BS EN 12063:2024



BSI Standards Publication

Execution of special geotechnical work — Sheet pile walls, combined pile walls, high modulus walls

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee B/526, Geotechnics.

A list of organizations represented on this committee can be obtained on request to its committee manager.

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Execution of special geotechnical work - Sheet pile walls, combined pile walls, high modulus walls

Exécution des travaux géotechniques spéciaux - Rideaux de palplanches, rideaux mixtes, rideaux à forte inertie

Ausführung von Arbeiten im Spezialtiefbau - Spundwandkonstruktionen

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European foreword

This document (EN 12063:2024) has been prepared by Technical Committee CEN/TC 288 “Execution of special geotechnical works”, the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by November 2024, and conflicting national standards shall be withdrawn at the latest by November 2024.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 12063:1999.

The general scope of TC 288 is the standardization of the execution procedures for geotechnical works (including testing and control methods) and of the required material properties. WG19 has been charged to revise EN 12063:1999, with the subject area of sheet pile walls.

In comparison with the previous edition EN 12063:1999, the following technical modifications have been made:

— the document has been technically revised;

— normative reference has been updated;

— all figures have been revised;

— combined pile walls, high modulus walls, synthetic sheet pile walls, precast concrete sheet pile walls and timber sheet pile walls have been added in the scope;

— execution classes have been introduced in the document;

— five new annexes were added:

  — Annex G, Additional tolerance for tubular piles;

  — Annex H, Ground movement due to installation;

  — Annex I, Precast concrete sheet piles and capping beams;

  — Annex J, Synthetic sheet piles;

  — Annex K, Percussive drilling as installation method for tubular piles.

Any feedback and questions on this document should be directed to the users’ national standards body. A complete listing of these bodies can be found on the CEN website.

According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Türkiye and the United Kingdom.

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1 Scope

This document specifies requirements, recommendations and information concerning the execution of permanent or temporary sheet pile walls, combined pile walls, high modulus wall structures and the handling of equipment and materials.

This document does not give requirements and recommendations for the installation of specific parts of the structure such as ground anchorages, displacement piles and micropiles which are covered by other documents.

This document is applicable to steel sheet pile walls, combined walls, high modulus walls, synthetic sheet pile walls (composite), precast concrete sheet pile walls and timber sheet pile walls. Tubular piles included in combined walls and high modulus walls can be filled with concrete.

Composite structures such as Berliner walls and sheet pile walls in combination with shotcrete, are not covered by this document.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 1090-2, *Execution of steel structures and aluminium structures - Part 2: Technical requirements for steel structures*

EN 1537, *Execution of special geotechnical works - Ground anchors*

EN 1992 (all parts), *Eurocodes 2: Design of concrete structures*

EN 1993-1-1, *Eurocode 3 - Design of steel structures - Part 1-1: General rules and rules for buildings*

EN 1993-5, *Eurocode 3 - Design of steel structures - Part 5: Piling*

EN 1997 (all parts), *Eurocode 7: Geotechnical design*

EN 10020, *Definition and classification of grades of steel*

EN 10079, *Definition of steel products*

EN 10219-1, *Cold formed welded structural hollow sections of non-alloy and fine grain steels - Part 1: Technical delivery conditions*

EN 10219-2, *Cold formed welded steel structural hollow sections - Part 2: Tolerances, dimensions and sectional properties*

EN 10248-1, *Hot-rolled steel sheet piles - Part 1: Technical delivery conditions*

EN 10248-2, *Hot rolled sheet piling of non alloy steels - Part 2: Tolerances on shape and dimensions*

EN 10249-1, *Cold formed sheet piling of non alloy steels - Part 1: Technical delivery conditions*

EN 10249-2, *Cold formed sheet piling of non alloy steels - Part 2: Tolerances on shape and dimensions*

EN 12699, *Execution of special geotechnical works - Displacement piles*

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EN 14199, *Execution of special geotechnical works - Micropiles*

EN 15804, *Sustainability of construction works - Environmental product declarations - Core rules for the product category of construction products*

EN 16228-1, *Drilling and foundation equipment - Safety - Part 1: Common requirements*

EN 16228-2, *Drilling and foundation equipment - Safety - Part 2: Mobile drill rigs for civil and geotechnical engineering, quarrying and mining*

EN 16228-4, *Drilling and foundation equipment - Safety - Part 4: Foundation equipment*

EN 16228-6, *Drilling and foundation equipment - Safety - Part 6: Jetting, grouting and injection equipment*

EN 16228-7, *Drilling and foundation equipment - Safety - Part 7: Interchangeable auxiliary equipment*

EN ISO 3834-3, *Quality requirements for fusion welding of metallic materials - Part 3: Standard quality requirements (ISO 3834-3:2021)*

EN ISO 3834-4, *Quality requirements for fusion welding of metallic materials - Part 4: Elementary quality requirements (ISO 3834-4:2021)*

EN ISO 5817, *Welding - Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) - Quality levels for imperfections (ISO 5817:2023)*

EN ISO 9606-1, *Qualification testing of welders - Fusion welding - Part 1: Steels (ISO 9606-1:2012 including Cor 1:2012 and Cor 2:2013)*

EN ISO 9692-1, *Welding and allied processes - Types of joint preparation - Part 1: Manual metal arc welding, gas-shielded metal arc welding, gas welding, TIG welding and beam welding of steels (ISO 9692-1:2013)*

EN ISO 9692-2, *Welding and allied processes - Joint preparation - Part 2: Submerged arc welding of steels (ISO 9692-2:2024)*

EN ISO 15607, *Specification and qualification of welding procedures for metallic materials - General rules (ISO 15607:2019)*

EN ISO 15609-1, *Specification and qualification of welding procedures for metallic materials - Welding procedure specification - Part 1: Arc welding (ISO 15609-1:2019)*

EN ISO 22477 (all parts), *Geotechnical investigation and testing - Testing of geotechnical structures (ISO 22477)*

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3 Terms and definitions and symbols

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at https://www.electropedia.org/

— ISO Online browsing platform: available at https://www.iso.org/obp

3.1 Terms and definitions

3.1.1
anchorage
anchoring system for the sheet pile wall, for example anchor plates or anchor walls including the connecting rods (tie rods), screw anchors, ground and rock anchors, and drilled anchors with grouted or expanded bodies

Note 1 to entry: Anchors can be pre-stressed (active) or not (passive).

3.1.2
auxiliary structures
structure necessary for the proper and safe execution of the sheet piling works, example, a guiding system

3.1.3
bracing
system of waling and struts to support the structure

3.1.4
combined pile wall or
combined wall
embedded retaining wall composed of primary and secondary elements

Note 1 to entry: The primary elements are normally steel tubular piles, H piles or box types, spaced uniformly along the length of the wall. The secondary elements are generally steel sheet piles of various types installed in the spaces between the primary elements and connected to them by interlocks (see Figure 1).

3.1.5
comparable experience
documented, or other clearly established information related to the ground and installation conditions, involving similar types of soil and rock and for which similar behaviour is expected

Note 1 to entry: Information gained locally is considered to be particularly relevant.

3.1.6
connector
hot rolled or fabricated device that connects adjacent piles by means of a thumb and finger or similar configuration to make a continuous wall

Note 1 to entry: Connectors perform the same function as interlocks but are fabricated separately and not as an integral part of the pile.

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3.1.7
crimping
preventing differential movement of adjacent sheet piles by locally deforming the interlock connection

Note 1 to entry: Used for shear transmission in U-shaped sheet piles and for safe handling.

3.1.8
cushion
material, fitted into a recess in the driving cap, which smooths the impact force of the falling hammer on the driving cap and on the head of the sheet pile

3.1.9
de-clutching
disconnection of the interlock connection during pile driving

3.1.10
de-clutching detector
instrument for determining the integrity of the interlock connection, that is whether adjacent pile interlocks are fully engaged during and/or after installation

3.1.11
driving
method, or combination of methods, for installing a pile into the ground to the required depth

Note 1 to entry: See EN 1993-5

EXAMPLE impact, vibrating, pressing, resonance, screwing.

3.1.12
driving assistance
method to reduce the penetration resistance during driving

EXAMPLE jetting, pre-drilling, blasting.

3.1.13
driving cap
device, placed on the top of the sheet pile which transmits the blow of the hammer evenly, thereby preventing damage of the sheet pile head

Note 1 to entry: See Figure 5.

3.1.14
driving method
method of driving such as panel driving, pitch and drive, staggered driving by means of impact, vibration, pressing or by a combination of these

3.1.15
execution class
classified set of requirements specified for the execution of the works as a whole, of an individual sheet pile or of a detail of a sheet pile

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3.1.16
ground release shackle or
quick release shackle
automatic device for safety lifting sheet piles from the ground and placing them in the vertical position

Note 1 to entry: See Annex A and Figure A.8.

3.1.17
guide frame
frame consisting of one or more stiff guide beams, normally of steel or wood, to position and maintain the alignment of sheet piles during pitching and driving

3.1.18
hammer
part of piling equipment for driving sheet piles by percussion impact

3.1.19
high modulus wall
retaining wall formed by interlocking primary steel elements that have the same geometry

Note 1 to entry: The elements can consist of fabricated profiles, see Figure 3 and Figure 4, to obtain a high section modulus.

3.1.20
interlock connection
portion of a sheet pile that connects adjacent elements by means of a thumb and finger or similar configuration to make a continuous wall

Note 1 to entry: Interlock connections for steel sheet piles can be described as:

— free: threaded interlocks that are neither crimped nor welded;

— crimped: interlocks of threaded single piles that have been mechanically connected by crimped points to form a shear connection;

— welded: interlocks of threaded single piles that have been mechanically connected by continuous or intermittent partial penetration butt welds to form a shear connection.

3.1.21
leader
beam or similar structure, attached to the driving rig, to guide the sheet pile and the hammer (or the vibrator) during driving

Note 1 to entry: See Figure 5, Figure 6 and Figure 7.

3.1.22
leader slide
guiding device connecting the drive cap and/or the hammer to the leader

Note 1 to entry: See Figure 5 and Figure 6.

