A guide to choosing composites for structural strengthening
A guide to choosing composites for structural strengthening

The use of composites is now one of the consolidated strengthening techniques employed for the static and seismic upgrading of existing reinforced concrete, masonry and wooden structures. Mapei has a line of products available that have been perfected and consolidated through more than 17 years of experience, from the classic polymer matrix and fibre Mapei FRP System to the more modern concept of strengthening based on the use of inorganic matrixes and fibres, the Mapei FRP System, and the innovative anti-seismic protection system, MapeWrap EQ System.

Mapei FRP System

A complete range of composites made from very high strength fibres and polymeric resins specially formulated for the strengthening and static and seismic upgrading of structures made from normal, pre-stressed and reinforced concrete, steel, masonry or wood. Strengthening systems from the Mapei FRP System line comply with the indications of the technical reference document CNR DT 200/2004 and are classified as TYPE A certified systems, offering considerable advantages in terms of final quality and safety of installations carried out.
Guide to choosing

**Mapei FRG System**

A complete range of composites which, unlike traditional FRP, uses an inorganic, pozzolanic binder rather than a polymeric matrix to guarantee excellent chemical-physical and elasto-mechanical compatibility with masonry substrates (stone, bricks and tuff). They may be applied to repair structures in reinforced concrete and masonry.

**MapeWrap EQ System**

An innovative protection system in the form of “seismic wallpaper” to give people more time to evacuate a building if there is an earthquake. It acts like an “air-bag” for internal and external secondary partition walls (e.g. buffer walls), and stops walls collapsing or tipping over during seismic activity.
Planitop HPC and Planitop HPC Floor
High Performance Micro-Concrete

A system made from High Performance Fibre Reinforced Concrete (HPFRC). The main performance properties characterising this new type of cementitious composite are extremely high compressive strength and its capacity to absorb high fracture energy, or ductility. And lastly, its tensile strength allows for considerably less traditional reinforcement to be used, in accordance with the technical document CNR DT 204/2006.

Types of installation using FRP

- Repairing and static and seismic upgrading of unstable or weak structures where shear strength needs to be supplemented;
- Confinement of compressed or compressed/flexed members (pillars, bridge piles, chimneys) to improve their load-bearing properties or their ductility where longitudinal reinforcement also needs to be supplemented;
- Strengthening flexed members by creating an external sleeve to areas subjected to tensile loads;
- Repairing structures with localised impact damage, such as bridge beams hit by trucks carrying tall or wide loads;
- Seismic upgrading and restoration of domed structures without increasing their seismic mass and without the risk of liquids percolating towards the internal surface;
- Creating sleeves around beam-pillar hinge zones for seismic upgrading;
- Strengthening load-bearing members in buildings whose structural system has been modified due to new architectural requirements or change in use;
- Repairs to structures damaged by fire.

Types of installation using FRG

- Structural strengthening of facing walls, applied on the internal and/or external face;
- Strengthened reinforcement for both concrete and masonry members to distribute stresses induced by seismic activity more uniformly;
- Strengthened reinforcement and attachment points to hold load-bearing walls together correctly and more solidly to structures with a reinforced concrete framework.
Advantages of using **Mapei FRP** and **FRG Systems**

There are numerous advantages deriving from the use of products from the **Mapei FRP** and **FRG System** lines compared with traditional repair techniques, and the most significant are as follows:

- Simple, quick application: thanks to their low weight, they do not require special equipment or lifting gear to put them in place, only a small workforce is required to place the materials in a very short space of time and, in many cases, it is not even necessary to interrupt the normal activities of the structure itself;
- Highly durable;
- High mechanical performance;
- Unlike repair work by cladding with steel plates (the beton plaqué technique), there is no problem of corrosion of the strengthening materials applied;
- No increase of the mass involved: installations using **Mapei FRP** and **FRG System** do not increase the overall mass of the structural members that have been strengthened. This aspect is extremely important, particularly in the field of seismic upgrading, where the stresses are proportional to the mass involved;
- Installations are completely reversible: installations using **Mapei FRP** and **FRG System** are completely reversible, in that the strengthening materials and layers of adhesive may be completely removed and the structure returned to the same condition as before the installation. This characteristic is particularly important when carrying out work to make buildings temporarily safe, especially on those of historical interest.
Strengthening reinforced concrete structures

