EUROPEAN ASSESSMENT DOCUMENT

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SRP (STEEL REINFORCED POLYMER) KIT MADE OF STEEL MICRO-WIRES, FIBERGLASS MESH AND EPOXY ADHESIVE

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 SRP kit is a structural reinforcement system consisting of a unidirectional sheet made of ultra-high strength galvanized steel micro-cords, fixed to a fiberglass micromesh applied through an epoxy mineral adhesive on reinforced concrete and masonry (clay and natural stone).

The steel fabric is made of galvanized Ultra High Tensile Strength Steel (UHTSS) micro wires which are twisted around each other to form cords made of five wires, three straight and two twisted around them. The twisting of the individual wires to form the cords provides an interlocking mechanism with the epoxy matrix to enhance bond.

Wires are manufactured in accordance with ISO 16120 1-4. Cords are in accordance with ISO 17832 for mechanical and geometrical properties, including angle of torsion of wires.

To provide protection against corrosion, the micro wires are coated with zinc in accordance with EN 10244-2 or ASTM A475 with a minimum mass of 22g/kg (0.35 oz./lb.)

Steel fabrics are bonded to the surface of structural elements via wet lay-up by an epoxy resin.

The resin is a two-component, epoxy thixotropic gel system, complying with the performance requirements of EN 1504-4 and it is used for impregnation and gluing of structural reinforcement systems. It complies with the performance requirements indicated by EN 1504-6 for grouting structural connectors or anchor bars.

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)

The “SRP (Steel Reinforced Polymer) kit” is suited for highly specialized applications in civil engineering. In particular, it is used to strengthen clay and natural stone masonry, reinforced and pre-stressed concrete structural elements in either flexure, shear, pure axial and combined axial-bending stresses, to retrofit structural elements under seismic, dynamic and impulsive loads, to improve the strength and stiffness of beam-column joints and ultimately to reduce ultimate limit state deformations of structural elements. Different layers of SRP composite can be used to satisfy the strengthening design according to the manufacturer’s instructions.

The contribution of the product to the strengthened member cannot increase the structural capacity more than 50% of that of the unstrengthen member. Such limitation does not apply to exceptional or seismic loads.

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 "SRP (Steel Reinforced Polymer) kit" for the intended use of 50 years when installed in the works (provided that the "SRP (Steel Reinforced Polymer) kit" is subject to appropriate installation). These provisions are based upon the current state of the art and the available knowledge and experience.

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

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

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

2 ESSENTIAL CHARACTERISTICS AND RELEVANT ASSESSMENT METHODS AND CRITERIA

2.1 Essential characteristics of the product

Table 2.1 shows how the performance of the "SRP (Steel Reinforced Polymer) kit made of steel micro-wires, fiberglass mesh and epoxy adhesive" is assessed in relation to the essential characteristics.

Table 2.1 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	Tensile strength	2.2.1	Level σ_u [MPa]
2	Strain		Level ε_u [mm/mm]
3	Modulus of elasticity		Level and description E [GPa]
4	Interlaminar shear strength	2.2.2	Level and description τ [MPa] and failure mode
5	Lap tensile strength	2.2.3	Level Lap length, l_{lap} [mm] Lap tensile strength , σ_{lap} [MPa]
6	Bond strength on substrate: pull-off test	2.2.4.1	Level f_h [MPa] $f_{h,ret}$ [%] (and relative exposure conditions)
7	Bond strength on substrate: single-lap shear test	2.2.4.2	Level P_{max} [N] P_{deb} [N] $P_{max,ret}$ [%] $P_{deb,ret}$ [%] (and relative exposure conditions)
8	Pull out from substrate	2.2.5	Level Pull out strength $\sigma_{pull\text{-}out}$ [MPa] Pull out displacement $\delta_{pull\text{-}out}$ [mm] Retained pull-out strength $\sigma_{pull\text{-}out,ret}$ [%] (and relative exposure conditions)

No	Essential characteristic	Assessment method	Type of expression of product performance *(level, class, description)*
9	Freezing and Thawing	2.2.6	Level and description Tensile strength $\sigma_{u,FT}$ [MPa] Modulus of elasticity E_{FT} [GPa] Strain $\varepsilon_{u,FT}$ [mm/mm] Interlaminar shear strength τ_{FT} [MPa] Retained tensile strength $\sigma_{u,FT,ret}$ [%] Retained modulus of elasticity $E_{FT,ret}$ [%] Retained interlaminar shear strength $\tau_{FT,ret}$ [%] (and relative exposure conditions)
10	Water resistance	2.2.7	Level and description Tensile strength $\sigma_{u,w}$ [MPa] Modulus of elasticity E_w [GPa] Strain $\varepsilon_{u,w}$ [mm/mm] Interlaminar shear strength τ_w [MPa] Lap tensile strength $\sigma_{lap,w}$ [MPa] Retained tensile strength $\sigma_{u,w,ret}$ [%] Retained modulus of elasticity $E_{w,ret}$ [%] Retained interlaminar shear strength $\tau_{w,ret}$ [%] Retained lap tensile strength $\sigma_{lap,w,ret}$ [%] (and relative exposure conditions)
11	Saltwater resistance	2.2.8	Level and description Tensile strength $\sigma_{u,sw}$ [MPa] Modulus of elasticity E_{sw} [GPa] Strain $\varepsilon_{u,sw}$ [mm/mm] Interlaminar shear strength τ_{sw} [MPa] Lap tensile strength $\sigma_{lap,sw}$ [MPa] Retained tensile strength $\sigma_{u,sw,ret}$ [%] Retained modulus of elasticity $E_{sw,ret}$ [%] Retained interlaminar shear strength $\tau_{sw,ret}$ [%] Retained lap tensile strength $\sigma_{lap,sw,ret}$ [%] (and relative exposure conditions)

12	Alkali resistance	2.2.9	Level and description Tensile strength $\sigma_{u,alk}$ [MPa] Modulus of elasticity E_{alk} [GPa] Strain $\varepsilon_{u,alk}$ [mm/mm] Interlaminar shear strength τ_{alk} [MPa] Lap tensile strength $\sigma_{lap, alk}$ [MPa] Retained tensile strength $\sigma_{u, alk,ret}$ [%] Retained modulus of elasticity $E_{alk,ret}$ [%] Retained interlaminar shear strength $\tau_{alk,ret}$ [%] Retained lap tensile strength $\sigma_{lap,alk,ret}$ [%] (and relative exposure conditions)
13	Alkali soil resistance	2.2.10	Level and description Tensile strength $\sigma_{u,soil}$ [MPa] Modulus of elasticity E_{soil} [GPa] Strain $\varepsilon_{u,soil}$ [mm/mm] Retained tensile strength $\sigma_{u,soil,ret}$ [%] Retained modulus of elasticity $E_{soil,ret}$ [%] (and relative exposure conditions)
14	Dry heat resistance	2.2.11	Level and description Tensile strength $\sigma_{u,heat}$ [MPa] Modulus of elasticity E_{heat} [GPa] Strain $\varepsilon_{u,heat}$ [mm/mm] Retained tensile strength $\sigma_{u, heat,ret}$ [%] Retained modulus of elasticity $E_{heat,ret}$ [%] (and relative exposure conditions)
15	Fuel resistance	2.2.12	Level and description Tensile strength $\sigma_{u,fuel}$ [MPa] Modulus of elasticity E_{fuel} [GPa] Strain $\varepsilon_{u,fuel}$ [mm/mm] Retained tensile strength $\sigma_{u,fuel,ret}$ [%] Retained modulus of elasticity $E_{fuel,ret}$ [%] (and relative exposure conditions)
16	Creep behaviour related to the adhesion on substrate	2.2.13	Level and description Displacement vs time (tabular) Maximum load $P_{max,creep}$ [N] after creep Bond capacity $P_{deb,creep}$ [N] after creep
17	Tensile strength after low number of cycles (seismic behaviour)	2.2.14	Level and description Number of cycles causing failure n_{seism} *or* Tensile strength $\sigma_{u,seism}$ [MPa] Modulus of elasticity E_{seism} [GPa] Strain $\varepsilon_{u,seism}$ [mm/mm]

