APPLICATION OF COMPOSITE MATERIALS
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G.1.1 FLEXURAL STRENGTHENING OF FLOOR BEAMS AND JOISTS BY
APPLYING PULTRYD CARBON FIBRE PLATES
Procedure

Preparation of the substrate
Prepare all surfaces to be treated by completely removing all the deteriorated concrete with a hand or
power chisel (see section F.1.1.2) or with other suitable means, such as hydro-scarifying (see section
F.1.1.1), to obtain a solid, sufficiently rough substrate with no detached portions. If the deteriorated
congrete has been removed with a hand or power chisel, clean all exposed steel reinforcement with a
brush (see section F.1.1.2) or by hydro-sandblasting (see section F.1.1.3) to remove the rust and
bring the steel reinforcement back to a bare metal finish.
Hydro-sandblasting is not required if the surface has been prepared by hydro-scarifying, but you must
wait quite a long time after this operation before treating the steel reinforcement due to on-site
logistics requirements.

Protection of steel reinforcement
After removing all the rust, treat the steel reinforcement with two coats of Mapefer 1K
one-component, anti-corrosion cementitious mortar (see section F.2.1.1) or Mapefer
two-component, anti-corrosion cementitious mortar (see section F.2.1.2). The specific function of
both these products, made from cementitious binders, powdered polymers and corrosion inhibitors, is
to prevent the formation of rust.

Repair operations
Clean all surfaces to be repaired and saturate the substrate leaving a dry surface (s.s.d.) by
hydro-cleaning (see section F.1.1.4).
Repair the concrete using one of the following products:

- Mapegrout 430 one-component, normal-setting, shrinkage-compensating, class R3 thixotropic
  mortar for layers from 0.5 to 3.5 cm thick (see section F.3.2.1);
- Mapegrout T40 one-component, normal-setting, shrinkage-compensating, class R3 thixotropic
  mortar for layers from 1 to 3.5 cm thick (see section F.3.2.2).
These cementitious mortars are supplied in pre-blended powder form, and must be mixed with the
amount of water indicated in their relative Technical Data Sheet to form a well-blended, lump-free
mix.
When preparing the mortar, add Mapecur SRA (see section F.6.1.1), a special shrinkage-reducing
agent, at a dose of 0.25% by weight on the weight of the mortar.
Apply the mortar with a trowel or by spray within the application temperature range indicated in the
Technical Data Sheet.
If the area of concrete to be repaired is thicker than the values indicated, carry out this operation by
applying several layers of mortar and embedding electro-welded steel mesh in the mortar (see section
F.1.3.1). The dimensions of the mesh (diameter of steel wire and mesh pitch) must be according to
design specifications, and it is used to compensate for hygrometric shrinkage and to guarantee
sufficient contrast to the expansive action of the mortar.

Final protective layer
After applying the strengthening system, protect the surfaces using Planitop 200 one-component,
fine-grained, natural-finish cementitious mortar with high adhesion for smoothing and finishing the
surface of concrete and render, including old surfaces treated with quartz paint or scratch-effect
plastic coating as long as they are well-bonded and difficult to remove (see section F.9.1.5). As an
alternative, surfaces may be protected using Elastocolor Paint elastic acrylic coating (see section
F.12.3.1) or Elastocolor Rasante SF fibre-reinforced, elastomeric undercoat with good filling
properties, with added fine sand (see section F.12.3.3).
STRENGTHENING CONCRETE STRUCTURES

G.1.1.1 Application of high-strength pultruded carbon fibre plates with a low modulus of elasticity

Supply and application of high-strength, pultruded carbon fibre plates (≥ 3,100 MPa) with a low modulus of elasticity (170 GPa), elongation at failure equal to 2% and a minimum fibre content of 68% (such as Carboplate E170 produced by MAPEI S.p.A.), with a double protective plastic film (peel-ply) and pre-impregnated with epoxy resin.

Apply the plates using the following procedure:

- cut the Carboplate to the length required;
- remove the protective film (peel-ply) from the Carboplate;
- with a flat trowel, apply an even layer from 1.0 to 1.5 mm thick of two-component, thixotropic epoxy adhesive for structural bonds (such as MapeWrap 11 produced by MAPEI S.p.A.) on the Carboplate and on the substrate to which the plate is to be bonded.

The thixotropic epoxy adhesive must have the following performance characteristics:

- Tensile strength (ASTM C 579) (MPa): 30
- Compressive strength (ASTM C 579) (MPa): 70
- Compressive modulus of elasticity (ASTM C 579) (MPa): 8000
- Flexural modulus of elasticity (ISO 178) (MPa): 4000
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)

In the case of particularly porous and inconsistent substrates, treat surfaces with a specific two-component fluid primer (such as MapeWrap Primer 1 produced by MAPEI S.p.A) with the following performance characteristics:

- Density of mix (g/cm³): 1.1
- Brookfield viscosity (rotor 1 - 10 rpm) (mPa·s): 300
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)

Apply the Carboplate with a light, even pressure.

The product must have the following performance characteristics:

- Density (g/cm³): 1.61
- Fibre content (%): 68
- Thickness (mm): 1.4
- Width (mm): 50 100 150
- Resistant section (mm²): 70 140 210
- Weight (g/m): 113 225 338
- Tensile strength (MPa): > 3,100
- Elongation at failure (%): 2
- Shear strength (MPa): 77
The following are included and calculated in the price for work completed according to specification:

- vacuuming all surfaces;
- application of two-component epoxy **primer** as described above;
- application of thixotropic epoxy grout as described above (average thickness 1.5 mm).

10% waste of plates and adhesives.

- per linear metre of plate: width 50 mm ..........(€/m)
- per linear metre of plate: width 100 mm ..........(€/m)
- per linear metre of plate: width 150 mm ..........(€/m)
STRENGTHENING CONCRETE STRUCTURES

STRENGTHENING CONCRETE STRUCTURES BY APPLYING POLYMER MATRIX COMPOSITES (FRP)

G.1.1.2 Application of high-strength pultruded carbon fibre plates with a medium modulus of elasticity

Supply and application of high-strength, pultruded carbon fibre plates (≥ 3,100 MPa) with a medium modulus of elasticity (200 GPa), elongation at failure equal to 1.4% and a minimum fibre content of 68% (such as Carboplate E200 produced by MAPEI S.p.A.), with a double protective plastic film (peel-ply) and pre-impregnated with epoxy resin.

Apply the plates using the following procedure:

- cut the Carboplate to the length required;
- remove the protective film (peel-ply) from the Carboplate;
- with a flat trowel, apply an even layer from 1.0 to 1.5 mm thick of two-component, thixotropic epoxy adhesive (such as MapeWrap 11 produced by MAPEI S.p.A.) on the Carboplate and on the substrate to which the plate is to be bonded.

The thixotropic epoxy adhesive must have the following performance characteristics:

- Tensile strength (ASTM C 579) (MPa): 30
- Compressive strength (ASTM C 579) (MPa): 70
- Compressive modulus of elasticity (ASTM C 579) (MPa): 8000
- Flexural modulus of elasticity (ISO 178) (MPa): 4000
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)

In the case of particularly porous and inconsistent substrates, treat surfaces with a specific two-component fluid primer (such as MapeWrap Primer 1 produced by MAPEI S.p.A.) with the following performance characteristics:

- Density of mix (g/cm³): 1.1
- Brookfield viscosity (rotor 1-10 rpm) (mPa·s): 300
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)
- apply the Carboplate with a light, even pressure.

The product must have the following performance characteristics:

- Density (g/cm³): 1.61
- Fibre content (%): 68
- Thickness (mm): 1.4
- Width (mm): 50 100 150
- Resistant section (mm²): 70 140 210
- Weight (g/m): 113 225 338
- Tensile strength (MPa): ≥ 3,300
- Elongation at failure (%): 1.4
- Shear strength (MPa): 77
The following are included and calculated in the price for work completed according to specification:

- vacuuming all surfaces;
- application of two-component epoxy primer as described above;
- application of thixotropic epoxy grout as described above (average thickness 1.5 mm).
- 10% waste of plates and adhesives.

- per linear metre of plate: width 50 mm ............(€/m)
- per linear metre of plate: width 100 mm ............(€/m)
- per linear metre of plate: width 150 mm ............(€/m)
G.1 STRENGTHENING CONCRETE STRUCTURES

STRENGTHENING CONCRETE STRUCTURES BY APPLYING POLYMER MATRIX COMPOSITES (FRP)

G.1.1.3 Application of high-strength pultruded carbon fibre plates with a high modulus of elasticity

Supply and application of high-strength, pultruded carbon fibre plates (≥ 2,500 MPa) with a high modulus of elasticity (250 GPa), elongation at failure equal to 0.9% and a minimum fibre content of 65% (such as Carboplate E250 produced by MAPEI S.p.A.), with a double protective plastic film (peel-ply) and pre-impregnated with epoxy resin.

Apply the plates using the following procedure:

– cut the Carboplate to the length required;
– remove the protective film (peel-ply) from the Carboplate;
– with a flat trowel, apply an even layer from 1.0 to 1.5 mm thick of two-component, thixotropic epoxy adhesive for structural bonds (such as MapeWrap 11 produced by MAPEI S.p.A.) on the Carboplate and on the substrate to which the plate is to be bonded.

The thixotropic epoxy adhesive must have the following performance characteristics:

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile strength (ASTM C 579) (MPa)</td>
<td>≥ 2,500</td>
</tr>
<tr>
<td>Compressive strength (ASTM C 579) (MPa)</td>
<td>70</td>
</tr>
<tr>
<td>Compressive modulus of elasticity (ASTM C 579) (MPa)</td>
<td>8000</td>
</tr>
<tr>
<td>Flexural modulus of elasticity (ISO 178) (MPa)</td>
<td>4000</td>
</tr>
<tr>
<td>Adhesion to concrete (after 7 days at +23°C) (MPa)</td>
<td>&gt; 3 (failure of substrate)</td>
</tr>
</tbody>
</table>

In the case of particularly porous and inconsistent substrates, treat surfaces with a specific two-component fluid primer (such as MapeWrap Primer 1 produced by MAPEI S.p.A.) with the following performance characteristics:

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density of mix (g/cm³)</td>
<td>1.1</td>
</tr>
<tr>
<td>Brookfield viscosity (rotor 1-10 rpm) (mPa-s)</td>
<td>300</td>
</tr>
<tr>
<td>Adhesion to concrete (after 7 days at +23°C) (MPa)</td>
<td>&gt; 3 (failure of substrate)</td>
</tr>
</tbody>
</table>

– apply the Carboplate with a light, even pressure.

The product must have the following performance characteristics:

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density (g/cm³):</td>
<td>1.61</td>
</tr>
<tr>
<td>Fibre content (%):</td>
<td>65</td>
</tr>
<tr>
<td>Thickness (mm):</td>
<td>1.4</td>
</tr>
<tr>
<td>Width (mm):</td>
<td>50 – 150</td>
</tr>
<tr>
<td>Resistant section (mm²):</td>
<td>70 – 210</td>
</tr>
<tr>
<td>Weight (g/m):</td>
<td>113 – 338</td>
</tr>
<tr>
<td>Tensile strength (MPa):</td>
<td>≥ 2,500</td>
</tr>
<tr>
<td>Elongation at failure (%):</td>
<td>0.9</td>
</tr>
<tr>
<td>Shear strength (MPa):</td>
<td>77</td>
</tr>
</tbody>
</table>
The following are included and calculated in the price for work completed according to specification:

- vacuuming all surfaces;
- application of two-component epoxy primer as described above;
- application of thixotropic epoxy grout as described above (average thickness 1.5 mm).
- 10% waste of plates and adhesives.

- per linear metre of plate: width 50 mm ........................................ €/m
- per linear metre of plate: width 100 mm ........................................ €/m
- per linear metre of plate: width 150 mm ........................................ €/m
G.1 STRENGTHENING CONCRETE STRUCTURES
STRENGTHENING CONCRETE STRUCTURES BY APPLYING POLYMER MATRIX COMPOSITES (FRP)

G.1.2 FLEXURAL STRENGTHENING OF FLOOR BEAMS AND JOISTS BY APPLYING CARBON FIBRE FABRIC

Procedure

Preparation of the substrate
Prepare all surfaces to be treated by completely removing all the deteriorated concrete with a hand or power chisel (see section F.1.1.2) or with other suitable means, such as hydro-scarifying (see section F.1.1.1), to obtain a solid, sufficiently rough substrate with no detached portions. If the deteriorated concrete has been removed with a hand or power chisel, clean all exposed steel reinforcement with a brush (see section F.1.1.2) or by hydro-sandblasting (see section F.1.1.3) to remove the rust and bring the steel reinforcement back to a bare metal finish.

Hydro-sandblasting is not required if the surface has been prepared by hydro-scarifying, but you must wait quite a long time after this operation before treating the steel reinforcement due to on-site logistics requirements.

Protection of steel reinforcement
After removing all the rust, treat the steel reinforcement with two coats of Mapefer 1K one-component, anti-corrosion cementitious mortar (see section F.2.1.1) or Mapefer two-component, anti-corrosion cementitious mortar (see section F.2.1.2). The specific function of both these products, made from cementitious binders, powdered polymers and corrosion inhibitors, is to prevent the formation of rust.

Repair operations
Clean all surfaces to be repaired and saturate the substrate leaving a dry surface (s.s.d.) by hydro-cleaning (see section F.1.1.4).

Repair the concrete using one of the following products:

- Mapegrout 430 one-component, normal-setting, shrinkage-compensating, class R3 thixotropic mortar for layers from 0.5 to 3.5 cm thick (see section F.3.2.1);
- Mapegrout T40 one-component, normal-setting, shrinkage-compensating, class R3 thixotropic mortar for layers from 1 to 3.5 cm thick (see section F.3.2.2).

These cementitious mortars are supplied in pre-blended powder form, and must be mixed with the amount of water indicated in their respective Technical Data Sheet to form a well-blended, lump-free mix.

When preparing the mortar, add Mapecure SRA (see section F.6.1.1), a special shrinkage-reducing agent, at a dose of 0.25% by weight on the weight of the mortar.

Apply the mortar with a trowel or by spray within the application temperature range indicated in the Technical Data Sheet.

If the area of concrete to be repaired is thicker than the values indicated, carry out this operation by applying several layers of mortar and embedding electro-welded steel mesh in the mortar (see section F.1.3.1). The dimensions of the mesh (diameter of steel wire and mesh pitch) must be according to design specifications, and it is used to compensate for hygrometric shrinkage and to guarantee sufficient contrast to the expansive action of the mortar.

Final protective layer
After applying the strengthening system, protect the surfaces using Planitop 200 one-component, fine-grained, natural-finish cementitious mortar with high adhesion for smoothing and finishing the surface of concrete and render, including old surfaces treated with quartz paint or scratch-effect plastic coating as long as they are well-bonded and difficult to remove (see section F.9.1.5). As an alternative, surfaces may be protected using Elastocolor Paint elastic acrylic coating (see section F.12.3.1) or Elastocolor Rasante SF fibre-reinforced, elastomeric undercoat with good filling properties, with added fine sand (see section F.12.3.3).
G.1 STRENGTHENING CONCRETE STRUCTURES
STRENGTHENING CONCRETE STRUCTURES BY APPLYING POLYMER MATRIX COMPOSITES (FRP)

G.1.2.1 Application of high-strength, unidirectional carbon fibre fabric with a high modulus of elasticity

Supply and protected application of high-strength, unidirectional carbon fibre fabric (4,830 N/mm²) with a high modulus of elasticity (230,000 N/mm²) (such as MapeWrap C UNI-AX produced by MAPEI S.p.A.).

Apply the fabric with the “wet” or “dry” system technique using the following procedure:
- apply a coat of epoxy primer (such as MapeWrap Primer 1 produced by MAPEI S.p.A.);
- skim the substrate with epoxy grout (such as MapeWrap 11 produced by MAPEI S.p.A.);
- impregnate the fabric before application for the “wet” system (such as with MapeWrap 21 produced by MAPEI S.p.A.);
- as an alternative, impregnate the fabric after application for the “dry” system (such as with MapeWrap 31 produced by MAPEI S.p.A.).

