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European Assessment Document for

High load-bearing and low load-bearing single anchor earth retaining structures made of steel

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This European Assessment Document (EAD) has been developed taking into account up-to-date technical and scientific knowledge at the time of issue and is published in accordance with the relevant provisions of Regulation (EU) 305/2011 as a basis for the preparation and issuing of European Technical Assessments (ETA).

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1 SCOPE OF THE EAD

1.1 Description of the construction product

The high load-bearing and low load-bearing single anchor earth retaining structures made of steel, named “high load-bearing earth retaining structures” and “low load-bearing earth retaining structures” thereafter, are prefabricated steel structure kits.

The high load-bearing earth retaining structures and low load-bearing earth retaining structures transfer the load they receive from the embankment to the foundation by a supporting element, the anchorage. The anchorage is not subject of this EAD.

The products or materials applied for coating do not consist of more than 1% of organic materials (based on volume or weight, whichever is the more onerous).

The products are 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, e.g., with regard to the intended end use conditions, 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 as long as the details of the assessment methods as laid down in this EAD are respected.

1.1.1 High load-bearing earth retaining structures

High load-bearing earth retaining structures consist of: a frontal protection element and, optionally, a main rod with restraining bars.

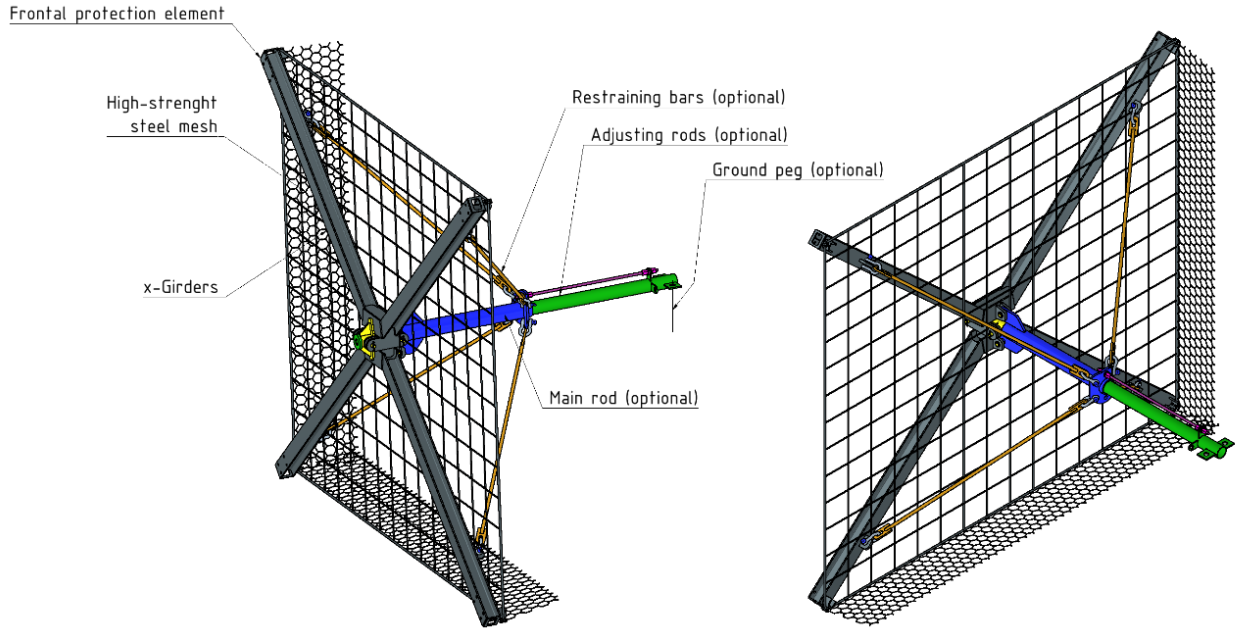


Figure 1.1.1.1: High load-bearing earth retaining structures of quadratic shape for slope stabilisation

The frontal protection element can have a quadratic or a trapezoid shape (see Figure 1.1.1.1 and Figure 1.1.1.2). The frontal protection element consists of two crossing X-shaped steel girders (named X-girders

thereafter) that are covered with a layer of a high-strength steel mesh on the earth-filling side. The high strength steel mesh is framed with ~~the~~ ropes or steel profiles as shown on Figure 1.1.1.1 and Figure 1.1.1.2.

Additionally, the ends of the frontal protection element are braced to the end of the main rod with four restraining bars. The connection is made by means of connection plates and rope shackles.

The connection between high load-bearing earth retaining structures and anchorage is achieved by an anchor plate, an anchor plate with tube, an auxiliary construction made of a main rod with adjusting rods and ground peg or deadman (anchor) plate as shown in Figure 1.1.1.3 (whereas the adjusting rod, a ground peg or deadman (anchor) plate are used for installation but not contributing to the performance of the kit). The main rod forms an angle α_m of 80° to 90° to the plane of the frontal protection element. The anchor pile passes through the main rod, the frontal protection element and through the anchor plate and is fixed in the middle of the frontal protection element, on the side, opposite to earth-filling side (see Figure 1.1.1.3 and Figure 1.1.1.4).

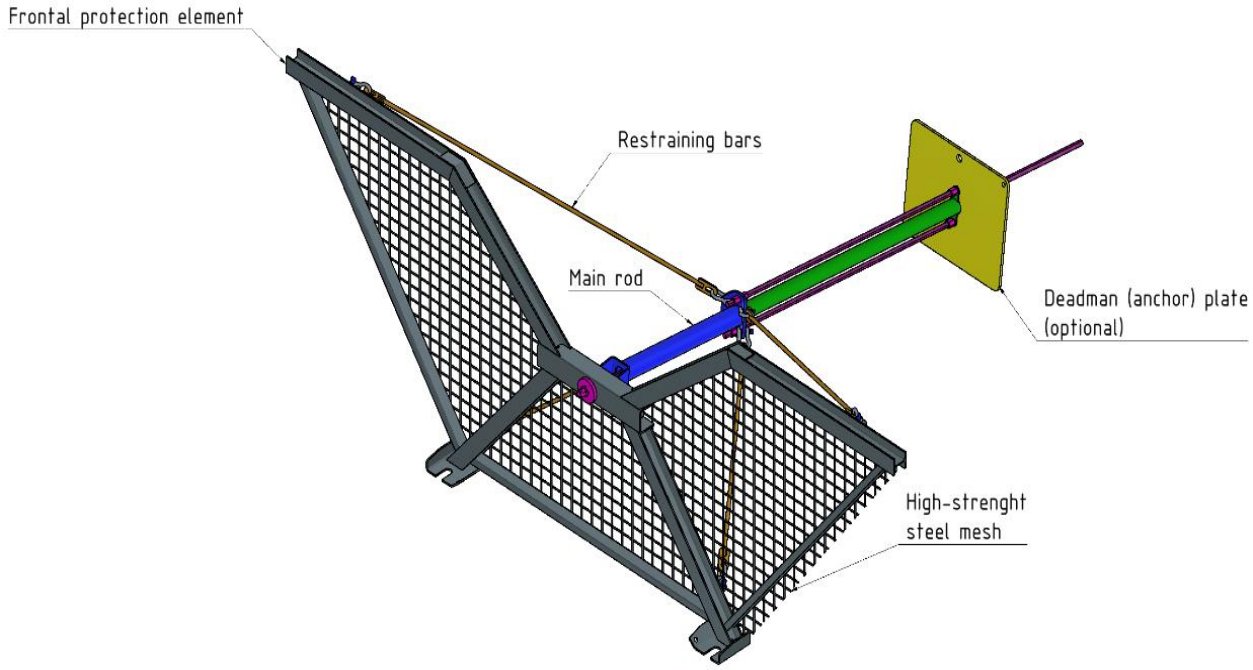


Figure 1.1.1.2: High load bearing earth retaining structures of trapezoid shape for stabilisation of torrent beds

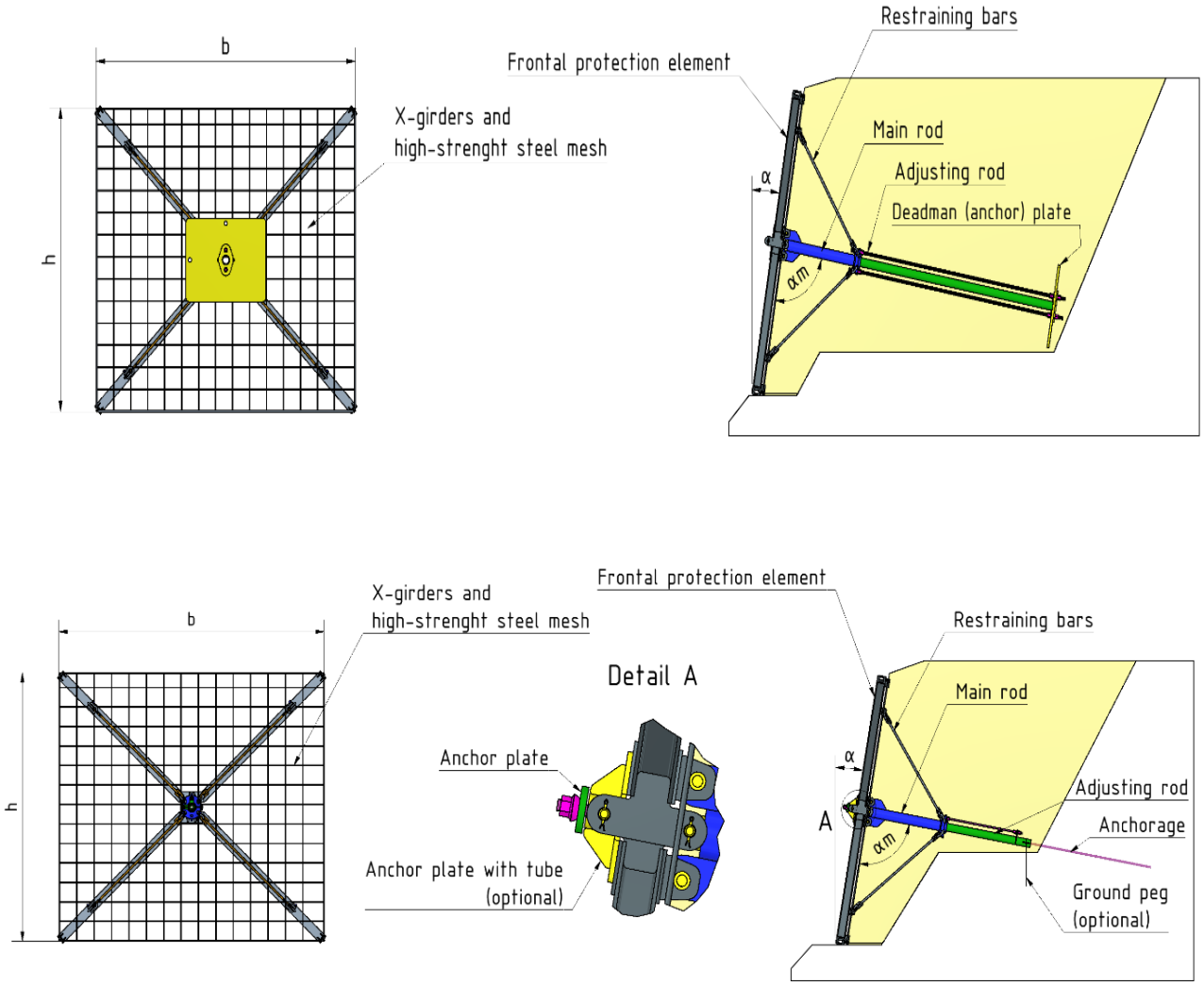
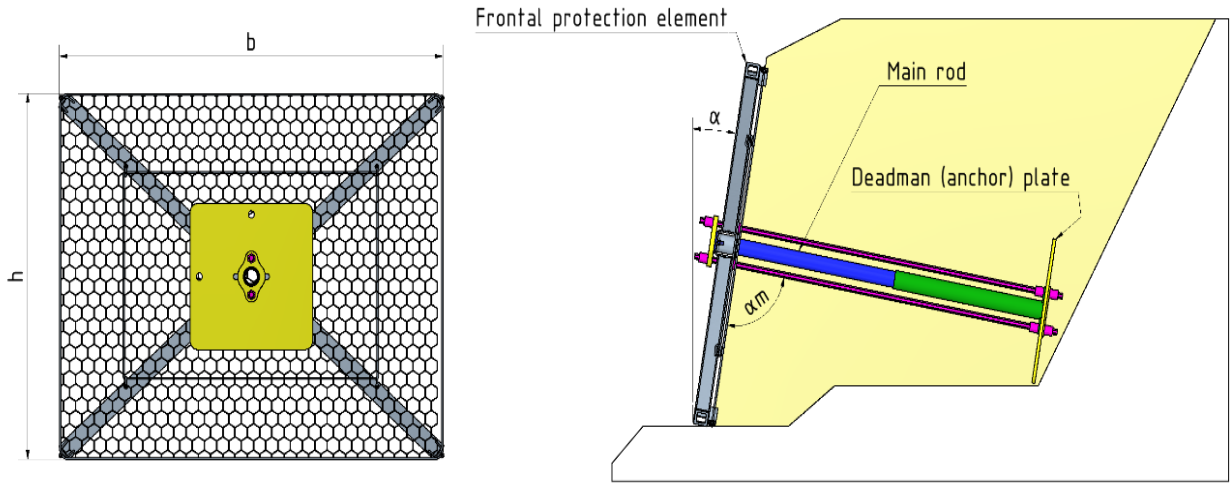


