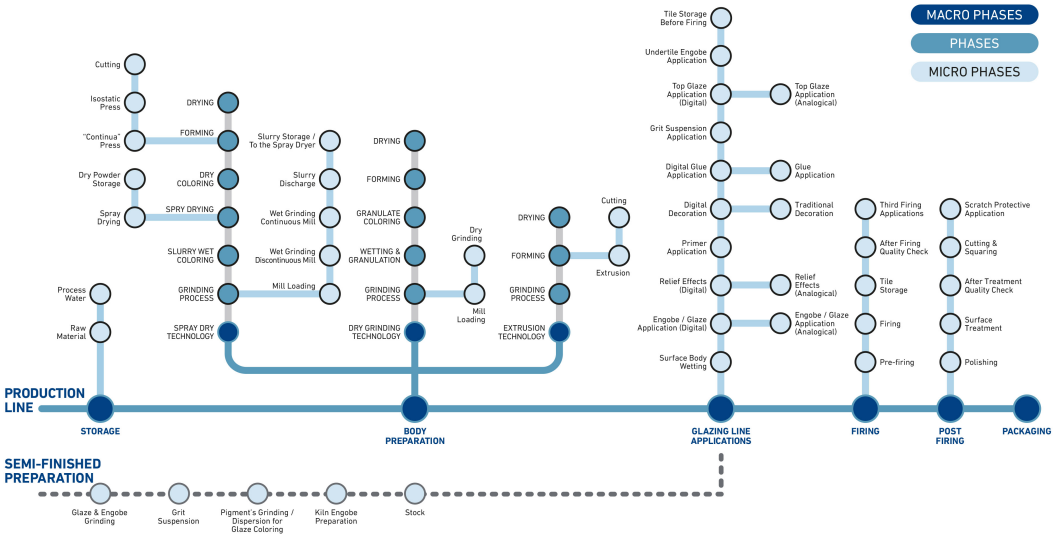
ZSCHIMMER & SCHWARZ
CERAMCO

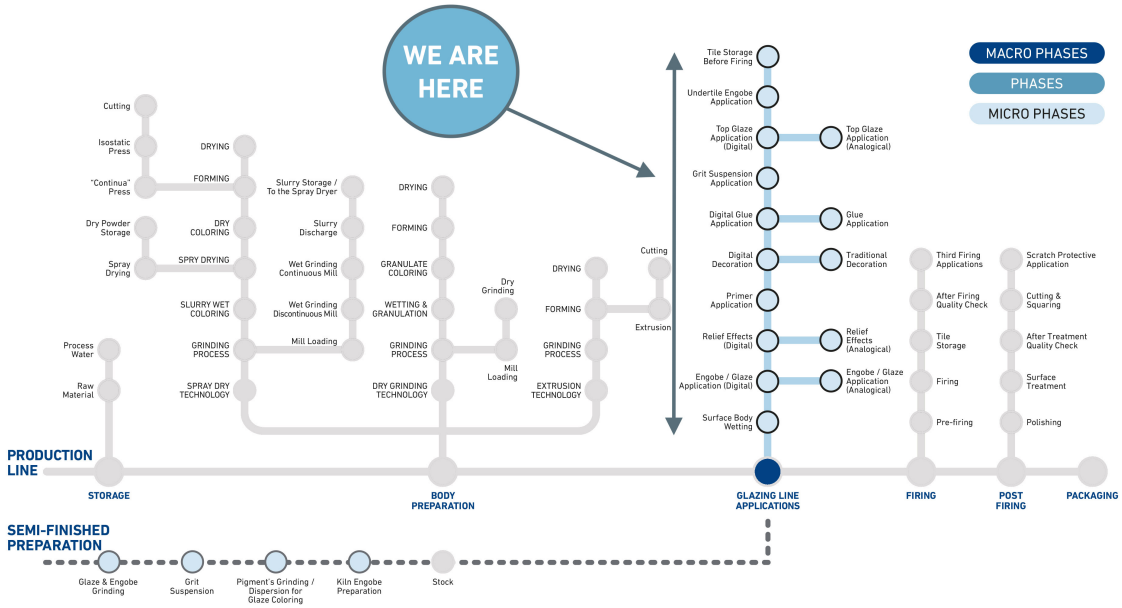
APPARENTLY INVISIBLE YET CONSTANTLY PRESENT

