

Ruredil X MESH GOLD

PBO (Poliparafenilenbenzobisoxazolo) mesh in a stabilised inorganic matrix for flexural and shear strength reinforcement of concrete



Ruredil
Technical info

The material

RUREDIL X MESH GOLD is a patented new FRCM (Fibre Reinforced Cementitious Matrix) system, a ground-breaking application of FRP or high performance fibre structural reinforcement systems called FRP.

The RUREDIL X MESH GOLD system consists of a Polyparaphenylene benzobisoxazole (PBO) mesh and a stabilised inorganic matrix designed to connect the mesh with the concrete substrate.

Its outstanding mechanical performance allows this composite material to equal the performance of conventional carbon fibre FRP's with epoxy binders.

Properties

Benefits as compared to conventional FRPs

RUREDIL X MESH GOLD offers the following benefits over an FRP system employing epoxy or polyester resins:

Same resistance to high temperatures as substrate

The structural properties of FRP systems depend on temperature. The glassy transition temperature (T_g) of epoxy resins – normally between 40 and 80°C – is the chemical/physical quantity determining the performance of an FRP system, independently of the fiber used (carbon, aramid, etc.)

When the outdoor temperature exceeds the glassy transition temperature, the epoxy resin is no longer capable of serving the function of transferring stress from the structure to the high modulus fiber buried in it, making it ineffective as structural reinforcement. This behavior is attributable to total loss of the adhesive bond between the resin and the fiber and/or between the resin and the support.

RUREDIL X MESH GOLD is not influenced by outdoor temperature after it hardens, and is fire-resistant because it is inorganic, like the concrete base. FRP systems not only fail to resist fire, but contribute to it by emitting toxic fumes.

Moisture resistance

RUREDIL X MESH GOLD's adhesion to concrete is not affected by relative humidity, unlike FRP systems. Epoxy resin degrades with prolonged exposure to moisture, losing its adhesive properties and therefore its ability to transfer stress to structural fiber.

Applicability of inorganic material to damp substrates

FRP systems can only be applied to dry substrates, as polyester and epoxy resins will not catalyse in the presence of water.



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

In 2013 Ruredil has achieved product certification for the FRCM composite called **Ruredil X Mesh Gold**, that consists of a polyparaphenylene benzobisoxazole (PBO) fiber mesh, (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).

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.

Ease of handling

The premixed substance is mixed with the amount of water specified in the instructions and applied like a conventional cement mortar, with the PBO structural mesh buried in it.

Workability

There are essentially no differences in workability time between 5 °C and 40 °C. Resins' pot life depends on temperature, which limits applicability of FRPs under unfavourable temperature and humidity conditions.

It is not toxic like the resins used in FRPs

RUREDIL X MESH GOLD is applied under ordinary working conditions applicable to cement mortars.

Tools may be cleaned with water

FRPs require cleaning with special solvents and, in many cases, tools cannot be used again.

Applications

RUREDIL X MESH GOLD is suitable for reinforcement of reinforced concrete and pre-compressed reinforced concrete structures, including those subject to the simultaneous action of fire and high temperatures.

RUREDIL X MESH GOLD is applied to reinforced concrete and pre-compressed reinforced concrete structures for:

- Flex reinforcement;
- Shear strength;
- Torsion reinforcement;
- Confinement of beam columns with low eccentricity;
- Confinement and longitudinal reinforcement of beam columns with high eccentricity.

RUREDIL X MESH GOLD is suitable for work in seismic zones for:

- increasing resistance to simple flex fatigue or combined pressing and bending action of pillars and beams;
- increasing resistance to shear stress of pillars and beams;
- increasing the flexibility of the terminal portions of beams and pillars by binding;
- increasing the resistance to tensile stress of the panels of beam-pillar nodes with fibres aligned with tensile stress isostatics.

Application methods

Preparation of the substrate

Eliminate dust and loose parts, then gently sand mechanically or with a high-pressure water jet cleaner to completely eliminate the thin layer of cement grout. Be careful to remove residues from surface treatments such as paint, release agents, insulation, etc. Make sure the surface is flat after this operation. In the presence of macroscopic surface defects, correct with mortars from the EXOCEM line. Always bevel corners if they are to be bound with composite material.