List of system

1. Flexural strengthening of beams, floor joists and floor slabs
2. Shear strengthening of beams
3. Confinement of columns
4. Combined bending and axial load strengthening at the base of pillars embedded in foundations
5. Strengthening frames: confinement of column-beam junctions
6. Anti-seismic protection for non structural partition walls
7. Anti-overturning system for buffer walls
8. Anti-collapse system for floor slabs
9. Strengthening the outer face of floor slabs
1 Flexural strengthening of beams, floor joists and floor slabs

The strengthening system may be applied using Carboplate pultruded carbon fibre plates such as:

- **Carboplate E 170**
- **Carboplate E 200**
- **Carboplate E 250**

(*ref. Application cycle for Carboplate plates*)
(*ref. “Design Guide” procedure G.1.2 and relative technical specifications*)

The strengthening system may be formed by applying carbon fibre, glass fibre, basalt fibre or steel fibre fabric such as:

- **MapeWrap C UNI-AX**
- **MapeWrap C UNI-AX HM**
- **MapeWrap G UNI-AX**
- **MapeWrap B UNI-AX**
- **MapeWrap S Fabric**

(**ref. Application cycle for MapeWrap fabric**)
(*ref. “Design Guide” procedure G.1.3 and relative technical specifications*)

2 Shear strengthening of beams

The strengthening system may be formed by applying carbon fibre, glass fibre, basalt fibre or steel fibre fabric such as:

- **MapeWrap C UNI-AX**
- **MapeWrap C UNI-AX HM**
- **MapeWrap C BI-AX**
- **MapeWrap C QUADRI-AX**
- **MapeWrap G UNI-AX**
- **MapeWrap B UNI-AX**
- **MapeWrap S Fabric**

(**ref. Application cycle for MapeWrap fabric**)
(****ref. Application cycle for MapeWrap steel fibres**)
(*ref. “Design Guide” procedure G.1.4 and relative technical specifications*)
3 Confinement of columns

Compressive strength and ductility may be increased by applying one of the following:
- MapeWrap C UNI-AX
- or
- MapeWrap C UNI-AX HM

Ductility may be increased by applying one of the following:
- MapeWrap G UNI-AX
- or
- MapeWrap B UNI-AX

(***ref. Application cycle for MapeWrap fabric)
(*ref. “Design Guide” procedures G.1.5 and G.1.6 and relative technical specifications)

4 Combined bending and axial load strengthening at the base of pillars embedded in foundations

The strengthening system may be formed by carrying out the following operations:
1) Bending and axial load strengthening using one of the following:
   - MapeWrap S Fabric
   - or
   - MapeWrap C UNI-AX
   - or
   - Carboplate E 170/E 200/E 250

2) Anchoring ropes using one of the following:
   - MapeWrap S Fabric
   - or
   - MapeWrap S FIOCCO

3) Confinement of pillars:
   - MapeWrap C UNI-AX

(*ref. “Design Guide” procedure G.1.9 and relative technical specifications)

5 Strengthening frames: confinement of column-beam junctions

The strengthening system may be formed by carrying out the following operations:
1) Shear strengthening: MapeWrap S Fabric
2) Increasing shear strength of column-beam junction: MapeWrap C QUADRI-AX
3) Confinement of the ends of pillars: MapeWrap C UNI-AX
4) Shear strengthening of the ends of beams: MapeWrap C UNI-AX

(*ref. “Design Guide” procedure G.1.7 and relative technical specifications)
**Guide to choosing**

### 6. Anti-seismic protection for non structural partition walls

The strengthening system is formed by applying:
- **MapeWrap EQ Net**
- **MapeWrap EQ Adhesive**

(*ref. "Design Guide" procedure G.3.2 and relative technical specifications)

### 7. Anti-overturning system for buffer walls

The strengthening system is formed by applying:
- **Planitop HDM/Planitop HDM Maxi**
- **Mapegrid G 120**
- **MapeWrap S FIOCCO**

(*ref. "Design Guide" procedure G.3.1 and relative technical specifications)

### 8. Anti-collapse system for floor slabs

The strengthening system is formed by applying:
- **MapeWrap EQ Net**
- **MapeWrap EQ Adhesive**