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3.1.23
leading mandrel
steel template connected to the synthetic or wooden pile to be installed, to guide the alter and to loosen the ground

Note 1 to entry: See Annex J.

3.1.24
leading system
whole system to guide the sheet pile and the driving device during driving

Note 1 to entry: See Figure 7.

3.1.25
mandrel
steel template enabling the installation process of a synthetic or wooden pile

Note 1 to entry: See Annex J.

3.1.26
refusal
lack of ability of a pile to be driven further due to limitations of driving energy, elastic limit of material, or ground conditions

Note 1 to entry: Refusal criteria shall be agreed between parties and shall relate time, energy and penetration move.

3.1.27
rock dowel
rod protruding from the toe of the sheet pile, used for fixing sheet piles to the bed-rock

Note 1 to entry: See Figure 30.

3.1.28
sheet pile press
leader guided or self-walking device pushing statically the sheet piles into the ground

Note 1 to entry: See Figure 8 and Figure 9.

3.1.29
sheet pile wall
line of sheet piles that forms a continuous wall by threading of the interlocks

3.1.30
sheet pile wall structure
structure, consisting of sheet piles, ground and rock, anchorages, bracing and/or walings, which retains ground and/or water

Note 1 to entry: The elements are shown in Figure 10.

3.1.31
site investigation
investigations on and near site to verify geotechnical conditions, find out existing structures above and below ground and their foundations and possible drivability tests

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3.1.32
splice plate
steel plate which joins two lengths of sheet pile together

Note 1 to entry: See Annex B, Figure B.2.

3.1.33
steel sheet pile
product obtained by hot rolling or cold forming steel (e.g. drawing, bending, roll forming) to a shape such that, by interlocking of the joints or fitting of longitudinal grooves or by means of special fasteners, it forms partitions or continuous walls

3.1.34
straight web sheet pile
flat or slightly bend sheet pile section with interlocks, which is mainly working in tension only, generally used in circular or diaphragm cells

Note 1 to entry: See Figure 2.

3.1.35
strut
long compression member, usually of steel, wood or reinforced concrete, for the support of the sheet pile walls and normally connected to the walings

Note 1 to entry: It can be pre-stressed.

3.1.36
synthetic sheet pile
extruded sheet piles of polymer and fibres

Note 1 to entry: See Annex J.

3.1.37
template
specific type of guide frame, used for positioning curved and angled sheet pile walls

Note 1 to entry: They often incorporate a working platform or access staging for piling operators.

3.1.38
threader
device fixed to the toe of a sheet pile to guide the sheet pile into the interlock of a sheet pile already placed in the guide frame

Note 1 to entry: See Annex A and Figure A.12.

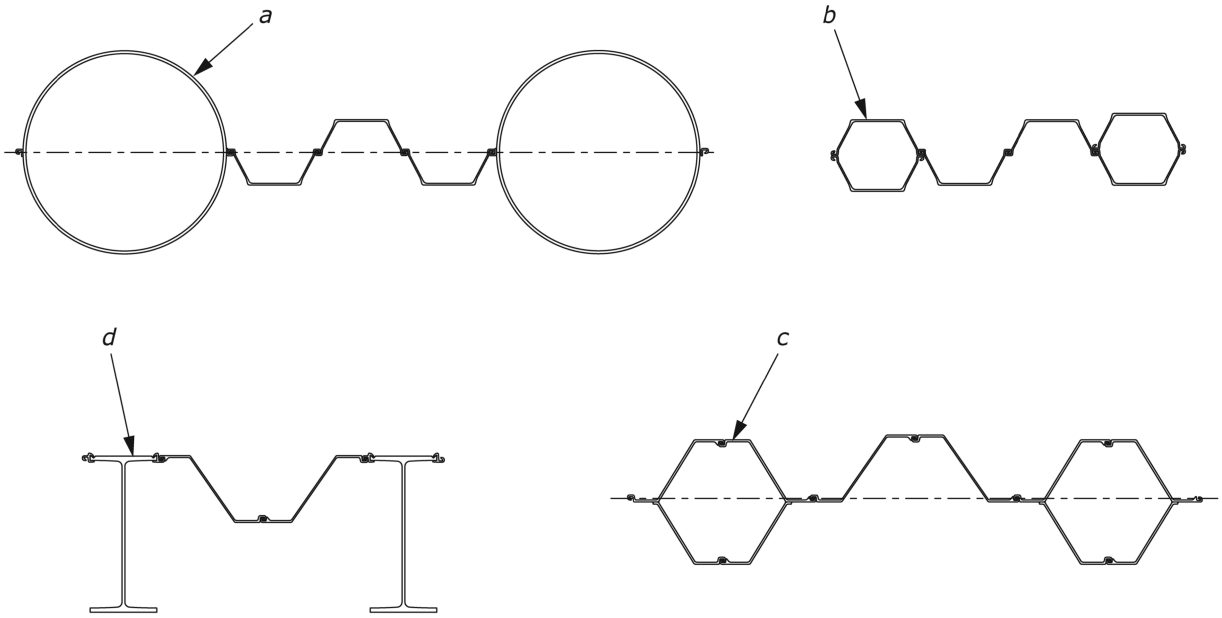
3.1.39
travelling mandrel
steel template with the same geometry as the synthetic or wooden pile to be installed, enabling the installation process

Note 1 to entry: See Figure 27 and Annex J.

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3.1.40
vibrator
vibrating unit for the driving and the extraction of the sheet piles and the primary and secondary elements of a combined wall

3.1.41
waling
horizontal beam, usually of steel or reinforced concrete, fixed to the retaining wall and used to transmit the design support force for the wall into the anchors, tension piles or struts



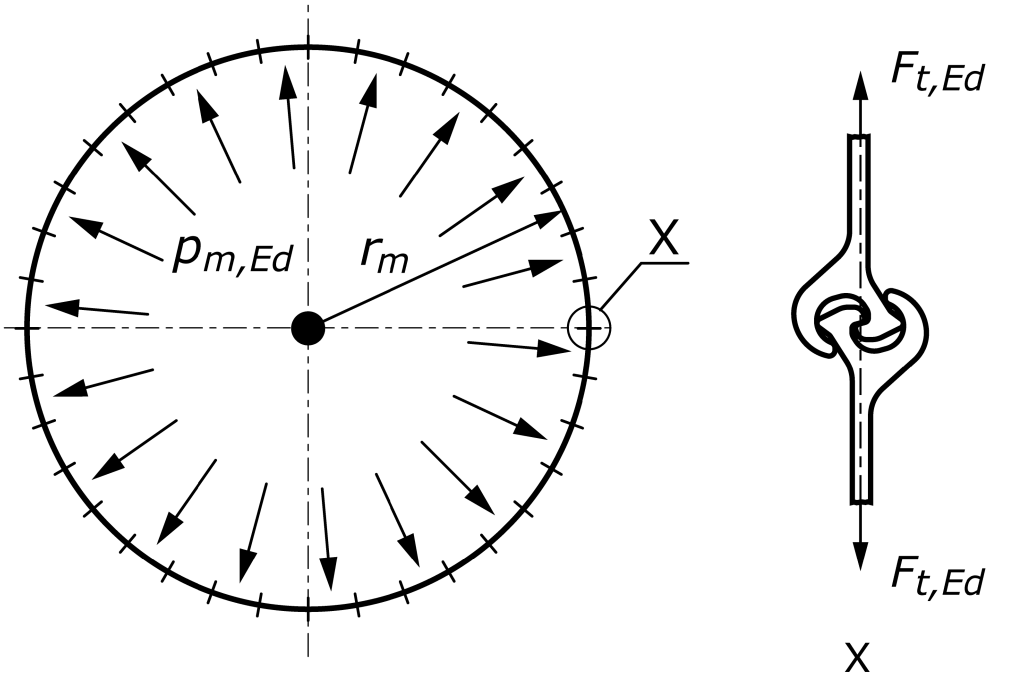
Key

a	tubes + sheet piles	c	Z box piles + Z sheet piles
b	U box piles + U sheet piles	d	H beams + Z sheet piles

Figure 1 — Examples of combined walls

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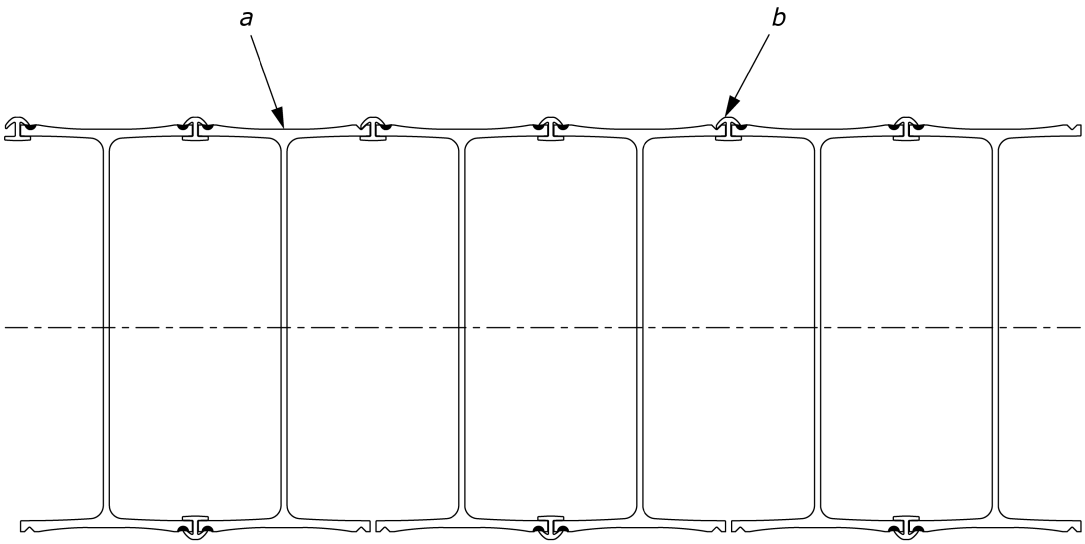
Key

r_m initial radius of the main cell in a cellular cofferdam

$P_{m,Ed}$ design value of the internal pressure acting in the main cell of a cellular cofferdam

$F_{t,Ed}$ design value of the circumferential tensile force in a cellular cofferdam