Preparation of the product

Pour about 90% of the required amount of water into the mixer, then start the mixer and add RUREDIL X MORTAR 750 uninterruptedly to prevent lumps from forming. Mix for 2-3 minutes; add the rest of the water up to the quantity specified in the technical information sheet and mix for 1-2 minutes more.

Let the mix rest for about 2-3 minutes, then mix again and apply.

Laying of the product

Dampen the substrate, saturating it with water and being sure to remove excess water. Apply RUREDIL X MORTAR 750 with a smooth metal trowel in a layer about 3-4 mm thick; wait a couple of minutes and then bury RUREDIL X MESH GOLD in it. Apply a second layer of RUREDIL X MORTAR 750 about 3-4 mm thick to cover the mesh completely.

If the mortar becomes unworkable, do not add any more water, but mix for about 1-2 minutes and then continue applying.

The RUREDIL X MESH GOLD system should not be applied in sunshine, during the hot hours of the day in summer, or with moderate or strong winds.

If it is raining, shelter the structure from the rain.

The product should be applied at temperatures of between +5 °C and +35 °C; low temperatures (4-10°C) will slow down setting considerably; while high temperatures (35-50 °C) will rapidly cause the mortar to become unworkable.

Curing

In environments exposed to sun and wind protection may be required (CURING S or wet non-woven fabric). If it is about to rain, shelter the reinforcement appropriately.

Technical properties

PBO FIBRES PROPERTIES	
Density	1.56 g/cm ³
Tensile strength	5.8 GPa
Modulus of elasticity	270 GPa
Ultimate deformation	2.15 %
Breakdown temperature	650 °C
Coefficient of thermal dilation (10-6 °C-1)	- 6

MESH PROPERTIES	
Weight of PBO fibres in the mesh	88 g/m ²
Equivalent dry fabric thickness in the direction of the warp	0,0455 mm
Equivalent dry fabric thickness in the direction of the weft	0,0115 mm
Ultimate tensile stress of the warp per unit of width	264,0 kN/m
Ultimate tensile stress of the weft per unit of width	66,5 kN/m
Mesh weight (Substrate + PBOfiber)	110 g/m ² ± 3%

INORGANIC MATRIX PROPERTIES	
Consistency (UNI EN 13395-1)	175 mm
Specific weight of fresh mortar	1,80 ± 0,05 g/cc
Litres of H ₂ O for 100 kg of Ruredil X Mortar 750	24 - 28 liters
Yield kg/m ² /mm (dry product)	≈ 1,400 - 1,450 kg/m ² /mm
Compressive strength (UNI EN 196-1)	40,0 MPa (at 28 days)
Bending strength (UNI EN 196-1)	> 4,0 MPa (at 28 days)
Secant modulus of elasticity (UNI EN 13412)	> 7.000 MPa (at 28 days)

SPECIFICATIONS OF THE RUREDIL X MESH GOLD 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 GOLD, 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).

Durability of the RUREDIL X MESH GOLD system

The mechanical properties of the RUREDIL X MESH GOLD system are not influenced by high temperatures and fire since the binding matrix is inorganic, as in all FRCM systems. The graphic shown in figure N.1 illustrates the load increase of samples reinforced with RUREDIL X MESH GOLD exposed to different temperatures, compared with samples without reinforcement. It should be pointed out that bending strength of concrete drastically decreases at temperatures exceeding +130 °C.