Figure 1.1.1.3: Example for assembly of high load-bearing earth retaining structures with restraining bars



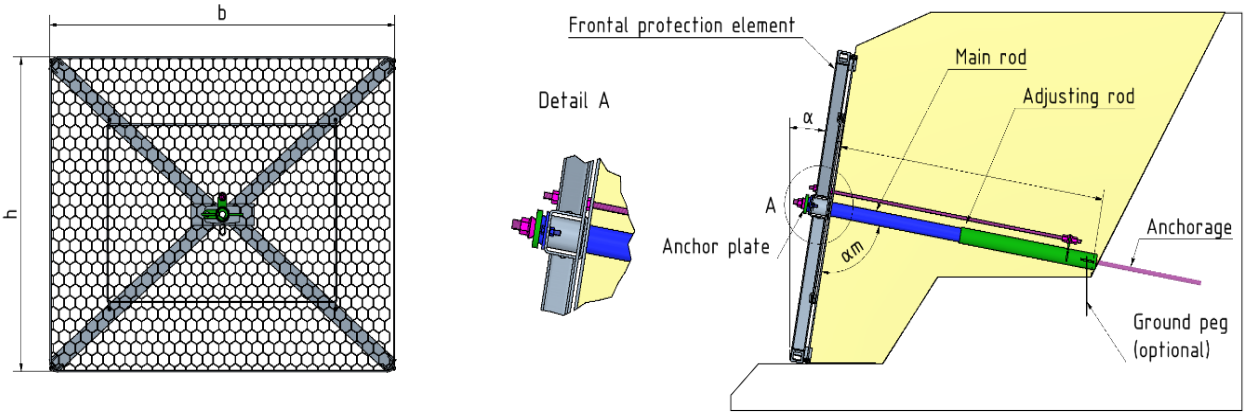


Figure 1.1.1.4: Example for assembly of high load-bearing earth retaining structures

1.1.2 Low load-bearing earth retaining structures

Low load-bearing earth retaining structures (Figure 1.1.2.1 and Figure 1.1.2.2) consist of a frontal protection element. The frontal protection element is of rectangular shape (not trapezoid shape) and consists of two crossing X-shaped steel beams covered with a layer of steel mash on the earth-filling side. The steel mesh is framed with main perimeter steel ropes connected to the steel beams. The central protection element may contain secondary steel ropes (Figure 1.1.2.2) connected to the main perimeter steel ropes. The crossing steel beams are connected together in a central node. The frontal protection element is restrained from the thrust it receives from the ground directly by steel anchor bar whose purpose is to connect it to the foundation. The bottom part of the frontal protection element is fixed to the ground using the bottom steel wire rope and bottom steel anchor bar.

The earth-filling, steel anchor bar, front erosion control mat and bottom steel anchor bar are not covered by this EAD.

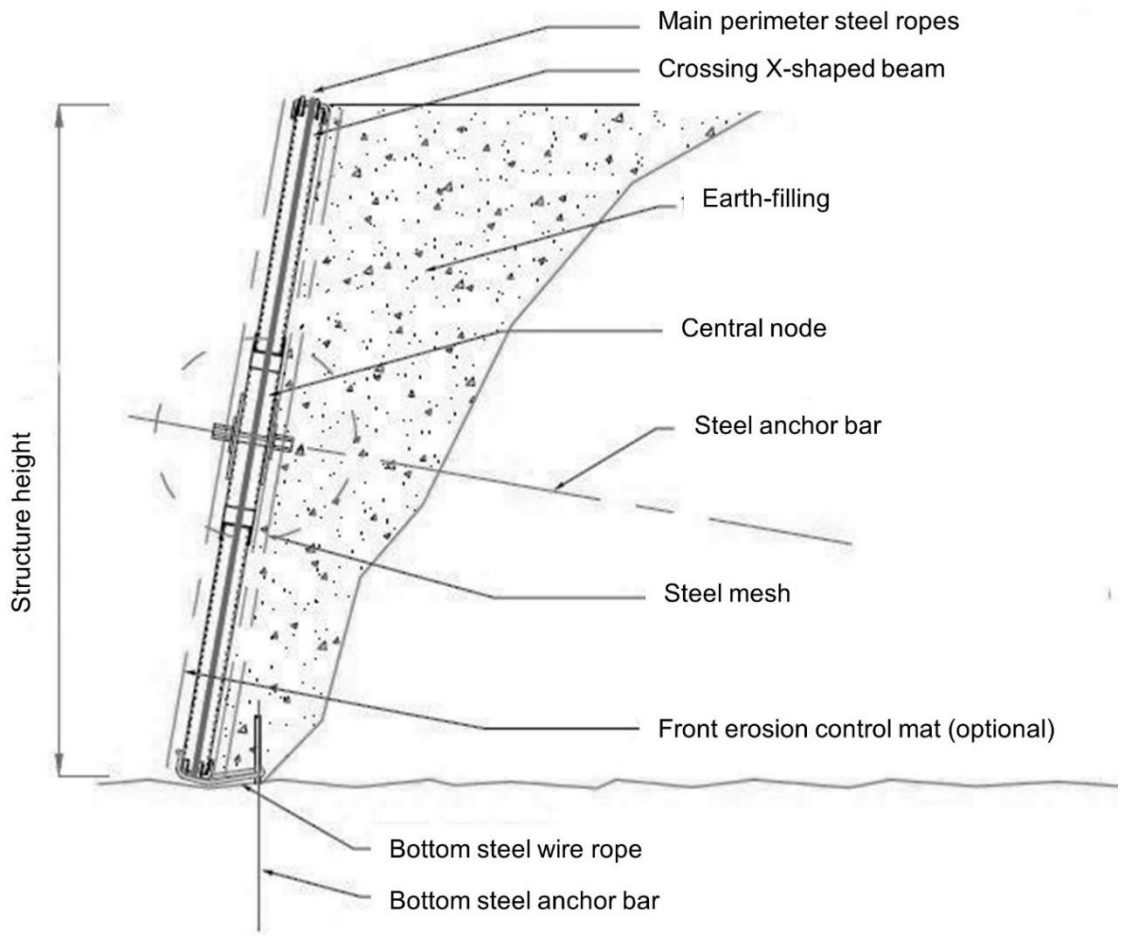


Figure 1.1.2.1: Low load-bearing earth retaining structures for slope stabilisation

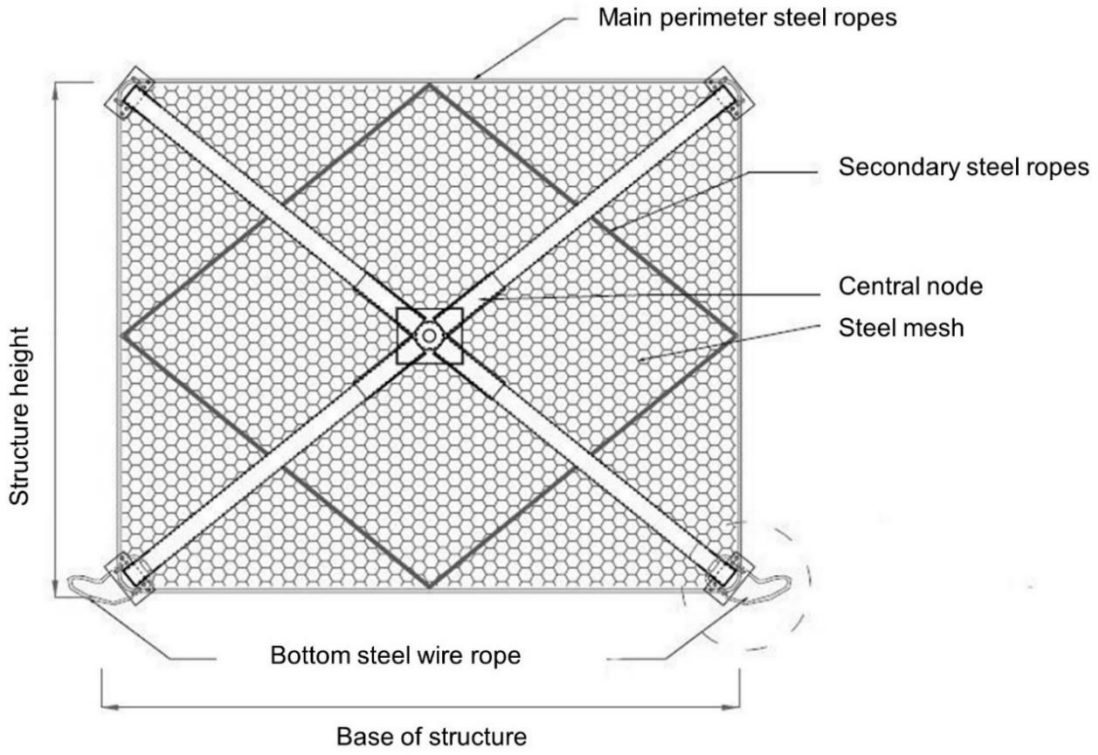


Figure 1.1.2.2: Low load-bearing earth retaining structures for slope stabilisation

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

1.2.1 Intended use(s)

The product is intended to be used to secure embankments in following cases:

- Slope stabilization barrier (road and forest road construction, restauration of landslides in immediate measures, restauration of timber embankment walls);
- Stabilization barrier for torrent beds, canals with debris flow, gully protection.

The high load-bearing earth retaining structures and low load-bearing earth retaining structures are intended to be used in atmospheric conditions according to EN ISO 9223[1] in terms of corrosivity category C2 or, when the product is used in the coastal area, category C3.

The low load-bearing earth retaining structure is intended to be used in cases where the maximum force transferred to the anchorage of is equal or lower than 100 kN.

The high load-bearing earth retaining structure is intended to be used in cases where the maximum force transferred to the anchorage can be greater than 100 kN.

The high load-bearing earth retaining structures can be installed horizontally or upright in one or more rows, connected to each other in the row with rope clamps and rope shackles (see Figure 1.2.1.3).

The high load-bearing earth retaining structures can be installed in more than one row and under different inclinations, measured from the vertical axis. Examples of the installation are given in Figure 1.2.1.1 and Figure 1.2.1.2.

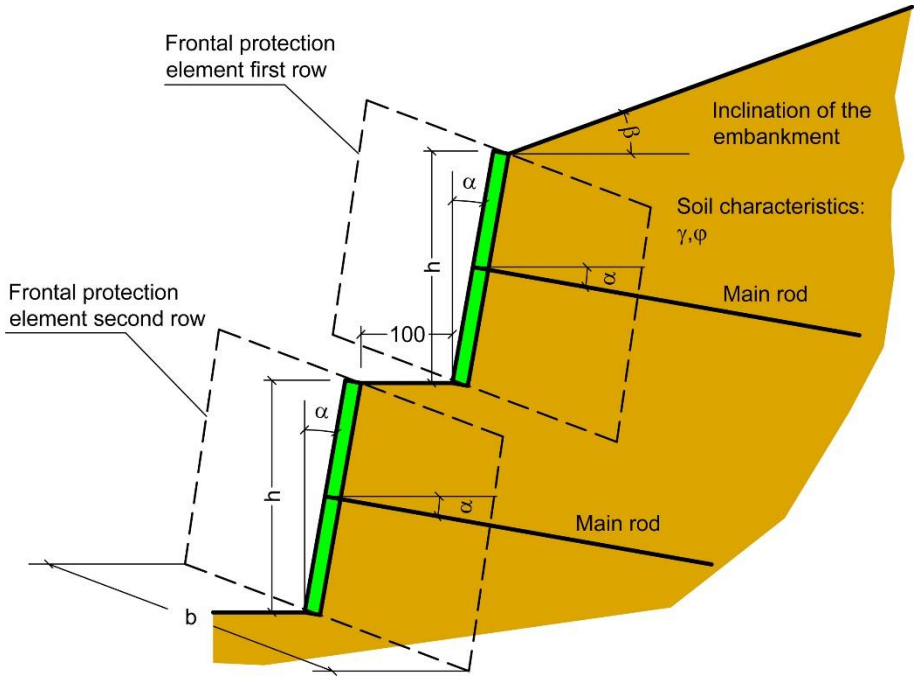


Figure 1.2.1.1: Example of two-row installation of high load-bearing earth retaining structures with embankment (Indicated dimensions are in centimetres)

1 All undated references to standards in this EAD are to be understood as references to the dated versions listed in chapter 4.

