

# RUREDIL X MESH C10

FRCM structural reinforcement system with two-way carbon mesh and stabilized inorganic matrix for reinforcement of masonry constructions



Ruredil  
Technical info

## The material

RUREDIL X MESH C10 is a structural reinforcement system consisting of a bidirectional carbon fiber mesh and a stabilized inorganic matrix of pozzolanic nature specially formulated for use on masonry substrates. This patented system, named FRCM (Fiber Reinforced Cementitious Matrix), does not use epoxy resin but a matrix consisting of a pozzolanic hydraulic binder perfectly compatible with the masonry substrate. The system can be used in structural reinforcement works of masonry structures, replacing and improving reliability and performance of traditional techniques based on the use of glass fiber and steel mesh and, more generally, of FRP systems with all types of fibers.

The RUREDIL X MESH C10 system consists of:

- RUREDIL X MESH C10: carbon fiber mesh, 100 cm wide and 15 m long;
- RUREDIL X MORTAR 25: stabilized inorganic matrix according to the UNI EN 998-2 standard.



## Properties

The system RUREDIL X MESH C10, through the use of the inorganic matrix RUREDIL X MORTAR 25, provides better performance than an FRP reinforcement with epoxy resin or polyester base:

- Increase of shear strength of masonry panels, bearing capacity of columns and pillars, and elimination of the formation of connection lines of arches and vaults, encouraging the redistribution of stresses in the structure;
- High increase in ductility in the structural reinforced component, high capacity of energy dissipation and high reliability of the system, even when subjected to cyclic overloads (e.g. earthquake);
- Maintenance of normal substrate breathability and exclusion of the formation of surface condensation, a possible source of degradation for wall decorations\*;
- High resistance to high temperatures: after hardening of the matrix, the system is not influenced by the external temperature, unlike the FRPs, whose resin loses the adhesive properties between 30 °C and 80 °C depending on its vitreous transition temperature ;
- Excellent fire resistance: the system ensures an identical reaction to that of the substrate since the inorganic matrix retains its characteristics unaltered at temperatures up to 550 °C; it is not combustible, has low smoke emission, and does not release any incandescent particles;
- High durability under conditions of ambient humidity: the inorganic matrix is not affected, while the epoxy resin is degraded with prolonged exposure to high levels of humidity;
- Effectiveness of laying even on damp substrates: moisture enhances the adhesion

### RUREDIL X MESH C10 according to the Guidelines AC434 issued by ICC - ES

In 2013 Ruredil has achieved product certification for the FRCM composite called **Ruredil X Mesh C10**, based on carbon fibers, (in accordance with AC 434): "Acceptance Criteria For Masonry and Concrete Strengthening Using Fiber-Reinforced Cementitious Matrix (FRCM) Composite Systems". Tests required for product certification were performed at the accredited laboratory of the University of Miami and relative certification was issued by the American ICC-ES. The International Code Council Evaluation Service (ICC-ES) is an American company that does technical evaluation of products and issues relative certifications ([www.icc-es.org](http://www.icc-es.org)).

Having been performed by an accredited laboratory, this certification provides further technical evidence that the product is code-compliant, that means that product performance described may be used in any structural reinforcement project utilizing the Ruredil FRCM systems.

of the hydraulic matrix, while the same condition reduces the adhesion of organic resins to the substrate;

- Ease of handling: the preparation of the inorganic matrix is carried out as for all hydraulic products;
- Easy application even on rough and irregular surfaces: it does not require preliminary trimming, which is required for the FRP systems;
- Wide range of environmental conditions for applicability: no limitation between 5 °C and 40 °C, while the FRPs have narrower range;
- Non-toxicity of the matrices used for the operators and the environment: they are comparable to a traditional inorganic mortar, and epoxy resins are harmful by inhalation and contact with skin and require adequate protections for operators, such as respiratory masks and gloves ;
- Easy cleaning of the equipment used: the use of water alone is sufficient, with no use of solvents required for resins, which are harmful to humans and the environment.

