PRODUCTS FOR CEMENT, MORTARS, SLURRIES AND RELATED PRODUCTS

TECHNICAL DOCUMENT

GLASS FIBRE MESHES FOR FAÇADE RENDERS

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CSTB le futur en construction

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MODIFICATION HISTORY

Revision n°	Application date	Modifications
00	**29/06/2020**	**Update of the document presentation and of the document reference (This document cancels and replaces the Technical requirements of 8 May 2017)** **Important changes:** **Addition of reference documents (ETAG 004 (2013) guide or the EAD040083-00-0404) related to tests methods.** **Deletion of parts 3 and 4 (Characteristics classification and monitoring checks carried out by the manufacturer) having been moved to the reference document QB12 rev04)**

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1 MINIMAL SPECIFICATIONS AND TESTS

1.1 Identification tests

Test	Test Method	Specification
Surface density	§ 2.1 of the present document	/
Ash content	§ 2.2 of the present document	/
Mesh dimensions and number of threads	§ 2.3 of the present document	In compliance with the mesh dimension class M (average mesh dimensions when they are not square) **M1**: m ≤ 3 mm **M2**: 3 < m ≤ 5 mm **M3**: 5 < m ≤ 8 mm **M4**: m > 8 mm

1.2 Tensile strength tests

Test	Test Method	Specification
Tensile strength at the initial state	§ 2.4 of the present document	In compliance with tensile strength class T (measured in tension at failure at initial state $R_{initial}$): **T1**: $R_{initial}$ > 30 N/mm **T2**: $R_{initial}$ > 35 N/mm **T3**: $R_{initial}$ > 40 N/mm **T4**: $R_{initial}$ > 45 N/mm
3 ions tensile strength (24 hours – 60°C)	NF EN 13496 in force	/
3 ions tensile strength test (28 days – 23°C)	§ 2.4 of the present document	In compliance with alkali resistance class Ra (relative residual strength measured in tension after conservation in alkaline solution according to parameters r and R_{aged}): *See table below*
Cement tensile strength test (30, 60 and at 90 days – 23°C)	§ 2.4 of the present document	

Ra classes specification details:

	Strength after soaking in an alkaline solution					
	r: relative residual strength			R_{aged}: residual strength		
	90 days - cement		28 days - 3 ions		90 days - cement	28 days - 3 ions
Ra 1	≥ 40 %	and	≥ 50 %	and	≥ 15 N/mm	≥ 20 N/mm
Ra 2	≥ 50 %	and	≥ 60 %	and	≥ 25 N/mm	
Ra 3	≥ 60 %	and	≥ 70 %	and	≥ 35 N/mm	

1.3 Elongation

Test	Test Method	Specification
Elongation test	§ 2.5 of the present document	In compliance with elongation class E (strength measured at 0.5% elongation at the initial state): **E1**: $R_{0,5} \leq 2$ N/mm **E2**: $2 < R_{0,5} \leq 5$ N/mm **E3**: $5 < R_{0,5} \leq 8$ N/mm **E4**: $R_{0,5} > 8$ N/mm

2 TEST METHODS

2.1 Surface density

The test is conducted in accordance with specifications of the ETAG 004 (2013) or the EAD 040083-00-0404.

The test is carried out on three samples.

The surface density σ of the mesh is obtained by measuring and weighing a 1-metre length of mesh. The width of the sample must be the same as that of the roll.

$$\boldsymbol{\sigma = \frac{P}{S}}$$

P: mass of the sample in g

S: surface area of the sample in m²

The result is expressed in g/m².

2.2 Ash content

The test is conducted in accordance with specifications of the ETAG 004 (2013) or the EAD 040083-00-0404.

The test is carried out on three samples.

It involves square-shaped samples of about 100 mm² cut out at least 100 mm from the edge of the roll.

The ash content is determined at (625 ± 20) °C, until it reaches constant mass.

The crucibles are first dried in an oven at (900 ± 5) °C for at least 30 minutes, then cooled back down and kept at room temperature in a desiccator until the test.

Each crucible is weighed to determine its mass M_0.

The sample is cut up into small pieces and placed in the crucible. The whole unit is weighed to obtain the mass M_1 (crucible + mesh).

Each crucible is placed in the oven at room temperature (not pre-heated). The oven temperature is then raised to (625 ± 20) °C, then held at (625 ± 20) °C for 5 hours.

After cooling, each crucible is placed in a desiccator for at least 2 hours and until it reaches room temperature.

