

# Carboplate System

**STRUCTURAL STRENGTHENING SYSTEM CONSISTING OF PULTRUDED PLATES IN HIGH-STRENGTH CARBON FIBRE AND EPOXY RESINS TO BOND THE PLATES (FRP) COVERED BY CERTIFICATE OF TECHNICAL ASSESSMENT (CVT) N° 206/2019 CLASSES C150/230 – C190/1800 – C200/1800**

CVT

## PRODUCTS USED IN THE SYSTEM:

**Carboplate E170 - Carboplate E200 - Carboplate E250  
MapeWrap 11 - MapeWrap 12 - Adesilex PG1 - Adesilex PG2**

### WHERE TO USE

This system is recommended for the repair and structural strengthening of under-dimensioned or damaged reinforced concrete, steel and wooden elements, to improve the flexural strength of reinforced concrete and wooden elements and to upgrade or improve the seismic capacity of structures in high risk areas.

### Some application examples

- Repair and static upgrading of reinforced concrete beams, floor joists and floor slabs to integrate the section resistant to flexural loads.
- Flexural strengthening of wooden beams and joists.
- Repairing structures damaged by fire.
- Repairing structures damaged by earthquakes.
- Renovating two-dimensional structures such as plates, sheets and storage tanks with a large radius.
- Strengthening the deck of viaducts after increasing their static and/or dynamic loads.
- Strengthening industrial and/or commercial structures after increasing their static loads following the installation of new machinery, equipment, etc.
- Strengthening vehicle access ramps in civil and industrial buildings.
- Strengthening structures subjected to vibrations.
- Strengthening load-bearing members in buildings whose structural system has been modified due to new architectural requirements or change in use.

The system is covered by Certificate of Technical Assessment N° 206/2019 (which replace the previous certificates N° 2467/2018 and N° 288/2017) issued by the 2° Div. of the STC (Central Technical Service) of the CSLP (Ministry of Public Works).

### TECHNICAL CHARACTERISTICS

The **CARBOPLATE SYSTEM** is made up of **CARBOPLATE E170**, **CARBOPLATE E200** or **CARBOPLATE E250** pultruded plates made from high-strength carbon fibres and **MAPEWRAP 11**, **MAPEWRAP 12**, **ADESILEX PG1** or **ADESILEX PG2** adhesive to level off surfaces and bond the plates.

The **CARBOPLATE SYSTEM** may be used as an alternative to Traditional Reinforced Techniques to clad structures in reinforced concrete, pre-stressed concrete steel and wood. **CARBOPLATE E170**: pultruded plates made from high strength, low-modulus carbon fibres.

**CARBOPLATE E200**: pultruded plates made from high strength, medium-modulus carbon fibres.

**CARBOPLATE E250**: pultruded plates made from high strength, high-modulus carbon fibres.

**MAPEWRAP 11 / MAPEWRAP 12 / ADESILEX PG1 / ADESILEX PG2**: epoxy grouts with a thixotropic consistency to level off surfaces and make structural bonds made from:  
– component A (resin);  
– component B (catalyser).

Thanks to their special composition and the manufacturing process employed, **CARBOPLATE** plates have

guaranteed properties in every point and have the following characteristics:

- high tensile strength;
- lightweight;
- compact;
- excellent fatigue strength.

**MAPEWRAP 11**, **MAPEWRAP 12**, **ADESILEX PG1** and **ADESILEX PG2** respond to the principles defined in EN 1504-9 (*"Products and systems for protecting and repairing concrete structures: definitions, requirements, quality control and conformity assessment. General principles for the use of products and systems"*), and the minimum requirements of EN 1504-4 (*"Structural bonding"*).

### ADVANTAGES

Unlike work carried out using conventional techniques, thanks to its extremely low weight, the **CARBOPLATE SYSTEM** may be installed in a very short space of time without having to use any particular tools or equipment, and often without interrupting the use of the structure. Compared with the cladding technique with metal plates (*béton plaqué*), the **CARBOPLATE SYSTEM** does not require temporary supports during application and there is no risk of corrosion to the strengthening system. Compared with cladding using fabric impregnated directly on site, the **CARBOPLATE SYSTEM** is quicker and easier to apply and the quality of the work is less dependent on the experience and skill of the installation team.

**CARBOPLATE** plates also have quite a good level of flexibility which means



# Carboplate System

the system may also be used to bind cylindrical structures (storage tanks, silos, etc.) with a bending radius of more than 3 metres.