At every stage of the ceramic production process

A journey through problems & solutions



#09 MECHANICAL RESISTANCE OF RAW AND DRYED TILES



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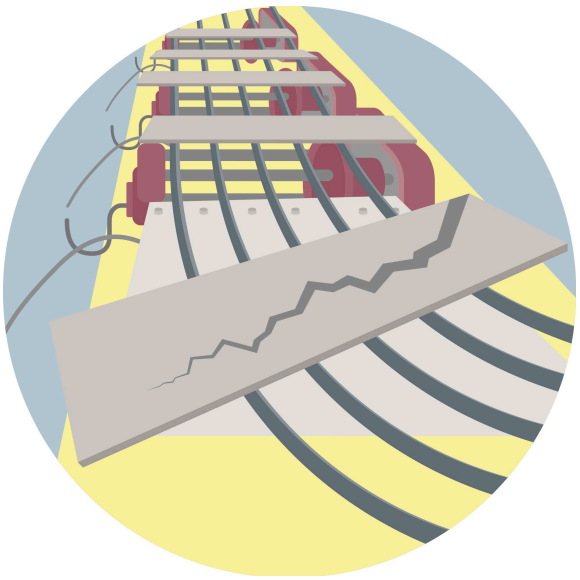
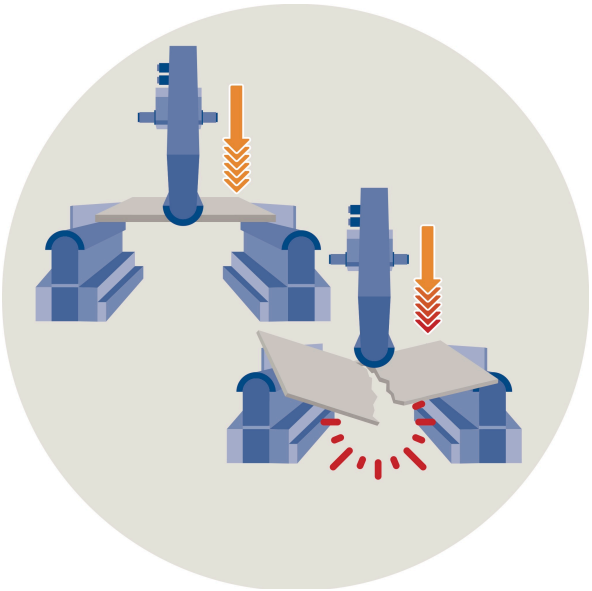