*(\*) Certificate of "Water vapor permeability testing" according to the 21-85 standard issued by the National Research Council IBAM- Lecce- 2002*

*"Determination of Water vapor permeability" according to the UNI-EN 1015-19 issued by the Test and Research Institute M. Masini- Rho- Milan 2012*

## Applications

RUREDIL X MESH C10 is used for reinforcement of masonry structures, including those subject to fire or high temperatures. In particular, it applies to:

- Static reinforcement;
- Seismic improvement;
- Seismic retrofitting;
- Replacement of traditional reinforced slabs, performed with glass or welded steel mesh.

## Application methods

### Preparation of the substrate

- Remove the pre-existing plaster by means of demolition with electric or compressed air hammers. If it is not possible to use mechanical means, proceed by simply chipping.
- Remove the protective surface treatments, the "gripping primers" or any other substance that may affect proper adhesion to the substrate.
- Perform beating and removal of any non-adhering parts with sandblasting or washing with water at low pressure with brushing.
- Before proceeding with laying of the reinforcement, perform the regularization of the substrate using the appropriate mortars from the RUREWALL line, following the instructions contained in the relevant data sheets.

### Preparation of the product

- Pour about 90% of the water required into the mixer, then operate the mixer by adding RUREDIL X MORTAR 25 without interruption to avoid the formation of lumps.
- Mix the dough for 2-3 minutes, then add, if necessary, the remaining water provided in the technical specifications and stir for another 1-2 minutes. Let the mix rest for about 2-3 minutes, then mix it again and apply it.
- It is recommended not to mix by hand.

## Laying of the product

- Apply RUREDIL X MORTAR 25 with smooth metal trowel, thickness of about 3 mm and sink RUREDIL X MESH C10 inside.
- Apply a second layer of about 3 mm RUREDIL X MORTAR 25 so as to completely cover the mesh, taking care to apply the next layer when the previous one is not yet completely hardened. RUREDIL X MESH C10 shall be applied with orientation of 0°/90°, with respect to the ground level or the setting line of masonry bricks. In case several layers of RUREDIL X MESH C10 are required, repeat the operation, always wet on wet, preferably alternating the 0°/90° orientation with the +45°/-45° orientation (diagonally to the previous mesh layer) or as prescribed by the designer.
- In the junction points, provide an overlap of about 10 cm.
- If the mortar loses workability, do not add more water, but stir the mixture for about 1-2 minutes before continuing to apply it.
- It is recommended not to perform the application of the RUREDIL X MESH C10 system in the sun, during the hot hours of summer months, with moderate or strong winds.
- It is advisable to apply the product at temperatures between +5 °C and +35 °C.
- Lower temperatures (4-10 °C) considerably slow down setting, while higher temperatures (35-50 °C) cause quick loss of mortar workability.

## Curing

- As in the common use of any cement mortar, in harsh environmental conditions (strong wind or sun exposure) it is necessary to provide for the use of an anti-evaporation agent (CURING S) or the use of a moistened non-woven cloth.
- In case of rain, protect the applied reinforcement through appropriate means.

## Technical properties

SPECIFICATIONS OF CARBON FIBER	
Tensile strength	4,800 MPa
Modulus of elasticity	240 GPa
Fiber density	1.82 g/cm <sup>3</sup>
Elongation at break	1.8 %

SPECIFICATIONS OF RUREDIL X MESH C10	
Weight of carbon fibers in the mesh	168 g/m <sup>2</sup>
Thickness for calculation of the carbon section at 0° and 90°	0.047 mm

SPECIFICATIONS OF INORGANIC MATRIX RUREDIL X MORTAR 25	
Consistency (UNI EN 1015-3)	165 mm
Specific density of fresh mortar (UNI EN 1015-6)	1.50 ± 0.05 g/cc
Mix water per 100 kg RUREDIL X MORTAR 25	24 - 28 liters
Yield (dry product)	≈ 1.200 kg/m <sup>2</sup> /mm
Compressive strength (UNI EN 196-1)	> 20.0 MPa (at 28 days)
Flexural strength (UNI EN 196-1)	> 3.5 MPa (at 28 days)
Secant modulus of elasticity (UNI EN 13412)	> 7000 MPa (at 28 days)

## SPECIFICATIONS OF THE RUREDIL X MESH C10 SYSTEM

Reaction to fire class (UNI EN 13501-1)	A2 - No contribution to fire s1 - low smoke emission d0 - no flaming droplets/particles
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### Conformity of structural reinforcement systems with European Standard UNI EN 13501-1 (Fire)

#### FRCM: Fiber Reinforced Cementitious Matrix

The structural reinforcements FRCM, such as RUREDIL X MESH C10, are classified as materials that do not give any contribution to increasing fire even in a fully developed fire. Also, they do not cause toxic fumes and do not form incandescent drops, which are potentially very dangerous for people during a fire.