## RECOMMENDATIONS

- Before bonding the plates, make sure the tensile strength of the concrete substrate is  $>1.5$  MPa.
- Do not use the **CARBOPLATE SYSTEM** on concrete that has not been correctly cured.
- On particularly absorbent substrates or on concrete in areas with a high level of R.H. (underpasses, underground rooms, cellars, etc.), it is recommended to prime the substrates with **MAPEWRAP PRIMER 1** before bonding the **CARBOPLATE SYSTEM** (refer to the relative Technical Data Sheet for preparation and application instructions). When applying **MAPEWRAP 11**, **MAPEWRAP 12**, **ADESILEX PG1** or **ADESILEX PG2** adhesive, the primer must still be wet.
- All workers must use protective gloves and goggles and anti-solvent safety masks.

## APPLICATION PROCEDURE

### Substrate preparation

Surfaces on which the **CARBOPLATE SYSTEM** is to be applied must be perfectly clean, dry, strong and even (maximum surface roughness 1 mm). Wooden structures: repair wooden elements and structures, where required, by applying adhesives from the **MAPEWOOD** line. Concrete structures: sandblast the surface to remove all traces of stripping oil, paint and cement laitance. If concrete is deteriorated deep down into the element, remove all damaged parts using a hammer, a jack-hammer or by hydro-scarifying. Remove all traces of rust from the steel reinforcement and protect the reinforcement by applying **MAPEFER** two-component anti-corrosion cementitious mortar or **MAPEFER 1K** one-component anti-corrosion cementitious mortar (refer to the relative Technical Data Sheet for application procedures). Repair the surface of concrete with

products from the **MAPEGROUT** line. Wait at least three weeks before applying the **CARBOPLATE SYSTEM**. If for logistics purposes the strengthening intervention needs to be carried out immediately, use either **ADESILEX PG1** or **ADESILEX PG2** epoxy mortar to repair the damaged concrete.

Seal any cracks in the structure by injecting them with **EPOJET** or **EPOJET LV** (suitable only for dry or slightly damp cracks) or with **FOAMJET T** or **FOAMJET F** (suitable for damp cracks or if water is seeping in).

Refer to the relative Technical Data Sheet for details on how to apply the aforementioned products.

## APPLICATION PROCEDURE FOR THE CARBOPLATE SYSTEM

Application phases

1. Preparation of **MAPEWRAP 11** / **MAPEWRAP 12** / **ADESILEX PG1** / **ADESILEX PG2**.
2. Bonding the **CARBOPLATE** plates.

### 1. Preparation of MAPEWRAP 11 / MAPEWRAP 12 or ADESILEX PG1 / ADESILEX PG2

If the temperature is between  $+5^{\circ}\text{C}$  and  $+20^{\circ}\text{C}$  use **MAPEWRAP 11** or **ADESILEX PG1**: at  $+23^{\circ}\text{C}$  their workability time is around 35 minutes after mixing.

For higher temperatures it is recommended to use **MAPEWRAP 11** or **ADESILEX PG2**: at  $+23^{\circ}\text{C}$  their workability time is around 50 minutes after mixing.

The two components that make up **MAPEWRAP 11** / **MAPEWRAP 12** and **ADESILEX PG1** / **ADESILEX PG2** must be mixed together. Pour component B into component A and mix with a drill at low-speed with a mixing attachment until they form an even, grey paste. Mixing ratio for all products: 3 parts by weight of component A with 1 part by weight of component B.

The contents are pre-dosed. Do not use partial quantities of the components to avoid making dosage errors when mixing, otherwise the product may not harden completely.

**2. Bonding the CARBOPLATE plates** **CARBOPLATE** is supplied in rolls that need to be cut to length with a hand grinder fitted with a diamond disk. Also, during the manufacturing process, a plastic film is applied (*peel-ply*) to both sides of the **CARBOPLATE** to protect the disk from dirt when handling and cutting the plates.

Before bonding the **CARBOPLATE**, remove the film from the side that will be in contact with the epoxy adhesive chosen for the work.

Prime the surface to be strengthened with **MAPEWRAP PRIMER 1** (in the case of particularly absorbent substrates or concrete in surroundings with a high level of R.H.).

Apply an even layer around 1-1.5 mm thick of **MAPEWRAP 11** / **MAPEWRAP 12** or **ADESILEX PG1** / **ADESILEX PG2** adhesive (depending on the surrounding temperature) with a flat spreader on the side of the **CARBOPLATE** from which the plastic film has been removed.

Apply another layer of **MAPEWRAP 11** / **MAPEWRAP 12** or **ADESILEX PG1** / **ADESILEX PG2** on the substrate (clean and dry) to which the plate is to be bonded. The adhesive must be applied while the **MAPEWRAP PRIMER 1** is still wet.

