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SHALLOW AND REUSABLE FOUNDATION KIT FOR LIGHTWEIGHT STRUCTURES

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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) No 305/2011 as a basis for the preparation and issuing of European Technical Assessments (ETA).

Contents

1 SCOPE OF THE EAD

1.1 Description of the construction product

The shallow foundation kit consists of a precast reinforced concrete block passed through by four steel tubes hammered diagonally into the ground.

The precast concrete block is partially or completely buried into the ground and it includes the connection elements to support the lightweight structure. The approximate dimensions of the block are:

- Length x width: (260 mm ± 10 %) x (260 mm ± 10 %).
- Height: between 280 mm and 350 mm.

The steel tubes pass through the block and penetrate the ground with an inclination of 40 º approximately referred to the vertical and up to an approximate depth of 70 cm or 90 cm, which can reach up to 120 cm if necessary, depending on the tube length (shallow foundation).

The foundation kit is reusable.

The system has the following accessories: plastic plugs for the top of the tubes and sealant for the joint between plastic plug and precast concrete block.

The lightweight structure is supported by the required number of foundation kits.

In the planning and construction of the precast concrete block, the required embedment depth in the ground and soil quality must be taken into account to ensure a sufficient freeze-thaw resistance.

This EAD is covering the foundation kit and its components as described in Annex A.

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.

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

1.2.1 Intended use(s)

Shallow foundations of permanent or temporal lightweight structures.

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 shallow and reusable foundation kit for the intended use of 50 years when installed in the works. 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.

1.3 Specific terms used in this EAD (if necessary in addition to the definitions in CPR, Art 2)

ϕ: internal friction angle of a soil. Angle whose tangent is the derivative of the shear resistance related to the effective normal pressure.

c: cohesion of a soil. Shear resistance of a soil when the effective normal pressure is non-existent.

K: Winkler modulus. Relationship between the stress applied on a surface and the displacement produced.

γ: soil density.

N_c, N_q, N_γ: bearing capacity factors. Dimensionless factors which depend on exclusively of the internal friction angle of a soil. They are designated cohesion factor, overload factor and specific weight factor, respectively.

q_u: ultimate soil bearing capacity.

q_a: allowable soil bearing capacity.

P_0: overburden pressure.

B: width of footing.

K_p: passive lateral earth pressure coefficient $\left(K_p = \tan^2 \left(45 + \frac{\phi}{2} \right) \right)$.

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[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 shallow and reusable foundation kit is assessed in relation to the essential characteristics.

Table 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 *(level, class, description)*
Basic Works Requirement 1: Mechanical resistance and stability			
1	Compression resistance of the concrete block to point loads	2.2.1	Level
2	Compression resistance of the concrete block to surface loads	2.2.2	Level
3	Compression resistance (failure by cave-in of the foundation unit)	2.2.3	Level
4	Tensile resistance of the concrete block	2.2.4	Level
5	Tensile resistance (failure by pulling the foundation unit out)	2.2.5	Level
6	Bending resistance	2.2.6	Level
7	Resistance to horizontal efforts	2.2.7	Level
8	Maximum compression load for a given foundation displacement	2.2.8	Level
9	Maximum compression load allowing the steel tubes to be reused	2.2.9	Level
10	Maximum tensile load allowing the steel tubes to be reused	2.2.10	Level
11	Protection against corrosion	2.2.11	Level
12	Prevention of the cracking of the concrete blocks	2.2.12	Level
Basic Works Requirement 2: Safety in case of fire			
13	Reaction to fire	2.2.13	Class

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

Characterisation of products to be assessed shall be done in accordance with available specifications, notably:

- Concrete block: strength of the concrete, main components used in the manufacturing of the concrete and nominal dimensions (see clause A.1.1 of Annex A).

- Steel tubes: type and dimensions (see clause A.1.2 of Annex A).

The essential characteristics of the product are divided between the characteristics that depend exclusively on the components of the product, and the characteristics that depend on the mechanical properties of the soil in which the foundation kit is to be installed.

The mechanical properties of the soil are defined by the combination of the internal friction angle (ϕ), the cohesion (c), the Winkler modulus (K), the soil density (γ) and the foundation depth.

Regarding the assessment procedure of the essential characteristics: the assessment is based on the three models shown in EN 1997-1 -calculation model, empirical model and numerical model- are used. The empirical and the numerical model are used to validate the calculation model.

Regarding the essential characteristics of the foundation kit in service conditions (when the essential characteristics depend on the soil properties): the calculation model is used.

The foundation kit is applicable to the geotechnical categories 1 and 2 as defined in EN 1997-1.

2.2.1 Compression resistance of the concrete block to point loads

The compression resistance of the concrete block to point loads shall be determined in accordance with the test procedure in Annex B.1.

The 5 %-fractile value with a confidence level of 75 % using a normal distribution of the compression resistance to point loads shall be expressed in the ETA by means of a level.

2.2.2 Compression resistance of the concrete block to surface loads

The compression resistance of the concrete block to surface loads shall be determined in accordance with the test procedure of Annex B.2.

The 5 %-fractile value with a confidence level of 75 % using a normal distribution of the compression resistance to surface loads of the concrete loads shall be expressed in the ETA by means of a level.

2.2.3 Compression resistance (failure by cave-in of the foundation unit)

The compression resistance (failure by cave-in of the foundation unit) will be determined based on the following approach, mainly in two steps:

    a) Calculation of the cave-in resistance of the foundation unit;

    b) Comparison tests to verify the calculation results achieved;

Additionally, a third step can also be used:

c) A finite element method (FEM) modelling to verify the calculation results achieved can be used. The minimum number of the required comparison tests can be halved if a FEM modelling is available. The assessment criterion of the FEM modelling vs. the calculation results of the same configurations must be fulfilled.

The steps of the approach are described below:

a) Calculation of the cave-in resistance of the foundation unit

The cave-in resistance of the foundation unit shall be calculated by the sum of the cave-in resistance of the concrete block (clause a.1)) and the downward jacking resistance of the steel tubes (clause a.2)).

a.1) Cave-in resistance of the concrete block

The cave-in resistance of the concrete block shall be determined by using a calculation method based on Terzaghi's bearing capacity theory and considering the properties of the soil.

The concrete block activates stresses and deformations only in the first 2,00 m below the kit. Therefore, the concrete block can be considered a shallow foundation with its particular shape, and its mechanism of resistance can be simulated using traditional failure mechanisms based on the Terzaghi's bearing capacity theory.

For calculation purposes, the concrete block is considered equivalent to a shallow foundation with its supporting plane in the base of the concrete block and whose dimensions are variable according to the friction coefficient of the soil.

The bearing capacity factors N_c, N_q and N_γ are function of the soil internal friction angle ϕ.

$$N_q = \frac{1+\sin\phi}{1-\sin\phi}\cdot e^{\pi\cdot\tan\phi} \qquad\qquad \text{(equation 1)}$$

$$N_c = (N_q-1)\cdot\cot\phi \qquad\qquad \text{(equation 2)}$$

$$N_\gamma = 1{,}5\cdot(N_q-1)\cdot\tan\phi \qquad\qquad \text{(equation 3)}$$

The ultimate soil bearing capacity (q_u) [kN/m^2] is obtained from the Terzaghi's bearing capacity equation.

$$q_u = c\cdot N_c + p_0\cdot N_q + \frac{1}{2}\cdot\gamma\cdot B\cdot N_\gamma \qquad\qquad \text{(equation 4)}$$

$$q_a = \frac{q_u}{\gamma_R} \qquad\qquad \text{(equation 5)}$$

$$R_c = q_a\cdot B^2 \qquad\qquad \text{(equation 6)}$$

Where:

   q_a: allowable soil bearing capacity of the soil [kN];

   R_c: cave-in resistance of the concrete block [kN];

   γ_R: safety factor;

Parameters of the soil and of the foundation kit needed for the design:

- Internal friction angle (ϕ).

- Cohesion (c).

- Soil density (γ).

- Overburden pressure (p_0).

- Width of footing (B).

a.2) Downward jacking resistance of the steel tubes

A similar mechanism to the point mechanism used for deep foundations is assumed. The tip resistance shall be determined.

The steel tubes shall be discretised in sections to obtain the variation of soil performances with the depth.

A reduction coefficient of 0,7 shall be applied to R_p because of the longitudinal and not point jacking of the tubes.

$$R_s = 0{,}7 \cdot R_p \qquad \text{(equation 7)}$$

Where:

R_s: downward jacking resistance of the steel tubes.

R_p: resistance assumed by the tip.

$$R_p = \left(q_{pf} + q_{pc} \right) \cdot A_p \qquad \text{(equation 8)}$$

Where:

q_{pf}: frictional tip resistance per unit.

q_{pc}: cohesive tip resistance per unit.

A_p: area of the tip. The horizontal projection is considered for inclined tubes.

$$q_{pf} = f_p \cdot \sigma'_{vp} \cdot N_q \leq 20 \text{ MPa} \qquad \text{(equation 9)}$$

Where:

f_p (corrective factor) = 3.