(*ref. "Design Guide" procedure G.3.2 and relative technical specifications)

### 9. Strengthening the outer face of floor slabs

The strengthening system is formed by applying:
- **Planitop HPC Floor**

(*ref. "Design Guide" procedure G.1.12 and relative technical specifications)

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**Sleeves made from Carboplate plates are formed by applying the following epoxy system:**

1. Epoxy primer – **MapeWrap Primer 1**
2. Epoxy adhesive – **MapeWrap 11 (or MapeWrap 12)**
3. **Carboplate carbon fibre plates**
4. Epoxy adhesive – **MapeWrap 11 (or MapeWrap 12)**
5. Surface dusting with sand – **QUARTZ 1.2/QUARTZ 1.9**

**Sleeves made from MapeWrap fabrics are formed by applying the following epoxy system:**

1. Epoxy primer – **MapeWrap Primer 1**
2. Epoxy adhesive – **MapeWrap 11 (or MapeWrap 12)**
3. Epoxy adhesive to impregnate the fabric using the “dry system” – **MapeWrap 31**
4. Epoxy adhesive to impregnate the fabric using the “wet system” – **MapeWrap 21**
5. **CARBON/ GLASS/ BASALT fibres**
6. Surface dusting with sand – **QUARTZ 1.2/QUARTZ 1.9**

**Sleeves made from MapeWrap steel fibres are formed by applying the following epoxy system:**

1. Epoxy primer – **MapeWrap Primer 1**
2. Epoxy adhesive – **MapeWrap 11 (or MapeWrap 12)**
3. **STEEL fibres**
4. Surface dusting with sand – **QUARTZ 1.2/QUARTZ 1.9**
Strengthening masonry structures

List of system

1. Structural strengthening of masonry arches and vaults using inorganic matrix composites – Mapei FRG System
2. Structural strengthening of masonry arches and vaults using organic matrix composites – Mapei FRP System
3. Shear strengthening of walls using inorganic matrix composites – Mapei FRG System
4. Reinforced stitching for disconnected masonry (corner and “t” intersections)
5. Strengthening of wooden structures
6. Tie area strips

(*) the characteristics of the products correspond precisely with those listed in the RELIUS GUIDE LINES for the repair and strengthening of structural elements, buffer walls and partition walls.
1 Structural strengthening of masonry arches and vaults using inorganic matrix composites – *Mapei FRG System*

The strengthening system may be formed by applying:
- **Planitop HDM Restauro**
- **Mapegrid G 220**

Or
- **Planitop HDM Restauro**
- **Mapegrid B 250**

Dedicated connections are recommended to protect the strengthening using: **MapeWrap G FIOCCO** or **MapeWrap B FIOCCO**

(*ref. “Design Guide” procedures G.2.4, G.2.8 and G.2.9 and relative technical specifications*)

2 Structural strengthening of masonry arches and vaults using organic matrix composites – *Mapei FRP System*

The strengthening system may be formed by applying dedicated bands of carbon fibre, glass fibre or basalt fibre fabric such as:
- **MapeWrap C UNI-AX**
- **MapeWrap C BI-AX**
- **MapeWrap C QUADRI-AX**
- **MapeWrap G UNI-AX**
- **MapeWrap G QUADRI-AX**
- **MapeWrap B UNI-AX**

(***ref. Application cycle for MapeWrap fabric**)

Dedicated connections are recommended to protect the strengthening using: **MapeWrap G FIOCCO** or **MapeWrap B FIOCCO**

(*ref. “Design Guide” procedures G.2.4 and G.2.10 and relative technical specifications*)
3 Shear strengthening of walls using inorganic matrix composites – Mapei FRG System

The strengthening system may be formed by applying the following:
- **Planitop HDM Restauro**
- **Mapegrid G 220**

Or
- **Planitop HDM Restauro**
- **Mapegrid B 250**

Dedicated connections are recommended to protect the strengthening using: **MapeWrap G FIOCCO** or **MapeWrap B FIOCCO**

(*ref. “Design Guide” procedures G.2.4 and G.2.6 and relative technical specifications*)

