Kraft Curing Systems GmbH, 49699 Lindern, Germany

Temperature difference in the chamber – the enemy of quality

Daniel Rafter and Stefan Rick, Kraft Curing Systems GmbH, Germany

Different climate zones in curing chambers are more the norm than the exception. They cause color differences and problems in the strength of concrete products. These effects are caused by the curing process. Good insulation, uniform air distribution and accurate heat and humidity control are the remedies.

Temperature differences in rooms are normal condition

You don't have to be a thermodynamics engineer to know that warm air rises to the top of a space. Each of us has seen this phenomenon before, whether at the campfire, barbecuing or over the hot asphalt in summer. But why is that so? Warmer air has a lower density than colder air. The molecules absorb energy and are more strongly in motion, their distance to each other becomes larger.

In living rooms we can experience this on our own bodies at colder temperatures. A radiator heats the air in the room and creates the effect described above, which is further enhanced by the design and position of the radiator. Warm and dry air accumulates under the ceiling. When it cools down, it sinks to the floor. Its ability to absorb moisture decreases, the humidity increases and additionally cools the lower part of the room. The result, especially in winter: we get a warm head but we still have cold feet. Especially in less well insulated, older buildings and when heating with convector heaters, this is the normal case.

What appears uncomfortable in living rooms and in the worst case has health consequences, is also unfavourable for high-quality concrete products. However, the differences here are far greater. While with badly insulated living space may have temperature differences of up to 10°C with a ceiling height of 2,50m (e.g. 17°C at the floor and 27°C under the ceiling), the deviations will exist to a greater magnitude in curing chambers with ceiling heights of up to 10 meters. Measurements carried out by Kraft as part of curing chamber inspections have already recorded differences of more than 20°C.

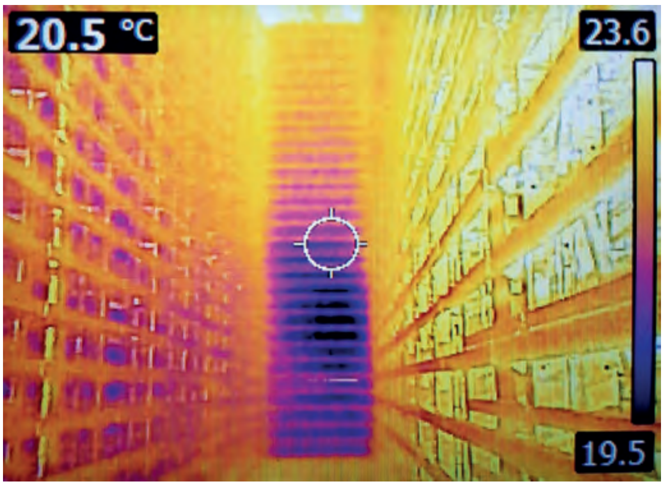

Fig. 1: Thermal image of a filled stack of boards in the rack passage. Clearly visible: in the lower area, the rack and also the concrete products are relatively cooler. They become warmer the further up the rack they are stored – an undesirable effect. (Picture: Kraft Curing Systems)

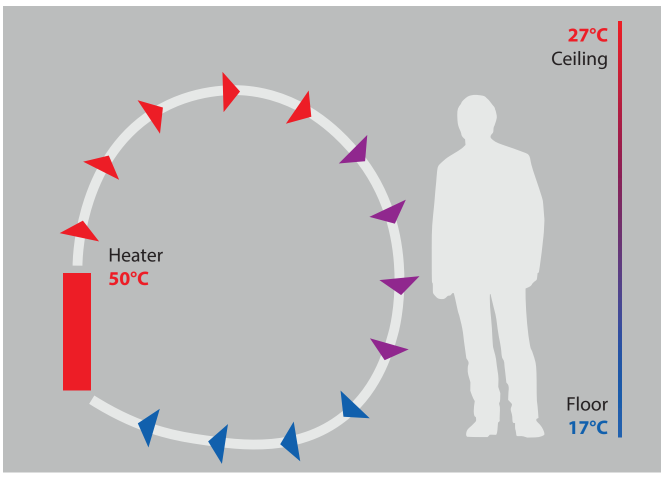

Fig. 2: "Warm head and cold feet" - the typical effect of classic heating of living spaces can be transferred to the conditions in concrete hardening chambers and also causes negative effects there. (Drawing: Kraft Curing Systems)

WWW.KRAFT-TREX.COM

T-REX GRANULATE DISPENSER

PROTECTION IN LAYERS

FOR CONCRETE PRODUCTS

biodegradable Granulate

LAYER SECUREMENT
against moving

SURFACE PROTECTION
against scratches

PREVENTS EFFLORESCENCE
air circulation ensures hydration

ECOLOGICAL
biodegradable granulate

AUTOMATIC OPERATION
sensors detect products

DURABLE SYSTEM
no wear parts

KRAFT CURING

WWW.KRAFTCURING.COM

CONCRETE CURING SOLUTIONS. **MADE IN GERMANY**

Temperature differences have a negative influence on concrete quality

In order to achieve the highest possible quality and uniformity, concrete manufacturers are interested in improving their products current curing conditions. This hardening process, also known as hydration, must be identical in all areas of the chamber. Only then are identical concrete products the result. The temperature in the vicinity of the concrete product is a decisive factor influencing the course of this chemical process.