1. MECHANICAL RESISTANCE: REGULATIONS AND MEASUREMENTS

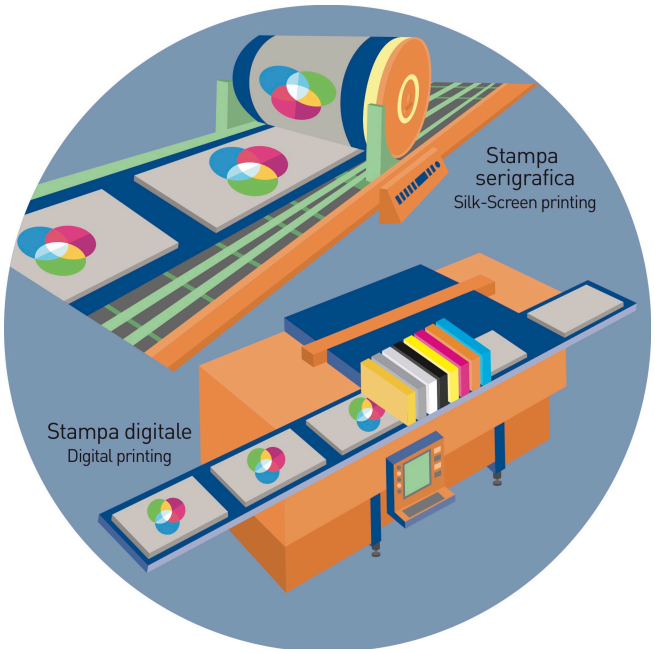
The **mechanical resistance** value of raw ceramics tiles is regulated by the UNI EN ISO 10545/4 and it is measured by a device called *chrometer*.
This is a specific precision tool that is able to define the **breaking force** and the **flexural strength** of the ceramic support by applying a force that gradually increases in the middle of the sample under examination, until it breaks.



Mechanical resistance must always be carefully checked.

This was in the past when the ceramic support used to undergo to high stresses in terms of **bending and compression** due to the old decoration process by means of flat screen printing or silicon engraved roller machine by which there was a real contact between the tool (such as a roller for example) and the raw tile.
And – even if with a different approach – it is important still now, despite traditional decoration processes have been increasingly replaced by the digital printing process that by nature do not stress the support with any weight.

2. FROM CONTACT DECORATION TO DIGITAL DECORATION: MECHANICAL RESISTANCE & NEW PERSPECTIVES



If on the one hand new decoration processes have partly removed the pressures on the ceramic support, the increasing of tiles' dimensions – that today can reach significant sizes, larger than 120x300cm – have, on the other hand, make it more sensitive to deformation. The support also undergoes to all those stresses that may occur on the conveyor rollers and that can deform or even break the tile.

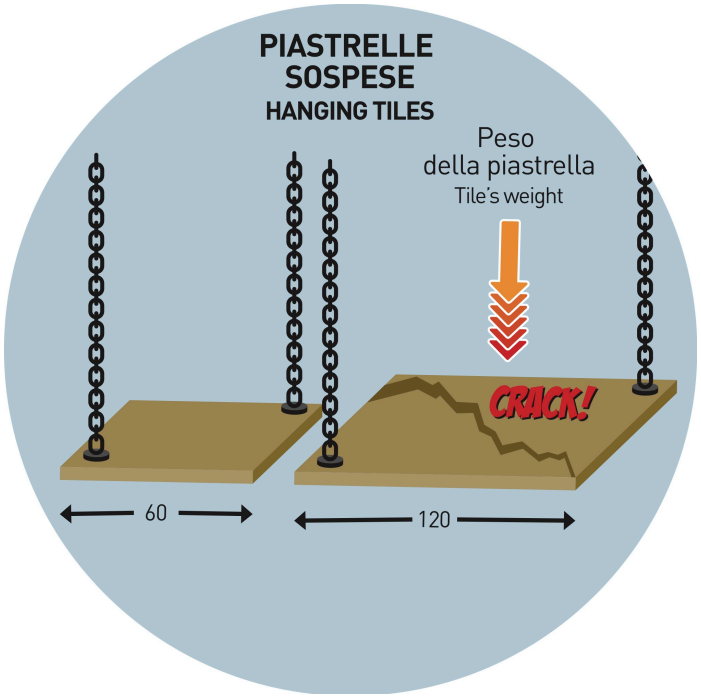
For this reason, it should be better to talk about **MAXIMUM ANGLE OF DEFORMATION** (before its breaking point) instead of resistance to the bending.

Why?

3. LARGE-SIZE CERAMICS AND FRESH PERSPECTIVE ON THE TOPIC

Large-size ceramics are often subjected along the production line to the **stress of their own weight** that can cause deformations until they break.

Here's a practical example.



Let's take two different tiles with the same thickness (60x60 and 120x120) and then let's try to keep them suspended by hanging them at their opposite edges, or corners

What happens?