#### Classification of reaction to fire: A2 - s1,d0

#### FRP: Fiber Reinforced Polymer

The structural reinforcements with FRP, such as Carbon Fiber Reinforced Polymer, are, however, classified as combustible materials, susceptible to flash over.

#### Classification of Reaction to fire: E

The FRP systems contribute to the generation and/or spread of fire and need adequate protection with intumescent products (according to the DT 200/2013).

### Design criteria for reinforcement of masonry structures with the RUREDIL X MESH C10 system

A masonry structure reinforced with the reinforcement system RUREDIL X MESH C10 allows the existence of a stress status that could not exist in the absence of reinforcement. In fact, the plating made with RUREDIL X MESH C10 prevents the formation of connection lines between two adjacent blocks due to the formation of tangential stresses on the surface of the interface between reinforcement and substrate.

The possible failure modes of the masonry-composite structural component occurs, therefore, due to:

1. Break of masonry structures due to compression;
2. Tensile failure of the reinforcement material (in rare cases);
3. Delamination of the reinforcement which is caused by the detachment of the reinforcement from the substrate and removal of a layer of masonry structure (in 99% of cases).

In the spirit of the Technical Document CNR-DT200/2013, the sizing of a reinforcement must be calculated considering the relation:

$$\epsilon_{fd} = \min\{\epsilon_{fRd}, \epsilon_{fdd}\}$$

where:

$\epsilon_{fRd}$  = expansion to breaking of the reinforcement

$\epsilon_{fdd}$  = maximum expansion for intermediate delamination

Therefore, it is important, for design purposes, to quantify the value  $\epsilon_{fRd}$ , which coincides, in most cases, with the value  $\epsilon_{fdd}$  of the previous relation, the value of which refers to the crisis mode No. 3.

In the case of RUREDIL X MESH C10 system, this deadline was deducted through an extensive testing campaign carried out at Ruredil spa's Laboratory of the Department of Structural Engineering of Materials.

For the analysis of the mechanical properties of the adhesion bond between the wall and RUREDIL X MESH C10 system, a test was used, called double-shear push test in the

### Storage

- RUREDIL X MESH C10: keep the package in a dry place away from sources of heat.
- RUREDIL X MORTAR 25: it is sensitive to moisture and should therefore be kept indoors and in a dry place, at a temperature between +5 °C and +35 °C. Once opened, use all the content. The shelf life in sealed bags is 24 months from packing.

technical literature (Yao et al. 2004).

These tests have allowed to associate each anchorage length adopted with the corresponding delamination strength and the corresponding delamination expansion, understood as delamination dilation of the ends.

The table below shows the calculation values of end delamination dilation  $\epsilon_{\text{fdd}2}$ , intermediate delamination  $\epsilon_{\text{fdd}}$ , tensile strength up to delamination F, and effective length  $L_{\text{eff}}$  obtained for specimens consisting of walls made with different materials:

DELAMINATION VALUES ON DIFFERENT SUBSTRATES (ACCORDING TO DT 200/2013)				
	Solid bricks in good condition	Perforated bricks	Tufa blocks	Solid bricks in poor condition
End delamination dilation $\epsilon_{\text{fdd}2}$ (%)	3.3	1.4	4.1	2.8
Intermediate delamination dilation $\epsilon_{\text{fdd}}$ (%)	6.6	2.8	8.1	5.6
Tensile strength up to delamination F (MPa)	1,650	700	2,060	1,415
Effective length $L_{\text{eff}}$ (mm)	250	250	250	250

It is emphasized that the calculated resistances shown in the table can only be accessed if the masonry structure has adequate mechanical properties. Otherwise, it may cause premature failure in the masonry and, consequently, the crisis with sliding of the fibers in the cement matrix may not be achieved. Therefore, it is recommended to carefully assess the mechanical properties of the substrate and verify that the substrate is suitable to plating of the reinforcement system.