RUREDIL X MESH GOLD: Load increase according to temperature

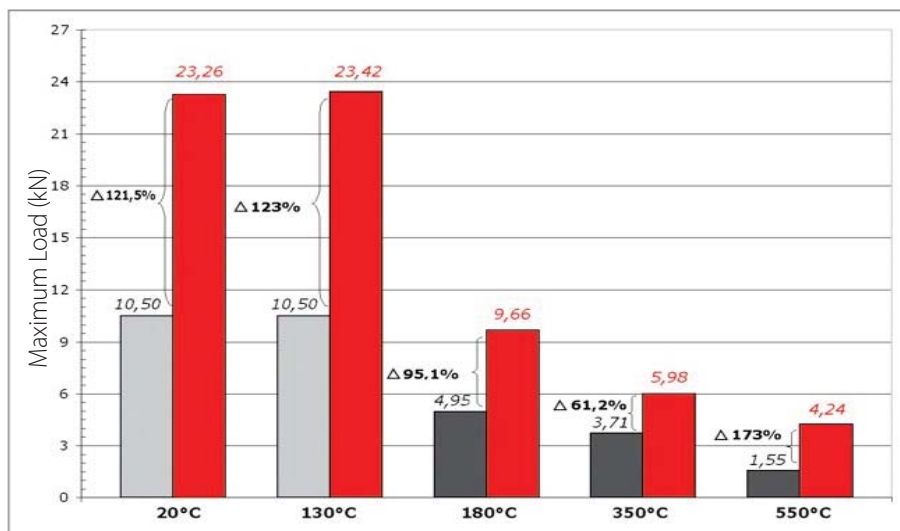


Figure 1

Storage

- RUREDIL X MESH GOLD: Store in a dry place away from heat.
- As RUREDIL X MORTAR 750 is inorganic it is sensitive to damp, and must be kept indoors in a dry place. Use up the whole package once it has been opened. Store at temperatures between +5°C and +35°C. The shelf life in sealed bags is 24 months from packing.

In fact, traditional FRP systems completely lose their mechanical properties after one hour of exposure to + 80°C because rigid resin becomes gummy. In addition, resin becomes unable to transfer concrete stress to carbon fibre as from + 45°C (Figure N.2).

C- FRP: Maximum load according to temperature with equal period of exposure (1h)

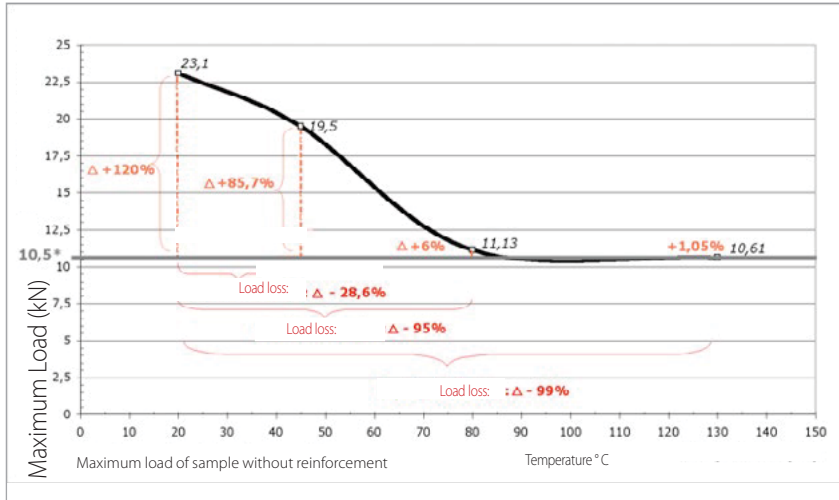


Figure 2

According to the accelerated tests performed at +80°C thermohygrometric conditions and 100% relative humidity, PBO-FRCM reinforcement does not have any chemical or mechanical alterations whereas C-FRP loses 100% of its efficiency (Figure N.3).