4 Reinforced stitching for disconnected masonry (corner and “t” intersections)

Reinforced stitching is carried out using **Carbotube** and **Injectors Φ23** in combination with:
- **Epojet** and **Epojet LV** epoxy resins;
- **Mape-Antique I, Mape-Antique F21** or **Mape-Antique I-15** fluid slurry

(*ref. “Design Guide” procedure G.2.7 and relative technical specifications*)
5 Strengthening of wooden structures

Flexural strengthening of wooden beams using Carboplate pultruded carbon fibre plates such as:
- **Carboplate E 170**
- **Carboplate E 200**
- **Carboplate E 250**

(**ref. Application cycle for Carboplate plates**)
(*ref. “Design Guide” procedure G.4.4 and relative technical specifications)

Flexural strengthening of wooden beams using carbon fibre, glass fibre, basalt fibre or steel fibre fabric such as:
- **MapeWrap C UNI-AX**
- **MapeWrap C BI-AX**
- **MapeWrap G UNI-AX**
- **MapeWrap B UNI-AX**
- **MapeWrap S Fabric**

(**ref. Application cycle for MapeWrap fabric**)
(****ref. Application cycle for MapeWrap steel fibre fabric**)
(*ref. “Design Guide” procedure G.4.5 and relative technical specifications)

Flexural strengthening of wooden beams using pultruded carbon fibre or glass fibre bars such as:
- **Maperod C**
- **Maperod G**

used in combination with **MapeWood Paste 140** thixotropic epoxy adhesive or **Mapefix EP 385** epoxy chemical anchor

(*ref. “Design Guide” procedure G.4.6 and relative technical specifications)

6 Tie area strips

The strengthening system may be applied using carbon fibre, glass fibre or basalt fibre fabric such as:
- **MapeWrap C UNI-AX**
- **MapeWrap G UNI-AX**
- **MapeWrap B UNI-AX**

(***ref. Application cycle for MapeWrap fabric**)

Dedicated connections are recommended to protect the strengthening using: **MapeWrap C FIOCCO**, **MapeWrap G FIOCCO** or **MapeWrap B FIOCCO**

(*ref. “Design Guide” procedures G.2.4 and G.2.11 and relative technical specifications)
Strengthening prefabricated industrial buildings

List of system

1. Combined bending and axial load strengthening around the pillar’s base using fibre-reinforced composites with “anchoring ropes”
2. Confinement and combined bending and axial load strengthening at the pillar’s base by forming a sleeve in high performance fibre-reinforced concrete (HPFRC)
3. Connecting buffer walls to load-bearing structures using an anti-overturning system

(*) the characteristics of the products correspond precisely with those listed in the “Guide lines for localised and global interventions on single storey industrial buildings not designed according to anti-seismic criteria” issued after the earthquake in Emilia Romagna.
1 Combined bending and axial load strengthening around the pillar’s base using fibre-reinforced composites with “anchoring ropes”

The strengthening system may be formed by carrying out the following operations:
1) Combined bending and axial load strengthening using one of the following:
   - MapeWrap S Fabric;
   - MapeWrap C UNI-AX

2) Anchoring ropes using one of the following:
   - MapeWrap S Fabric;
   - MapeWrap S FIOCCO

3) Confinement of pillars: MapeWrap C UNI-AX
   (*ref. “Design Guide” procedure G.1.9 and relative technical specifications)

2 Confinement and combined bending and axial load strengthening at the pillar’s base by forming a sleeve in high performance fibre-reinforced concrete (HPFRC)

The strengthening system is formed by applying:
- Planitop HPC
- Fibres HPC

(*ref. “Design Guide” procedure G.1.10 and relative technical specifications)

3 Connecting buffer walls to load-bearing structures using an anti-overturning system

The strengthening system is formed by applying:
- Planitop HDM/Planitop HDM Maxi
- Mapegrid G 120
- MapeWrap S FIOCCO