The whole unit is weighed again to obtain the mass M_2 (crucible + mesh).

The ash content is calculated as follows:

$$\boldsymbol{t_{625}}(\%) = \frac{\boldsymbol{M_2 - M_0}}{\boldsymbol{M_1 - M_0}} \times \mathbf{100}$$

The result is expressed as a % of the initial mass.

2.3 Mesh dimensions and number of threads

The test is conducted in accordance with specifications of the ETAG 004 (2013) or the EAD 040083-00-0404.

These are the dimensions of the openings (the thickness of the threads is not taken into account).

The test is performed in two locations on the mesh, at least 5 metres apart.

The distance between the threads is determined by measuring distance *D* between the 21 adjacent threads (i.e. 20 meshes; see figure 3).

Thickness *e* of a thread is determined from the centre of the meshes (see figure 3).

The average thickness $\bar{e}$ of a thread is obtained by measuring at least 10 threads, chosen at random, in the direction under consideration, using a measuring magnifier:

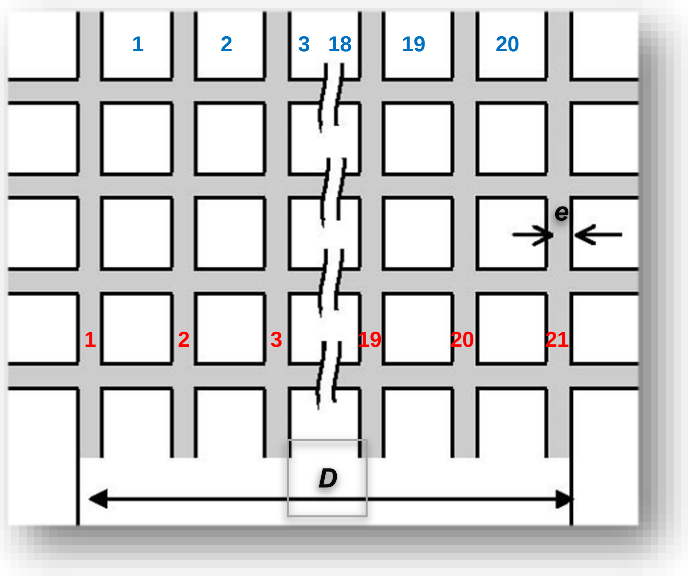


Figure 3. Determining the mesh dimensions

$$\bar{e} = \sum_{i=1}^{10} \frac{ei}{10}$$

Dimension *m* of the mesh, expressed in mm, is calculated as follows:

$$\boldsymbol{m} = \frac{\boldsymbol{D} - (\mathbf{21} \times \bar{\boldsymbol{e}})}{\mathbf{20}}$$

Dimension *m* must be determined in both the “warp” and “weft” directions of the mesh.

The *n* number of threads is determined as follows, by counting *N* number of threads over a 200 mm width:

$$\boldsymbol{n} = \boldsymbol{Partie\ enti\grave{e}re}\left(\frac{\boldsymbol{N}+\mathbf{2}}{\mathbf{4}}\right)$$

2.4 Tensile strength at failure and elongation

Tests at the « initial state » and at « 28 days – 3 ions » are conducted in accordance with specifications of the ETAG 004 (2013) or of the EAD 040083-00-0404.

2.4.1 Principle

Using tensile tests, the aim is to determine the mesh’s tensile strength at failure and elongation at break. The tests are conducted on samples at the initial state and on samples kept in alkaline solutions:

- *“28 days - 3 ions”*: conservation for 28 days in a solution made alkaline by adding 1 g/L NaOH, 4 g/L KOH and 0.5 g/L $Ca(OH)_2$ to distilled water;
- *“90 days - cement”*: conservation for 30, 60 and 90 days in a solution made alkaline by adding 25% by mass of white cement to tap water.

2.4.2 Sample preparation

For each conditioning type, 10 samples are cut in the “warp” direction and 10 samples in the “weft” direction.

The samples are cut out in accordance with the cutting plans in Appendix 1.

The samples include a minimal of 5 threads and are approximately 50 mm wide by 300 mm long.

The samples are cut out at least 150 mm away from the edge of the roll. A series is composed of 10 samples cut in the same direction.

The samples taken must be spread out in such a way that no two samples contain the same warp or weft threads (see Appendix 1). The 10 samples from each series are attached together and identified.

2.4.3 Test method

Preparing the alkaline solutions: “3 ions” solution and “cement” solution

Each alkaline solution is intended to be used to carry out a single test campaign on mesh.