18	Tensile strength after high number of cycles (fatigue actions)	2.2.15	Level and description Number of cycles causing failure $n_{fatigue}$ *or* Tensile strength $\sigma_{u,fatigue}$ [MPa] Modulus of elasticity $E_{fatigue}$ [GPa] Strain $\varepsilon_{u,fatigue}$ [mm/mm]
19	Tensile strength on bent fabric	2.2.16	Level Tensile strengths $\sigma_{u,f,straight}$ and $\sigma_{u,f,bent}$ [MPa] (ambient) Tensile strengths $\sigma_{u,f,straight,sw}$ and $\sigma_{u,f,bent,sw}$ [MPa] (saltwater conditioning)
20	Creep rupture	2.2.17	Level Deformation $\varepsilon_{u,creep}$ [mm/mm] Time at which the failure occurs t_u *or* Deformation $\varepsilon_{u,creep}$ [mm/mm]
21	Void content	2.2.18	Level V [%]
22	Glass Transition Temperature of resin	2.2.19	Level T_g [°C]
Basic Works Requirement 2: Safety in case of fire			
23	Reaction to fire	2.2.20	Class
Basic Works Requirement 4: Safety and accessibility in use			
Same as Basic Works Requirement 1			

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

2.2.1 Mechanical properties of the kit

Purpose of the test

Tensile tests are performed to evaluate the tensile strength, the modulus of elasticity and the strain of the SRP kit.

Test method

The mechanical properties of specimens shall be determined according to EN 2561.

Tests shall be conducted parallel to the primary direction of the micro wire cords of the steel structural reinforcement fabric and considering the number of layers proposed by the manufacturer in his instructions. In case of more layers, test the minimum and the maximum number of layers. If values of mechanical properties are significantly different, test at least one intermediate value of layers. Interpolation for intermediate sizes may be used to determine the mechanical properties. Other tests may be necessary to confirm the assumed interpolation formula.

A minimum number of twenty samples for each number of layers to be subjected to uniaxial tensile test have to be prepared for each SRP configuration (i.e. weight per unit area), laid up according to the following procedure.

Steel fabric of 25 mm width and 250 mm length will be cut from larger panels in order to maintain a specific number of cords for a fixed weight per unit area, i.e. the same number of cords for all samples of the same SRP configuration.

Preparation of composite specimens is done through a mold (plexiglass, teflon or other easily disassembling material), where a first uniform layer of resin is laid down according to the manufacturer's specifications, a layer of steel fabric is pressed down so to allow impregnation and a further layer of resin is laid down until complete covering is obtained. In case of more layers of fabric, this procedure shall be repeated for all the numbers of layers.

Tests are to be performed under standard conditions of temperature and relative humidity (21±2°C, 50±5% RH).

Assessment

The average value (arithmetic mean) and characteristic value of the tensile strength σ_u [MPa], modulus of elasticity E [GPa] and strain ε_u [mm/mm] have to be determined.

The characteristic value will be determined by using the appropriate value of k_n for unknown V_X reported in EN 1990, Annex D, Table D1.

2.2.2 Interlaminar shear strength

Purpose of the test

This test method allows to determine the apparent interlaminar shear strength of fibre-reinforced plastic composites by the short-beam method.

Test method

Composite inter-laminar shear strength tests on SRP panels shall follow the general procedures of EN ISO 14130, with the exception that the minimum specimen length, *l* shall be 50 mm and the minimum specimen width, *b* shall be 25 mm. In any case, the following specimen dimensions have to be respected:

Specimen length, *l* = 10 × thickness, but with minimum 50 mm, Specimen width, *b* = 5 × thickness, but with minimum 25 mm.

The thickness shall be obtained by overlapping at least two layers of composite material.

A minimum number of twenty specimens are required to be tested under standard condition of temperature and relative humidity (21±2°C, 50±5% RH). A summary of the number of specimens to be tested is reported in Annex A.

Assessment

The average value (arithmetic mean) and characteristic value of the interlaminar shear strength τ [MPa] have to be determined. The characteristic value will be determined by using the appropriate value of k_n for unknown V_X reported in EN 1990, Annex D, Table D1.

If failure modes different from the interlaminar shear occur, the statement "No interlaminar shear failure evidenced" shall be reported in the ETA.

2.2.3 Lap tensile strength

Purpose of the test

When applying SRP composite materials for strengthening of structural masonry or concrete members, splices and laps can be necessary for the grid reinforcement. To determine the relative tensile strength at the grid overlap area, lap tensile strength testing is required.

Test method

This test shall be performed on specimens with a joint configuration that closely simulates the actual joint in field application. The general test procedures as described in EN 2561 shall be used on tension tests of SRP composite panels. The specimens shall consist of only one layer of lapped SRP material. The steel fabric in the panel shall be two pieces with an overlap length in the middle. The tested lap length shall be the minimum lap length recommended by the manufacturer; however, the lap length should not be shorter than the tab length defined in EN 2561. Each piece of steel fabric shall have the same dimensions as described in the tensile strength testing (Section 2.2.1), such that the overlap length is positioned at mid-length of the tests specimen.

Ten specimens shall be tested in standard laboratory conditions (21±2°C, 50±5% RH). A summary of the number of specimens to be tested is reported in Annex A.

Assessment

The used overlap length l_{lap} [mm] shall be reported in the ETA.

The average value (arithmetic mean) and characteristic value of the lap tensile strength $\sigma_{lap}=F/A_{f,tot}$ [MPa] have to be determined, where $A_{f,tot}$ represents the fabric cross sectional area evaluated as the number of yarns *n* multiplied by the single yarn cross sectional area A_f.

The characteristic value will be determined by using the appropriate value of k_n for unknown V_X reported in EN 1990, Annex D, Table D1.

2.2.4 Bond strength on substrates

Definition of reference substrates

- *Concrete*

  Concrete type MC (0,40) will be prepared with the sandblasted surface in accordance with EN 1766.

- *Masonry*

Masonry shall be compliant with EN 771-1 (clay) and EN 771-6 (natural stones) and must be chosen with as homogeneous as possible mechanical and physical-chemical characteristics, to reduce the dispersion of the results. In particular, clay bricks shall have a compressive strength comprised in the range 15-25 MPa. The average effective resistance must be evaluated through at least six compression tests on cubic/cylindrical samples of brick, of approximately 50 mm size/diameter, made of the brick thickness. For the realization of masonry specimens a mortar with class not exceeding M5 shall be used (EN 998-2).

Natural stone bricks (tuff) shall have a compressive strength comprised in the range 4-12 MPa. The average effective resistance must be evaluated through at least six compression tests on cubic samples, of approximately 150 mm size.

2.2.4.1 Pull-off test

Purpose of the test

The test allows to determine the adhesive strength of bonded SRP on different substrates. It determines the bond strength to the substrate or the tensile strength of either the overlay or substrate, whichever is weaker.

Test method

For tensile bond testing, thirty-five SRP specimens shall be prepared for each substrate. One layer of SRP material shall be applied onto the substrate according to the manufacturer's instructions. Thirty specimens shall then be exposed to water, saltwater and alkali conditions for 1,000 and 3,000 hours according to the procedures of 2.2.7, 2.2.8 and 2.2.9. Five specimens shall be kept in standard laboratory conditions (21±2°C, 50±5% RH) as control specimens. A summary of the minimum number of specimens to be tested is reported in Annex A.

The test shall follow the general procedures of EN 1542 with the following deviations to take into account the different substrates:

- Concrete: prisms with 300 mm x 300 mm x 100 mm sizes (according to EN 1542);
- Masonry: test shall be conducted on solid bricks. Dollies shall be bonded on the larger surface of the brick or natural stone leaving a distance from the edges equal to the size of the dollies.