The smaller one, despite its weight is not small, does not suffer any damage. On the other side, the larger tile could more easily break in the middle due to its own weight.

This simple example underlines that **the modulus of rapture is identical (since we did not apply any extra weight) but the result is very different**.

It also explains that, even without pressure, large-sized raw tiles can be more easily affected for example by the presence of bumps along the production line or by a planarity of the conveyor rollers.

IMPACT RESISTANCE

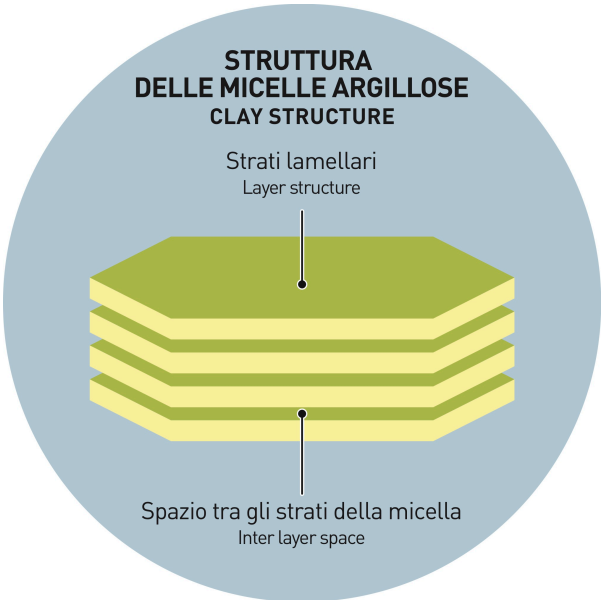
The weight of the tile also affects the **impact resistance**.

A small collision along the production line could not be a problem for a small-sized raw tile because the tile could be easily blocked along the line without breaking (leading, however, to different kinds of problems such as a production stop). The same collision might be instead critical for a larger-sized raw tile that could probably crack.

4. TYPE OF CLAYS

After this short introduction, the question is:
what are the elements to consider that can affect the mechanical resistance of a tile?

The answer is in this case quite easy:
Clays – I mean the kind and the nature of clays - are surely the first in line.



The different features of clays differently impact not only the quality of the tiles but also the proper development of the production process.

Among the several raw materials available on the market, plastic, or very plastic clays – marked by a high surface area and by the ability to absorb a large amount of water – can certainly improve the mechanical features of raw tiles, even if their use is properly and carefully calibrated by producers.

Why?

Because all ceramic body are usually made of different kind of clays that are blended to reach a good level of fluidization, sintering, proper coefficients of thermal expansion as well as a constant tension of water during the drying and so the evaporation process.

Nevertheless, **to reduce the use of very plastic clays means to renounce to high-performing raw materials in terms of mechanical resistance**. This reduction can sometimes produce ceramic bodies unable to avoid tiles cracking along the glazing line.

So, one may ask: why don't' we change the formula of the mix and so we solve the problem at its origin? To modify the formulation of ceramic mix is very complex and that's why it is usually better to take different actions.