The solutions are prepared in containers allowing the samples to be fully submerged.

The container holding the alkaline solution must be as defined in Paragraph 5.3 of standard EN 13496.

These containers, equipped with a cover to prevent evaporation, must be placed in a room kept at a constant temperature of (23 ± 2) °C.

<table>
<tr><th>“3 ions” solution</th><th>“Cement” solution</th></tr>
<tr><td colspan="2">The solution is prepared the day prior to sample submersion by adding:</td></tr>
<tr><td>to 2 L of distilled water:
- 2 g of NaOH, minimum 97% purity
- 8 g of KOH, minimum 85% purity
- 1 g of Ca $(OH)_2$ minimum 96% purity
i.e. a concentration of:
- 1 g/L NaOH
- 4 g/L KOH
- 0.5 g/L $Ca(OH)_2$.
The mixture is mechanically agitated for at least 30 minutes.</td><td>in 10 L of tap water:
(2.5 ± 0.1) kg of white cement (LAFARGE super-white cement CPJ CEM II/B 32.5 R CP2).
The mixture is manually agitated for about 5 minutes.
Stainless steel grating is positioned on top of the bed of cement after it sets, about 12 hours after preparation.</td></tr>
<tr><td></td><td></td></tr>
<tr><td>A test campaign is 2 series of 10 samples (1 series in the “warp” direction, 1 series in the “weft” direction) submerged for 28 days in the 2 L alkaline solution.
To suspend the samples in the tube, use an iron wire (1 mm diameter) sheathed in plastic shaped to fit snugly against the rim of the cylinder, then attach the samples and dip them into the tube.
</td><td>A test campaign is 6 series of 10 samples (3 series in the “warp” direction, 3 series in the “weft” direction) submerged flat and fanned out in the alkaline solution.
Two series of 10 samples (1 series in the “warp” direction, 1 series in the “weft” direction) are thus left submerged for 30, 60 and 90 days respectively.
Note: the samples are not all necessarily placed in the solution at the same time (it depends on the schedule).</td></tr>
</table>

Rinsing - Drying

When submersion in an alkaline solution is complete, the samples are taken out, and then successively conditioned as follows:

- They are fanned out and submerged, without stirring, for 5 minutes in an acid solution[1] obtained by adding 5 mL of hydrochloric acid (HCl diluted to 35%) to 4 L of water;
- They are then successively placed in 3 water baths[1] of 4 L each. The samples remain in each bath for 5 minutes,

- They are then conditioned at (23 ± 2) °C and (50 ± 5) °C% RH:
  - for 48 hours, for samples aged in the “3 ions” solution;
  - for 7 days, for samples aged in the “cement” solution.

Note: Any manipulation that could cause the fibres to deteriorate must be avoided (e.g. folding, pressing, etc.).

[1] Use only for two series of mesh (one series in the “warp” direction and one series in the “weft” direction)

Tensile test

The test is performed:

- at the initial state, on samples previously conditioned for 7 days at (23 ± 2) °C and (50 ± 5) °C% RH;
- after ageing, on samples conditioned in alkaline solutions.

The tensile test machine must be equipped with jaws covered in a material that ensures the sample will be held, without slipping, across its entire width (e.g. rubber) and must allow the tensile strength at failure and elongation at break to be determined.

The samples are aligned with the jaws such that the distance between the jaws is approximately 200 mm. The test is conducted at a constant tension rate of (100 ± 5) mm/min.

The maximum force *Fmax* in N as well as the elongation at break are recorded.

Tests during which the samples slipped in the jaws or broke at the location of the jaws are not taken into account.

2.4.4 Expression of results

Results of force/deformation curves

The tensile strength at failure R is the maximum force recorded divided by the width of the sample tested. It is expressed in N/mm.

$$\mathrm{R} = \frac{F_{max}}{50}$$

The relative elongation at break (or deformation at break) ε is expressed in %.