When a circular cut is not feasible, it shall be allowed to cut the substrate in a hexagonal geometry to circumscribe the disk used for testing.

Assessment

The failure mode has to be recorded for each individual test result according to the indications of EN 1542.

The average (arithmetic mean) pull off strength f_h [MPa] shall be reported in the ETA, together with the compressive strength of the substrate f_b [MPa] and the axial surface strength of the substrate $f_{h,sub}$ [MPa] according to EN 1542.

The percentage of bond capacity $f_{h,ret}$ [%] retained by exposed specimens with respect to control specimens and the exposure conditions shall also be reported in the ETA.

2.2.4.2 Single-lap shear test

Purpose of the test

The test allows to determine the shear bond strength of SRP composite systems adhesively applied to a flat concrete or masonry substrate.

Test method

A minimum of thirty-five SRP specimens shall be prepared. One layer of SRP composite shall be applied onto the substrate in accordance with the manufacturer's instructions. Thirty specimens shall then be exposed to water, saltwater and alkali conditions for 1,000 and 3,000 hours according to the procedures of 2.2.7, 2.2.8 and 2.2.9. Five specimens shall be kept in standard laboratory conditions as control specimens. The test shall follow the general procedure reported in Annex B.

A summary of the number of specimens to be tested is reported in Annex A.

Assessment

The average value (arithmetic mean) and characteristic value of the peak load P_{max} [N] and the bond capacity P_{deb} [N] shall be reported in the ETA, together with the compressive strength f_b [MPa] and the axial surface strength $f_{h,sub}$ [MPa] of the substrate. The characteristic value will be determined by using the appropriate value of k_n for unknown V_X reported in EN 1990, Annex D, Table D1.

The percentage of bond capacity ($P_{max,ret}$ [%] and $P_{deb,ret}$ [%]) retained by exposed specimens with respect to control specimens and the exposure conditions shall also be reported in the ETA.

2.2.5 Pull out from substrates

Purpose of the test

The possibility to anchor the SRP sheet inside the structural element to be strengthened is foreseen to improve the anchorage strength of the reinforcement. The test is therefore performed to determine the pull-out strength of SRP anchors from different substrates.

Test method

Thirty-five SRP specimens shall be prepared according to the indications given in Annex C. The SRP material shall be anchored in the substrate in accordance with the manufacturer's instructions. Thirty specimens shall then be exposed to water, saltwater and alkali conditions for 1,000 and 3,000 hours according to the procedures of 2.2.7, 2.2.8 and 2.2.9. Five specimens shall be kept in standard laboratory conditions as control specimens. Test shall be performed according to EN 1881, with the deviations indicated in Annex C.

Assessment

A description of the type of failure or combination of failure types shall be given.

The average (arithmetic mean) pull out strength $\sigma_{pull\text{-}out}= F_{max}/A_{f,tot}$ [MPa] and the value of displacement in correspondence of the peak load $\delta_{pull\text{-}out}$ [mm] shall be reported in the ETA, together with the compressive strength of the substrate f_b [MPa] and the axial surface strength of the substrate $f_{h,sub}$ [MPa] according to EN 1542.

The percentage of pull out strength $\sigma_{pull\text{-}out,ret}$ [%] retained by exposed specimens with respect to control specimens and the exposure conditions shall also be reported in the ETA.

2.2.6 Freezing and Thawing

Purpose of the test

This test is performed to evaluate the influence of freeze-thaw cycles on the behaviour of the SRP kit.

Test method

Freezing and thawing conditioning shall be conducted on both tension SRP composite panel specimens (Section 2.2.1) and interlaminar shear SRP specimens (Section 2.2.2). The size of specimens shall be the same as that required for tensile and interlaminar shear testing (described in Section 2.2.1 and 2.2.2). The samples shall be conditioned for one week in a humidity chamber [>95% humidity, 38±1°C]. They shall then be subjected to twenty freeze-thaw cycles. Each cycle consists of a minimum of four hours at -18±1°C, followed by 12 hours in a humidity chamber [>95% humidity, 38±1°C]. The conditioned specimens are then tested in direct tension according to 2.2.1. and for interlaminar shear strength according to test described in 2.2.2. A summary of the minimum number of specimens to be tested is reported in Annex A.

Assessment

Conditioned specimens are visually examined prior to testing using 5× magnification to describe surface changes, such as erosion, cracking, crazing, checking, and chalking.

The average value (arithmetic mean) and characteristic value of the tensile strength $\sigma_{u,FT}$ [MPa], modulus of elasticity E_{FT} [GPa], $\varepsilon_{u,FT}$ [mm/mm] and interlaminar shear strength τ_{FT} [MPa] have to be determined. The characteristic value will be determined by using the appropriate value of k_n for unknown V_X reported in EN 1990, Annex D, Table D1.

The percentage of mechanical properties ($\sigma_{u,FT,ret}$ [%], $E_{FT,ret}$ [%]) and interlaminar shear strength $\tau_{FT,ret}$ [%] retained by exposed specimens with respect to the value recorded for unconditioned specimens (Section 2.2.1 and 2.2.2) and the exposure conditions shall also be reported in the ETA.

2.2.7 Water resistance

Purpose of the test

This test is performed to evaluate the influence of water on the behaviour of the SRP kit.

Test method

Conditioning shall be conducted on both tension SRP composite panel specimens (Section 2.2.1), inter-laminar shear SRP specimens (Section 2.2.2) and lap tensile specimens (Section 2.2.3). Conditioning is done according to ASTM D 2247-11 and ASTM E104-02 for 1,000 and 3,000 hours at a temperature of 38±1°C and relative humidity >95%. Conditioned specimens are then tested in direct tension according to 2.2.1, for interlaminar shear strength according to the procedure described in 2.2.2 and for lap tensile strength according to 2.2.3. A summary of the minimum number of specimens to be tested is reported in Annex A.

Assessment

Conditioned specimens are visually examined prior to testing using 5× magnification to describe surface changes, such as erosion, cracking, crazing, checking, and chalking.

The average value (arithmetic mean) and characteristic value of the tensile strength $\sigma_{u,w}$ [MPa], modulus of elasticity E_w [GPa], strain $\varepsilon_{u,w}$ [mm/mm], interlaminar shear strength τ_w [MPa] and lap tensile strength $\sigma_{lap,w}$ [MPa] have to be determined. The characteristic value will be determined by using the appropriate value of k_n for unknown V_X reported in EN 1990, Annex D, Table D1.

The percentage of average mechanical properties($\sigma_{u,w,ret}$ [%], $E_{w,ret}$ [%]), interlaminar shear strength $\tau_{w,ret}$ [%] and lap tensile strength $\sigma_{lap,w,ret}$ [%] retained by exposed specimens with respect to the value recorded for unconditioned specimens (Section 2.2.1 and 2.2.2) and the exposure conditions shall also be reported in the ETA.

2.2.8 Saltwater resistance

Purpose of the test

This test is performed to evaluate the influence of saltwater on the efficiency of the SRP kit.

Test method

Conditioning shall be conducted on both tension SRP composite panel specimens (Section 2.2.1), inter-laminar shear SRP specimens (Section 2.2.2) and lap tensile specimens (Section 2.2.3). Conditioning is done by immerging specimens in saltwater according to ASTM D1141-98 e ASTM C581-03 for 1,000 and 3,000 hours at a temperature of 23±1°C. Conditioned specimens are then tested in direct tension according to 2.2.1, for interlaminar shear strength according to the procedure described in 2.2.2 and for lap tensile strength according to 2.2.3. A summary of the number of specimens to be tested is reported in Annex A.

Assessment

Conditioned specimens are visually examined prior to testing using 5× magnification to describe surface changes, such as erosion, cracking, crazing, checking, and chalking.