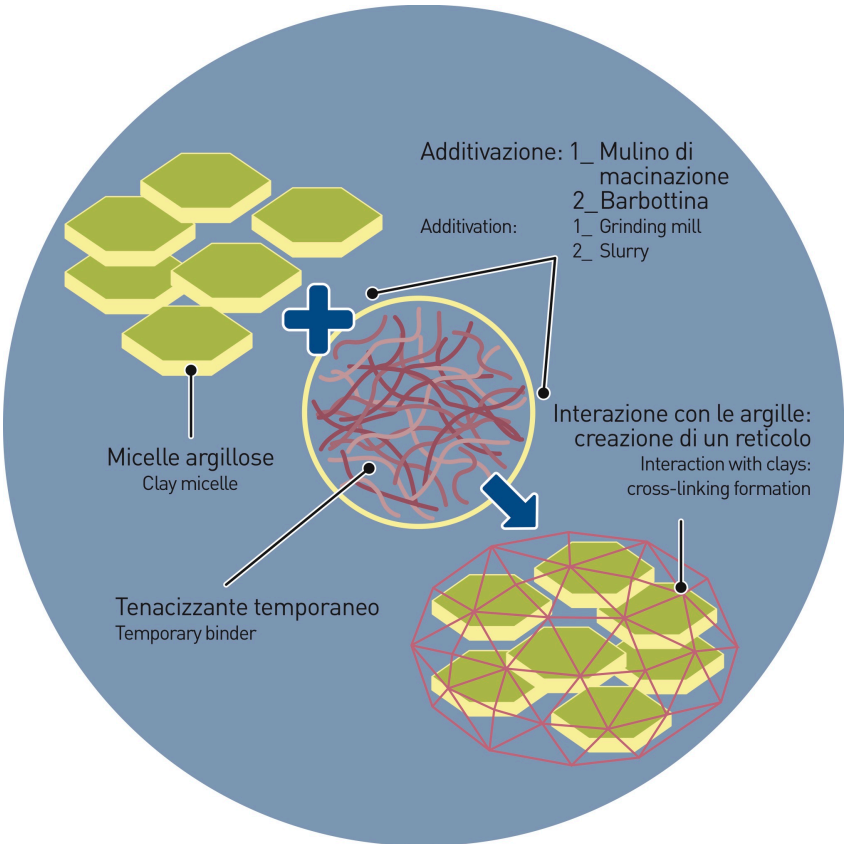
5. HOW TO SOLVE THE PROBLEM: TEMPORARY BINDERS

The use of **temporary binders** (so called according to their ability to bind the tile only until the pre-firing stage) is surely the easiest way to increase the mechanical resistance of dry tiles.
They differently act from *tout court* binders that, once they are added to the ceramic mixture, permanently increase the mechanical resistance of the tile, even after firing.

WHAT IS A TEMPORARY BINDER?

Binders are usually organic molecules able to promote a binding action towards the raw materials of the mixture, especially with clays.

What happens from a chemical point of view?



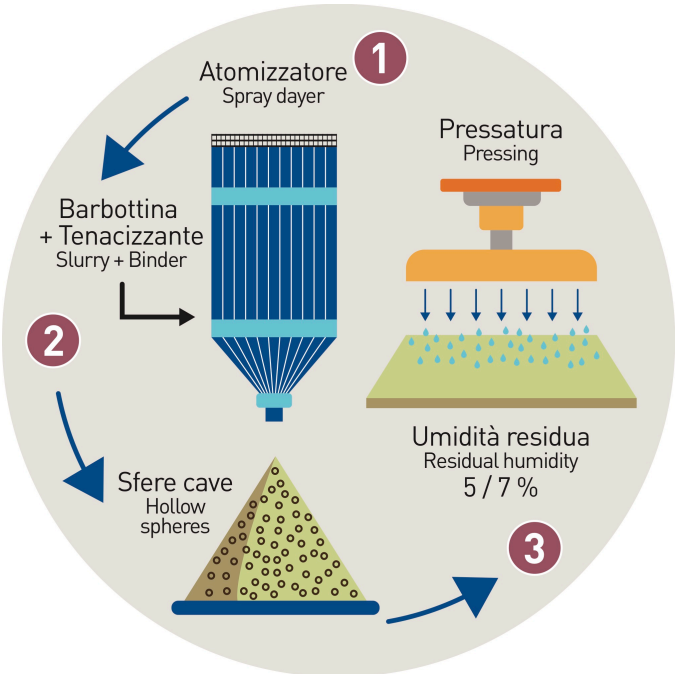
A molecule of temporary binder contains functional groups (parts of the molecule able to chemically interact with other materials) able to form a **lattice or a cross-linking** both between the

micelle and the hard inorganic raw materials. It basically links together the inorganic particles, increasing the resistance of the tiles after drying process.