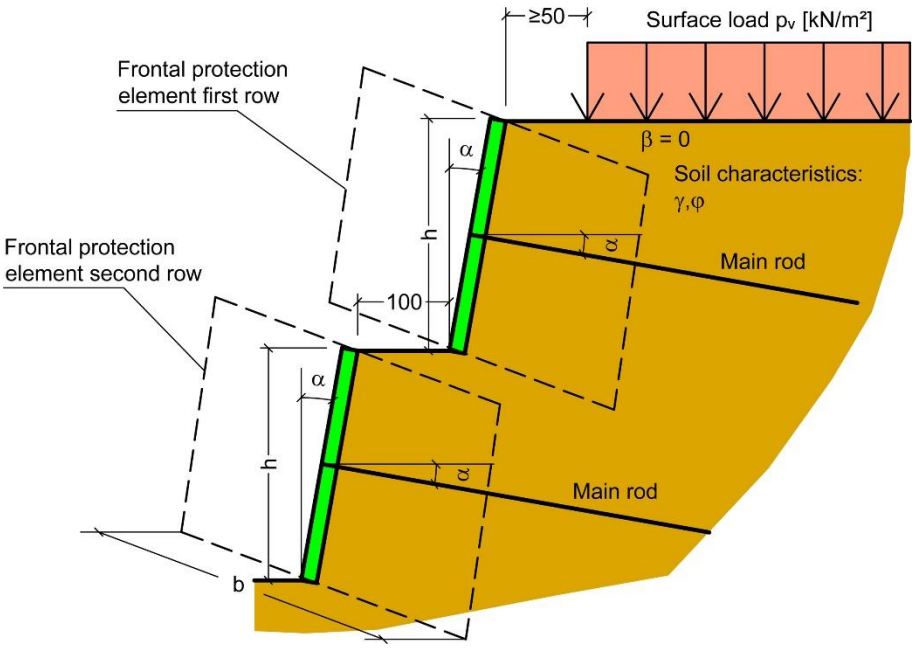


Figure 1.2.1.2: Example of two-row installation of high load-bearing earth retaining structures with surface load (Indicated dimensions are in centimetres)

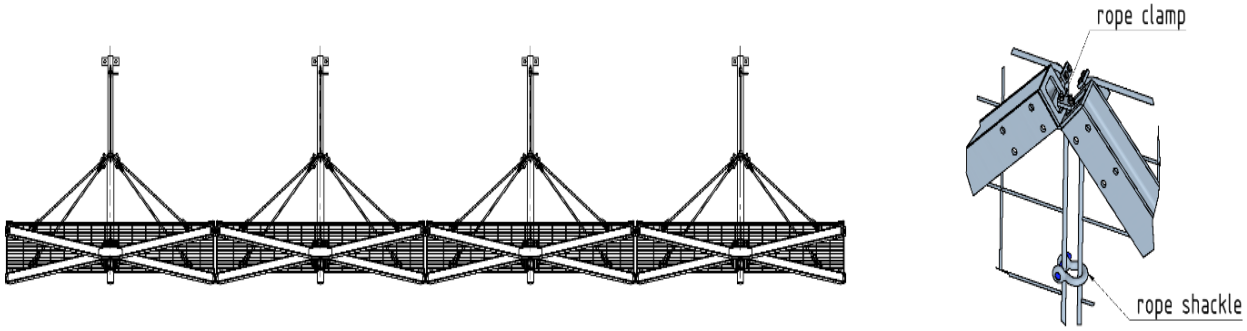


Figure 1.2.1.3: One row installation of high load-bearing earth retaining structures; connection with rope clamps and rope shackles

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 high load-bearing earth retaining structures and low load-bearing earth retaining structures for the intended use of 25 years when installed in the works (provided that the high load-bearing earth retaining structures and low load-bearing earth retaining structures are subject to appropriate installation (see 1.1)). 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[2]. The assessed mass loss of the coating according to Clause 2.2.6 is the parameter for the expression of the working life in the ETA in accordance with EN 10244-2.

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

2 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.

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.

1.3 Specific terms used in this EAD

1.3.1 Symbols

In this EAD specific terms apply (see Figure 1.2.1.1 and Figure 1.2.1.2):

Symbol	Description
h	Frontal protection element height (wall height) [m]
b	Frontal protection element width [m]
α	Wall slope angle [°]
α_m	Angle formed by the main rod in relation to the plane of the frontal protection element
ß	Terrain slope angle [°]
γ	Specific weight [kg/m^3]
φ	Angle of inner friction [°]
p_v	Surface load [kN]
DBR	Dark Brown Rust according to EAD 230005-00-0106

2 ESSENTIAL CHARACTERISTICS AND RELEVANT ASSESSMENT METHODS AND CRITERIA

2.1 Essential characteristics of the product

Table 2.1.1 shows how the performance of high load-bearing earth retaining structures is assessed in relation to the essential characteristics.

Table 2.1.1: Essential characteristics of the product and methods and criteria for assessing 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	Maximum force transferred to the anchorage of high load-bearing earth retaining structures	2.2.1	Level maximum applied tension force F [kN]
Basic Works Requirement 2: Safety in case of fire			
2	Reaction to fire	2.2.3	Class
Basic Works Requirement 3: Hygiene, health and the environment			
3	Content, emission and/or release of dangerous substances	2.2.4	Level toxicity in biological tests as EC20-values for each dilution ratio maximum determined biological degradability in "...% within ...hours/days"
Basic Works Requirement 4: Safety and accessibility in use			
4	Load-deformation behaviour	2.2.5	Level maximum deformation u_{total} [mm] at the endpoint of the X girder
Aspects of durability			
5	Durability	2.2.6	Description

Table 2.1.2 shows how the performance of low load-bearing earth retaining structures is assessed in relation to the essential characteristics.

Table 2.1.2: Essential characteristics of the product and methods and criteria for assessing 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	Maximum force transferred to the anchorage of low load-bearing earth retaining structures	2.2.2	Level maximum applied tension force F [kN] and forces on anchor F_1 [kN] and foundations F_2 and F_3 [kN]
Basic Works Requirement 2: Safety in case of fire			
2	Reaction to fire	2.2.3	Class
Basic Works Requirement 3: Hygiene, health and the environment			
3	Content, emission and/or release of dangerous substances	2.2.4	Level toxicity in biological tests as EC20-values for each dilution ratio maximum determined biological degradability in "...% within ...hours/days"
Aspects of durability			
4	Durability	2.2.6	Description

2.2 Methods and criteria for assessing the performance of the product in relation to essential characteristics of the product

This chapter is intended to provide instructions for TABs. Therefore, the use of wordings such as “shall be stated in the ETA” or “it has to be given in the ETA” shall be understood only as such instructions for TABs on how results of assessments shall be presented in the ETA. Such wordings do not impose any obligations for the manufacturer and the TAB shall not carry out the assessment of the performance in relation to a given essential characteristic when the manufacturer does not wish to declare this performance in the Declaration of Performance.

If for any components covered by harmonised standards or European Technical Assessments the manufacturer of the component has included the performance regarding the relevant essential characteristic in the Declaration of Performance, retesting of that component for issuing the ETA under the current EAD is not required.

2.2.1 Maximum force transferred to the anchorage of high load-bearing earth retaining structures

Purpose of the assessment

Determination of the maximum force transferred to the anchorage.

Assessment method

The assessment shall be done in accordance with Annex A for each geometric assembly of the frontal protection element (rectangle or trapezoid) in accordance with Clause 1.1.1 and each size of the high load-bearing earth retaining structure.

Expression of results

The result of the assessment, to be given in the ETA, is the maximum applied tension force F [kN], reported in accordance with Annex A .

2.2.2 Maximum force transferred to the anchorage of low load-bearing earth retaining structures

Purpose of the assessment

Determination of the maximum force transferred to the anchorage.

Assessment method

The assessment shall be done in accordance with Annex C for each geometric assembly of the frontal protection element and the supporting structure according to Clause 1.1.2 and each size of the low load-bearing earth retaining structure.

Expression of results

The result of the assessment, to be given in the ETA, is the maximum applied tension force F [kN], forces on anchor F_1 [kN] and foundations F_2 and F_3 [kN] reported in accordance with Annex C.

2.2.3 Reaction to fire

The high load-bearing earth retaining structures and low load-bearing earth retaining structures are considered to satisfy the requirements of class A1 of the reaction-to-fire performance in accordance with the Commission Decision 96/603/EC, as amended by Commission Decisions 2000/605/EC and 2003/424/EC, 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, when the conditions referred to above are fulfilled, the performance of the product is Class A1 which shall be given in the ETA.

2.2.4 Content, emission and/or release of dangerous substances

Purpose of the assessment

This assessment shall be performed if the product is coated.

The performance of the product related to the emissions and/or release and, where appropriate, the content of dangerous substances shall be assessed on the basis of the information provided by the manufacturer[3], after identifying the release scenarios taking into account the intended use of the product and the Member States where the manufacturer intends his product to be made available on the market. The identified intended release scenario for this product and intended use with respect to dangerous substances is:

S/W1: Product with direct contact to soil-, ground- and surface water.

The leaching of dangerous substances therefore shall be checked.

Assessment method

For the intended use covered by the release scenario S/W1 the performance of the organic coating of wire, if organic coating is used, concerning leachable substances shall be assessed. A leaching test with subsequent eluate analysis shall take place, each in duplicate. Leaching tests of the organic coating of wire shall be conducted according to EN 16637-2 for scenario I according to Annex A, clause A.1. The leachant shall be pH-neutral demineralised water and the ratio of liquid volume to surface area shall be (80 ± 10) l/m². Each test specimen to be tested shall be prepared by cutting off the piece of finally organic coated wire of length l_w (mm) calculated according to equation:

$$l_w = \frac{40000}{\pi \cdot D_c^2}$$

Where:

l_w (mm) is cut off length of organic coated wire and D_c is a wire diameter with organic coating, if relevant.

After that, cut off pieces of organic coated wire shall be wound into a coil of diameter suitable for following preparation of eluates.

In eluates of "6 hours" and "64 days", the following biological tests shall be conducted:

- Acute toxicity test with Daphnia magna Straus according to EN ISO 6341;
- Toxicity test with algae according to EN ISO 15799;
- Luminescent bacteria test according to EN ISO 11348-1, EN ISO 11348-2 or EN ISO 11348-3 (those methods are equivalent).

For each biological test, EC20-values shall be determined for dilution ratios 1:2, 1:4, 1:6, 1:8 and 1:16.

If the parameter TOC is higher than 10 mg/l, the following biological tests shall be conducted with the eluates of "6 hours" and "64 days" eluates:

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3 The manufacturer may be asked to provide to the TAB the REACH related information which shall accompany the DoP (cf. Article 6(5) of Regulation (EU) No 305/2011).
The manufacturer is not obliged to:
- provide the chemical constitution and composition of the product (or of constituents of the product) to the TAB, or
- provide a written declaration to the TAB stating whether the product (or constituents of the product) contain(s) substances which are classified as dangerous according to Directive 67/548/EEC and Regulation (EC) No 1272/2008 and listed in the "Indicative list on dangerous substances" of the SGDS, taking into account the installation conditions of the construction product and the release scenarios resulting from there.

Any information provided by the manufacturer regarding the chemical composition of the products is not to be distributed to EOTA, to other TABs or beyond.

- Biological degradation according to OECD Test Guideline 301, part A, B or E (those methods are equivalent).

Expression of results

Determined toxicity in biological tests shall be expressed as EC20-values for each dilution ratio. Maximum determined biological degradability shall be expressed as "...% within ...hours/days". The respective test methods for analysis shall be specified.

2.2.5 Load-deformation behaviour

Purpose of the assessment

This assessment shall determine the maximum deformation of the structural X-girders under applied loads.

Assessment method

The assessment shall be done according to Annex B, in conjunction with the assessment of maximum force transferred to the anchorage according to Annex A, for each geometric constellation of frontal protection element (rectangle or trapezoid) according to Clause 1.1.1 and each size of the high load-bearing earth retaining structure.

Expression of results

The maximum deformation u_{total} [mm] at the endpoint of the X girder shall be stated in the ETA.

2.2.6 Durability

Purpose of the assessment

Depending on the environment (defined by corrosivity category in Clause 1.2.1) in which the high load-bearing earth retaining structures and low load-bearing earth retaining structures are installed the durability shall be determined by means of thickness/mass of coating.

Assessment method

The assessment of durability for the following elements:
- carbon steel hot dip galvanized according to EN ISO 1461, Clause 4 and Clause 6,
- stranded ropes, spiral ropes, and steel wire and wire products coated according to EN 10244-2, Clause 4,
- wire rope grips/clips/clamps, shackles and other ancillaries
    - hot dip galvanized according to EN ISO 1461, Clause 4 and 6 or
    - zinc plated according to EN ISO 4042, Clause 4 or
    - non-electrolytically zinc flake coated according to EN 13858, Clause 6.2 or
    - zinc-nickel coated according to EN ISO 19598, Clause 8,

shall be carried out in the following order:

1. Determination of the initial coating thickness according to EN ISO 2178, Clause 7 and EN ISO 1463, Clause 7
2. Determination of the class of the coating according to EN 10244-2, Clause 4.2.1
3. Testing according to EN ISO 9227 where the test duration shall correspond to the corrosivity category in accordance with EN ISO 12944-6, Clause 5.6, Table 1.
   Determination of the coating thickness according to EN ISO 2178, Clause 7 and EN ISO 1463, Clause 7.

