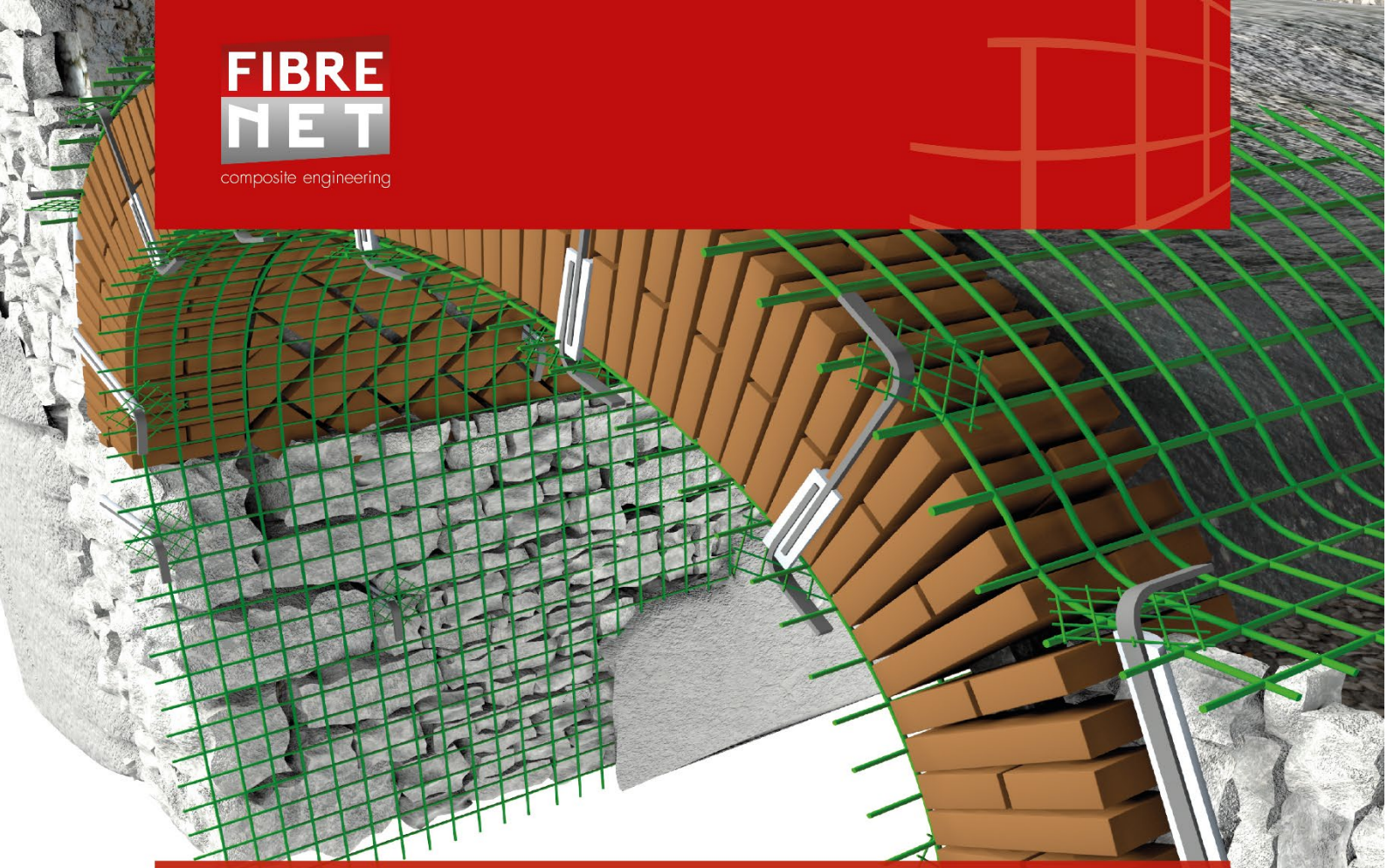
FIBRE NET
composite engineering



RI-STRUTTURA
VAULT REINFORCEMENT SYSTEM
TECHNICAL DATA SHEET

RI-STRUTTURA System (C.R.M.) is qualified with CE marking according to EAD 340392-00-0104 – CRM (Composite Reinforced Mortar) Systems for strengthening concrete and masonry structures.