σ'_{vp}: effective vertical pressure on tip level before the tube installation. The value of soil density (γ) is used.

N_q: bearing capacity factor.

$$q_{pc} = N_p \cdot c_u \qquad \text{(equation 10)}$$

Where:

N_p: it depends on the embedding of the tube. A value of 9 is assumed.

c_u: shear resistance of the soil without draining. It is equivalent to the cohesion.

This resistance shall be calculated for one steel tube and shall be multiplied by the 4 steel tubes of each foundation unit.

b) Comparison tests to verify the calculation results achieved

The compression resistance (failure by cave-in of the foundation) in soils whose mechanical performances shall be within the range shown below will be determined in accordance with the test procedure of Annex B.3.

- Density (kg/m^3): 1.700 – 2.300.
- Cohesion (kPa): 1 – 15.
- Internal friction angle ($^\circ$): 25 – 40.

At least four tests must be conducted.

c)　A finite element method (FEM) modelling to verify the calculation results achieved

The values obtained from the calculation of the cave-in resistance of the foundation unit (clause a)) are to be considered the compression resistance (failure cave-in of the foundation unit) values.

The following criteria must be fulfilled when assessing the resulting values from the steps above:

- Values obtained from testing (clause b)) ≥ 2 x [values obtained from the calculations (clause a))].

- Values from the FEM modelling (clause c)) ≥ 3 x [values obtained from the calculations (clause a))].

The values of the compression resistance (failure cave-in of the foundation unit) in accordance with the soil definition shall be expressed in the ETA by means of a level.

2.2.4　Tensile resistance of the concrete block

The tensile resistance of the concrete block will be calculated taking as reference the strut and tie model together with the indications of EN 1992-4.

The resistance to tension loads for the concrete cone failure mode will be calculated in accordance with EN 1992-4. The characteristic resistance of the anchor calculated in accordance with this standard will be considered the resistance to tension loads of the concrete cone.

The following aspects must be taken into account when calculating the characteristic resistance of the anchor:

- Uncracked concrete is assumed.

- The geometric effect of spacing and edge distance on the characteristic resistance is taken into account by the value $A_{c,N}/A^0_{c,N}$. $A_{c,N}$ is limited by the edges of the concrete block.

- The disturbance of the distribution of stresses in the concrete due to edges of the concrete member is to be considered.

- It is assumed that the shell spalling factor ($\Psi_{re,N}$) and the factor $\Psi_{ec,N}$ are 1,0.

- The considerations for anchorages with three or more edges apply to h_{ef}.

The tensile resistance of the concrete block shall be expressed in the ETA by means of a level.

2.2.5　Tensile resistance (failure by pulling the foundation unit out)

The tensile resistance (failure by pulling the foundation unit out) will be determined based on the following approach, mainly in two steps:

a)　Calculation based on the resistance of the soil to be passed through by the tubes;

b)　Comparison tests to verify the calculation results achieved;

Additionally, a third step can also be used:

c)　A finite element method (FEM) modelling to verify the calculation results achieved can be used. The minimum number of the required comparison tests can be halved if a FEM modelling is available. The assessment criterion of the FEM modelling vs. the calculation results of the same configurations must be fulfilled.

The steps of the approach are described below:

a) Calculation based on the resistance of the soil to be passed through by the tubes

The tensile resistance shall be obtained from the horizontal stress supported by the soil (σ_h) determined by the equation 12 and from the limitation due to the weight of the soil above the tubes (T) determined by the equation 13.

The tensile resistance (failure by pulling the foundation out) is the minimum between σh/3 and T.

$$R_T = \text{mín} \left\{ \frac{\sigma_h}{3}; T \right\}$$ (equation 11)

Where:

R_T: tensile resistance (failure by pulling the foundation out).

σ_h: horizontal stress supported by the soil.

T: weight of the soil above the tubes.

a.1) Horizontal stress supported by the soil (σ_h)

A pseudo-elastic strain-deformation behaviour of the soil is assumed, so that every compression stress (N) causes a tensile stress (T) in the perpendicular plane, which fulfils $T = 0{,}3 \cdot N$.

If a vertical crack appears it means that the lateral earth pressure of the soil is overcome. This will correspond with a passive situation since it is necessary that the soil opens to let the tubes go through it.

The Bell's relationship for soil with cohesion and passive situations is used to calculate the total lateral earth pressure.

$$\sigma_h = K_p \cdot \sigma_v + 2 \cdot c \cdot \sqrt{K_p}$$ (equation 12)

Where:

σ_h: horizontal stress.

K_p : passive earth pressure coefficient $\left(K_p = \tan^2 \left(45 + \frac{\phi}{2} \right) \right)$; ϕ: Internal friction angle.

σ_v : vertical stress ($\sigma_v = h \cdot \gamma$); h: depth; γ: soil density.

c: cohesion.

When the vertical load (F) exceeds a third of the horizontal stress ($\sigma_h/3$) the soil opens and the tubes go through it.

a.2) Weight of the soil above the tubes (T)

Additionally, the maximum vertical load that the tubes can transmit to the soil is limited by the weight of the soil above the tubes. This volume of soil corresponds to a wedge with an inclination angle of 30º with respect to the vertical, whose edge is in contact with the tube. The adhesion of this wedge to the soil is based on the cohesion of the soil. Therefore, the maximum vertical load (T) is defined as follows:

$$T = 2 \cdot c \cdot \frac{\cos \phi}{1 + \sin \phi}$$ (equation 13)

Where:

c: cohesion.

ϕ: internal friction angle.

This equation is obtained from the application of the Mohr-Coulomb theory for pure tensile efforts.

b) Comparison tests to verify the calculation results achieved

The tensile resistance (failure by pulling the foundation out) in soils whose mechanical performances shall be within the range shown below will be determined in accordance with the test procedure of Annex B.4.

- Density (kg/m^3): 1.700 – 2.300.

- Cohesion (kPa): 1 – 15. Additionally, at least one test must be conducted in soils with a cohesion between 20 kPa and 30 kPa.

- Internal friction angle (^{0}): 25 – 40.

At least four tests must be conducted.

c) A finite element method (FEM) modelling to verify the calculation results achieved

The values obtained from the calculation based on the resistance of the soil to be passed through by the tubes (clause a)) are to be considered the tensile resistance (failure by pulling the foundation unit out) values.

The following criteria must be fulfilled when assessing the resulting values from the steps above:

- Values obtained from testing (clause b)) ≥ 2 x [values obtained from the calculations (clause a))].

- Values from the FEM modelling (clause c)) ≥ 3 x [values obtained from the calculations (clause a))].

The values of the tensile resistance (failure by pulling the foundation unit out) in accordance with the soil definition shall be expressed in the ETA by means of a level.

2.2.6   Bending resistance

The bending resistance will be determined based on the following approach, mainly in two steps:

a) Calculation based on the lateral jacking resistance of the steel tubes;

b) Comparison tests to verify the calculation results achieved;

Additionally, a third step can also be used:

c) A finite element method (FEM) modelling to verify the calculation results achieved can be used. The minimum number of the required comparison tests can be halved if a FEM modelling is available. The assessment criterion of the FEM modelling vs. the calculation results of the same configurations must be fulfilled.

The steps of the approach are described below:

a) Calculation based on the lateral jacking resistance of the steel tubes;

The lateral jacking resistance of the steel tubes shall be calculated using the formulas for lateral jacking resistance of piles.

The steel tubes shall be discretised in sections to obtain the variation of soil performances with the depth.

The following formula is applied:

$$s(z) = \left(9 \cdot c + 3 \cdot \gamma \cdot z \cdot \frac{1 + \sin \phi}{1 - \sin \phi} \right) \cdot D \qquad \text{(equation 14)}$$

Where:

s(z): lateral jacking resistance as a function of depth (z).

c: cohesion.

ɣ: soil density.

z: depth.

ɸ: internal friction angle.

D: vertical projection of the cross section of the steel tubes.
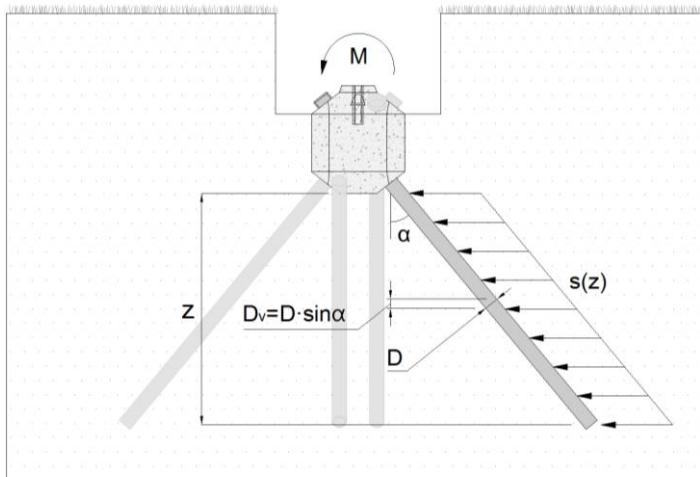

Figure 1: Parameters used to determine the lateral jacking resistance of the tubes.

b)   Comparison tests to verify the calculation results achieved

The bending resistance in soils whose mechanical performances shall be within the range shown below will be determined in accordance with the test procedure of Annex B.5.

