of sheet piles is 60 % of length of king piles
$G_{100\%}$: Length of sheet piles is 100 % of length of king piles
$I_{sys}$: Moment of inertia of combined wall
$W_{sys,pl}$: Plastic section modulus of combined wall
$W_{sys,el}$: Elastic section modulus of combined wall
$M_{Rd}$: Design value of bending moment resistance with specified steel grade

| Primary elements | | | Secondary elements = Triple VL603 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pile | $d$ | $t$ | $b_{sys}$ | $G_{60\%}$ | $G_{100\%}$ | $I_{sys}$ | $W_{sys,pl}$ | $W_{sys,el}$ | $M_{Rd,S355}$ | $M_{Rd,S440}$ | $M_{Rd,S460}$ | $M_{Rd,S550}$ |
| | [mm] | [mm] | [m] | [kg/m$^2$] | [kg/m$^2$] | [cm$^4$/m] | [cm$^3$/m] | [cm$^3$/m] | [kNm/m] * | [kNm/m] * | [kNm/m] * | [kNm/m] * |
| **RR400** | 406.4 | 10 | 2.252 | 98 | 135 | 10 867 | 698 | 535 | 248 | 235 | 246 | 244 [294] |
| | | 12.5 | 2.252 | 109 | 145 | 13 333 | 861 | 656 | 306 | 379 | 396 | 361 |
| **RR450** | 457.0 | 10 | 2.303 | 101 | 137 | 15 237 | 868 | 667 | 308 | 293 | 307 | 303 [367] |
| | | 12.5 | 2.303 | 113 | 149 | 18 734 | 1 073 | 820 | 381 | 472 | 377 | 451 |
| **RR500** | 508.0 | 10 | 2.354 | 104 | 139 | 20 612 | 1 054 | 811 | 288 | 296 [357] | 309 [373] | 367 [446] |
| | | 12.5 | 2.354 | 117 | 152 | 25 385 | 1 304 | 999 | 463 | 440 | 460 | 456 [550] |
| | | 14.2 | 2.354 | 126 | 161 | 28 547 | 1 471 | 1 124 | 522 | 647 | 517 | 618 |
| | | 16 ** | 2.354 | 135 | 170 | 31 822 | 1 646 | 1 253 | 584 | 724 | 757 | |
| **RR550** | 559.0 | 10 | 2.405 | 107 | 142 | 27 028 | 1 253 | 967 | 343 | 351 [425] | 367 [445] | 436 [532] |
| | | 12.5 | 2.405 | 121 | 155 | 33 331 | 1 553 | 1 193 | 551 | 525 | 549 | 543 [656] |
| | | 14.2 | 2.405 | 131 | 165 | 37 518 | 1 753 | 1 342 | 622 | 591 | 617 | 613 [738] |
| | | 16 ** | 2.405 | 140 | 174 | 41 864 | 1 962 | 1 498 | 697 | 863 | 903 | |
| **RR600** | 610.0 | 10 | 2.456 | 110 | 144 | 34 547 | 1 466 | 1 133 | 333 [402] | 410 [498] | 428 [521] | 507 [623] |
| | | 12.5 | 2.456 | 125 | 159 | 42 653 | 1 817 | 1 398 | 496 | 510 [615] | 533 [643] | 634 [769] |
| | | 14.2 | 2.456 | 135 | 169 | 48 047 | 2 053 | 1 575 | 729 | 693 | 725 | 718 [866] |
| | | 16 | 2.456 | 146 | 179 | 53 657 | 2 299 | 1 759 | 816 | 774 | 809 | 968 |
| | | 18 | 2.456 | 157 | 191 | 59 768 | 2 569 | 1 960 | 912 | 1 131 | 1 182 | 1 078 |
| **RR650** | 660.0 | 10 | 2.506 | 113 | 146 | 43 045 | 1 686 | 1 304 | 382 [463] | 470 [574] | 490 [600] | 580 [717] |
| | | 12.5 | 2.506 | 129 | 162 | 53 195 | 2 092 | 1 612 | 572 | 587 [709] | 613 [742] | 728 [887] |
| | | 14.2 | 2.506 | 139 | 172 | 59 961 | 2 364 | 1 817 | 645 | 799 | 693 [836] | 826 [999] |
| | | 16 | 2.506 | 151 | 183 | 67 008 | 2 649 | 2 031 | 940 | 893 | 934 | 926 [1117] |
| | | 18 | 2.506 | 163 | 196 | 74 696 | 2 961 | 2 264 | 1 051 | 1 303 | 1 041 | 1 245 |
| **RR700** | 711.0 | 10 | 2.557 | 116 | 148 | 52 914 | 1 922 | 1 488 | 434 [528] | 533 [655] | 556 [685] | 656 [819] |
| | | 12.5 | 2.557 | 132 | 164 | 65 445 | 2 385 | 1 841 | 654 | 668 [810] | 697 [847] | 828 [1013] |
| | | 14.2 | 2.557 | 144 | 176 | 73 811 | 2 697 | 2 076 | 737 | 757 [914] | 790 [955] | 941 [1142] |
| | | 16 | 2.557 | 155 | 187 | 82 534 | 3 023 | 2 322 | 1 073 | 1 022 | 1 068 | 1057 [1277] |
| | | 18 | 2.557 | 168 | 201 | 92 065 | 3 381 | 2 590 | 1 200 | 1 139 | 1 191 | 1182 [1424] |
| | | 20 | 2.557 | 181 | 214 | 101 428 | 3 736 | 2 853 | 1 326 | 1 644 | 1 718 | |

* = Design value of bending moment resistance ($M_{pl}$ for cross-section classes 1 and 2, $M_{el}$ for cross-section class 3 and value with local buckling considered in cross-section class 4) (in cross-section class 4 $M_{el}$ is shown in brackets [ ] for situations where the requirements given in EN 1993-5 clause 5.5.4(9) are fulfilled).
** = Diameter - wall thickness combination not in normal production, check availability from SSAB sales.
*** = Wall thickness not in normal production, check availability from SSAB sales.