The average value (arithmetic mean) and characteristic value of the tensile strength $\sigma_{u,sw}$ [MPa], modulus of elasticity E_{sw} [GPa], strain $\varepsilon_{u,sw}$ [mm/mm], interlaminar shear strength τ_{sw} [MPa] and lap tensile strength $\sigma_{lap,sw}$ [MPa] have to be determined. The characteristic value will be determined by using the appropriate value of k_n for unknown V_X reported in EN 1990, Annex D, Table D1.

The percentage of average mechanical properties ($\sigma_{u,sw,ret}$ [%], $E_{sw,ret}$ [%]), interlaminar shear strength $\tau_{sw,ret}$ [%] and lap tensile strength $\sigma_{lap,sw,ret}$ [%] retained by exposed specimens with respect to the value recorded for unconditioned specimens (Section 2.2.1, 2.2.2 and 2.2.3) and the exposure conditions shall also be reported in the ETA.

2.2.9 Alkali resistance

Purpose of the test

This test is performed to evaluate the influence of alkali attack on the efficiency of the SRP kit.

Test method

Conditioning shall be conducted on both tension SRP composite panel specimens (Section 2.2.1), interlaminar shear SRP specimens (Section 2.2.2) and lap tensile specimens (Section 2.2.3). Conditioning is done by immerging specimens in a liquid with pH≥9.5 for 1,000 and 3,000 hours at a temperature of 23±2°C. Conditioned specimens are then tested in direct tension according to 2.2.1, for interlaminar shear strength according to the procedure described in 2.2.2 and for lap tensile strength according to 2.2.3. A summary of the number of specimens to be tested is reported in Annex A.

Assessment

Conditioned specimens are visually examined prior to testing using 5× magnification to describe surface changes, such as erosion, cracking, crazing, checking, and chalking.

The average value (arithmetic mean) and characteristic value of the tensile strength $\sigma_{u,alk}$ [MPa], modulus of elasticity E_{alk} [GPa], strain $\varepsilon_{u,alk}$ [mm/mm], interlaminar shear strength τ_{alk} [MPa] and lap tensile strength $\sigma_{lap,alk}$ [MPa] have to be determined. The characteristic value will be determined by using the appropriate value of k_n for unknown V_X reported in EN 1990, Annex D, Table D1.

The percentage of average mechanical properties ($\sigma_{u,alk,ret}$ [%], $E_{alk,ret}$ [%]), interlaminar shear strength $\tau_{alk,ret}$ [%] and lap tensile strength $\sigma_{lap,alk,ret}$ [%] retained by exposed specimens with respect to the values recorded for unconditioned specimens (Section 2.2.1, 2.2.2 and 2.2.3) and the exposure conditions shall also be reported in the ETA.

2.2.10 Alkali soil resistance

Purpose of the test

This test is performed to evaluate the influence of alkali soil attack on the performance of the SRP kit, due to polymer degradation induced by SRP burials in soils having very low or very high pH.

Test method

The alkali soil resistance testing shall be performed on five tension SRP composite panel specimens (Section 2.2.1) conditioned for 1,000 hours.

Specimens shall be buried in soil vertically to a depth of about 125 mm, measured to the top of the specimen. The containers of soil and buried SRP composite specimens shall be stored in a room with the temperature maintained between 32˚C to 38˚C. The soil shall be rich in cellulose-destroying microorganisms, have a pH of 6.5-7.5, and have oven-dry moisture content between 25 and 30 percent throughout the test period. The microbiological activity of the soil shall be checked frequently by tensile testing cotton duck that has been buried in the soil, with the tensile strength loses of the cotton duck being a minimum of 70 and 90 percent after one- and two-week exposures, respectively.

At the end of 1,000 hours of exposure, conditioned specimens of the SRP composite are then tested for tensile strength, tensile modulus, and strain in accordance with EN 2561 (Section 2.2.1).

A summary of the minimum number of specimens to be tested is reported in Annex A.

Assessment

Conditioned specimens are visually examined prior to testing using 5× magnification to describe surface changes, such as erosion, cracking, crazing, checking, and chalking.

The average value (arithmetic mean) and characteristic value of the tensile strength $\sigma_{u,soil}$ [MPa], modulus of elasticity E_{soil} [GPa] and strain $\varepsilon_{u,soil}$ [mm/mm] have to be determined. The characteristic value will be determined by using the appropriate value of k_n for unknown V_X reported in EN 1990, Annex D, Table D1.

The percentage of average mechanical properties ($\sigma_{u,soil,ret}$ [%], $E_{soil,ret}$ [%]) retained by exposed specimens with respect to the values recorded for unconditioned specimens (Section 2.2.1) and the exposure conditions shall also be reported in the ETA.

2.2.11 Dry heat resistance

Purpose of the test

This test is performed to evaluate the influence of dry heat on the efficiency of the SRP kit.

Test method

Conditioning shall be conducted on tension SRP composite panel specimens (Section 2.2.1) according to ASTM D3045 for 1,000 and 3,000 hours. Conditioned specimens are then tested for tensile strength, tensile modulus, and strain according to 2.2.1. A summary of the minimum number of specimens to be tested is reported in Annex A.

Assessment

Conditioned specimens are visually examined prior to testing using 5× magnification to describe surface changes, such as erosion, cracking, crazing, checking, and chalking.

The average value (arithmetic mean) and characteristic value of the tensile strength $\sigma_{u,heat}$ [MPa], modulus of elasticity E_{heat} [GPa] and strain $\varepsilon_{u,heat}$ [mm/mm] have to be determined. The characteristic value will be determined by using the appropriate value of k_n for unknown V_X reported in EN 1990, Annex D, Table D1.

The percentage of average mechanical properties ($\sigma_{u,heat,ret}$ [%], $E_{heat,ret}$ [%]) retained by exposed specimens with respect to the values recorded for unconditioned specimens (Section 2.2.1) and the exposure conditions shall also be reported in the ETA.

2.2.12 Fuel resistance

Purpose of the test

This test is performed to evaluate the influence of fuel conditioning on the efficiency of the SRP kit.

Test method

Conditioning shall be conducted on tension SRP composite panel specimens (Section 2.2.1). Specimens shall be prepared and exposed to diesel fuel reagent for a minimum of four hours. After conditioning, the specimens shall be tested in their primary direction for tensile strength, tensile modulus, and strain according to 2.2.1.

Assessment

Conditioned specimens are visually examined prior to testing using 5× magnification to describe surface changes, such as erosion, cracking, crazing, checking, and chalking.

The average value (arithmetic mean) and characteristic value of the tensile strength $\sigma_{u,fuel}$ [MPa], modulus of elasticity E_{fuel} [GPa] and strain $\varepsilon_{u,fuel}$ [mm/mm] have to be determined.

The characteristic value will be determined by using the appropriate value of k_n for unknown V_X reported in EN 1990, Annex D, Table D1.

The percentage of average mechanical properties ($\sigma_{u,fuel,ret}$ [%], $E_{fuel,ret}$ [%]) retained by exposed specimens with respect to the values recorded for unconditioned specimens (Section 2.2.1) and the exposure conditions shall also be reported in the ETA.

2.2.13 Creep behaviour related to the adhesion on substrates

Purpose of the test

This test is performed to determine the tensile creep under standard conditions or under maximum service temperature conditions recommended by the manufacturer.

Test method

Five specimens shall be prepared for each substrate according to the procedure of Section 2.2.4.2. The SRP material bonded to the substrate is subjected to a continuous tensile load equal to the 30% of the corresponding averaged maximum load of Section 2.2.4.2 for half a year. During the duration of the test, the pieces are stored at 23±2°C and 80±5% RH, or such other conditions as specified by the manufacturer. After long-term loading the bond strength shall be measured for each specimens at standard environmental conditions.