- Density (kg/m^3): 1.700 – 2.300.
- Cohesion (kPa): 1 – 15.
- Internal friction angle (^{0}): 25 – 40.

At least four tests must be conducted.

c)   A finite element method (FEM) modelling to verify the calculation results achieved

The values obtained from the calculation based on the lateral jacking resistance of the steel tubes (clause a)) are to be considered the bending resistance values.

The following criteria must be fulfilled when assessing the resulting values from the steps above:

- Values obtained from testing (clause b)) ≥ 2 x [values obtained from the calculations (clause a))].
- Values from the FEM modelling (clause c)) ≥ 3 x [values obtained from the calculations (clause a))].

The bending resistance in accordance with the soil definition shall be expressed in the ETA by means of a level.

2.2.7   Resistance to horizontal efforts

The resistance to horizontal efforts will be determined based on the following approach, mainly in two steps:

    a) Calculation of the resistance to horizontal efforts;

    b) Comparison tests to verify the calculation results achieved;

Additionally, a third step can also be used:

    c) A finite element method (FEM) modelling to verify the calculation results achieved can be used. The minimum number of required comparison tests can be halved if a FEM modelling is available. The assessment criterion of the FEM modelling vs. the calculation results of the same configurations must be fulfilled.

The steps of the approach are described below:

a)   Calculation of the resistance to horizontal efforts;

The resistance to horizontal efforts shall be calculated by the sum of the resistance to lateral displacement of the concrete block (clause a.1)) and the lateral jacking resistance of the steel tubes (clause a.2)).

a.1)   Resistance to lateral displacement of the concrete block

The resistance to lateral displacement of the concrete block shall be determined by using the methodology from passive earth pressure.

The following formula is applied:

$$R_1 = \left(9 \cdot c + 3 \cdot \gamma \cdot z \cdot \left(\frac{1+ \sin \phi}{1- \sin \phi} \right) \right) \cdot S \qquad \text{(equation 15)}$$

Where:

      c: cohesion

      γ: soil density

      z: depth of the midpoint of the face of the concrete block pressing the soil

      ϕ: internal friction coefficient

      S: Surface of the concrete block pressing the soil

a.2)   Lateral jacking resistance of the steel tubes

The lateral jacking resistance of the steel shall be determined by the methodology indicated in clause 2.2.6 a).

b)   Comparison tests to verify the calculation results achieved

The resistance to horizontal efforts in soils whose mechanical performances shall be within the range shown below will be determined in accordance with the test procedure of Annex B.6.

- Density (kg/m^3): 1.700 – 2.300.
- Cohesion (kPa): 1 – 15.
- Internal friction angle (⁰): 25 – 40.

At least four tests must be conducted. Two foundation units are tested at the same time, so it counts as two tests.

c)   A finite element method (FEM) modelling to verify the calculation results achieved

The values obtained from the calculation based on the resistance to lateral displacement of the concrete block (clause a.1)) and the lateral jacking resistance of the steel tubes (clause a.2)) are to be considered the bending resistance values.

The following criteria must be fulfilled when assessing the resulting values from the steps above:

- Values obtained from testing (clause b)) ≥ 2 x [values obtained from the calculations (clause a))].

- Values from the FEM modelling (clause c)) ≥ 3 x [values obtained from the calculations (clause a))].

The resistance to horizontal efforts in accordance with the soil definition shall be expressed in the ETA by means of a level.

2.2.8   Maximum compression load for a given foundation displacement

The maximum compression load for a given foundation displacement will be determined based on the following approach, mainly in two steps:

- a) Calculation using the Winkler modulus

- b) Comparison tests to verify the calculation results achieved

Additionally, a third step can also be used:

- c) A finite element method (FEM) modelling to verify the calculation results achieved can be used. The minimum number of the required comparison tests can be halved if a FEM modelling is available. The assessment criterion of the FEM modelling vs. the calculation results of the same configurations must be fulfilled.

The steps of the approach are described below:

a) Calculation using the Winkler modulus

The Winkler modulus measures the rigidity of a soil (K) and gives a relationship between the vertical load applied (F), the area in contact with the surface of the soil in which the load is applied (A) and the vertical displacement achieved (δ).

$$K = \frac{F}{\delta \cdot A}$$ (equation 16)

The existing values for the Winkler modulus referred to a defined surface K_{30} (A = 30 cm x 30 cm) in the literature or National regulations for the different type of soils will be provided. The soil is defined by the internal friction angle (φ) and the cohesion (c).

The Winkler modulus for the equivalent dimensions (K) will be obtained by application of the equivalent dimensions to the Winkler modulus (K_{30}).

The maximum compression load applicable (F_{max}) is obtained from the equation (16), in which K is already obtained from the soil properties, δ is the given foundation displacement and A is the equivalent area of the foundation.

b) Comparison tests to verify the calculation results achieved;

The maximum compression load for a given foundation displacement in soils whose mechanical performances shall be within the range shown below will be determined in accordance with the test procedure of Annex B.4.

- Density (kg/m^3): 1.700 – 2.300.

- Cohesion (kPa): 1 – 15. Additionally, at least one test must be conducted in soils with a cohesion between 20 kPa and 30 kPa.

- Internal friction angle (^{o}): 25 – 40.

At least four tests must be conducted. The tests consist in monitoring the compression resistance tests.

c) A finite element method (FEM) modelling to verify the calculation results achieved;

The values obtained from the calculation using the Winkler modulus (clause a)) are to be considered the maximum compression load for a given foundation displacement values.

The following criteria must be fulfilled when assessing the resulting values from the steps above:

- Values obtained from testing (clause b)) ≥ 1,6 x [values obtained from the calculations (clause a))].

- Values from the FEM modelling (clause c)) ≥ 1,6 x [values obtained from the calculations (clause a))].

The values of the maximum load for a given foundation displacement in accordance with the soil definition shall be expressed in the ETA by means of a level.

2.2.9   Maximum compression load allowing the steel tubes to be reused

The maximum compression load allowing the steel tubes to be reused will be determined based on the following approach, mainly in two steps:

- a) Calculation of the maximum compression load allowing the steel tubes to be reused;

- b) Comparison tests to verify the calculation results achieved;

Additionally, a third step can also be used:

- c) A finite element method (FEM) modelling to verify the calculation results achieved can be used. The minimum number of the required comparison tests can be halved if a FEM modelling is available. The assessment criterion of the FEM modelling vs. the calculation results of the same configurations must be fulfilled.

The steps of the approach are described below:

a) Calculation of the maximum compression load allowing the steel tubes to be reused;

The maximum compression load allowing the steel tubes to be reused shall be determined from the calculation of the maximum resistant bending moment of the steel tubes.

The following hypothesis for the calculation of the maximum resistance bending moment is considered:

- The same resistant mechanism as for the compression resistance (failure by cave-in of the foundation unit) is developed.

The following procedure shall be applied:

- The maximum resistant bending moment of the steel tubes is calculated from the materials and geometry of the tubes, under the consideration of the embedment of the tubes in the concrete block. A reduction of the 30 % of the bending moment from the calculation is applied.

The maximum resistant bending moment shall be compared with the bending moment due to the applied loads, calculated under the following hypothesis:

- The bending moment due to the applied loads is uniformly distributed along the steel tube, reaching the maximum value in the point between tube and concrete block.

- The steel tube is embedded in the concrete block.

b)   Comparison tests to verify the calculation results achieved;

The test procedure of Annex B.8 shall be applied.

The load achieving the maximum resistant bending moment of the steel tubes from the calculations shall be applied in the tests.

The applied load in the tests to reach this bending moment depend on the mechanical properties of the soil.

The mechanical properties of the soils in which the foundation unit is to be installed shall be within the range shown below:

- Density (kg/m^3): 1.700 – 2.300.
- Cohesion (kPa): 1 – 15.
- Internal friction angle (^{0}): 25 – 40.

At least two tests must be conducted.

c)   A finite element method (FEM) modelling to verify the calculation results achieved;

The values obtained from the calculation (clause a)) are to be considered the maximum compression load allowing the steel tubes to be reused. This is not a single value, it is value depending on the mechanical properties of the soil.

The following criteria must be fulfilled when assessing the resulting values from the steps above:

- Values obtained from testing (clause b)) ≥ 1,6 x [values obtained from the calculations (clause a))].

- Values from the FEM modelling (clause c)) ≥ 1,6 x [values obtained from the calculations (clause a))].

The values of the maximum compression load allowing the tubes to be reused in accordance with the soil definition shall be expressed in the ETA by means of a level.