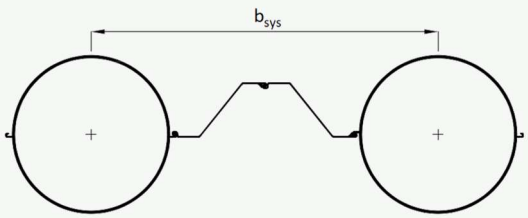
| Primary elements | | | Secondary elements = Triple VL603 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Pile | $d$ | $t$ | $b_{sys}$ | $G_{60\%}$ | $G_{100\%}$ | $I_{sys}$ | $W_{sys,pl}$ | $W_{sys,el}$ | $M_{Rd,S355}$ | $M_{Rd,S440}$ | $M_{Rd,S460}$ | $M_{Rd,S550}$ |
| | [mm] | [mm] | [m] | [kg/m²] | [kg/m²] | [cm⁴/m] | [cm³/m] | [cm³/m] | [kNm/m] * | [kNm/m] * | [kNm/m] * | [kNm/m] * |
| **RR750** | 762.0 | 10 | 2.608 | 118 | 150 | 64 045 | 2 168 | 1 681 | 488 [597] | 598 [740] | 623 [773] | 734 [925] |
| | | 12.5 | 2.608 | 136 | 167 | 79 268 | 2 693 | 2 081 | 611 [739] | 753 [915] | 785 [957] | 931 [1144] |
| | | 14.2 | 2.608 | 148 | 179 | 89 444 | 3 045 | 2 348 | 833 | 854 [1033] | 892 [1080] | 1060 [1291] |
| | | 16 | 2.608 | 160 | 192 | 100 066 | 3 415 | 2 626 | 932 | 1 156 | 1001 [1208] | 1192 [1445] |
| | | 18 | 2.608 | 174 | 205 | 111 686 | 3 821 | 2 931 | 1 357 | 1 290 | 1 348 | 1336 [1612] |
| | | 20 | 2.608 | 188 | 219 | 123 115 | 4 223 | 3 231 | 1 499 | 1 422 | 1 486 | |
| **RR800** | 813.0 | 10 | 2.659 | 121 | 152 | 76 481 | 2 425 | 1 881 | 544 [668] | 665 [828] | 692 [865] | 813 [1035] |
| | | 12.5 | 2.659 | 139 | 170 | 94 720 | 3 013 | 2 330 | 683 [827] | 840 [1025] | 876 [1072] | 1037 [1282] |
| | | 14.2 | 2.659 | 152 | 182 | 106 925 | 3 408 | 2 630 | 934 | 954 [1157] | 996 [1210] | 1183 [1447] |
| | | 16 | 2.659 | 165 | 195 | 119 677 | 3 823 | 2 944 | 1 045 | 1073 [1295] | 1120 [1354] | 1333 [1619] |
| | | 18 | 2.659 | 179 | 210 | 133 640 | 4 279 | 3 288 | 1 519 | 1 447 | 1 512 | 1495 [1808] |
| | | 20 | 2.659 | 193 | 224 | 147 390 | 4 731 | 3 626 | 1 679 | 1 595 | 1 668 | |
| | | 21 *** | 2.659 | 201 | 231 | 154 185 | 4 955 | 3 793 | 1 759 | 1 669 | 1 745 | |
| | | 22 *** | 2.659 | 208 | 239 | 160 927 | 5 178 | 3 959 | 1 838 | 2 278 | 1 821 | |
| **RR900** | 914.0 | 10 | 2.760 | 125 | 155 | 105 126 | 2 961 | 2 300 | 658 [817] | 800 [1012] | 832 [1058] | 970 [1265] |
| | | 12.5 | 2.760 | 145 | 175 | 130 329 | 3 681 | 2 852 | 831 [1012] | 1019 [1255] | 1062 [1312] | 1252 [1569] |
| | | 14.2 | 2.760 | 159 | 189 | 147 226 | 4 166 | 3 222 | 944 [1144] | 1162 [1417] | 1212 [1482] | 1435 [1772] |
| | | 16 | 2.760 | 173 | 203 | 164 906 | 4 675 | 3 608 | 1 281 | 1309 [1588] | 1367 [1660] | 1623 [1985] |
| | | 18 | 2.760 | 189 | 218 | 184 299 | 5 236 | 4 033 | 1 432 | 1469 [1774] | 1535 [1855] | 1826 [2218] |
| | | 20 | 2.760 | 204 | 234 | 203 428 | 5 793 | 4 451 | 2 056 | 1 959 | 2 048 | |
| | | 21 *** | 2.760 | 212 | 242 | 212 895 | 6 069 | 4 659 | 2 154 | 2 050 | 2 143 | |
| | | 22 *** | 2.760 | 220 | 250 | 222 296 | 6 344 | 4 864 | 2 252 | 2 140 | 2 238 | |
| **RR1000** | 1016.0 | 12.5 | 2.862 | 151 | 180 | 173 348 | 4 398 | 3 412 | 987 [1211] | 1206 [1501] | 1256 [1570] | 1474 [1877] |
| | | 14.2 | 2.862 | 166 | 194 | 195 934 | 4 980 | 3 857 | 1125 [1369] | 1380 [1697] | 1439 [1774] | 1698 [2121] |
| | | 16 | 2.862 | 181 | 210 | 219 594 | 5 591 | 4 323 | 1267 [1535] | 1560 [1902] | 1628 [1988] | 1928 [2377] |
| | | 18 | 2.862 | 198 | 226 | 245 581 | 6 265 | 4 834 | 1 716 | 1755 [2127] | 1832 [2224] | 2176 [2659] |
| | | 20 | 2.862 | 215 | 243 | 271 252 | 6 933 | 5 340 | 1 896 | 1945 [2349] | 2032 [2456] | |
| | | 21 *** | 2.862 | 223 | 252 | 283 970 | 7 265 | 5 590 | 1 984 | 2039 [2460] | 2130 [2571] | |
| | | 22 *** | 2.862 | 231 | 260 | 296 609 | 7 596 | 5 839 | 2 697 | 2 569 | 2227 [2686] | |
| **RR1200** | 1220.0 | 12.5 | 3.066 | 162 | 188 | 281 907 | 5 945 | 4 621 | 1311 [1641] | 1589 [2033] | 1651 [2126] | 1918 [2542] |
| | | 14.2 | 3.066 | 178 | 205 | 318 906 | 6 734 | 5 228 | 1504 [1856] | 1834 [2300] | 1909 [2405] | 2235 [2875] |
| | | 16 | 3.066 | 195 | 222 | 357 737 | 7 565 | 5 865 | 1704 [2082] | 2086 [2580] | 2174 [2698] | 2559 [3225] |
| | | 18 | 3.066 | 214 | 241 | 400 471 | 8 483 | 6 565 | 1920 [2331] | 2359 [2889] | 2461 [3020] | 2909 [3611] |
| | | 20 | 3.066 | 233 | 260 | 442 774 | 9 394 | 7 259 | 2131 [2577] | 2625 [3194] | 2740 [3339] | |
| | | 21 *** | 3.066 | 243 | 269 | 463 765 | 9 848 | 7 603 | 2 699 | 2756 [3345] | 2877 [3497] | |
| | | 22 *** | 3.066 | 252 | 279 | 484 649 | 10 299 | 7 945 | 2 820 | 2886 [3496] | 3013 [3655] | |

* = Design value of bending moment resistance ($M_{pl}$ for cross-section classes 1 and 2, $M_{el}$ for cross-section class 3 and value with local buckling considered in cross-section class 4) (in cross-section class 4 $M_{el}$ is shown in brackets [ ] for situations where the requirements given in EN 1993-5 clause 5.5.4(9) are fulfilled).