RI-STRUTTURA is the reinforcement system by Fibre Net composed of preformed GFRP meshes, angles and connectors made by alcali-resistant glass fibers and thermosetting resins, combined with structural mortars, also NHL lime based. This system guarantees important, uniform and widespread structural improvement of the mechanical and ductility properties with a low increase in terms of stiffness of the GFRP elements. **RI-STRUTTURA** guarantees high durability thanks to the absence of corrosion. The system is reversible and improves the shear and flexural resistance of the structures.

CRM Accertamento di Equivalenza
n° 9946.17-12-2020

CE

RI-STRUTTURA
VAULT REINFORCEMENT SYSTEM

APPLICATION FIELD

Arches and vaults in stone or brick, whether structural or not, are among the architectural elements most subject to deterioration due to seismic events, structural failure or excessive loads. The occurrence of these deformation states leads to the formation of plastic hinges dangerous for the stability of the vault itself. The criticality of these artifacts, often significant from the historical and architectural point of view, makes it necessary to carry out structural consolidation interventions that are minimally invasive, compatible and respectful of the element specifics. The frequent presence of paintings or decorations on the intrados, moreover, constitutes a further critical element, as it makes the use of non-breathable materials inadvisable.

RI-STRUTTURA intervention on arches and vaults consists in the realization, on the extrados and possibly also on the intrados, of a thin mortar coating with a low elastic modulus, preferably lime-based, reinforced with a preformed GFRP mesh. The solidification of the hood to the arch or to the vault is then guaranteed by transversal GFRP L-shaped connectors. Thus allows to obtain a homogeneous and widespread structural improvement, with high mechanical and ductility characteristics and with a modest increase in the stiffness of the structure. **RI-STRUTTURA** System allows to increase the resistance of the wall both in gravitational and horizontal actions such as seismic and wind action. GFRP meshes and preformed components grant high durability and lonlasting effectiveness of the system, the reduction of heat bridges nearby the connection points. The thickness plaster application limits the increase of masses.

SYSTEMS COMPONENTS

FBMESH – GFRP MESH

GFRP mesh produced with Textrusion™ technology, provided with CE marking, whose bars are made of long glass fibers, impregnated with epoxy-vinylester thermosetting resin.

Characteristics	FBMESH__T96	FBMESH__T192
Mesh dimension	33x33 / 66x66 / 99x99 mm	66x66 / 99x99 mm
Minimum wire section	8,9 mm²	14,1 mm²
Roll size (external)	Ø 50÷70 x 200 cm	Ø 50÷70 x 200 cm
Tensile resistance (wire)(characteristic) value (2)	4,3 kN	5,5 kN
Young's modulus (2)	25000 MPa	25500 MPa
Resistance at the mesh joint (characteristic) value (2)	0,25 kN	0,43 kN
Wire failure strain (2)	1,45 %	1,50 %
Wire tensile strength (characteristic) value (2)	365 MPa	395 MPa
Reaction to fire (3)	A2-s1, d0, Class B-s1, d0 Class	B-s1, d0 Class

FBANG – GFRP CORNER REINFORCEMENT

Preformed GFRP (Glass Fiber Reinforced Polymer) angle elements provided with CE marking, manufactured with Textrusion™ technology. The bars are made of fiberglass impregnated with a thermosetting resin. Glass fibers and epoxy-vinylester thermosetting resin are worked and weaved orthogonally to obtain a monolithic square mesh.

Characteristics	FBANG__T96	FBANG__T192
Mesh dimension	33x33 / 66x66 / 99x99 mm	66x66 / 99x99 mm
Minimum wire section	8,9 mm²	14,1 mm²

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Element dimension	33 x 33 x 200 cm	33 x 33 x 200 cm
Angle ranges	90° ± 15°	90° ± 15°
Tensile resistance (wire) (characteristic) (2)	4,3 kN	5,5 kN
Young's modulus (2)	25000 MPa	25500 MPa
Resistance at the mesh joint (characteristic) (2)	0,25 kN	0,43 kN
Wire failure strain	1,45 %	1,50 %
Wire tensile strength (characteristic) (2)	365 MPa	395 MPa
Reaction to fire (3)	A2-s1, d0 Class B-s1, d0 Class	B-s1, d0 Class

FBCON_L – GFRP "L-SHAPED" CONNECTOR

GFRP "L-shaped" connector, for the connection of FBMESH to the masonry, provided with CE marking made of pre-stressed and impregnated glass fiber with epoxy-vinylester thermosetting resin.