The epoxy primer (such as MapeWrap Primer 1 produced by MAPEI S.p.A.) must have the following performance characteristics:
- Density of mix (g/cm³): 1.1
- Brookfield viscosity (rotor 1-10 rpm) (mPa-s): 300
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)

The thixotropic epoxy adhesive (such as MapeWrap 11 produced by MAPEI S.p.A.) must have the following performance characteristics:
- Tensile strength (ASTM C 579) (MPa): 30
- Compressive strength (ASTM C 579) (MPa): 70
- Compressive modulus of elasticity (ASTM C 579) (MPa): 8000
- Flexural modulus of elasticity (ISO 178) (MPa): 4000
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)

The adhesive used to impregnate the fabric for the “wet” system (such as MapeWrap 21 produced by MAPEI S.p.A.) must have the following performance characteristics:
- Brookfield viscosity (rotor 1-10 rpm) (mPa-s): 300
- Tensile strength (ASTM D 638) (MPa): 30
- Tensile elongation (ASTM D 638) (%): 1.2
- Compressive strength (ASTM C 579) (MPa): 65
- Flexural modulus of elasticity (ISO 178) (MPa): 2500
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)

The adhesive used to impregnate the fabric for the “dry” system (such as MapeWrap 31 produced by MAPEI S.p.A.) must have the following performance characteristics:
- Brookfield viscosity (rotor 3-5 rpm) (mPa-s): 7000
- Tensile strength (ASTM D 638) (MPa): 40
- Tensile elongation (ASTM D 638) (%): 1.8
- Compressive strength (ASTM C 579) (MPa): 60
- Compressive modulus of elasticity (ASTM C 579) (MPa): 1400
- Flexural modulus of elasticity (ISO 178) (MPa): 3000
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)

According to the type of operation to be carried out, there are various sizes of fabric available (10, 20 or 40 cm wide) with a weight of 300 or 600 g/m².
The carbon fibre fabric must have the following characteristics, respectively:

<table>
<thead>
<tr>
<th>Property</th>
<th>300</th>
<th>600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (g/m²)</td>
<td>300</td>
<td>600</td>
</tr>
<tr>
<td>Density (kg/m³)</td>
<td>1,800</td>
<td>1,800</td>
</tr>
<tr>
<td>Equivalent thickness of dry fabric (mm)</td>
<td>0.166</td>
<td>0.333</td>
</tr>
<tr>
<td>Resistant area per unit of width (mm²/m)</td>
<td>166.6</td>
<td>333.3</td>
</tr>
<tr>
<td>Tensile strength (N/mm²)</td>
<td>4.830</td>
<td>4.830</td>
</tr>
<tr>
<td>Maximum load per unit of width (kN/m)</td>
<td>&gt; 800</td>
<td>&gt; 1,600</td>
</tr>
<tr>
<td>Tensile modulus of elasticity (N/mm²)</td>
<td>230,000</td>
<td>230,000</td>
</tr>
<tr>
<td>Elongation at failure (%)</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Bond strength to concrete (N/mm²)</td>
<td>&gt; 3 (failure of substrate)</td>
<td>&gt; 3 (failure of substrate)</td>
</tr>
</tbody>
</table>

The following are included and calculated in the price for work completed according to specification:

- vacuuming all surfaces;
- application of fabric according to procedure described above;
- per square metre of fabric: weight 300 g/m² .................................. (€/m²)
- per square metre of fabric: weight 600 g/m² .................................. (€/m²)
G.1 STRENGTHENING CONCRETE STRUCTURES
STRENGTHENING CONCRETE STRUCTURES BY APPLYING POLYMER MATRIX COMPOSITES (FRP)

G.1.2.2 Application of high-strength, unidirectional carbon fibre fabric with a very high modulus of elasticity

Supply and protected application of high-strength, unidirectional carbon fibre fabric (4,410 N/mm²) with a very high modulus of elasticity (390,000 N/mm²) (such as MapeWrap C UNI-AX HM produced by MAPEI S.p.A.).

Apply the fabric with the “wet” or “dry” system technique using the following procedure:

- apply a coat of epoxy primer (such as MapeWrap Primer 1 produced by MAPEI S.p.A.);
- skim the substrate with epoxy grout (such as MapeWrap 11 produced by MAPEI S.p.A.);
- impregnate the fabric before application for the “wet” system (such as with MapeWrap 21 produced by MAPEI S.p.A.);
- as an alternative, impregnate the fabric after application for the “dry” system (such as with MapeWrap 31 produced by MAPEI S.p.A.).

The epoxy primer (such as MapeWrap Primer 1 produced by MAPEI S.p.A.) must have the following performance characteristics:

- Density of mix (g/cm³): 1.1
- Brookfield viscosity (rotor 1-10 rpm) (mPa·s): 300
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)

The thixotropic epoxy adhesive (such as MapeWrap 11 produced by MAPEI S.p.A.) must have the following performance characteristics:

- Tensile strength (ASTM C 579) (MPa): 30
- Compressive strength (ASTM C 579) (MPa): 70
- Compressive modulus of elasticity (ASTM C 579) (MPa): 8000
- Flexural modulus of elasticity (ISO 178) (MPa): 4000
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)

The adhesive used to impregnate the fabric for the “wet” system (such as MapeWrap 21 produced by MAPEI S.p.A.) must have the following performance characteristics:

- Brookfield viscosity (rotor 1-10 rpm) (mPa·s): 300
- Tensile strength (ASTM D 638) (MPa): 30
- Tensile elongation (ASTM D 638) (%): 1.2
- Compressive strength (ASTM C 579) (MPa): 65
- Flexural modulus of elasticity (ISO 178) (MPa): 2500
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)

The adhesive used to impregnate the fabric for the “dry” system (such as MapeWrap 31 produced by MAPEI S.p.A.) must have the following performance characteristics:

- Brookfield viscosity (rotor 3-5 rpm) (mPa·s): 7000
- Tensile strength (ASTM D 638) (MPa): 40
- Tensile elongation (ASTM D 638) (%): 1.8
- Compressive strength (ASTM C 579) (MPa): 60
- Compressive modulus of elasticity (ASTM C 579) (MPa): 1400
- Flexural modulus of elasticity (ISO 178) (MPa): 3000
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)

According to the type of operation to be carried out, there are various sizes of fabric available (10, 20 or 40 cm wide) with a weight of 300 or 600 g/m².
The carbon fibre fabric must have the following characteristics, respectively:

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>300</th>
<th>600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (g/m²)</td>
<td>300</td>
<td>600</td>
</tr>
<tr>
<td>Density (kg/m³)</td>
<td>1,820</td>
<td>1,820</td>
</tr>
<tr>
<td>Equivalent thickness of dry fabric (mm)</td>
<td>0.164</td>
<td>0.329</td>
</tr>
<tr>
<td>Resistant area per unit of width (mm²/m)</td>
<td>164.8</td>
<td>329.6</td>
</tr>
<tr>
<td>Tensile strength (N/mm²)</td>
<td>4,410</td>
<td>4,410</td>
</tr>
<tr>
<td>Maximum load per unit of width (kN/m)</td>
<td>&gt; 700</td>
<td>&gt; 1,400</td>
</tr>
<tr>
<td>Tensile modulus of elasticity (N/mm²)</td>
<td>390,000</td>
<td>390,000</td>
</tr>
<tr>
<td>Elongation at failure (%)</td>
<td>1.1</td>
<td>1.1</td>
</tr>
<tr>
<td>Bond strength to concrete (N/mm²)</td>
<td>&gt; 3</td>
<td>(failure of substrate)</td>
</tr>
</tbody>
</table>

The following are included and calculated in the price for work completed according to specification:

- vacuuming all surfaces;
- application of fabric according to procedure described above;

- per square metre of fabric: weight 300 g/m² ...........(€/m²)
- per square metre of fabric: weight 600 g/m² ...........(€/m²)
G.1 STRENGTHENING CONCRETE STRUCTURES

G.1.3 SHEAR STRENGTHENING OF CARBON FIBRE COMPOSITES

Procedure

Preparation of the substrate
Prepare all surfaces to be treated by completely removing all the deteriorated concrete with a hand or power chisel (see section F.1.1.2) or with other suitable means, such as hydro-scarifying (see section F.1.1.1), to obtain a solid, sufficiently rough substrate with no detached portions. If the deteriorated concrete has been removed with a hand or power chisel, clean all exposed steel reinforcement with a brush (see section F.1.1.2) or by hydro-sandblasting (see section F.1.1.3) to remove the rust and bring the steel reinforcement back to a bare metal finish.

Hydro-sandblasting is not required if the surface has been prepared by hydro-scarifying, but you must wait quite a long time after this operation before treating the steel reinforcement due to on-site logistics requirements.

Protection of steel reinforcement
After removing all the rust, treat the steel reinforcement with two coats of Mapefer 1K one-component, anti-corrosion cementitious mortar (see section F.2.1.1) or Mapefer two-component, anti-corrosion cementitious mortar (see section F.2.1.2). The specific function of both these products, made from cementitious binders, powdered polymers and corrosion inhibitors, is to prevent the formation of rust.

Repair operations
Clean all surfaces to be repaired and saturate the substrate leaving a dry surface (s.s.d.) by hydro-cleaning (see section F.1.1.4).

Repair the concrete using one of the following products:

- Mapegrout 430 one-component, normal-setting, shrinkage-compensating, class R3 thixotropic mortar for layers from 0.5 to 3.5 cm thick (see section F.3.2.1);
- Mapegrout T40 one-component, normal-setting, shrinkage-compensating, class R3 thixotropic mortar for layers from 1 to 3.5 cm thick (see section F.3.2.2).

These cementitious mortars are supplied in pre-blended powder form, and must be mixed with the amount of water indicated in their relative Technical Data Sheet to form a well-blended, lump-free mix.

When preparing the mortar, add Mapecure SRA (see section F.6.1.1), a special shrinkage-reducing agent, at a dose of 0.25% by weight on the weight of the mortar.

Apply the mortar with a trowel or by spray within the application temperature range indicated in the Technical Data Sheet.

If the area of concrete to be repaired is thicker than the values indicated, carry out this operation by applying several layers of mortar and embedding electro-welded steel mesh in the mortar (see section F.1.3.1). The dimensions of the mesh (diameter of steel wire and mesh pitch) must be according to design specifications, and it is used to compensate for hygrometric shrinkage and to guarantee sufficient contrast to the expansive action of the mortar.

Final protective layer
After applying the strengthening system, protect the surfaces using Planitop 200 one-component, fine-grained, natural-finish cementitious mortar with high adhesion for smoothing and finishing the surface of concrete and render, including old surfaces treated with quartz paint or scratch-effect plastic coating as long as they are well-bonded and difficult to remove (see section F.9.1.5). As an alternative, surfaces may be protected using Elastocolor Paint elastic acrylic coating (see section F.12.3.1) or Elastocolor Rasante SF fibre-reinforced, elastomeric undercoat with good filling properties, with added fine sand (see section F.12.3.3).
G.1 STRENGTHENING CONCRETE STRUCTURES
STRENGTHENING CONCRETE STRUCTURES BY APPLYING POLYMER MATRIX COMPOSITES (FRP)

G.1.3.1 Application of high-strength, unidirectional carbon fibre fabric with a high modulus of elasticity

Supply and protected application of high-strength, unidirectional carbon fibre fabric (4,830 N/mm²) with a high modulus of elasticity (230,000 N/mm²) (such as MapeWrap C UNI-AX produced by MAPEI S.p.A.).

Apply the fabric with the “wet” or “dry” system technique using the following procedure:

– apply a coat of epoxy primer to the substrate (such as MapeWrap Primer 1 produced by MAPEI S.p.A.);
– apply an epoxy grout (such as MapeWrap 11 produced by MAPEI S.p.A.) to the substrate;
– impregnate the fabric before application for the “wet” system (such as with MapeWrap 21 produced by MAPEI S.p.A.);
– as an alternative, impregnate the fabric after application for the “dry” system (such as with MapeWrap 31 produced by MAPEI S.p.A.);

The epoxy primer (such as MapeWrap Primer 1 produced by MAPEI S.p.A.) must have the following performance characteristics:

- Density of mix (g/cm³): 1.1
- Brookfield viscosity (rotor 1-10 rpm) (mPa·s): 300
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)

The thixotropic epoxy adhesive (such as MapeWrap 11 produced by MAPEI S.p.A.) must have the following performance characteristics:

- Tensile strength (ASTM C 579) (MPa): 30
- Compressive strength (ASTM C 579) (MPa): 70
- Compressive modulus of elasticity (ASTM C 579) (MPa): 8000
- Flexural modulus of elasticity (ISO 178) (MPa): 4000
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)

The adhesive used to impregnate the fabric for the “wet” system (such as MapeWrap 21 produced by MAPEI S.p.A.) must have the following performance characteristics:

- Brookfield viscosity (rotor 1-10 rpm) (mPa·s): 300
- Tensile strength (ASTM D 638) (MPa): 30
- Tensile elongation (ASTM D 638) (%): 1.2
- Compressive strength (ASTM C 579) (MPa): 65
- Flexural modulus of elasticity (ISO 178) (MPa): 2500
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)

The adhesive used to impregnate the fabric for the “dry” system (such as MapeWrap 31 produced by MAPEI S.p.A.) must have the following performance characteristics:

- Brookfield viscosity (rotor 3-5 rpm) (mPa·s): 7000
- Tensile strength (ASTM D 638) (MPa): 40
- Tensile elongation (ASTM D 638) (%): 1.8
- Compressive strength (ASTM C 579) (MPa): 60
- Compressive modulus of elasticity (ASTM C 579) (MPa): 1400
- Flexural modulus of elasticity (ISO 178) (MPa): 3000
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)
According to the type of operation to be carried out, there are various sizes of fabric available (10, 20 or 40 cm wide) with a weight of 300 or 600 g/m².

The carbon fibre fabric must have the following characteristics, respectively:

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>300</th>
<th>600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (g/m²)</td>
<td>300</td>
<td>600</td>
</tr>
<tr>
<td>Density (kg/m³)</td>
<td>1,800</td>
<td>1,800</td>
</tr>
<tr>
<td>Equivalent thickness of dry fabric (mm)</td>
<td>0.166</td>
<td>0.333</td>
</tr>
<tr>
<td>Resistant area per unit of width (mm²/m)</td>
<td>166.6</td>
<td>333.3</td>
</tr>
<tr>
<td>Tensile strength (N/mm²)</td>
<td>4,830</td>
<td>4,830</td>
</tr>
<tr>
<td>Maximum load per unit of width (kN/m)</td>
<td>&gt; 800</td>
<td>&gt; 1,600</td>
</tr>
<tr>
<td>Tensile modulus of elasticity (N/mm²)</td>
<td>230,000</td>
<td>230,000</td>
</tr>
<tr>
<td>Elongation at failure (%)</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Bond strength to concrete (N/mm²)</td>
<td>&gt; 3</td>
<td>(failure of substrate)</td>
</tr>
</tbody>
</table>

The following are included and calculated in the price for work completed according to specification:

- vacuuming all surfaces;
- application of fabric according to procedure described above;

- per square metre of fabric: weight 300 g/m² .................................. (€/m²)
- per square metre of fabric: weight 600 g/m² .................................. (€/m²)
G.1 STRENGTHENING CONCRETE STRUCTURES
STRENGTHENING CONCRETE STRUCTURES BY APPLYING POLYMER MATRIX COMPOSITES (FRP)

G.1.3.2 Application of high-strength, unidirectional carbon fibre fabric with a very high modulus of elasticity

Supply and protected application of high-strength, unidirectional carbon fibre fabric (4,410 N/mm²) with a very high modulus of elasticity (390,000 N/mm²) (such as MapeWrap C UNI-AX HM produced by MAPEI S.p.A.).

Apply the fabric with the “wet” or “dry” system technique using the following procedure:

- apply a coat of epoxy primer to the substrate (such as MapeWrap Primer 1 produced by MAPEI S.p.A.);
- trowel apply an epoxy grout (such as MapeWrap 11 produced by MAPEI S.p.A.) to the substrate;
- impregnate the fabric before application for the “wet” system (such as with MapeWrap 21 produced by MAPEI S.p.A.);
- as an alternative, impregnate the fabric after application for the “dry” system (such as with MapeWrap 31 produced by MAPEI S.p.A.).

The epoxy primer (such as MapeWrap Primer 1 produced by MAPEI S.p.A.) must have the following performance characteristics:

- Density of mix (g/cm³): 1.1
- Brookfield viscosity (rotor 1-10 rpm) (mPa·s): 300
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)

The thixotropic epoxy adhesive (such as MapeWrap 11 produced by MAPEI S.p.A.) must have the following performance characteristics:

- Tensile strength (ASTM C 579) (MPa): 30
- Compressive strength (ASTM C 579) (MPa): 70
- Compressive modulus of elasticity (ASTM C 579) (MPa): 8000
- Flexural modulus of elasticity (ISO 178) (MPa): 4000
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)

The adhesive used to impregnate the fabric for the “wet” system (such as MapeWrap 21 produced by MAPEI S.p.A.) must have the following performance characteristics:

- Brookfield viscosity (rotor 1-10 rpm) (mPa·s): 300
- Tensile strength (ASTM D 638) (MPa): 30
- Tensile elongation (ASTM D 638) (%): 1.2
- Compressive strength (ASTM C 579) (MPa): 65
- Flexural modulus of elasticity (ISO 178) (MPa): 2500
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)

The adhesive used to impregnate the fabric for the “dry” system (such as MapeWrap 31 produced by MAPEI S.p.A.) must have the following performance characteristics:

- Brookfield viscosity (rotor 3-5 rpm) (mPa·s): 7000
- Tensile strength (ASTM D 638) (MPa): 40
- Tensile elongation (ASTM D 638) (%): 1.8
- Compressive strength (ASTM C 579) (MPa): 60
- Compressive modulus of elasticity (ASTM C 579) (MPa): 1400
- Flexural modulus of elasticity (ISO 178) (MPa): 3000
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)
According to the type of operation to be carried out, there are various sizes of fabric available (10, 20 or 40 cm wide) with a weight of 300 or 600 g/m².