** = Diameter - wall thickness combination not in normal production, check availability from SSAB sales.

*** = Wall thickness not in normal production, check availability from SSAB sales.

**Table 4. Combined walls with double Z sheet piles as secondary elements, width of single sheet pile 700 mm.**




$b_{sys}$: System width
$G_{60\%}$: Length of sheet piles is 60 % of length of king piles
$G_{100\%}$: Length of sheet piles is 100 % of length of king piles
$I_{sys}$: Moment of inertia of combined wall
$W_{sys,pl}$: Plastic section modulus of combined wall
$W_{sys,el}$: Elastic section modulus of combined wall
$M_{Rd}$: Design value of bending moment resistance with specified steel grade

| Primary elements | | | Secondary elements = Double ZZ18-700 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pile | $d$ | $t$ | $b_{sys}$ | $G_{60\%}$ | $G_{100\%}$ | $I_{sys}$ | $W_{sys,pl}$ | $W_{sys,el}$ | $M_{Rd,S355}$ | $M_{Rd,S440}$ | $M_{Rd,S460}$ | $M_{Rd,S550}$ |
| | [mm] | [mm] | [m] | [kg/m$^2$] | [kg/m$^2$] | [cm$^4$/m] | [cm$^3$/m] | [cm$^3$/m] | [kNm/m] * | [kNm/m] * | [kNm/m] * | [kNm/m] * |
| **RR400** | 406.4 | 10 | 1.852 | 107 | 142 | 13 213 | 848 | 650 | 301 | 286 | 299 | 324 [358] |
| | | 12.5 | 1.852 | 119 | 155 | 16 212 | 1 047 | 798 | 372 | 461 | 482 | 439 |
| **RR450** | 457.0 | 10 | 1.903 | 110 | 145 | 18 440 | 1 050 | 807 | 373 | 355 | 371 | 400 [444] |
| | | 12.5 | 1.903 | 124 | 159 | 22 672 | 1 298 | 992 | 461 | 571 | 456 | 546 |
| **RR500** | 508.0 | 10 | 1.954 | 114 | 148 | 24 831 | 1 269 | 978 | 347 | 356 [430] | 372 [450] | 483 [538] |
| | | 12.5 | 1.954 | 129 | 163 | 30 581 | 1 571 | 1 204 | 558 | 530 | 554 | 599 [662] |
| | | 14.2 | 1.954 | 139 | 173 | 34 390 | 1 772 | 1 354 | 629 | 780 | 623 | 745 |
| | | 16 ** | 1.954 | 150 | 184 | 38 336 | 1 983 | 1 509 | 704 | 872 | 912 | |
| **RR550** | 559.0 | 10 | 2.005 | 117 | 150 | 32 420 | 1 503 | 1 160 | 412 | 421 [510] | 440 [534] | 570 [638] |
| | | 12.5 | 2.005 | 134 | 167 | 39 981 | 1 862 | 1 430 | 661 | 629 | 658 | 710 [787] |
| | | 14.2 | 2.005 | 145 | 178 | 45 003 | 2 103 | 1 610 | 746 | 708 | 741 | 802 [886] |
| | | 16 ** | 2.005 | 157 | 190 | 50 216 | 2 354 | 1 797 | 836 | 1 036 | 1 083 | |
| **RR600** | 610.0 | 10 | 2.056 | 120 | 153 | 41 268 | 1 751 | 1 353 | 397 [480] | 489 [595] | 511 [622] | 661 [744] |
| | | 12.5 | 2.056 | 138 | 170 | 50 951 | 2 171 | 1 671 | 593 | 609 [735] | 636 [768] | 827 [919] |
| | | 14.2 | 2.056 | 150 | 182 | 57 395 | 2 452 | 1 882 | 871 | 828 | 866 | 935 [1035] |
| | | 16 | 2.056 | 162 | 195 | 64 096 | 2 746 | 2 102 | 975 | 925 | 967 | 1 156 |
| | | 18 | 2.056 | 176 | 209 | 71 396 | 3 069 | 2 341 | 1 090 | 1 350 | 1 412 | 1 287 |
| **RR650** | 660.0 | 10 | 2.106 | 123 | 155 | 51 221 | 2 006 | 1 552 | 454 [551] | 559 [683] | 583 [714] | 752 [854] |
| | | 12.5 | 2.106 | 142 | 174 | 63 298 | 2 489 | 1 918 | 681 | 698 [844] | 729 [882] | 946 [1055] |
| | | 14.2 | 2.106 | 155 | 186 | 71 350 | 2 813 | 2 162 | 768 | 951 | 825 [995] | 1072 [1189] |
| | | 16 | 2.106 | 168 | 199 | 79 735 | 3 152 | 2 416 | 1 119 | 1 063 | 1 111 | 1202 [1329] |
| | | 18 | 2.106 | 183 | 214 | 88 883 | 3 524 | 2 693 | 1 251 | 1 550 | 1 239 | 1 481 |
| **RR700** | 711.0 | 10 | 2.157 | 126 | 157 | 62 727 | 2 278 | 1 764 | 515 [626] | 632 [776] | 659 [812] | 848 [970] |
| | | 12.5 | 2.157 | 146 | 177 | 77 581 | 2 828 | 2 182 | 775 | 792 [960] | 827 [1004] | 1071 [1200] |
| | | 14.2 | 2.157 | 159 | 190 | 87 499 | 3 197 | 2 461 | 874 | 897 [1083] | 937 [1132] | 1217 [1354] |
| | | 16 | 2.157 | 173 | 204 | 97 840 | 3 584 | 2 752 | 1 272 | 1 211 | 1 266 | 1366 [1514] |
| | | 18 | 2.157 | 189 | 220 | 109 138 | 4 009 | 3 070 | 1 423 | 1 351 | 1 412 | 1529 [1688] |
| | | 20 | 2.157 | 204 | 235 | 120 237 | 4 429 | 3 382 | 1 572 | 1 949 | 2 037 | |

* = Design value of bending moment resistance ($M_{pl}$ for cross-section classes 1 and 2, $M_{el}$ for cross-section class 3 and value with local buckling considered in cross-section class 4) (in cross-section class 4 $M_{el}$ is shown in brackets [ ] for situations where the requirements given in EN 1993-5 clause 5.5.4(9) are fulfilled).
** = Diameter - wall thickness combination not in normal production, check availability from SSAB sales.
*** = Wall thickness not in normal production, check availability from SSAB sales.