In view of the constantly increasing quality demands of customers worldwide, temperature differences during the curing process also increase the risk of defects leading to complaints. The rejection rate increases and the reputation as a quality manufacturer suffers. There are mainly two properties of the finished concrete products that are negatively influenced by temperature differences: the color or color intensity and the density or strength.

Temperature difference leads to different colors

The most obvious effect of temperature differences in the curing environment, which is also immediately apparent to the layperson, is color differences. The reason for this is a different rate of hydration. At higher temperatures this happens faster than at lower temperatures. In principle, hydration takes place in such a way that the cement reacts with the water present in the concrete mixture to form the so-called cement stone. Depending on the temperature at which this reaction takes place, the cement paste forms more or less large crystals with fine branches, the crystal needles.

The size of, and the fineness of the crystal needles are responsible for how the light hitting the concrete is scattered and what color impression is created. "Higher hardening temperatures lead to finer crystals. The stronger light scattering of fine crystal needles causes the concrete color to be lighter than that of an otherwise identical concrete that has been hardened at a lower temperature. However, this phenomenon usually only becomes apparent when the temperature difference reaches a certain order of magnitude, e.g. when a steam-hardened concrete is compared with a concrete that has been hardened at normal room temperature. (from: Einfärbung von Beton - Verarbeitungstechnische Hinweise für Pigmente, Publication by Scholz Farbpigmente, 11/2011)".

It is important to note that the effect is permanent. Since the process of crystallization of the cement particles is completed after a only few hours, it does not help to wait any longer for the finished product to lighten after a few days of storage and to adapt to the lighter bricks of the same batch. This adjustment does not occur.

Influence of Curing Temperature on Colored Concrete

Fig. 3: Influence of the curing temperature on the color impression of concrete blocks. Higher temperatures lead to lighter colors (Picture: Kraft Curing Systems)

Temperature difference leads to different strengths

A not immediately recognizable, but equally important effect of temperature differences in the curing environment are differences in the strength of concrete products. In addition to the known influencing factors such as water-cement ratio and cement type, the climatic factors; moisture and temperature are decisive for the strength development of the concrete. The strength develops faster at the beginning of hydration, as time passes the rate of strength gain decreases. The temperature has a major influence on the strength development, especially on the early strength. "The influences have a particularly strong effect on the initial hardening in the first few days. A lower water-cement ratio and higher cement strength result in faster strength development. It is also accelerated by higher temperatures (from: beton.wiki: Strength development)".

The influence of the curing temperature also has a lasting effect on strength. As can be seen from fig. 4, even after a storage period of 28 days at lower temperatures the final strength is not as well developed as at a production temperature of 20°C. Here, too, it does not help to wait long enough to achieve the desired final strength.

Depending on the cement used, the observed effects are sometimes stronger and indeed sometimes weaker. However, they are always present, and they are definitely undesirable because they result in poorer quality product. The hardening of a concrete products at lower temperatures can lead to flaking corners and edges (immediate effect) or to faster wear and shortened service life (long-term effect). If these problems occur in a batch with perfect pavers, the entire batch may be under scrutiny from exacting customers.