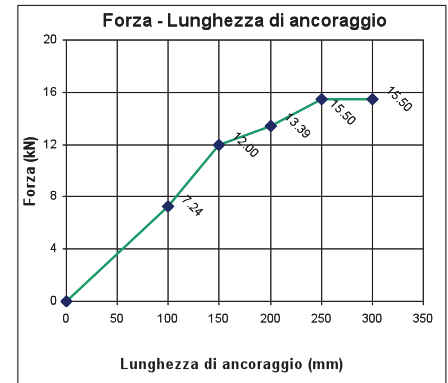


Fig. 1. Diagram of delamination force-anchoring length in solid brick masonry in a good condition.

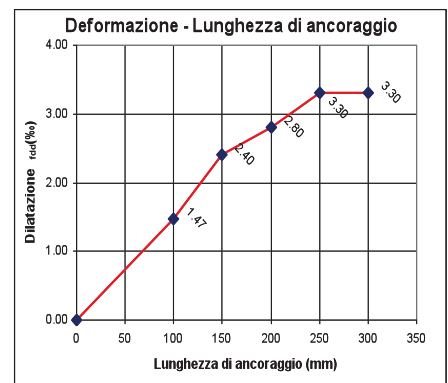


Fig. 2. Diagram  $\epsilon_{\text{fdd}}$ -anchoring length for solid brick masonry in a good condition.

## Note

The **Design** of reinforcement shall be based, as for each type of composite material, on a careful assessment of the characteristics of the structure to be strengthened. In particular, the quality of materials used (concrete, steel, masonry, and related mortar) and their possible state of degradation and their static efficiency (such as the amount of the existing metal reinforcement, the state of the concrete cover and corrosion of reinforcement) shall be investigated. The crisis mode of the structure shall be assessed before and after the reinforcement.

The **Designer** needs to know the mechanical properties and durability of the structural reinforcement in the various temperature and humidity conditions in which it will be applied. Prior to delivery of final design, the designer shall estimate, on the basis of compelling evidence in situ, the mechanical characterization of the structure and local damage (cracking and peeling) to repair. A global load test before and after the work is strongly recommended, in order to certify the operation of the structure-composite coupling.

The **Project Manager** will have to make an accurate check of acceptance of the composite material under the mechanical and stability conditions in the various environmental conditions of application of the composite material, in accordance with the conditions laid down by the designer regarding the bonding surfaces and enforcement of a preliminary test, in addition to the usual monitoring activities on the installation, including the application of the composite material.

## CATALOGUE SPECIFICATIONS RUREDIL X MESH C10

### Chemical/physical specifications:

Mesh length: 15 m ± 3%

### Composition:

Carbon fiber mesh.

### Definition of performance:

Bi-directional carbon mesh for structural reinforcements with inorganic base of masonry structures.

### Packaging

15 m<sup>2</sup> rolls (length 15 m, height 100 cm)

### Consumption:

To consider a web overlap of approx. 10 cm on the junctions.

### Code

0109113020

Updated 10.2012

Our company is certified according to UNI EN ISO 9001:2008 standard by ICMQ and Certiquality for the "Design, production and trade of chemical and special products for the building sector." Our quality system is based on the sale through catalog, a contractual tool between our Company and Customers. Ruredil, with this tool, guarantees to its Customers that the product to be delivered complies with the specific chemical and physical properties specified in this catalog sheet. This sale relieves us from the issuance of the certificate of analysis which, by its nature, only guarantees the performance of a specific supply.

## CATALOGUE SPECIFICATIONS RUREDIL X MORTAR 25

### Chemical/physical specifications:

#### Density ():

specific gravity (fresh mortar):  
1,50 ± 0,05 g/cc  
Consistency: 165 mm ± 10  
Compliant with the UNI EN 998-2 standard

### Composition:

Stabilized pozzolanic inorganic matrix.

### Definition of performance:

Stabilized pozzolanic inorganic matrix for FRCC structural reinforcements of masonry buildings and structures.

### Packaging

25 kg bags

### Yield:

4/5 bags for 1 mesh roll according to the substrate condition.

### Code

0105033020

Updated 02.2014

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