Assessment

The displacement of each SRP specimen relative to the substrate is measured and recorded:

- before applying the tensile load;
- immediately after applying the tensile load;
- start of the creep curve;
- after one day, two days and every seven days until the test is completed at six months (reference value).

The average value (arithmetic mean) and characteristic value of the maximum load $P_{max,creep}$ [N] and the bond capacity $P_{deb,creep}$ [N] shall be reported in the ETA. The characteristic value will be determined by using the appropriate value of k_n for unknown V_X reported in EN 1990, Annex D, Table D1.

2.2.14 Tensile strength after low number of cycles (seismic behaviour)

Purpose of the test

This test is performed to determine the system behaviour under cyclic loading (seismic behaviour).

Test method

Five specimens shall be prepared according to the procedure of Section 2.2.1, with a minimum number of fabric layers.

Fifteen cycles at 1 Hz shall be applied on the specimens. The cyclic loads consist of a lower stress level equal to 5% of the respective characteristic short time tensile strength (Section 2.2.1) and an upper stress level equal to 90% of the respective characteristic short time tensile strength. If no failure occurs during the cycles, the specimens shall be tested in direct tension according to 2.2.1.

Assessment

The number of cycles n_{seism} causing failure shall be reported in the ETA or, if no failure occurs during the cycles, the average value (arithmetic mean) and characteristic value of the tensile strength $\sigma_{u,seism}$ [MPa], modulus of elasticity E_{seism} [GPa] and strain $\varepsilon_{u,seism}$ [mm/mm] have to be determined and reported in the ETA. The characteristic value will be determined by using the appropriate value of k_n for unknown V_X reported in EN 1990, Annex D, Table D1.

2.2.15 Tensile strength after high number of cycles (fatigue actions)

Purpose of the test

This test is performed to determine the system behaviour under fatigue loading.

Test method

Five specimens shall be prepared according to the procedure of Section 2.2.1, with a minimum number of fabric layers. Dynamic tests with 2×10^6 cycles shall be carried out under a swing width of 10% (R = 0.1) and an upper load of 60% of the respective average short-time tensile strength (Section 2.2.1). The testing frequency shall be chosen to be between 1 to 3 Hz. Cyclic loads shall be applied on the specimens until fatigue failure or the limit number of cycles is reached. Test specimens reaching the limit number of cycles without failure are to be tested in direct tension according to 2.2.1. Test shall be performed in standard laboratory conditions (21±2°C, 50±5% RH).

Assessment

The number of cycles $n_{fatigue}$ causing failure shall be reported in the ETA or, if no failure occurs during the cycles, the average value (arithmetic mean) and characteristic value of the tensile strength $\sigma_{u,fatigue}$ [MPa], modulus of elasticity $E_{fatigue}$ [GPa] and strain $\varepsilon_{u,fatigue}$ [mm/mm] have to be determined and reported in the ETA. The characteristic value will be determined by using the appropriate value of k_n for unknown V_X reported in EN 1990, Annex D, Table D1.

2.2.16 Tensile strength on bent fabric

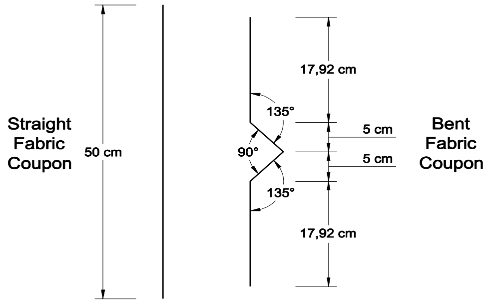
Purpose of the test

The purpose of this test is to evaluate possible degradation of the steel fabric wires when subjected to pre-bending and aggressive environment.

Test method

Table 2.2 shows the geometry and the shape of the fabric coupons. A minimum of five straight fabric specimens and five bent fabric specimens are required as control specimens. Tensile testing to determine the tensile strength of the SRP fabric shall be conducted in accordance with EN 2561 with deviations as listed in Table 2.2. Tests shall be conducted on primary grid direction. Five coupons of the straight and five coupons of bent configurations shall be then exposed to the saltwater conditioning environment given in Section 2.2.8 followed by testing in direct tension in accordance with EN 2561.

Table 2.2 Testing parameters for SRP fabric in direct tension

DEVIATIONS FROM EN 2561	COUPONS SHAPE	NUMBER OF SPECIMENS AND CONDITIONING		
Record only maximum load Specimen width = 2.50 cm (min) Specimen length = 50 cm (min)		Straight specimens	Ambient	5
			Saltwater	5
		Bent specimens	Ambient	5
			Saltwater	5

Assessment

The average value (arithmetic mean) and characteristic value of the tensile strengths $\sigma_{u,f,straight}$ and $\sigma_{u,f,bent}$ [MPa] in ambient and the average and characteristic value of the tensile strengths $\sigma_{u,f,straight,sw}$ and $\sigma_{u,f,bent,sw}$ [MPa] after conditioning shall be determined and reported in the ETA, together with the exposure conditions. The characteristic value will be determined by using the appropriate value of k_n for unknown V_X reported in EN 1990, Annex D, Table D1.

2.2.17 Creep rupture

Test method

Creep test shall be performed on 5 specimens according to ASTM D2990 Section 6.3. Load shall be applied for at least 3,000 hours. The load shall be such that the stress in the most tensile stressed SRP fibre is equal to 0.55 σ_u (ultimate tensile strength of composite material). Values shall be determined in the primary direction.

Assessment

The deformation resulting from the permanent applied load shall be measured and represented as a function of time.

If failure occurs before the end of the 3,000 hours, the time t_u (number of hours) and the last recorded deformation $\varepsilon_{u,creep}$ [mm/mm] at which failure occurs shall be reported in the ETA.

If no failure occurs during the permanent load, the deformation $\varepsilon_{u,creep}$ [mm/mm] reached at the end of the examination period shall be recorded.

2.2.18 Void content

Void content shall be evaluated according to EN ISO 7822 – Method A. The average value shall be given in the ETA.

2.2.19 Glass transition temperature of resin

Glass transition temperature (T_g) shall be evaluated on three specimens according to EN ISO 11357-2, by using the DSC (Differential Scanning Calorimetry) method. The specimen under test must be in solid state.

For this purpose, the specimens, after the mixing of the reagents, shall be conditioned for 3 days at atmospheric pressure under standard temperature and humidity conditions (23±2°C, 50±5% RH). The glass transition temperature must only be measured during the first heating cycle; the heating speed must be 10°C/min. The minimum value among the three shall be given in the ETA.

2.2.20 Reaction to fire

The SRP kit shall be tested, using the test method(s) relevant for the corresponding reaction to fire class, in order to be classified according to Commission Delegated Regulation (EU) 2016/364.

The performance class obtained from the tests shall be reported in the ETA.

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 1999/469/EC**.

The system is: **2+**

In addition, with regard to reaction to fire for products covered by this EAD the applicable European legal act is: **Decision 1999/469/EC**, as amended by **Decision 2001/596/EC**.

The systems are:

1 for A1, A2, B, C classes (Products/materials for which a clearly identifiable stage in the production process results in an improvement of the reaction to fire classification, e.g. an addition of fire retardants or a limiting of organic material).

3 for A1, A2, B, C classes (Products/Materials for which **there is not** a clearly identifiable stage in the production process resulting in an improvement of the reaction to fire classification) and D, E classes.

4 for A1 to E classes (Products/materials that do not require to be tested for reaction to fire, e.g. Products/materials of Classes A1 according to Commission Decision 96/603/EC) and F class.

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 3.1.

Table 3.1 Control plan for the manufacturer; cornerstones

No	Subject/type of control *(product, raw/constituent material, component – indicating characteristic concerned)*	Test or control method *(refer to 2.2 or 3.4)*	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	Incoming material	Supplier data check	Control Plan	-	100% batch
2	Bond between cords and glass grid	Visual check	Control Plan	-	100% batch
3	Distance between cords	Visual check / Caliber	Control Plan	-	100% batch
4	Mass of zinc	EN 10244-2	Control Plan	-	100% batch
5	Superficial uniformity of galvanization	Electron microscope with EDS	Control Plan	-	100% batch
6	Tensile strength of steel fabric	EN 2561	Control Plan	-	Every six months

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 SRP kit are laid down in Table 3.2.