The carbon fibre fabric must have the following characteristics, respectively:

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>300</th>
<th>600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (g/m²)</td>
<td>300</td>
<td>600</td>
</tr>
<tr>
<td>Density (kg/m³)</td>
<td>1.820</td>
<td>1.820</td>
</tr>
<tr>
<td>Equivalent thickness of dry fabric (mm):</td>
<td>0.164</td>
<td>0.329</td>
</tr>
<tr>
<td>Resistant area per unit of width (mm²/m):</td>
<td>164.8</td>
<td>329.6</td>
</tr>
<tr>
<td>Tensile strength (N/mm²):</td>
<td>4,410</td>
<td>4,410</td>
</tr>
<tr>
<td>Maximum load per unit of width (kN/m):</td>
<td>&gt; 700</td>
<td>&gt; 1,400</td>
</tr>
<tr>
<td>Tensile modulus of elasticity (N/mm²):</td>
<td>390,000</td>
<td>390,000</td>
</tr>
<tr>
<td>Elongation at failure (%):</td>
<td>1.1</td>
<td>1.1</td>
</tr>
<tr>
<td>Bond strength to concrete (N/mm²):</td>
<td>&gt; 3 (failure of substrate)</td>
<td></td>
</tr>
</tbody>
</table>

The following are included and calculated in the price for work completed according to specification:

- vacuuming all surfaces;
- application of fabric according to procedure described above;
- per square metre of fabric: weight 300 g/m²                    (€/m²)
- per square metre of fabric: weight 600 g/m²                    (€/m²)
G.1 STRENGTHENING CONCRETE STRUCTURES

STRENGTHENING CONCRETE STRUCTURES BY APPLYING POLYMER MATRIX COMPOSITES (FRP)

G.1.3.3 Application of high-strength, bi-directional carbon fibre fabric with a high modulus of elasticity

Supply and protected application of high-strength, bi-directional carbon fibre fabric (4,830 N/mm²) with a high modulus of elasticity (230,000 N/mm²) (such as MapeWrap C BI-AX produced by MAPEI S.p.A.).

Apply the fabric with the “dry” system technique using the following procedure:
- apply a coat of epoxy primer to the substrate (such as MapeWrap Primer 1 produced by MAPEI S.p.A.);
- trowel apply an epoxy grout (such as MapeWrap 11 produced by MAPEI S.p.A.) to the substrate;
- impregnate the fabric after application for the “dry” system technique (such as with MapeWrap 31 produced by MAPEI S.p.A.);

The epoxy primer (such as MapeWrap Primer 1 produced by MAPEI S.p.A.) must have the following performance characteristics:

- Density of mix (g/cm³): 1.1
- Brookfield viscosity (rotor 1-10 rpm) (mPa·s): 300
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)

The thixotropic epoxy adhesive (such as MapeWrap 11 produced by MAPEI S.p.A.) must have the following performance characteristics:

- Tensile strength (ASTM C 579) (MPa): 30
- Compressive strength (ASTM C 579) (MPa): 70
- Compressive modulus of elasticity (ASTM C 579) (MPa): 8000
- Flexural modulus of elasticity (ISO 178) (MPa): 4000
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)

The adhesive used to impregnate the fabric for the “dry” system (such as MapeWrap 31 produced by MAPEI S.p.A.) must have the following performance characteristics:

- Brookfield viscosity (rotor 3-5 rpm) (mPa·s): 7000
- Tensile strength (ASTM D 638) (MPa): 40
- Tensile elongation (ASTM D 638) (%): 1.8
- Compressive strength (ASTM C 579) (MPa): 60
- Compressive modulus of elasticity (ASTM C 579) (MPa): 1400
- Flexural modulus of elasticity (ISO 178) (MPa): 3000
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)

According to the type of operation to be carried out, there are various sizes of fabric available (20 or 40 cm wide) with a weight of 230 or 360 g/m².
The carbon fibre fabric must have the following characteristics, respectively:

<table>
<thead>
<tr>
<th>Property</th>
<th>230</th>
<th>360</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (g/m²)</td>
<td>230</td>
<td>360</td>
</tr>
<tr>
<td>Density (kg/m³)</td>
<td>1,810</td>
<td>1,810</td>
</tr>
<tr>
<td>Equivalent thickness of dry fabric (mm):</td>
<td>0.064</td>
<td>0.10</td>
</tr>
<tr>
<td>Resistant area per unit of width (mm²/m):</td>
<td>64.2</td>
<td>105</td>
</tr>
<tr>
<td>Tensile strength (N/mm²):</td>
<td>4,830</td>
<td>4,830</td>
</tr>
<tr>
<td>Maximum load per unit of width (kN/m):</td>
<td>&gt; 305</td>
<td>&gt; 500</td>
</tr>
<tr>
<td>Tensile modulus of elasticity (N/mm²):</td>
<td>230,000</td>
<td>230,000</td>
</tr>
<tr>
<td>Elongation at failure (%)</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Bond strength to concrete (N/mm²):</td>
<td>&gt; 3</td>
<td>failure of substrate</td>
</tr>
</tbody>
</table>

The following are included and calculated in the price for work completed according to specification:
- vacuuming all surfaces;
- application of fabric according to procedure described above;

- per square metre of fabric: weight 230 g/m² ..........(€/m²)
- per square metre of fabric: weight 360 g/m² ..........(€/m²)
G.1 STRENGTHENING CONCRETE STRUCTURES
STRENGTHENING CONCRETE STRUCTURES BY APPLYING POLYMER MATRIX COMPOSITES (FRP)

G.1.3.4 Application of high-strength, quadraxial carbon fibre fabric with a high modulus of elasticity

Supply and protected application of high-strength, quadraxial carbon fibre fabric (4,830 N/mm²) with a high modulus of elasticity (230,000 N/mm²) (such as MapeWrap C Quadri-AX produced by MAPEI S.p.A.).

Apply the fabric with the “dry” system technique using the following procedure:

– apply a coat of epoxy primer to the substrate (such as MapeWrap Primer 1 produced by MAPEI S.p.A.);
– trowel apply an epoxy grout (such as MapeWrap 11 produced by MAPEI S.p.A.) to the substrate;
– impregnate the fabric after application for the “dry” system technique (such as with MapeWrap 31 produced by MAPEI S.p.A.);

The epoxy primer (such as MapeWrap Primer 1 produced by MAPEI S.p.A.) must have the following performance characteristics:

<table>
<thead>
<tr>
<th>Performance Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density of mix (g/cm³)</td>
<td>1.1</td>
</tr>
<tr>
<td>Brookfield viscosity (rpm)</td>
<td>300</td>
</tr>
<tr>
<td>Adhesion to concrete</td>
<td>&gt; 3 (failure of substrate)</td>
</tr>
</tbody>
</table>

The thixotropic epoxy adhesive (such as MapeWrap 11 produced by MAPEI S.p.A.) must have the following performance characteristics:

<table>
<thead>
<tr>
<th>Performance Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile strength (ASTM C 579)</td>
<td>30</td>
</tr>
<tr>
<td>Compressive strength (ASTM C 579)</td>
<td>70</td>
</tr>
<tr>
<td>Compressive modulus of elasticity (ASTM C 579)</td>
<td>8000</td>
</tr>
<tr>
<td>Flexural modulus of elasticity (ISO 178)</td>
<td>4000</td>
</tr>
<tr>
<td>Adhesion to concrete</td>
<td>&gt; 3 (failure of substrate)</td>
</tr>
</tbody>
</table>

The adhesive used to impregnate the fabric for the “dry” system (such as MapeWrap 31 produced by MAPEI S.p.A.) must have the following performance characteristics:

<table>
<thead>
<tr>
<th>Performance Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brookfield viscosity (rpm)</td>
<td>7000</td>
</tr>
<tr>
<td>Tensile strength (ASTM D 638)</td>
<td>40</td>
</tr>
<tr>
<td>Tensile elongation (ASTM D 638) (%)</td>
<td>1.8</td>
</tr>
<tr>
<td>Compressive strength (ASTM C 579)</td>
<td>60</td>
</tr>
<tr>
<td>Compressive modulus of elasticity (ASTM C 579)</td>
<td>1400</td>
</tr>
<tr>
<td>Flexural modulus of elasticity (ISO 178)</td>
<td>3000</td>
</tr>
<tr>
<td>Adhesion to concrete</td>
<td>&gt; 3 (failure of substrate)</td>
</tr>
</tbody>
</table>

According to the type of operation to be carried out, there are various sizes of fabric available (30 or 48 cm wide) with a weight of 380 or 760 g/m².
The carbon fibre fabric must have the following characteristics, respectively:

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>380</th>
<th>760</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (g/m²):</td>
<td>380</td>
<td>760</td>
</tr>
<tr>
<td>Density (kg/m³):</td>
<td>1,810</td>
<td>1,810</td>
</tr>
<tr>
<td>Equivalent thickness of dry fabric (mm):</td>
<td>0.053</td>
<td>0.106</td>
</tr>
<tr>
<td>Resistant area per unit of width (mm²/m):</td>
<td>53.1</td>
<td>106.1</td>
</tr>
<tr>
<td>Tensile strength (N/mm²):</td>
<td>4,830</td>
<td>4,830</td>
</tr>
<tr>
<td>Maximum load per unit of width (kN/m):</td>
<td>&gt; 254</td>
<td>&gt; 500</td>
</tr>
<tr>
<td>Tensile modulus of elasticity (N/mm²):</td>
<td>230,000</td>
<td>230,000</td>
</tr>
<tr>
<td>Elongation at failure (%):</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Bond strength to concrete (N/mm²):</td>
<td>&gt; 3 (failure of substrate)</td>
<td></td>
</tr>
</tbody>
</table>

The following are included and calculated in the price for work completed according to specification:
- vacuuming all surfaces;
- application of fabric according to procedure described above;
- per square metre of fabric: weight 380 g/m² ………..(€/m²)
- per square metre of fabric: weight 760 g/m² ………..(€/m²)
G.1 STRENGTHENING CONCRETE STRUCTURES
STRENGTHENING CONCRETE STRUCTURES BY APPLYING POLYMER MATRIX COMPOSITES (FRP)

G.1.3.5 Application of high-strength steel fibre fabric

Supply and protected application of high-strength steel fibre fabric (2,845 N/mm²) (such as MapeWrap S Fabric produced by MAPEI S.p.A.).

Apply the fabric with the “dry” system technique using the following procedure:

- apply a coat of epoxy primer (such as MapeWrap Primer 1 produced by MAPEI S.p.A.);
- skim the substrate with epoxy grout (such as MapeWrap 11 produced by MAPEI S.p.A.);
- apply the high-strength steel fibre fabric (such as MapeWrap S Fabric produced by MAPEI S.p.A.);
- apply another layer of epoxy grout (such as MapeWrap 11 produced by MAPEI S.p.A.) so it covers the strengthening fabric evenly.

The epoxy primer (such as MapeWrap Primer 1 produced by MAPEI S.p.A.) must have the following performance characteristics:

- Density of mix (g/cm³): 1.1
- Brookfield viscosity (rotor 1-10 rpm) (mPa·s): 300
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)

The thixotropic epoxy adhesive (such as MapeWrap 11 produced by MAPEI S.p.A.) must have the following performance characteristics:

- Tensile strength (ASTM C 579) (MPa): 30
- Compressive strength (ASTM C 579) (MPa): 70
- Compressive modulus of elasticity (ASTM C 579) (MPa): 8000
- Flexural modulus of elasticity (ISO 178) (MPa): 4000
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)

The steel fibre fabric must have the following characteristics:

- Weight (g/m²): 2,100
- Average failure load per thread (N): 3,600
- Resistant area per unit of width (mm²/m): 373.8
- Tensile strength (N/mm²): > 2,845
- Maximum load per unit of width (kN/m): 735
- Tensile modulus of elasticity (N/mm²): 210,000
- Elongation at failure (%): 2.6
- Bond strength to concrete (N/mm²): > 2.4 (failure of substrate)
- Tensile strength of impregnated fabric (N/mm²): > 1,900
- Tensile modulus of elasticity of impregnated fabric (N/mm²): > 190,000
- Elongation at failure of impregnated fabric (%): > 1
The following are included and calculated in the price for work completed according to specification:
- vacuuming all surfaces;
- application of fabric according to procedure described above;
- per linear metre of fabric applied ........ (€/m)
G.1 STRENGTHENING CONCRETE STRUCTURES
STRENGTHENING CONCRETE STRUCTURES BY APPLYING POLYMER MATRIX COMPOSITES (FRP)

G.1.3.6 Application of high-strength steel fibre cord

Supply and application of high-strength steel fibre cord (2,845 N/mm²) (such as MapeWrap S Fiocco produced by MAPEI S.p.A.).

Apply the cord using the following procedure:
- make holes in the substrate with a suitable diameter and depth;
- apply a coat of epoxy primer (such as MapeWrap Primer 1 produced by MAPEI S.p.A.) inside the holes with a bottlebrush;
- fill the holes with epoxy grout (such as MapeWrap 11 produced by MAPEI S.p.A.) in the holes;
- splay out the fibres at the other end of the cord and cover them with an even layer of epoxy grout (such as MapeWrap 11 produced by MAPEI S.p.A.).

The epoxy primer (such as MapeWrap Primer 1 produced by MAPEI S.p.A.) must have the following performance characteristics:

- Density of mix (g/cm³): 1.1
- Brookfield viscosity (rotor 1-10 rpm) (mPa·s): 300
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)

The thixotropic epoxy adhesive (such as MapeWrap 11 produced by MAPEI S.p.A.) must have the following performance characteristics:

- Tensile strength (ASTM C 579) (MPa): 30
- Compressive strength (ASTM C 579) (MPa): 70
- Compressive modulus of elasticity (ASTM C 579) (MPa): 8000
- Flexural modulus of elasticity (ISO 178) (MPa): 4000
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)

The steel fibre cord is available in two diameters (10 and 12 mm) and must have the following characteristics, respectively:

- Linear density (g/m): 4.84
- Tensile strength (N/mm²): 2,086
- Tensile modulus of elasticity (N/mm²): 210,000
- Elongation at failure (%): > 2.0
- Thickness (mm): 4.30 (Ø 10 mm) 5.20 (Ø 12 mm)
- Resistant area per unit of width (mm²/m): 4,300 5,200
- Maximum load per unit of width (kN/m): 8,969.8 10,847.2
The following are included and calculated in the price for work completed according to specification:
– vacuuming all surfaces;
– application of cord according to procedure described above;
– per metre of cord applied: diameter 10 mm ................(€/m)
– per metre of cord applied: diameter 12 mm ................(€/m)
G.1 STRENGTHENING CONCRETE STRUCTURES
STRENGTHENING CONCRETE STRUCTURES BY APPLYING POLYMER MATRIX COMPOSITES (FRP)

G.1.4 CONFINEMENT OF COLUMNS - INCREASING COMPRESSION STRENGTH AND DUCTILITY BY APPLYING CARBON FIBRE COMPOSITES

Procedure

Preparation of the substrate
Prepare all surfaces to be treated by completely removing all the deteriorated concrete with a hand or power chisel (see section F.1.1.2) or with other suitable means, such as hydro-scarifying (see section F.1.1.1), to obtain a solid, sufficiently rough substrate with no detached portions. If the deteriorated concrete has been removed with a hand or power chisel, clean all exposed steel reinforcement with a brush (see section F.1.1.2) or by hydro-sandblasting (see section F.1.1.3) to remove the rust and bring the steel reinforcement back to a bare metal finish.

Hydro-sandblasting is not required if the surface has been prepared by hydro-scarifying, but you must wait quite a long time after this operation before treating the steel reinforcement due to on-site logistics requirements.

Protection of steel reinforcement
After removing all the rust, treat the steel reinforcement with two coats of Mapefer 1K one-component, anti-corrosion cementitious mortar (see section F.2.1.1) or Mapefer two-component, anti-corrosion cementitious mortar (see section F.2.1.2). The specific function of both these products, made from cementitious binders, powdered polymers and corrosion inhibitors, is to prevent the formation of rust.