Figure 2 — Example of cell made of straight web sheet piles



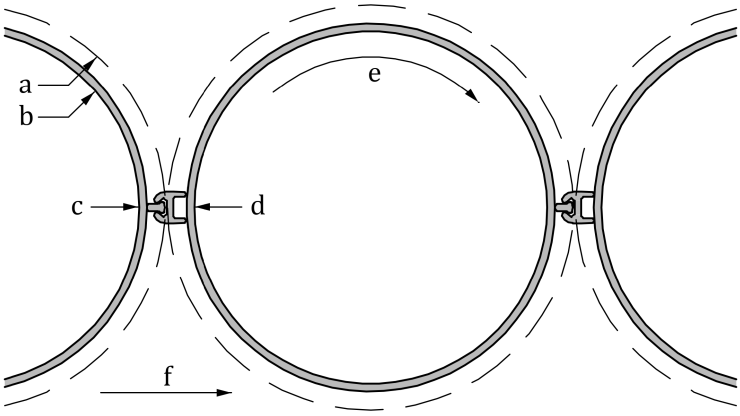
Key

a H beam

b connector welded to H beam

Figure 3 — Example of high modulus wall with H-Piles

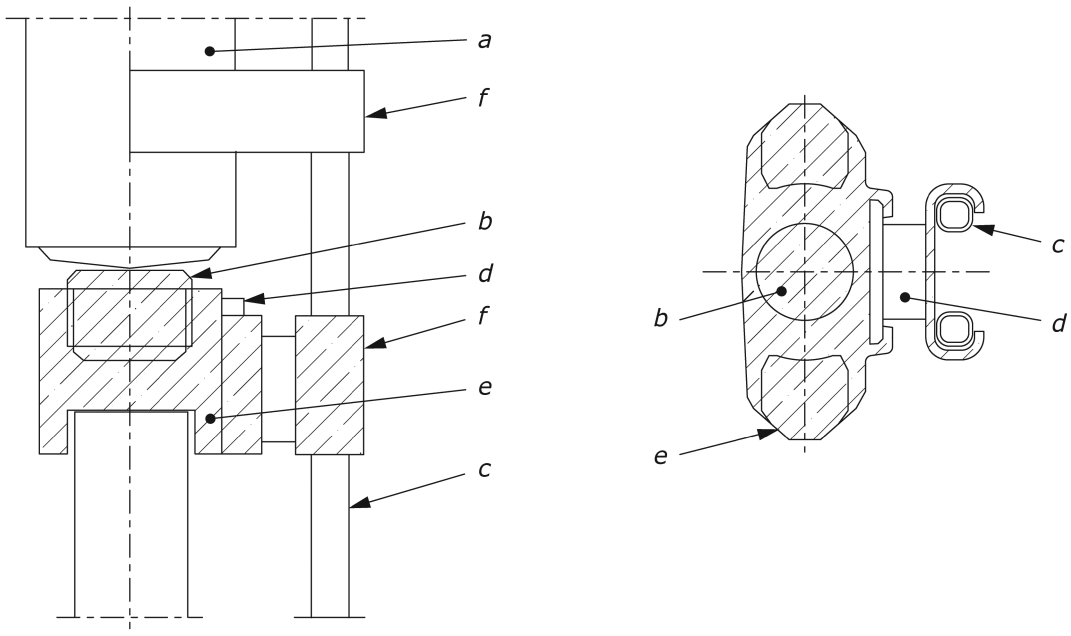
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Key

a	outer diameter of reamers	d	pile with wide connector installed second
b	non-rotating pile tube	e	rotational direction of pilot bit and reamer
c	pile with narrow connector installed first	f	direction of propagation

Figure 4 — Example of high modulus wall with tubular piles

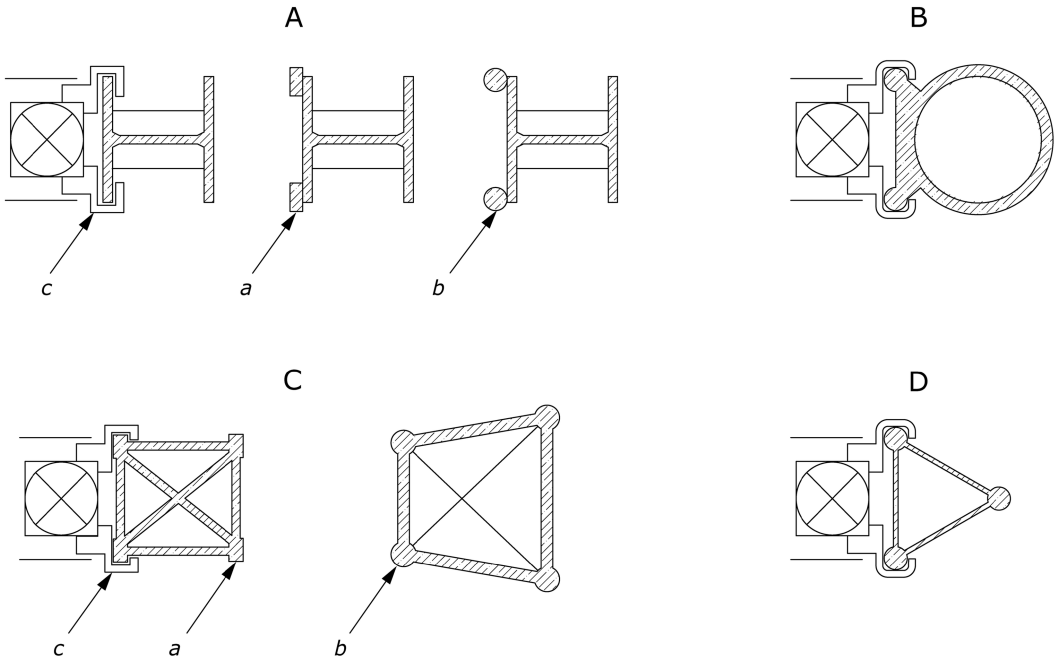


Key

a	impact hammer	*d*	sliding guide
b	cushion	*e*	driving cap
c	leader	*f*	leader slide

Figure 5 — Example of a driving cap

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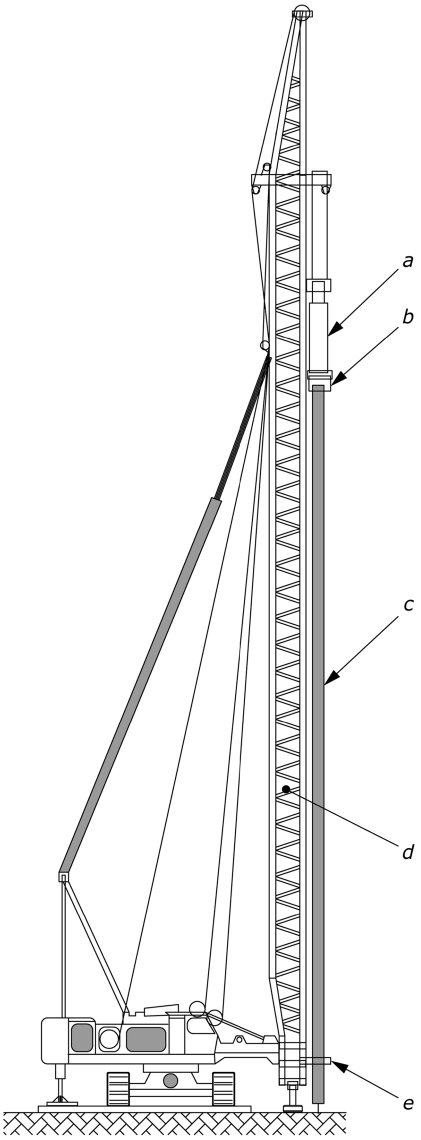


Key

A	H beam leader	a	square profile
B	tubular leader	b	round profile
C	truss leader	c	leader slide
D	triangular leader		

Figure 6 — Examples of leading systems

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Key

a	hammer	d	leader
b	driving cap	e	pile guide
c	sheet pile		

NOTE Exhaustive list of driving method is given in EN 16228-1, EN 16228-2, EN 16228-4, EN 16228-6 and EN 16228-7.