RUREDIL X MESH GOLD vs. C-FRP: Maximum load at +80°C - 100% relative humidity

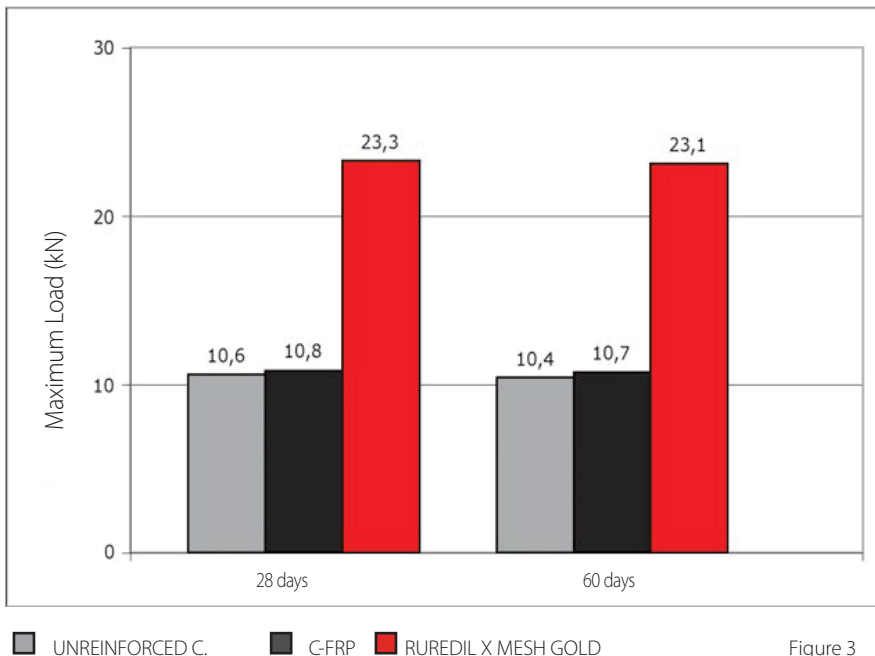


Figure 3

Bending stress reinforcement for concrete beams

The efficiency of concrete beams reinforced with RUREDIL X MESH GOLD has been carefully studied and tested. In fact, bending stress tests were performed on three or four points of concrete beams (40 cm x 25 cm) with 1.6 and 2.2m clearance. Different types of reinforcement were tested, similar to the ones referred to in figures N.4, N.5, N.6 and N.7. Certain test results concerning load - centre line displacement diagrams have been included in the above mentioned figures. The benefits of fibre reinforcement can be appreciated by the collapse load increase when compared with samples without reinforcement.

- Flex reinforcement of reinforced concrete beams with RUREDIL X MESH GOLD may be achieved with application to areas under tension and bracketing, resulting in an increase in distributed collapse load of around 10-50% or more of the current value.
- The typical reinforcement morphology consists of strips of variable length in the intrados, possibly folded over onto lateral surfaces and, where possible, with at least one U-shaped bracketing strip at the end of the longitudinal cover.