Table 3.2 Control plan for the notified body; cornerstones

No	Subject/type of control *(product, raw/constituent material, component – indicating characteristic concerned)*	Test or control method *(refer to 2.2 or 3.4)*	Criteria, if any	Minimum number of samples	Minimum frequency of control
Initial inspection of the manufacturing plant and of factory production control					
1	Ascertain that the factory production control with the staff and equipment are suitable to ensure a continuous and orderly manufacturing of the components of the SRP kit.	-	As defined in the control plan	-	1
2	<u>Only for AVCP system 1</u> Control of the manufacturing plant and of the factory production regarding the constancy of performance related to reaction to fire, taking into account the limitation on organic material and/or the addition of fire retardant. In particular, ascertain that there is: - Presence of suitable test equipment - Presence of trained personnel - Presence of an appropriate quality assurance system and necessary stipulations	As defined in the control plan	As defined in the control plan	As defined in the control plan	At the beginning of the contract between NB and Manufacturer
Continuous surveillance, assessment and evaluation of factory production control					
1	Verifying that the system of factory production control and the specified automated manufacturing process are maintained taking account of the control plan.	-	As defined in the control plan	-	1/year
2	<u>Only for AVCP system 1</u> Continuous surveillance, assessment and evaluation of the factory production control carried out by the manufacturer regarding the constancy of performance related to reaction to fire, taking into account the limitation on organic material and/or the addition of fire retardant. In particular: - Inspection of factory, of the production of the product and of the facilities for factory production control - Evaluation of the documents concerning the factory production control	As defined in the control plan	As defined in the control plan	As defined in the control plan	Once per year

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 771-1	Specification for masonry units - Part 1: Clay masonry units
EN 771-6	Specification for masonry units - Part 6: Natural stone masonry units
EN 1504-4	Products and systems for the protection and repair of concrete structures - Definitions, requirements, quality control and evaluation of conformity - Part 4: Structural bonding
EN 1504-6	Products and systems for the protection and repair of concrete structures - Definitions, requirements, quality control and evaluation of conformity - Part 6: Anchoring of reinforcing steel bar
EN 1542	Products and systems for the protection and repair of concrete structures - Test methods - Measurement of bond strength by pull-off
EN 1766	Products and systems for the protection and repair of concrete structures - Test methods - Reference concretes for testing.
EN 1881	Products and systems for the protection and repair of concrete structures - Test methods - Testing of anchoring products by the pull-out method
EN 1990	Eurocode - Basis of structural design
EN 2561	Aerospace series - Carbon fibre reinforced plastics - Unidirectional laminates - Tensile test parallel to the fibre direction
EN 10244-2	Steel Wire And Wire Products - Non-ferrous Metallic Coatings On Steel Wire - Part 2: Zinc Or Zinc Alloy Coatings
EN ISO 7822	Textile glass reinforced plastics - Determination of void content - Loss on ignition, mechanical disintegration and statistical counting methods
EN ISO 11357-2	Plastics -- Differential scanning calorimetry (DSC) -- Part 2: Determination of glass transition temperature and glass transition step height
EN ISO 14130	Fibre-reinforced plastic composites - Determination of apparent interlaminar shear strength by short-beam method
ISO 16120	Non-alloy steel wire rod for conversion to wire
ISO 17832	Non-parallel steel wire and cords for tyre reinforcement
ASTM A475	Standard specification for zinc-coated steel wire strand
ASTM C581-03	Practice for Determining the Chemical Resistance of Thermosetting Resins Used in Glass-fiber-reinforced Structures Intended for Liquid Service.
ASTM D1141-98	Practice for Preparation of Substitute Ocean Water
ASTM D2247-11	Practice for Testing Water Resistance of Coatings in 100% Relative Humidity
ASTM D2990	Standard Test Methods for Tensile, Compressive, and Flexural Creep and Creep- Rupture of Plastics
ASTM D3045	Standard Practice for Heat Aging of Plastics Without Load
ASTM E104-02	Standard Practice for Maintaining Constant Relative Humidity by Means of Aqueous Solutions

ANNEX A – SUMMARY OF TESTS FOR THE KIT

	Essential characteristic	TEST TYPE	CONDITIONING	Minimum number of specimens
Mechanical properties	Tensile strength Strain Modulus of elasticity	Direct tension	N/A	20
	Interlaminar shear strength	Short-beam	N/A	20
	Lap tensile strength	Direct tension	N/A	10
Interaction with substrate	Bond strength on substrate(1)	Pull-Off	Ambient (control specimens)	5
			Water (1000 and 3000 hrs)	10
			Saltwater (1000 and 3000 hrs)	10
			Alkali (1000 and 3000 hrs)	10
			TOTAL	**35**
	Bond strength on substrate(1)	Single-lap shear	Ambient (control specimens)	5
			Water (1000 and 3000 hrs)	10
			Saltwater (1000 and 3000 hrs)	10
			Alkali (1000 and 3000 hrs)	10
			Creep	5
			TOTAL	**40**
	Pull out from substrate(1)	Pull-out	Ambient (control specimens)	5
			Water (1000 and 3000 hrs)	10
			Saltwater (1000 and 3000 hrs)	10
			Alkali (1000 and 3000 hrs)	10
			TOTAL	**35**
Ageing	Freezing and Thawing	Direct tension	20 freeze-thaw cycles (four hours at -18±1°C followed by 12 hours >95% humidity and 38±1°C)	5
		Interlaminar shear	20 freeze-thaw cycles (four hours at -18±1°C followed by 12 hours >95% humidity and 38±1°C)	5
			TOTAL	**10**
	Water resistance	Direct tension	1000 hours	5
			3000 hours	5
		Interlaminar shear	1000 hours	5

	Essential characteristic	TEST TYPE	CONDITIONING	Minimum number of specimens
			3000 hours	5
		Lap tensile strength	1000 hours	5
			3000 hours	5
			TOTAL	**30**
	Saltwater resistance	Direct tension	1000 hours	5
			3000 hours	5
		Interlaminar shear	1000 hours	5
			3000 hours	5
		Lap tensile strength	1000 hours	5
			3000 hours	5
			TOTAL	**30**
	Alkali resistance	Direct tension	1000 hours	5
			3000 hours	5
		Interlaminar shear	1000 hours	5
			3000 hours	5
		Lap tensile strength	1000 hours	5
			3000 hours	5
			TOTAL	**30**
	Alkali soil resistance	Direct tension	1000 hours	5
			TOTAL	**5**
	Dry heat resistance	Direct tension	1000 hours	5
			3000 hours	5
			TOTAL	**10**
	Fuel resistance	Direct tension	4 hours minimum	5
			TOTAL	**5**
Cyclic loading	Tensile strength after low number of cycles (seismic behaviour)	Direct tension	N/A	**5**
	Tensile strength after high number of cycles (fatigue actions)	Direct tension	N/A	**5**

Notes:
(1) These tests are to be repeated for each substrate foreseen by the intended use of the product (concrete, clay and natural stone masonry)

ANNEX B – SINGLE-LAP SHEAR TEST

This test method describes the apparatus and procedure for evaluating the bond properties of SRP composite systems adhesively applied to a flat concrete or masonry substrate.

B1. Summary of Test Method

The direct single-lap shear test is conducted using a push-pull configuration, where the substrate prism with square or rectangular cross-section is restrained while the composite strip is pulled until failure.

B2. Apparatus

Tests are conducted using a direct single-lap shear test set-up. The prism is restrained against movement by two steel plates placed against the square or rectangular end cross-sections of the prism. The bottom square plate shall be gripped to the testing machine. The top plate is a rectangular steel element connected to the bottom one through four steel bars bolted to the two plates.