Figure 7 — Example of a sheet pile driving rig with fixed leader

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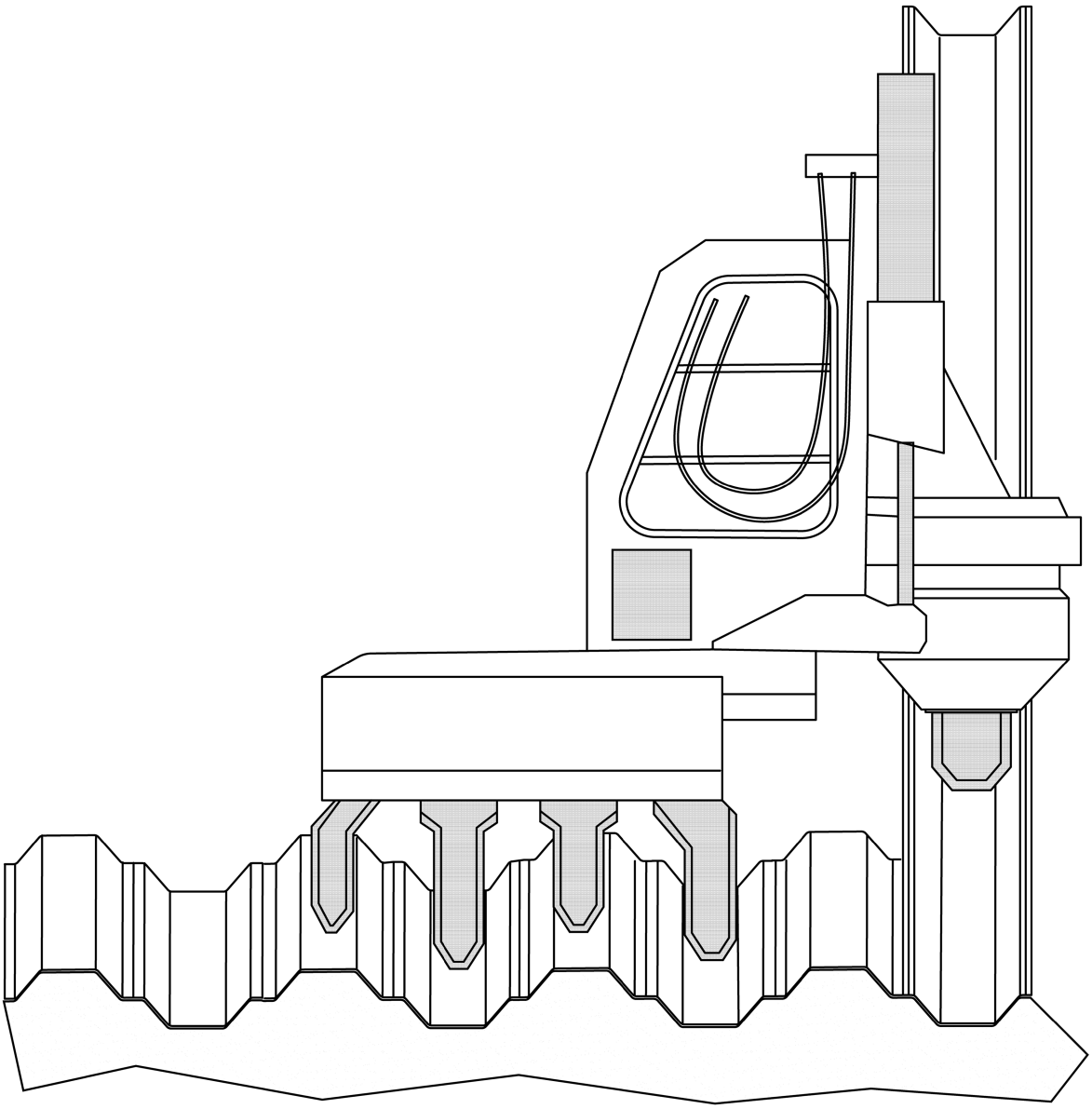


Figure 8 — Example of a self-walking press

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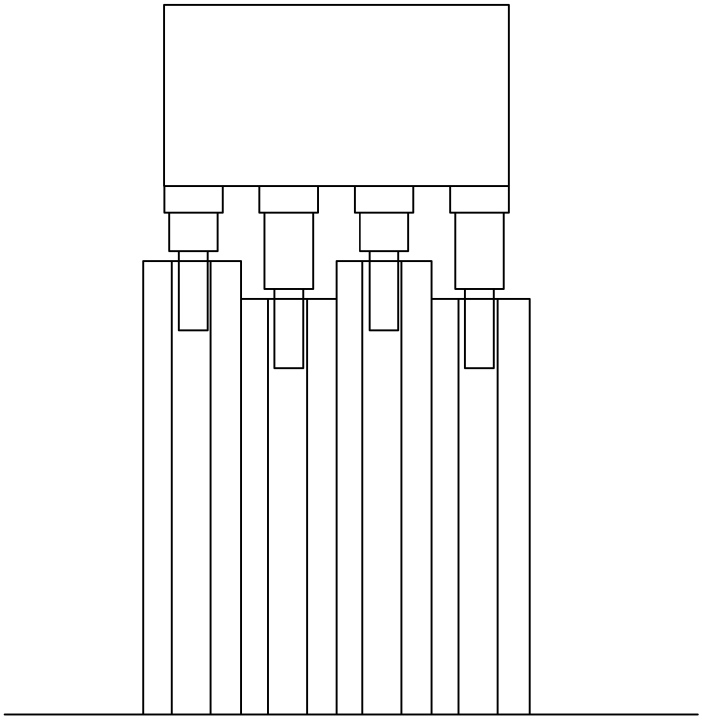
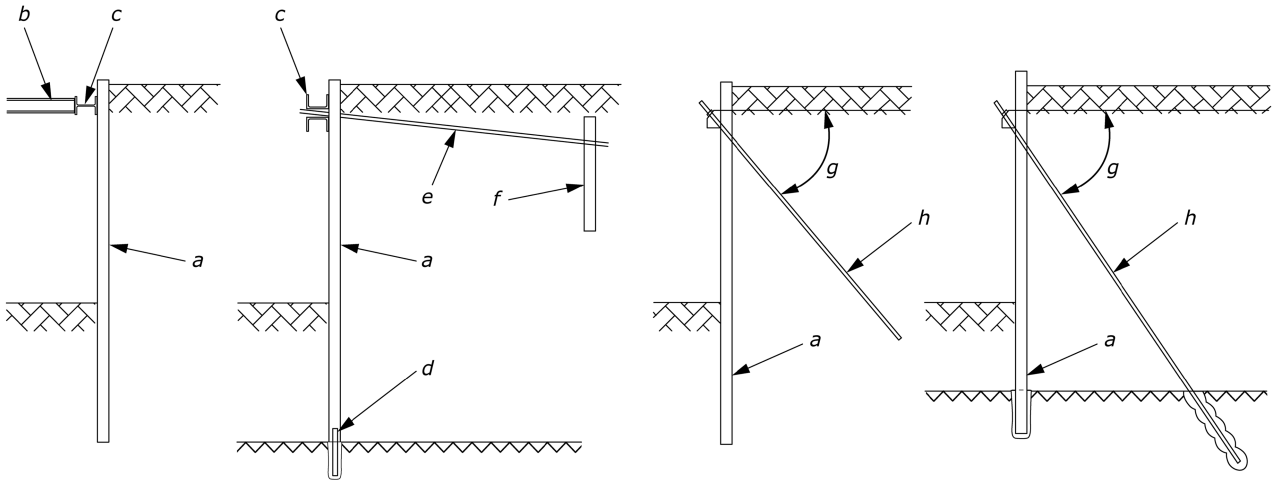


Figure 9 — Example of a leader-guided press

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Key

a	sheet piles	e	tie rod
b	strut	f	anchor plate or screen (deadman)
c	waling	g	variable angle
d	rock dowel	h	ground anchor or tension pile

Figure 10 — Examples of sheet pile wall structures

4 Information needed for the execution of the work

4.1 General information

The following information shall be made available or otherwise dealt with before the execution of the work:

— location maps of the construction site, including access roads and possible hindrances;

— level and position of fixed reference points at or near the construction site;

— limitations concerning the access for equipment and materials;

— location of all services such as electricity, telephone, water and gas supply pipes and sewers;

— geotechnical data of the construction site:

  — composition and stratification of the ground and its variation across the site;

  — strength and deformation properties of the soil and rock layers;

  — the possible presence of stones and boulders in the ground;

  — the possibility of cohesive ground adhering to the piles when extracted (see 8.11);

— hydrogeological data of the area of the construction site;

— specifications of the sheet pile walls, including all details such as type, profile, grade, protection and preservation systems and whether any fixings of the interlocks are required to ensure transmission of the longitudinal shear forces;

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— presence of sensitive buildings and/or installations near the construction site;

— restrictions concerning noise, vibrations and settlement;

— restrictions concerning driving method and driving assistance;

— restrictions regarding the permeability of the sheet pile wall for water or other fluids;

— various stages of the execution of the sheet pile wall structure required by the design;

— in the case of waterfront structures; the water levels and their fluctuations (amplitude, frequency and the cause of the fluctuations, e.g. discharge of a barrage, tide, etc.);

— data regarding possible ground contamination;

— a list of any identified specific items to be investigated (see 4.2);

— refusal criteria;

— execution class or classes (EXC), see 4.3.

4.2 Specific information

4.2.1 The following specific information shall be made available or otherwise dealt with before the beginning of the works:

— all specific design information which is required for the execution;

— restrictions related to the presence, at or near the site, of ground anchors, cathodic protection devices and similar;

— presence of unexploded munitions;

— the history of the building site: presence of foundation remnants or other artificial elements in the ground.

4.2.2 Information about the following matters should be made available or otherwise dealt with before the beginning of the work:

— special aspects particular to the project, such as corrosion and abrasion problems;

— comparable experience from works in the neighbourhood or from similar works carried out under similar conditions;

— the condition of nearby buildings, structures or installations and the nature and depth of their foundation;

— data about adverse weather conditions, for example, wind conditions and frequency;

— severe frost action in the ground, where this can lead to overstressing of the sheet pile wall.

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4.3 Execution classes

4.3.1 Four execution classes 1 to 4, denoted EXC1 to EXC4, are given, for which requirement strictness increases from EXC1 to EXC3 with EXC4 being based on EXC3 with further project specific requirements. The execution specification shall specify the relevant execution class or classes.

NOTE Provision for the selection of an appropriate execution class are given in EN 1993-1-1 and EN 1993-5.

4.3.2 In addition to the provisions for the selection of an appropriate execution class according to EN 1993-1-1 and EN 1993-5, the following provisions shall apply:

1) permanent structures should be executed in minimum EXC2;

2) if not specified, EXC2 should be applied for permanent structures and EXC1 for temporary structures.

5 Site investigation

5.1 Geotechnical investigation

5.1.1 General

5.1.1.1 The geotechnical investigation shall fulfil the requirements of EN 1997 (all parts).

NOTE Guidance is given in EN 1997-2 on the depth and the contents of investigations.

5.1.1.2 The depth and the extent of the geotechnical investigation should be sufficient to identify all ground formations and layers affecting the construction, to determine the relevant properties of the ground and to recognize the ground conditions (e.g. where end bearing is to be relied on, it should demonstrate that any competent founding stratum is not immediately underlain by a weaker stratum where there is a possibility of a punching failure or excessive movements).

5.1.1.3 Relevant experience of the execution of comparable foundation works under similar conditions and/or in the vicinity of the site should be taken into account when determining the extent of site investigation (reference to relevant experience is permitted if appropriate means of verification are taken, e.g. by penetration, pressuremeter or other tests).

5.1.1.4 When additional soil and rock data are required for the selection of driving methods, procedures, equipment, auxiliary structures etc. or for checking the execution, the investigation shall comply with EN 1997-2.

5.1.1.5 The geotechnical investigation report shall be available in time, to allow for reliable design and execution of pile walls, (e.g. the choice of method of execution).

5.1.1.6 The sufficiency of the geotechnical investigation shall be checked for the design and execution of the pile walls.

