Boksburg Tel (010) 447 7100
Midrand Tel (010) 446 6745

TIP NO. 7

Quantum Readymix Concrete

THE EFFECT OF WATER ON HARDENED CONCRETE

Water is not only essential for the production of concrete, but is also one of the most influential components in the production and curing of concrete. It is critical to control the volume of water in fresh concrete and the presence of water during curing.

CONTROL OF WATER IN THE PRODUCTION OF CONCRETE

Water content is one of the most critical factors in concrete mix design. Water is not only essential for workability, but the water content of concrete has a direct influence on concrete strength, durability, workability and shrinkage. Concrete strength is one of the most critical properties of hardened concrete and is determined primarily by the ratio of water to cement. Laboratory testing determines the relationship between water content, cement content and compressive strength. These quantities are then used at concrete batch plants to ensure delivered concrete meets the specified strength in structures.

Fresh concrete is designed to contain the correct quantity of water at the design slump to ensure strength is achieved. If more water is added to the concrete on site, to increase the slump above design slump, strength will be reduced. The practice of adding additional water on site is commonly referred to as 'retempering'. The graph below shows an example of the reduction of strength due to retempering water being added on site. It can be seen in this example that the addition of 10 litres of water per cubic metre reduces compressive strength by almost 10%.

The use of additional water not only affects compressive strength, but also affects concrete durability and shrinkage. Additional water increases the volume of voids in the hardened concrete. These voids are knows and capillary pores. An increase in capillary pores allows water to move more freely through the concrete, reducing concrete durability and increasing shrinkage potential.

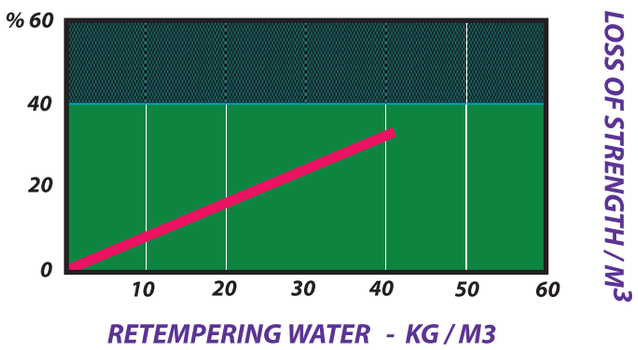
As can be seen in this example, an increase in water that results in an increase in water:cement ratio from 0.5 to 0.6 can increase capillary pore volume by approximately 10%, approximately doubling the volume of pores in the concrete. This has a very detrimental effect on concrete strength, durability and shrinkage.

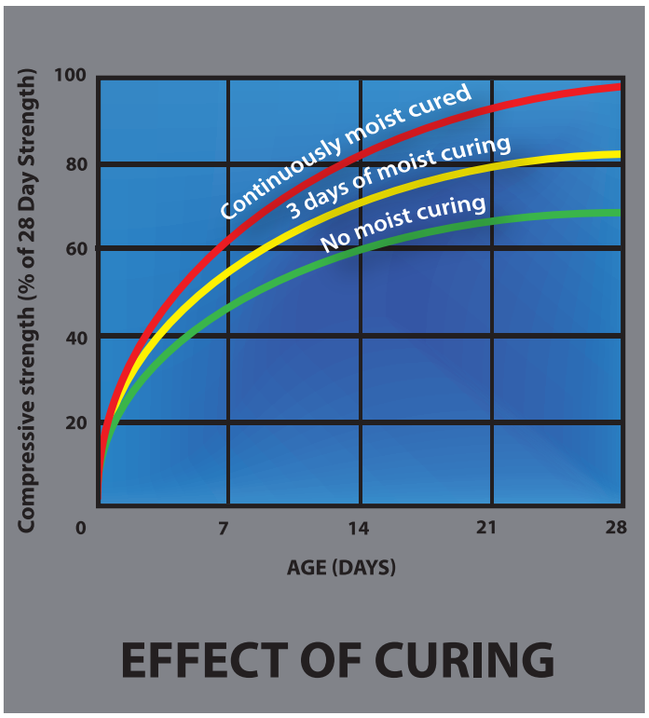
CONTROL OF WATER FOR THE CURING OF CONCRETE

Not only is it important to control the volume of concrete used in the production of concrete, but it is also critical to control the loss of water from concrete.

