EUROPEAN ASSESSMENT DOCUMENT

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STRUCTURAL STEEL PILES WITH HOLLOW SECTIONS AND RIGID SPLICES

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Contents

1 SCOPE OF THE EAD

1.1 Description of the construction product

Steel piles consist of a hollow section structural steel pipe. It may also include mechanical joints (e.g. external or internal friction splice or threaded splice) or welded joint, a pile tip (e.g. bottom and rock shoe or bottom plate), a bearing plate or other additional accessories. Product is illustrated in the Annex A.

Hollow section steel pipe is made of structural steel. Outside diameters of the piles are according to standard 10219-2 Annex C. Steel grades used in pile pipes are either according to the standard EN10219 or alternatively steels S440J2H, S440MH, S550J2H or S550MH. Chemical and mechanical properties of S440J2H, S440MH, S550J2H or S550MH steel grades are presented in the Annex B.

Bearing plate can be with or without holes, and it consists of steel plate and plate concentrator. Steel grades used in bearing plates are according to the standards EN10219 and EN 10025.

External splice is outside of pile pipe locating pile joint where connection is based on friction. Steel grades used in external splice are either according to the standard EN10219 or alternatively steels S440J2H, S440MH, S550J2H or S550MH.

Internal splice is inside of pile locating pile joint where connection is based on friction. Steel grades used in internal splice are according to the standards EN 10294-1, EN 10297-1 and EN 10025.

Threaded splice is pile joint with or without sleeve where connection is based on threads. Steel grades used in threaded sleeve splice are according to the standards EN 10219, EN 10294-1, EN 10297-1 or alternatively steels S440J2H, S440MH, S550J2H or S550MH.

Bottom and rock shoe is pile tip which is fastened to the lower end of the pile by welding or mechanically with friction and conical surface. Pile tip can also have expander head which make shaft grouting possible. The installation procedures of the shaft grouted pile and grouting materials are not part of the ETA. The procedure and the material of the grouting should be done according to EN 14199 and EN 12699. Rock shoe is additionally equipped with a dowel made of structural or special steel. Steel grades used in bottom and rock shoes are according to the standards EN 10025, EN 10294-1, EN 10297-1 and EN 10083.

☒ The product is not covered by a harmonised European standard (hEN).

Concerning product packaging, transport, storage, maintenance, replacement and repair it is the responsibility of the manufacturer to undertake the appropriate measures and to advise his clients on the transport, storage, maintenance, replacement and repair of the product as he considers necessary.

It is assumed that the product will be installed according to the manufacturer's instructions or (in absence of such instructions) according to the usual practice of the building professionals.

Relevant manufacturer's stipulations having influence on the performance of the product covered by this European Assessment Document shall be considered for the determination of the performance and detailed in the ETA.

The installation and execution of piles shall be in accordance with EN 1993-5 (chapter 8), EN 14199, EN 1536 and EN 12699 as far as national regulations admit it.

Steel pipe piles are dimensioned in accordance with valid European (CEN) norms and standards and/or national regulations and guidelines.

1.2 Information on the intended use(s) of the construction product

1.2.1 Intended use(s)

The products are used as the foundation piles in all kind of structures where the pile foundations are needed e.g. buildings, bridges, harbours or other traffic structures. The piles are designed generally as an end bearing pile but designing as a shaft bearing pile is also possible. Products can be also used as a part of retaining wall according to EN 12063. The piles are designed for loading by axial forces or horizontal forces or combined loads. In the designing of tension piles the requirements for pile splices presented on chapter 2.2.1 to 2.2.4 have to take into account. If the pile is under considerable cyclical stress they must be taken into account separately.

1.2.2 Working life/Durability

The assessment methods included or referred to in this EAD have been written based on the manufacturer's request to take into account a working life of the structural steel piles for the intended use of 100 years when installed in the works (depending of chosen material thickness and environmental conditions which are defined in Eurocode EN 1993-5 paragraph 4.4). These provisions are based upon the current state of the art and the available knowledge and experience.

When assessing the product the intended use as foreseen by the manufacturer shall be taken into account. The real working life may be, in normal use conditions, considerably longer without major degradation affecting the basic requirements for works[1].