The temporary binder is usually added inside the mills during grinding / milling process or directly in the barbottina / slurry (the mix of clays, raw materials, and water).

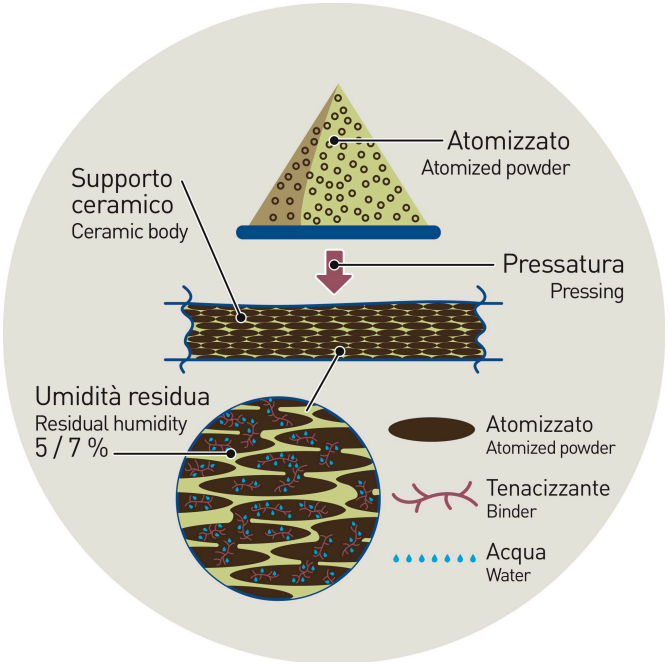
6. THE WATER'S ROLE

The slurry, once it has reached the proper features, enters the atomizers where the water undergoes to a strong and violent evaporation process that leads to the formation of granules (hollow spheres) marked by a residual humidity that normally ranges from 5% to 7%.



After the process inside the atomizer, the atomized clay powder, that already contains the temporary binder, forms after pressing stage, the raw ceramic body that keeps inside the residual humidity.

RESIDUAL HUMIDITY
The presence of the latter exactly prevents the binder to completely perform, being surrounded by water molecules. So, at this moment, clay's particles are only partially bound.



The temporary binder, in fact, starts its action only after the drying process: the dryer completes the evaporation of the residual humidity that – leaving the clays, the hard raw materials and the temporary binder's molecules – leads to the formation of bonds between organic and inorganic molecules.

7. DIFFERENT KIND OF BINDERS AND OTHER POSSIBLE ACTIONS

As usual, even in this case, it does not exist a universal product that can be indifferently used in all production sites. It is always necessary to study inside the lab the proper solution that can fit the different parameters of producers.

Following here some other scenarios that can affect the raw tile's mechanical resistance.
The list could be very much longer but these example can give you an idea about how different the can be origins of the problem.

1. **Over-wetting of the raw ceramic support** → In this case, it could be possible to increase the density of the glaze or, more generally, to decrease the amount of water along the glazing line
2. **Improper set-up of the dryer** → For example, the water could be too rapidly expelled producing therefore a too rapid withdrawal of the ceramic body that could give arise to tensions, facilitating the formation of crack or points of fragility
3. **Defect produced during the pressing process** → Such as in-homogeneity in the density of the ceramic mixture after pressing
4. **Low humidity of the atomized powder** → This could lead to a low cohesion of the ceramic body. To solve the problem it could be probably necessary to better regulate the dryer's parameters in order to provide the granules with a higher residual humidity
5. **Dry coloring of the ceramic body** → Use of proper powdered binders

In all these cases, depending on the severity of the context, it is possible to take a first action in the different production steps (such as drying or pressing) adjusting the parameters, and secondly using the proper temporary binder that has to be studied according to the target.