2.2.10   Maximum tensile load allowing the steel tubes to be reused

The maximum tensile load allowing the steel tubes to be reused will be determined based on the following approach, mainly in two steps:

a)   Calculation of the maximum tensile load allowing the steel tubes to be reused;

b)   Comparison tests to verify the calculation results achieved;

Additionally, a third step can also be used:

c)   A finite element method (FEM) modelling to verify the calculation results achieved can be used. The minimum number of the required comparison tests can be halved if a FEM modelling is available. The assessment criterion of the FEM modelling vs. the calculation results of the same configurations must be fulfilled.

The steps of the approach are described below:

a)   Calculation of the maximum tensile load allowing the steel tubes to be reused;

The maximum tensile load allowing the steel tubes to be reused shall be determined from the calculation of the maximum resistant bending moment of the steel tubes.

The following hypothesis for the calculation of the maximum resistance bending moment is considered:

- The same resistant mechanism as for the tensile resistance (failure by pulling the foundation out) is developed.

The same procedure as for clause 2.2.9 applies.

b) Comparison tests to verify the calculation results achieved;

The test procedure of Annex B.9 shall be applied.

The load achieving the maximum resistant bending moment of the steel tubes from the calculations shall be applied in the tests.

The applied load in the tests to reach this bending moment depends on the mechanical properties of the soil.

The mechanical properties of the soils in which the foundation unit is to be installed shall be within the range shown below:

- Density (kg/m^3): 1.700 – 2.300.
- Cohesion (kPa): 1 – 15.
- Internal friction angle (^{0}): 25 – 40.

At least two tests must be conducted.

c) A finite element method (FEM) modelling to verify the calculation results achieved;

The values obtained from the calculation (clause a)) are to be considered the maximum tensile load allowing the steel tubes to be reused. This is not a single value, it is value depending on the mechanical properties of the soil.

The following criteria must be fulfilled when assessing the resulting values from the steps above:

- Values obtained from testing (clause b)) ≥ 1,6 x [values obtained from the calculations (clause a))].

- Values from the FEM modelling (clause c)) ≥ 1,6 x [values obtained from the calculations (clause a))].

The values of the maximum tensile load allowing the steel tubes to be reused in accordance with the soil definition shall be expressed in the ETA by means of a level.

2.2.11 Protection against corrosion

The protection against corrosion of the kit is based on the protection against corrosion of its components (steel tubes and concrete blocks).

- Steel tubes

The assessment of the protection against corrosion of the steel tubes is based on a reduction of the thickness and on the surface coating expressed by the sacrificial corrosion allowance.

The performances of the steel tubes stated in this EAD will be maintained if the reduction of the thickness after exposure to ambient conditions in accordance with the table 4.1 of EN 1993-5, is lower than the nominal thickness of the hot dip galvanized of the steel tubes.

Table 4.1 of EN 1993-5 shows the loss of thickness (mm) due to corrosion for the expected working life in the types of soils in which the foundation kit is to be installed.

The steel tubes are hot-dip galvanised according to the requirements of EN ISO 1461. The thickness of the hot dip galvanized shall be expressed in the ETA.

- Concrete blocks

The admissible exposure classes for the concrete block in accordance with the cement type, cement content, water content, ratio water/cement, minimum concrete strength, minimum cover and minimum content of air (if exposure classes related to freeze-thaw are proposed) , as well as the value of the chemical characteristics of the soil will be determined from EN 206 and shall be expressed in the ETA.

2.2.12 Prevention of the cracking of the concrete blocks

The cracking of the concrete blocks will be calculated case-by-case for each building work depending on the applied load, on the type of applied effort and on the characteristics of the concrete block.

The recommended maximum crack width in the concrete blocks in accordance with the exposure class is shown in table 7.1 of EN 1992-1-1. A reference to this table shall be made in the ETA.

2.2.13 Reaction to fire

The shallow foundation kit is 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 product is class A1.

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: Decision 1999/94/EC amended by Decision 2012/202/EU.

The system is: 2+.

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.

Table 3   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]**					
1	Compression resistance of the concrete	EN 12390-2	Manufacturer's Control Plan	3	Every 500 blocks manufactured at most, and every change of manufacturing parameters
2	Concrete dosing	3.4.1	Manufacturer's Control Plan	All the production	Every mixture
3	Dimensions of steel tubes	**Error! Reference source not found.** Clause 7 of EN 10210-2	Manufacturer's Control Plan	5 % of the amount delivered	Each delivery
4	Compatibility between concrete block and steel tubes	3.4.2	Manufacturer's Control Plan	All the production	Continuously

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 the shallow foundation kit are laid down in Table 4.

Table 4   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 verify the ability of the manufacturer for a continuous and orderly manufacturing of the product according to the Manufacturer's Control Plan. In particular, the following items shall be appropriately considered: • Personnel and equipment. • The suitability of the factory production control established by the manufacturer. • Full implementation of the prescribed test plan.				---
Continuous surveillance, assessment and evaluation of factory production control					
2	The notified body shall verify: • The manufacturing process • The system of factory production control • The implementation of the prescribed test plan according to the Manufacturer's Control Plan Are maintained.				Once per year

3.4   Special methods of control and testing used for the verification of constancy of performance

3.4.1   Concrete dosing

The dosing of the concrete used in the manufacturing of the block shall be determined by weighting each of the concrete components. The dosing will adjust to the manufacturer's nominal dosing.

3.4.2   Compatibility between the concrete block and the steel tubes

The compatibility between the concrete block and the steel tubes shall be determined by passing the steel tubes through the concrete block.

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 1997-1	Eurocode 7: Geotechnical design. Part 1: General rules.
EN 1993-5	Eurocode. Design of Steel structures. Part 5: Piling
EN ISO 1461	Hot dip galvanized coatings on fabricated iron and steel articles. Specifications and test methods
EN 1992-1-1	Eurocode 2: Design of concrete structures. Part 1-1: General rules and rules for buildings
EN 12390-2	Testing hardened concrete. Part 2: Making and curing specimens for strength tests
EN 10210-2	Hot finished structural hollow sections of non-alloy and fine grain steels. Part 2: Tolerances, dimensions and sectional properties.
EN 197-1	Cement. Part 1: Composition, specifications and conformity criteria for common cements.
EN 12620	Aggregates for concrete.
EN 934-2	Admixtures for concrete, mortar and grout. Part 2: Concrete admixtures. Definitions, requirements, conformity, marking and labelling.
EN 14889-2	Fibres for concrete. Part 2: Polymer fibres. Definitions, specifications and conformity.
API 5CT	American Petroleum Institute. Specification 5CT for Casing and Tubing
ASTM D1143 / D1143M	Standard test methods for deep foundations under static axial compressive load.
EN 206	Concrete. Specification, performance, production and conformity
EN 1992-4	Eurocode 2: Design of concrete structures. Part 4: Design of fastenings for use in concrete.

ANNEX A – DESCRIPTION OF THE FOUNDATION KIT AND ITS COMPONENTS

A.1   MATERIAL PROPERTIES AND DIMENSIONS

The figures of the main shallow foundation kit and of its incorporation into the ground can be seen below.

Figure A.1: Shallow foundation kit.
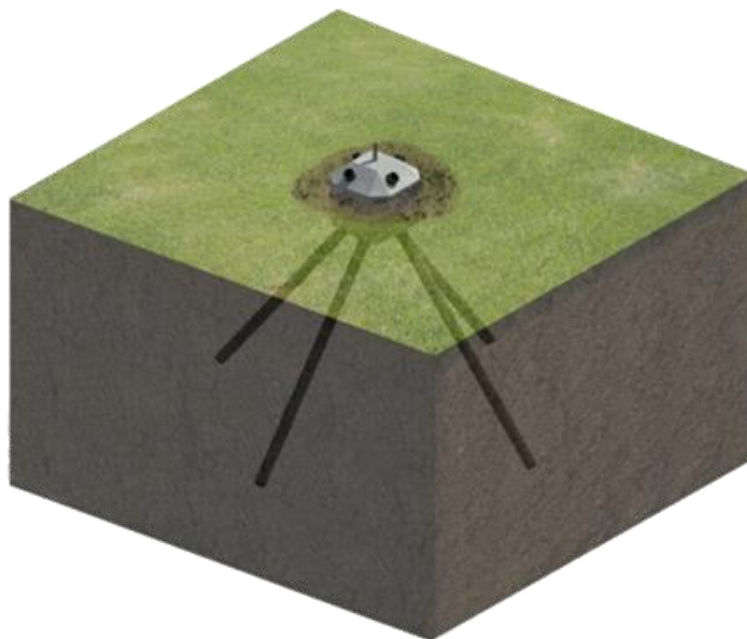
Figure A.2: Shallow foundation kit into the ground.

A.1.1 Concrete block

The strength of the concrete used in the block is ≥ 30 N/mm^2.

The main characteristics of the components used in the manufacturing of the concrete are the following:

- Type of cement, bearing the CE marking in accordance with EN 197-1.
- Size of aggregates, bearing the CE marking in accordance with EN 12620.
- Water.
- Type of additives used, bearing the CE marking in accordance with EN 934-2.
- Fibres for concrete for structural purposes, bearing the CE marking in accordance with EN 14889-2.
- Fibres for concrete for cracking control.