(*ref. “Design Guide” procedure G.3.1 and relative technical specifications)
| **Carboplate** | Pultruded carbon fibre plate impregnated with epoxy resin with a protective plastic film on both faces. |
| **Carbotube** | Pultruded carbon fibre tube impregnated with epoxy resin for reinforced injections in masonry. |
| **Epojet** | Two-component, super-fluid epoxy resin for injections and anchorings. |
| **Epojet LV** | Two-component epoxy resin with a very low viscosity for injecting into microcracks. |
| **Injectors Ø 23** | Plastic injectors with a non-return valve for injecting epoxy resin. |
| **Mape-Antique F21** | Super-fluid, salt-resistant, hydraulic binder with fillers made from lime and Eco-Pozzolan applied by injection for consolidating masonry and render, including the frescoed ones. |
| **Mape-Antique I** | Super-fluid, salt-resistant, lime and Eco-Pozzolan-based, hydraulic binder with fillers applied by injection for consolidating masonry. |
| **Mape-Antique I-15** | Salt-resistant, fillerized, lime and Eco-Pozzolan-based hydraulic binder for making super-fluid injection slurry for consolidating masonry. |
| **Mapefix EP 385** | Pure epoxy, resin-based chemical anchor for structural loads. Certified for threaded bar, construction bars, core-drilled holes and C1 seismic loads. |
| **Mapegrid B 250** | Primed basalt-fibre mesh (250 g/m²) for structural reinforcement of stone, brick, tuff and concrete surfaces. |
| **Mapegrid G 120** | Pre-primed, alkali-resistant (A.R.) glass fibre mesh, for localised reinforced "strengthening" of masonry substrates. |
| **Mapegrid G 220** | Alkali-resistant, primed glass fibre mesh for structural "reinforced" strengthening of stone, brick and tuff substrates. |
**Maperod C**
- Pultruded carbon fibre rods impregnated with epoxy resin for structural strengthening of damaged concrete and masonry elements.

**Mapewood Paste 140**
- Thixotropic epoxy adhesive for restoring wooden structural elements.

**Maperod G**
- Pultruded carbon fibre rods impregnated with epoxy-modified vinylester resin for structural reinforcement of damaged reinforced concrete, brick, stone and tuff elements.

**Mapewood Primer 100**
- Fluid epoxy impregnator in water dispersion for consolidating and priming wooden structures.

**MapeWrap 11**
- Two-component, normal-setting, thixotropic epoxy grout for evening out concrete surfaces.

**Mapewood**
- Paste 140

**MapeWrap 12**
- Two-component, slow-setting, thixotropic epoxy grout for evening out concrete surfaces.

**MapeWrap 21**
- Two-component, super-fluid epoxy resin for impregnating MAPEWRAP using the “damp system”.

**MapeWrap 31**
- Two-component, medium-viscosity epoxy adhesive for impregnating MAPEWRAP using the “dry system”.

**MapeWrap B FIOCCO**
- Basalt fibre cord to be impregnated with MAPEWRAP 21 (two-component, super-fluid epoxy resin).

**MapeWrap B UNI-AX**
- Unidirectional, high strength basalt fibre fabric. The fibre is available in two weights with the same width.

**MapeWrap C BI-AX**
- Balanced, high-strength, bi-directional carbon fibre fabric.

**MapeWrap C FIOCCO**
- Carbon fibre cord to be impregnated with MAPEWRAP 21 (two-component, super-fluid epoxy resin).
**MapeWrap C QUADRI-AX**
- Balanced, high-strength, quadridirectional carbon fibre fabric.

**MapeWrap C UNI-AX HM**
- High-strength, unidirectional carbon fibre fabric with a high modulus of elasticity (230,000 N/mm²).

**MapeWrap C QUADRI-AX UNI-AX**
- High-strength, unidirectional carbon fibre fabric with a high modulus of elasticity (390,000 N/mm²).

**MapeWrap EQ Adhesive**
- One-component, ready-to-use, polyurethane-based adhesive in watery dispersion with very low emission level of volatile organic compounds (VOC) for impregnating MAPEWRAP EQ NET bi-directional, primed glass fibre fabric.

**MapeWrap EQ Net**
- Bi-directional, primed glass fibre fabric to protect secondary partition walls in buildings from seismic activity.