5.1.1.7 If the geotechnical investigations are not sufficient, a supplementary investigation shall be conducted.

5.2 Specific requirements

5.2.1 Particular attention shall be paid to the following aspects, which are relevant to the execution of pile walls:

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— the ground level at any point of investigation or testing relative to the recognized national datum or to a fixed reference chart datum;

— piezometric levels of all water-tables and permeability of the ground;

— presence of boulders or obstructions which can cause difficulties during driving and, an assessment of their size and frequency, when applicable;

— presence, position, strength of hard rock or other hard materials which can cause difficulties during driving and may require the use of special tools;

— presence, extent and thickness of any strata that can be sensitive to water infiltration or to stress caused by piling works (e.g. impact, percussion or vibration);

— underground strata where high ground-water velocities exist;

— detrimental chemistry of groundwater, soil and rock, and water temperatures if required;

— detrimental chemistry of waste materials;

— presence of pre-treated ground, which can have an adverse effect during excavation;

— mining beneath the site;

— site stability problems (slope stability for instance).

5.2.2 The strength of the soil and rock shall be determined by laboratory tests and/or *in situ* tests over the full depth of the sheet piles and to a certain depth below their base.

NOTE The investigation depth depends on the nature of the ground and the function of the sheet piles (foundation or retaining structure or both).

5.2.3 When pile walls are required to reach or penetrate into rock, the level of the rock surface shall be determined.

NOTE The area to investigate depends on the function of the pile wall (foundation or retaining structure or both).

5.2.4 When pile walls are required to reach or penetrate into rock, the properties of the rock, including the degree of weathering and the extent and direction of fissuring shall be assessed.

5.3 Driveability of sheet piles

5.3.1 When driveability is investigated, stiffness and slenderness of sheet piles and any restrictions in the design regarding techniques to assist driving (for instance jetting or pre-drilling) shall be taken into account.

5.3.2 When no comparable experience exists, one or more driving tests should be carried out before the sheet pile work commences.

NOTE The driving data obtained from the test is used to improve the efficiency of the driving operations and to confirm the choice of the profile. It indicates if driving assistance is necessary and what the influence on ground properties and other important matters might be. A driving test can also indicate if it is possible to use rock dowels.

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6 Materials and products

6.1 Steel sheet piles and other steel components

6.1.1 New sheet piles shall comply with EN 10248-1, EN 10248-2, EN 10249-1, EN 10249-2 and EN 10079.

6.1.2 Re-used and repurposed steel used as steel piles shall, as a minimum, comply with the requirements concerning geometrical and material properties specified in the design and shall be free from damage and deleterious matters that would affect strength and durability.

6.1.3 Tubes used for primary elements of a combined wall and high modulus walls shall comply with EN 10219-1, EN 10219-2 and Annex G.

6.1.4 Special connectors such as those shown in Figure B.4, shall comply with EN 10248-1 and EN 10248-2.

6.2 Timber sheet piles

Permanent timber sheet pile wall structures in saturated grounds shall be of a high durability class, such as tropical hard wood and impregnated pine wood (see Annex F).

6.3 Synthetic sheet piles

6.3.1 Synthetic sheet pile wall structures shall be of high ultraviolet, chemical and biological resistance.

6.3.2 Synthetic sheet piles shall comply with the national product standards, if existing.

6.4 Other materials and products

All other materials and products (including the backfill) shall meet the design specifications and relevant product standards (if any exist).

6.5 Corrosion protection for steel sheet piles and preservation of timber and synthetic sheet piles

6.5.1 Paints, coatings and other means of corrosion protection of the steel elements and the preservation treatment of timber and synthetic sheet piles, shall comply with the design specifications and relevant standards.

6.5.2 Cathodic protection can also be used to protect a steel sheet pile wall structure. Sacrificial steel (additional thickness) can be considered as a corrosion protection method. A combination of previous methods can be considered.

6.6 Sealings for interlock connections

6.6.1 Sealing materials for reducing the permeability of the interlocks shall comply with the design specifications.

6.6.2 When permeability requirements are important it should be demonstrated by full scale tests on project location and certified by third parties that the proposed product satisfies the design specifications.

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6.7 Environmental product declaration (EPD)

An EPD (Environmental Product Declaration) according to EN 15804 shall be provided by the manufacturer if requested.

7 Considerations related to design

7.1 General

7.1.1 Design of pile walls is not covered by the scope of this document, but selection of execution method may impact design.

7.1.2 All elements for pile walls structures should be designed according to:

— EN 1990 (all parts), Eurocode — Basis of structural design

— EN 1991 (all parts), Eurocode 1 — Action on structures

— EN 1992 (all parts), Eurocode 2 — Design of concrete structures

— EN 1993 (all parts), Eurocode 3 — Design of steel structures

— EN 1993-5, Eurocode 3 — Design of steel structures — Part 5: Piling

— EN 1995 (all parts), Eurocode 5 — Design of timber structures

— EN 1997 (all parts), Eurocode 7 — Geotechnical design

7.2 Selection of a pile type

7.2.1 The selection of a sheet pile type, profile and quality, shall, as a minimum, comply with the general design considerations.

7.2.2 The selection of a primary element type, profile and quality for combined walls and for high modulus walls shall, as a minimum, comply with the general design considerations.

7.2.3 The selection shall ensure adequate driveability as established in 5.3.

7.2.4 The lack of shear transmission should be taken into account according to EN 1993-5 when selecting a U-pile instead of a Z-pile.

7.2.5 In case of combined walls, the sheet pile profile for the secondary elements shall be selected not only on the basis of strength considerations but also on flexibility, slenderness and driveability.

7.2.6 In case of combined walls, the sheet pile for the secondary elements shall be selected to take into account deviations which can occur after driving the primary elements, as indicated in Figure 11.

NOTE 1 The danger of de-clutching depends mainly on the following conditions:

— accuracy of positioning and verticality of the primary elements;

— ground conditions;

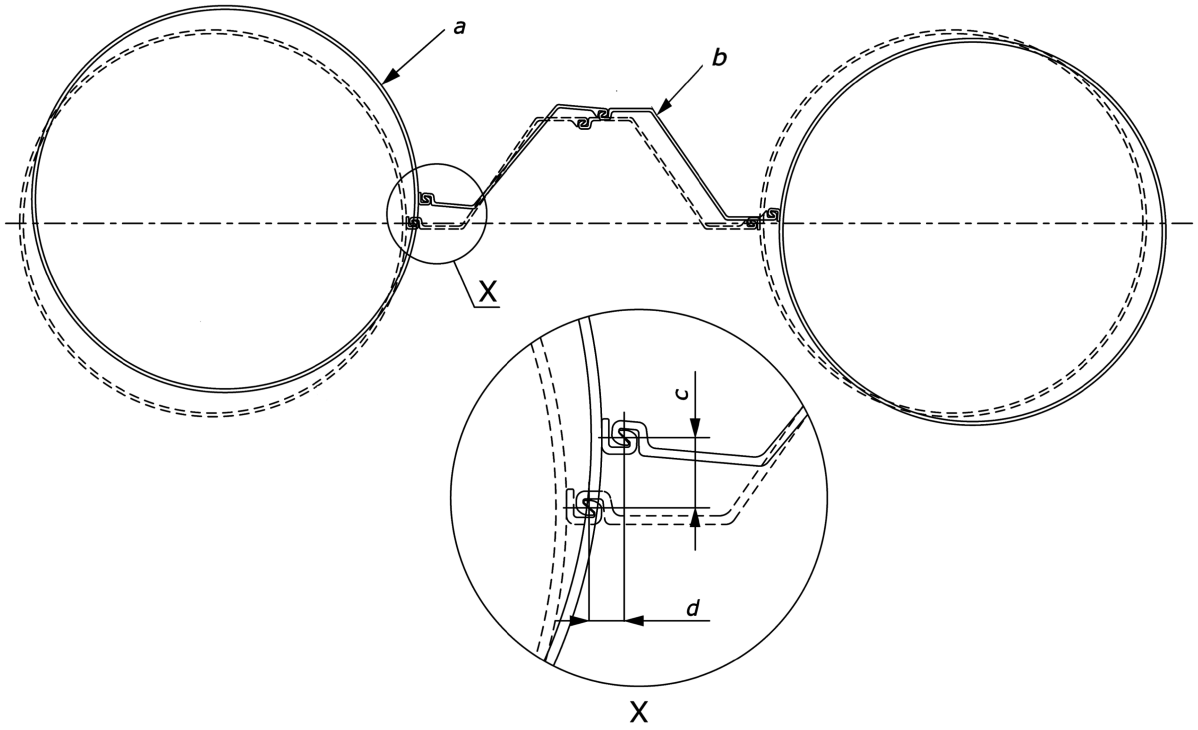
— the deformation behaviour of the sheet piles;

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— interlock type and condition.

NOTE 2 The danger of de-clutching does not depend on the orientation (inward or outward) of the secondary sheet piles.

7.2.7 In case of combined walls, secondary elements should preferably be Z-form sheet piles in order to reduce de-clutching risk.



Key

===	Design
—	as built
a	primary element
b	secondary element
c	transversal tolerance
d	longitudinal tolerance

Figure 11 — Examples of deviations for combined walls

7.3 Other structural elements

7.3.1 In addition to sheet pile wall itself, the selection of the elements which are necessary for the sheet pile wall structure, such as anchorage, struts and waling, shall take into account adverse loading and site conditions.

7.3.2 Ground anchors shall comply with EN 1537.

7.4 Sequence of execution

7.4.1 The various stages of the execution works shall be identical to the stages required by the design.

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7.4.2 The criteria for progressing from one stage to the next shall be defined.

As a minimum, for each stage of the execution works, this involves the following:

— the levels and tolerances for backfilling and/or excavation;

— the levels and tolerances of the groundwater and the free water;

— the characteristics of the materials and the quality of the fill on both sides of the sheet pile wall and of the anchor plates;

— displacements of the sheet pile wall, as anticipated at the end of each stage;

— restrictions regarding surcharges.