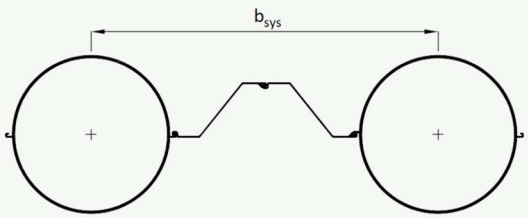
| Primary elements | | | Secondary elements = Double ZZ18-700 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pile | $d$ | $t$ | $b_{sys}$ | $G_{60\%}$ | $G_{100\%}$ | $I_{sys}$ | $W_{sys,pl}$ | $W_{sys,el}$ | $M_{Rd,S355}$ | $M_{Rd,S440}$ | $M_{Rd,S460}$ | $M_{Rd,S550}$ |
| | [mm] | [mm] | [m] | [kg/m²] | [kg/m²] | [cm⁴/m] | [cm³/m] | [cm³/m] | [kNm/m] * | [kNm/m] * | [kNm/m] * | [kNm/m] * |
| **RR750** | 762.0 | 10 | 2.208 | 129 | 159 | 75 647 | 2 561 | 1 985 | 577 [705] | 706 [874] | 736 [913] | 945 [1092] |
| | | 12.5 | 2.208 | 150 | 180 | 93 628 | 3 180 | 2 457 | 722 [872] | 889 [1081] | 928 [1130] | 1200 [1352] |
| | | 14.2 | 2.208 | 164 | 194 | 105 648 | 3 597 | 2 773 | 984 | 1008 [1220] | 1053 [1276] | 1366 [1525] |
| | | 16 | 2.208 | 178 | 208 | 118 194 | 4 033 | 3 102 | 1 101 | 1 365 | 1183 [1427] | 1537 [1706] |
| | | 18 | 2.208 | 195 | 225 | 131 919 | 4 513 | 3 462 | 1 602 | 1 523 | 1 593 | 1721 [1904] |
| | | 20 | 2.208 | 211 | 241 | 145 418 | 4 988 | 3 817 | 1 771 | 1 679 | 1 756 | |
| **RR800** | 813.0 | 10 | 2.259 | 132 | 161 | 90 024 | 2 855 | 2 215 | 640 [786] | 782 [974] | 815 [1019] | 1043 [1218] |
| | | 12.5 | 2.259 | 153 | 183 | 111 492 | 3 546 | 2 743 | 803 [974] | 988 [1207] | 1031 [1262] | 1331 [1509] |
| | | 14.2 | 2.259 | 168 | 197 | 125 859 | 4 011 | 3 096 | 1 099 | 1123 [1362] | 1173 [1424] | 1519 [1703] |
| | | 16 | 2.259 | 183 | 213 | 140 868 | 4 500 | 3 465 | 1 230 | 1262 [1525] | 1319 [1594] | 1712 [1906] |
| | | 18 | 2.259 | 200 | 230 | 157 304 | 5 037 | 3 870 | 1 788 | 1 703 | 1 780 | 1920 [2128] |
| | | 20 | 2.259 | 217 | 247 | 173 488 | 5 569 | 4 268 | 1 977 | 1 878 | 1 963 | |
| | | 21 *** | 2.259 | 226 | 255 | 181 486 | 5 833 | 4 465 | 2 071 | 1 964 | 2 054 | |
| | | 22 *** | 2.259 | 234 | 263 | 189 423 | 6 095 | 4 660 | 2 164 | 2 682 | 2 144 | |
| **RR900** | 914.0 | 10 | 2.360 | 137 | 165 | 122 944 | 3 463 | 2 690 | 769 [955] | 935 [1184] | 973 [1238] | 1238 [1480] |
| | | 12.5 | 2.360 | 160 | 188 | 152 419 | 4 305 | 3 335 | 971 [1184] | 1191 [1467] | 1242 [1534] | 1597 [1834] |
| | | 14.2 | 2.360 | 176 | 204 | 172 180 | 4 872 | 3 768 | 1104 [1338] | 1359 [1658] | 1418 [1733] | 1831 [2072] |
| | | 16 | 2.360 | 192 | 220 | 192 857 | 5 468 | 4 220 | 1 498 | 1531 [1857] | 1598 [1941] | 2071 [2321] |
| | | 18 | 2.360 | 211 | 239 | 215 536 | 6 124 | 4 716 | 1 674 | 1718 [2075] | 1795 [2170] | 2330 [2594] |
| | | 20 | 2.360 | 229 | 257 | 237 907 | 6 774 | 5 206 | 2 405 | 2 291 | 2 395 | |
| | | 21 *** | 2.360 | 238 | 266 | 248 978 | 7 097 | 5 448 | 2 520 | 2 397 | 2 506 | |
| | | 22 *** | 2.360 | 247 | 275 | 259 974 | 7 419 | 5 689 | 2 634 | 2 503 | 2 617 | |
| **RR1000** | 1016.0 | 12.5 | 2.462 | 166 | 193 | 201 512 | 5 113 | 3 967 | 1147 [1408] | 1401 [1745] | 1460 [1825] | 1869 [2182] |
| | | 14.2 | 2.462 | 183 | 210 | 227 767 | 5 789 | 4 484 | 1307 [1592] | 1604 [1973] | 1673 [2062] | 2153 [2466] |
| | | 16 | 2.462 | 201 | 228 | 255 272 | 6 499 | 5 025 | 1473 [1784] | 1813 [2211] | 1892 [2312] | 2445 [2764] |
| | | 18 | 2.462 | 220 | 247 | 285 481 | 7 283 | 5 620 | 1 995 | 2040 [2473] | 2130 [2585] | 2759 [3091] |
| | | 20 | 2.462 | 240 | 267 | 315 322 | 8 060 | 6 207 | 2 204 | 2261 [2731] | 2362 [2855] | |
| | | 21 *** | 2.462 | 250 | 277 | 330 106 | 8 446 | 6 498 | 2 307 | 2370 [2859] | 2476 [2989] | |
| | | 22 *** | 2.462 | 260 | 286 | 344 799 | 8 830 | 6 787 | 3 135 | 2 986 | 2589 [3122] | |
| **RR1200** | 1220.0 | 12.5 | 2.666 | 177 | 202 | 324 204 | 6 837 | 5 315 | 1508 [1887] | 1827 [2339] | 1899 [2445] | 2407 [2923] |
| | | 14.2 | 2.666 | 196 | 221 | 366 753 | 7 745 | 6 012 | 1730 [2134] | 2109 [2645] | 2196 [2766] | 2803 [3307] |
| | | 16 | 2.666 | 216 | 240 | 411 411 | 8 700 | 6 744 | 1959 [2394] | 2399 [2968] | 2500 [3102] | 3210 [3709] |
| | | 18 | 2.666 | 238 | 262 | 460 557 | 9 756 | 7 550 | 2208 [2680] | 2713 [3322] | 2830 [3473] | 3649 [4153] |
| | | 20 | 2.666 | 259 | 284 | 509 207 | 10 804 | 8 348 | 2451 [2963] | 3019 [3673] | 3151 [3840] | |
| | | 21 *** | 2.666 | 270 | 295 | 533 347 | 11 325 | 8 743 | 3 104 | 3170 [3847] | 3309 [4022] | |
| | | 22 *** | 2.666 | 281 | 306 | 557 365 | 11 845 | 9 137 | 3 244 | 3319 [4020] | 3466 [4203] | |

* = Design value of bending moment resistance ($M_{pl}$ for cross-section classes 1 and 2, $M_{el}$ for cross-section class 3 and value with local buckling considered in cross-section class 4) (in cross-section class 4 $M_{el}$ is shown in brackets [ ] for situations where the requirements given in EN 1993-5 clause 5.5.4(9) are fulfilled).