Wire rope net panels shall be assessed in accordance with EAD 230005-00-0106, Clause 2.2.4;

Expression of results

In the ETA it shall be stated:

- The type and thickness/mass of coating for every element;
- Exposure time with surface DBR (Dark Brown Rust) ≤ 5 % [hours] for wire rope net panels, according to EAD 230005-00-0103, Clause 2.2.4.

3 ASSESSMENT AND VERIFICATION OF CONSTANCY OF PERFORMANCE

3.1 System(s) of assessment and verification of constancy of performance to be applied

For the products covered by this EAD the applicable European legal act is Commission Decision 2003/728/EC (EU).

The system is 1.

3.2 Tasks of the manufacturer

The cornerstones of the actions to be undertaken by the manufacturer of the product in the procedure of assessment and verification of constancy of performance are laid down in Table 3.2.1.

The manufacturer (regarding the components he buys from the market with DoP) shall take into account the Declaration of Performance issued by the manufacturer of that component. No retesting is necessary.

Table 3.2.1 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) [including testing of samples taken at the factory in accordance with a prescribed test plan]					
	X-girders and main rod and other steel elements:				
1	Structural steel grade	Inspection document according to EN 10204, type 3.1	As defined in control plan	1 per steel grade	Each delivery
2	Welding	EN 1090-2, Clause 12.4 Welding shall be verified by visual check In addition, Non-destructive testing	As defined in control plan	-	Each 1 per welding type every 250 items But minimum one per welding type per year for each supplier
3	Corrosion protection	EN ISO 1461	EN ISO 1461	5 per type (from different coils)	Once / year
	High-strength steel mesh:				
4	Dimensions of rope net	EAD 230005-00-0106, Clause 2.2.1.5	As defined in control plan	3 per type	Each delivery or every 50 panels of the same delivery
5	Dimensions of double twisted steel wire mesh	EAD 230008-00-0106, Clause 2.2.1	As defined in control plan	3 per type	Each delivery or every 50 panels of the same delivery
6	Wire breaking/ Elongation	EAD 230008-00-0106, Clause 2.2.3	As defined in control plan	3 per type	Every 50 panels of the same delivery; in case of less than 50 panels/year: once per year per supplier
7	Tensile strength of double twisted steel wire mesh	EAD 230008-00-0106, Clause 2.2.3	As defined in control plan	3 per type	Every 50 panels of the same delivery; in case of less than 50 panels/year: once per year per supplier

No	Subject/type of control	Test or control method	Criteria, if any	Minimum number of samples	Minimum frequency of control
8	Corrosion protection for rope net	EN 10244-2	As defined in control plan	3 per type	Each delivery
9	Corrosion protection for wire mesh	EN 10025-2 EN 10244-2	As defined in control plan	3 per type	Each delivery
	Ropes:				
10	Designation	General for steel wire ropes EN 12385-2, Clause 4 and EN 12385-10 for spiral ropes, Clause 5.6	As defined in control plan	3 per type	Each reel or 50 panels Alternatively, 1 per year test + inspection document for each delivery according to EN 10204, type 3.1
11	Breaking force and elongation	General for steel wire ropes EN 12385-2 and EN 12385-10 for spiral ropes	As defined in control plan	3 per type	Each reel or 50 panels Alternatively,1 per year test + inspection document for each delivery according to EN 10204, type 3.1
12	Geometrical properties	EN 12385-10	As defined in control plan	3 per type	Each reel or 50 panels Alternatively, 1 per year test + inspection document for each delivery according to EN 10204, type 3.1
13	Corrosion protection	EN 10244-2	As defined in control plan	3 per type	Each reel or 50 panels Alternatively, 1 per year test + inspection document for each delivery according to EN 10204, type 3.1
	Rope shackles and rope clamps:				
14	Working load limit (WLL)	EN 13889, Table 2	As defined in control plan	5 per type	Once / year
15	Corrosion protection	EN 13858 EN ISO 1461 EN ISO 4042 EN ISO 10683 EN ISO 19598	As defined in control plan	5 per type	Once / year

3.3 Tasks of the notified body

The cornerstones of the actions to be undertaken by the notified body in the procedure of assessment and verification of constancy of performance for high load-bearing earth retaining structures and low load-bearing earth retaining structures are laid down in Table 3.3.1.

Table 3.3.1 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 *(for systems 1+, 1 and 2+ only)*					
1	Notified Body will ascertain that the factory production control with the staff and equipment are suitable to ensure a continuous and orderly manufacturing of the high load-bearing earth retaining structures and low load-bearing earth retaining structures.	Verification of the complete FPC as described in the control plan agreed between the TAB and the manufacturer	According to Control plan	According to Control plan	When starting the production or a new line
Continuous surveillance, assessment and evaluation of factory production control *(for systems 1+, 1 and 2+ only)*					
2	The Notified Body will ascertain that the system of factory production control and the specified manufacturing process are maintained taking account of the control plan.	Verification of the controls carried out by the manufacturer as described in the control plan agreed between the TAB and the manufacturer with reference to the raw materials, to the process and to the product as indicated in Table 3.2.1	According to Control plan	According to Control plan	1 (once)/year

4 REFERENCE DOCUMENTS

EN 1090-2: 2018+A1:2024	Execution of steel structures and aluminium structures Part 2: Technical requirements for steel structures
EN 10025-2:2019	Hot rolled products of structural steels - Part 2: Technical delivery conditions for non-alloy structural steels
EN 10025-4:2019+A1:2022	Hot rolled products of structural steels - Part 4: Technical delivery conditions for thermomechanical rolled weldable fine grain structural steels
EN 10204:2004	Metallic products – Types of inspection documents
EN 10244-2:2023	Steel wire and wire products – Non-ferrous metallic coatings on steel wire – Part 2: Zinc or zinc alloy coatings
EN 12385-2:2002+A1:2008	Steel wire ropes - Safety - Part 2: Definitions, designation and classification
EN 12385-10:2003+A1:2008	Steel wire ropes - Safety - Part 10: Spiral ropes for general structural applications
EN 13858:2006	Corrosion protection of metals - Non-electrolytically applied zinc flake coatings on iron or steel components
EN 13889:2003+A1:2008	Forged steel shackles for general lifting purposes - Dee shackles and bow shackles - Grade 6 - Safety
EN 16637-2:2023	Construction products. Assessment of release of dangerous substances. Part 2: Horizontal dynamic surface leaching test
EN ISO 1461:2022	Hot dip galvanized coatings on fabricated iron and steel articles - Specifications and test methods (ISO 1461:2022)
EN ISO 1463:2021	Metallic and oxide coatings - Measurement of coating thickness - Microscopical method (ISO 1463:2021)
EN ISO 2178:2016	Non-magnetic coatings on magnetic substrates - Measurement of coating thickness - Magnetic method (ISO 2178:2016)
EN ISO 3452-1:2021	Non-destructive testing. Penetrant testing. Part 1: General principles
EN ISO 4042:2022	Fasteners - Electroplated coating systems
EN ISO 6341:2012	Water quality - Determination of the inhibition of the mobility of Daphnia magna Straus (Cladocera, Crustacea) - Acute toxicity test (ISO 6341:2012)
EN ISO 9223:2012	Corrosion of metals and alloys – Corrosivity of atmospheres – Classification, determination and estimation (ISO 9223:2012)
EN ISO 9227:2022/A1:2024	Corrosion tests in artificial atmospheres - Salt spray tests - Amendment 1: Footnote of warning (ISO 9227:2022/Amd 1:2024)
EN ISO 10683:2018	Fasteners – Non-electrolytically applied zinc flake coating systems (ISO 10683:2018)
EN ISO 11348-1:2008/A1:2018	Water quality - Determination of the inhibitory effect of water samples on the light emission of Vibrio fischeri (Luminescent bacteria test) - Part 1: Method using freshly prepared bacteria - Amendment 1 (ISO 11348-1:2007/Amd 1:2018)
EN ISO 11348-2:2008/A1:2018	Water quality - Determination of the inhibitory effect of water samples on the light emission of Vibrio fischeri (Luminescent bacteria test) - Part 2: Method using liquid-dried bacteria - Amendment 1 (ISO 11348-2:2007/Amd 1:2018)
EN ISO 11348-3:2008/A1:2018	Water quality - Determination of the inhibitory effect of water samples on the light emission of Vibrio fischeri (Luminescent bacteria test) - Part 3: Method using freeze-dried bacteria - Amendment 1 (ISO 11348-3:2007/Amd 1:2018)
EN ISO 12944-6:2018	Paints and varnishes - Corrosion protection of steel structures by protective paint systems - Part 6: Laboratory performance test methods (ISO 12944-6:2018)

EN ISO 14688-1:2018	Geotechnical investigation and testing - Identification and classification of soil - Part 1: Identification and description (ISO 14688-1:2017)
EN ISO 17638:2016	Non-destructive testing of welds - Magnetic particle testing
EN ISO 19598:2016	Metallic coatings - Electroplated coatings of zinc and zinc alloys on iron or steel with supplementary Cr(VI)-free treatment (ISO 19598:2016)
EN ISO 22477-5:2018	Geotechnical investigation and testing - Testing of geotechnical structures – Part 5: Testing of grouted anchors (ISO 22477-5:2018)
EN ISO 15799:2022	Soil quality. Guidance on the ecotoxicological characterization of soils and soil material (ISO 15799:2019)
EAD 230005-00-0106	Wire rope net panels
EAD 230008-00-0106	Double twisted steel wire mesh reinforced or not with ropes
OECD (1992), Test no. 301	*Ready Biodegradability,* OECD Guidelines for the Testing of Chemicals, Section 3, OECD Publishing, Paris, https://doi.org/10.1787/9789264070349-en.

ANNEX A: MAXIMUM FORCE TRANSFERRED TO THE ANCHORAGE AND THE LOAD-DEFORMATION BEHAVIOUR OF HIGH LOAD BEARING EARTH RETAINING STRUCTURE

A.1 Experiment setup

A.1.1 Materials for construction of the experimental setup

- A high load-bearing earth retaining structure (including a main rod, if part of the product) depending on the type of structure (according to Figure 1.1.1.1 and Figure 1.1.1.2, respectively, in Clause 1.1.1;
- A fixed support element on the opposite side at minimum distance of 1,3 x h from a high load-bearing earth retaining structure, which shall withstand sliding and toppling during the test, see Figure A.1.2.1;
- Two fixed support elements with dimensions as the high load-bearing earth retaining structure – left and right to the high load-bearing earth retaining structure, see Figure A.1.1.1. Fixed support elements shall withstand the sliding and toppling during the test;
- A shiftable steel telescope element as distance holders between the high load-bearing earth retaining structure and the fixed support element on the opposite side, see Figure A.1.2.1;
- A steel bar which shall withstand the expected tension force for the connection of the high load-bearing earth retaining structure and the fixed support element on the opposite side, see Figure A.1.2.1.

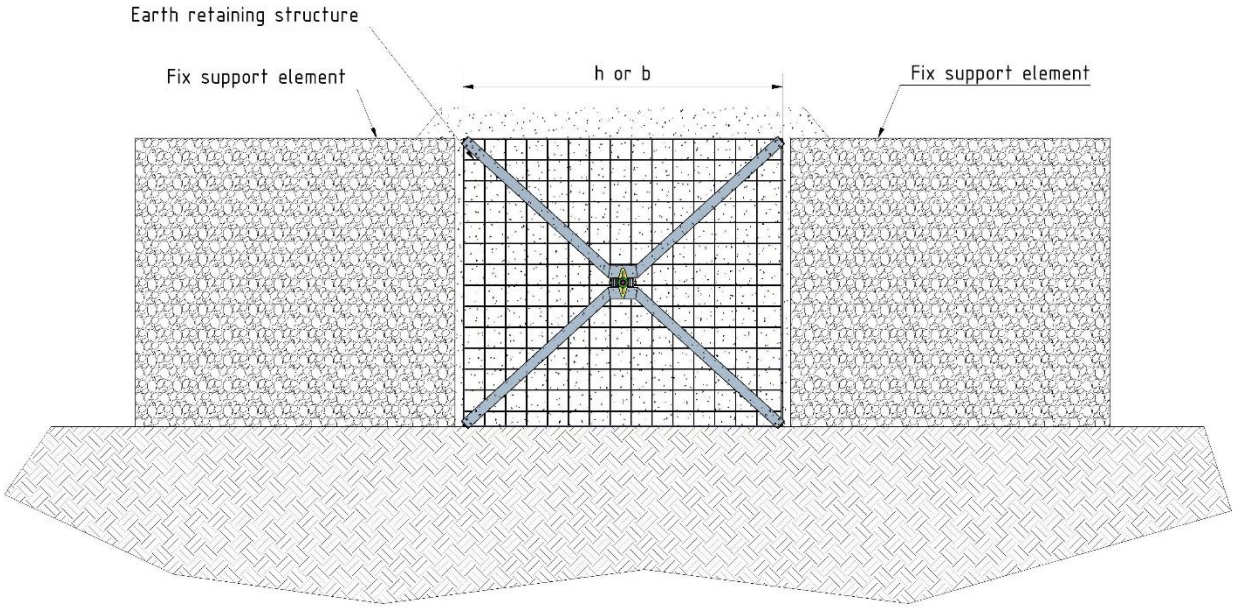


Figure A.1.1.1: Experimental element

A.1.2 Installation

A connection of the high load-bearing earth retaining structures on one side to the fixed support element and fixed support element on the other side shall be made by steel bar (according to Clause A.1.1) and shiftable steel telescope element (according to Clause A.1.1). The steel bar shall be inserted through frontal protection element, main rod (if part of the product) and shiftable steel telescope element.