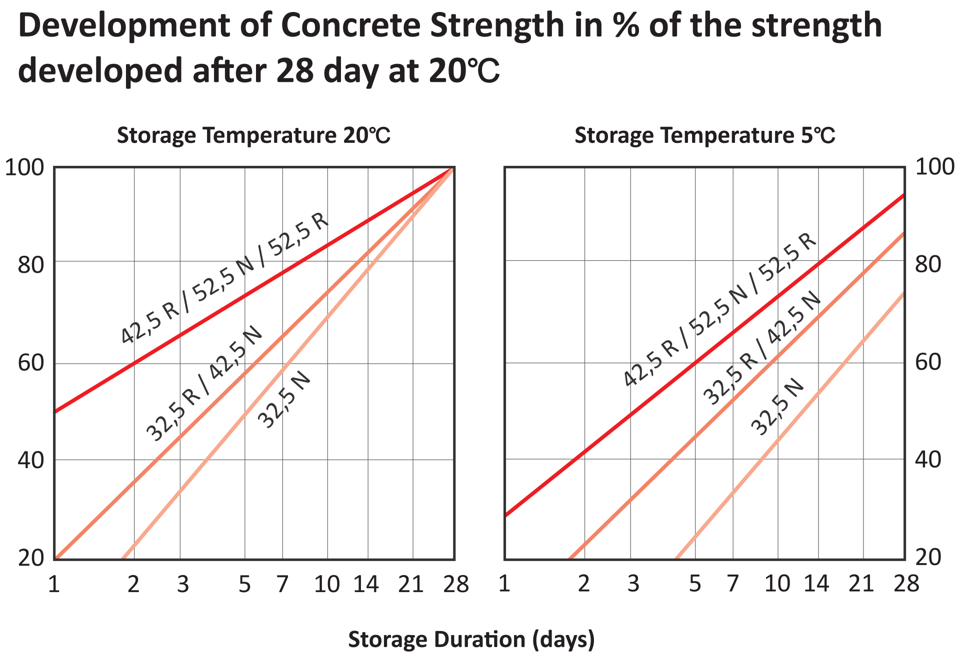

Fig. 4: Illustration of the dependence of the strength development of different cements at different temperatures. (Graphic: Kraft Curing Systems)

Avoid temperature differences - but how?

Understanding these problems is key to the solution. Kraft Curing Systems believes that accelerated curing of concrete products should take place without compromising product quality, namely; color and strength. As a developer of heating and air circulation equipment for the concrete industry with over 25 years of experience, Kraft has taken the challenge and created Quadrix®, a state-of-the-art system that provides a uniform curing environment for accelerated curing of concrete slabs and paving stones. To further increase the uniformity of the curing climate, Kraft has developed its own curing rack in addition to the Quadrix system, which plays an active role in the curing process.

By integrating the rack into the curing system (columns and cross-connections act as air ducts), the Quadrix system can circulate a large volume of heated air, typically 30,000 m³ per hour, through the entire rack structure at extremely low air speeds. This innovative approach allows a temperature accuracy of +/- 1 degree Celsius at any point in the curing environment, regardless of the size and shape of the chamber.

The Quadrix air handling unit at the heart of the system offers adjustable curing temperatures between 35 and 40 degrees Celsius with energy efficiency of 94%. Powerful radial fans, stainless-steel heat exchanger and burner working in combination with the Kraft Curing Rack maintain this uniform temperature across the entire curing area.

Fig. 5: Every single perimeter column of the Kraft rack functions as an air duct, heating the chamber floor, thus avoiding condensation and eliminating corrosion. (Picture: Kraft Curing Systems)

If the Quadrix unit is the heart of the system, the racks are the lungs, helping to create a truly homogeneous curing environment through comprehensive air circulation. In a conventional rack, between 8 and 14 vertical supply ducts are used to distribute the air inside the chamber. This inevitably leads to a less-than-ideal blending of the heated supply air with the chamber air, resulting in unfavourable temperature differences, therefore humidity differences will exist as seen in the thermal image. This problem is eliminated in the Kraft Curing Rack. Due to their new role as air supply ducts, the support columns also contribute to the heating of the floor slab. The large mass of the slab behaves like a storage heater, gently emitting heat to the curing environment using indirect radiant heating, like you experience from a tiled bathroom floor with underfloor heating.

In addition to achieving an extremely small temperature difference within the curing climate, the use of the columns as air ducts in the Kraft system improves the longevity of the structure. The heated air flowing through the columns has a heating effect on the steel. The entire structure is slightly warmer than the ambient air, preventing condensation and corrosion.

In traditional systems, poorly insulated floor slabs form thermal bridges to the outside in the area of the exterior walls. The temperature beside the chamber wall is therefore always lower than the inner areas of the curing environment. The perimeter columns are always cooler than the inner ones, which tend to collect condensation and corrode, sometimes until the point of failure. Since in the Kraft Curing Rack system each column adjacent to the chamber wall is supplied with warm air, the dew point shifts outside the curing chamber, where it can no longer cause harm to the rack structure or building.

The result of this thoughtfully designed equipment is a totally balanced, tailor-made curing environment which gives concrete producers the means to control what is arguably one of the most important steps in the manufacture of high-quality concrete products. The highest quality concrete requires the highest quality curing environment. ■

Kraft Curing sponsored the free download possibility of the pdf of this article for all readers of CPI. Please check the website *www.cpi-worldwide.com/channels/kraft_curing* or scan the QR code with your smartphone to get direct access to this website.

FURTHER INFORMATION

KRAFT CURING
CONCRETE CURING SOLUTIONS · MADE IN GERMANY

Kraft Curing Systems GmbH
Mühlenberg 2
49699 Lindern, Germany
T +49 5957 96120
F +49 5957 961210
info@kraftcuring.com
www.kraftcuring.com