Repair operations
Clean all surfaces to be repaired and saturate the substrate leaving a dry surface (s.s.d.) by hydro-cleaning (see section F.1.1.4).

Repair the concrete using one of the following products:

- Mapegrout 430 one-component, normal-setting, shrinkage-compensating, class R3 thixotropic mortar for layers from 0.5 to 3.5 cm thick (see section F.3.2.1);
- Mapegrout T60 one-component, normal-setting, shrinkage-compensating, class R4 thixotropic mortar for layers from 1 to 3.5 cm thick (see section F.4.1.2).

These cementitious mortars are supplied in pre-blended powder form, and must be mixed with the amount of water indicated in their relative Technical Data Sheet to form a well-blended, lump-free mix.

When preparing the mortar, add Mapecure SRA (see section F.6.1.1), a special shrinkage-reducing agent, at a dose of 0.25% in weight on the weight of the mortar.

Apply the mortar with a trowel or by spray within the application temperature range indicated in the Technical Data Sheet.

If the area of concrete to be repaired is thicker than the values indicated, carry out this operation by applying several layers of mortar and embedding electro-welded steel mesh in the mortar (see section F.1.3.1). The dimensions of the mesh (diameter of steel wire and mesh pitch) must be according to design specifications, and it is used to compensate for hygroscopic shrinkage and to guarantee sufficient contrast to the expansive action of the mortar.

Smooth all corners to form a rounded edge with a radius of at least 20 mm.

Final protective layer
After applying the strengthening system, protect the surfaces using Planitop 200 one-component, fine-grained, natural-finish cementitious mortar with high adhesion for smoothing and finishing the surface of concrete and render, including old surfaces treated with quartz paint or scratch-effect plastic coating as long as they are well-bonded and difficult to remove (see section F.9.1.5). As an alternative, surfaces may be protected using Elastocolor Paint elastic acrylic coating (see section F.12.3.1) or Elastocolor Rasante SF fibre-reinforced, elastomeric undercoat with good filling properties, with added fine sand (see section F.12.3.3).
G.1 STRENGTHENING CONCRETE STRUCTURES
STRENGTHENING CONCRETE STRUCTURES BY APPLYING POLYMER MATRIX COMPOSITES (FRP)

G.1.4.1 Application of high-strength, unidirectional carbon fibre fabric with a high modulus of elasticity

Supply and protected application of high-strength, unidirectional carbon fibre fabric (4,830 N/mm²) with a high modulus of elasticity (230,000 N/mm²) (such as MapeWrap C UNI-AX produced by MAPEI S.p.A.).

Apply the fabric with the “wet” or “dry” system technique using the following procedure:

- apply a coat of epoxy primer to the substrate (such as MapeWrap Primer 1 produced by MAPEI S.p.A.);
- trowel apply an epoxy grout (such as MapeWrap 11 produced by MAPEI S.p.A.) to the substrate;
- impregnate the fabric before application for the “wet” system (such as with MapeWrap 21 produced by MAPEI S.p.A.);
- as an alternative, impregnate the fabric after application for the “dry” system (such as with MapeWrap 31 produced by MAPEI S.p.A.).

N.B. the ends of each layer of fabric used for confining purposes must overlap by at least 20 cm.

The epoxy primer (such as MapeWrap Primer 1 produced by MAPEI S.p.A.) must have the following performance characteristics:

- Density of mix (g/cm³): 1.1
- Brookfield viscosity (rotor 1-10 rpm) (mPa·s): 300
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)

The thixotropic epoxy adhesive (such as MapeWrap 11 produced by MAPEI S.p.A.) must have the following performance characteristics:

- Tensile strength (ASTM C 579) (MPa): 30
- Compressive strength (ASTM C 579) (MPa): 70
- Compressive modulus of elasticity (ASTM C 579) (MPa): 8000
- Flexural modulus of elasticity (ISO 178) (MPa): 4000
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)

The adhesive used to impregnate the fabric for the “wet” system (such as MapeWrap 21 produced by MAPEI S.p.A.) must have the following performance characteristics:

- Brookfield viscosity (rotor 1-10 rpm) (mPa·s): 300
- Tensile strength (ASTM D 638) (MPa): 30
- Tensile elongation (ASTM D 638) (%): 1.2
- Compressive strength (ASTM C 579) (MPa): 65
- Flexural modulus of elasticity (ISO 178) (MPa): 2500
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)

The adhesive used to impregnate the fabric for the “dry” system (such as MapeWrap 31 produced by MAPEI S.p.A.) must have the following performance characteristics:

- Brookfield viscosity (rotor 3-5 rpm) (mPa·s): 7000
- Tensile strength (ASTM D 638) (MPa): 40
- Tensile elongation (ASTM D 638) (%): 1.8
- Compressive strength (ASTM C 579) (MPa): 60
- Compressive modulus of elasticity (ASTM C 579) (MPa): 1400
- Flexural modulus of elasticity (ISO 178) (MPa): 3000
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)
According to the type of operation to be carried out, there are various sizes of fabric available (10, 20 or 40 cm wide) with a weight of 300 or 600 g/m².

The carbon fibre fabric must have the following characteristics, respectively:

- **Weight (g/m²):** 300 600
- **Density (kg/m³):** 1,800 1,800
- **Equivalent thickness of dry fabric (mm):** 0.166 0.333
- **Resistant area per unit of width (mm²/m):** 166.6 333.3
- **Tensile strength (N/mm²):** 4,830 4,830
- **Maximum load per unit of width (kN/m):** > 800 > 1,600
- **Tensile modulus of elasticity (N/mm²):** 230,000 230,000
- **Elongation at failure (%):** 2 2
- **Bond strength to concrete (N/mm²):** > 3 (failure of substrate)

The following are included and calculated in the price for work completed according to specification:

- vacuuming all surfaces;
- application of fabric according to procedure described above;

  - per square metre of fabric: weight 300 g/m²  
  ........(€/m²)
  - per square metre of fabric: weight 600 g/m²  
  ........(€/m²)
G.1 STRENGTHENING CONCRETE STRUCTURES
STRENGTHENING CONCRETE STRUCTURES BY APPLYING POLYMER MATRIX
COMPOSITES (FRP)

G.1.4.2 Application of high-strength, unidirectional carbon fibre fabric with a
very high modulus of elasticity

Supply and protected application of high-strength, unidirectional carbon fibre fabric (4,410 N/mm²)
with a very high modulus of elasticity (390,000 N/mm²) (such as MapeWrap C UNI-AX HM produced
by MAPEI S.p.A.).

Apply the fabric with the “wet” or “dry” system technique using the following procedure:

- apply a coat of epoxy primer (such as MapeWrap Primer 1 produced by MAPEI S.p.A.);
- skim the substrate with epoxy grout (such as MapeWrap 11 produced by MAPEI S.p.A.);
- impregnate the fabric before application for the “wet” system (such as with MapeWrap 21
produced by MAPEI S.p.A.);
- as an alternative, impregnate the fabric after application for the “dry” system (such as with
MapeWrap 31 produced by MAPEI S.p.A.).

N.B. the ends of each layer of fabric used for confining purposes must overlap by at least 20 cm.
The epoxy primer (such as MapeWrap Primer 1 produced by MAPEI S.p.A.) must have the following
performance characteristics:

Density of mix (g/cm³): 1.1
Brookfield viscosity (rotor 1-10 rpm) (mPa-s): 300
Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)

The thixotropic epoxy adhesive (such as MapeWrap 11 produced by MAPEI S.p.A.) must have the
following performance characteristics:

Tensile strength (ASTM C 579) (MPa): 30
Compressive strength (ASTM C 579) (MPa): 70
Compressive modulus of elasticity (ASTM C 579) (MPa): 8000
Flexural modulus of elasticity (ISO 178) (MPa): 4000
Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)

The adhesive used to impregnate the fabric for the “wet” system (such as MapeWrap 21 produced
by MAPEI S.p.A.) must have the following performance characteristics:

Brookfield viscosity (rotor 1-10 rpm) (mPa-s): 300
Tensile strength (ASTM D 638) (MPa): 30
Tensile elongation (ASTM D 638) (%): 1.2
Compressive strength (ASTM C 579) (MPa): 65
Flexural modulus of elasticity (ISO 178) (MPa): 2500
Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)

The adhesive used to impregnate the fabric for the “dry” system (such as MapeWrap 31 produced
by MAPEI S.p.A.) must have the following performance characteristics:

Brookfield viscosity (rotor 3-5 rpm) (mPa-s): 7000
Tensile strength (ASTM D 638) (MPa): 40
Tensile elongation (ASTM D 638) (%): 1.8
Compressive strength (ASTM C 579) (MPa): 60
Compressive modulus of elasticity (ASTM C 579) (MPa): 1400
Flexural modulus of elasticity (ISO 178) (MPa): 3000
Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)
According to the type of operation to be carried out, there are various sizes of fabric available (10, 20 or 40 cm wide) with a weight of 300 or 600 g/m².

The carbon fibre fabric must have the following characteristics, respectively:

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>300</th>
<th>600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (g/m²)</td>
<td>300</td>
<td>600</td>
</tr>
<tr>
<td>Density (kg/m³)</td>
<td>1.820</td>
<td>1.820</td>
</tr>
<tr>
<td>Equivalent thickness of dry fabric (mm):</td>
<td>0.164</td>
<td>0.329</td>
</tr>
<tr>
<td>Resistant area per unit of width (mm²/m):</td>
<td>164.8</td>
<td>329.6</td>
</tr>
<tr>
<td>Tensile strength (N/mm²):</td>
<td>4,410</td>
<td>4,410</td>
</tr>
<tr>
<td>Maximum load per unit of width (kN/m):</td>
<td>&gt; 700</td>
<td>&gt; 1,400</td>
</tr>
<tr>
<td>Tensile modulus of elasticity (N/mm²):</td>
<td>390,000</td>
<td>390,000</td>
</tr>
<tr>
<td>Elongation at failure (%)</td>
<td>1.1</td>
<td>1.1</td>
</tr>
</tbody>
</table>

The following are included and calculated in the price for work completed according to specification:
- vacuuming all surfaces;
- application of fabric according to procedure described above;
- per square metre of fabric: weight 300 g/m² ........................................ (€/m²)
- per square metre of fabric: weight 600 g/m² ........................................ (€/m²)
G.1 STRENGTHENING CONCRETE STRUCTURES
STRENGTHENING CONCRETE STRUCTURES BY APPLYING POLYMER MATRIX COMPOSITES (FRP)

G.1.5 CONFINEMENT OF COLUMNS - INCREASING DUCTILITY BY APPLYING COMPOSITES
Procedure

Preparation of the substrate
Prepare all surfaces to be treated by completely removing all the deteriorated concrete with a hand or power chisel (see section F.1.1.2) or with other suitable means, such as hydro-scarifying (see section F.1.1.1), to obtain a solid, sufficiently rough substrate with no detached portions. If the deteriorated concrete has been removed with a hand or power chisel, clean all exposed steel reinforcement with a brush (see section F.1.1.2) or by hydro-sandblasting (see section F.1.1.3) to remove the rust and bring the steel reinforcement back to a bare metal finish. Hydro-sandblasting is not required if the surface has been prepared by hydro-scarifying, but you must wait quite a long time after this operation before treating the steel reinforcement due to on-site logistics requirements.

Protection of steel reinforcement
After removing all the rust, treat the steel reinforcement with two coats of Mapefer 1K one-component, anti-corrosion cementitious mortar (see section F.2.1.1) or Mapefer two-component, anti-corrosion cementitious mortar (see section F.2.1.2). The specific function of both these products, made from cementitious binders, powdered polymers and corrosion inhibitors, is to prevent the formation of rust.

Repair operations
Clean all surfaces to be repaired and saturate the substrate leaving a dry surface (s.s.d.) by hydro-cleaning (see section F.1.1.4).
Repair the concrete using one of the following products:

- Mapegrout 430 one-component, normal-setting, shrinkage-compensating, class R3 thixotropic mortar for layers from 0.5 to 3.5 cm thick (see section F.3.2.1);
- Mapegrout T60 one-component, normal-setting, shrinkage-compensating, class R4 thixotropic mortar for layers from 1 to 3.5 cm thick (see section F.4.1.2).
These cementitious mortars are supplied in pre-blended powder form, and must be mixed with the amount of water indicated in their relative Technical Data Sheet to form a well-blended, lump-free mix.

When preparing the mortar, add Mapecure SRA (see section F.6.1.1), a special shrinkage-reducing agent, at a dose of 0.25% in weight on the weight of the mortar.
Apply the mortar with a trowel or by spray within the application temperature range indicated in the Technical Data Sheet.

If the area of concrete to be repaired is thicker than the values indicated, carry out this operation by applying several layers of mortar and embedding electro-welded steel mesh in the mortar (see section F.1.3.1). The dimensions of the mesh (diameter of steel wire and mesh pitch) must be according to design specifications, and it is used to compensate for hygrometric shrinkage and to guarantee sufficient contrast to the expansive action of the mortar.
Smooth all corners to form a rounded edge with a radius of at least 20 mm.

Final protective layer
After applying the strengthening system, protect the surfaces using Planitop 200 one-component, fine-grained, natural-finish cementitious mortar with high adhesion for smoothing and finishing the surface of concrete and render, including old surfaces treated with quartz paint or scratch-effect plastic coating as long as they are well-bonded and difficult to remove (see section F.9.1.5). As an alternative, surfaces may be protected using Elastocolor Paint elastic acrylic coating (see section F.12.3.1) or Elastocolor Rasante SF fibre-reinforced, elastomeric undercoat with good filling properties, with added fine sand (see section F.12.3.3).
G.1 STRENGTHENING CONCRETE STRUCTURES
STRENGTHENING CONCRETE STRUCTURES BY APPLYING POLYMER MATRIX COMPOSITES (FRP)

G.1.5.1 Application of unidirectional glass fibre fabric

Supply and protected application of unidirectional glass fibre fabric (such as MapeWrap G UNI-AX produced by MAPEI S.p.A.) to confine columns to increase their ductility.

Apply the fabric with the “wet” or “dry” system technique using the following procedure:

- apply a coat of epoxy primer (such as MapeWrap Primer 1 produced by MAPEI S.p.A.);
- skim the substrate with epoxy grout (such as MapeWrap 11 produced by MAPEI S.p.A.);
- impregnate the fabric before application for the “wet” system (such as with MapeWrap 21 produced by MAPEI S.p.A.);
- as an alternative, impregnate the fabric after application for the “dry” system (such as with MapeWrap 31 produced by MAPEI S.p.A.).

N.B. the ends of each layer of fabric used for confining purposes must overlap by at least 20 cm.

The epoxy primer (such as MapeWrap Primer 1 produced by MAPEI S.p.A.) must have the following performance characteristics:

- Density of mix (g/cm³): 1.1
- Brookfield viscosity (rotor 1-10 rpm) (mPa·s): 300
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)

The thixotropic epoxy adhesive (such as MapeWrap 11 produced by MAPEI S.p.A.) must have the following performance characteristics:

- Tensile strength (ASTM C 579) (MPa): 30
- Compressive strength (ASTM C 579) (MPa): 70
- Compressive modulus of elasticity (ASTM C 579) (MPa): 8000
- Flexural modulus of elasticity (ISO 178) (MPa): 4000
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)

The adhesive used to impregnate the fabric for the “wet” system (such as MapeWrap 21 produced by MAPEI S.p.A.) must have the following performance characteristics:

- Brookfield viscosity (rotor 1-10 rpm) (mPa·s): 300
- Tensile strength (ASTM D 638) (MPa): 30
- Tensile elongation (ASTM D 638) (%): 1.2
- Compressive strength (ASTM C 579) (MPa): 65
- Flexural modulus of elasticity (ISO 178) (MPa): 2500
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)

The adhesive used to impregnate the fabric for the “dry” system (such as MapeWrap 31 produced by MAPEI S.p.A.) must have the following performance characteristics:

- Brookfield viscosity (rotor 3-5 rpm) (mPa·s): 7000
- Tensile strength (ASTM D 638) (MPa): 40
- Tensile elongation (ASTM D 638) (%): 1.8
- Compressive strength (ASTM C 579) (MPa): 60
- Compressive modulus of elasticity (ASTM C 579) (MPa): 1400
- Flexural modulus of elasticity (ISO 178) (MPa): 3000
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)
According to the type of operation to be carried out, there are various sizes of fabric available (30 or 60 cm wide) with a weight of 300 or 900 g/m².