The steel bar shall then be fastened at the high load-bearing earth retaining structure on one side, to prevent it from being pulled out. On the opposite side a pulling device (e.g., a hollow piston hydraulic cylinder) shall be installed.

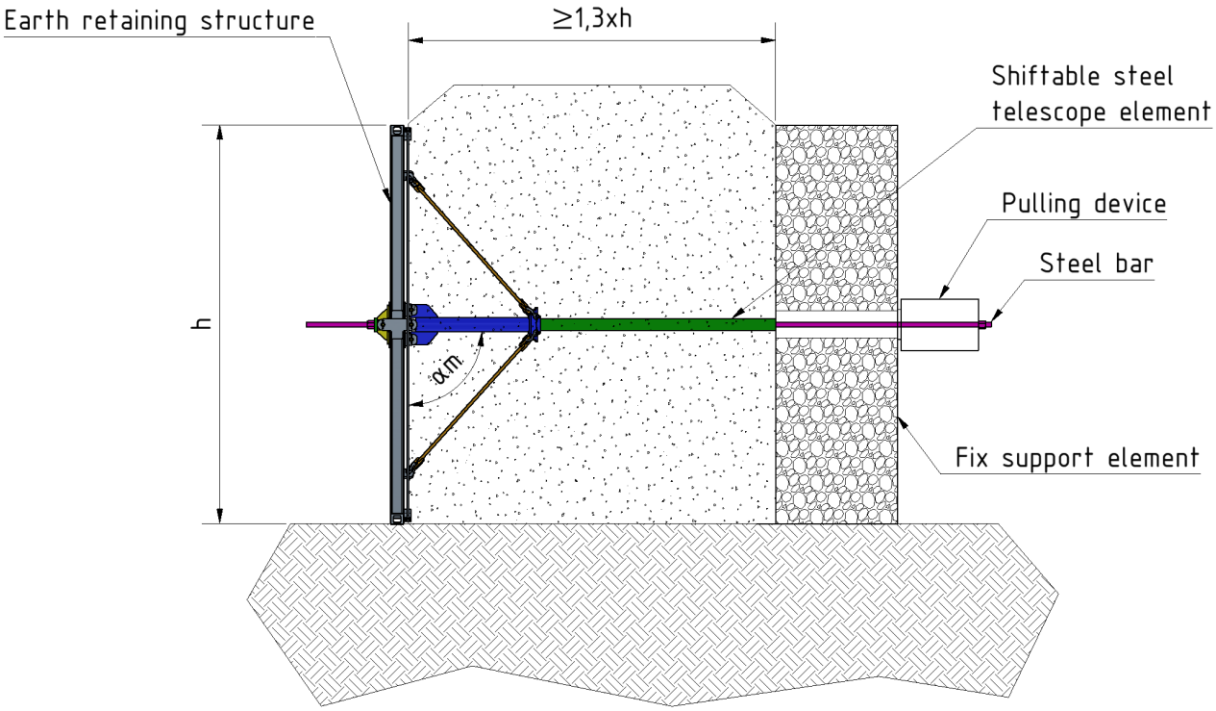


Figure A.1.2.1: Connection of opposite elements

A.2 Measuring devices

If the cross section of the rectangle frontal protection element is greater than 6 m^2, the instrumentation setup according to Clause A.2.1 applies.

If the cross section of the frontal protection element is trapezoid the instrumentation setup according to Clause A.2.2 applies.

If the cross section of the rectangle frontal protection element is less or equal 6 m^2, the instrumentation setup according to Clause A.2.3 applies.

A.2.1 Instrumentation setup 1

The following measuring sensors shall be installed at the frontal protection element for testing:

- Minimum 4 measuring points with rope load cells for wire rope measuring (capacity of 10000 kg, load limiting accuracy ±2% on full scale, creep at nominal load in 30 minutes < 0,05%type);
- Minimum 8 measuring points with T-rosette strain gauges on upper (air side) and lower (earth side) flange of X-girders; in total 16 T-rosette strain gauges with following characteristics: k-factor (Gage factor) tolerance +/- 1% of calibrated value, Transverse sensitivity < 2,5%, Maximum ductility: +/-5%;
- Minimum 3 measuring points with T-rosette strain gauges on the restraining bars; in total 6 T-rosette strain gauges with following characteristics: k-factor (Gage factor) tolerance +/- 1% of calibrated value, Transverse sensitivity < 2,5%, Maximum ductility: +/-5%;
- Hollow Piston Hydraulic Cylinder; $F_{max} \geq 876$ kN or equivalent.

The arrangement and labelling of the sensors and their designation is given in Figure A.2.1.1 as an example. The positions of the measuring points of the T-rosette strain gauges are shown in red, the rope tension cells in turquoise and the T-rosette strain gauges of the restraining bars in green.

Because of the symmetry of the high load-bearing earth retaining structures, no instrumentation needs to be used on the upper left restraining bars.

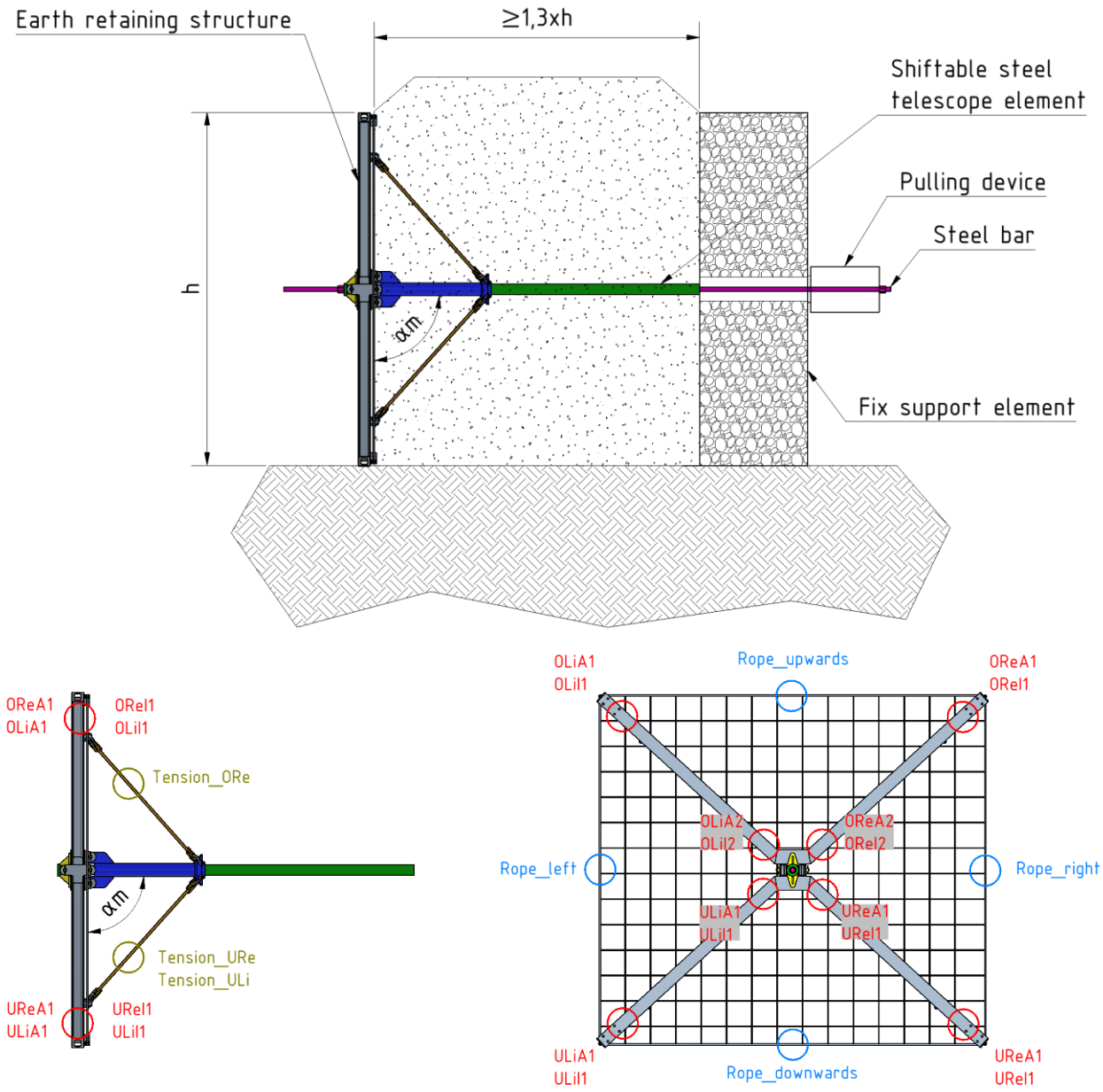


Figure A.2.1.1: Arrangement of the sensors and their designation in the instrumentation setup 1

- OLiA1 (O...Top; Li...Left; A...outside or air side; 1…Corner of the X-girders)
- UReI2 (U...Bottom; Re...Right; I...Inside or earth side: 2…Intersection of the X-girders)

A.2.2 Instrumentation setup 2

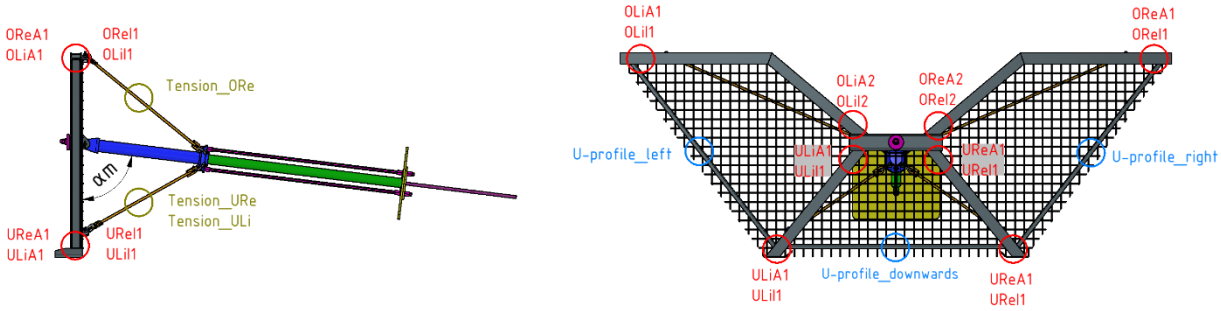


Figure A.2.2.1: Arrangement of the sensors and their designation in the instrumentation setup 2

- OLiA1 (O...Top; Li...Left; A...outside or air side; 1…Corner of the X-girders)
- URel2 (U...Bottom; Re...Right; I...Inside or earth side: 2…Intersection of the X-girders)

Following measuring sensors shall be installed at the frontal protection element for testing:

- Minimum 4 measuring points with rope load cells for wire rope measuring (capacity of 10000 kg, load limiting accuracy ±2% on full scale, creep at nominal load in 30 minutes < 0,05% type);
- Minimum 8 measuring points with T-rosette strain gauges on upper (air side) and lower (earth side) flange of X-girders; in total 16 T-rosette strain gauges with following characteristics: k-factor (Gage factor) tolerance +/- 1% of calibrated value, Transverse sensitivity < 2,5%, Maximum ductility: +/-5%;
- Minimum 3 measuring points with T-rosette strain gauges on the restraining bars; in total 6 T-rosette strain gauges with following characteristics: k-factor (Gage factor) tolerance +/- 1% of calibrated value, Transverse sensitivity < 2,5%, Maximum ductility: +/-5%;
- Hollow Piston Hydraulic Cylinder; $F_{max} \geq 876$ kN or equivalent.

The arrangement and labelling of the sensors and their designation is given in Figure A.2.2.1 as an example. The positions of the measuring points of the T-rosette strain gauges are shown in red, the rope tension cells in turquoise and the T-rosette strain gauges of the restraining bars in green.

Because of the symmetry of the high load-bearing earth retaining structures, no instrumentation needs to be used on the upper left restraining bars.

A.2.3 Instrumentation setup 3

Following measuring sensors shall be installed at the frontal protection element for testing:

- Minimum 4 measuring points with rope load cells for wire rope measuring (capacity of 4000 kg, load limiting accuracy ±2% on full scale, creep at nominal load in 30 minutes < 0,05%type);
- Minimum 4 measuring points with T-rosette strain gauges on upper (air side) and lower (earth side) flange of X-girders; in total 8 T-rosette strain gauges with following characteristics: k-factor (Gage factor) tolerance +/- 1% of calibrated value, Transverse sensitivity < 2,5%, Maximum ductility: +/-5%;
- Hollow Piston Hydraulic Cylinder; $F_{max} \geq 396$ kN or equivalent.