The indications given as to the working life of the construction product cannot be interpreted as a guarantee neither given by the product manufacturer or his representative nor by EOTA when drafting this EAD nor by the Technical Assessment Body issuing an ETA based on this EAD, but are regarded only as a means for expressing the expected economically reasonable working life of the product.

[1] The real working life of a product incorporated in a specific works depends on the environmental conditions to which that works is subject, as well as on the particular conditions of the design, execution, use and maintenance of that works. Therefore, it cannot be excluded that in certain cases the real working life of the product may also be shorter than referred to above.

2 ESSENTIAL CHARACTERISTICS AND RELEVANT ASSESSMENT METHODS AND CRITERIA

2.1 Essential characteristics of the product

Table 1 shows how the performance of structural steel piles is assessed in relation to the essential characteristics.

Table 1 **Essential characteristics of the product and assessment methods and criteria for the performance of the product in relation to those essential characteristics**

No	Essential characteristic	Assessment method	Type of expression of product performance
Basic Works Requirement 1: Mechanical resistance and stability			
1	Bending resistance and bending stiffness	clause 2.2.1	values
2	Tension resistance	clause 2.2.2	values
3	Compression resistance	clause 2.2.3	values
4	Robustness of pile joints	clause 2.2.4	values
5	Material properties and dimensional tolerances	clause 2.2.5	declaration
6	Resistance to corrosion	clause 2.2.6	declaration
Basic Works Requirement 2: Safety in case of fire			
7	Reaction to fire	clause 2.2.7	Reaction to fire

2.2 Assessment methods and criteria for the performance of the product in relation to essential characteristics of the product

Mechanical resistance and stability of the steel pile containing mechanical joint is verified using methods presented on chapters 2.2.1 - 2.2.4.

The scope of testing of pile joints will be defined using grouping so that functionality of mechanical splices can verify with adequate confidence in different pile diameter, wall thickness and steel grade combinations, or grouping the products and choosing weakest to be tested in each group.

Statistical determination of tension, compression and bending resistances of the joint is done according to EN 1990: Basis of structural design, Annex D: Design assisted by testing.

Ultimate limit state verifications should be carried out for failure of the piles and their connections to the structure according to EN 1993-5, EN 1992 and EN 1994.

When performing type tests, material strength of used steel material should be tested or checked from the inspection documents and exact dimensions should be measured.

Testing of resistance of a pile with joint and testing or calculating of resistance of a pile without joint is carried out without the loss of thickness due to corrosion.

2.2.1 Bending resistance and bending stiffness

2.2.1.1 Method of verification

Testing shall be conducted according to the method described in the Annex A, point A 1.5 of the standard EN 12794. Location of loading and measuring points can vary according to pile size.

2.2.1.2 Method of assessing

Bending stiffness of the pile with pile joint shall be at least 0,75 x of the bending stiffness of the similar pile without pile joint in moment range 0,3 – 0,8 x M. Reference value for bending stiffness of the pile without joint can be tested by the same test method or calculated according to EN 1993-5.

Bending resistance of the pile with pile joint shall be at the same level as bending resistance of the similar pile without joint.

2.2.2 Tension resistance

2.2.2.1 Method of verification

Testing shall be conducted according to the method described in the Annex D.

2.2.2.2 Method of assessing

Tension resistance of the pile with joint shall be at least 15 % of the tension resistance of the similar pile without joint.

2.2.3 Compression resistance

2.2.3.1 Method of verification

Testing shall be conducted according to the method described in the Annex D.

Test is not necessary if pile pipes to be jointed are supported on each other in the whole cross section area and pile joint meets the criteria presented in the chapters 2.2.1, 2.2.2 and 2.2.4.

2.2.3.2 Method of assessing

Compression resistance of the pile with pile joint shall be at least in the same level as compression resistance of the similar pile without joint.

2.2.4 Robustness of pile joints

2.2.4.1 Method of verification

Robustness of pile joints for a driven pile shall be tested by an impact test. The impact test shall be done before bending, tension and compression tests of the joined pile. Impact test is done according to principles in Annex A of EN 12794.

Robustness of pile joints for drilled pile shall be tested by a tightening test. Tightening of the pile joint is done according to the instructions of the manufacturer before bending, tension and compression tests of the joined pile.