It is determined by taking length l of the sample as the origin of the deformations, corresponding to a 10 N pre-tension. Δ_l is the elongation at break in mm.

$$\varepsilon(\%) = \frac{\Delta \mathrm{l}}{l} \text{ x } 100$$

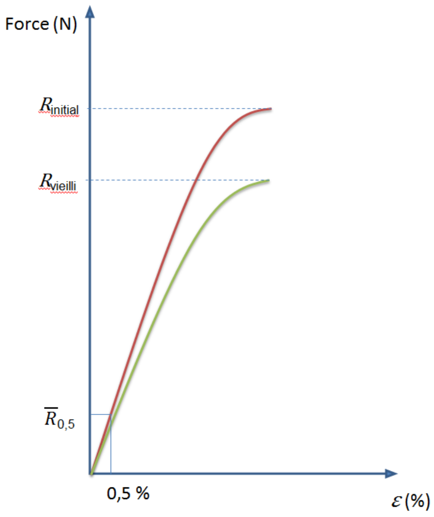


Figure 2 : Measuring the mesh's tensile strength - force/deformation curve

Results

For each series of samples, the averages $\bar{R}$ (in N/mm) and $\overline{A\ell}$ (in %) are calculated.

The relative residual strength *r* is calculated in % and is given by the relation:

$$r\ (\%) = \frac{\bar{R}_{\text{aged}}}{\bar{R}_{\text{initial}}} \times 100$$

$\bar{R}_{vieilli}$ tensile strength after ageing, called average residual strength, in N/mm

$\bar{R}_{initial}$ average tensile strength at the initial state, in N/mm

Excluding abnormal values

Any value (x_i) that fails to satisfy the following relation must be eliminated:

$$|\bar{X} - x_i| \leq 2{,}5\ \sigma$$

With σ the standard deviation of the series calculated according to the following relation:

$$\sigma = \sqrt{\frac{\sum(x_i - \bar{X})^2}{(n-1)}}$$

$\bar{X}$average of the series

n = number of samples in the series

x_i = individual values of the series

2.5 Elongation

The elongation $\bar{R}_{0,5}$ (in N/mm) is the average of the tensile strengths measured at 0.5% elongation, at the initial state.

3 Appendices

Appendix 1 : Mesh sample cutting plan for the tensile test

In order to guarantee more consistent results, the CSTB defined a sample cutting plan for tensile tests (see Paragraph 2.2.4 of this document).

All samples must be identified according to the following principle:

- the direction (warp or weft);
- nature of conditioning (initial, 30/60/90 days cement or 3 ions solution).

Two sets of samples are taken. The second set must be taken after making sure to remove at least a 5-metre length of mesh following the last sample from the first set.

Note: any samples in an area showing irregularities will be avoided (...).

Legend:

- **Identifying the direction:**
  C: samples cut in the "warp" direction
  T: samples cut in the "weft" direction

- **Identifying the nature of the conditioning:**
  I: samples in the initial state
  C3: samples to be conditioned in the cement solution for 30 days
  C6: samples to be conditioned in the cement solution for 60 days
  C9: samples to be conditioned in the cement solution for 90 days
  N: samples to be conditioned in the 3 ions solution for 28 days