The displacement and the applied load have to be recorded continuously during the test.

Slip measurement—Linear variable differential transducers (LVDTs) can be mounted on the substrate surface close to the top edge of the bonded region to measure the displacement of the SRP plate with respect to the substrate (an example is shown in Figure 1). The LVDTs (named LVDT a and b in Figure 1) react off of a thin aluminium Ω-shaped plate bonded to the bare fibres immediately outside the bonded length.

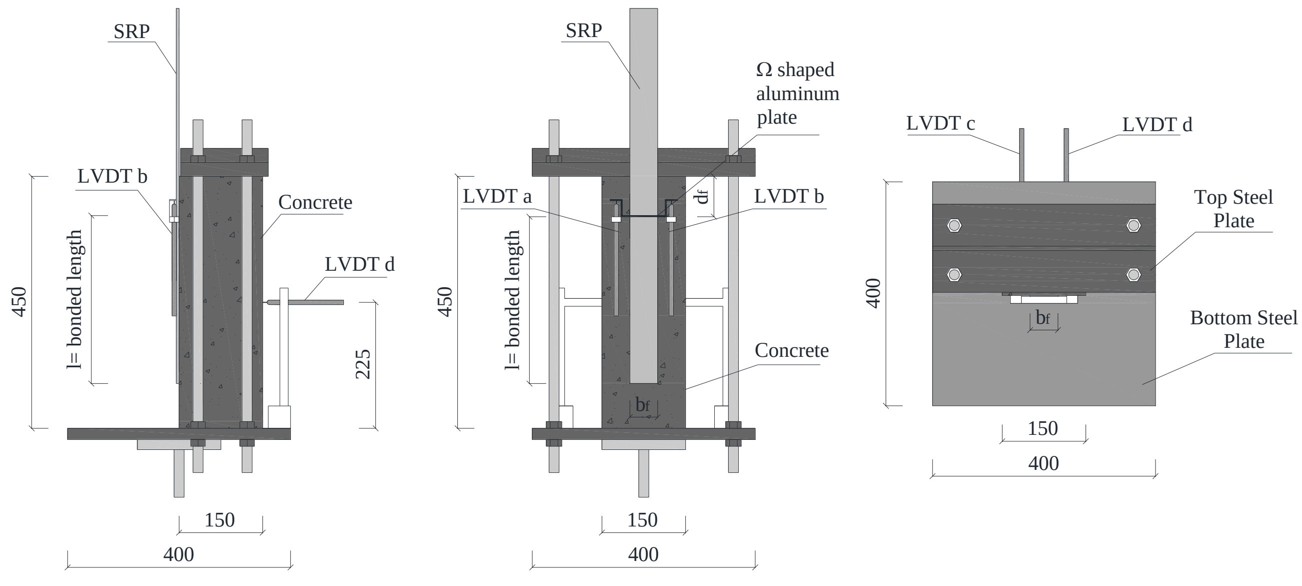


Figure 1: Schematic of Suitable Apparatus for Direct Single-Lap Shear Test.

Optional rotation measurement— Two optional LVDTs (named LVDT c and d in Figure 1) can be used to monitor the horizontal displacement of the substrate in the direction perpendicular to the face of the composite strip. The LVDT c and d react off of the face of the substrate block parallel to the one to which the composite is applied. The measurement point should be approximately at half of the length of the substrate.

B3. Test Specimen and Sampling

Concrete

The concrete test specimen shall conform to all requirements of EN 1766, considering an MC (0,40) concrete type. The dimensions of the concrete prism shall be 150 mm width × 150 mm depth × 450 mm length. Dimensions of the prism can be varied as long as the indicated dimensions are considered the minimum values admissible. The sides of the specimen shall be at right angles with the top and bottom. All surfaces shall be smooth and free of scars, indentations, holes, or inscribed identification marks. The prisms are reinforced on one face (neither the casting one nor the end cross-sections shall be used) with bonded SRP reinforcement. Because the formed faces of the concrete prism might have a different amount of aggregates near the surface, the position of the face used to apply the SRP composite with respect to the casting one shall be clearly identified in the report.

Surface preparation of the specimen face that will receive the SRP system shall be in accordance with the manufacturer's requirements of the SRP system being tested. Details of the surface preparation shall be recorded with the test data.

The distance d_f between the beginning of the bonded area and the top edge (at loaded end of the composite strip) of the concrete prism shall be 70 mm to avoid spalling of concrete. Bond breaking is easily accomplished using, for example, masking tape that covers the concrete surface from the top edge to the beginning of the bonded area.

Masonry

Test shall be performed on masonry made of bricks compliant with EN 771-1 (clay) or EN 771-6 (natural stone) (see Section 2.2.4 for details). Masonry shall be composed of layers of bricks so that the total length is at least 380 mm. In case of natural stone, the number of layers shall be comprised between 3 and 6. The thickness of the mortar shall be 10 mm. The width of the face where the reinforcement is applied shall be of at least 125 mm.

Surface preparation of the specimen face that will receive the SRP system shall be in accordance with the manufacturer's requirements of the SRP system being tested. Details of the surface preparation shall be recorded with the test data.

The distance d_f between the beginning of the bonded area and the top edge (at loaded end of the composite strip) of the masonry element shall be 20 mm. Bond breaking is easily accomplished using, for example, masking tape that covers the masonry surface from the top edge to the beginning of the bonded area.

SRP system

The SRP system applied to one face of the specimen shall meet the following requirements as shown in Figure 2 and Figure 3:

- The SRP system shall be applied in accordance with the manufacturer's recommended procedure. The manufacturer's instructions should be followed as to the elapsed time between SRP system application and testing.
- The width of the applied SRP system b_f shall be a multiple of the fabric grid spacing and shall be at least 50 mm. The SRP system shall be centered on the strengthened face of the substrate.
- The bonded length of the applied SRP system l should be equal to 300 mm. The SRP system shall be centered on the strengthened face of the substrate.
- The composite strip will be longer than the bonded length l. A support for the SRP strip, which overhangs from the substrate element (Figure 2) shall be provided in order to cast the composite with all the fibers parallel to the substrate surface. The total length L_f of the SRP composite shall be computed in accordance to Equation (1):

$$L_f = l + d_f + 300 \text{ mm} \quad (1)$$

The overhang length can be reduced if the testing machine does not allow to fit long SRP strips, but cannot be less than 150 mm.

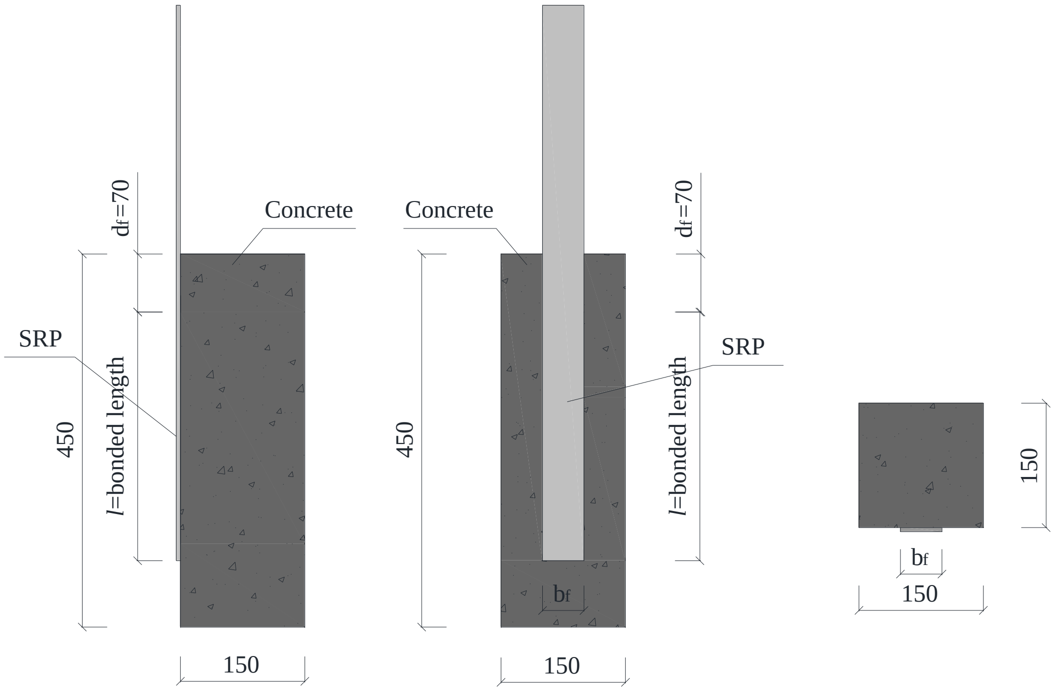


Figure 2: Specimen Dimensions and Details of Bonded SRP system (concrete specimens).