Characteristics	FBCON_L
Connector dimensions	Long part: to 10 to 100 cm, short part 10 cm
Connector section	10.0 x 7.0 mm²
Cross sectional area	78.9 mm²
Connector tensile strength (characteristic)	380 MPa
Young's modulus (2)	26500 MPa

Properties	M.U.	Minimum value between the two directions		Test method Reference Regulation
		Average	Characteristic	
Connector extraction force (average value), F_{anc} on brick support	kN	17.0, 18.0, 21.3 (VINYL15) 17.5, 20.4, 22.5 (FB-RC30/3)		IT Qualification Guideline
Connector extraction force (average value), F_{anc} on tuff support	kN	4.9, 6.2, 6.8 (VINYL15) 8.0, 11.2, 12.5 (FB-RC30/3)		IT Qualification Guideline
Connector extraction force (average value), F_{anc} on stone support	kN	19.4, 22.0, 24.2 (VINYL15) 22.3, 24.0, 25.9 (FB-RC30/3)		IT Qualification Guideline
Crisis load of the junction for Overlap (average value), F_c	kN	14.0, 17.9, 22.5 (VINYL15) 21.1, 27.0, 36.6 (FB-RC30/3)		IT Qualification Guideline

Values with INTEGRA FIXA – VYNIL 15.

STRESS DISTRIBUTION ELEMENT - FB AREA MESH - FBFAZ33X33T96AR

GFRP mesh element provided with CE marking, produced with Textrusion™ technology, whose bars are made of long glass fibers, impregnated with epoxy-vinylester thermosetting resin.

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Characteristics	FBFAZ33X33T96AR
Mesh dimension	33x33 mm
Minimum wire section	8,9 mm^2
Element dimensions	150 x 150 mm
Tensile resistance (wire) (characteristic) value [2]	4,3 kN
Young's modulus [2]	25000 MPa
Resistance at the mesh joint (characterist) value [2]	0,25 kN
Wire failure strain [2]	1,45 %
Wire tensile strength (characteristic) value [2]	365 MPa
Reaction to fire [3]	B-s1, d0 Class

Steel connector - FBDPP

Element in stainless steel AISI 316, consisting of a nut M8 and a circular plate of diameter 38 mm and thickness 1.2 mm, glued to the vaulted surfaces in masonry by resin embedding.

Characteristics	FBDPP
Material	Acciaio INOX AISI 316
Circular plate diameter	38 mm
Circular plate thickness	1.2 mm
Nut threading	M8
Nut height	6.5 mm2
Maximum load	4.85 kN
Tension	5 MPa

PB-D_-G17/ PB-D_-G17AM Bars

GFRP (Glass Fiber Reinforced Polymer) smooth PB-DØ or improved adhesion PB-DØAM preformed bars.

Characteristics	PB-D_-G17	PB-D_-G17AM
Bar diameter (mm)	4 / 6 / 8 / 10 / 12 / 16 / 20 / 26	4 / 6 / 8 / 10 / 12 / 16 / 20 / 26
Bar section (mm^2)	13 / 28 / 50 / 79 / 113 / 201 / 314 / 531	13 / 28 / 50 / 79 / 113 / 201 /314 / 531
Weight	37 / 56 / 91 / 157 / 214 / 404 / 505 / 656	37 / 56 / 91 / 157 / 214 / 404 / 505 / 656
Bar finish	Smooth	Improved adhesion
Tensile strenght medium composite (MPa)	800	800
Tensile strenght characteristc composite (MPa)	560	560
Composite Young's modulus (GPa)	350	350

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INTEGRA FIXA - VINYL15 Resin

Two-component, vinylester, styrene-free chemical anchor in cartridges for heavy and structural loads, for fixing reinforcing bars and reinforcing irons on concrete, reinforced concrete, solid masonry, hollow bricks and wood substrates.