Lay the **CARBOPLATE** on the adhesive, press down evenly along the whole length of the plate with a firm, rubber roller and remove any excess resin with a spreader, taking care not to move the plate.

When cladding curved elements or structures, the plates must be held in position with temporary clamps or stays until the resin has completely hardened (24 hours is usually enough before the clamps or stays can be removed).

If more than one layer of **CARBOPLATE** is required, once the **MAPEWRAP 11** / **MAPEWRAP 12** or **ADESILEX PG1** / **ADESILEX PG2** has hardened, carefully peel the protective film from the upper side of the plate bonded to the element or structure.

(For further information on the technical characteristics of each resin product used for the **CARBOPLATE SYSTEM** refer to the relative Technical Data Sheet).

## FINISHING AND PROTECTING THE SYSTEM

If the strengthened areas need to be treated with a finishing product, remove the protective film from the exposed side of the **CARBOPLATE**, apply a layer around 1 mm thick of **MAPEWRAP 11** / **MAPEWRAP 12** or **ADESILEX PG1** / **ADESILEX PG2** and broadcast the resin while still wet with 1.2 to 1.9 mm quartz sand. Once the resin products used in the system have hardened (approx. 1-2 days at  $+23^{\circ}\text{C}$ ), the surface may be finished off with a skim-coat of fine-textured cementitious compound such as

## **PLANITOP 200** or **PLANITOP 210**

(refer to the relative Technical Data Sheet). If the strengthened area is to be covered by a false ceiling, the aforementioned finishing procedure is not required.

For external applications, protect the system once the resin systems have completely hardened by applying a coat of **MAPELASTIC** two-component, elastic cementitious mortar (refer to the relative Technical Data Sheet). This product forms an efficient barrier against UV rays, which makes it particularly recommended for structures exposed to direct sunlight. To protect the system from fire it may be dressed with panels, which are usually made from calcium-silicate, or with a layer of intumescent render, as specified in article 4.8.2.3 of CNR DT 200 R1/2013.

### **PRECAUTIONS TO BE TAKEN DURING AND AFTER APPLICATION**

The temperature during application must be at least +5°C and the structure must be dry and protected from rain and dust carried by the wind.

After completing the application operations, make sure the treated surfaces are kept at a temperature of at least +5°C.

Protect strengthened surfaces from rain for at least 24 hours if the temperature does not drop below +15°C, or for at least 3 days if the temperature is lower.

### **PRECAUTIONS TO BE TAKEN WHEN HANDLING THE PRODUCTS**

All workers must wear waterproof rubber gloves, goggles and protective clothing when preparing and applying the carbon fibre plates and epoxy systems (**MAPEWRAP 11** / **MAPEWRAP 12** or **ADESILEX PG1** / **ADESILEX PG2**). Avoid contact with the eyes or skin. If they come into

contact with the skin, wash off with plenty of soap and water. If they come into contact with the eyes, wash with plenty of clean water and seek medical advice.

If the products are applied in closed environments, make sure they are well ventilated to guarantee a continuous circulation of fresh air. For further information please refer to the Material Safety Data Sheet for each product.

### **Cleaning**

Epoxy systems form an extremely strong bond, including on metal, and it is recommended to clean all work tools with solvent (such as ethanol, toluene, etc.) before the products harden.

### **CONSUMPTION OF ADHESIVE**

The consumption rate for **MAPEWRAP 11** / **MAPEWRAP 12** or **ADESILEX PG1** / **ADESILEX PG2** depends on the width of the **CARBOPLATE** plates and is usually around:

- 50 mm plates: 160-200 g/m;
- 100 mm plates: 320-400 g/m;
- 150 mm plates: 480-600 g/m.

### **PACKAGING AND STORAGE**

**CARBOPLATE** is supplied in a cardboard box containing 1 roll x 25 metres long.

**MAPEWRAP 11** / **MAPEWRAP 12** and **ADESILEX PG1** / **ADESILEX PG2** are supplied in 6 kg kits comprising one 4.5 kg tub (component A) and one 1.5 kg can (component B).

All the products from the system must be stored in a dry, covered area.