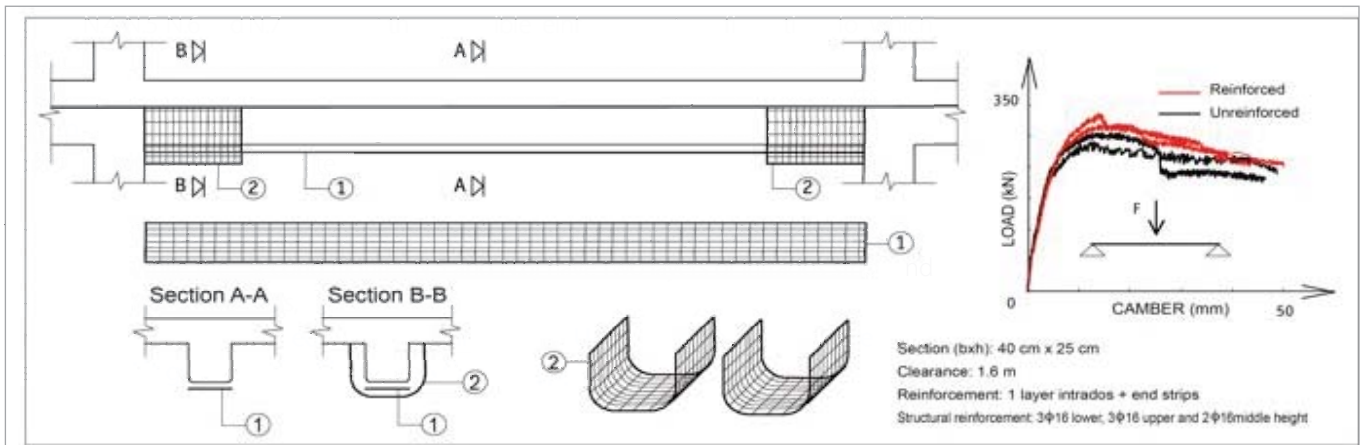


Figure 4

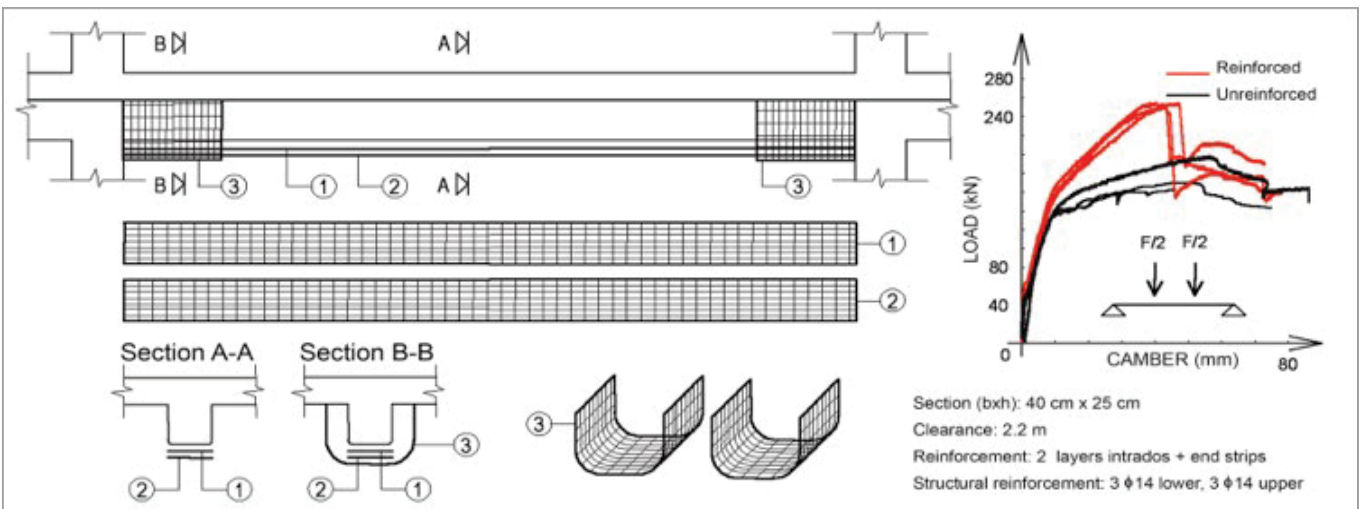


Figure 5

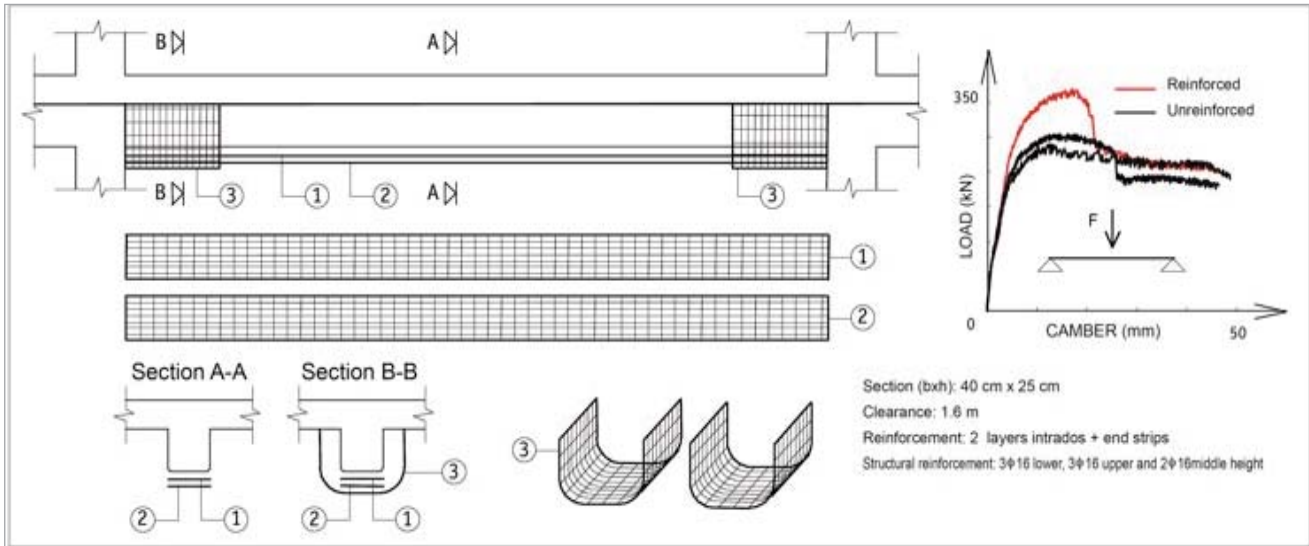


Figure 6

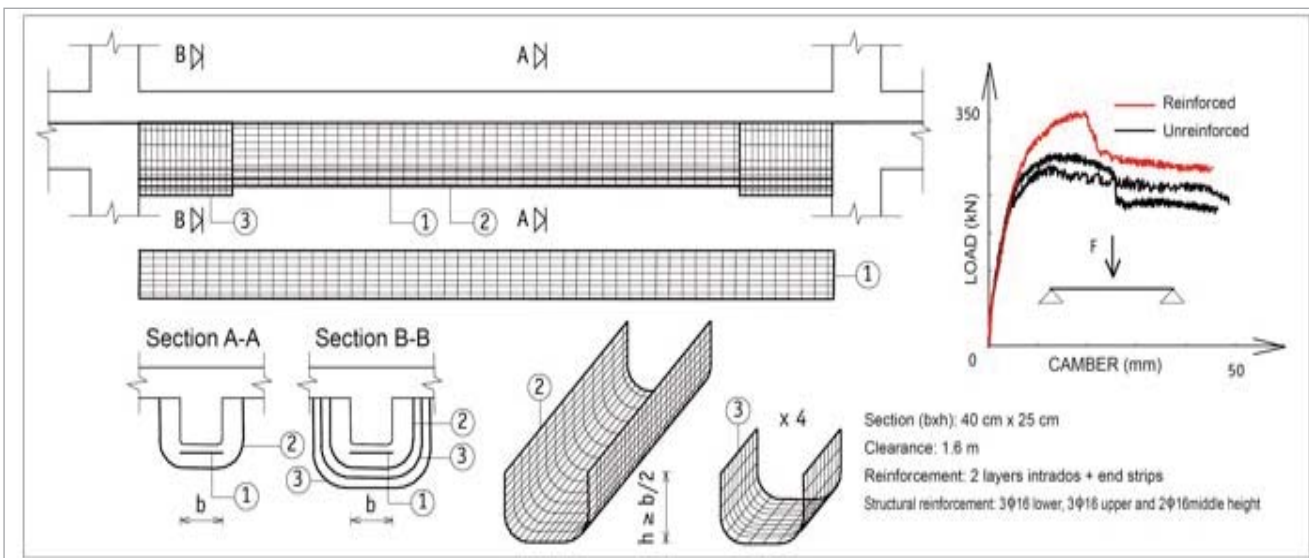


Figure 7

Design criteria for reinforcement with RUREDIL X Mesh GOLD for inflected reinforced concrete beams

According to the technical document CNR- DT 200/2013, the dimensioning of the flexural reinforcement can be performed at the ultimate state by considering a design resistance of the reinforcement taking the “intermediate peeling” crisis into account. With RUREDIL X MESH GOLD, usually this happens by sliding between fibres and cementitious matrix.