2.2.4.2 Method of assessing

Joined driven pile shall pass the following test sequence:

– Amount of impacts is at least 200, if the mass of ram is at least 20 times higher than the meter-mass of the pile. Amount of impacts is at least 2000, if the mass of ram is less than 20 times higher than the meter-mass of the pile.

– Stress level in the test shall be at least 0,5 × yield strength of the pile pipe.

The measurement of stress level shall be done according to the standard ASTM D 4945, Standard test method for High-Strain Dynamic Testing of Piles.

Required tightening moment for drilled pile in tightening test will be defined by the manufacturer.

Resistance of the pile can be seen adequate if the pile and pile joint perform as it is planned in impact or tightening test.

2.2.5 Material properties and dimensional tolerances

2.2.5.1 Method of verification

Manufacturing and testing of the pile pipe material shall be conducted according to the standard EN 10219. Testing of the pile component material shall be conducted according to the relevant standard described in the chapter 1.1. Testing shall be done by material manufacturer.

The dimensions and shape shall be declared and measured. Measurement and target values of all relevant dimensions and the tolerances of them shall be declared in the FPC documentation of the manufacturer. Measurement shall be done in a purposeful way that guarantees that the product is fit for the intended use.

2.2.5.2 Method of assessing

Material properties of pile pipe are according to the standard EN 10219 or Annex B of this EAD. Material properties of the pile components are according to the relevant standard described in the chapter 1.1 or according to Annex B. Material properties shall be checked from the material certificates. For pile pipe material, material certificate 3.1 is required according to the standard EN 10204.

Tolerances of the pile pipe and external friction splice pipe are given in Annex C. The pipe tolerances that are not mentioned in Annex C are according to EN 10219-2. Tolerances of the pile components are according to EN 22768-1 (tolerance class Medium), if FPC documentation does not give additional information.

The measurement method of dimensional tolerances shall be evaluated. ETA shall contain the main dimensions.

2.2.6 Resistance to corrosion

2.2.6.1 Method of verification

According to the standard EN 1993-5 paragraph 4.4.

2.2.6.2 Method of assessing

According to the standard EN 1993-5 paragraph 4.4 depending on the installation environment aggressiveness and designed material thicknesses.

In the case of piles without concrete filling possible internal corrosion should take into account sealing of the pile and possible entering of soil and water to the pile.

2.2.7 Reaction to fire

The structural steel piles are considered to satisfy the requirements for performance class A1 of the characteristic reaction to fire in accordance with the EC Decision 96/603/EC (as amended) without the need for testing on the basis of it fulfilling the conditions set out in that Decision and its intended use being covered by that Decision.

Therefore the performance of the products are A1.

3 ASSESSMENT AND VERIFICATION OF CONSTANCY OF PERFORMANCE

3.1 System(s) of assessment and verification of constancy of performance

For the products covered by this EAD the applicable European legal act is: 1999/94/EC.

The system to be applied is: 2+

3.2 Tasks of the manufacturer

The cornerstones of the actions to be undertaken by the manufacturer of the products in the process of assessment and verification of constancy of performance are laid down in Table 2.

Table 2 Control plan for the manufacturer; cornerstones

No	Subject/type of control	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control
Factory production control (FPC)					
1	Incoming raw materials	Material certificates or product certificates, dimensions checking			Every delivery or every melting
2	Dimensions	Essential dimensions influencing on the performance			According to the prescribed control plan
3	Handling of non-conforming products	According to written procedure			Every shift

3.3 Tasks of the notified body

The cornerstones of the actions to be undertaken by the notified body in the process of assessment and verification of constancy of performance for structural steel piles are laid down in Table 3.

Table 3 Control plan for the notified body; cornerstones

No	Subject/type of control	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control
Initial inspection of the manufacturing plant and of factory production control					
1	The notified body shall ascertain that, in accordance with the prescribed control plan, the factory, in particular the staff and equipment, and the factory quality control, are suitable to ensure a continuous and orderly manufacturing of pile with the specifications given in quality control agreement.				
Continuous surveillance, assessment and evaluation of factory production control					
2	The notified body shall visit the factory at least once a year for routine inspections. It shall verify that the system of factory quality control and the specified manufacturing processes are maintained, taking account of the prescribed control plan.				