Characteristics	INTEGRA FIXA - VINYL15								
Design adhesion tensions according to EN 1992-1-1 [MPa]	C16/20	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
To Φ8 from Φ14	1.60	2.00	2.30	2.70	3.00	3.40	3,70	4.00	4.30
To Φ16 from Φ20	1.60	2.00	2.30	2.70	3.00	3.40	3,70	4.00	4.00
Φ25	1.60	2.00	2.30	2.70	3.00	3.40	3.40	3.40	3.40
Φ28	1.60	2.00	2.30	2.70	3.00	3.40	3.40	3.40	3.40
Φ32	1.60	2.00	2.30	2.70	2.70	2.70	2.70	2.70	2.70

FB-RC30/3 - FB-RC30/3-600 Resins

Two-component thixotropic epoxy resin supplied in cartridges or bins.

Characteristics	Betontex FB-RC30/3	Betontex FB-RC30/3-600
Tensile strenght (MPa)	60	60
Composite Young's modulus (MPa)	3000	3000
Stretch at break (%)	2,9	2,9
Compressive strength (MPa)	60	60
Shear strength (MPa)	> 12	> 12
Compressive shear strength (MPa)	at 50°C > 40 at 60°C > 50 at 70°C > 50	at 50°C > 40 at 60°C > 50 at 70°C > 50

Mortars based on NHL hydraulic lime and lime and hydraulic binders

Characteristics of EPOCA Mortars	RASO NHL RNHL 105	CALCE NHL 105	CALCE NHL 110	CALCE NHL 115	CALCE NHL THERMIC 800
Binder type	NHL hydraulic lime	NHL hydraulic lime	NHL hydraulic lime	NHL hydraulic lime	NHL hydraulic lime
Compression strenght –28 days (MPa)	-	≥ 5	≥ 10	≥ 15	≥ 8
Young's modulus (GPa)	-	≤ 7	≤ 8	≤ 10	≤ 5

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Characteristics of EPOCA Mortars	RASO NHL RNHL 105	CALCE NHL 105	CALCE NHL 110	CALCE NHL 115	CALCE NHL THERMIC 800
Class and typology	CS I	CS III - M5	CS IV – M10	CS IV – M15	CS III - M5
Bending strength - 28 days (MPa)	-	≥ 1	≥ 1,5	≥ 4	≥ 2
Adhesion to the brick support (MPa)	-	≥ 0,5	≥ 0,5	≥ 0,5	≥ 0,5
Adhesion to the concrete support (MPa)	-	≥ 0,5	≥ 1	≥ 1	≥ 1

Characteristics of MATERIA Mortars	RASO LEGO RL 103	RINFORZA RZ 205	RINFORZA RZ 210	RINFORZA RZ 215	RINFORZA RZ 220
Binder type	Lyme and hydraulic binders	Lyme and hydraulic binders	Lyme and hydraulic binders	Lyme and hydraulic binders	Lyme and hydraulic binders
Compression strength –28 days (MPa)	-	≥ 5	≥ 10	≥ 15	≥ 20
Young's modulus (GPa)	-	≥ 6	≤ 8	≤ 10	≤ 15
Class and typology	CS IV	CS III – GP – M5	CS IV - GP - M10	CS IV – GP - M15	CS IV – GP - M20
Bending strength - at 28 giorni (MPa)	-	≥ 1	≥ 1,5	≥ 1,5	≥ 4
Adhesion to the brick support (MPa)	-	≥ 0,2	≥ 0,5	≥ 0,5	≥ 0,5
Adhesion to the concrete support (MPa)	-	≥ 0,5	≥ 1	≥ 1	≥ 1

CHARACTERISTICS

- Excellent mechanical characteristics
- Lightness e low thickness
- High corrosion resistence
- Different mortars compatibility
- Non-magnetic, radiotransparent, dielectric

ADVANTAGES

- Durability
- Widespread and homogeneous mechanical improvement
- Masonry breathability
- Ease and speed of application, worksite safety
- Reversibility
- Reduction of costs and time for handling and installation
- Reduction in overall intervention costs
- Reduction of heat bridges at connection points

INSTALLATION PROCEDURE

RI-STRUTTURA System with GFRP FBCON_L connectors

1. Removal of the existing plaster and deteriorated parts and scarification of about 10±15 mm of the bedding joints to facilitate the adherence of the mortar, at the extrados and/or intrados depending on the intervention possibility.

