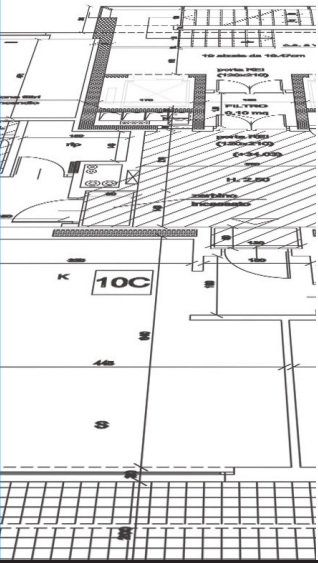


G

APPLICATION OF COMPOSITE MATERIALS



G

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G.1 STRENGTHENING CONCRETE STRUCTURES

STRENGTHENING CONCRETE STRUCTURES BY APPLYING POLYMER MATRIX COMPOSITES (FRP)

G.1.1 FLEXURAL STRENGTHENING OF FLOOR BEAMS AND JOISTS BY APPLYING PULTRUDED 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 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.1.1.1 Application of high-strength pultruded carbon fibre plates with a low modulus of elasticity

Supply and application of high-strength, pultruded carbon fibre plates ($\geq 3,100$ 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/cm ³): | 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/cm ³): | 1.61 | | |
| Fibre content (%): | 68 | | |
| Thickness (mm): | 1.4 | | |
| Width (mm): | 50 | 100 | 150 |
| Resistant section (mm ²): | 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)



G.1 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 ($\geq 3,100$ 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 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/cm ³): | 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/cm ³): | 1.61 | | |
| Fibre content (%): | 68 | | |
| Thickness (mm): | 1.4 | | |
| Width (mm): | 50 | 100 | 150 |
| Resistant section (mm ²): | 70 | 140 | 210 |
| Weight (g/m): | 113 | 225 | 338 |
| Tensile strength (MPa): | $\geq 3,300$ | | |
| 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 ($\geq 2,500$ 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:

| | |
|---|----------------------------|
| 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/cm ³): | 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/cm ³): | 1.61 | | |
| Fibre content (%): | 65 | | |
| Thickness (mm): | 1.4 | | |
| Width (mm): | 50 | 100 | 150 |
| Resistant section (mm ²): | 70 | 140 | 210 |
| Weight (g/m): | 113 | 225 | 338 |
| Tensile strength (MPa): | $\geq 2,500$ | | |
| 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.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 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.1.2.1 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/cm ³): | 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 |
| Compressive modulus of elasticity (ASTM C 579) (MPa): | 2000 |
| 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/m ²): | 300 | 600 |
| Density (kg/m ³): | 1,800 | 1,800 |
| Equivalent thickness of dry fabric (mm): | 0.166 | 0.333 |
| Resistant area per unit of width (mm ² /m): | 166.6 | 333.3 |
| Tensile strength (N/mm ²): | 4.830 | 4.830 |
| Maximum load per unit of width (kN/m): | > 800 | > 1,600 |
| Tensile modulus of elasticity (N/mm ²): | 230,000 | 230,000 |
| Elongation at failure (%): | 2 | 2 |
| Bond strength to concrete (N/mm ²): | > 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.1.2.2 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/cm ³): | 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 |
| Compressive modulus of elasticity (ASTM C 579) (MPa): | 2000 |
| 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/m ²): | 300 | 600 |
| Density (kg/m ³): | 1,820 | 1,820 |
| Equivalent thickness of dry fabric (mm): | 0.164 | 0.329 |
| Resistant area per unit of width (mm ² /m): | 164.8 | 329.6 |
| Tensile strength (N/mm ²): | 4,410 | 4,410 |
| Maximum load per unit of width (kN/m): | > 700 | > 1,400 |
| Tensile modulus of elasticity (N/mm ²): | 390,000 | 390,000 |
| Elongation at failure (%): | 1.1 | 1.1 |
| Bond strength to concrete (N/mm ²): | > 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.1.3 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 **Mapecer 1K** one-component, anti-corrosion cementitious mortar (see section [F.2.1.1](#)) or **Mapecer** 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:

- **Mapecrout 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](#));
- **Mapecrout 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/cm ³): | 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 |
| Compressive modulus of elasticity (ASTM C 579) (MPa): | 2000 |
| 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/m ²): | 300 | 600 |
| Density (kg/m ³): | 1,800 | 1,800 |
| Equivalent thickness of dry fabric (mm): | 0.166 | 0.333 |
| Resistant area per unit of width (mm ² /m): | 166.6 | 333.3 |
| Tensile strength (N/mm ²): | 4,830 | 4,830 |
| Maximum load per unit of width (kN/m): | > 800 | > 1,600 |
| Tensile modulus of elasticity (N/mm ²): | 230,000 | 230,000 |
| Elongation at failure (%): | 2 | 2 |
| Bond strength to concrete (N/mm ²): | > 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.1.3.2 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/cm ³): | 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 |
| Compressive modulus of elasticity (ASTM C 579) (MPa): | 2000 |
| 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/m ²): | 300 | 600 |
| Density (kg/m ³): | 1,820 | 1,820 |
| Equivalent thickness of dry fabric (mm): | 0.164 | 0.329 |
| Resistant area per unit of width (mm ² /m): | 164.8 | 329.6 |
| Tensile strength (N/mm ²): | 4,410 | 4,410 |
| Maximum load per unit of width (kN/m): | > 700 | > 1,400 |
| Tensile modulus of elasticity (N/mm ²): | 390,000 | 390,000 |
| Elongation at failure (%): | 1.1 | 1.1 |
| Bond strength to concrete (N/mm ²): | > 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.1.3.3 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/cm ³): | 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:

| | | |
|--|----------------------------|---------|
| Weight (g/m ²): | 230 | 360 |
| Density (kg/m ³): | 1,810 | 1,810 |
| Equivalent thickness of dry fabric (mm): | 0.064 | 0.10 |
| Resistant area per unit of width (mm ² /m): | 64.2 | 105 |
| Tensile strength (N/mm ²): | 4,830 | 4,830 |
| Maximum load per unit of width (kN/m): | > 305 | > 500 |
| Tensile modulus of elasticity (N/mm ²): | 230,000 | 230,000 |
| Elongation at failure (%): | 2 | 2 |
| Bond strength to concrete (N/mm ²): | > 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 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:

| | |
|---|----------------------------|
| Density of mix (g/cm ³): | 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 (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/m ²): | 380 | 760 |
| Density (kg/m ³): | 1,810 | 1,810 |
| Equivalent thickness of dry fabric (mm): | 0.053 | 0.106 |
| Resistant area per unit of width (mm ² /m): | 53.1 | 106.1 |
| Tensile strength (N/mm ²): | 4,830 | 4,830 |
| Maximum load per unit of width (kN/m): | > 254 | > 500 |
| Tensile modulus of elasticity (N/mm ²): | 230,000 | 230,000 |
| Elongation at failure (%): | 2 | 2 |
| Bond strength to concrete (N/mm ²): | > 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 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/cm ³): | 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/m ²): | 2,100 |
| Average failure load per thread (N): | 3,600 |
| Resistant area per unit of width (mm ² /m): | 373.8 |
| Tensile strength (N/mm ²): | > 2,845 |
| Maximum load per unit of width (kN/m): | 735 |
| Tensile modulus of elasticity (N/mm ²): | 210,000 |
| Elongation at failure (%): | 2.6 |
| Bond strength to concrete (N/mm ²): | > 2.4 (failure of substrate) |
| Tensile strength of impregnated fabric (N/mm ²): | > 1,900 |
| Tensile modulus of elasticity of impregnated fabric (N/mm ²): | > 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.);
- place the portions of high-strength steel fibre cord (such as **MapeWrap S Fiocco** 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/cm ³): | 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/mm ²): | 2,086 | |
| Tensile modulus of elasticity (N/mm ²): | 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 (mm ² /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 COMPRESSIVE 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 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.1.4.1 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/cm ³): | 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 |
| Compressive modulus of elasticity (ASTM C 579) (MPa): | 2000 |
| 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/m ²): | 300 | 600 |
| Density (kg/m ³): | 1,800 | 1,800 |
| Equivalent thickness of dry fabric (mm): | 0.166 | 0.333 |
| Resistant area per unit of width (mm ² /m): | 166.6 | 333.3 |
| Tensile strength (N/mm ²): | 4,830 | 4,830 |
| Maximum load per unit of width (kN/m): | > 800 | > 1,600 |
| Tensile modulus of elasticity (N/mm ²): | 230,000 | 230,000 |
| Elongation at failure (%): | 2 | 2 |
| Bond strength to concrete (N/mm ²): | > 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/cm ³): | 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 |
| Compressive modulus of elasticity (ASTM C 579) (MPa): | 2000 |
| 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/m ²): | 300 | 600 |
| Density (kg/m ³): | 1,820 | 1,820 |
| Equivalent thickness of dry fabric (mm): | 0.164 | 0.329 |
| Resistant area per unit of width (mm ² /m): | 164.8 | 329.6 |
| Tensile strength (N/mm ²): | 4,410 | 4,410 |
| Maximum load per unit of width (kN/m): | > 700 | > 1,400 |
| Tensile modulus of elasticity (N/mm ²): | 390,000 | 390,000 |
| Elongation at failure (%): | 1.1 | 1.1 |