The arrangement and labelling of the sensors and their designation is shown in Figure A.2.3.1 as an example. The positions of the measuring points of the T-rosette strain gauges are shown in red, the rope tension cells in turquoise and the T-rosette strain gauges of the restraining bars in green.

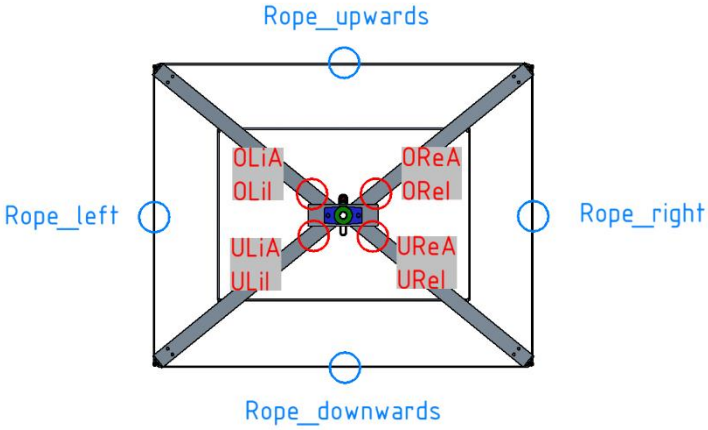


Figure A.2.3.1: Arrangement of the sensors and their designation in the instrumentation setup 3

(Trapezoid and quadratic cross-section)

- OLiA (O...Top; Li...Left; A...outside or air side)
- URel (U...Bottom; Re...Right; I...Inside or earth side)

Because of the symmetry of the high load-bearing earth retaining structures, no instrumentation needs to be used on the upper left restraining bars.

A.3 Test procedure

One specimen for each geometric constellation (rectangle or trapezoid) according to Clause 1.1.1 and each size of the high load-bearing earth retaining structure shall be tested. The testing shall be done at the ambient temperature 5°C - 35°C.

The test procedure is divided into three phases: the installation of the filling material (1), the increase of the load in the steel bar in different load stages (LS) (2) and a reduction in the load on the steel bar (3).

Phase 1

After placing the high load-bearing earth retaining structure as described in Figure A.1.2.1 and connecting the measuring sensors as described in Clause A.2 to the measuring amplifier, the space between the installed earth high load-bearing retaining structure and fixed support element on the other side shall be filled with a mixed-grain soil, slightly silty sandy gravel according to EN ISO 14688-1. The material shall be compacted, e.g., by using a trench roller.

Phase 2

After completion of the Phase 1, the steel bar shall be subjected to different load stages using a pulling device. Each load level shall be kept constant over a period of at least 10 minutes. Load stages shall increase in the range of up to 200 kN in each step. Whereas, the definition of the increasement within one step may vary, depending on maximum proof load envisaged. Minimum 5 steps shall be conducted. Phase 2 should be terminated if failure is observed in any part of the product. The maximum applied test force is limited by P_p and must not be exceeded for safety reasons.

Maximum proof load shall be:

$P_p = 0{,}8 \cdot f_K \cdot A_t$, where: A_t is a cross-sectional area of the main rod and f_k a characteristic tensile strength according to EN 10025-2.

The minimum accuracy of the measured load shall be in accordance with EN ISO 22477-5, Clause 4.4.

Phase 3

In this phase the tension force shall be reduced to 0 kN.

The filling material shall be removed.

Possible deformations and damages (e.g., on the connecting parts and welding seams) shall be inspected and documented.

A.4 Measurements

The measured data and the applied tension force in the steel bar shall be recorded and saved at a sampling rate of minimum 300 Hz over the entire test period including backfilling (Phase 1 to Phase 3).

The recorded results shall be divided into phases: installation of the filling material (1), the load increases in the steel bar in different load stages (2) and a reduction in the load on the steel bar member (3).

The data at each measuring sensor shall be presented as a time - force/strain diagram.

A.5 Results

The test result is the maximum tensile force F [kN] in the steel bar, corresponding to the moment when the measured strain at any component under test reaches the value corresponding to the steel yield strength, according to EN 10025-4.

A.6 Test report

Test report shall include at least:

1. Description of the test setup and tests specimen according to Clause A.1 and Clause A.2;
2. Description of the filling material and ambient temperature according to Clause A.3;
3. Observations of the possible deformations and damages according to Clause A.3;
4. The data at each measuring sensor, presented as a time - force/strain diagram according to A.4;
5. Outcome according to Clause A.5.

ANNEX B: CALCULATION OF MAXIMUM DEFORMATION

The assessment of the maximum deformation of the endpoints of the X-girders u_{total} described in this Annex applies to the high load-bearing earth retaining structure. For this assessment, the measured data according to A.4 shall be used.

B.1 Calculation of the maximum deformation for the instrumentation setup 1 and instrumentation setup 2

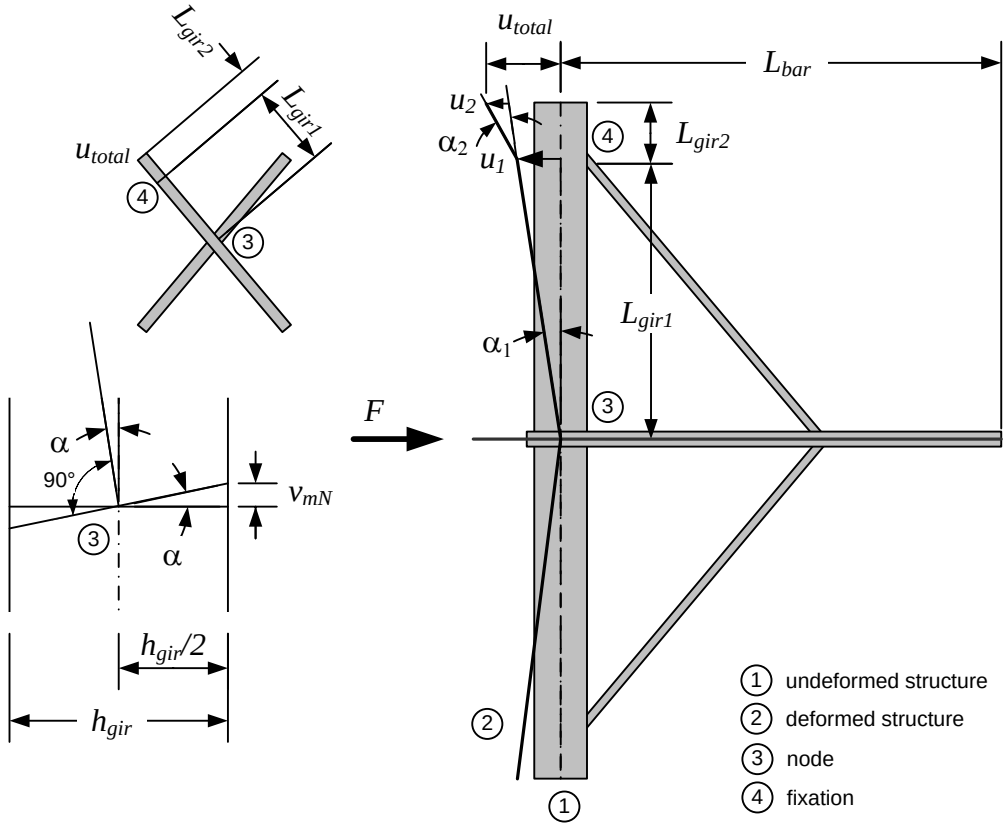


Figure B.1.1 Determination of maximal deformation – Installation setup 1 and installation setup 2

The calculation of the maximum deformation shall be performed for the instrumentation setup 1 in accordance with A.2.1 of this EAD and instrumentation setup 2 in accordance with A.2.2 of this EAD.

The maximum deformation u_{total} of the end point of X girder is:

$u_{total} = u_1 + u_2$

Where:

u_1 = deformation at the fixation of the X-shaped steel girder

u_2 = deformation at the end of the X-shaped steel girder

$$u_1 = L_{gir1} \cdot tan\alpha_1 \qquad \alpha_1 = arctan\left(\frac{v_{mN}}{hgir/2}\right)$$

$$u_2 = L_{gir2} \cdot tan\alpha_2 \qquad \alpha_2 = arctan\left(\frac{v_{mF}}{hgir/2}\right)$$

where:
$v_{mN} = mean\ value\ (OLiA2, OLiI2, OReA2, OReI2)$, is the mean value of the maximum registered strains at strain cells OLiA2, OLiI2, OReA2 and OReI2 in [mm] (see index 3 in Figure B.1.1), as defined in A.2.1 and A.2.2

$v_{mF} = mean\ value\ (OLiA1, OLiI1, OReA1, OReI1)$, is the mean value of maximum registered strains at the fixation at cells OLiA1, OLiI1, OReA1 and OReI11 in [mm], as defined in A.2.1 and A.2.2

h_{gir} = section height of X-shaped steel girder

L_{gir1} = length of X-shaped steel girder (node to fixation)

L_{gir2} = length of X-shaped steel girder (fixation to end)

B.2 Calculation of the maximum deformation for the instrumentation setup 3

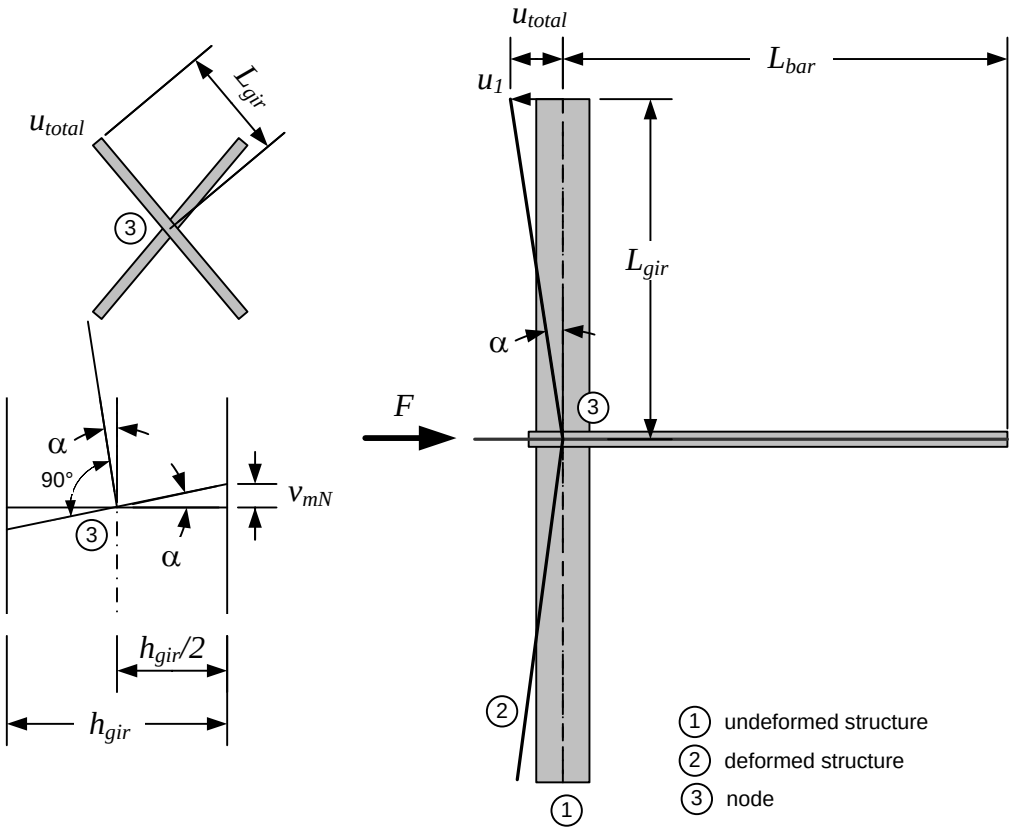


Figure B.2.1 Determination of maximal deformation – Instrumentation setup 3

The calculation of the maximum deformation shall be performed for the instrumentation setup 3 in accordance with A.2.3 of this EAD.

The maximum deformation u_{total} of the end point of X girder is:

$u_{total} = u_1$

where:

u_1 = deformation at the end of the X-shaped steel girder

$$u_1 = L_{gir} \cdot tan\alpha \qquad \alpha = arctan\left(\frac{v_{mN}}{hgir/2}\right)$$

where:

$v_{mN} = mean\ value\ (OLiA, OLiI, OReA, OReI)$: the mean value of the maximum registered strains at strain cells OLiA, OLiI, OReA and OReI in [mm] (see index 3 in Figure B.2.1)

v_{mN} = mean value of measured strain at the node

h_{gir} = section height of X-shaped steel girder

L_{gir} = length of X-shaped steel girder

ANNEX C: MAXIMUM FORCE TRANSFERRED TO THE ANCHORAGE OF RETAINING STRUCTURES OF LOW LOAD-BEARING CAPACITY

The test method described in this Annex applies to the low load-bearing earth retaining structure according to Clause 1.1.2.

C.1 Test equipment, test specimen and installation of test specimen

The testing tower shall be made of 4 main columns and two horizontal frames at the top level, Figure C.1.1 (in yellow).