2. Execution of 24 mm diameter holes for the passing FBCON_L connectors in the number foreseen by the design, to be made in compact areas of the masonry, preferably with dry rotating tools. It's ufficient a 14 - 18 mm diameter hole when only one connector is foreseen (non-passing holes or reinforcement on only one side of the vault);

3. Drilling of holes to make connections and strenghthen of reinforced coating using PB_-G17 or PB_-G17AM GFRP preformed bars in the number required by the project. Drilling shall be performed with dry rotary tools. Drill a hole equal to twice the diameter of the bar in case of solidification with lime grout injection. Drill a hole equal to the diameter of the bar increased of 5 mm in case of grouting with epoxy/vinylester resin.

4. Cleaning the holes and the vault with compressed air, washing and wetting the surface to saturation (where possible) and applying a first coat of rought coat;

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5. Installation of the FBMESH. The mesh is cut by means of shears and/or cutters or with an angle grinder. Overlap the mesh strips for about 15 cm in order to guarantee the mechanical continuity. Do not bend the mesh at a sharp angle in order to avoid possible breakage of the fibers.

6. Installation of FBANG angles at the edges between the masonry and the vault (where provided by design);

7. Insert FBCON_L connector of length equal to the thickness of the vault (or less in case of non passing connections). If necessary, cut off the excess part of the connector.

8. Optional installation of FBMESH on the other side of the vault;

9. Insertion in the hole of the second FBCON_L connector, creating an overlap of at least 10 - 15 cm, and injection of thixotropic vinylester-epoxy resin to solidify the two elements. Where applicable, apply FBFAZ;

10. Insertion of preformed PB_-G17 or PB_-G17AM GFRP bars in the connection holes by performing a slight rotation to allow a perfect distribution and adhesion of the binder around the bar.

11. Application of a new layer of mortar plaster with the characteristics of the project, with a minimum thickness of about 30 mm per side. In order to avoid cracks in the coating, the GFRP elements must be covered by at least 1 cm of mortar. The mesh must be positioned in the middle of the mortar thickness.

RI-STRUTTURA System with stainless steel connectors FBDPP

1. Removal of the existing plaster and deteriorated parts and scarification of about 10 - 15 mm of the bedding joints to promote the adherence of mortar, to the extrados and/or intrados depending on the possibility of intervention;

2. Drilling of holes to make connections and reinforcement of the reinforced coating using PB_-G17 or PB_-G17AM GFRP preformed bars in the number foreseen by the design. Drilling shall be performed with dry rotary tools. Drill a hole equal to twice the diameter of the bar in case of solidification with lime grout injection. Drill a hole equal to the diameter of the bar increased of 5 mm in case of grouting with epoxy/vinylester resin.

3. Cleaning of the connector application surface with iron brush and following complete cleaning of the vault with compressed air;

4. Punctual application of FB-RC30/3-600 or FB-RC30/3 thixotropic epoxy resin to the moisture-free surface to solidify the FBDPP stainless steel connector. The amount of resin needed to solidify a single connector is about 40g. Place FBDPP on the freshly applied resin by allowing the adhesive to flow out through the holes in the base of the connector. Wait about 24 hours for the polymerization of the resin;

5. Washing and wetting the surface to saturation (where possible) and applying a first layer of coating;

6. Installation of FBMESH on the affected side of the vault. The mesh cutting is made by means of shears and/or cutters or with an angle grinder. Overlap the mesh strips for about 15 cm in order to guarantee the mechanical continuity. Do not bend the mesh at a sharp angle in order to avoid possible breakage of the fibers;

7. Assembly of FBANG in correspondence of the corners between the masonry and the vault (where provided for in the project);

8. Insertion of the preformed PB_-G17 or PB_-G17AM GFRP bars in the connection holes by performing a slight rotation to allow a perfect distribution and adhesion of the binder around the bar;

9. Application of a new layer of coating with the design characteristics, with a minimum thickness of about 30 mm per side. In order to avoid cracks in the coating, the GFRP elements must be covered by at least 1 cm of mortar. The mesh must be positioned in the middle of the thickness.

SPECIFICATION ITEM

RI-STRUTTURA is qualified with CE marking according to EAD 340392-00-0104 – CRM (Composite Reinforced Mortar) Systems for strengthening concrete and masonry structures.