** = Diameter - wall thickness combination not in normal production, check availability from SSAB sales.

*** = Wall thickness not in normal production, check availability from SSAB sales.

## Table 5. Combined walls with double Z sheet piles as secondary elements, width of single sheet pile 770 mm.




$b_{sys}$: System width
$G_{60\%}$: Length of sheet piles is 60 % of length of king piles
$G_{100\%}$: Length of sheet piles is 100 % of length of king piles
$I_{sys}$: Moment of inertia of combined wall
$W_{sys,pl}$: Plastic section modulus of combined wall
$W_{sys,el}$: Elastic section modulus of combined wall
$M_{Rd}$: Design value of bending moment resistance with specified steel grade

| Primary elements | | | Secondary elements = Double ZZ14-770 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pile | $d$ | $t$ | $b_{sys}$ | $G_{60\%}$ | $G_{100\%}$ | $I_{sys}$ | $W_{sys,pl}$ | $W_{sys,el}$ | $M_{Rd,S355}$ | $M_{Rd,S440}$ | $M_{Rd,S460}$ | $M_{Rd,S550}$ |
| | [mm] | [mm] | [m] | [kg/m$^2$] | [kg/m$^2$] | [cm$^4$/m] | [cm$^3$/m] | [cm$^3$/m] | [kNm/m] * | [kNm/m] * | [kNm/m] * | [kNm/m] * |
| **RR400** | 406.4 | 10 | 1.992 | 101 | 135 | 12 285 | 789 | 605 | 280 | 266 | 278 | 276 [333] |
| | | 12.5 | 1.992 | 113 | 147 | 15 073 | 974 | 742 | 346 | 428 | 448 | 408 |
| **RR450** | 457.0 | 10 | 2.043 | 104 | 138 | 17 176 | 978 | 752 | 347 | 331 | 346 | 342 [413] |
| | | 12.5 | 2.043 | 118 | 151 | 21 118 | 1 209 | 924 | 429 | 532 | 425 | 508 |
| **RR500** | 508.0 | 10 | 2.094 | 108 | 141 | 23 171 | 1 185 | 912 | 324 | 332 [401] | 347 [420] | 413 [502] |
| | | 12.5 | 2.094 | 122 | 155 | 28 536 | 1 466 | 1 123 | 520 | 494 | 517 | 512 [618] |
| | | 14.2 | 2.094 | 132 | 165 | 32 091 | 1 654 | 1 263 | 587 | 728 | 581 | 695 |
| | | 16 ** | 2.094 | 142 | 175 | 35 773 | 1 850 | 1 408 | 657 | 814 | 851 | |
| **RR550** | 559.0 | 10 | 2.145 | 111 | 143 | 30 304 | 1 405 | 1 084 | 385 | 394 [477] | 411 [499] | 488 [596] |
| | | 12.5 | 2.145 | 127 | 159 | 37 371 | 1 741 | 1 337 | 618 | 588 | 615 | 608 [735] |
| | | 14.2 | 2.145 | 137 | 169 | 42 066 | 1 965 | 1 505 | 698 | 662 | 692 | 687 [828] |
| | | 16 ** | 2.145 | 148 | 180 | 46 938 | 2 200 | 1 679 | 781 | 968 | 1 012 | |
| **RR600** | 610.0 | 10 | 2.196 | 114 | 146 | 38 637 | 1 639 | 1 267 | 372 [450] | 458 [557] | 478 [583] | 567 [697] |
| | | 12.5 | 2.196 | 131 | 162 | 47 703 | 2 032 | 1 564 | 555 | 570 [688] | 596 [719] | 709 [860] |
| | | 14.2 | 2.196 | 142 | 173 | 53 736 | 2 296 | 1 762 | 815 | 775 | 810 | 803 [969] |
| | | 16 | 2.196 | 154 | 185 | 60 010 | 2 571 | 1 968 | 913 | 866 | 905 | 1 082 |
| | | 18 | 2.196 | 167 | 198 | 66 845 | 2 874 | 2 192 | 1 020 | 1 264 | 1 322 | 1 205 |
| **RR650** | 660.0 | 10 | 2.246 | 117 | 148 | 48 028 | 1 881 | 1 455 | 426 [517] | 524 [640] | 547 [669] | 647 [800] |
| | | 12.5 | 2.246 | 135 | 165 | 59 353 | 2 334 | 1 799 | 638 | 654 [791] | 683 [827] | 813 [989] |
| | | 14.2 | 2.246 | 147 | 177 | 66 903 | 2 637 | 2 027 | 720 | 892 | 773 [933] | 921 [1115] |
| | | 16 | 2.246 | 159 | 190 | 74 765 | 2 955 | 2 266 | 1 049 | 997 | 1 042 | 1033 [1246] |
| | | 18 | 2.246 | 173 | 203 | 83 343 | 3 304 | 2 526 | 1 173 | 1 454 | 1 162 | 1 389 |
| **RR700** | 711.0 | 10 | 2.297 | 120 | 150 | 58 904 | 2 139 | 1 657 | 483 [588] | 593 [729] | 619 [762] | 730 [911] |
| | | 12.5 | 2.297 | 139 | 169 | 72 853 | 2 655 | 2 049 | 728 | 744 [902] | 776 [943] | 922 [1127] |
| | | 14.2 | 2.297 | 151 | 181 | 82 166 | 3 002 | 2 311 | 821 | 842 [1017] | 880 [1063] | 1047 [1271] |
| | | 16 | 2.297 | 164 | 194 | 91 876 | 3 365 | 2 584 | 1 195 | 1 137 | 1 189 | 1176 [1421] |
| | | 18 | 2.297 | 179 | 209 | 102 486 | 3 764 | 2 883 | 1 336 | 1 268 | 1 326 | 1316 [1586] |
| | | 20 | 2.297 | 193 | 223 | 112 909 | 4 159 | 3 176 | 1 476 | 1 830 | 1 913 | |

* = Design value of bending moment resistance ($M_{pl}$ for cross-section classes 1 and 2, $M_{el}$ for cross-section class 3 and value with local buckling considered in cross-section class 4) (in cross-section class 4 $M_{el}$ is shown in brackets [ ] for situations where the requirements given in EN 1993-5 clause 5.5.4(9) are fulfilled).
** = Diameter - wall thickness combination not in normal production, check availability from SSAB sales.
*** = Wall thickness not in normal production, check availability from SSAB sales.