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 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/cm ³): | 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 |
| Compressive modulus of elasticity (ASTM C 579) (MPa): | 2000 |
| 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:

| | | |
|--|----------------------------|-------|
| Type of fibres: | type E glass | |
| Weight (g/m ²): | 300 | 900 |
| Density (kg/m ³): | 2,620 | 2,620 |
| Equivalent thickness of dry fabric (mm): | 0.16 | 0.48 |
| Resistant area per unit of width (mm ² /m): | 114.1 | 342.2 |
| Tensile strength (N/mm ²): | 2,560 | 2,560 |
| Tensile modulus of elasticity (N/mm ²): | 70 | 70 |
| Elongation at failure (%): | > 3 | > 3 |
| Bond strength to concrete (N/mm ²): | > 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 900 g/m²(€/m²)



G.1 STRENGTHENING CONCRETE STRUCTURES

STRENGTHENING CONCRETE STRUCTURES BY APPLYING POLYMER MATRIX COMPOSITES (FRP)

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/cm ³): | 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:

| | | |
|--|----------------------------|-------|
| Type of fibres: | basalt 1220 tex | |
| Weight (g/m ²): | 400 | 600 |
| Density (kg/m ³): | 2,750 | 2,750 |
| Equivalent thickness of dry fabric (mm): | 0.143 | 0.214 |
| Resistant area per unit of width (mm ² /m): | 142.6 | 214.2 |
| Tensile strength (N/mm ²): | 2,560 | 2,560 |
| Tensile modulus of elasticity (N/mm ²): | 89 | 89 |
| Elongation at failure (%): | > 3 | > 3 |
| Bond strength to concrete (N/mm ²): | > 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 400 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.1.6 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.

Quadraxial 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:

| | |
|---|----------------------------|
| Density of mix (g/cm ³): | 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 |
| Compressive modulus of elasticity (ASTM C 579) (MPa): | 2000 |
| 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/m ²): | 300 | 600 |
| Density (kg/m ³): | 1,800 | 1,800 |
| Equivalent thickness of dry fabric (mm): | 0.166 | 0.333 |
| Resistant area per unit of width (mm ² /m): | 166.6 | 333.3 |
| Tensile strength (N/mm ²): | 4,830 | 4,830 |
| Maximum load per unit of width (kN/m): | > 800 | > 1.600 |
| Tensile modulus of elasticity (N/mm ²): | 230,000 | 230,000 |
| Elongation at failure (%): | 2 | 2 |
| Bond strength to concrete (N/mm ²): | > 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)

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

| | |
|---|----------------------|
| density of mix (kg/m ³): | 1,850 |
| compressive strength (EN 12190) (N/mm ²): | ≥ 25 (after 28 days) |
| flexural strength (EN196/1) (N/mm ²): | ≥ 7 (after 28 days) |
| compressive modulus of elasticity (N/mm ²): | 8,000 |
| adhesion to masonry (N/mm ²): | ≥ 2.0 |

- 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/cm ³): | 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 |
| Compressive modulus of elasticity (ASTM C 579) (MPa): | 2000 |
| Flexural modulus of elasticity (ISO 178) (MPa): | 2500 |
| Adhesion to concrete (after 7 days at +23°C +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/m ²): | 300 | 600 |
| Density (kg/m ³): | 1,800 | 1,800 |
| Equivalent thickness of dry fabric (mm): | 0.166 | 0.333 |
| Resistant area per unit of width (mm ² /m): | 166.6 | 333.3 |
| Tensile strength (N/mm ²): | 4,830 | 4,830 |
| Maximum load per unit of width (kN/m): | > 800 | > 1,600 |
| Tensile modulus of elasticity (N/mm ²): | 230,000 | 230,000 |
| Elongation at failure (%): | 2 | 2 |
| Bond strength to concrete (N/mm ²): | > 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.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:

| | |
|---|----------------------|
| Density of mix (kg/m ³): | 1,850 |
| Compressive strength (EN 12190) (N/mm ²): | ≥ 25 (after 28 days) |
| Flexural strength (EN196/1) (N/mm ²): | ≥ 7 (after 28 days) |
| Compressive modulus of elasticity (N/mm ²): | 8,000 |
| Adhesion to masonry (N/mm ²): | ≥ 2.0 |