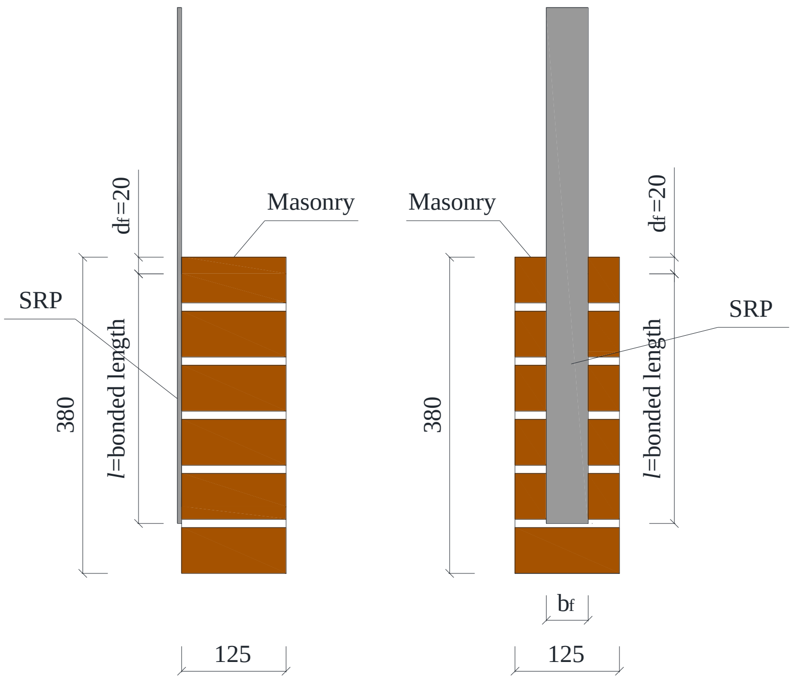


Figure 3: Specimen Dimensions and Details of Bonded SRP system (masonry specimens).

B4. Test Procedure

1. Center the specimen in order to have the composite strip perfectly aligned with the clamping wedge.
2. Apply an initial pre-compression to the support by tightening the bolts of the four steel bars used to connect the top and bottom plates. The total pre-compression force applied to the four steel bars shall be measured using a torque wrench. The total pre-compression shall be not greater than one fourth of the maximum applied load expected. In addition, the total force applied to the four steel bars divided by the cross-sectional area of the prism shall provide a stress that is lower or equal to one tenth of the compressive strength of substrate.

3. Clamp the loaded end of the composite strip within the wedges of the testing machine. Slowly adjust the position of the head of the machine so that no force is applied to the composite prior to testing when the composite strip is firmly clamped.
4. Pull the composite strip in displacement control, increasing the displacement of the machine stroke continuously and without shock. The displacement shall be increased at a constant rate equal to 0.3 mm/min.
5. Perform the test in stroke until the composite strip completely debonds from the concrete substrate.
6. The expected load response in terms of applied load versus global slip measured by LVDT a and b shall resemble the idealize response of Figure 4 if debonding occurs in a thin layer of the substrate, within the adhesive, or at the adhesive-fiber interface. The maximum force P_{max} corresponds to the maximum applied force, while the bond capacity P_{deb} corresponds to the nominally constant load observed after the maximum load drop and shall be computed as the average of the values of force in the interval of values of slip corresponding to the minimum load after the drop of the load corresponding to P_{max} and the end of the test.

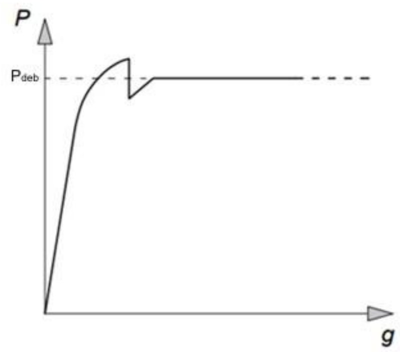


Figure 4: Example of load-displacement curve.

B5. Report

Report the following information to the maximum extent applicable:

Test Parameters

- Date of test, test temperature and relative humidity.
- Length of SRP system to the nearest 1 mm for each specimen.
- Width of SRP system to the nearest 1 mm for each specimen.
- Distance between the beginning of the bonded area and edge of substrate to the nearest 1 mm for each specimen.

Test Results —Provide results for each test and average and statistics for sample population.

- Maximum applied force P_{max} in N for each specimen.
- Maximum measured displacement in mm for each specimen.
- Global slip measurement corresponding to the maximum applied force— the average measurement obtained from LVDT a and b, named global slip, *g*, shall be calculated for each specimen.
- Out of plane displacement corresponding to the maximum applied force measurement— If LVDT c and d are used, the obtained values shall be reported for each specimen.
- The load-global slip response shall be reported.
- Failure mode for each specimen.
- Bond capacity P_{deb} and coefficient of variation
- Corrections made to data including test values omitted from calculated average and basis for omitting test values (such as failure mode). Note any other deviations from the procedure.

ANNEX C – PULL OUT TEST

C1. Test specimens

Concrete

The concrete test blocks shall be cast from concrete type MC (0,40) as specified in EN 1766. The dimensions of the concrete prism shall be 150 mm width × 150 mm depth × 300 mm length.

A hole of 20 mm diameter and 150 mm depth shall be drilled by a rotary percussive or diamond drill, as specified by the manufacturer, in the centre of the cast (150 x 150) mm face of the block.

Immediately after the drilling operation the hole shall be cleaned in accordance with manufacturer's instructions and the test block shall then be placed in its required orientation and the anchoring operation may be undertaken.

Masonry

Masonry bricks and mortar shall comply with the indications given in 2.2.4. A one brick wall with dimensions of about 250 mm width × 250 mm depth × 300 mm height shall be built.

A hole of 20 mm diameter and 150 mm depth shall be drilled in the middle of the mortar joint.

Immediately after the drilling operation the hole shall be cleaned in accordance with the manufacturer's instructions and the test block shall then be placed in its required orientation and the anchoring operation may be undertaken.

SRP system

Steel fabric coupons 100 mm large and 600 mm long and shall be cut from larger panels. One terminal edge of the fabric, through adequate operations indicated by the manufacturer, shall be rolled in order to obtain a single cylinder that will be used as a connector for the intended anchoring operation. The resin shall be prepared and placed, and the SRP system installed, strictly in accordance with the manufacturer's Instructions. The other end shall be left as plane fabric in order to apply the tensile force.

C2. Apparatus

The test set-up is in deviation from the one presented in EN 1881. The concrete or masonry elements shall be restrained against movement in order to allow the application of a tensile force to the free end of the SRP system, through an apparatus similar to the one used for tensile testing.

C3. Test procedure

Test procedure shall follow the general prescriptions of EN 1881, with the exception that a displacement rate of 1 mm/min shall be used until failure.