**CARBOPLATE** is available in various levels of modulus of elasticity and each version is available in 3 different widths (50, 100 and 150 mm):

- **CARBOPLATE** E 170/50/1.4
- **CARBOPLATE** E 170/100/1.4
- **CARBOPLATE** E 170/150/1.4
- **CARBOPLATE** E 200/50/1.4
- **CARBOPLATE** E 200/100/1.4

- **CARBOPLATE** E 200/150/1.4
- **CARBOPLATE** E 250/50/1.4
- **CARBOPLATE** E 250/100/1.4
- **CARBOPLATE** E 250/150/1.4

### **NOTES**

Procedures regarding the safe handling of the products are contained in the Safety Data Sheet for each single product in the system. However, the use of protective gloves and goggles is recommended when mixing and applying the products.

### **WARNING**

*Although the technical details and recommendations contained in this data sheet correspond to the best of our knowledge and experience, all the above information must, in all cases, be taken as merely indicative and subject to confirmation after long-term, practical applications. For this reason, anyone who intends using this product must ensure beforehand that it is suitable for the envisaged application. In all cases, the user alone is fully responsible for any consequences deriving from the use of this product.*

### **SAFETY INSTRUCTIONS FOR PREPARATION AND APPLICATION**

**CARBOPLATE E 170**, **CARBOPLATE E 200** and **CARBOPLATE E 250** are articles and referring to the current European regulations (Reg. 1906/2007/CE - REACH) do not require the preparation of the Safety Data Sheet. During use it is recommended to wear gloves and goggles and follow the safety requirements of the workplace in which work is carried out.

PRODUCT FOR PROFESSIONAL USE.

Regarding **MAPEWRAP 11**, **MAPEWRAP 12**, **ADESILEX PG1** and **ADESILEX PG 2**, always refer to the latest, updated version of the Technical Data Sheet available on the company website [www.mapei.com](http://www.mapei.com)





**Application of MapeWrap Primer 1**



**Application of MapeWrap 11 / 12 or Adesilex PG1 / PG2 on the substrate**



**Removing the protective film from a Carboplate plate**



**Application of MapeWrap 11 / 12 or Adesilex PG1 / PG2 on a Carboplate plate**



**Application of a Carboplate plate**



**Beam strengthened with the Carboplate System**



**Skim-coat of MapeWrap 11 / 12 or Adesilex PG1 / PG2 to prepare for the finishing product**



## GEOMETRICAL AND PHYSICAL CHARACTERISTICS

Property		Test method reference standard	Value
Type of fibre		high-strength carbon	
Type of matrix		epoxy resin	
Thickness of plate (mm)		micrometre: 0-25 mm	1.40
Width (mm)		Vernier: 0-150 mm	50/100/150
Resistant section (mm <sup>2</sup> )		–	70 / 140 / 210
Length (m)		tape measure: ± 10 mm	various
Colour		visual check	black
Density (g/cm <sup>3</sup> )	fibre	–	1.80
	matrix		1.20
Fibre content (%)	by weight	–	70 ± 3
	by volume		68 ± 3
Glass transition temperature of pultrusion resin T <sub>g,rp</sub> (°C)		ISO 11357-2:1999(E) DSC	80
Glass transition temperature of resin to bond the plates T <sub>g,ri</sub> (°C)		ISO 11357-2:2013(E) <sup>(1)</sup>	71
Minimum and maximum service temperature (°C) <sup>(2)</sup>		ACI 440.2R-08	-10 to +56 <sup>(3)</sup>
Reaction to fire		EN 13501-1:2007	Euroclass E
Resistance to fire		–	N/A

Note:

(1) On samples cured for 7 days at +23°C.

(2) Refers to the surface temperature of the resin, not the surrounding temperature.

(3) Maximum service temperature is considered to be 15°C lower than the glass transition temperature of the adhesive, as specified in CNR-DT 200 R1/2013 ref. ACI 440.2R-08.

Note: this assumption is highly precautionary; the ACI mentioned refers to T<sub>g</sub> values measured by DMA (Dynamic Mechanical Analysis), a method that gives reading around 15-20°C higher than the DSC (Differential Scansion Calorimeter) method used in this case as specified by European standards.

## MECHANICAL PROPERTIES OF THE CARBOPLATE SYSTEM ACCORDING TO CVT No. 206/2019

Class according to Legislation DPCS (Prime Ministerial Decree) LL.PP. No. 220, 9.7.2015:		C150/2300	C190/1800	C200/1800
Modulus of elasticity of laminate (for net area of fibres) (GPa)	Chart value	150	190	200
Strength of laminate (for net area of fibres) (MPa)	Chart value	2,300	1,800	1,800