- 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/cm ³): | 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 21** 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 |
| Compressive modulus of elasticity (ASTM C 579) (MPa): | 2000 |
| 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:

| | | |
|--|----------------------------|-------|
| Type of fibres: | type E glass | |
| Weight (g/m ²): | 300 | 900 |
| Density (kg/m ³): | 2,620 | 2,620 |
| Equivalent thickness of dry fabric (mm): | 0.16 | 0.48 |
| Resistant area per unit of width (mm ² /m): | 114.1 | 342.2 |
| Tensile strength (N/mm ²): | 2,560 | 2,560 |
| Tensile modulus of elasticity (N/mm ²): | 70 | 70 |
| Elongation at failure (%): | > 3 | > 3 |
| Bond strength to concrete (N/mm ²): | > 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 900 g/m²(€/m²)



G.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/m ³): | 1,850 |
| Compressive strength (EN 12190) (N/mm ²): | ≥ 25 (after 28 days) |
| Flexural strength (EN196/1) (N/mm ²): | ≥ 7 (after 28 days) |
| Compressive modulus of elasticity (N/mm ²): | 8,000 |
| Adhesion to masonry (N/mm ²): | ≥ 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/cm ³): | 1.54 |
| Nominal diameter (mm): | 9.7 |
| Content of carbon fibre by weight (%): | 71 |
| Cross-section area (mm ²): | 73.9 |
| Tensile strength (N/mm ²): | 2,000 |
| Shear strength (EN 1502-3) (N/mm ²): | 75 |
| Tensile modulus of elasticity (N/mm ²): | 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:

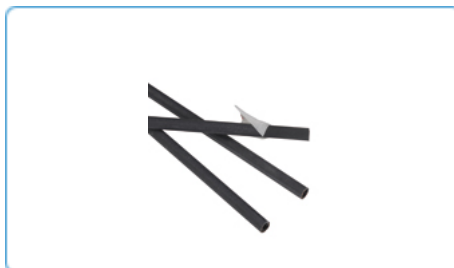
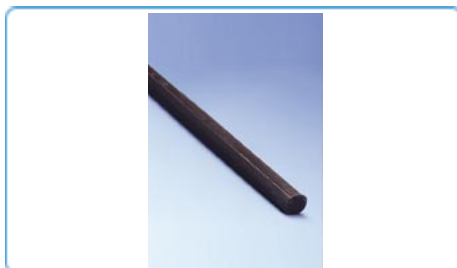
| | |
|---|-------------------------|
| Density (g/cm ³): | 1.995 |
| Nominal diameter (mm): | 9.53 |
| Content of carbon fibre by weight (%): | 75 |
| Cross-section area (mm ²): | 71.26 |
| Tensile strength (N/mm ²): | 760 |
| Tensile modulus of elasticity (N/mm ²): | 40,800 |
| Elongation at failure (%): | 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/cm ³): | 1.610 |
| Outside diameter (mm): | 10 |
| Inside diameter (mm): | 8 |
| Content of carbon fibre by weight (%): | 68 |
| Tensile strength (N/mm ²): | 3,100 |
| Tensile modulus of elasticity (N/mm ²): | 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 (€/m)
- per linear metre of pultruded tube (€/m)



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:

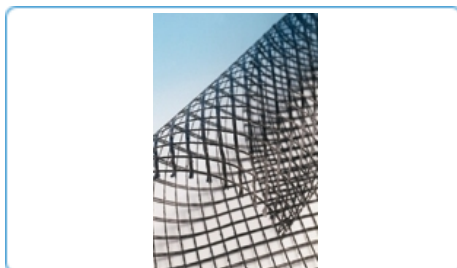
| | |
|-----------------------------|------------------|
| Type of fibre: | A.R. glass fibre |
| Weight (g/m ²): | 225 |
| Mesh size (mm): | 25×25 |
| Tensile strength (kN/m): | 45 |
| Elongation at failure (%): | < 3 |