7.4.3 Special attention shall be paid to the execution of structures using straight web sheet piles.

7.4.4 The internal pressure of cellular structures shall always be greater than external pressure so that interlocks are always in tension, unless supported by auxiliary structures.

7.5 Specific design related considerations

7.5.1 The following matters should be specified in the design if appropriate:

— method of fixing the interlocks;

— method of attaching the connectors to the primary elements of a combined wall, taking into consideration EN 10248-2;

— quality of the welding;

— method of cutting steel elements;

— method to assist driving and the depth to which it may be applied;

— shape of rock shoe and other measures necessary to secure the toe of the sheet piles in the bedrock;

— in soft clays overlying bedrock, the method of preventing the clay from squeezing through the gap between the pile toe and the bed-rock;

— quality of the backfill or the method of placement thereof;

— pre-stressing of the struts or anchors in order to reduce displacements in the ground behind the sheet pile wall;

— time restraints during critical execution sequences;

— methods and levels of de-watering;

— type, kind and method of coating steel elements and preserving timber parts;

— cathodic protection methods;

— compatibility of the interlock sealant and the coating material;

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— special requirements regarding the permeability of the sheet pile wall, including performance criteria for materials, procedures and testing;

— consequences of extracting the sheet piles on adjacent buildings, installations and services, on settlements of the ground surface and on the creation of an open path between ground layers with different groundwater regimes (layers under artesian pressure);

— measurements needed to check settlements, displacements and vibrations;

— preventing ground water flow under the wall structure (cut-off).

8 Execution of sheet pile wall structures

8.1 General

8.1.1 The sequence of executing the sheet pile wall structure shall be carried out in accordance with 7.4.

8.1.2 If the foreseen sequence of the works cannot be maintained, a revision which meets the requirements of 7.4 shall be established in compliance with the design.

8.1.3 Each sheet pile should be referenced.

8.2 Site preparation

8.2.1 The site shall be prepared in such a way that operations can be carried out safely and efficiently.

8.2.2 The execution and use of other structural elements shall be in accordance with 7.3.

8.2.3 Access roads and mooring facilities to the construction site may have to comply with special regulations of local authorities.

8.3 Storage and handling of the sheet piles

8.3.1 Information regarding the storage and handling of steel sheet piles is given in Annex A.

8.3.2 Handling and storage of the sheet piles on the site shall be carried out in such a way that significant damage to the straightness of the sheet piles, to the interlocks and to the coatings, does not occur.

8.3.3 The recommendations given by the sheet pile manufacturers for handling and storing the sheet piles should be followed.

8.3.4 Sheet piles should be stored in such a way that they can be lifted easily in the sequence of use.

8.3.5 Sheet piles of different types and/or steel grades shall be stored separately and marked properly.

8.3.6 Storage and handling of straight web sheet piles shall be carried out with utmost care in order to avoid distortion of the profiles.

8.3.7 When storing coated steel sheet piles, spacers shall be inserted between each sheet pile in a stack (see Annex A).

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8.3.8 Primary elements of a combined wall shall be stored and supported on wood or a similar soft material placed between the elements in order to avoid permanent distortion of the profiles.

8.3.9 Special precautions should be taken when handling primary elements in order to prevent damage to coating and/or connectors.

8.3.10 The length and stiffness of the individual sheet piles shall be taken into account when assessing the number and positions of the supports of a stack of sheet piles to avoid sagging which may cause permanent deformations.

8.3.11 Special devices for lifting and positioning the sheet piles should be used, such as shackles, welded lifting hooks and similar, in order to avoid damage to the sheet piles and in particular to the interlocks.

8.3.12 When ground release shackles for lifting the sheet piles are used, their operation shall be verified before use.

8.3.13 If preservation or corrosion treatment of sheet piles and other elements is carried out at the construction site, precautions should be taken to ensure that storage and application of products and materials are in accordance with local regulations on health, safety and environmental aspects.

8.3.14 Handling holes can be prefabricated in the factory or made on jobsite, according to specifications.

8.4 Welding and cutting of steel elements

8.4.1 Welding and cutting of sheet piles and the preparation of primary elements for combined walls shall comply with the quality specified in the design.

NOTE Information regarding welding is given in Annex B. Figures presented in this paragraph are examples, other welding solutions are not excluded.

8.4.2 Edge preparation and cutting of the steel elements shall be carried out in such a manner that embrittlement due to flame cutting does not have a significant adverse effect on the quality of the joint. The dimensional tolerances of EN ISO 9692-1, or in Figure 19 shall be complied with. The prepared piles shall be in accordance with EN 10248-2, EN 10249-2 and EN 10219-2.

8.4.3 If steel sheet piling made of U-piles has been connected by intermittent welding in order to enhance the shear force transmission in these interlocks, a length of not less than 500 mm should be made continuous at each end of the pile in order to avoid possible overstressing during installation, unless otherwise specified by the relevant authority or agreed for a specific project by the relevant parties.

8.4.4 Reference should be made to EN 1993-1-8 for the design of the welds.

8.4.5 Unless specified otherwise, joint preparation, welding processes and the description or the qualification of the welding procedure shall be in accordance with Tables 1, 2 and 3.

8.4.6 For tubular primary elements of combined walls it shall be ensured that the distance between the connector and a longitudinal seam of the element is ≥ 300 mm. For tubular elements of combined walls and high modulus walls it shall be ensured that the circular and spiral seams on the elements are levelled at the position of the connector. The welds between tubular piles and connectors shall be executed and inspected in reference to the requirements in the design.

8.4.7 Dimensions of splice plate to be determined by design.

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8.4.8 Achievable angles for bending should be checked with a sheet pile manufacturer, see Figure 17.

8.4.9 For larger angles, cutting and welding shall be used, see Figure 17.

8.4.10 Preferably due to risk of de-clutching this type of connector profile should be used as shown in Figure 16.

8.4.11 For seal welds applied to double H piles, the weld throat may be less than 6 mm, see Figure 21.

8.4.12 Connectors shall be welded on sheet piles prior to installation, see Figure 23.

8.4.13 After welding the procedure for checking the position of the connectors on tubular primary elements shall be as follows (see Figure 24):

— position the element on a horizontal plane and rotate it such that line P at top end of the element is horizontal:

  — by using levelling techniques mark the position T on the element at the third points along the length and at the lower end of the connectors as indicated in Figure 24;

  — check compliance with the following tolerances at the top end, the third points and the lower end of the connector:

    L ± 10 mm

    R ± 10 mm

    where

    L and R are measured along the outer circumference of the element, see Figure 24;

— maximum percentage are:

  2 % angle deviation; and

  0,2 % straightness requirement of connector length.

8.4.14 The metal deposited by welding shall, as a minimum, have the mechanical characteristics equivalent to those of the base material.

8.4.15 Quality Steel (QS) according to EN 10248-1 and steel grades S420xxx and S460xxx according to EN 10219-1, shall be welded using basic filler metals with low hydrogen. The level of hydrogen in the deposited metal shall be ≤ 10 ml/100 g.

8.4.16 In order to prevent all risks of cracking, preheating temperatures shall take account of the steel carbon equivalent, the welding process and the type of joint. The temperature of a weld shall be ≤ 250 °C before the next welding pass is started. Preheating shall extend for at least 75 mm on each side of the weld.

NOTE Preheating temperatures for different thicknesses and steel grades are given in Table B.3.

8.4.17 Steps shall be given to prevent damaging the steel by induced stress and distortion due to welding.

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8.4.18 Welds of acceptance class D according to EN ISO 5817 shall be carried out by qualified operatives. Welds of acceptance class C according to EN ISO 5817 shall be carried out by operatives qualified in accordance with EN ISO 9606-1.

8.4.19 The tolerances of sheet piles and primary piles lengthened either by butt welds or by splice plates shall be in accordance with EN 10248-2, EN 10249-2 or EN 10219-2 referred to in Clause 2 and with Annex G.

8.4.20 The tolerances of strengthened sheet piles and primary elements shall be in accordance with EN 10248-2, EN 10249-2 or EN 10219-2 and with Annex G.

8.4.21 The tolerances of corner piles, straight web junction piles, box piles and fabricated primary elements shall be in accordance with EN 10248-2, EN 10249-2 or EN 10219-2 and with Annex G.

8.4.22 Where steel sheet piles are to be spliced by butt welding, the interlock may be left un-welded, unless a seal weld is required or if it is specified in the design. No weld inside the interlock shall be made.

8.4.23 Wherever possible, joints shall be positioned at a level with low stress through the cross-section.

8.4.24 The joints of the adjacent sections shall be offset by at least 1 m.

8.4.25 Sheet piles shall not have sudden variations of the section in the longitudinal direction of the pile. Plates, strips, splice plates and partial sheet piles for strengthening, shall be chamfered (see Figure 25).

8.4.26 Plates should be no more than 20 % thicker than the parts of the section being spliced, and should never exceed 25 mm thick.

8.4.27 Testing and inspection of welds shall be in accordance with Tables 1, 2 and 3.

8.4.28 If strengthening of the sheet pile is specified, the method should take into account the expected driving conditions and the design specifications.

NOTE The strengthening details depend mainly on the presence of obstructions in the ground. Figure 26 gives an example of a simple reinforcement of head and toe of a double U-sheet pile.