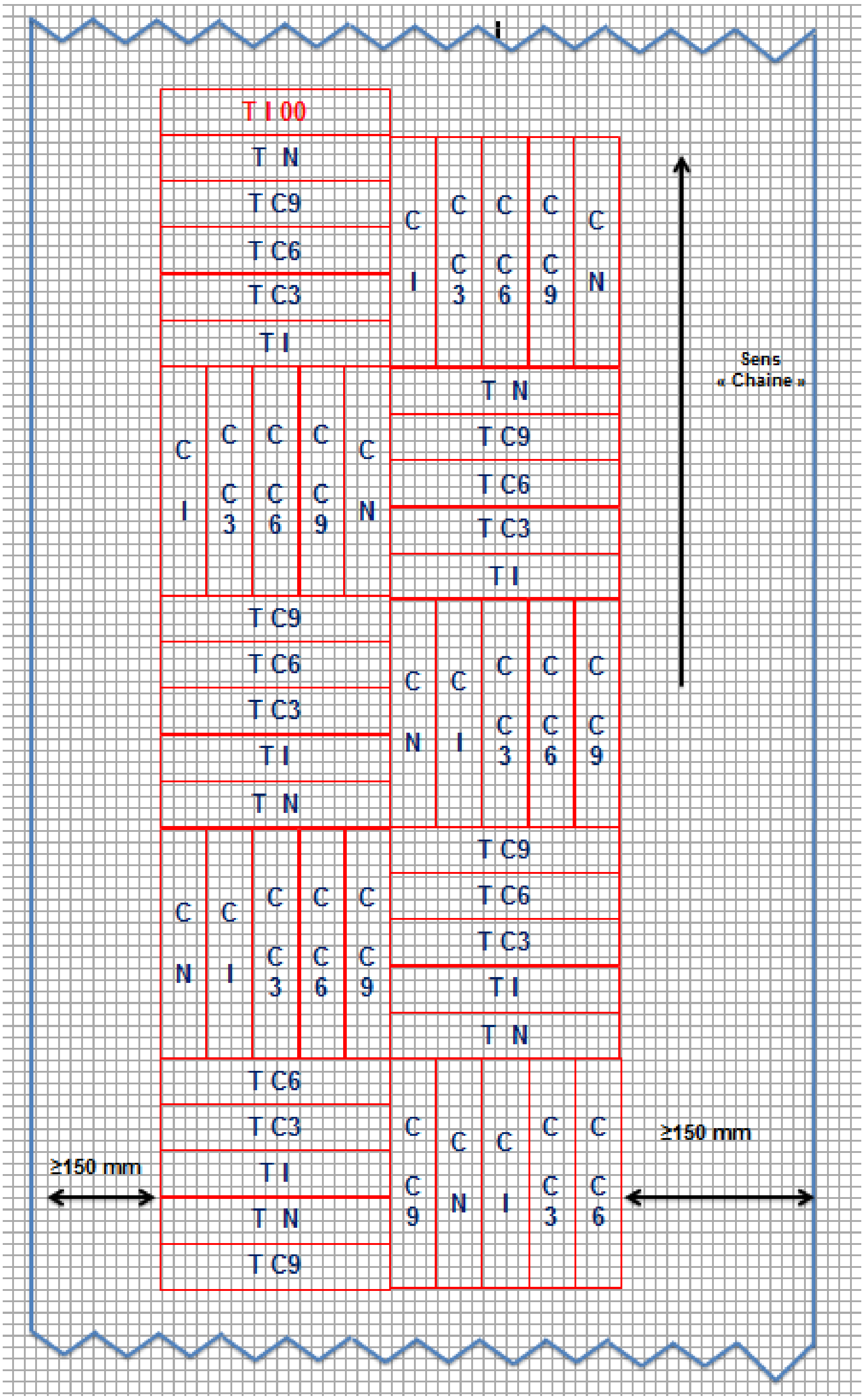
Note: the samples noted in TI 00 and CI 00 are used to adjust the tensile strength testing machine.

Examples:

C C9: this is a sample cut in the "warp" direction and which will be conditioned for 90 days in the "cement" solution.

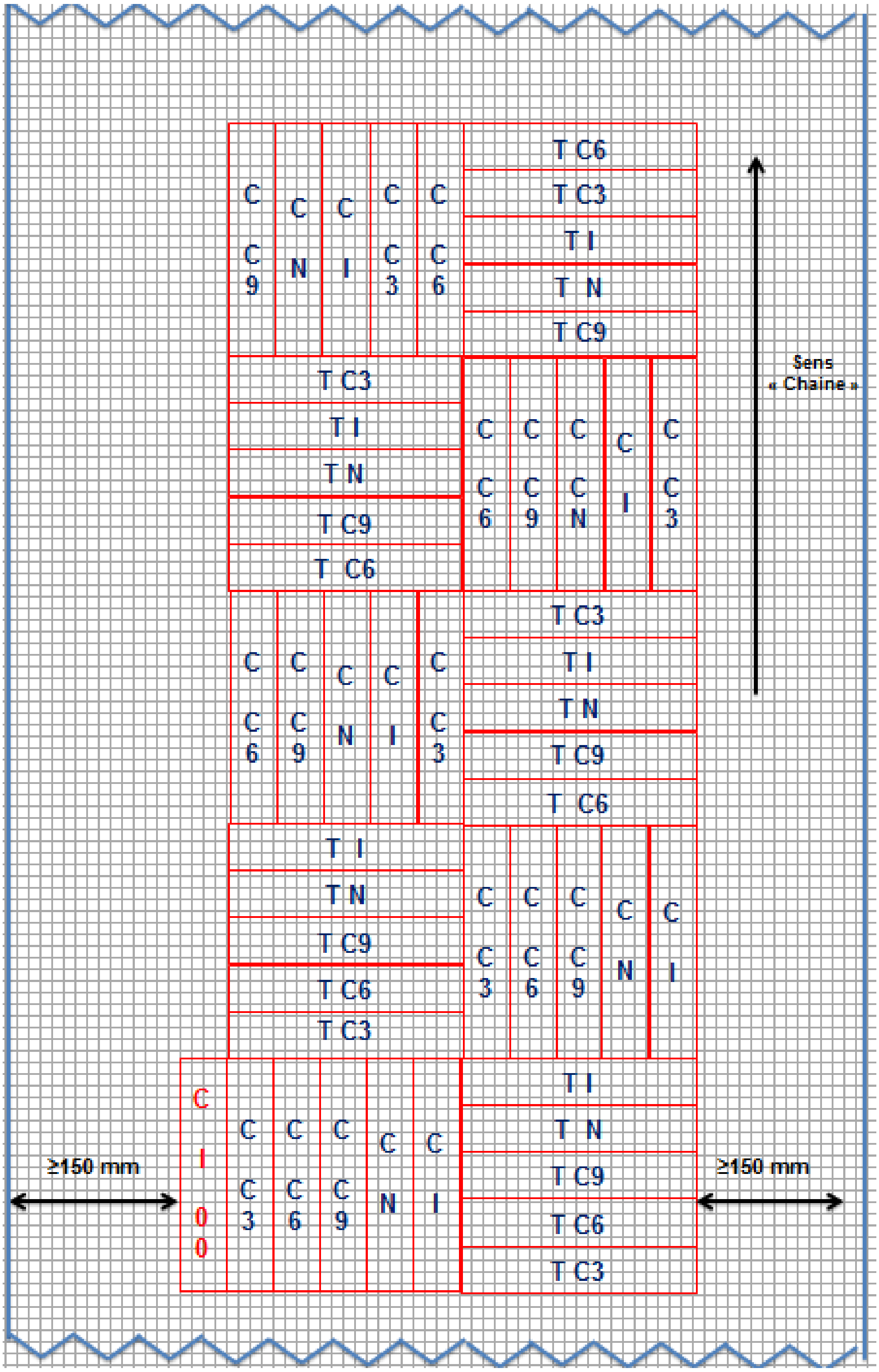
T N: this is a sample cut in the "weft" direction and which will be conditioned for 28 days in the "3 ions" solution.