Property	Test method reference standard	CARBOPLATE E170 SYSTEM	CARBOPLATE E200 SYSTEM	CARBOPLATE E250 SYSTEM
Average normal tensile modulus of elasticity E <sub>f</sub> (GPa)	UNI EN 13706-1-2-3	160	190	250
Average tensile strength f <sub>fib</sub> (MPa)		2,900	3,300	2,500
Typical tensile strength f <sub>fib,k</sub> (MPa)		2,700	3,100	2,400
Average tensile deformation at failure ε <sub>fib</sub> (%)		1.8	1.8	1.00
Typical deformation at failure ε <sub>fib,k</sub> (%)		1.6	1.6	0.95
Shear strength (MPa)		77	70	79
Coefficient of thermal expansion (m/m/°C)		0,6 x 10 <sup>-6</sup>	0,8 x 10 <sup>-6</sup>	0,4 x 10 <sup>-6</sup>

# MECHANICAL PROPERTIES OF THE CARBOPLATE SYSTEM ACCORDING EN 2561

Property	Test method reference standard	CARBOPLATE E170 SYSTEM	CARBOPLATE E200 SYSTEM	CARBOPLATE E250 SYSTEM
Average normal tensile modulus of elasticity $E_f$ (GPa)	EN 2561	170	200	250
Average tensile strength $f_{fib}$ (MPa)		$\geq 3,100$	3,300	2,500
Average tensile deformation at failure $\epsilon_{fib,k}$ (%)		$\geq 1.60$	$\geq 1.40$	$\geq 0.77$

## SYSTEM SPECIFICATIONS

Repair and structural strengthening of under-dimensioned or damaged reinforced concrete, steel and wooden elements, improving the flexural strength of reinforced concrete and wooden elements and upgrading or improving the seismic capacity of structures in high risk areas. Repair and static upgrading of reinforced concrete beams, floor joists and floor slabs to integrate the section resistant to flexural loads, flexural strengthening of wooden elements, repairs to reinforced concrete elements damaged by fire, upgrading or improving the seismic capacity of structures in high risk areas, strengthening viaduct decks after increasing their static and/or dynamic loads, strengthening vehicle access ramps in civil and industrial buildings and strengthening industrial and commercial structures after increasing their static loads following the installation of new machinery or equipment by applying a strengthening system (such as the **CARBOPLATE SYSTEM** by MAPEI S.p.A., consisting of **CARBOPLATE**, pultruded plates made from high-strength carbon fibres, protected on both sides by a film of plastic (peel-ply), bonded in place with **MAPEWRAP 11 / MAPEWRAP 12** or **ADESILEX PG1 / ADESILEX PG2** epoxy adhesive according to the following procedure:

- preparation of **MAPEWRAP 11 / MAPEWRAP 12 / ADESILEX PG1 / ADESILEX PG2**;
- bonding the **CARBOPLATE** plates;
  - cutting the **CARBOPLATE** to the length required;
  - removing the protective film (*peel-ply*) from the **CARBOPLATE**;
  - priming the surface to be strengthened, where required, with **MAPEWRAP PRIMER 1**;
  - application of an even layer around 1-1.5 mm thick of **MAPEWRAP 11 / MAPEWRAP 12** or **ADESILEX PG1 / ADESILEX PG2** two-component thixotropic epoxy adhesive for structural bonds with a flat spreader on both the **CARBOPLATE** and the substrate to which the plate is to be bonded;
  - application of the **CARBOPLATE** by pressing it down lightly.

The modulus of elasticity and the width of the plate may be chosen according to the type of work to be carried out.

The system, applied according to Certificate of Technical Suitability (CVT) N° 206/2019 issued by the 2° Div. of the STC (Central Technical Service) of the CSLP (Ministry of Public Works), must have the following characteristics:

	CARBOPLATE E170 SYSTEM	CARBOPLATE E200 SYSTEM	CARBOPLATE E250 SYSTEM
Class according to Legislation DPCS (Prime Ministerial Decree) LL.PP. No. 220, 9.7.2015:	C150/2300	C190/1800	C200/1800
Density of fibres $\rho_{fib}$ (g/cm <sup>3</sup> )	1.80	1.80	1.80
Fibre content by volume (%)	$68 \pm 3$	$68 \pm 3$	$68 \pm 3$
Thickness (mm)	1.4	1.4	1.4
Width (mm)	50/100/150	50/100/150	50/100/150
Resistant section (mm <sup>2</sup> )	70/140/210	70/140/210	70/140/210
Average normal tensile modulus of elasticity $E_f$ (GPa)	160	190	250
Typical tensile strength $f_{fib,k}$ (MPa)	2,700	3,100	2,400
Typical elongation at failure $\epsilon_{fib,k}$ (%)	1.6	1.6	0.95
Shear strength (MPa)	77	70	79