The glass fibre fabric must have the following characteristics, respectively:

<table>
<thead>
<tr>
<th>Type of fibres</th>
<th>Weight (g/m²)</th>
<th>Density (kg/m³)</th>
<th>Equivalent thickness of dry fabric (mm)</th>
<th>Resistant area per unit of width (mm²/m)</th>
<th>Tensile strength (N/mm²)</th>
<th>Tensile modulus of elasticity (N/mm²)</th>
<th>Elongation at failure (%)</th>
<th>Bond strength to concrete (N/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>type E glass</td>
<td>300</td>
<td>2,620</td>
<td>0.16</td>
<td>114.1</td>
<td>2,560</td>
<td>70</td>
<td>&gt; 3</td>
<td>&gt; 3 (failure of substrate)</td>
</tr>
<tr>
<td></td>
<td>900</td>
<td>2,620</td>
<td>0.48</td>
<td>342.2</td>
<td>2,560</td>
<td>70</td>
<td>&gt; 3</td>
<td></td>
</tr>
</tbody>
</table>

The following are included and calculated in the price for work completed according to specification:

- vacuuming all surfaces;
- application of fabric according to procedure described above;
- per square metre of fabric: weight 300 g/m²  ..........(€/m²)
- per square metre of fabric: weight 900 g/m²  ..........(€/m²)
G.1 STRENGTHENING CONCRETE STRUCTURES

G.1.5.2 Application of high-strength, unidirectional basalt fibre fabric

Supply and protected application of unidirectional basalt fibre fabric (4,840 MPa) such as MapeWrap B UNI-AX produced by MAPEI S.p.A. to confine columns to increase their ductility.

Apply the fabric with the “dry” system technique using the following procedure:

- apply a coat of epoxy primer to the substrate (such as MapeWrap Primer 1 produced by MAPEI S.p.A.);
- trowel apply an epoxy grout (such as MapeWrap 11 produced by MAPEI S.p.A.) to the substrate;
- impregnate the fabric after application for the “dry” system technique (such as with MapeWrap 31 produced by MAPEI S.p.A.).

N.B. the ends of each layer of fabric used for confining purposes must overlap by at least 20 cm.

The epoxy primer (such as MapeWrap Primer 1 produced by MAPEI S.p.A.) must have the following performance characteristics:

- Density of mix (g/cm³): 1.1
- Brookfield viscosity (rotor 1-10 rpm) (mPa·s): 300
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)

The thixotropic epoxy adhesive (such as MapeWrap 11 produced by MAPEI S.p.A.) must have the following performance characteristics:

- Tensile strength (ASTM C 579) (MPa): 30
- Compressive strength (ASTM C 579) (MPa): 70
- Compressive modulus of elasticity (ASTM C 579) (MPa): 8000
- Flexural modulus of elasticity (ISO 178) (MPa): 4000
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)

The adhesive used to impregnate the fabric for the “dry” system (such as MapeWrap 31 produced by MAPEI S.p.A.) must have the following performance characteristics:

- Brookfield viscosity (rotor 3-5 rpm) (mPa·s): 7000
- Tensile strength (ASTM D 638) (MPa): 40
- Tensile elongation (ASTM D 638) (%): 1.8
- Compressive strength (ASTM C 579) (MPa): 60
- Compressive modulus of elasticity (ASTM C 579) (MPa): 1400
- Flexural modulus of elasticity (ISO 178) (MPa): 3000
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)
According to the type of work to be carried out, the fabric is available in 40 cm wide rolls with a weight of 400 or 600 g/m².

The basalt fibre fabric must have the following characteristics, respectively:

<table>
<thead>
<tr>
<th>Type of fibres:</th>
<th>basalt 1220 tex</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (g/m²):</td>
<td>400</td>
</tr>
<tr>
<td>Density (kg/m³):</td>
<td>2.750</td>
</tr>
<tr>
<td>Equivalent thickness of dry fabric (mm):</td>
<td>0.143 0.214</td>
</tr>
<tr>
<td>Resistant area per unit of width (mm²/m):</td>
<td>142.6 214.2</td>
</tr>
<tr>
<td>Tensile strength (N/mm²):</td>
<td>2,560 2,560</td>
</tr>
<tr>
<td>Tensile modulus of elasticity (N/mm²):</td>
<td>89 89</td>
</tr>
<tr>
<td>Elongation at failure (%):</td>
<td>&gt; 3 &gt; 3</td>
</tr>
<tr>
<td>Bond strength to concrete (N/mm²):</td>
<td>&gt; 3 (failure of substrate)</td>
</tr>
</tbody>
</table>

The following are included and calculated in the price for work completed according to specification:

- vacuuming all surfaces;
- application of fabric according to procedure described above;
- per square metre of fabric: weight 400 g/m² ..........(€/m²)
- per square metre of fabric: weight 600 g/m² ..........(€/m²)
G.1 Strengthening Concrete Structures

G.1.6 Confinement of Beam-Column Joints by Applying Carbon Fibre Composites

Procedure

Preparation of the substrate
Prepare all surfaces to be treated by completely removing all the deteriorated concrete with a hand or power chisel (see section F.1.1.2) or with other suitable means, such as hydro-scarifying (see section F.1.1.1), to obtain a solid, sufficiently rough substrate with no detached portions. If the deteriorated concrete has been removed with a hand or power chisel, clean all exposed steel reinforcement with a brush (see section F.1.1.2) or by hydro-sandblasting (see section F.1.1.3) to remove the rust and bring the steel reinforcement back to a bare metal finish.

Hydro-sandblasting is not required if the surface has been prepared by hydro-scarifying, but you must wait quite a long time after this operation before treating the steel reinforcement due to on-site logistics requirements.

Protection of steel reinforcement
After removing all the rust, treat the steel reinforcement with two coats of Mapefer 1K one-component, anti-corrosion cementitious mortar (see section F.2.1.1) or Mapefer two-component, anti-corrosion cementitious mortar (see section F.2.1.2). The specific function of both these products, made from cementitious binders, powdered polymers and corrosion inhibitors, is to prevent the formation of rust.

Repair operations
Clean all surfaces to be repaired and saturate the substrate leaving a dry surface (s.s.d.) by hydro-cleaning (see section F.1.1.4).

Repair the concrete using one of the following products:

- Mapegrout 430 one-component, normal-setting, shrinkage-compensating, class R3 thixotropic mortar for layers from 0.5 to 3.5 cm thick (see section F.3.2.1);
- Mapegrout T60 one-component, normal-setting, shrinkage-compensating, class R4 thixotropic mortar for layers from 1 to 3.5 cm thick (see section F.4.1.2).

These cementitious mortars are supplied in pre-blended powder form, and must be mixed with the amount of water indicated in their relative Technical Data Sheet to form a well-blended, lump-free mix.

When preparing the mortar, add Mapecure SRA (see section F.6.1.1), a special shrinkage-reducing agent, at a dose of 0.25% by weight on the weight of the mortar.

Apply the mortar with a trowel or by spray within the application temperature range indicated in the Technical Data Sheet.

If the area of concrete to be repaired is thicker than the values indicated, carry out this operation by applying several layers of mortar and embedding electro-welded steel mesh in the mortar (see section F.1.3.1). The dimensions of the mesh (diameter of steel wire and mesh pitch) must be according to design specifications, and it is used to compensate for hygrometric shrinkage and to guarantee sufficient contrast to the expansive action of the mortar.

Smooth all corners to form a rounded edge with a radius of at least 20 mm.

Final protective layer
After applying the strengthening system, protect the surfaces using Planitop 200 one-component, fine-grained, natural-finish cementitious mortar with high adhesion for smoothing and finishing the surface of concrete and render, including old surfaces treated with quartz paint or scratch-effect plastic coating as long as they are well-bonded and difficult to remove (see section F.9.1.5). As an alternative, surfaces may be protected using Elastocolor Paint elastic acrylic coating (see section F.12.3.1) or Elastocolor Rasante SF fibre-reinforced, elastomeric undercoat with good filling properties, with added fine sand (see section F.12.3.3).
G.1 STRENGTHENING CONCRETE STRUCTURES
STRENGTHENING CONCRETE STRUCTURES BY APPLYING POLYMER MATRIX COMPOSITES (FRP)

G.1.6.1 Application of high-strength, unidirectional and quadraxial carbon fibre fabric with a high modulus of elasticity

Unidirectional fabric: confinement of tops of columns and ends of beams.
Quadaxial fabric: application of corner guards on beam-column joints and fabric on the inner and outer parts of joint hubs.

Supply and protected application of high-strength, unidirectional and quadraxial carbon fibre fabric (4,830 N/mm²) with a high modulus of elasticity (230,000 N/mm²) (such as MapeWrap C UNI-AX and MapeWrap C Quadri-AX produced by MAPEI S.p.A.) to confine columns.

Apply the fabric with the “wet” or “dry” system technique using the following procedure:

- apply a coat of epoxy primer to the substrate (such as MapeWrap Primer 1 produced by MAPEI S.p.A.);
- trowel apply an epoxy grout (such as MapeWrap 11 produced by MAPEI S.p.A.) to the substrate;
- impregnate the fabric before application for the “wet” system (such as with MapeWrap 21 produced by MAPEI S.p.A.);
- as an alternative, impregnate the fabric after application for the “dry” system (such as with MapeWrap 31 produced by MAPEI S.p.A.).

N.B. the ends of each layer of fabric used for confining purposes must overlap by at least 20 cm.
The epoxy primer (such as MapeWrap Primer 1 produced by MAPEI S.p.A.) must have the following performance characteristics:

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density of mix (g/cm³):</td>
<td>1.1</td>
</tr>
<tr>
<td>Brookfield viscosity (rotor 1-10 rpm) (mPa·s):</td>
<td>300</td>
</tr>
<tr>
<td>Adhesion to concrete (after 7 days at +23°C) (MPa):</td>
<td>&gt; 3 (failure of substrate)</td>
</tr>
</tbody>
</table>

The thixotropic epoxy adhesive (such as MapeWrap 11 produced by MAPEI S.p.A.) must have the following performance characteristics:

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile strength (ASTM C 579) (MPa):</td>
<td>30</td>
</tr>
<tr>
<td>Compressive strength (ASTM C 579) (MPa):</td>
<td>70</td>
</tr>
<tr>
<td>Compressive modulus of elasticity (ASTM C 579) (MPa):</td>
<td>8000</td>
</tr>
<tr>
<td>Flexural modulus of elasticity (ISO 178) (MPa):</td>
<td>4000</td>
</tr>
<tr>
<td>Adhesion to concrete (after 7 days at +23°C) (MPa):</td>
<td>&gt; 3 (failure of substrate)</td>
</tr>
</tbody>
</table>

The adhesive used to impregnate the fabric for the “wet” system (such as MapeWrap 21 produced by MAPEI S.p.A.) must have the following performance characteristics:

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brookfield viscosity (rotor 1-10 rpm) (mPa·s):</td>
<td>300</td>
</tr>
<tr>
<td>Tensile strength (ASTM D 638) (MPa):</td>
<td>30</td>
</tr>
<tr>
<td>Tensile elongation (ASTM D 638) (%):</td>
<td>1.2</td>
</tr>
<tr>
<td>Compressive strength (ASTM C 579) (MPa):</td>
<td>65</td>
</tr>
<tr>
<td>Flexural modulus of elasticity (ISO 178) (MPa):</td>
<td>2500</td>
</tr>
<tr>
<td>Adhesion to concrete (after 7 days at +23°C) (MPa):</td>
<td>&gt; 3 (failure of substrate)</td>
</tr>
</tbody>
</table>

The adhesive used to impregnate the fabric for the “dry” system (such as MapeWrap 31 produced by MAPEI S.p.A.) must have the following performance characteristics:

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brookfield viscosity (rotor 3-5 rpm) (mPa·s):</td>
<td>7000</td>
</tr>
<tr>
<td>Tensile strength (ASTM D 638) (MPa):</td>
<td>40</td>
</tr>
<tr>
<td>Tensile elongation (ASTM D 638) (%):</td>
<td>1.8</td>
</tr>
<tr>
<td>Compressive strength (ASTM C 579) (MPa):</td>
<td>60</td>
</tr>
<tr>
<td>Compressive modulus of elasticity (ASTM C 579) (MPa):</td>
<td>1400</td>
</tr>
<tr>
<td>Flexural modulus of elasticity (ISO 178) (MPa):</td>
<td>3000</td>
</tr>
<tr>
<td>Adhesion to concrete (after 7 days at +23°C) (MPa):</td>
<td>&gt; 3 (failure of substrate)</td>
</tr>
</tbody>
</table>
According to the type of operation to be carried out, there are various sizes of fabric available (10, 20 or 40 cm wide) with a weight of 300 or 600 g/m². The carbon fibre fabric must have the following characteristics, respectively:

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>300</th>
<th>600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (g/m²):</td>
<td>300</td>
<td>600</td>
</tr>
<tr>
<td>Density (kg/m³):</td>
<td>1,800</td>
<td>1,800</td>
</tr>
<tr>
<td>Equivalent thickness of dry fabric (mm):</td>
<td>0.166</td>
<td>0.333</td>
</tr>
<tr>
<td>Resistant area per unit of width (mm²/m):</td>
<td>166.6</td>
<td>333.3</td>
</tr>
<tr>
<td>Tensile strength (N/mm²):</td>
<td>4,830</td>
<td>4,830</td>
</tr>
<tr>
<td>Maximum load per unit of width (kN/m):</td>
<td>&gt; 800</td>
<td>&gt; 1,600</td>
</tr>
<tr>
<td>Tensile modulus of elasticity (N/mm²):</td>
<td>230,000</td>
<td>230,000</td>
</tr>
<tr>
<td>Elongation at failure (%):</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Bond strength to concrete (N/mm²):</td>
<td>&gt; 3 (failure of substrate)</td>
<td></td>
</tr>
</tbody>
</table>
The following are included and calculated in the price for work completed according to specification:
– vacuuming all surfaces;
– application of fabric according to procedure described above;
– per square metre of fabric: weight 300 g/m²  ………(€/m²)
– per square metre of fabric: weight 600 g/m²  ………(€/m²)

According to the type of operation to be carried out, there are various sizes of fabric available (30 or 48 cm wide) with a weight of 380 or 760 g/m².
The carbon fibre fabric must have the following characteristics, respectively:

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>380 g/m²</th>
<th>760 g/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (g/m²)</td>
<td>380</td>
<td>760</td>
</tr>
<tr>
<td>Density (kg/m³)</td>
<td>1.810</td>
<td>1.810</td>
</tr>
<tr>
<td>Equivalent thickness of dry fabric (mm):</td>
<td>0.053</td>
<td>0.106</td>
</tr>
<tr>
<td>Resistant area per unit of width (mm²/m):</td>
<td>53.1</td>
<td>106.1</td>
</tr>
<tr>
<td>Tensile strength (N/mm²):</td>
<td>4,830</td>
<td>4,830</td>
</tr>
<tr>
<td>Maximum load per unit of width (kN/m):</td>
<td>&gt; 254</td>
<td>&gt; 500</td>
</tr>
<tr>
<td>Tensile modulus of elasticity (N/mm²):</td>
<td>230,000</td>
<td>230,000</td>
</tr>
<tr>
<td>Elongation at failure (%)</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Maximum load per unit of width (kN/m):</td>
<td>&gt; 254</td>
<td>&gt; 500</td>
</tr>
<tr>
<td>Tensile modulus of elasticity (N/mm²):</td>
<td>230,000</td>
<td>230,000</td>
</tr>
<tr>
<td>Elongation at failure (%)</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Bond strength to concrete (N/mm²):</td>
<td>&gt; 3 (failure of substrate)</td>
<td></td>
</tr>
</tbody>
</table>

The following are included and calculated in the price for work completed according to specification:
– vacuuming all surfaces;
– application of fabric according to procedure described above;
– per square metre of fabric: weight 380 g/m²  ………(€/m²)
– per square metre of fabric: weight 760 g/m²  ………(€/m²)
G.2 STRENGTHENING MASONRY STRUCTURES

G.2.1 STRENGTHENING MASONRY STRUCTURES BY APPLYING POLYMER MATRIX COMPOSITES (FRP)

G.2.1.1 Application of high-strength, unidirectional carbon fibre fabric with a high modulus of elasticity

Supply and protected application of high-strength, unidirectional carbon fibre fabric (4,830 N/mm²) with a high modulus of elasticity (230,000 N/mm²) (such as MapeWrap C UNI-AX produced by MAPEI S.p.A.) to strengthen masonry elements.

Level the surface of uneven substrates before applying the strengthening system using two-component, fibre-reinforced, pozzolan-reaction mortar with a low modulus of elasticity (such as Planitop HDM Maxi produced by MAPEI S.p.A.).