Figure 3: First set :



The samples are approximately 50 mm wide by 300 mm long.

Figure 5 : Second set :



The samples are approximately 50 mm wide by 300 mm long.

Appendix 2 : Definitions

Reinforcement

Component intended to improve the mechanical characteristics of the render. The reinforcements covered in this document are glass fibre meshes

Normal reinforcement

Reinforcement enabling distribution of the render's internal stresses and deformations in order to reduce the chances the render will crack.

One normal reinforcement can be placed on top of another in the same render layer to improve impact resistance.

Strengthened reinforcement

Specific reinforcement incorporated into a render in addition to a normal reinforcement in order to improve impact resistance.

Glass fibre mesh

Product composed of a meshed network of glass fibre threads protected by a coating, usually organic. The glass fibre meshes to which this document applies are used to reinforce façade renders.

These meshes can be one of two types, woven (most common case; see figure 1) or heat-welded (see figure 2).

Normal reinforcement mesh is distinguished from strengthened reinforcement mesh.

Mesh

Square or rectangular opening left between a mesh material's interlaced threads.

Warp

All the threads extending vertically and serving as a support for the mesh's weft threads. The length of the mesh roll corresponds to the "warp" direction.

Weft

All threads positioned perpendicular to the mesh's warp threads. The width of a mesh roll corresponds to the "weft" direction.

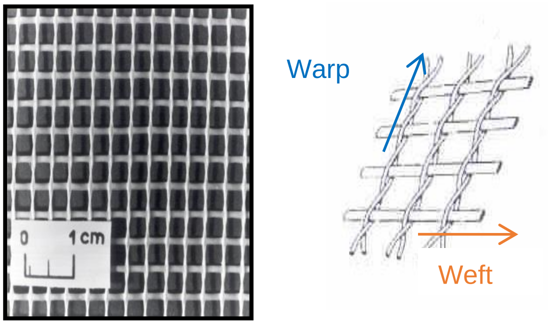


Figure 1. Woven mesh (example).

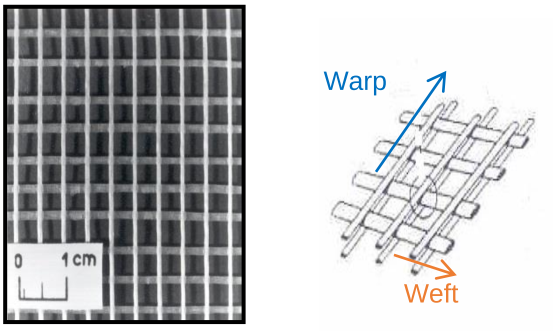


Figure 2. Heat-welded mesh (example).