The two-component mortar must have the following characteristics:

| | |
|---|----------------------|
| Density of mix (kg/m ³): | 1,850 |
| Compressive strength (EN 12190) (N/mm ²): | ≥ 25 (after 28 days) |
| Flexural strength (EN196/1) (N/mm ²): | ≥ 7 (after 28 days) |
| Compressive modulus of elasticity (N/mm ²): | 8,000 |
| Adhesion to masonry (N/mm ²): | ≥ 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:

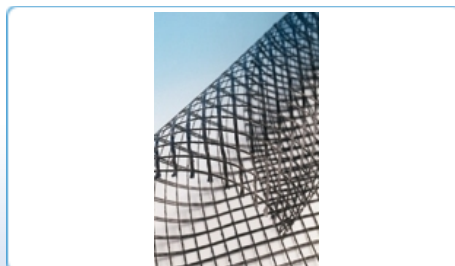
| | |
|-----------------------------|------------------|
| Type of fibre: | A.R. glass fibre |
| Weight (g/m ²): | 225 |
| Mesh size (mm): | 25x25 |
| Tensile strength (kN/m): | 45 |
| Elongation at failure (%): | < 3 |

The two-component mortar must have the following characteristics:

| | |
|--|--|
| Density of mix (kg/m ³): | 1,900 |
| Compressive strength (EN 12190) (N/mm ²): | ≥ 15 (after 28 days) |
| Initial shear strength (EN 1502-3) (N/mm ²): | 0.15 |
| Compressive modulus of elasticity (N/mm ²): | 8,000 |
| Adhesion to masonry (N/mm ²): | ≥ 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 STRENGTHENING MASONRY STRUCTURES

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/m ²): | 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/m ³): | 1,850 |
| Compressive strength (EN 12190) (N/mm ²): | ≥ 25 (after 28 days) |
| Flexural strength (EN196/1) (N/mm ²): | ≥ 7 (after 28 days) |
| Compressive modulus of elasticity (N/mm ²): | 8,000 |
| Adhesion to masonry (N/mm ²): | ≥ 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.2.2.4 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/m ²): | 125 |
| Mesh size (mm): | 12.7×12.7 |
| Tensile strength (kN/m): | 30 |
| Elongation at failure (%): | < 3 |

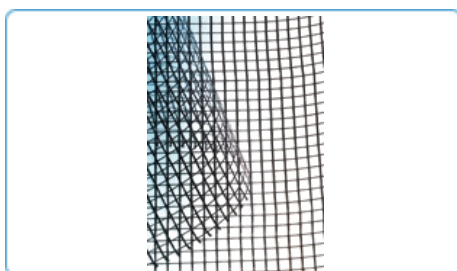
The two-component mortar must have the following characteristics:

| | |
|---|----------------------|
| Density of mix (kg/m ³): | 1,850 |
| Compressive strength (EN 12190) (N/mm ²): | ≥ 25 (after 28 days) |
| Flexural strength (EN196/1) (N/mm ²): | ≥ 7 (after 28 days) |
| Compressive modulus of elasticity (N/mm ²): | 8,000 |
| Adhesion to masonry (N/mm ²): | ≥ 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.3 STRENGTHENING WOODEN STRUCTURES

STRENGTHENING WOODEN STRUCTURES BY APPLYING POLYMER MATRIX COMPOSITES (FRP)

G.3.1 FLEXURAL STRENGTHENING OF FLOOR BEAMS AND JOISTS BY APPLYING PULTRUDED CARBON FIBRE PLATES

G.3.1.1 Application of high-strength pultruded carbon fibre plates with a low modulus of elasticity

Supply and application of high-strength, pultruded carbon fibre plates ($\geq 3,100$ 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/cm ³): | 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/cm ³): | 1.61 | | |
| Fibre content (%): | 68 | | |
| Thickness (mm): | 1.4 | | |
| Width (mm): | 50 | 100 | 150 |
| Resistant section (mm ²): | 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)