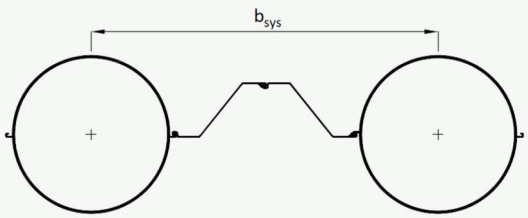
| Primary elements | | | Secondary elements = Double ZZ14-770 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pile | $d$ | $t$ | $b_{sys}$ | $G_{60\%}$ | $G_{100\%}$ | $I_{sys}$ | $W_{sys,pl}$ | $W_{sys,el}$ | $M_{Rd,S355}$ | $M_{Rd,S440}$ | $M_{Rd,S460}$ | $M_{Rd,S550}$ |
| | [mm] | [mm] | [m] | [kg/m²] | [kg/m²] | [cm⁴/m] | [cm³/m] | [cm³/m] | [kNm/m] * | [kNm/m] * | [kNm/m] * | [kNm/m] * |
| **RR750** | 762.0 | 10 | 2.348 | 123 | 152 | 71 136 | 2 409 | 1 867 | 542 [663] | 664 [822] | 692 [859] | 815 [1027] |
| | | 12.5 | 2.348 | 142 | 172 | 88 046 | 2 991 | 2 311 | 678 [820] | 836 [1017] | 872 [1063] | 1034 [1271] |
| | | 14.2 | 2.348 | 155 | 185 | 99 349 | 3 382 | 2 608 | 926 | 948 [1147] | 990 [1199] | 1177 [1434] |
| | | 16 | 2.348 | 169 | 199 | 111 147 | 3 793 | 2 917 | 1 036 | 1 284 | 1112 [1342] | 1325 [1604] |
| | | 18 | 2.348 | 185 | 214 | 124 053 | 4 244 | 3 256 | 1 507 | 1 433 | 1 498 | 1484 [1791] |
| | | 20 | 2.348 | 200 | 229 | 136 747 | 4 691 | 3 589 | 1 665 | 1 579 | 1 651 | |
| **RR800** | 813.0 | 10 | 2.399 | 126 | 154 | 84 770 | 2 688 | 2 085 | 603 [740] | 737 [918] | 767 [959] | 901 [1147] |
| | | 12.5 | 2.399 | 146 | 174 | 104 986 | 3 339 | 2 583 | 757 [917] | 931 [1136] | 971 [1188] | 1149 [1420] |
| | | 14.2 | 2.399 | 160 | 188 | 118 514 | 3 777 | 2 915 | 1 035 | 1058 [1283] | 1104 [1341] | 1311 [1604] |
| | | 16 | 2.399 | 174 | 203 | 132 648 | 4 237 | 3 263 | 1 158 | 1189 [1436] | 1242 [1501] | 1477 [1795] |
| | | 18 | 2.399 | 190 | 219 | 148 124 | 4 743 | 3 644 | 1 684 | 1 603 | 1 676 | 1658 [2004] |
| | | 20 | 2.399 | 206 | 235 | 163 364 | 5 244 | 4 019 | 1 862 | 1 768 | 1 849 | |
| | | 21 *** | 2.399 | 214 | 243 | 170 895 | 5 492 | 4 204 | 1 950 | 1 850 | 1 934 | |
| | | 22 *** | 2.399 | 222 | 251 | 178 368 | 5 739 | 4 388 | 2 037 | 2 525 | 2 018 | |
| **RR900** | 914.0 | 10 | 2.500 | 130 | 158 | 116 059 | 3 269 | 2 540 | 726 [902] | 883 [1117] | 918 [1168] | 1071 [1397] |
| | | 12.5 | 2.500 | 152 | 180 | 143 883 | 4 064 | 3 148 | 917 [1118] | 1124 [1385] | 1172 [1448] | 1382 [1732] |
| | | 14.2 | 2.500 | 167 | 195 | 162 538 | 4 599 | 3 557 | 1042 [1263] | 1282 [1565] | 1338 [1636] | 1584 [1956] |
| | | 16 | 2.500 | 183 | 210 | 182 057 | 5 162 | 3 984 | 1 414 | 1445 [1753] | 1509 [1833] | 1792 [2191] |
| | | 18 | 2.500 | 200 | 228 | 203 466 | 5 781 | 4 452 | 1 581 | 1622 [1959] | 1694 [2048] | 2016 [2449] |
| | | 20 | 2.500 | 218 | 245 | 224 584 | 6 395 | 4 914 | 2 270 | 2 162 | 2 261 | |
| | | 21 *** | 2.500 | 226 | 254 | 235 036 | 6 700 | 5 143 | 2 378 | 2 263 | 2 366 | |
| | | 22 *** | 2.500 | 235 | 262 | 245 415 | 7 003 | 5 370 | 2 486 | 2 363 | 2 470 | |
| **RR1000** | 1016.0 | 12.5 | 2.602 | 159 | 185 | 190 670 | 4 838 | 3 753 | 1085 [1332] | 1326 [1651] | 1381 [1727] | 1621 [2064] |
| | | 14.2 | 2.602 | 174 | 201 | 215 512 | 5 477 | 4 242 | 1237 [1506] | 1518 [1867] | 1583 [1951] | 1867 [2333] |
| | | 16 | 2.602 | 191 | 218 | 241 537 | 6 150 | 4 755 | 1394 [1688] | 1716 [2092] | 1790 [2187] | 2120 [2615] |
| | | 18 | 2.602 | 210 | 236 | 270 121 | 6 891 | 5 317 | 1 888 | 1930 [2340] | 2015 [2446] | 2393 [2925] |
| | | 20 | 2.602 | 228 | 255 | 298 357 | 7 626 | 5 873 | 2 085 | 2140 [2584] | 2235 [2702] | |
| | | 21 *** | 2.602 | 238 | 264 | 312 345 | 7 991 | 6 149 | 2 183 | 2243 [2705] | 2343 [2828] | |
| | | 22 *** | 2.602 | 247 | 273 | 326 247 | 8 355 | 6 422 | 2 966 | 2 826 | 2450 [2954] | |
| **RR1200** | 1220.0 | 12.5 | 2.806 | 169 | 194 | 308 028 | 6 495 | 5 050 | 1433 [1793] | 1736 [2222] | 1804 [2323] | 2096 [2777] |
| | | 14.2 | 2.806 | 187 | 212 | 348 455 | 7 358 | 5 712 | 1644 [2028] | 2004 [2513] | 2086 [2628] | 2442 [3142] |
| | | 16 | 2.806 | 206 | 231 | 390 884 | 8 266 | 6 408 | 1861 [2275] | 2280 [2819] | 2376 [2948] | 2796 [3524] |
| | | 18 | 2.806 | 227 | 251 | 437 578 | 9 269 | 7 173 | 2097 [2547] | 2578 [3156] | 2689 [3300] | 3178 [3945] |
| | | 20 | 2.806 | 248 | 272 | 483 801 | 10 265 | 7 931 | 2329 [2816] | 2869 [3490] | 2994 [3648] | |
| | | 21 *** | 2.806 | 258 | 283 | 506 737 | 10 760 | 8 307 | 2 949 | 3012 [3655] | 3144 [3821] | |
| | | 22 *** | 2.806 | 268 | 293 | 529 556 | 11 254 | 8 681 | 3 082 | 3153 [3820] | 3293 [3993] | |

* = Design value of bending moment resistance ($M_{pl}$ for cross-section classes 1 and 2, $M_{el}$ for cross-section class 3 and value with local buckling considered in cross-section class 4) (in cross-section class 4 $M_{el}$ is shown in brackets [ ] for situations where the requirements given in EN 1993-5 clause 5.5.4(9) are fulfilled).