Steel rebars are used for the perimetral reinforcement of the block.

Different types of concrete blocks are possible according to the number of connections to the structure above and to the block height.

The connections to the structure supported on the concrete block are made by means of hexagon nuts embedded in the concrete block, whose dimensions are typically M16 but can be modified. These nuts are connected to threaded rods inside the concrete block. The number of nuts in the concrete block can be 1, 4 or 5 according to the type of block. Nuts and threaded rods can be of galvanised or stainless steel.

The nominal dimensions of the concrete block are the following:

- Length x width: (260 mm ± 10 %) x (260 mm ± 10 %).
- Height: between 280 mm and 350 mm.

The concrete block is passed through by 4 diagonal holes in order to allow the use of steel tubes through it.
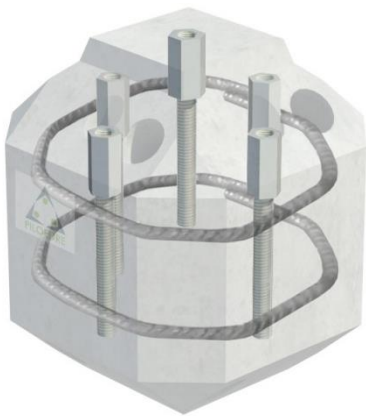
Figure A.3: Typical distribution of steel reinforcements and connections (5) in the concrete block.

A.1.2 Steel tubes

The steel tubes to be used when anchoring the concrete block to the ground are made of galvanised steel quality N80 in accordance with API 5CT, with a minimum yield strength of 500 N/mm^2.

The following types of steel tubes are possible:

Outer diameter	Thickness	Length $^{(*)}$
42,9 mm ± 10 %	Between 2,9 mm and 7,0 mm	Between 900 mm and 1.200 mm

(*) Steel tubes up to 1.500 mm are possible depending on the type of soil.

Table A.1: Dimensions of the steel tubes.

ANNEX B – TEST PROCEDURES

The procedures for testing the foundation kit (clauses B.3 to B.9) are inspired in the main principles of ASTM D1143 / D1143M.

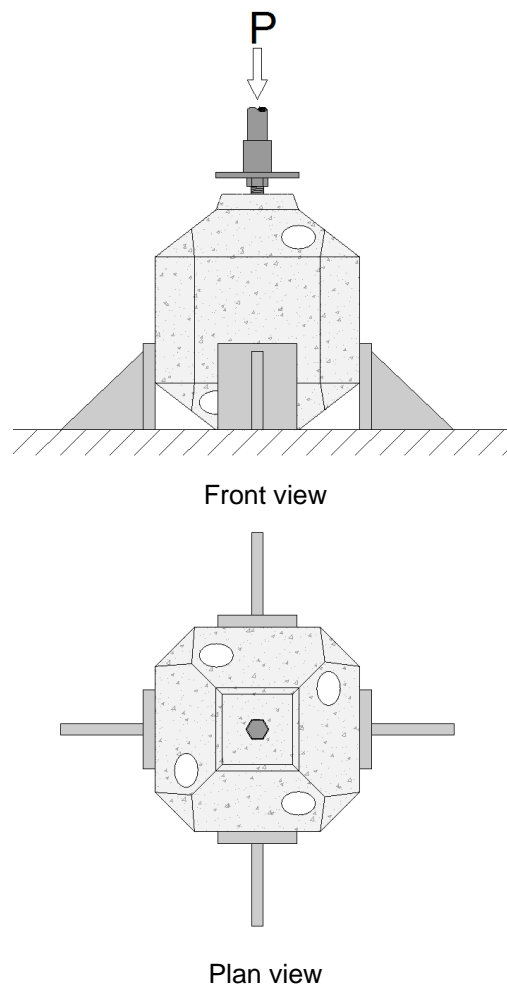## B.1 COMPRESSION RESISTANCE OF THE CONCRETE BLOCK TO POINT LOADS

B.1.1 PRINCIPLE

This test consists in the measurement of the resistance of the concrete block when it is submitted to point loads.

B.1.2 LOADING APPARATUS, LOADED MEMBERS AND SUPPORT FRAMES

The loading apparatus must be able to apply the load on the concrete block by means of the same type of threaded rods defined by the manufacturer to transmit the load in final use conditions.

The twist of the concrete block during the load application must be prevented by means of, for instance, angular profiles in the laterals of the concrete block. This restraint must not cause the confinement of the concrete (see figure B.1).

P

Front view

Plan view

Figure B.1: Example of test setup and load application for the compression resistance of the concrete load to point loads.

B.1.3 TEST DEVELOPMENT

The load is to be applied in compression and in axial direction to the block up to the failure of the block or up to a maximum defined load.

The test will be conducted up to a maximum defined load instead of breaking the block, if this maximum defined load is higher to the maximum compression resistance value (failure by cave-in of the foundation unit) achieved in the test (see clause 2.2.3.b) whichever they were the mechanical properties of the soil.

This maximum defined load is to be declared by the manufacturer.

At least 4 concrete blocks shall be tested.

The load shall be applied in five steps of the maximum defined load.

The displacement of the specimen under load is to be measured at each step by means of one or two sensors placed on both sides of the application of the load, with an accuracy of 0,25 mm.

The compression resistance of the concrete at the day of testing and at the age of 28 days will be determined.

B.1.4 TEST RESULTS

The load, displacement, deformation and the damages of the concrete block are to be recorded.

The formation and growing of cracking in the block is to be recorded.

The load at which the concrete block breaks block or the maximum defined load achieved is to be considered the failure load or the maximum load of the concrete block respectively for further calculations.

The devices used to collect the required data must guarantee to gather them properly. For instance: a camera for recording possible cracking, etc.

The 5 %-fractile of the failure or maximum loads of the concrete block measured in a test series is to be calculated according to statistical procedures for a confidence level of 90 %. If a precise verification does not take place, a normal distribution and an unknown standard deviation of the population shall be assumed.

$F_{u,5\%} = F_{u,m} \cdot (1 - k_s \cdot c_v);$

e.g.: n = 5 specimens: $k_s = 3{,}40$

n = 10 specimens: $k_s = 2{,}57$

If the same (pre-defined) maximum load without breaking of the block ($F_{u,m}$) is achieved in all the specimens of the test series, then it can be assumed than $F_{u,5\%} = F_{u,m}$.
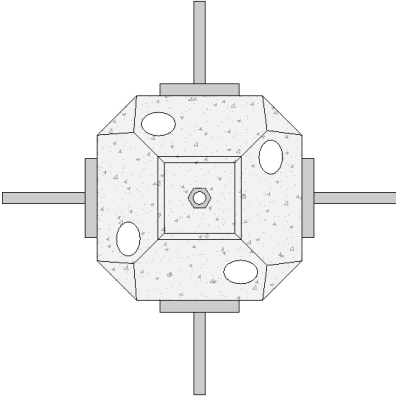
B.2 COMPRESSION RESISTANCE OF THE CONCRETE BLOCK TO SURFACE LOADS

The same test procedure for compression resistance for the concrete block to point loads (annex B.1) applies with the following modifications:

- A surface load must be applied instead of a point load. The load must be applied on the top face evenly applied on all its surface (see figure B.2).

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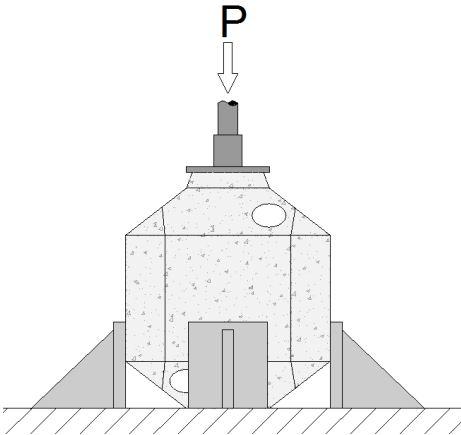
Front view

Plan view

Figure B.2: Example of test setup and load application for the compression resistance of the concrete load to surface loads.

B.3 COMPRESSION RESISTANCE (FAILURE BY CAVE-IN OF THE FOUNDATION UNIT)

B.3.1 PRINCIPLE

The test consists in the measurement of the vertical displacement at the top side of the foundation kit during the application of a step by step downwards vertical load (see figure B.3).

The mechanical properties of the soil (internal friction angle (ϕ), cohesion (c), Winkler modulus (K), soil density (γ) and foundation depth) in which the foundation kit is to be installed must be available. The maximum load of the foundation kit in this soil must be calculated in accordance with the calculation method shown in this EAD.

B.3.2 INSTALLATION OF THE SPECIMEN

The foundation kit is to be installed in the soil following the manufacturer instructions.

The top side of the foundation kit is to be 5 cm approximately above the soil level.

B.3.3 LOADING APPARATUS, LOADED MEMBERS AND SUPPORTING FRAMES

A supporting frame used as a reaction structure with a capacity of at least 10 % higher than the maximum estimated load is to be installed above the foundation kit. This frame can consist of a metal platform with its supports placed at a distance of at least 200 cm of the centre of the foundation kit.