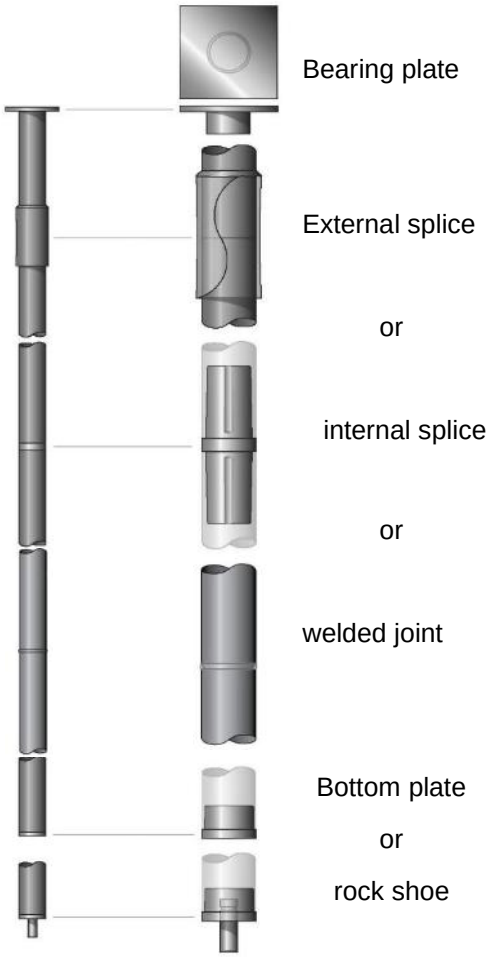
4 REFERENCE DOCUMENTS

As far as no edition date is given in the list of standards thereafter, the standard in its current version at the time of issuing the European Technical Assessment, is of relevance.

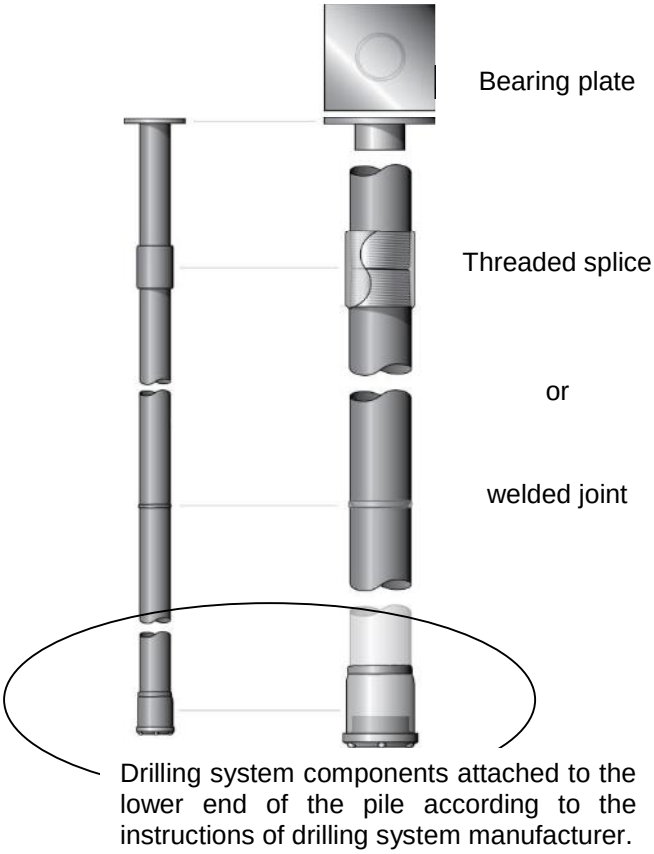
EN 1990	Eurocode Basis of structural design
EN 1992	Eurocode 2 Design of concrete structures
EN 1993-5	Eurocode 3 Design of steel structures. Part 5: Piling
EN 1994	Eurocode 4 Design of composite steel and concrete structures
EN 10204	Material certificates of metallic materials
EN 12794	Precast concrete products. Foundation piles
EN 12699	Execution of special geotechnical work. Displacement piles
EN 14199	Execution of special geotechnical works. Micropiles
EN 1536	Execution of special geotechnical work. Bored piles
EN 12063	Execution of special geotechnical work. Sheet-pile walls
EN 22768-1	General tolerances. Part 1: Tolerances for linear and angular dimensions without individual tolerance indicators
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 structural hollow sections of non-alloy and fine grain steels. Part 2: Tolerances, dimensions and sectional properties
EN 10025 -1	Hot rolled products of structural steels Part 1: General technical delivery conditions
EN 10083-1	Steels for quenching and tempering Part 1: General technical delivery conditions
EN 10294-1	Hollow bars for machining. Technical delivery conditions. Part 1: Non alloy and alloy steels
EN 10297-1	Seamless circular steel tubes for mechanical and general engineering purposes. Technical delivery conditions. Part 1: Non-alloy and alloy steel tubes