Water not only acts as a lubricant to make concrete workable, but it is water that reacts with the cement particles, causing the growth of crystals. These calcium silicate hydrate crystals continue to grow until the water and cement that caused their formation is used up. These crystals are responsible for the setting and strength gain of concrete. In order for concrete to gain its full strength, it is important that the water used in the mix design remains in the concrete until its design strength has been achieved. If concrete dries out too quickly, losing this water, crystals can no longer be formed and concrete stops gaining strength. Concrete is typically designed to achieve strength at 28 days. If the concrete loses its water during this time it will not achieve the design strength. This process of retaining the moisture content of concrete is known as curing. The graph on the next page shows the importance of curing (retaining water):

EFFECTS OF RETEMPERING WATER ON THE STRENGTH OF CONCRETE





EFFECT OF CURING

As can be seen in the graph, if concrete is kept continuously wet for 28 days, it will achieve its 28-day design strength. The 28-day strength of concrete is severely impacted if the concrete is not kept wet. In this example, when no curing was provided, 28-day strength was only about two thirds of the design strength. With only three days of effective curing this strength increased to over 80%. In very hot, dry conditions the lack of curing could be even more detrimental than in this example. The first 7 days are most critical, but curing should continue as long as is practical.

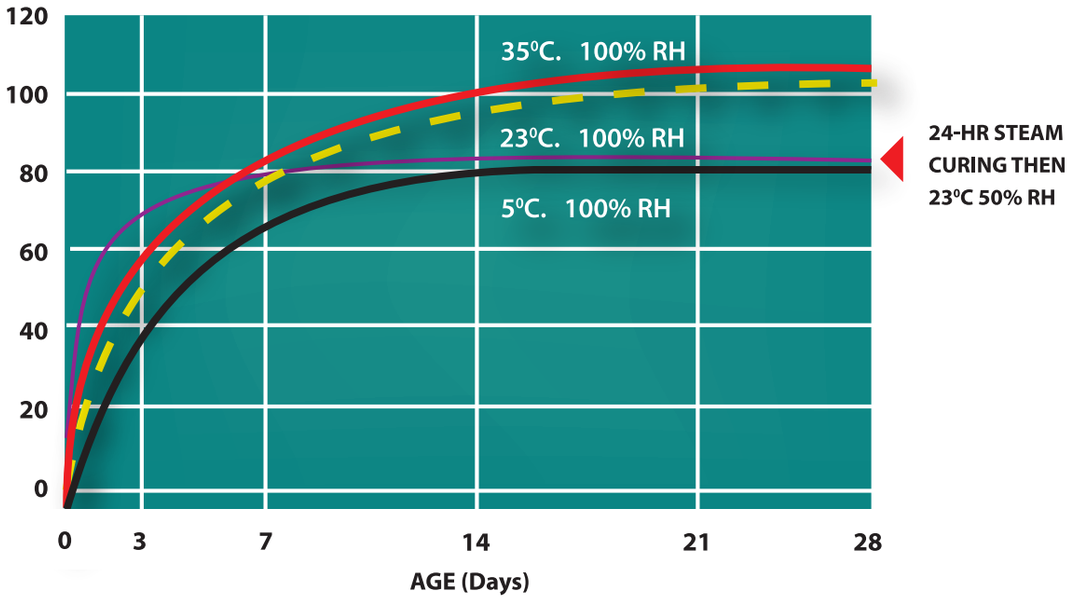
SOME ADVANTAGES OF WATER CONTROL AND EFFECTIVE CURING

- Design strength achieved.
- Abrasion resistance improved, less risk of premature wear and/or dusting.
- Lower risk of random cracking.
- Durability improved with less risk of ingress and attack by deleterious agents.
- Lower rate of surface carbonation and therefore better protection of reinforcing steel.
- Efficient use of all the cement used in the mix.
- All these advantages lead to longer lasting structures.

NOTE THE EFFECT OF TEMPERATURE ON CONCRETE

Concrete curing not only requires water, but is severely affected by concrete temperature during the curing period. The following graph shows one example of the effect of temperature on concrete strength. It can be seen from this example that at 5^0 Celsius this concrete achieved approximately half of the 3-day strength and only 80% of the 28-day strength achieved by the concrete at 23^0 Celsius. It can also be seen that 24 hours of steam curing significantly improves early strengths, but reduces 28-day strength. It is important to take account of temperature when considering the strength gain of concrete. **Concrete cast in winter will take significantly longer to achieve strength than the same concrete cast in summer.** Note that the example given below is not representative of all concrete mixes, but for the cement type used in this example only. Mixes containing fly ash will not follow the profile below, but will achieve lower early strengths at all temperatures.

% OF 28 DAY COMPRESSIVE STRENGTH WHEN CURED AT 23°C AND 100% RH



EFFECT OF CURING TEMPERATURE ON THE RATE GAIN OF CONCRETE OF STRENGTH