Apply the fabric with the “wet” or “dry” system technique using the following procedure:

- smooth surfaces where required using two-component, pozzolan-reaction mortar with a low modulus of elasticity (such as Planitop HDM Maxi produced by MAPEI S.p.A.).

The two-component mortar must have the following characteristics:

- apply a coat of epoxy primer to the substrate (such as MapeWrap Primer 1 produced by MAPEI S.p.A.);
- trowel apply an epoxy grout (such as MapeWrap 11 produced by MAPEI S.p.A.) to the substrate;
- impregnate the fabric before application for the “wet” system (such as with MapeWrap 21 produced by MAPEI S.p.A.);
- as an alternative, impregnate the fabric after application for the “dry” system (such as with MapeWrap 31 produced by MAPEI S.p.A.).

The epoxy primer (such as MapeWrap Primer 1 produced by MAPEI S.p.A.) must have the following performance characteristics:

- Density of mix (g/cm³): 1.1
- Brookfield viscosity (rotor 1-10 rpm) (mPa·s): 300
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)

The thixotropic epoxy adhesive (such as MapeWrap Primer 11 produced by MAPEI S.p.A.) must have the following performance characteristics:

- Tensile strength (ASTM C 579) (MPa): 30
- Compressive strength (ASTM C 579) (MPa): 70
- Compressive modulus of elasticity (ASTM C 579) (MPa): 8000
- Flexural modulus of elasticity (ISO 178) (MPa): 4000
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)
The adhesive used to impregnate the fabric for the “wet” system (such as MapeWrap 21 produced by MAPEI S.p.A.) must have the following performance characteristics:

- Brookfield viscosity (rotor 1-10 rpm) (mPa·s): 300
- Tensile strength (ASTM D 638) (MPa): 30
- Tensile elongation (ASTM D 638) (%): 1.2
- Compressive strength (ASTM C 579) (MPa): 65
- Flexural modulus of elasticity (ISO 178) (MPa): 2500
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)

The adhesive used to impregnate the fabric for the “dry” system (such as MapeWrap 31 produced by MAPEI S.p.A.) must have the following performance characteristics:

- Brookfield viscosity (rotor 3-5 rpm) (mPa·s): 7000
- Tensile strength (ASTM D 638) (MPa): 40
- Tensile elongation (ASTM D 638) (%): 1.8
- Compressive strength (ASTM C 579) (MPa): 60
- Compressive modulus of elasticity (ASTM C 579) (MPa): 1400
- Flexural modulus of elasticity (ISO 178) (MPa): 3000
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)

According to the type of operation to be carried out, there are various sizes of fabric available (10, 20 or 40 cm wide) with a weight of 300 or 600 g/m².

The carbon fibre fabric must have the following characteristics, respectively:

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>300</th>
<th>600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (g/m²)</td>
<td>300</td>
<td>600</td>
</tr>
<tr>
<td>Density (kg/m³)</td>
<td>1,800</td>
<td>1,800</td>
</tr>
<tr>
<td>Equivalent thickness of dry fabric (mm)</td>
<td>0.166</td>
<td>0.333</td>
</tr>
<tr>
<td>Resistant area per unit of width (mm²/m)</td>
<td>166.6</td>
<td>333.3</td>
</tr>
<tr>
<td>Tensile strength (N/mm²)</td>
<td>4,830</td>
<td>4,830</td>
</tr>
<tr>
<td>Maximum load per unit of width (kN/m)</td>
<td>&gt; 800</td>
<td>&gt; 1,600</td>
</tr>
<tr>
<td>Tensile modulus of elasticity (N/mm²)</td>
<td>230,000</td>
<td>230,000</td>
</tr>
<tr>
<td>Elongation at failure (%)</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Bond strength to concrete (N/mm²)</td>
<td>&gt; 3</td>
<td>&gt; 3 (failure of substrate)</td>
</tr>
</tbody>
</table>
The following are included and calculated in the price for work completed according to specification:
– vacuuming all surfaces;
– application of fabric according to procedure described above;
– per square metre of fabric: weight 300 g/m²  ……….(€/m²)
– per square metre of fabric: weight 600 g/m²  ……….(€/m²)
G.2.1.2 Application of unidirectional glass fibre composites

Supply and protected application of unidirectional glass fibre fabric (such as MapeWrap G UNI-AX produced by MAPEI S.p.A.) to strengthen masonry elements.

Apply the fabric with the “wet” or “dry” system technique using the following procedure:
- smooth surfaces where required using two-component, pozzolan-reaction mortar with a low modulus of elasticity (such as Planitop HDM Maxi produced by MAPEI S.p.A.).

The two-component mortar must have the following characteristics:

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density of mix (kg/m³)</td>
<td>1.850</td>
</tr>
<tr>
<td>Compressive strength (EN 12190) (N/mm²):</td>
<td>≥ 25 (after 28 days)</td>
</tr>
<tr>
<td>Flexural strength (EN196/1) (N/mm²):</td>
<td>≥ 7 (after 28 days)</td>
</tr>
<tr>
<td>Compressive modulus of elasticity (N/mm²):</td>
<td>8,000</td>
</tr>
<tr>
<td>Adhesion to masonry (N/mm²):</td>
<td>≥ 2.0</td>
</tr>
</tbody>
</table>

- apply a coat of epoxy primer to the substrate (such as MapeWrap Primer 1 produced by MAPEI S.p.A.);
- trowel apply an epoxy grout (such as MapeWrap 11 produced by MAPEI S.p.A.) to the substrate;
- impregnate the fabric before application for the “wet” system (such as with MapeWrap 21 produced by MAPEI S.p.A.);
- as an alternative, impregnate the fabric after application for the “dry” system (such as with MapeWrap 31 produced by MAPEI S.p.A.).

The epoxy primer (such as MapeWrap Primer 1 produced by MAPEI S.p.A.) must have the following performance characteristics:

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density of mix (g/cm³):</td>
<td>1.1</td>
</tr>
<tr>
<td>Brookfield viscosity (rotor 1-10 rpm) (mPa-s):</td>
<td>300</td>
</tr>
<tr>
<td>Adhesion to concrete (after 7 days at +23°C) (MPa):</td>
<td>&gt; 3 (failure of substrate)</td>
</tr>
</tbody>
</table>

The thixotropic epoxy adhesive (such as MapeWrap 21 produced by MAPEI S.p.A.) must have the following performance characteristics:

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile strength (ASTM C 579) (MPa):</td>
<td>30</td>
</tr>
<tr>
<td>Compressive strength (ASTM C 579) (MPa):</td>
<td>70</td>
</tr>
<tr>
<td>Compressive modulus of elasticity (ASTM C 579) (MPa):</td>
<td>8000</td>
</tr>
<tr>
<td>Flexural modulus of elasticity (ISO 178) (MPa):</td>
<td>4000</td>
</tr>
<tr>
<td>Adhesion to concrete (after 7 days at +23°C) (MPa):</td>
<td>&gt; 3 (failure of substrate)</td>
</tr>
</tbody>
</table>

The adhesive used to impregnate the fabric for the “wet” system (such as MapeWrap 21 produced by MAPEI S.p.A.) must have the following performance characteristics:

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brookfield viscosity (rotor 1-10 rpm) (mPa-s):</td>
<td>300</td>
</tr>
<tr>
<td>Tensile strength (ASTM D 638) (MPa):</td>
<td>30</td>
</tr>
<tr>
<td>Tensile elongation (ASTM D 638) (%):</td>
<td>1.2</td>
</tr>
<tr>
<td>Compressive strength (ASTM C 579) (MPa):</td>
<td>65</td>
</tr>
<tr>
<td>Flexural modulus of elasticity (ISO 178) (MPa):</td>
<td>2500</td>
</tr>
<tr>
<td>Adhesion to concrete (after 7 days at +23°C) (MPa):</td>
<td>&gt; 3 (failure of substrate)</td>
</tr>
</tbody>
</table>

The adhesive used to impregnate the fabric for the “dry” system (such as MapeWrap 31 produced by MAPEI S.p.A.) must have the following performance characteristics:

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brookfield viscosity (rotor 3-5 rpm) (mPa-s):</td>
<td>7000</td>
</tr>
<tr>
<td>Tensile strength (ASTM D 638) (MPa):</td>
<td>40</td>
</tr>
<tr>
<td>Tensile elongation (ASTM D 638) (%):</td>
<td>1.8</td>
</tr>
<tr>
<td>Compressive strength (ASTM C 579) (MPa):</td>
<td>60</td>
</tr>
<tr>
<td>Compressive modulus of elasticity (ASTM C 579) (MPa):</td>
<td>1400</td>
</tr>
<tr>
<td>Flexural modulus of elasticity (ISO 178) (MPa):</td>
<td>3000</td>
</tr>
<tr>
<td>Adhesion to concrete (after 7 days at +23°C) (MPa):</td>
<td>&gt; 3 (failure of substrate)</td>
</tr>
</tbody>
</table>
According to the type of operation to be carried out, there are various sizes of fabric available (30 or 60 cm wide) with a weight of 300 or 900 g/m².

The glass fibre fabric must have the following characteristics, respectively:

<table>
<thead>
<tr>
<th>Type of fibres:</th>
<th>type E glass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (g/m²):</td>
<td>300</td>
</tr>
<tr>
<td>Density (kg/m³):</td>
<td>2.620</td>
</tr>
<tr>
<td>Equivalent thickness of dry fabric (mm):</td>
<td>0.16</td>
</tr>
<tr>
<td>Resistant area per unit of width (mm²/m):</td>
<td>114.1</td>
</tr>
<tr>
<td>Tensile strength (N/mm²):</td>
<td>2,560</td>
</tr>
<tr>
<td>Tensile modulus of elasticity (N/mm²):</td>
<td>70</td>
</tr>
<tr>
<td>Elongation at failure (%):</td>
<td>&gt; 3</td>
</tr>
<tr>
<td>Bond strength to concrete (N/mm²):</td>
<td>&gt; 3 (failure of substrate)</td>
</tr>
</tbody>
</table>

The following are included and calculated in the price for work completed according to specification:

- vacuuming all surfaces;
- application of fabric according to procedure described above;

- per square metre of fabric: weight 300 g/m² …………(€/m²)
- per square metre of fabric: weight 900 g/m² …………(€/m²)
G.2.2 STRENGTHENING MASONRY STRUCTURES

G.2.1.3 Application of pultruded carbon fibre elements pre-impregnated with epoxy resin

Supply and application of a system comprising pultruded carbon fibre rods (such as Maperod C produced by MAPEI S.p.A.), glass fibre rods (such as Maperod G produced by MAPEI S.p.A) or carbon fibre tubes (such as Carbotube produced by MAPEI S.p.A.) to form “reinforced tacking” and/or connection elements between walls at right angles to each other.

Apply the pultruded elements using the following procedure:

– make holes in the walls to cross and intercept cracks or portions of wall which need to be connected;
– vacuum all traces of dust from inside the holes;
– place the strengthening bars or tubes in the holes after grouting the surface of the holes with two-component, fibre-reinforced, pozzolan-reaction mortar with a low modulus of elasticity (such as Planitop HDM Maxi produced by MAPEI S.p.A.).

The two-component mortar must have the following characteristics:

Density of mix (kg/m³): 1,850
Compressive strength (EN 12190) (N/mm²): ≥ 25 (after 28 days)
Flexural strength (EN196/1) (N/mm²): ≥ 7 (after 28 days)
Compressive modulus of elasticity (N/mm²): 8,000
Adhesion to masonry (N/mm²): ≥ 2.0

– inject slurry made from a sulphate-resistant, pozzolan-reaction, super-fluid, fillerised hydraulic binder (such as Mape-Antique F21 produced by Mapei S.p.A.) which, because of its special formulation with water-retaining agents, does not require that masonry is saturated beforehand. If pultruded carbon fibre tubes are used (such as Carbotube produced by MAPEI S.p.A.), use special injectors with non-return valves (such as Injectors Ø 23 produced by MAPEI S.p.A.).

The pultruded carbon fibre bars pre-impregnated with epoxy resin must have the following characteristics:

Matrix: epoxy resin
Density (g/cm³): 1.54
Nominal diameter (mm): 9.7
Content of carbon fibre by weight (%): 71
Cross-section area (mm²): 73.9
Tensile strength (N/mm²): 2,000
Shear strength (EN 1502-3) (N/mm²): 75
Tensile modulus of elasticity (N/mm²): 155,000
Elongation at failure (%): 1.5
Coefficient of thermal expansion (longitudinal direction) (m/m/°C): 6-10 x 10-6

The pultruded glass fibre bars pre-impregnated with epoxy resin must have the following characteristics:

Density (g/cm³): 1.995
Nominal diameter (mm): 9.53
Content of carbon fibre by weight (%): 75
Cross-section area (mm²): 71.26
Tensile strength (N/mm²): 760
Tensile modulus of elasticity (N/mm²): 40,800
Elongation at failure (%): 2.0
Coefficient of thermal expansion (longitudinal direction) (m/m/°C): 6-10 x 10-6
The pultruded carbon fibre tubes pre-impregnated with epoxy resin must have the following characteristics:

- **Density** (g/cm³): 1.610
- **Outside diameter** (mm): 10
- **Inside diameter** (mm): 8
- **Content of carbon fibre by weight (%)**: 68
- **Tensile strength** (N/mm²): 3,100
- **Tensile modulus of elasticity** (N/mm²): 170,000
- **Elongation at failure (%)**: 1.6
- **Coefficient of thermal expansion (longitudinal direction)** (m/m°C): 0.6 x 10⁻⁶

The following are included and calculated in the price for work completed according to specification:

- **per linear metre of pultruded bar**
- **per linear metre of pultruded tube**
G.2 STRENGTHENING MASONRY STRUCTURES

G.2.2 STRENGTHENING MASONRY STRUCTURES BY APPLYING INORGANIC MATRIX COMPOSITES (FRG)

G.2.2.1 Application of pre-primed, alkali-resistant glass fibre mesh

Supply and application of a system comprising pre-primed, alkali-resistant, A.R. glass fibre mesh (such as Mapegrid G 220 produced by MAPEI S.p.A) and two-component, fibre-reinforced, pozzolan-reaction, cementitious mortar with a low modulus of elasticity (such as Planitop HDM or Planitop HDM Maxi produced by MAPEI S.p.A). Apply the system using the following procedure:

- apply the first layer of two-component mortar (such as Planitop HDM or Planitop HDM Maxi produced by MAPEI S.p.A.) after levelling the surface, if required, with the same mortar;
- place the strengthening mesh in position (such as Mapegrid G 220 produced by MAPEI S.p.A);
- apply the second layer of mortar (such as Planitop HDM or Planitop HDM Maxi produced by MAPEI S.p.A) so that it completely covers the reinforcement mesh with an even coat.

The A.R. glass fibre reinforcement mesh must have the following characteristics:

Type of fibre: A.R. glass fibre
Weight (g/m²): 225
Mesh size (mm): 25×25
Tensile strength (kN/m): 45
Elongation at failure (%): < 3

The two-component mortar must have the following characteristics:

Density of mix (kg/m³): 1,850
Compressive strength (EN 12190) (N/mm²): ≥ 25 (after 28 days)
Flexural strength (EN196/1) (N/mm²): ≥ 7 (after 28 days)
Compressive modulus of elasticity (N/mm²): 8,000
Adhesion to masonry (N/mm²): ≥ 2.0

The following are included and calculated in the price for work completed according to specification:
- vacuuming all surfaces;
- application of system according to procedure described above;
- 15% overlap of reinforcement mesh;
- 10 mm thick layer of mortar
- per square metre of strengthening system (mesh+mortar) ……… (€/m²)
G.2 STRENGTHENING MASONRY STRUCTURES

G.2.2.2 Application of pre-primed, alkali-resistant glass fibre mesh using two-component, lime and eco-pozzolan mortar

Supply and application of a system comprising pre-primed, alkali-resistant, A.R. glass fibre mesh (such as Mapegrid G 220 produced by MAPEI S.p.A) and two-component, fibre-reinforced, pozzolan-reaction, lime and eco-pozzolan mortar with a low modulus of elasticity (such as Planitop HDM Restauro produced by MAPEI S.p.A). Apply the system using the following procedure:

- apply the first layer of two-component mortar (such as Planitop HDM Restauro produced by MAPEI S.p.A.) after levelling the surface, if required, with the same mortar;
- place the strengthening mesh in position (such as Mapegrid G 220 produced by MAPEI S.p.A.);
- apply the second layer of mortar (such as Planitop HDM Restauro produced by MAPEI S.p.A.) so that it completely covers the reinforcement mesh with an even coat.