The testing tower shall be properly stiffened by a bracing system (bracing bars or ropes) between the adjacent columns. The testing tower shall be approximately 9 meters high. At the top of the testing tower there shall be two horizontal structures positioned for a suspension test of the specimen.

The first horizontal structure, a horizontal frame made of steel square sections (Figure C.1.2, in yellow), shall be used as a load-bearing element for the second structure.

The second horizontal structure, an H-shaped horizontal frame made of steel sections, shall be positioned above the first structure (Figure C.1.3, in green). This H-shaped horizontal frame, a self-balanced structure, shall serve as an anchoring point for the specimen to be tested and shall allow the connection at the top level of the testing tower.

The load shall be generated by a traction bench located under the tower which shall be horizontal or vertical (depending on the laboratory). In case of horizontally placed traction bench (Figure C.1.1, in red), traction ropes that are deflected at 90° on the vertical by a deflector joint, shall allow to impose traction actions on the specimen positioned and anchored in the tower top level.

The test specimen shall be composed of the low load-bearing earth retaining structure (cross sections, mesh, perimeter rope) and the steel bar (simulating the anchor bar) passing through the central node. The steel bar shall be able to withstand the expected force acting on the specimen.

The test specimen shall be lifted and placed in a planar position inside the test frame with the side in contact with soil in site, positioned upward.

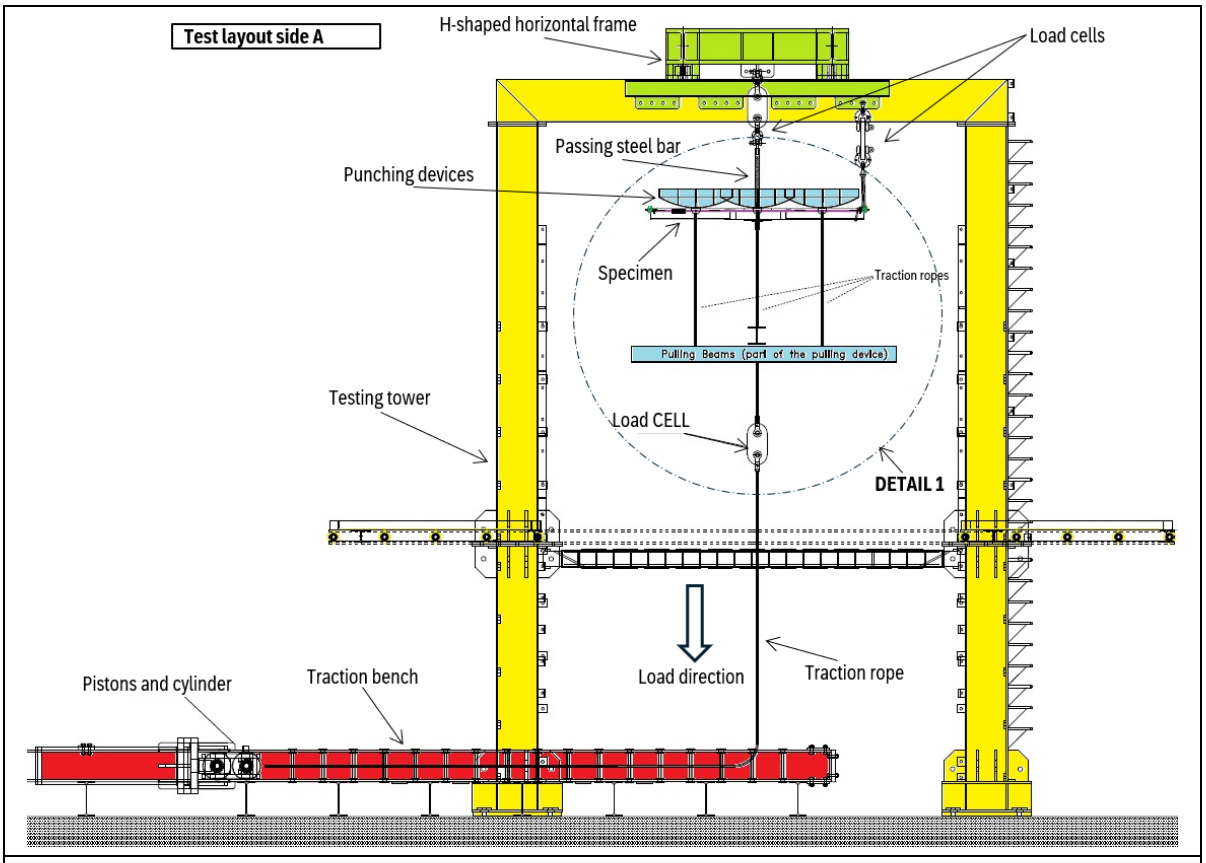
The test specimen shall be anchored to the second structure (H-shaped) at the top level of the testing tower with i) the central passing steel bar (simulates the anchor bar) passing through the central node (with nut and locknut on the structure) and monitored with a load cell (load cell 2), ii) and with the connecting base anchor ropes connected to the two lower “feet (lower ends of the sections)” of the low load-bearing earth retaining structure: these anchoring points corresponding to ground foundations are not part of the low load-bearing retaining structure to be assessed, but they shall be considered in the test layout for stabilization of specimen.

Shaped steel "punching devices" shall be placed on the 4 portions (Figure C.1.4) of the net of the low load-bearing earth retaining structure (delimited by the sections). Each "punching device" shall be completed by an "eyebolt" in the centre of his convex side.

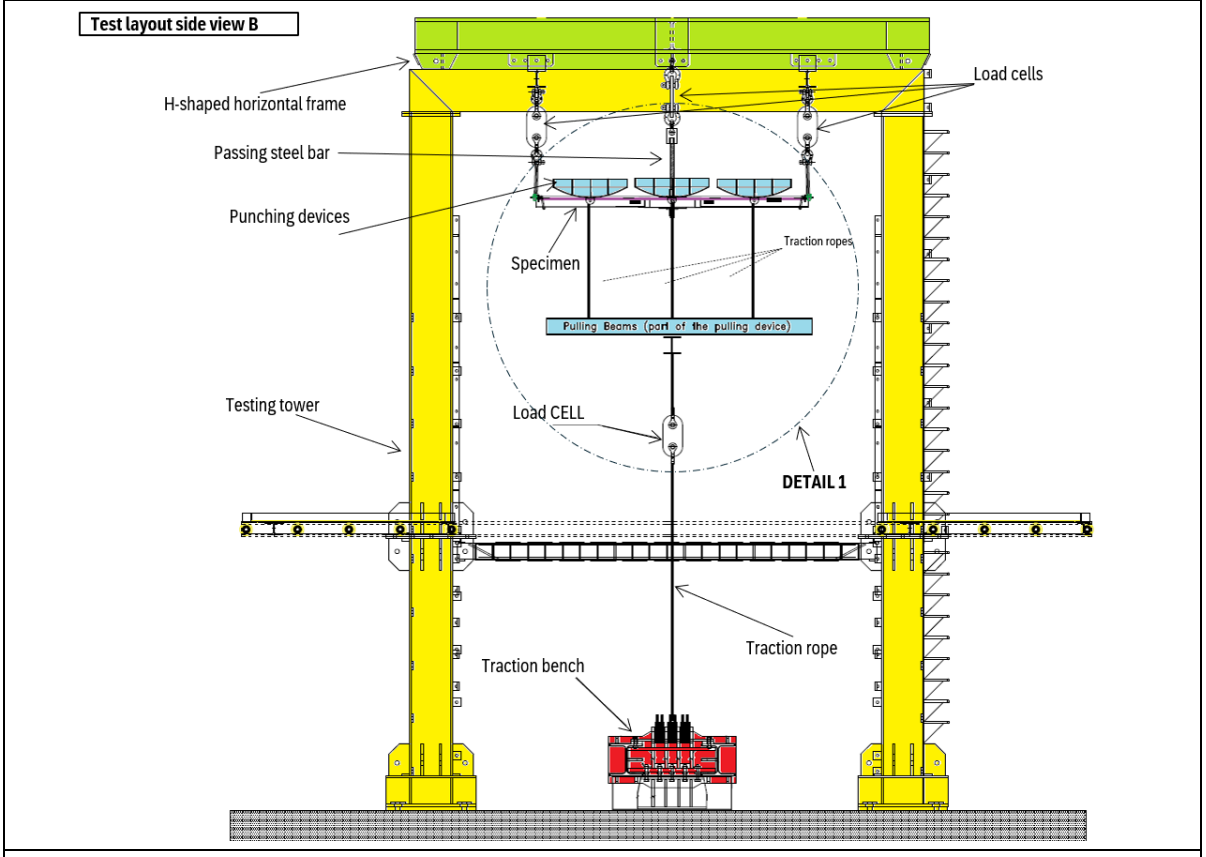
Each "punching device" shall not extend beyond the surface of the triangular portion of the net of the low load-bearing earth retaining structure delimited by the sections (circular base of the "punching device" shall be inscribed in the triangular portion).

Four steel ropes shall connect the four eyebolts of the "punching devices" with two cross-placed pulling beams through which the pulling of each “punching device” are vertical (without deviation angles).

Both the central bar and the base anchor ropes shall be connected via load cells to rigid constraints of the frame.



Test layout, side A



Test layout, side B

Figure C.1.1a: Test tower with suspended specimen, side views

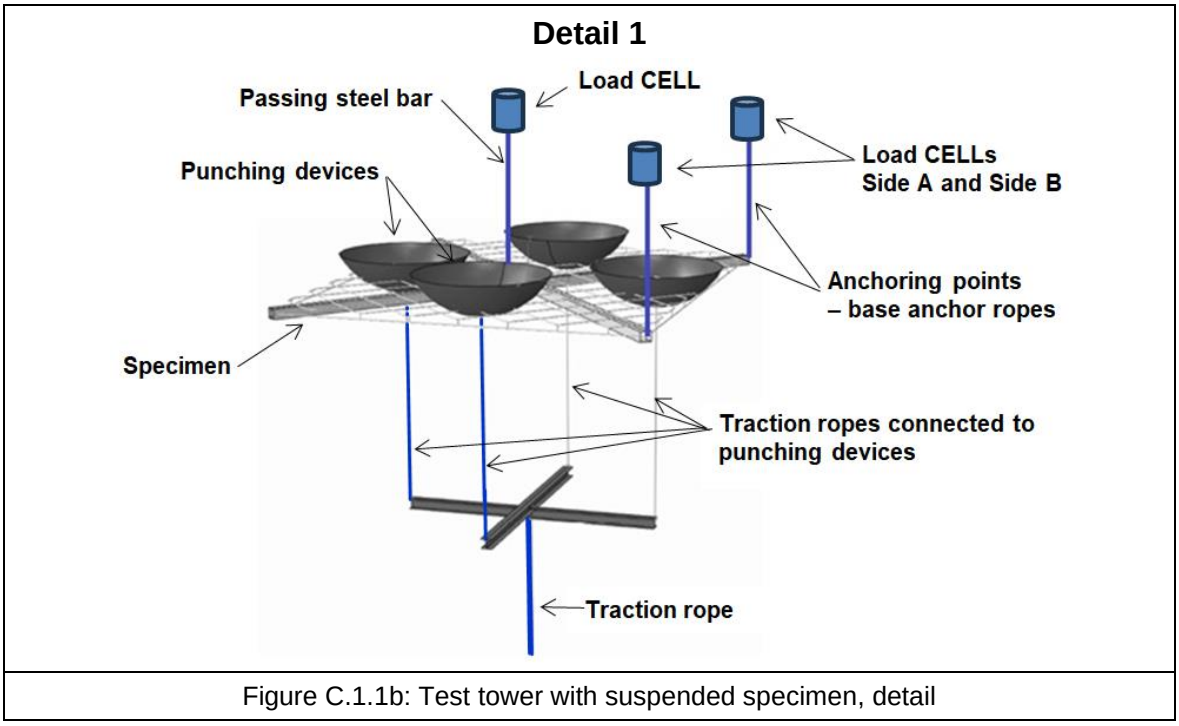


Figure C.1.1b: Test tower with suspended specimen, detail

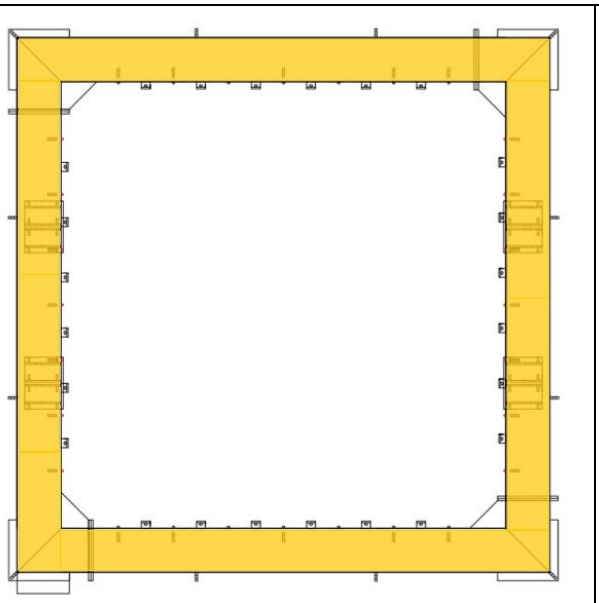


Figure C.1.2: First horizontal structure - horizontal frame in upper level of tower