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 ($\geq 3,100$ 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/cm ³): | 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/cm ³): | 1.61 | | |
| Fibre content (%): | 68 | | |
| Thickness (mm): | 1.4 | | |
| Width (mm): | 50 | 100 | 150 |
| Resistant section (mm ²): | 70 | 140 | 210 |
| Weight (g/m): | 113 | 225 | 338 |
| Tensile strength (MPa): | $\geq 3,300$ | | |
| 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 ($\geq 2,500$ 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/cm ³): | 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/cm ³): | 1.61 | | |
| Fibre content (%): | 65 | | |
| Thickness (mm): | 1,4 | | |
| Width (mm): | 50 | 100 | 150 |
| Resistant section (mm ²): | 70 | 140 | 210 |
| Weight (g/m): | 113 | 225 | 338 |
| Tensile strength (MPa): | $\geq 2,500$ | | |
| 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 **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/cm ³): | 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 (**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 (**MapeWrap 21**) 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 |
| Compressive modulus of elasticity (ASTM C 579) (MPa): | 2000 |
| 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 (**MapeWrap 31**) 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/m ²): | 300 | 600 |
| Density (kg/m ³): | 1,800 | 1,800 |
| Equivalent thickness of dry fabric (mm): | 0.166 | 0.333 |
| Resistant area per unit of width (mm ² /m): | 166.6 | 333.3 |
| Tensile strength (N/mm ²): | 4,830 | 4,830 |
| Maximum load per unit of width (kN/m): | > 800 | > 1,600 |
| Tensile modulus of elasticity (N/mm ²): | 230,000 | 230,000 |
| Elongation at failure (%): | 2 | 2 |
| Bond strength to concrete (N/mm ²): | > 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 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/cm ³): | 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 |
| Compressive modulus of elasticity (ASTM C 579) (MPa): | 2000 |
| 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/m ²): | 300 | 600 |
| Density (kg/m ³): | 1,800 | 1,800 |
| Equivalent thickness of dry fabric (mm): | 0.166 | 0.333 |
| Resistant area per unit of width (mm ² /m): | 166.6 | 333.3 |
| Tensile strength (N/mm ²): | 4,830 | 4,830 |
| Maximum load per unit of width (kN/m): | > 800 | > 1,600 |
| Tensile modulus of elasticity (N/mm ²): | 230,000 | 230,000 |
| Elongation at failure (%): | 2 | 2 |
| Bond strength to concrete (N/mm ²): | > 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 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:

| | |
|---|----------------------------|
| Density of mix (g/cm ³): | 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 (20 or 40 cm wide) with a weight of 230 or 360 g/m².

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

| | | |
|--|----------------------------|---------|
| Weight (g/m ²): | 230 | 360 |
| Density (kg/m ³): | 1,810 | 1,810 |
| Equivalent thickness of dry fabric (mm): | 0.064 | 0.10 |
| Resistant area per unit of width (mm ² /m): | 64.2 | 105 |
| Tensile strength (N/mm ²): | 4,830 | 4,830 |
| Maximum load per unit of width (kN/m): | > 305 | > 500 |
| Tensile modulus of elasticity (N/mm ²): | 230,000 | 230,000 |
| Elongation at failure (%): | 2 | 2 |
| Bond strength to concrete (N/mm ²): | > 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 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/cm ³): | 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/m ²): | 380 | 760 |
| Density (kg/m ³): | 1,810 | 1,810 |
| Equivalent thickness of dry fabric (mm): | 0.053 | 0.106 |
| Resistant area per unit of width (mm ² /m): | 53.1 | 106.1 |
| Tensile strength (N/mm ²): | 4,830 | 4,830 |
| Maximum load per unit of width (kN/m): | > 254 | > 500 |
| Tensile modulus of elasticity (N/mm ²): | 230,000 | 230,000 |
| Elongation at failure (%): | 2 | 2 |
| Bond strength to concrete (N/mm ²): | > 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:

| | |
|---|----------------------------|
| Density of mix (g/cm ³): | 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 steel fibre fabric must have the following characteristics:

| | |
|---|------------------------------|
| Weight (g/m ²): | 2,100 |
| Average failure load per thread (N): | 3,600 |
| Resistant area per unit of width (mm ² /m): | 373.8 |
| Tensile strength (N/mm ²): | > 2,845 |
| Maximum load per unit of width (kN/m): | 735 |
| Tensile modulus of elasticity (N/mm ²): | 210,000 |
| Elongation at failure (%): | 2.6 |
| Bond strength to concrete (N/mm ²): | > 2.4 (failure of substrate) |
| Tensile strength of impregnated fabric (N/mm ²): | > 1,900 |
| Tensile modulus of elasticity of impregnated fabric (N/mm ²): | > 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 system according to procedure described above;
- *per linear metre of fabric applied*(€/m)