The A.R. glass fibre reinforcement mesh must have the following characteristics:

Type of fibre: A.R. glass fibre
Weight (g/m²): 225
Mesh size (mm): 25x25
Tensile strength (kN/m): 45
Elongation at failure (%): < 3

The two-component mortar must have the following characteristics:

Density of mix (kg/m³): 1,900
Compressive strength (EN 12190) (N/mm²): ≥ 15 (after 28 days)
Initial shear strength (EN 1502-3) (N/mm²): 0.15
Compressive modulus of elasticity (N/mm²): 8,000
Adhesion to masonry (N/mm²): ≥ 0.80
Classification:
- type G masonry mortar, category M15;
- type GP masonry mortar, category CS IV

The following are included and calculated in the price for work completed according to specification:

- vacuuming all surfaces;
- application of mesh according to procedure described above;
- 15% overlap of reinforcement mesh;
- 10 mm thick layer of mortar

- per square metre of strengthening system (mesh+mortar) ................ (€/m²)
**G.2.2.3 Application of pre-primed, alkali-resistant basalt fibre mesh**

Supply and application of a system comprising pre-primed, alkali-resistant, basalt fibre mesh (such as **Mapegrid B 250** produced by MAPEI S.p.A) and two-component, fibre-reinforced, pozzolan-reaction, cementitious mortar with a low modulus of elasticity (such as **Planitop HDM** or **Planitop HDM Maxi** produced by MAPEI S.p.A). Apply the system using the following procedure:

- apply the first layer of two-component mortar (such as **Planitop HDM** or **Planitop HDM Maxi** produced by MAPEI S.p.A.) after evening out the surface, if required, with the same mortar;
- place the strengthening mesh in position (such as **Mapegrid B 250** produced by MAPEI S.p.A.);
- apply the second layer of mortar (such as **Planitop HDM** or **Planitop HDM Maxi** produced by MAPEI S.p.A.) so that it completely covers the reinforcement mesh with an even coat.

The basalt fibre reinforcement mesh must have the following characteristics:
- **Type of fibre:** pre-primed basalt fibres
- **Weight (g/m²):** 250
- **Mesh size (mm):** 6×6
- **Tensile strength (N/50 mm):** 30
- **Elongation at failure (%):** ≤ 2

The two-component mortar must have the following characteristics:
- **Density of mix (kg/m³):** 1,850
- **Compressive strength (EN 12190) (N/mm²):** ≥ 25 (after 28 days)
- **Flexural strength (EN196/1) (N/mm²):** ≥ 7 (after 28 days)
- **Compressive modulus of elasticity (N/mm²):** 8,000
- **Adhesion to masonry (N/mm²):** ≥ 2.0

The following are included and calculated in the price for work completed according to specification:
- vacuuming all surfaces;
- application of system according to procedure described above;
- 15% overlap of reinforcement mesh;
- 10 mm thick layer of mortar
- **per square metre of strengthening system (mesh+mortar)** \( \cdots \cdots \cdots \text{(€/m²)} \)
G.2

STRENGTHENING MASONRY STRUCTURES

G.2.2.4 Application of pre-primed, alkali-resistant glass fibre mesh to locally reinforce heterogeneous elements

Supply and application of a system comprising pre-primed, alkali-resistant, A.R. glass fibre mesh (such as Mapegrid G 120 produced by MAPEI S.p.A) and two-component, fibre-reinforced, pozzolan-reaction, cementitious mortar with a low modulus of elasticity (such as Planitop HDM or Planitop HDM Maxi produced by MAPEI S.p.A). Apply the system using the following procedure:

- apply the first layer of two-component mortar (such as Planitop HDM or Planitop HDM Maxi produced by MAPEI S.p.A.) after levelling the surface, if required, with the same mortar;
- place the strengthening mesh in position (such as Mapegrid G 120 produced by MAPEI S.p.A.);
- apply the second layer of mortar (such as Planitop HDM or Planitop HDM Maxi produced by MAPEI S.p.A.) so that it completely covers the reinforcement mesh with an even coat.

The A.R. glass fibre reinforcement mesh must have the following characteristics:

- Type of fibre: A.R. glass fibre
- Weight (g/m²): 125
- Mesh size (mm): 12.7×12.7
- Tensile strength (kN/m): 30
- Elongation at failure (%): < 3

The two-component mortar must have the following characteristics:

- Density of mix (kg/m³): 1,850
- Compressive strength (EN 12190) (N/mm²): ≥ 25 (after 28 days)
- Flexural strength (EN196/1) (N/mm²): ≥ 7 (after 28 days)
- Compressive modulus of elasticity (N/mm²): 8,000
- Adhesion to masonry (N/mm²): ≥ 2.0

The following are included and calculated in the price for work completed according to specification:

- vacuuming all surfaces;
- application of system according to procedure described above;
- 15% overlap of reinforcement mesh;
- 10 mm thick layer of mortar
- per square metre of strengthening system (mesh+mortar) …………(€/m²)
STRENGTHENING WOODEN STRUCTURES

STRENGTHENING WOODEN STRUCTURES BY APPLYING POLYMER MATRIX COMPOSITES (FRP)

FLEXURAL STRENGTHENING OF FLOOR BEAMS AND JOISTS BY APPLYING PULTRUDED CARBON FIBRE PLATES

Application of high-strength pultruded carbon fibre plates with a low modulus of elasticity

Supply and application of high-strength, pultruded carbon fibre plates (≥ 3,100 MPa) with a low modulus of elasticity (170 GPa), elongation at failure equal to 2% and a minimum fibre content of 68% (such as Carboplate E 170 produced by MAPEI S.p.A.), with a double protective plastic film (peel-ply) and pre-impregnated with epoxy resin.

Prepare the surfaces by planing or with a similar technique to completely remove the weak layer of wood on the surface and apply the plates using the following procedure:

- cut the Carboplate to the length required;
- remove the protective film (peel-ply) from the Carboplate;
- with a flat trowel, apply an even layer from 1.0 to 1.5 mm thick of two-component, thixotropic epoxy adhesive for structural bonds (such as Mapewood Paste 140 produced by MAPEI S.p.A.) on the Carboplate and on the substrate to which the plate is to be bonded.

The thixotropic epoxy adhesive must have the following performance characteristics:

- Tensile strength (ASTM C 579) (MPa): 30
- Compressive strength (ASTM C 579) (MPa): 70
- Compressive modulus of elasticity (ASTM C 579) (MPa): 8000
- Flexural modulus of elasticity (ISO 178) (MPa): 4000
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)

In the case of particularly porous and inconsistent substrates, treat surfaces with a specific two-component fluid primer (such as Mapewood Primer 100 produced by MAPEI S.p.A.) with the following performance characteristics:

- Density of mix (g/cm³): 1.1
- Brookfield viscosity (rotor 1-10 rpm) (mPa·s): 300
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)

– apply the Carboplate with a light, even pressure.

The product must have the following performance characteristics:

- Density (g/cm³): 1.61
- Fibre content (%): 68
- Thickness (mm): 1.4
- Width (mm): 50
- Resistant section (mm²): 70
- Weight (g/m): 113
- Tensile strength (MPa): > 3,100
- Elongation at failure (%): 2
- Shear strength (MPa): 77
The following are included and calculated in the price for work completed according to specification:

- vacuuming all surfaces;
- application of two-component epoxy Primer as described above;
- application of thixotropic epoxy grout as described above (average thickness 1.5 mm).
- 10% waste of plates and adhesives.

- per linear metre of plate: width 50 mm  
  ..........(€/m)
- per linear metre of plate: width 100 mm  
  ..........(€/m)
- per linear metre of plate: width 150 mm  
  ..........(€/m)
G.3 STRENGTHENING WOODEN STRUCTURES
STRENGTHENING WOODEN STRUCTURES BY APPLYING POLYMER MATRIX COMPOSITES (FRP)

G.3.1.2 Application of high-strength pultruded carbon fibre plates with a medium modulus of elasticity

Supply and application of high-strength, pultruded carbon fibre plates (≥ 3,100 MPa) with a medium modulus of elasticity (200 GPa), elongation at failure equal to 1.4% and a minimum fibre content of 68% (such as Carboplate E 200 produced by MAPEI S.p.A.), with a double plastic protective film (peel-ply) and pre-impregnated with epoxy resin. Prepare the surfaces by planing or with a similar technique to completely remove the weak layer of wood on the surface and apply the plates using the following procedure:

– cut the Carboplate to the length required;
– remove the protective film (peel-ply) from the Carboplate;
– with a flat trowel, apply an even layer from 1.0 to 1.5 mm thick of two-component, thixotropic epoxy adhesive for structural bonds (such as Mapewood Paste 140 produced by MAPEI S.p.A.) on the Carboplate and on the substrate to which the plate is to be bonded.

The thixotropic epoxy adhesive must have the following performance characteristics:

- Tensile strength (ASTM C 579) (MPa): 30
- Compressive strength (ASTM C 579) (MPa): 70
- Compressive modulus of elasticity (ASTM C 579) (MPa): 8000
- Flexural modulus of elasticity (ISO 178) (MPa): 4000
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)

In the case of particularly porous and inconsistent substrates, treat surfaces with a specific two-component fluid primer (such as Mapewood Primer 100 produced by MAPEI S.p.A.) with the following performance characteristics:

- Density of mix (g/cm³): 1.1
- Brookfield viscosity (rotor 1-10 rpm) (mPa·s): 300
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)

– apply the Carboplate with a light, even pressure.

The product must have the following performance characteristics:

- Density (g/cm³): 1.61
- Fibre content (%): 68
- Thickness (mm): 1.4
- Width (mm): 50 100 150
- Resistant section (mm²): 70 140 210
- Weight (g/m): 113 225 338
- Tensile strength (MPa): ≥ 3,300
- Elongation at failure (%): 1.4
- Shear strength (MPa): 77
The following are included and calculated in the price for work completed according to specification:

– vacuuming all surfaces;
– application of two-component epoxy Primer as described above;
– application of thixotropic epoxy grout as described above (average thickness 1.5 mm).
– 10% waste of plates and adhesives.

– per linear metre of plate: width 50 mm ............(€/m)
– per linear metre of plate: width 100 mm ..........(€/m)
– per linear metre of plate: width 150 mm ..........(€/m)
G.3 STRENGTHENING WOODEN STRUCTURES
STRENGTHENING WOODEN STRUCTURES BY APPLYING POLYMER MATRIX COMPOSITES (FRP)

G.3.1.3 Application of high-strength pultruded carbon fibre plates with a high modulus of elasticity

Supply and application of high-strength, pultruded carbon fibre plates (≥2,500 MPa) with a high modulus of elasticity (250 GPa), elongation at failure equal to 0.9% and a minimum fibre content of 65% (such as Carboplate E 250 produced by MAPEI S.p.A.), with a double protective plastic film (peel-ply) and pre-impregnated with epoxy resin.

Prepare the surfaces by planing or with a similar technique to completely remove the weak layer of wood on the surface and apply the plates using the following procedure:

- cut the Carboplate to the length required;
- remove the protective film (peel-ply) from the Carboplate;
- with a flat trowel, apply an even layer from 1.0 to 1.5 mm thick of two-component, thixotropic epoxy adhesive for structural bonds (such as Mapewood Paste 140 produced by MAPEI S.p.A.) on the Carboplate and on the substrate to which the plate is to be bonded.

The thixotropic epoxy adhesive must have the following performance characteristics:

- Tensile strength (ASTM C 579) (MPa): 30
- Compressive strength (ASTM C 579) (MPa): 70
- Compressive modulus of elasticity (ASTM C 579) (MPa): 8000
- Flexural modulus of elasticity (ISO 178) (MPa): 4000
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)

In the case of particularly porous and inconsistent substrates, treat surfaces with a specific two-component fluid primer (such as Mapewood Primer 100 produced by MAPEI S.p.A.) with the following performance characteristics:

- Density of mix (g/cm³): 1.1
- Brookfield viscosity (rotor 1-10 rpm) (mPa·s): 300
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)

– apply the Carboplate with a light, even pressure.

The product must have the following performance characteristics:

- Density (g/cm³): 1.61
- Fibre content (%): 65
- Thickness (mm): 1.4
- Width (mm): 50 100 150
- Resistant section (mm²): 70 140 210
- Weight (g/m): 113 225 338
- Tensile strength (MPa): ≥ 2,500
- Elongation at failure (%): 0.9
- Shear strength (MPa): 77
The following are included and calculated in the price for work completed according to specification:

– vacuuming all surfaces;
– application of two-component epoxy Primer as described above;
– application of thixotropic epoxy grout as described above (average thickness 1.5 mm).
– 10% waste of plates and adhesives.

– per linear metre of plate: width 50 mm ............(€/m)
– per linear metre of plate: width 100 mm ............(€/m)
– per linear metre of plate: width 150 mm ............(€/m)
G.3 STRENGTHENING WOODEN STRUCTURES
STRENGTHENING WOODEN STRUCTURES BY APPLYING POLYMER MATRIX COMPOSITES (FRP)

G.3.2 FLEXURAL STRENGTHENING OF FLOOR BEAMS AND JOISTS BY APPLYING CARBON FIBRE FABRIC

G.3.2.1 Application of high-strength, unidirectional carbon fibre fabric with a high modulus of elasticity

Supply and protected application of high-strength, unidirectional carbon fibre fabric (4,830 N/mm²) with a high modulus of elasticity (230,000 N/mm²) (such as MapeWrap C UNI-AX produced by MAPEI S.p.A.).

Apply the fabric with the “wet” or “dry” system technique using the following procedure:

- apply a coat of epoxy primer to the substrate (such as Mapewood Primer 100 produced by MAPEI S.p.A.);
- trowel apply an epoxy grout (such as Mapewood Paste 140 produced by MAPEI S.p.A.) to the substrate;
- impregnate the fabric before application for the “wet” system (such as with MapeWrap 21 produced by MAPEI S.p.A.);
- as an alternative, impregnate the fabric after application for the “dry” system (such as with Mapewood Paste 140 produced by MAPEI S.p.A.).

The epoxy primer (such as Mapewood Primer 100 produced by MAPEI S.p.A.) must have the following performance characteristics:

Density of mix (g/cm³):
Brookfield viscosity (rotor 1-10 rpm) (mPa·s):
Adhesion to concrete (after 7 days at +23°C) (MPa):

The thixotropic epoxy adhesive (Mapewood Paste 140 produced by MAPEI S.p.A.) must have the following performance characteristics:

Tensile strength (ASTM C 579) (MPa):
Compressive strength (ASTM C 579) (MPa):
Compressive modulus of elasticity (ASTM C 579) (MPa):
Flexural modulus of elasticity (ISO 178) (MPa):
Adhesion to concrete (after 7 days at +23°C) (MPa):

The adhesive used to impregnate the fabric for the “wet” system (MapeWrap 21) must have the following performance characteristics:

Brookfield viscosity (rotor 1-10 rpm) (mPa·s):
Tensile strength (ASTM D 638) (MPa):
Tensile elongation (ASTM D 638) (%):
Compressive strength (ASTM C 579) (MPa):
Compressive modulus of elasticity (ASTM C 579) (MPa):
Flexural modulus of elasticity (ISO 178) (MPa):
Adhesion to concrete (after 7 days at +23°C) (MPa):

The adhesive used to impregnate the fabric for the “dry” system (MapeWrap 31) must have the following performance characteristics:

Brookfield viscosity (rotor 3-5 rpm) (mPa·s):
Tensile strength (ASTM D 638) (MPa):
Tensile elongation (ASTM D 638) (%):
Compressive strength (ASTM C 579) (MPa):
Compressive modulus of elasticity (ASTM C 579) (MPa):
Flexural modulus of elasticity (ISO 178) (MPa):
Adhesion to concrete (after 7 days at +23°C) (MPa):

MapeWrap as produced by MAPEI S.p.A. (such as MapeWrap C UNI-AX).