The necessary weight to reach the prescribed reaction structure can be accommodated in this supporting frame.

The vertical load is to be applied by means of a hydraulic pump and a hydraulic jack. The relationship between the load and the hydraulic pressure is to be provided by the manufacturer of the hydraulic jack.

The load is to be applied to the foundation kit through a steel plate at the top of the kit.

Two measurements of the vertical displacement of the foundation kit are to be taken, at two equidistant points of the kit and aligned with its axis of symmetry. The system (auxiliary profiles) used to measure the displacement must be supported on the soil and at least 100 cm from the foundation kit. The calibrated measurement equipment must have an accuracy of at least 0,25 mm.

A calibrated manometer is to be used for the control of the pressure of the system, with an accuracy of at least the 5 % of the maximum pressure to be applied.

B.3.4 TEST DEVELOPMENT

The maximum load to be applied is calculated in accordance with the calculated method shown in clause 2.2.3 a) of this EAD.

The load is to be applied in steps between the 10 % and 15 % of the maximum load. 10 steps as a maximum are to be applied.

The load is to be maintained in each step during 150 s approximately. The load and the vertical displacement are to be measured at 60 s and 150 s.

The loading steps are done until it is not possible to keep the load constant or the maximum load is reached.

The procedure at the last loading step is the following:

- Three measurements (at 60 s, 150 s and 300 s) of load and vertical displacement at the last loading step are to be taken. The last loading measurement is to be considered the maximum load of the test.

- The kit is unloaded, taking measures at 60 s and 150 s.

- The kit is loaded in a step up to approximately the 100 % of the maximum load of the test, taking measures at 60 s and 150 s.

- The kit is unloaded finishing the test.

B.3.5 TEST RESULTS

The measurements of pressure (bars) imposed on the test specimen, load (kN) and vertical displacements (mm) for each loading step at 60 s and 150 s are to be noted.
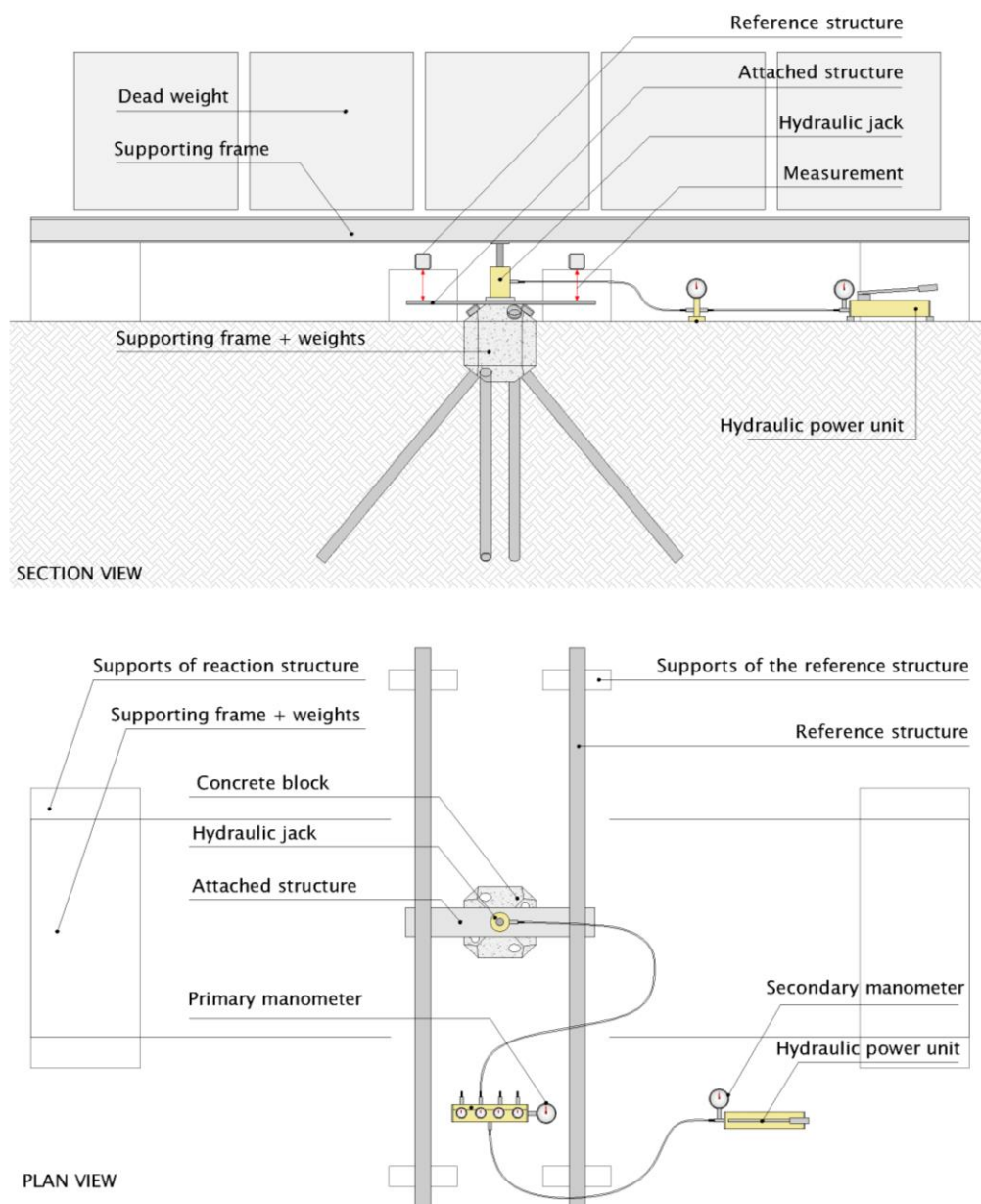
Figure B.3: Test scheme for the compression resistance of the kit (failure by cave-in of the foundation kit).

B.4 TENSILE RESISTANCE (FAILURE BY PULLING THE FOUNDATION UNIT OUT)

B.4.1 PRINCIPLE

The test consists in the measurement of the vertical displacement at the top side of the foundation kit during the application of a step by step upwards vertical load (see figure B.4).

The mechanical properties of the soil (internal friction angle (ϕ), cohesion (c), Winkler modulus (K), soil density (γ) and foundation depth) in which the foundation kit is to be installed must be available. The maximum load of the foundation kit in this soil must be calculated in accordance with the calculation method shown in this EAD.

B.4.2 INSTALLATION OF THE SPECIMEN

The foundation kit is to be installed in the soil following the manufacturer instructions.

The top side of the foundation kit is to be 20 cm approximately below the soil level.

B.4.3 LOADING APPARATUS, LOADED MEMBERS AND SUPPORTING FRAMES

A supporting frame used as a reaction structure with a capacity of at least 10 % higher than the maximum estimated load is to be installed above the foundation kit. This frame can consist of a metal platform with its supports placed at a distance of at least 200 cm from the centre of the foundation kit. The maximum load transmitted by the supports to the soil must not exceed 25 kN/m^2.

The necessary weight to reach the prescribed reaction structure can be accommodated in this supporting frame.

The vertical load is to be applied by means of a hydraulic pump and a hydraulic jack. The relationship between the load and the hydraulic pressure is to be provided by the manufacturer of the hydraulic jack.

The load is to be applied to the foundation kit through a threaded bar at the top of the kit.

Two measurements of the vertical displacement of the foundation kit are to be taken, at two equidistant points of the kit and aligned with its axis of symmetry. The system (auxiliary profiles) used to measure the displacement must be supported on the soil and at least 100 cm from the foundation kit. The calibrated measurement equipment must have an accuracy of at least 0,25 mm.

A calibrated manometer is to be used for the control of the pressure of the system, with an accuracy of at least the 10 % of the maximum pressure to be applied.

B.4.4 TEST DEVELOPMENT

The maximum load to be applied is calculated in accordance with the calculated method shown in clause 2.2.5 a) of this EAD.

The load is to be applied in steps between the 20 % and 25 % of the maximum load. 5 steps as a maximum are to be applied.

The load is to be maintained in each step during 150 s approximately. The load and the vertical displacement are to be measured at 60 s and 150 s.

The loading steps are done until it is not possible to keep the load constant or the maximum load is reached.

The procedure at the last loading step is the following:

- Three measurements (at 60 s, 150 s and 300 s) of load and vertical displacement at the last loading step are to be taken. The last loading measurement is to be considered the maximum load of the test.

- The kit is unloaded, taking measures at 60 s and 150 s.

- The kit is loaded in a step up to approximately the 100 % of the maximum load of the test, taking measures at 60 s and 150 s.

- The kit is unloaded finishing the test.