** = Diameter - wall thickness combination not in normal production, check availability from SSAB sales.

*** = Wall thickness not in normal production, check availability from SSAB sales.

## Table 6. Combined walls with double Z sheet piles as secondary elements, width of single sheet pile 800 mm.




$b_{sys}$: System width
$G_{60\%}$: Length of sheet piles is 60 % of length of king piles
$G_{100\%}$: Length of sheet piles is 100 % of length of king piles
$I_{sys}$: Moment of inertia of combined wall
$W_{sys,pl}$: Plastic section modulus of combined wall
$W_{sys,el}$: Elastic section modulus of combined wall
$M_{Rd}$: Design value of bending moment resistance with specified steel grade

| Primary elements | | | Secondary elements = Double AZ18-800 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pile | $d$ | $t$ | $b_{sys}$ | $G_{60\%}$ | $G_{100\%}$ | $I_{sys}$ | $W_{sys,pl}$ | $W_{sys,el}$ | $M_{Rd,S355}$ | $M_{Rd,S440}$ | $M_{Rd,S460}$ | $M_{Rd,S550}$ |
| | [mm] | [mm] | [m] | [kg/m$^2$] | [kg/m$^2$] | [cm$^4$/m] | [cm$^3$/m] | [cm$^3$/m] | [kNm/m] * | [kNm/m] * | [kNm/m] * | [kNm/m] * |
| **RR400** | 406.4 | 10 | 2.052 | 98 | 132 | 11 925 | 766 | 587 | 272 | 258 | 270 | 268 [323] |
| | | 12.5 | 2.052 | 110 | 144 | 14 632 | 945 | 720 | 336 | 416 | 435 | 396 |
| **RR450** | 457.0 | 10 | 2.103 | 102 | 135 | 16 686 | 950 | 730 | 337 | 321 | 336 | 332 [402] |
| | | 12.5 | 2.103 | 115 | 148 | 20 516 | 1 175 | 898 | 417 | 517 | 413 | 494 |
| **RR500** | 508.0 | 10 | 2.154 | 105 | 138 | 22 526 | 1 152 | 887 | 315 | 323 [390] | 337 [408] | 402 [488] |
| | | 12.5 | 2.154 | 119 | 152 | 27 742 | 1 425 | 1 092 | 506 | 481 | 502 | 498 [601] |
| | | 14.2 | 2.154 | 129 | 161 | 31 197 | 1 608 | 1 228 | 571 | 707 | 565 | 676 |
| | | 16 ** | 2.154 | 139 | 171 | 34 777 | 1 799 | 1 369 | 639 | 791 | 827 | |
| **RR550** | 559.0 | 10 | 2.205 | 109 | 140 | 29 479 | 1 367 | 1 055 | 374 | 383 [464] | 400 [485] | 475 [580] |
| | | 12.5 | 2.205 | 124 | 155 | 36 355 | 1 693 | 1 301 | 601 | 572 | 598 | 592 [715] |
| | | 14.2 | 2.205 | 134 | 165 | 40 921 | 1 912 | 1 464 | 679 | 644 | 673 | 668 [805] |
| | | 16 ** | 2.205 | 145 | 176 | 45 661 | 2 140 | 1 634 | 760 | 942 | 984 | |
| **RR600** | 610.0 | 10 | 2.256 | 112 | 143 | 37 609 | 1 596 | 1 233 | 362 [438] | 446 [543] | 465 [567] | 552 [678] |
| | | 12.5 | 2.256 | 128 | 159 | 46 434 | 1 978 | 1 522 | 540 | 555 [670] | 580 [700] | 691 [837] |
| | | 14.2 | 2.256 | 139 | 170 | 52 307 | 2 235 | 1 715 | 793 | 755 | 789 | 781 [943] |
| | | 16 | 2.256 | 150 | 181 | 58 414 | 2 503 | 1 915 | 889 | 843 | 881 | 1 053 |
| | | 18 | 2.256 | 163 | 194 | 65 067 | 2 797 | 2 133 | 993 | 1 231 | 1 287 | 1 173 |
| **RR650** | 660.0 | 10 | 2.306 | 115 | 145 | 46 778 | 1 832 | 1 418 | 415 [503] | 510 [624] | 532 [652] | 630 [780] |
| | | 12.5 | 2.306 | 132 | 162 | 57 809 | 2 273 | 1 752 | 622 | 637 [771] | 666 [806] | 792 [963] |
| | | 14.2 | 2.306 | 143 | 174 | 65 162 | 2 569 | 1 975 | 701 | 869 | 753 [908] | 897 [1086] |
| | | 16 | 2.306 | 155 | 186 | 72 819 | 2 878 | 2 207 | 1 022 | 971 | 1 015 | 1006 [1214] |
| | | 18 | 2.306 | 169 | 199 | 81 174 | 3 218 | 2 460 | 1 142 | 1 416 | 1 132 | 1 353 |
| **RR700** | 711.0 | 10 | 2.357 | 118 | 147 | 57 404 | 2 085 | 1 615 | 471 [573] | 578 [710] | 603 [743] | 711 [888] |
| | | 12.5 | 2.357 | 136 | 165 | 70 998 | 2 588 | 1 997 | 709 | 725 [879] | 757 [919] | 898 [1098] |
| | | 14.2 | 2.357 | 148 | 177 | 80 074 | 2 926 | 2 252 | 800 | 821 [991] | 857 [1036] | 1021 [1239] |
| | | 16 | 2.357 | 161 | 190 | 89 537 | 3 279 | 2 519 | 1 164 | 1 108 | 1 159 | 1146 [1385] |
| | | 18 | 2.357 | 175 | 204 | 99 877 | 3 668 | 2 809 | 1 302 | 1 236 | 1 292 | 1282 [1545] |
| | | 20 | 2.357 | 189 | 218 | 110 034 | 4 053 | 3 095 | 1 439 | 1 783 | 1 864 | |

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** = Diameter - wall thickness combination not in normal production, check availability from SSAB sales.
*** = Wall thickness not in normal production, check availability from SSAB sales.