ANNEX A COMPONENTS OF THE STEEL PILES

Driven pile



Drilled pile



Components of the steel piles

ANNEX B CHEMICAL COMPOSITION AND MECHANICAL PROPERTIES OF STEELS

Table 1. Chemical composition – Cast analysis for product thickness ≤ 20 mm

Steel grade	Type of deoxidation[a]	% by mass, maximum					
		C	Si	Mn	P	S	N[b]
S440J2H	FF	0,18	0,50	1,70	0,025	0,020	-
S550J2H	FF	0,16	0,50	2,20	0,030	0,030	-

[a] The deoxidation method is designated as follows:

FF: Fully killed steel containing nitrogen binding elements in amounts sufficient to bind available nitrogen (e.g. min. 0,020 % total Al or 0,015 % soluble Al).

[b] The maximum value for nitrogen does not apply if the chemical composition shows a minimum total Al content of 0,020 % with a minimum Al/N ratio of 2:1, or if sufficient other N-binding elements are present. The N-binding elements shall be recorded in the Inspection Document.

Table 2. Mechanical properties of non-alloy steel hollow sections in thicknesses ≤ 20 mm

Steel grade	Minimum yield strength R_{eH} MPa	Tensile strength R_m MPa	Minimum elongation A[a] %	Minimum impact energy KV[b] J		
	Specified thickness mm	Specified thickness mm	Specified thickness mm	at test temperature of		
	≤ 20	≤ 20	≤ 20	-20°C	0 °C	20 °C
S440J2H	440	490-630	17	27	-	-
S550J2H	550	605-760	14	27		-

[a] For pile sizes D/T < 15 (circular) the minimum elongation is reduced by 2

[b] For impact properties for reduced section test pieces see 6.7.2. EN 10219-1

Table 3. Chemical composition - Cast analysis for product thicknesses ≤ 20 mm, feedstock condition M[a]

Steel grade	Type of deoxidation[b]	Classification[c]	% by mass											
			C max.	Si max.	Mn max.	P max.	S max.	Nb max.	V max.	Al_{total}[d] min.	Ti max.	Ni max.	Mo[e] max.	N max.
S440MH	GF	SS	0,16	0,50	1,70	0,025	0,020	0,050	0,12	0,020	0,050	0,30	0,20	0,025
S550MH	GF	SS	0,14	0,50	2,00	0,025	0,020	0,050	0,12	0,020	0,050	0,30	0,20	0,025

[a] See 6.3. EN 10219-1

[b] The deoxidation method is designated as follows:

GF = Fully killed steel containing nitrogen binding elements in amounts sufficient to bind the available nitrogen and having a fine grained structure.

[c] SS = special steel.

[d] If sufficient N-binding elements are present, the minimum total Al content does not apply.

[e] The total sum of Cr, Cu and Mo shall not be higher than 0,60 %.

Table 4. Mechanical properties of hollow sections in thicknesses ≤ 20 mm – Feedstock material condition M

Steel grade	Minimum yield strength R_{eH} MPa	Tensile strength R_m MPa	Minimum elongation A[a] %	Minimum impact energy KV[b] J	
	Specified thickness mm	Specified thickness mm	Specified thickness mm	at test temperature of	
	≤ 20	≤ 20	≤ 20	-50°C	-20 °C
S440MH	440	490-630	17	-	40[c]
S550MH	550	605-760	14	-	40[c]

[a] For pile sizes D/T < 15 (circular) the minimum elongation is reduced by 2

[b] For impact properties for reduced section test pieces see 6.7.2. EN 10219-1

[c] This value corresponds to 27 J at -30 °C (see EN 1993-1-1).