MAPEI grout was produced by MAPEI S.p.A. (such as MapeWrap C UNI-AX).
According to the type of operation to be carried out, there are various sizes of fabric available (10, 20 or 40 cm wide) with a weight of 300 or 600 g/m².
The carbon fibre fabric must have the following characteristics, respectively:

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>300</th>
<th>600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (g/m²)</td>
<td>300</td>
<td>600</td>
</tr>
<tr>
<td>Density (kg/m³)</td>
<td>1,800</td>
<td>1,800</td>
</tr>
<tr>
<td>Equivalent thickness of dry fabric (mm)</td>
<td>0.166</td>
<td>0.333</td>
</tr>
<tr>
<td>Resistant area per unit of width (mm²/m)</td>
<td>166.6</td>
<td>333.3</td>
</tr>
<tr>
<td>Tensile strength (N/mm²)</td>
<td>4,830</td>
<td>4,830</td>
</tr>
<tr>
<td>Maximum load per unit of width (kN/m)</td>
<td>&gt; 800</td>
<td>&gt; 1,600</td>
</tr>
<tr>
<td>Tensile modulus of elasticity (N/mm²)</td>
<td>230,000</td>
<td>230,000</td>
</tr>
<tr>
<td>Elongation at failure (%)</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Bond strength to concrete (N/mm²)</td>
<td>&gt; 3 (failure of substrate)</td>
<td></td>
</tr>
</tbody>
</table>

The following are included and calculated in the price for work completed according to specification:
- vacuuming all surfaces;
- application of system according to procedure described above;
- per square metre of fabric: weight 300 g/m² ……..(€/m²)
- per square metre of fabric: weight 600 g/m² ……..(€/m²)
### G.3 STRENGTHENING WOODEN STRUCTURES
STRENGTHENING WOODEN STRUCTURES BY APPLYING POLYMER MATRIX COMPOSITES (FRP)

#### G.3.3 SHEAR STRENGTHENING OF CARBON FIBRE COMPOSITES

#### G.3.3.1 Application of high-strength, unidirectional carbon fibre fabric with a high modulus of elasticity

Supply and protected application of high-strength, unidirectional carbon fibre fabric (4,830 N/mm²) with a high modulus of elasticity (230,000 N/mm²) (such as Mapewrap C UNI-AX produced by MAPEI S.p.A.).

Apply the fabric with the “wet” or “dry” system technique using the following procedure:

- apply a coat of epoxy primer to the substrate (such as Mapewood Primer 100 produced by MAPEI S.p.A.);
- trowel apply an epoxy grout (such as Mapewood Paste 140 produced by MAPEI S.p.A.) to the substrate;
- impregnate the fabric before application for the “wet” system (such as with Mapewrap 21 produced by MAPEI S.p.A.);
- as an alternative, impregnate the fabric after application for the “dry” system (such as with Mapewrap 31 produced by MAPEI S.p.A.).

The epoxy primer (such as Mapewood Primer 100 produced by MAPEI S.p.A.) must have the following performance characteristics:

- Density of mix (g/cm³): 1.1
- Brookfield viscosity (rotor 1-10 rpm) (mPa·s): 300
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)

The thixotropic epoxy adhesive (such as Mapewood Paste 140 produced by MAPEI S.p.A.) must have the following performance characteristics:

- Tensile strength (ASTM C 579) (MPa): 30
- Compressive strength (ASTM C 579) (MPa): 70
- Compressive modulus of elasticity (ASTM C 579) (MPa): 8000
- Flexural modulus of elasticity (ISO 178) (MPa): 4000
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)

The adhesive used to impregnate the fabric for the “wet” system (such as Mapewrap 21 produced by MAPEI S.p.A.) must have the following performance characteristics:

- Brookfield viscosity (rotor 1-10 rpm) (mPa·s): 300
- Tensile strength (ASTM D 638) (MPa): 30
- Tensile elongation (ASTM D 638) (%): 1.2
- Compressive strength (ASTM C 579) (MPa): 65
- Flexural modulus of elasticity (ISO 178) (MPa): 2500
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)

The adhesive used to impregnate the fabric for the “dry” system (such as Mapewrap 31 produced by MAPEI S.p.A.) must have the following performance characteristics:

- Brookfield viscosity (rotor 3-5 rpm) (mPa·s): 7000
- Tensile strength (ASTM D 638) (MPa): 40
- Tensile elongation (ASTM D 638) (%): 1.8
- Compressive strength (ASTM C 579) (MPa): 60
- Compressive modulus of elasticity (ASTM C 579) (MPa): 1400
- Flexural modulus of elasticity (ISO 178) (MPa): 3000
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)
According to the type of operation to be carried out, there are various sizes of fabric available (10, 20 or 40 cm wide) with a weight of 300 or 600 g/m².

The carbon fibre fabric must have the following characteristics, respectively:

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>300 g/m²</th>
<th>600 g/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (g/m²)</td>
<td>300</td>
<td>600</td>
</tr>
<tr>
<td>Density (kg/m³)</td>
<td>1,800</td>
<td>1,800</td>
</tr>
<tr>
<td>Equivalent thickness of dry fabric (mm)</td>
<td>0.166</td>
<td>0.333</td>
</tr>
<tr>
<td>Resistant area per unit of width (mm²/m)</td>
<td>166.6</td>
<td>333.3</td>
</tr>
<tr>
<td>Tensile strength (N/mm²)</td>
<td>4,830</td>
<td>4,830</td>
</tr>
<tr>
<td>Maximum load per unit of width (kN/m)</td>
<td>&gt; 800</td>
<td>&gt; 1,600</td>
</tr>
<tr>
<td>Tensile modulus of elasticity (N/mm²)</td>
<td>230,000</td>
<td>230,000</td>
</tr>
<tr>
<td>Elongation at failure (%)</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Bond strength to concrete (N/mm²)</td>
<td>&gt; 3</td>
<td>(failure of substrate)</td>
</tr>
</tbody>
</table>

The following are included and calculated in the price for work completed according to specification:

- vacuuming all surfaces;
- application of system according to procedure described above;
- per square metre of fabric: weight 300 g/m² ..........(€/m²)
- per square metre of fabric: weight 600 g/m² ..........(€/m²)
G.3 STRENGTHENING WOODEN STRUCTURES
STRENGTHENING WOODEN STRUCTURES BY APPLYING POLYMER MATRIX COMPOSITES (FRP)

G.3.3.2 Application of high-strength, bi-directional carbon fibre fabric with a high modulus of elasticity

Supply and protected application of high-strength, bi-directional carbon fibre fabric (4,830 N/mm²) with a high modulus of elasticity (230,000 N/mm²) (such as MapeWrap C BI-AX produced by MAPEI S.p.A.).

Apply the fabric with the “dry” system technique using the following procedure:

- apply a coat of epoxy primer to the substrate (such as Mapewood Primer 100 produced by MAPEI S.p.A.);
- trowel apply an epoxy grout (such as Mapewood Paste 140 produced by MAPEI S.p.A.) to the substrate;
- impregnate the fabric after application for the “dry” system technique (such as with MapeWrap 31 produced by MAPEI S.p.A.);

The epoxy primer (such as Mapewood Primer 100 produced by MAPEI S.p.A.) must have the following performance characteristics:

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density of mix (g/cm³)</td>
<td>1.1</td>
</tr>
<tr>
<td>Brookfield viscosity (rotor 1-10 rpm) (mPa-s)</td>
<td>300</td>
</tr>
<tr>
<td>Adhesion to concrete (after 7 days at +23°C) (MPa)</td>
<td>&gt; 3 (failure of substrate)</td>
</tr>
</tbody>
</table>

The thixotropic epoxy adhesive (such as Mapewood Paste 140 produced by MAPEI S.p.A.) must have the following performance characteristics:

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile strength (ASTM C 579) (MPa)</td>
<td>30</td>
</tr>
<tr>
<td>Compressive strength (ASTM C 579) (MPa)</td>
<td>70</td>
</tr>
<tr>
<td>Compressive modulus of elasticity (ASTM C 579) (MPa)</td>
<td>8000</td>
</tr>
<tr>
<td>Flexural modulus of elasticity (ISO 178) (MPa)</td>
<td>4000</td>
</tr>
<tr>
<td>Adhesion to concrete (after 7 days at +23°C) (MPa)</td>
<td>&gt; 3 (failure of substrate)</td>
</tr>
</tbody>
</table>

The adhesive used to impregnate the fabric for the “dry” system (such as MapeWrap 31 produced by MAPEI S.p.A.) must have the following performance characteristics:

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brookfield viscosity (rotor 3-5 rpm) (mPa-s)</td>
<td>7000</td>
</tr>
<tr>
<td>Tensile strength (ASTM D 638) (MPa)</td>
<td>40</td>
</tr>
<tr>
<td>Tensile elongation (ASTM D 638) (%)</td>
<td>1.8</td>
</tr>
<tr>
<td>Compressive strength (ASTM C 579) (MPa)</td>
<td>60</td>
</tr>
<tr>
<td>Compressive modulus of elasticity (ASTM C 579) (MPa)</td>
<td>1400</td>
</tr>
<tr>
<td>Flexural modulus of elasticity (ISO 178) (MPa)</td>
<td>3000</td>
</tr>
<tr>
<td>Adhesion to concrete (after 7 days at +23°C) (MPa)</td>
<td>&gt; 3 (failure of substrate)</td>
</tr>
</tbody>
</table>
According to the type of operation to be carried out, there are various sizes of fabric available (20 or 40 cm wide) with a weight of 230 or 360 g/m².

The carbon fibre fabric must have the following characteristics, respectively:

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>230</th>
<th>360</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (g/m²)</td>
<td>230</td>
<td>360</td>
</tr>
<tr>
<td>Density (kg/m³)</td>
<td>1,810</td>
<td>1,810</td>
</tr>
<tr>
<td>Equivalent thickness of dry fabric (mm)</td>
<td>0.064</td>
<td>0.10</td>
</tr>
<tr>
<td>Resistant area per unit of width (mm²/m)</td>
<td>64.2</td>
<td>105</td>
</tr>
<tr>
<td>Tensile strength (N/mm²)</td>
<td>4,830</td>
<td>4,830</td>
</tr>
<tr>
<td>Maximum load per unit of width (kN/m)</td>
<td>&gt; 305</td>
<td>&gt; 500</td>
</tr>
<tr>
<td>Tensile modulus of elasticity (N/mm²)</td>
<td>230,000</td>
<td>230,000</td>
</tr>
<tr>
<td>Elongation at failure (%)</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Bond strength to concrete (N/mm²)</td>
<td>&gt; 3 (failure of substrate)</td>
<td></td>
</tr>
</tbody>
</table>

The following are included and calculated in the price for work completed according to specification:

- vacuuming all surfaces;
- application of system according to procedure described above;
- per square metre of fabric: weight 230 g/m²  ..........(€/m²)
- per square metre of fabric: weight 360 g/m²  ..........(€/m²)
G.3 STRENGTHENING WOODEN STRUCTURES
STRENGTHENING WOODEN STRUCTURES BY APPLYING POLYMER MATRIX COMPOSITES (FRP)

G.3.3.3 Application of high-strength, quadraxial carbon fibre fabric with a high modulus of elasticity

Supply and protected application of high-strength, quadraxial carbon fibre fabric (4,830 N/mm²) with a high modulus of elasticity (230,000 N/mm²) (such as MapeWrap C Quadri-AX produced by MAPEI S.p.A.).

Apply the fabric with the “dry” system technique using the following procedure:

- apply a coat of epoxy primer to the substrate (such as Mapewood Primer 100 produced by MAPEI S.p.A.);
- trowel apply an epoxy grout (such as Mapewood Paste 140 produced by MAPEI S.p.A.) to the substrate;
- impregnate the fabric after application for the “dry” system technique (such as with MapeWrap 31 produced by MAPEI S.p.A.);

The epoxy primer (such as Mapewood Primer 100 produced by MAPEI S.p.A.) must have the following performance characteristics:

- Density of mix (g/cm³): 1.1
- Brookfield viscosity (rotor 1-10 rpm) (mPa·s): 300
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)

The thixotropic epoxy adhesive (such as Mapewood Paste 140 produced by MAPEI S.p.A.) must have the following performance characteristics:

- Tensile strength (ASTM C 579) (MPa): 30
- Compressive strength (ASTM C 579) (MPa): 70
- Compressive modulus of elasticity (ASTM C 579) (MPa): 8000
- Flexural modulus of elasticity (ISO 178) (MPa): 4000
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)

The adhesive used to impregnate the fabric for the “dry” system (such as MapeWrap 31 produced by MAPEI S.p.A.) must have the following performance characteristics:

- Brookfield viscosity (rotor 3-5 rpm) (mPa·s): 7000
- Tensile strength (ASTM D 638) (MPa): 40
- Tensile elongation (ASTM D 638) (%): 1.8
- Compressive strength (ASTM C 579) (MPa): 60
- Compressive modulus of elasticity (ASTM C 579) (MPa): 1400
- Flexural modulus of elasticity (ISO 178) (MPa): 3000
- Adhesion to concrete (after 7 days at +23°C) (MPa): > 3 (failure of substrate)
According to the type of operation to be carried out, there are various sizes of fabric available (30 or 48 cm wide) with a weight of 380 or 760 g/m².

The carbon fibre fabric must have the following characteristics, respectively:

- **Weight (g/m²):** 380 760
- **Density (kg/m³):** 1,810 1,810
- **Equivalent thickness of dry fabric (mm):** 0.053 0.106
- **Resistant area per unit of width (mm²/m):** 53.1 106.1
- **Tensile strength (N/mm²):** 4,830 4,830
- **Maximum load per unit of width (kN/m):** > 254 > 500
- **Tensile modulus of elasticity (N/mm²):** 230,000 230,000
- **Elongation at failure (%):** 2 2
- **Bond strength to concrete (N/mm²):** > 3 (failure of substrate)

The following are included and calculated in the price for work completed according to specification:

- vacuuming all surfaces;
- application of system according to procedure described above;
- per square metre of fabric: weight 380 g/m² ................(€/m²)
- per square metre of fabric: weight 760 g/m² ................(€/m²)
G.3 **STRENGTHENING WOODEN STRUCTURES**

STRENGTHENING WOODEN STRUCTURES BY APPLYING POLYMER MATRIX COMPOSITES (FRP)

G.3.3.4 **Application of high-strength steel fibre fabric**

Supply and protected application of high-strength steel fibre fabric (2,845 N/mm²) (such as **MapeWrap S Fabric** produced by MAPEI S.p.A.).

Apply the fabric with the “dry” system technique using the following procedure:

- apply a coat of epoxy primer to the substrate (such as **Mapewood Primer 100** produced by MAPEI S.p.A.);
- trowel apply an epoxy grout (such as **Mapewood Paste 140** produced by MAPEI S.p.A.) to the substrate;
- apply the high-strength steel fibre fabric (such as **MapeWrap S Fabric** produced by MAPEI S.p.A.);
- apply another layer of epoxy grout (such as **Mapewood Paste 140** produced by MAPEI S.p.A.) so it covers the strengthening fabric evenly.

The epoxy primer (such as **MapeWrap Primer 1** produced by MAPEI S.p.A.) must have the following performance characteristics:

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density of mix (g/cm³)</td>
<td>1.1</td>
</tr>
<tr>
<td>Brookfield viscosity (rotor 1-10 rpm) (mPa-s)</td>
<td>300</td>
</tr>
<tr>
<td>Adhesion to concrete (after 7 days at +23°C) (MPa)</td>
<td>&gt; 3 (failure of substrate)</td>
</tr>
</tbody>
</table>

The thixotropic epoxy adhesive (such as **Mapewood Paste 140** produced by MAPEI S.p.A.) must have the following performance characteristics:

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile strength (ASTM C 579) (MPa)</td>
<td>30</td>
</tr>
<tr>
<td>Compressive strength (ASTM C 579) (MPa)</td>
<td>70</td>
</tr>
<tr>
<td>Compressive modulus of elasticity (ASTM C 579) (MPa)</td>
<td>8000</td>
</tr>
<tr>
<td>Flexural modulus of elasticity (ISO 178) (MPa)</td>
<td>4000</td>
</tr>
<tr>
<td>Adhesion to concrete (after 7 days at +23°C) (MPa)</td>
<td>&gt; 3 (failure of substrate)</td>
</tr>
</tbody>
</table>

The steel fibre fabric must have the following characteristics:

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (g/m²)</td>
<td>2,100</td>
</tr>
<tr>
<td>Average failure load per thread (N)</td>
<td>3,600</td>
</tr>
<tr>
<td>Resistant area per unit of width (mm²/m)</td>
<td>373.8</td>
</tr>
<tr>
<td>Tensile strength (N/mm²)</td>
<td>&gt; 2,845</td>
</tr>
<tr>
<td>Maximum load per unit of width (kN/m)</td>
<td>735</td>
</tr>
<tr>
<td>Tensile modulus of elasticity (N/mm²)</td>
<td>210,000</td>
</tr>
<tr>
<td>Elongation at failure (%)</td>
<td>2.6</td>
</tr>
<tr>
<td>Bond strength to concrete (N/mm²)</td>
<td>&gt; 2.4 (failure of substrate)</td>
</tr>
<tr>
<td>Tensile strength of impregnated fabric (N/mm²)</td>
<td>&gt; 1,900</td>
</tr>
<tr>
<td>Tensile modulus of elasticity of impregnated fabric (N/mm²)</td>
<td>&gt; 190,000</td>
</tr>
<tr>
<td>Elongation at failure of impregnated fabric (%)</td>
<td>&gt; 1</td>
</tr>
</tbody>
</table>
The following are included and calculated in the price for work completed according to specification:
– vacuuming all surfaces;
– application of system according to procedure described above;
– per linear metre of fabric applied \[\text{EUR/m}\]