On the basis of these experiments performed, the following figures may be suggested for calculated tensile strength of the reinforcement (taking also the intermediate peeling crisis into account):

- with one reinforcement layer and U-shaped strips at the end (as shown in figure N.4): $F_{fd} = 158.5 \text{ kN/m}$ (force per width unit of the reinforcement), corresponding to the calculated (warp) tensile strength $f_{Fd} = 3483 \text{ N/mm}^2$ and the calculated ultimate dilatation $\epsilon_{Fd} = 1,29\%$.
- with two reinforcement layers and U-shaped strips on the ends (as shown in figures N.5, N.6 and N.7): $F_{fd} = 294.8 \text{ kN/m}$ (force per width unit of the reinforcement),

corresponding to the calculated (warp) tensile strength $f_{Fd} = 3240 \text{ N/mm}^2$ and the calculated ultimate dilatation $\epsilon_{Fd} = 1,20\%$.

These figures are to be used exclusively for assessment of the ultimate momentum of reinforced sections.

The verification of peeling at the ends at the ultimate state can be carried out according to the technical document CNR-DT 200/2013, considering, for the various configurations, peeling tensions at the reinforcement end of about 20% of the calculated resistances indicated above.

The peeling of the reinforcement at the end can be prevented with U-shaped bracketing strips shown as in figure 5 (which also improve shear strength) and the conformation shown as in figure 7 in the surface layer of reinforcement.

The calculated resistances above can be achieved only if the concrete of the metal rod has suitable mechanical properties. Premature breakages of the metal rod might occur, also causing the crisis with sliding of the fibres in the cementitious matrix might not be achieved.

Careful assessment of the mechanical properties of the surface layer of the concrete is therefore recommended, as is reconstruction of the entire area covering the reinforcement rod if it is found to be inadequate and if the metal rods reveal a state of advanced corrosion.

Once the reinforcement section meeting the ultimate state has been determined, it is possible to check the operating limit and that concerning stresses.

Generally the pre-existing stress state (due to the existing loads upon reinforcement application) should be considered, from which a differential dilatation between support and reinforcement derives.

Note

*Reinforcement **projects** must in all cases, as for all composite materials, be based on careful assessment of the properties of the structure to be reinforced. Specifically, it is important to study the quality of the materials used (concrete and steel), the amount of metal reinforcement present, the condition of the concrete covering the reinforcement rods and corrosion of the rods. It is also essential to assess how the structure reacts to crisis before and after reinforcement.*

***Designer** should be acquainted with the mechanical properties and durability of the structural reinforcement under the different thermohygrometric conditions it will be used.*

Before handing over the executive project, the designer must estimate, on the basis of essential tests conducted on the structure, the mechanical properties of the concrete and local damage (cracking and peeling) to be repaired. A total load test is strongly recommended both before and after reinforcement to certify the functioning of the composite-concrete pair.

*Before accepting the work the **supervisor of works** must carefully check the composite material, taking into consideration the mechanical properties and stability under the different environmental conditions of application, compliance with the conditions specified by the engineer on the surfaces for adhesion, and conduct a preventive test in addition to the usual inspections of the installation, including application of the composite material.*

CATALOGUE SPECIFICATIONS RUREDIL X MESH GOLD

Chemical/physical specifications:

Mesh weight (Substrate + PBOfiber): 110 g/m² ± 3%

Composition:

PBO fiber mesh.

Definition of performance:

Bi-directional unbalanced PBO mesh for cementitious structural reinforcement of concrete constructions.

Package

15 m² reel (15 linear m, width 100 cm)

Code

0109133020

Consumption

Consider overlapping of sheets by about 10 cm at joints.

Updated: 07.2013

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 750

Chemical/physical specifications:

specific weight (fresh mortar): 1,80 ± 0,05 g/cc
Consistency: 175 mm ± 10
Compliant with the UNI EN 1504-3 standard

Composition:

Stabilised inorganic matrix.

Definition of performance:

Stabilised inorganic matrix for FRCC structural reinforcement of concrete elements and structures.

Package

25 kg bags

Code

0105032020

Yield

About 5 sacks for 1 reel of mesh.

Updated: 07.2013

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First edition 01.2014. This edition cancels and replaces all previous editions. The safety data sheet and technical specifications may be downloaded from www.ruredil.it.