**MapeWrap G QUADRI-AX**
- Balanced, quadri-directional glass fibre fabric.

**MapeWrap G UNI-AX**
- Unidirectional, high strength glass fibre fabric.

**MapeWrap G FIOCCO**
- Glass fibre cord to be impregnated with MAPEWRAP 21 (two-component, super-fluid epoxy resin).

**MapeWrap Primer 1**
- Two-component epoxy primer specifically formulated for the MAPEWRAP system.

**MapeWrap S FIOCCO**
- High-strength, steel fibre cord for structural strengthening.

**MapeWrap S Fabric**
- Unidirectional, high-strength metal fibre fabric for structural strengthening.

**Planitop HDM**
- Two-component, high-ductility, pozzolan-reaction mortar applied in layers up to 6 mm thick for "reinforced" structural strengthening of masonry substrates in combination with MAPEGRID G 120, MAPEGRID G 220 or MAPEGRID B 250 and for smoothing and levelling surfaces in concrete, stone, brickwork and tuff.
**Planitop HDM Maxi**

- Two-component, high-ductility, fibre-reinforced, pozzolan-reaction mortar applied in layers up to 25 mm thick for evening out stone, brickwork and tuff substrates before applying MAPEGRID G 120, MAPEGRID G 220 or MAPEGRID B 250.

**Planitop HPC**

- Castable, compensated-shrinkage, high-strength, high-ductility, fibre-reinforced cementitious mortar used in combination with fibres for repairing and reinforcing concrete.

**Planitop HPC Floor**

- Ultra-high strength, highly ductile, highly fluid, fibre-reinforced, compensated shrinkage cementitious mortar for strengthening the external face of floor slabs.

**Planitop HDM Restauro**

- Two-component, pre-blended, high-ductility, fibre-reinforced, hydraulic lime (NHL) and ECO-POZZOLAN-based light-coloured mortar, particularly recommended for “reinforced” structural strengthening of masonry substrates in combination with MAPEGRID G 120, MAPEGRID G 220 or MAPEGRID B 250 and for evening out stone, brickwork and tuff substrates.

**Fibres HPC**

- Stiff steel fibres used in combination with PLANITOP HPC mortar.

N.B.: PLANITOP HPC is sold with FIBRES HPC (1.625 kg of FIBRES HPC per 25 kg bag of PLANITOP HPC).
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**Problem**

- Reinforced concrete structures
  - Flexural strengthening for wooden beams
  - Flexural strengthening for reinforced concrete beams
  - Flexural strengthening for reinforced concrete floor joists
  - Flexural strengthening for reinforced concrete floor slabs
  - Shear strengthening for reinforced concrete beams
  - Confinement of reinforced concrete pillars, piles and chimney stacks
  - Combined bending and axial load strengthening at the base of pillars embedded in foundations
  - Confinement of column-beam junctions

- Mixed structures
  - Anti-seismic protection for non-structural partition walls
  - Anti-overturning system for buffer walls
  - Anti-collapse system for floor slabs
  - Strengthening the outer face of floor slabs

- Masonry structures
  - Confinement of masonry columns
  - Strengthening reinforcing ribs in vaults
  - Strengthening vaults and arches
  - Shear strengthening of bay walls
  - Stitching corner intersections (and "T" intersections) of walls
  - Tie area strips

**Guide to choosing**

- Carboplate Pultruded carbon fibre plates
  - MapeWrap C UNI-AX Carbon fibre fabric
  - MapeWrap C UNI-AX HM Carbon fibre fabric
  - MapeWrap C BI-AX Carbon fibre fabric
  - MapeWrap C QUADRI-AX Carbon fibre fabric
  - MapeWrap G UNI-AX Glass fibre fabric
  - MapeWrap G QUADRI-AX Glass fibre fabric
  - MapeWrap B UNI-AX Basalt fibre fabric
  - MapeWrap S Fabric Steel fibre fabric
- Mapegrid G 120 + Planitop HDM/Planitop HDM Maxi
  - Mapegrid G 220 + Planitop HDM/Planitop HDM Maxi
  - Mapegrid G 220 + Planitop HDM Restauro
  - Mapegrid B 250 + Planitop HDM/Planitop HDM Maxi
  - Mapegrid G 250 + Planitop HDM Restauro
  - Carbotube
  - Maperod C
  - Maperod G
  - MapeWrap C FIOCCO
  - MapeWrap G FIOCCO
  - MapeWrap S FIOCCO
  - MapeWrap EQ Net + MapeWrap EQ Adhesive
  - Planitop HPC + Fibres HPC
  - Planitop HPC Floor