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Table 1 — Welding requirements for steel sheet piles in EXC 1

Welding in EXC 1							**Testing and inspection of welds**		
Type of welded assembly	**Type of joint**	**Type of weld**	**Joint preparation**	**Allowable welding processes**	**Description/ qualification of welding procedure**		**Quality level according to** EN ISO 5817	**Type of testing**	**Extent of testing** [%]
					BS (EN 10248-1) [b] S235 JRC, S275 JRC, S355 J0C according to EN 10249-1 and grades according to EN 10219-1 [c]	QS (EN 10248-1) [d] and grades given in EN 10219-1 [e]			
General					EN ISO 3834-4 [h]	EN ISO 3834-4 [h]			
Lengthened piles									
- straight web sheet pile	butt joint [a] (see Figure 12 a)) / lap joint (see Figure 12 b))	EN ISO 9692-1	EN ISO 9692-1	_ f	–	–	no requirement [g]	to be agreed	to be agreed
- bending resistant pile	butt joint [a] (see Figure 13 a)) / lap joint (see Figure 13 b))	EN ISO 9692-1	EN ISO 9692-1	_ f	–	–	no requirement [g]	to be agreed	to be agreed
Strengthened piles	reinforcement plates (see Figure 14)	EN ISO 9692-1	EN ISO 9692-1	_ f	–	–	no requirement [g]	to be agreed	to be agreed
Junctions/ junction piles									
- all, expect straight web junction piles [i]	(oblique) T joint (see Figure 15 and Figure 16) / welded bent pile joint (see Figure 17) / lap joint (+corner joint) (see Figure 18)	EN ISO 9692-1	EN ISO 9692-1	_ f	–	–	no requirement [g]	to be agreed	to be agreed
- straight web junction piles	(oblique) T joint (see Figure 19)	half V-weld / double half V-weld EN ISO 9692-1 EN ISO 9692-2	according to Figure 19 EN ISO 9692-1 EN ISO 9692-2	_ f	–	–	no requirement [g]	to be agreed	to be agreed

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Welding in EXC 1							Testing and inspection of welds		
Type of welded assembly	**Type of joint**	**Type of weld**	**Joint preparation**	**Allowable welding processes**	**Description/ qualification of welding procedure**		**Quality level according to** EN ISO 5817	**Type of testing**	**Extent of testing** [%]
					BS (EN 10248-1) [b] S235 JRC, S275 JRC, S355 J0C according to EN 10249-1 and grades according to EN 10219-1 [c]	QS (EN 10248-1) [d] and grades given in EN 10219-1 [e]			
Box piles									
- contiguous interlock	butt joint (see Figure 20)	butt weld between curved elements EN ISO 9692-1	–	_ f	–	–	no requirement [g]	to be agreed	to be agreed
- connected interlock	lap joint (see Figure 21)	EN ISO 9692-1	–	_ f	–	–	no requirement [g]	to be agreed	to be agreed
- others	T-joint (see Figure 22) / lap joint (see Figure 22)	EN ISO 9692-1 EN ISO 9692-2	EN ISO 9692-1 EN ISO 9692-2	_ f	–	–	no requirement [g]	to be agreed	to be agreed
Welded interlocks (fixing, sealing)	butt weld (see Figure 23)	butt weld between curved elements	–	_ f	–	–	no requirement [g]	to be agreed	to be agreed

[a] For different thickness, the shape of the butted ends shall be in accordance with the design specifications.

[b] BS = Base Steel according to EN 10020.

[c] Steel grades according to EN 10219-1, Tables A.1, B.1 and B.2, except S420xxx and S460xxx.

[d] QS = Quality Steel according to EN 10020.

[e] Steel grades S420xxx and S460xxx.

[f] All processes described in 111, 114, 121, 122, 131, 135, 136, and 138 of EN ISO 4063 are permitted.

[g] Higher requirements can be agreed.

[h] Welding shall be undertaken in accordance with the requirements of the relevant part of EN ISO 3834. Welding Procedure Specifications according to EN ISO 15609-1.

[i] Also applies to weld-on interlocks connected by means of fillet welds.

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Table 2 — Welding requirements for steel sheet piles in EXC 2

Welding in EXC 2							Testing and inspection of welds		
Type of welded assembly	**Type of joint**	**Type of weld**	**Joint preparation**	**Allowable welding processes**	**Description/ qualification of welding procedure**		**Quality level according to** EN ISO 5817	**Type of testing**	**Extent of testing** [%]
					BS (EN 10248-1) [b] S235 JRC, S275 JRC, S355 J0C, according to EN 10249-1 and grades according to EN 10219-1 [c]	QS (EN 10248-1) [d] and grades given in EN 10219-1 [e]			
General					ISO 3834-3 [h]	ISO 3834-3 [h]			
Lengthened piles									
— straight web sheet pile	butt joint [a] (see Figure 12 a)) / lap joint (see Figure 12 b))	EN ISO 9692-1	EN ISO 9692-1	_ f	–	EN ISO 15609-1	C	visual [g]	100 [g]
— bending resistant pile	butt joint [a] (see Figure 13 a)) / lap joint (see Figure 13 b))	EN ISO 9692-1	EN ISO 9692-1	_ f	–	EN ISO 15609-1	C	visual [g]	100 [g]
Strengthened piles	reinforcement plates (see Figure 14)	EN ISO 9692-1	EN ISO 9692-1	_ f	–	–	C	visual [g]	100 [g]
Junctions / junction piles									
— all, expect straight web junction piles [i]	(oblique) T joint (see Figure 15 and Figure 16) / welded bent pile joint (see Figure 17) / lap joint (+ corner joint) (see Figure 18)	EN ISO 9692-1	EN ISO 9692-1	_ f	EN ISO 15607	EN ISO 15609-1	C	visual [g]	50 [g]
— straight web junction piles	(oblique) T joint (see Figure 19)	half V-weld / double half V-weld EN ISO 9692-1 EN ISO 9692-2	according to Figure 19 EN ISO 9692-1 EN ISO 9692-2	_ f	EN ISO 15607	EN ISO 15609-1	C	US + visual	10 US +100 (visual)
Box piles	butt joint	butt weld between		_ f	–	EN ISO 15609-1	D	visual [g]	100 [g]

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Welding in EXC 2							Testing and inspection of welds		
Type of welded assembly	**Type of joint**	**Type of weld**	**Joint preparation**	**Allowable welding processes**	**Description/ qualification of welding procedure**		**Quality level according to** EN ISO 5817	**Type of testing**	**Extent of testing** [%]
					BS (EN 10248-1) [b] S235 JRC, S275 JRC, S355 J0C, according to EN 10249-1 and grades according to EN 10219-1 [c]	QS (EN 10248-1) [d] and grades given in EN 10219-1 [e]			
-contiguous interlock	(see Figure 20)	curved elements EN ISO 9692-1	–						
— connected interlock	lap joint (see Figure 21)	EN ISO 9692-1	–	_ [f]	–	EN ISO 15609-1	D	visual [g]	100 [g]
— others	T-joint (see Figure 22)/ lap joint (see Figure 22)	EN ISO 9692-1 EN ISO 9692-2	EN ISO 9692-1 EN ISO 9692-2	_ [f]	–	EN ISO 15609-1	D	visual [g]	100 [g]
Welded interlocks (fixing, sealing)	butt weld (see Figure 23)	butt weld between curved elements	–	_ [f]	–	EN ISO 15609-1	D	visual [g]	100 [g]

[a] For different thickness, the shape of the butted ends shall be in accordance with the design specifications.

[b] BS = Base Steel according to EN 10020.

[c] Steel grades according to EN 10219-1, Tables A.1, B.1, and B.2, except S420xxx and S460xxx.

[d] QS = Quality Steel according to EN 10020.

[e] Steel grades S420xxx and S460xxx.

[f] All processes described in 111, 114, 121, 122, 131, 135, 136 and 138 of EN ISO 4063 are permitted.

[g] Butt joints with US tests on 10 % of the welds. For lap joints, PT or MT testing on 10 % of the welds.

[h] Welding shall be undertaken in accordance with the requirements of the relevant part of EN ISO 3834.

[i] Also applies to weld-on interlocks connected by means of fillet welds.

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Table 3 — Welding requirements for steel sheet piles in EXC 3

Welding in EXC 3							Testing and inspection of welds		
Type of welded assembly	**Type of joint**	**Type of weld**	**Joint preparation**	**Allowable welding processes**	**Description/qualification of welding procedure**		**Quality level according to** EN ISO 5817	**Type of testing**	**Extent of testing** [%]
					BS (EN 10248-1) [b] S235 JRC, S275 JRC, S355 J0C, according to EN 10249-1 and grades according to EN 10219-1 [c]	QS (EN 10248-1) [d] and grades given in EN 10219-1 [e]			
General					ISO 3834-3 [h]	ISO 3834-3 [h]			
Lengthened piles									
— straight web sheet pile	butt joint [a] (see Figure 12 a)) / lap joint (see Figure 12 b))	EN ISO 9692-1	EN ISO 9692-1	_ f	–	EN ISO 15609-1	C	visual [g]	100 [g]
— bending resistant pile	butt joint [a] (see Figure 13 a)) / lap joint (see Figure 13 b))	EN ISO 9692-1	EN ISO 9692-1	_ f	–	EN ISO 15609-1	C	visual [g]	100 [g]
Strengthened piles	reinforcement plates joint (see Figure 14)	EN ISO 9692-1	EN ISO 9692-1	_ f	–	–	C	visual [g]	100 [g]
Junctions / junction piles									
— all, expect straight web junction piles [i]	(oblique) T joint (see Figure 15 and Figure 16) / welded bent pile joint (see Figure 17) / lap joint (+corner joint) (see Figure 18)	EN ISO 9692-1	EN ISO 9692-1	_ f	EN ISO 15607	EN ISO 15609-1	C	visual [g]	50 [g]
— straight web junction piles	(oblique) T joint (see Figure 19)	half V-weld / double half V-weld EN ISO 9692-1 EN ISO 9692-2	according to Figure 19) EN ISO 9692-1 EN ISO 9692-2	_ f	EN ISO 15607	EN ISO 15609-1	C	US + visual	10 US +100 (visual)

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Welding in EXC 3							Testing and inspection of welds		
Type of welded assembly	**Type of joint**	**Type of weld**	**Joint preparation**	**Allowable welding processes**	**Description/qualification of welding procedure**		**Quality level according to** EN ISO 5817	**Type of testing**	**Extent of testing** [%]
					BS (EN 10248-1) [b] S235 JRC, S275 JRC, S355 J0C, according to EN 10249-1 and grades according to EN 10219-1 [c]	QS (EN 10248-1) [d] and grades given in EN 10219-1 [e]			
Box piles									
— contiguous interlock	butt joint (see Figure 20)	butt weld between curved elements EN ISO 9692-1	–	_ [f]	–	EN ISO 15609-1	D	visual [g]	100 [g]
— connected interlock	lap joint (see Figure 21)	EN ISO 9692-1	–	_ [f]	–	EN ISO 15609-1	D	visual [g]	100 [g]
— others	T-joint (see Figure 22) / lap joint (see Figure 22)	EN ISO 9692-1 EN ISO 9692-2	EN ISO 9692-1 EN ISO 9692-2	_ [f]	–	EN ISO 15609-1	D	visual [g]	100 [g]
Welded interlocks (fixing, sealing)	butt weld (see Figure 23)	butt weld between curved elements	–	_ [f]	–	EN ISO 15609-1	D	visual [g]	100 [g]

[a] For different thickness, the shape of the butted ends shall be in accordance with the design specifications.