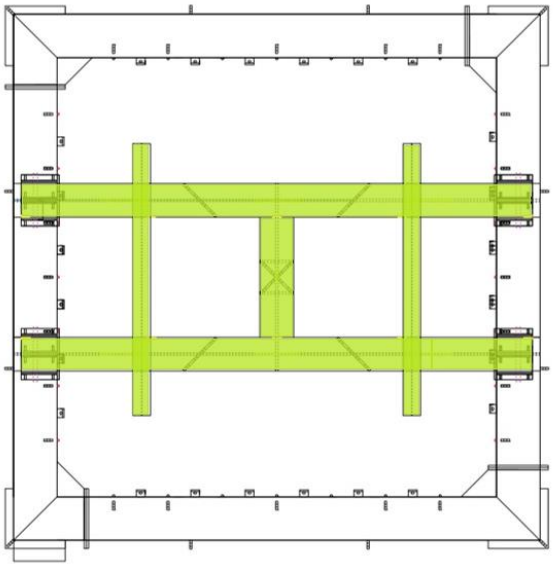
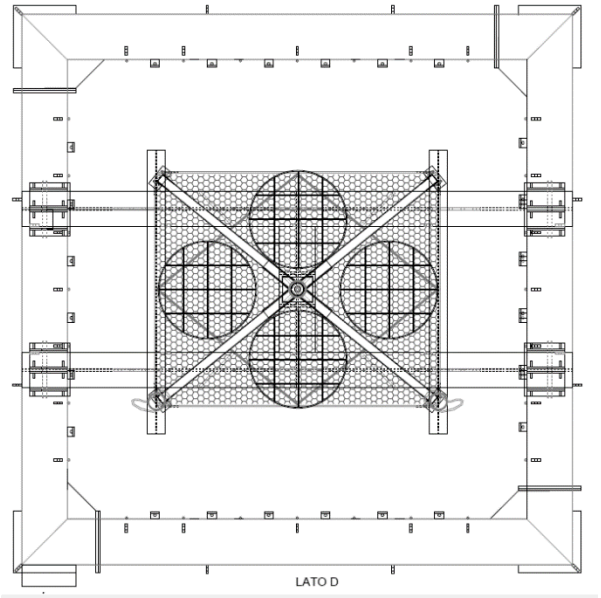
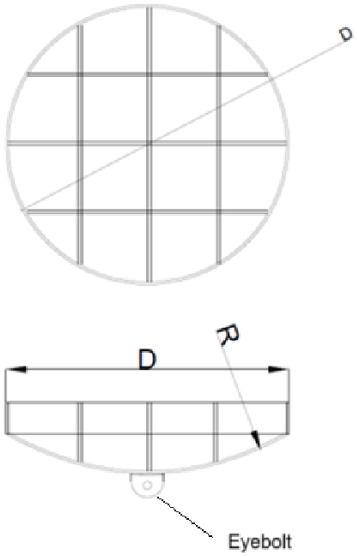


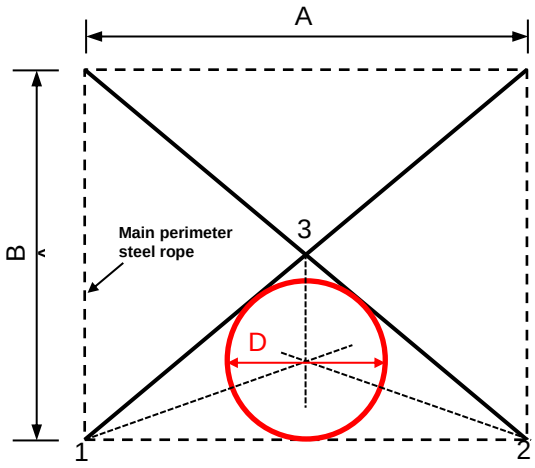
Figure C.1.3: Second horizontal structure - horizontal H-shaped frame in upper level of tower





D – specified depending on the dimensions of product (punching device to be inscribed in the triangular portion)

R = D



Diagonal of rectangle A×B

$C = \sqrt{A^2 + B^2}$

Area of triangle 123

$S = \frac{A.B}{4}$

Perimeter of triangle 123

$P = A + C$

Diameter of circle

$D = 2.\frac{2.S}{P}$

For main perimeter steel rope see Figure 1.1.2.1.

Figure C.1.4: “Punching devices” placed on the net portions

C.2 Measuring devices

Following measuring devices shall be installed:

- Minimum of 5 load cells;
- Minimum of 6 strain gauges;
- Equipment for magnetic particle or penetrant examination of welds.

The accuracy of the measurements shall be maximum 1 %. Tolerance in evaluation of yield strength of the steel shall be +/- 5 %.

C.3 Test procedure

The ropes of the punching devices are connected to the pulling device (two orthogonally connected pulling beams, see Figure C.1.1a and Figure C.1.1b). The piston acts on the traction rope connected to the pulling device and so indirectly loads the specimen through the punching devices.

The maximum load speed shall be 8 mm/min.

The tested structure (specimen) shall transfer the applied load to the central tie rod (passing steel bar) (load cell 2) and to the 2 lateral constraints located at the end of each beam on one side only (load cell – side A and load cell - side B) see Figure C.3.1.

The total load (force) shall be measured on the traction rope (load cell 4) together with the 3 load cells (load cell 2, load cell-side A and load cell-side B) placed on the constraints.

Load cells R1 and R2 (see Figure C.3.1) shall be placed on the perimeter rope in order to record the load acting in this rope.

Strain gauges (SGX) shall be installed on cross-beams according to Figure C.3.1. Strain gauges (SGX) shall be installed on cross-beams according to Figure C.3.1.

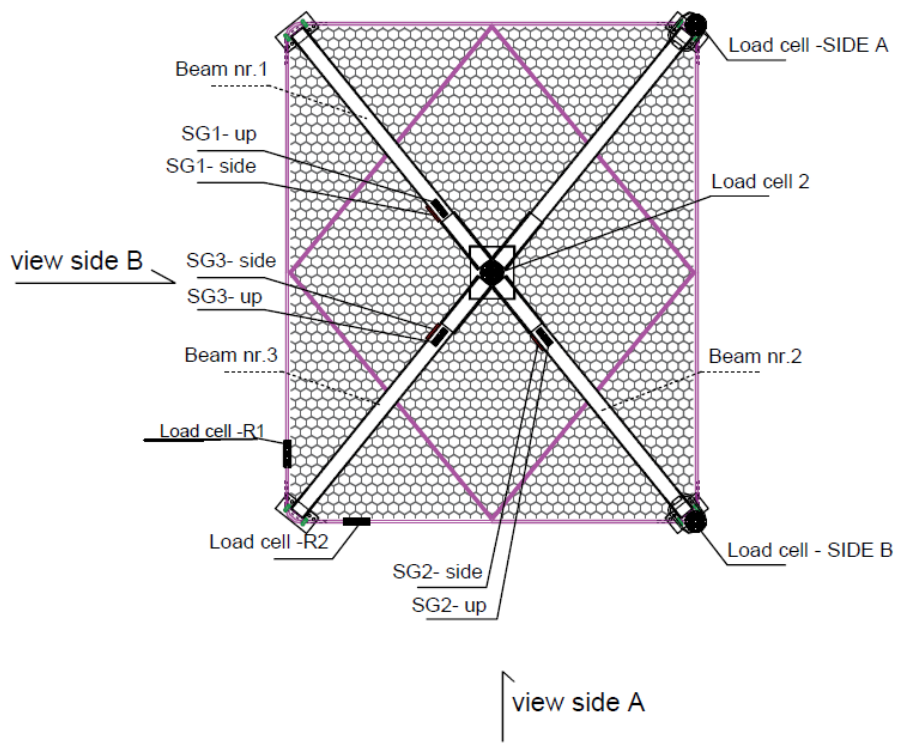
The force-strain diagrams (where the force is meant to be the force recorded by load cell 4 and the strain is meant to be the strains recorded by the strain gauges installed on the sections) shall be recorded during the test.

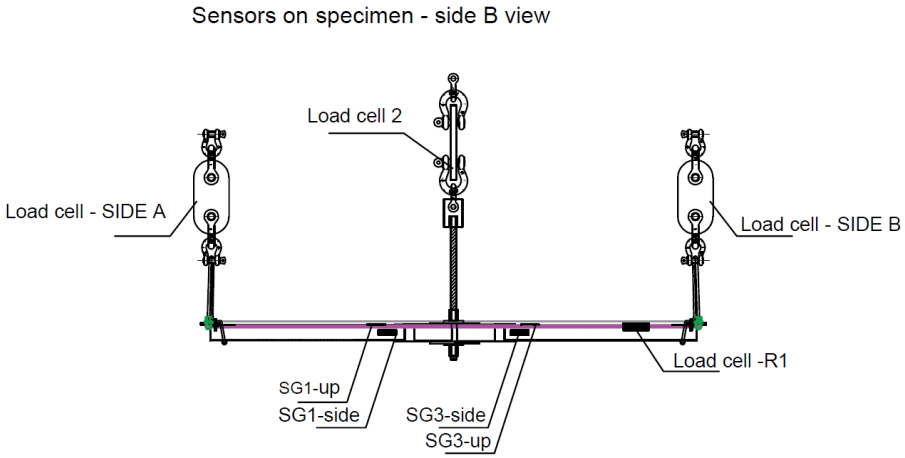
Following the application of the foreseen and recorded loads, the specimen shall be removed from the frame and examined visually to verify the presence of cracks or permanent deformations. The presence of local plasticization and/or local damage shall not affect the positive outcome of the test.

Loading of the specimen is not stopped exactly in the moment, when the “first” yield strength is achieved, what means, the specimen is tested up to the greater load than the load (declared force in the ETA) corresponding to the yield strength of cross-beams. Due to this overloading of the specimen some permanent local deformations (plastic deformations) can be formed. By visual examination of the specimen, after removing it from the frame, the positions of these eventual local plastic deformations shall confirm the correct placement of strain gauges on the cross-beams, which means, local plastic deformations shall occur in the vicinity of strain gauges, where the maximum stresses were estimated.

In case, the local plastic deformations of cross-beams are not located far from the strain gauges, the test shall not be accepted.

The welds shall be examined by NDT, for example MT (magnetic particle testing, in accordance with EN ISO 17638) or PT (penetrant test, in accordance with EN ISO 3452-1).





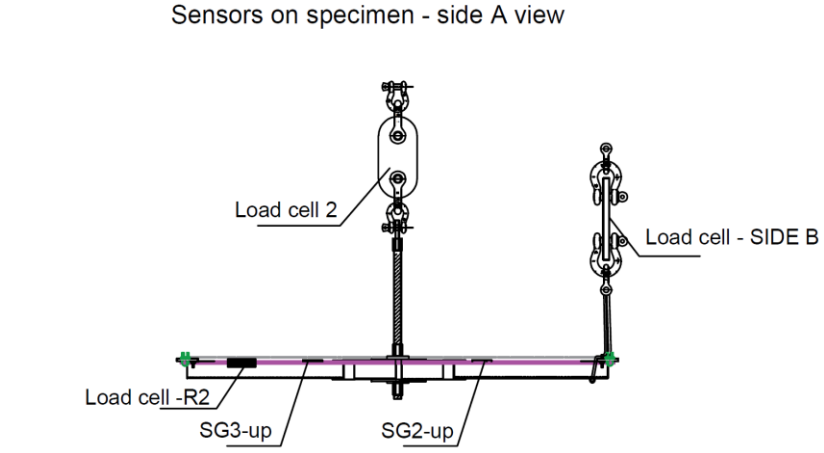


Figure C.3.1: Set up of measuring devices

C.4 Outcome of test

The maximum total force recorded in load cell 4, force F [kN], maximum force transferred to the anchorage recorded in load cell 2, force F_1 [kN], and forces transferred to the foundations recorded in load cell – side A, force F_2 [kN], and load cell - side B, force F_3 [kN], shall be measured when the strain at any position measured in steel sections reaches for the first time the value corresponding to the yield strength of the steel and these forces are considered as follows:

- Maximum force transferred to the anchorage: force recorded in load cell 2 (force F_1);
- Force on foundation 1: force recorded in load cell – side A (force F_2);
- Force on foundation 2: force recorded in load cell - side B (force F_3);
- The maximum total force: tension force recorded in load cell 4 (force F).

All forces shall be considered as the outcome of the test and reported in ETA.

C.5 Test report

Test report shall include at least:

1. Description of the test setup and test specimen according to Clause C.1 and Clause C.2;
2. Recorded force F – strain diagrams according to Clause C.3;
3. Recorded forces (F, F_1, F_2 and F_3) in all load cells according to Clause C.4;
4. Recorded forces (R_1 and R_2) in load cells installed in perimeter rope;
5. Observations of the possible deformations and damages according to Clause C.3.