B.4.5 TEST RESULTS

The measurements of pressure (bars) imposed on the test specimen, load (kN) and vertical displacements (mm) for each loading step at 60 s and 150 s are to be noted.
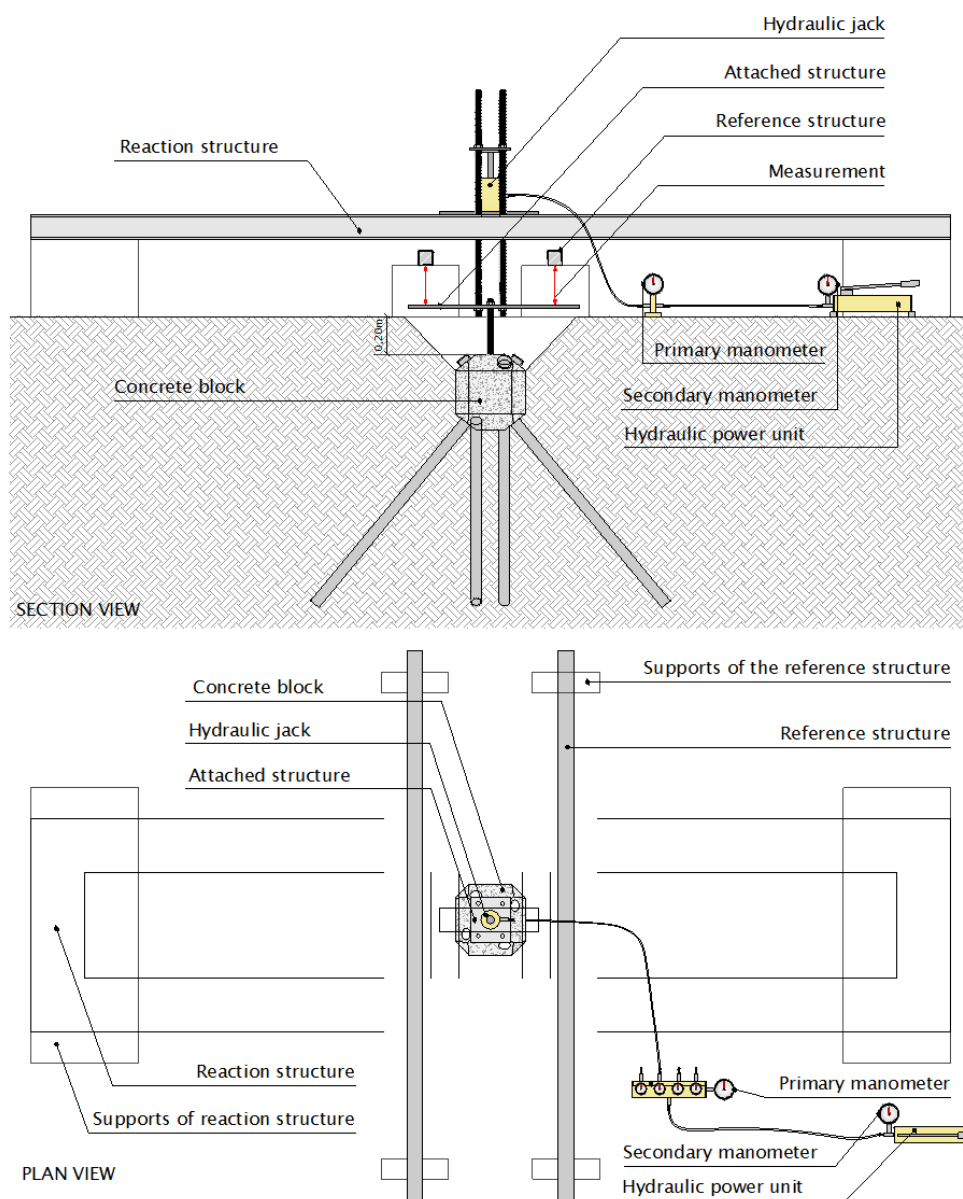

Figure B.4: Test scheme for the tensile resistance of the kit (failure by pulling the foundation out).

B.5   BENDING RESISTANCE

B.5.1 PRINCIPLE

The test consists in the measurement of the vertical displacement of the foundation kit during the application of a bending moment by means of an upwards vertical load with an eccentricity of 1 m (see figure B.7).

The mechanical properties of the soil (internal friction angle (ϕ), cohesion (c), Winkler modulus (K), soil density (γ) and foundation depth) in which the foundation kit is to be installed must be available. The maximum load of the foundation kit in this soil must be calculated in accordance with the calculation method shown in this EAD.

B.5.2 INSTALLATION OF THE SPECIMEN

The foundation kit is to be installed in the soil following the manufacturer instructions.

The top side of the foundation kit is to be 20 cm approximately below the soil level.

B.5.3 LOADING APPARATUS, LOADED MEMBERS AND SUPPORTING FRAMES

The vertical load is to be applied by means of only one hydraulic pump and a hydraulic jack or by means of another equivalent equipment (for instance, a crane) which allows the application of an upwards vertical load.

If a hydraulic pump and a hydraulic jack are used, the relationship between the load and the hydraulic pressure is to be provided by the manufacturer of the hydraulic jack. The maximum load transmitted by the supports of the piston to the soil must not exceed 25 kN/m^2. A calibrated manometer is to be used for the control of the pressure of the system, with an accuracy of at least the 10 % of the maximum pressure to be applied.

Whatever it was the equipment used, the load is to be applied to the foundation kit through a steel plate at the top the kit. This plate is threaded to the four nuts of the concrete block. This test can only be carried out with concrete blocks with four nuts.

Measurements of the vertical displacement of the foundation kit and measurements of pressure or load are to be taken. The distance between the vertical axis of the foundation kit and the measurement point is to be used to transform the vertical displacement to the degree turn.

The system (auxiliary profiles) used to measure the displacement must be supported on the soil and at least 100 cm from the foundation kit. The calibrated measurement equipment must have an accuracy of at least 0,25 mm.

B.5.4 TEST DEVELOPMENT

The maximum load to be applied is calculated in accordance with the calculated method shown in clause 2.2.6 a) of this EAD.

The load is to be applied in steps between the 20 % and 25 % of the maximum load. 5 steps as a maximum are to be applied.

The load is to be maintained in each step during 150 s approximately. The load and the displacement are to be measured at 60 s and 150 s.

The loading steps are done until it is not possible to keep the load constant or the maximum load is reached.

The procedure at the last loading step is the following:

- Three measurements (at 60 s, 150 s and 300 s) of load and vertical displacement at the last loading step are to be taken. The last loading measurement is to be considered the maximum load of the test.

- The kit is unloaded, taking measures at 60 s and 150 s.

- The kit is loaded in a step up to approximately the 100 % of the maximum load of the test, taking measures at 60 s and 150 s.

- The kit is unloaded finishing the test.

B.5.5 TEST RESULTS

The measurements of pressure (bars) imposed on the test specimen, load (kN) and vertical upwards displacement (mm) for each loading step at 60 s and 150 s are to be noted.
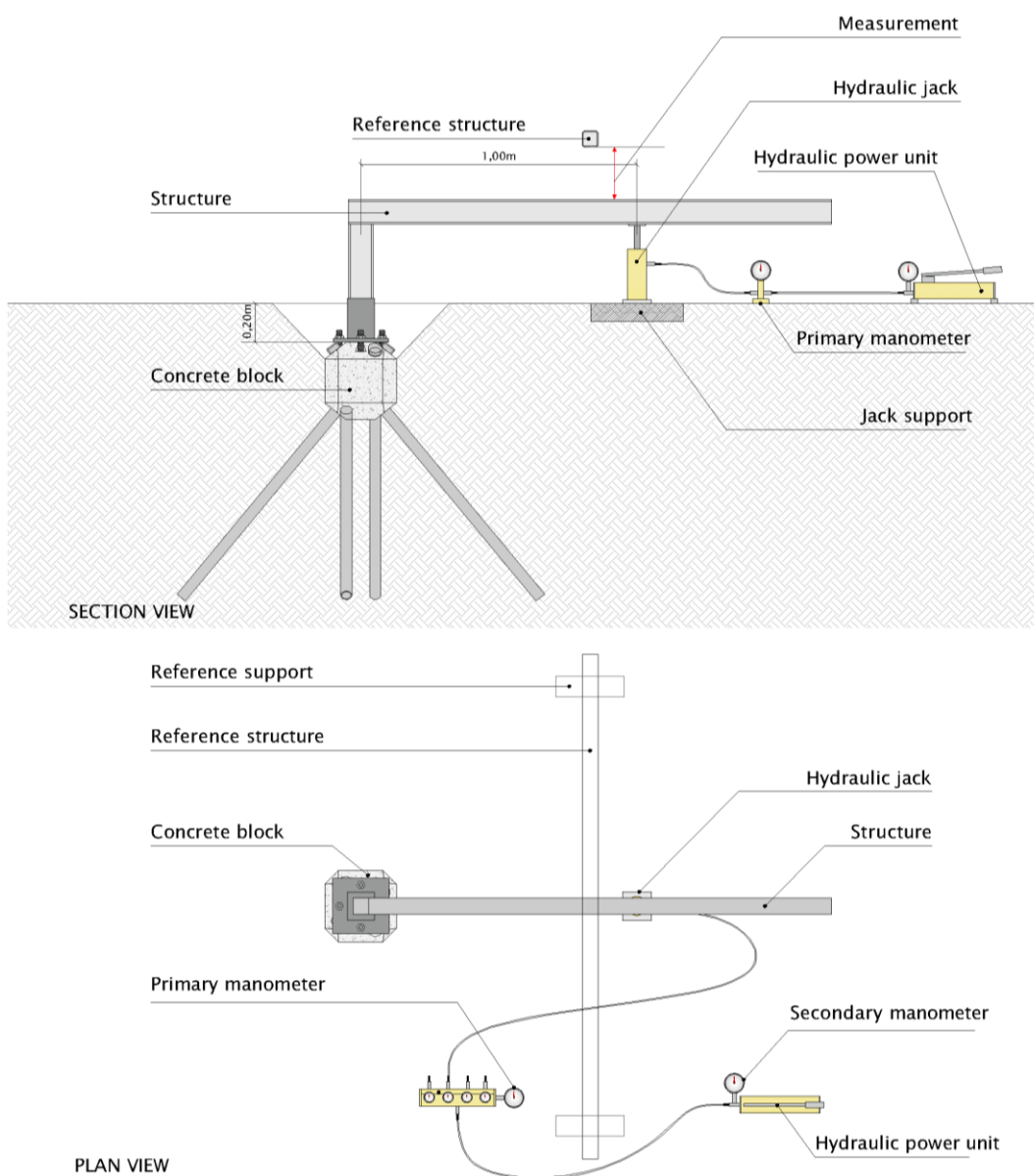
Figure B.5: Example of test scheme for the bending resistance of the kit if a pump and piston are used.