[b] BS = Base Steel according to EN 10020.

[c] Steel grades according to EN 10219-1, Tables A.1, B.1, and B.2, except S420xxx and S460xxx.

[d] QS = Quality Steel according to EN 10020.

[e] Steel grades S420xxx and S460xxx.

[f] All processes described in 111, 114, 121, 122, 131, 135, 136 and 138 of EN ISO 4063 are permitted.

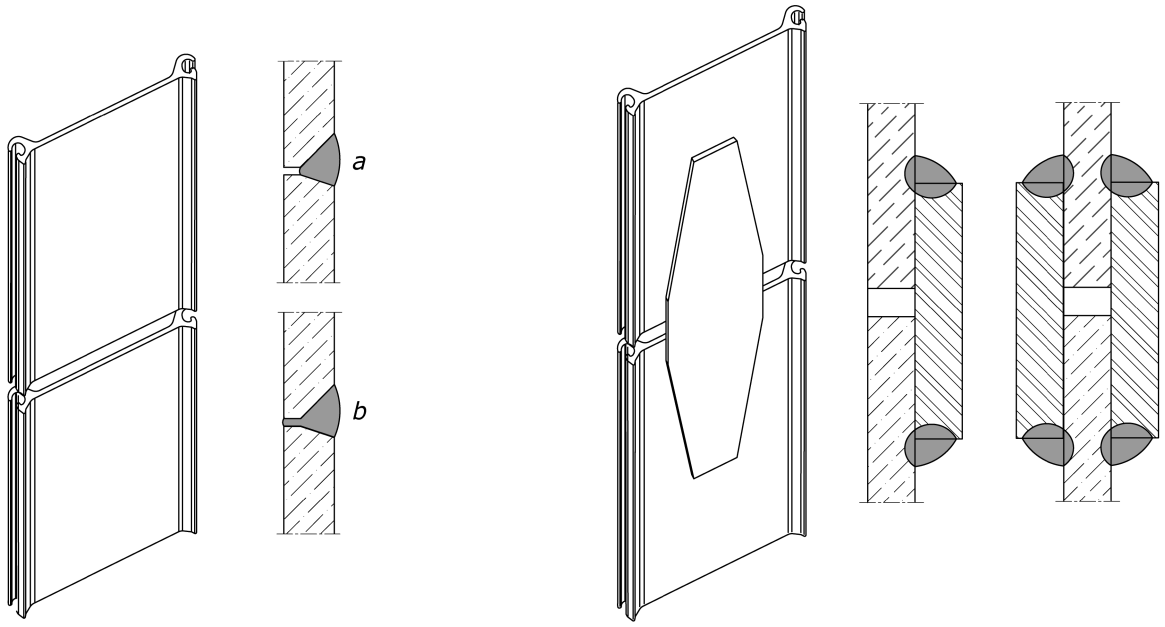
[g] Butt joints with US tests on 10 % of the welds. For lap joints, PT or MT testing on 10 % of the welds.

[h] Welding shall be undertaken in accordance with the requirements of the relevant part of EN ISO 3834.

[i] Also applies to weld-on interlocks connected by means of fillet welds.

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a) Butt joint of lengthened straight web sheet pile

b) Lap joint of a lengthened straight web sheet pile

Key

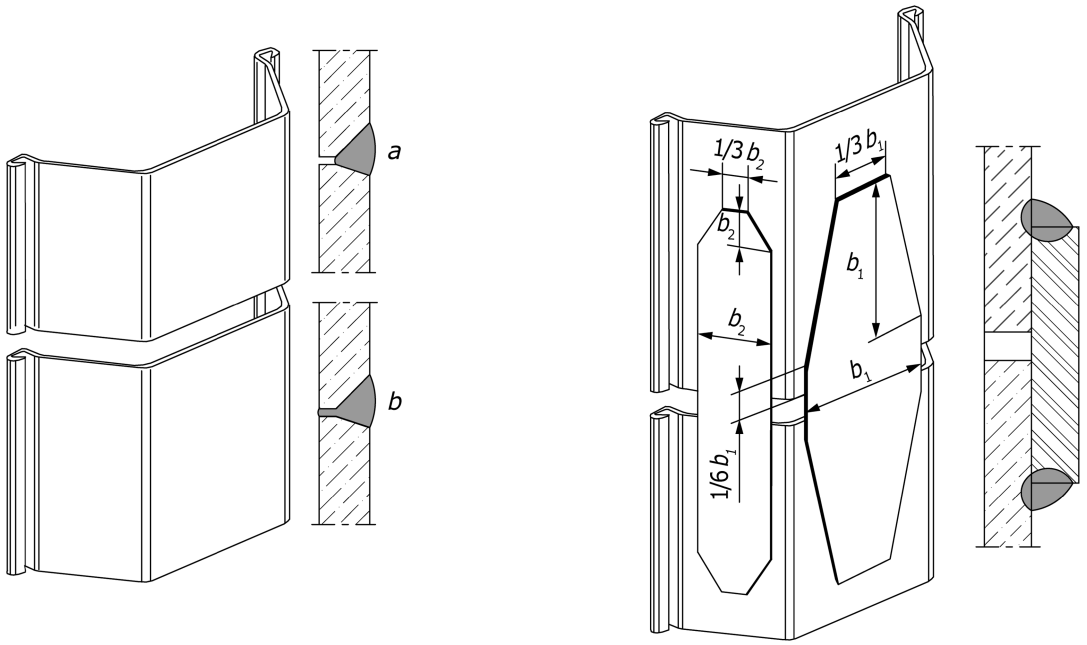
a seal weld (non-structural)

b structural weld

NOTE For straight web sheet pile interlock welding is only for the watertightness of the sheet pile wall.

Figure 12 — Examples of joints for straight web sheet piles

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a) Butt joint of lengthened bending resistant pile

b) Lap joint of lengthened bending resistant pile

Key

a seal weld (non-structural)

b structural weld

NOTE 1 b1 and b2 depend on calculations.

NOTE 2 For U-sheet pile and Z sheet pile, interlock welding is only for the watertightness of the sheet pile wall.

NOTE 3 For Z-sheet pile, structural interlock welding depends on calculations but can lead to driving issues.

Figure 13 — Examples of joints for U sheet piles

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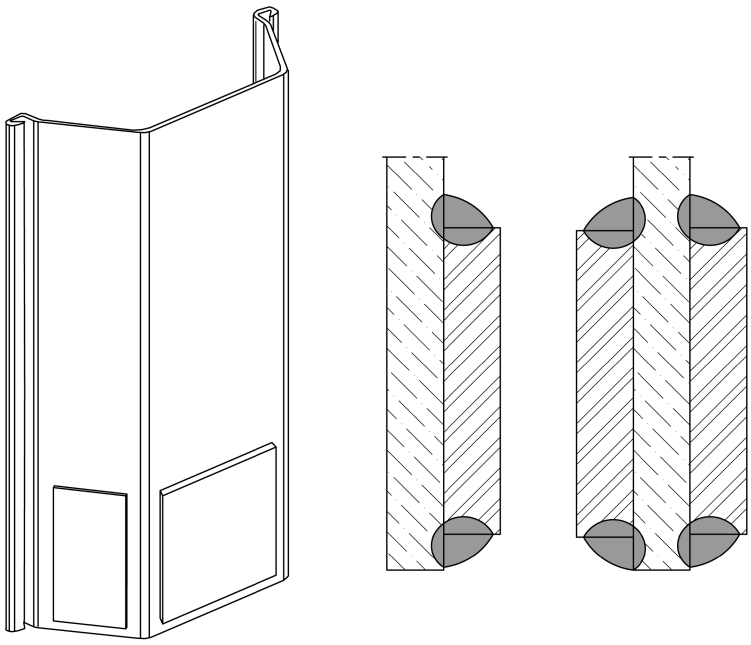


Figure 14 — Example of sheet pile toe reinforcement

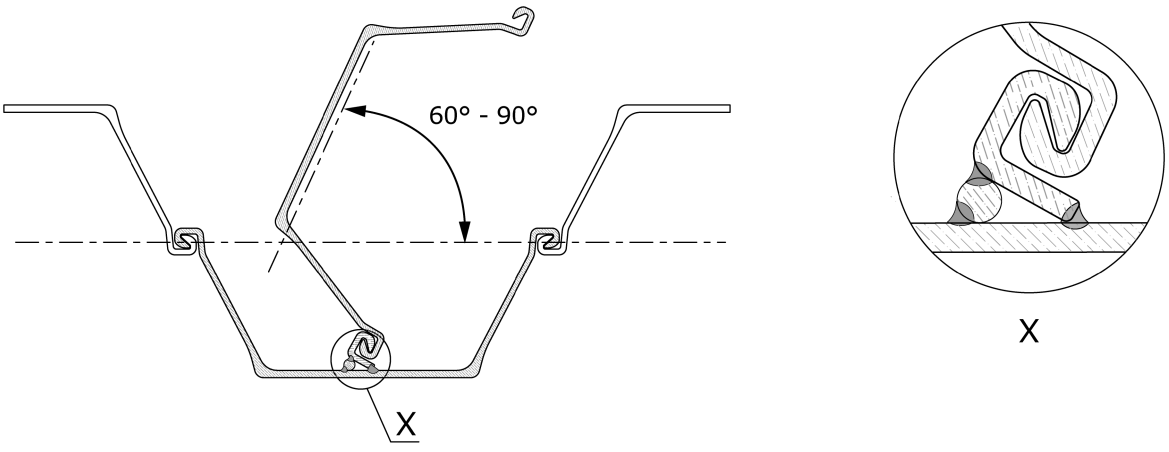


Figure 15 — Oblique T-junction of a junction pile

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