Table 5. Maximum carbon equivalent value (CEV) based on cast analysis [a]

Steel grade	Maximum CEV for nominal thicknesses ≤ 20 mm %
S440J2H	0,45
S550J2H	0,47
S440MH	0,42
S550MH	0,45

[a] See 6.6.2 EN 10219-1, Option 1.2.

ANNEX C TOLERANCES ON SHAPE AND MASS

Table 1. Tolerances on shape and mass, pile pipe

Characteristic	Circular hollow section
Outside diameter (D)*	D ≤ 350 mm ± 0,5 % D > 350 mm ± 1%
Thickness (T)	For D ≤ 406,4 mm: T ≤ 5 mm ± 10 % T > 5 mm ± 0,5 mm For D > 406,4 mm: ± 10 % with a maximum of ± 2 mm
Out-of-roundness (O)	D ≤ 150 mm ± 1,2% D > 150 mm, D ≤ 350 mm ± 1% D > 350 mm ± 2%
Straightness (e)	0,20 % of total length
Mass per unit length (*M*)	± 6 % on individual delivered lengths
*The diameter (D) shall be measured by circumference tape at the discretion of the manufacturer.	

Table 2, Tolerances on shape and mass, sleeve pipe (friction joint)

Characteristic	Circular hollow section
Inside diameter (D)*	D ≤ 150 mm ± 0,5 % D > 150 mm ± 0,3 %
Thickness (T)	For D ≤ 406,4 mm: T ≤ 5 mm ± 10 % T > 5 mm ± 0,5 mm For D > 406,4 mm: ± 10 % with a maximum of ± 2 mm
Out-of-roundness (O)	D ≤ 150 mm ± 1,2 % D > 150 mm ± 1 %
Straightness (e)	0,20 % of total length
Mass per unit length (*M*)	± 6 % on individual delivered lengths
Length of individual sleeve (L)	± 5 mm
*The diameter (D) shall be measured by circumference tape at the discretion of the manufacturer.	

ANNEX D COMPRESSION AND TENSILE TESTS OF PILE JOINTS

Compression and tensile resistance of pile joints are tested according to test arrangements presented in Figures 1 and 2. Characteristic compression and tensile capacity of the joint must fulfil the requirements presented in 2.2.2 and 2.2.3 after the joint is properly fastened and tightened according to manufacturer's instructions.

Compression test

Each test specimen must include the entire joint section connecting two pile elements. The minimum length of a specimen is $L \geq 2 \times D$ (D = outside diameter of the pile element, Fig. 1).

The specimen is compressed with central axial load (N) applied on the pile segments (Fig. 1).

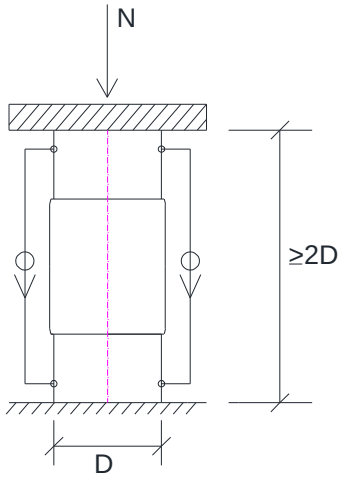


Fig. 1 Loading arrangements of compression test of pile joints.

During the tests the relative displacement of the specimen (minimum two displacement sensors at the opposite sides of the joint, Fig. 1), the applied compressive force (N) and the ultimate failure mechanism of the specimen are recorded.

Tensile test

Each test specimen must include the entire joint section connecting two pile elements. Any necessary fittings or attaching parts can be used to apply the tensile force on the pile segments. To achieve even load articulations at both ends of fastening of the test piece is recommended.

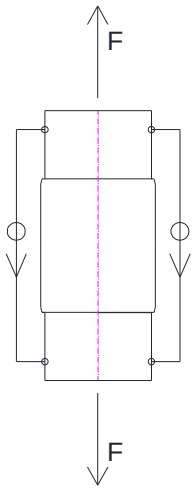


Fig.2 Loading arrangements of tensile test of pile joints.

A specimen is loaded with axial tensile force (F) applied on the pile segments (Fig. 2).

During the tensile tests the relative displacement of the specimen (e.g. two displacement sensors at the opposite sides of the joint, Fig. 2), the applied tensile force (F) and the ultimate failure mechanism of the specimen are recorded.