| Primary elements | | | Secondary elements = Double AZ18-800 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pile | $d$ | $t$ | $b_{sys}$ | $G_{60\%}$ | $G_{100\%}$ | $I_{sys}$ | $W_{sys,pl}$ | $W_{sys,el}$ | $M_{Rd,S355}$ | $M_{Rd,S440}$ | $M_{Rd,S460}$ | $M_{Rd,S550}$ |
| | [mm] | [mm] | [m] | [kg/m²] | [kg/m²] | [cm⁴/m] | [cm³/m] | [cm³/m] | [kNm/m] * | [kNm/m] * | [kNm/m] * | [kNm/m] * |
| RR750 | 762.0 | 10 | 2.408 | 120 | 149 | 69 364 | 2 349 | 1 821 | 529 [646] | 648 [801] | 675 [837] | 794 [1001] |
| | | 12.5 | 2.408 | 139 | 168 | 85 852 | 2 916 | 2 253 | 662 [800] | 815 [991] | 851 [1037] | 1008 [1239] |
| | | 14.2 | 2.408 | 152 | 181 | 96 873 | 3 298 | 2 543 | 903 | 925 [1119] | 966 [1170] | 1148 [1398] |
| | | 16 | 2.408 | 166 | 195 | 108 378 | 3 698 | 2 845 | 1 010 | 1 252 | 1084 [1308] | 1292 [1565] |
| | | 18 | 2.408 | 181 | 209 | 120 962 | 4 139 | 3 175 | 1 469 | 1 397 | 1 460 | 1447 [1746] |
| | | 20 | 2.408 | 195 | 224 | 133 340 | 4 574 | 3 500 | 1 624 | 1 540 | 1 610 | |
| RR800 | 813.0 | 10 | 2.459 | 123 | 151 | 82 702 | 2 622 | 2 034 | 588 [722] | 719 [895] | 749 [936] | 879 [1119] |
| | | 12.5 | 2.459 | 143 | 171 | 102 424 | 3 258 | 2 520 | 738 [894] | 908 [1109] | 947 [1159] | 1121 [1386] |
| | | 14.2 | 2.459 | 156 | 185 | 115 622 | 3 685 | 2 844 | 1 010 | 1032 [1252] | 1077 [1308] | 1279 [1564] |
| | | 16 | 2.459 | 170 | 199 | 129 411 | 4 134 | 3 184 | 1 130 | 1160 [1401] | 1211 [1464] | 1441 [1751] |
| | | 18 | 2.459 | 186 | 214 | 144 510 | 4 627 | 3 555 | 1 643 | 1 564 | 1 635 | 1617 [1955] |
| | | 20 | 2.459 | 202 | 230 | 159 378 | 5 116 | 3 921 | 1 816 | 1 725 | 1 804 | |
| | | 21 *** | 2.459 | 209 | 238 | 166 725 | 5 358 | 4 101 | 1 902 | 1 805 | 1 887 | |
| | | 22 *** | 2.459 | 217 | 245 | 174 016 | 5 599 | 4 281 | 1 988 | 2 464 | 1 969 | |
| RR900 | 914.0 | 10 | 2.560 | 128 | 155 | 113 339 | 3 192 | 2 480 | 709 [880] | 862 [1091] | 897 [1141] | 1046 [1364] |
| | | 12.5 | 2.560 | 149 | 177 | 140 511 | 3 969 | 3 075 | 895 [1091] | 1098 [1353] | 1145 [1414] | 1350 [1691] |
| | | 14.2 | 2.560 | 164 | 191 | 158 728 | 4 491 | 3 473 | 1018 [1233] | 1252 [1528] | 1307 [1598] | 1547 [1910] |
| | | 16 | 2.560 | 179 | 206 | 177 790 | 5 041 | 3 890 | 1 381 | 1411 [1712] | 1474 [1790] | 1750 [2140] |
| | | 18 | 2.560 | 196 | 223 | 198 697 | 5 646 | 4 348 | 1 543 | 1584 [1913] | 1654 [2000] | 1969 [2391] |
| | | 20 | 2.560 | 213 | 240 | 219 321 | 6 245 | 4 799 | 2 217 | 2 112 | 2 208 | |
| | | 21 *** | 2.560 | 221 | 249 | 229 527 | 6 543 | 5 022 | 2 323 | 2 210 | 2 310 | |
| | | 22 *** | 2.560 | 230 | 257 | 239 663 | 6 839 | 5 244 | 2 428 | 2 307 | 2 412 | |
| RR1000 | 1016.0 | 12.5 | 2.662 | 155 | 182 | 186 372 | 4 729 | 3 669 | 1061 [1302] | 1296 [1614] | 1350 [1688] | 1584 [2018] |
| | | 14.2 | 2.662 | 171 | 197 | 210 654 | 5 354 | 4 147 | 1209 [1472] | 1484 [1825] | 1547 [1908] | 1825 [2281] |
| | | 16 | 2.662 | 187 | 214 | 236 093 | 6 011 | 4 647 | 1363 [1650] | 1677 [2045] | 1750 [2138] | 2073 [2556] |
| | | 18 | 2.662 | 206 | 232 | 264 032 | 6 736 | 5 197 | 1 845 | 1887 [2287] | 1970 [2391] | 2339 [2859] |
| | | 20 | 2.662 | 224 | 250 | 291 632 | 7 454 | 5 741 | 2 038 | 2091 [2526] | 2184 [2641] | |
| | | 21 *** | 2.662 | 233 | 259 | 305 305 | 7 811 | 6 010 | 2 134 | 2192 [2644] | 2290 [2765] | |
| | | 22 *** | 2.662 | 242 | 268 | 318 894 | 8 167 | 6 277 | 2 899 | 2 762 | 2395 [2888] | |
| RR1200 | 1220.0 | 12.5 | 2.866 | 166 | 191 | 301 579 | 6 360 | 4 944 | 1403 [1755] | 1699 [2175] | 1766 [2274] | 2052 [2719] |
| | | 14.2 | 2.866 | 184 | 208 | 341 160 | 7 204 | 5 593 | 1609 [1985] | 1962 [2461] | 2042 [2573] | 2391 [3076] |
| | | 16 | 2.866 | 202 | 226 | 382 701 | 8 093 | 6 274 | 1822 [2227] | 2232 [2760] | 2326 [2886] | 2738 [3451] |
| | | 18 | 2.866 | 223 | 247 | 428 417 | 9 075 | 7 023 | 2054 [2493] | 2524 [3090] | 2632 [3231] | 3111 [3863] |
| | | 20 | 2.866 | 243 | 267 | 473 672 | 10 050 | 7 765 | 2280 [2757] | 2809 [3417] | 2931 [3572] | |
| | | 21 *** | 2.866 | 253 | 277 | 496 128 | 10 535 | 8 133 | 2 887 | 2949 [3579] | 3078 [3741] | |
| | | 22 *** | 2.866 | 263 | 288 | 518 470 | 11 018 | 8 500 | 3 017 | 3087 [3740] | 3224 [3910] | |

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## NOTES

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