B.6 RESISTANCE TO HORIZONTAL EFFORTS

B.6.1 PRINCIPLE

The test consists in the measurement of the horizontal displacement at the lateral side of two foundation kits during the application of a step by step lateral load (see figure B.8).

The mechanical properties of the soil (internal friction angle (ϕ), cohesion (c), Winkler modulus (K), soil density (γ) and foundation depth) in which the foundation kit is to be installed must be available. The maximum load of the foundation kit in this soil must be calculated in accordance with the calculation method shown in this EAD.

B.6.2 INSTALLATION OF THE SPECIMEN

Two foundation kits are to be installed in the soil following the manufacturer instructions and at 300 cm approximately.

The top side of the foundation kits are to be 20 cm approximately below the soil level.

B.6.3 LOADING APPARATUS, LOADED MEMBERS AND SUPPORTING FRAMES

A metal frame connecting both kits is to be installed. The action on one makes a reaction of the same value but contrary direction on the other.

The horizontal load is to be applied by means of only one hydraulic pump and piston hydraulic jack. The relationship between the load and the hydraulic pressure is to be provided by the manufacturer of the hydraulic jack. Alternatively, it is possible to install two identical hydraulic jacks connected to the same hydraulic pump.

The load is to be applied centred at the lateral face to the foundation kits.

Two measurements of the lateral displacement of the foundation kit are to be taken, one for each foundation kit. The system (auxiliary profiles) used to measure the displacement must be supported on the soil and at least 100 cm from the foundation kit. The calibrated measurement equipment must have an accuracy of at least 0,25 mm.

A calibrated manometer is to be used for the control of the pressure of the system, with a minimum accuracy of the 10 % of the maximum pressure to be applied.

B.6.4 TEST DEVELOPMENT

The maximum load to be applied is calculated in accordance with the calculated method shown in clause 2.2.7 a) of this EAD.

The load is to be applied in steps between the 20 % and 25 % of the maximum load. 5 steps as a maximum are to be applied.

The load is to be maintained in each step during 150 s approximately. The load and the displacement are to be measured at 60 s and 150 s.

The loading steps are done until it is not possible to keep the load constant or the maximum load is reached.

The procedure at the last loading step is the following:

- Three measurements (at 60 s, 150 s and 300 s) of load and vertical displacement at the last loading step are to be taken. The last loading measurement is to be considered the maximum load of the test.

- The kit is unloaded, taking measures at 60 s and 150 s.

- The kit is loaded in a step up to approximately the 100 % of the maximum load of the test, taking measures at 60 s and 150 s.

- The kit is unloaded finishing the test.

B.6.5 TEST RESULTS

The measurements of pressure (bars) imposed on the test specimen, load (kN) and horizontal displacements (mm) for each loading step at 60 s and 150 s are to be noted.
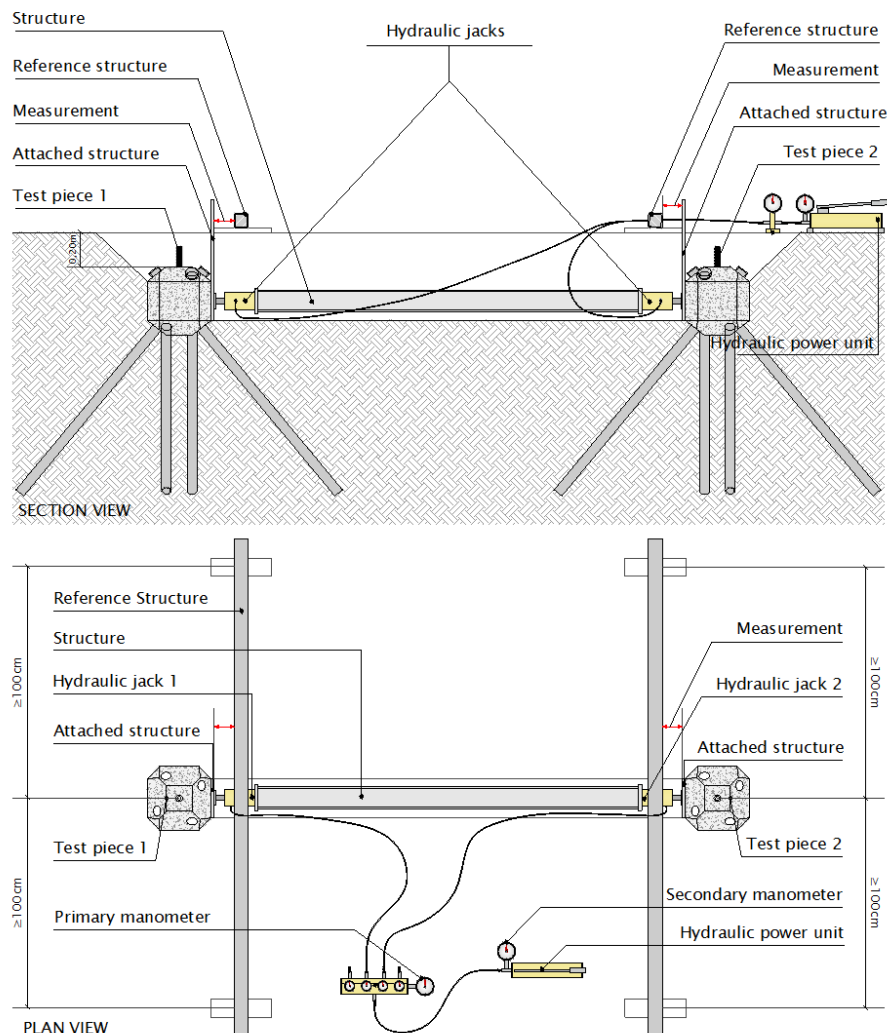

Figure B.6: Test scheme for the horizontal resistance of the kit.

B.7 MAXIMUM COMPRESSION LOAD FOR A GIVEN FOUNDATION DISPLACEMENT

The same test procedure for the compression resistance test (annex B.3) applies with the following modifications:

- The load at which the given displacement is to be achieved must be previously calculated in accordance with the provisions of the EAD.

- It is not necessary to conduct the test until the failure of the foundation kit. It is enough to conduct the test up to the calculated compression load for the given displacement, even the loading steps follow the maximum compression load, as in annex B.3.

- The value of 25 mm for the foundation displacement is recommended.

B.8 MAXIMUM COMPRESSION LOAD ALLOWING THE STEEL TUBES TO BE REUSED

The same test procedure for the compression resistance test (annex B.3) applies with the following modifications:

- The load at which the steel tubes can be reused must be previously calculated in accordance with the provisions of the EAD.

- The test is to be conducted in a single step up to the maximum compression load allowing the steel tubes to be reused, after that, the foundation kit is to be disassembled following the manufacturer instructions. The test is considered satisfactory if the steel tubes can be disassembled.

B.9 MAXIMUM TENSILE LOAD ALLOWING THE STEEL TUBES TO BE REUSED

The same test procedure for the tensile resistance test (annex B.4) applies with the following modifications:

- The load at which the steel tubes can be reused must be previously calculated in accordance with the provisions of the EAD.

- The test is to be conducted in a single step up to the maximum tensile load allowing the steel tubes to be reused, after that, the foundation kit is to be disassembled following the manufacturer instructions. The test is considered satisfactory if the steel tubes can be disassembled.