RI-STRUTTURA System allows for the reinforcement of structures of any kind using the CRM (Composite Reinforced Mortar) technique with the application of a G.F.R.P. (Glass Fiber Reinforced Polymer) preformed mesh in composite material, with a mesh size of mm, FBMESH, or equivalent, CE marked, consisting of glass fiber and vinylester-epoxy thermosetting resin. (Glass Fiber Reinforced Polymer), mesh _____ mm, FBMESH_____ of Fibre Net, or equivalent, consisting of glass fiber and vinylester-epoxy thermosetting resin, tensile strength characteristic of a single bar ≥ _____ kN, minimum section

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_____ mm² and having n° _____ bars/meter/side, equivalent tensile modulus N/mm² _____, elongation at break _____, equivalent tensile modulus E _____ N/mm², characteristic knot tensile strength ≥ _____ kN, with decay of tensile strength and elastic modulus for humid, alkaline and saline environments < 15%.
It also includes: the cleaning of the elements already scarified; the abundant washing of the surface; the execution of holes in number of _____/sqm and the supply and insertion of preformed "L" connectors in G.F.R.P. FBCON_L of Fibre Net, or equivalent, CE marked, consisting of glass fiber and vinylester-epoxy thermosetting resin, characteristic tensile strength ≥ 26.6 kN, equivalent tensile elastic modulus E _____ N/mm², having sections 10 x 7 mm and appropriate length according to the thickness of the vault, applied to the surface with an overlap of at least 10 cm and bonded by means of a styrene-free VINYL15 vinylester chemical anchor, complete with FBFAZ33X33T96AR stress distribution element(if provided for in the project). The execution of holes and the supply and insertion of preformed bars PB_-G17 or PB_-G17AM of Fibre Net, or equivalent, consisting of glass fiber and thermosetting resin of vinylester-epoxy type, characteristic tensile strength _____ kN, equivalent tensile elastic modulus E _____ N/mm², with diameter _____ mm and length equal to _____ and solidified with chemical anchor vinylester VINYL15, styrene-free, or lime grout to make connections and recovery of reinforced plaster counted in number of _____/sqm compared to the total area to be reinforced.
Including FBANG angles reinforcements in G.F.R.P. (Glass Fiber Reinforced Polymer) fiber-reinforced composite material (Glass Fiber Reinforced Polymer), CE marked, with mesh _____ mm, FBANG _____ of Fibre Net, or equivalent, consisting of glass fiber and thermosetting resin of vinylester-epoxy type, tensile strength characteristic single bar ≥ _____ kN, minimum section _____ mm² and having n° _____ bars/meter/side, equivalent tensile modulus _____ N/mm², elongation at break _____, characteristic knot tensile strength ≥ _____ kN, with decay of tensile strength and elastic modulus for humid, alkaline and saline environments < 15%, and counted at the rate of _____ % with respect to the total area to be reinforced.
Alternatively, for the connection system are included: the cleaning of the wall elements; the supply and gluing, with epoxy resin FB_____, of the stainless steel connection system FBDPP, consisting of threaded bushing and screw, in number of _____/m²;
Including the supply and application of EPOCA or MATERIA mortars, by Fibre Net or equivalent, premixed for structural applications with a minimum thickness of 30 mm, compressive strength _____ MPa, with trowel finish; modeled according to the shapes of the vault, recyclable materials in accordance with CSI protocols. Removal of existing plaster is to be provided separately. It also includes everything else needed to give the job finished, counted at actual size on the external wall.
Application on both faces or only one face of the waist and for thicknesses up to _____ cm.
It also includes the cost of turning up and fixing the network on the walls of the area, cuts, scraps and overlaps and whatever else is necessary to give the finished work (excluding emptying and cleaning of the vault).

Note 1: Where applicable.
Note 2: The values of mechanical properties refer to the minimum value in the direction of weft (transverse flat yarns) and warp(longitudinal twisted yarns).
Note 3: The reaction-to-fire rating is determined according to EN 13501-1:2007 + A1 2009. The minimum fire response according to this classification depends on the type of mesh:

Mesh	Fire reaction class
FBMESH33x33T96AR	B-s1, d0
FBMESH66x66T96AR	A2-s1, d0
FBMESH99x99T96AR	A2-s1, d0
FBMESH66x66T192AR	B-s1, d0
FBMESH99x99T192AR	B-s1, d0

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