Reducing plastic shrinkage cracking using micro fibres

Plastic shrinkage cracking (PCS) is one of the earliest forms of cracking in concrete and can be a major headache for engineers, contractors and property owners. These cracks occur within the first few hours after the concrete has been cast and are not only unsightly, but also reduces the durability and serviceability of a concrete structure, by serving as pathways whereby corrosive agents, for example: air, water and chloride can enter the concrete. PSC is caused by the loss of pore water from the concrete surface due to evaporation resulting in an internal capillary pressure build up. Environments with high evaporation rates increase the capillary pressure in the concrete and are characterised in South Africa by conditions with a low relative humidity, direct sunlight as well as high wind speeds and high ambient temperatures. Concrete elements with a large exposed surface, for example: slabs or pavements, are especially vulnerable to evaporation and therefore also PSC. The process of capillary pressure build up due to evaporation and the consequent cracking are illustrated in the figure.

The position of cracks depends on the geometry of the slab. If the slab has an uniform thickness, cracks patterns are mostly random. However, if the slab has a non-uniform thickness, as a result of a varying depth or rigid inclusions such as reinforcing steel, crack patterns are normally linked to the positions of these slab non-uniformities.

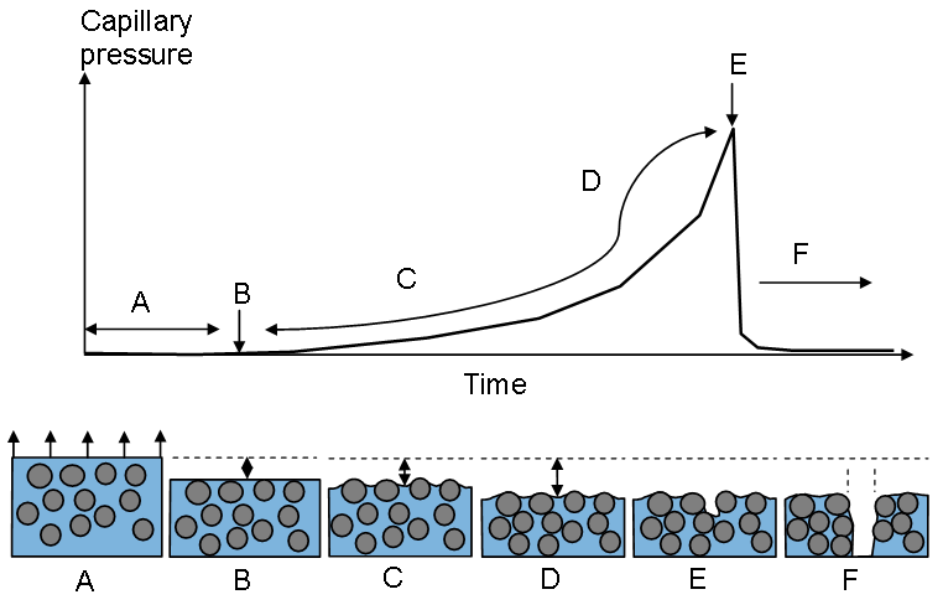
There are several external and internal measures that can be applied to prevent or reduce PSC. External measures influence the external environment of the concrete slab and are aimed at minimising water loss through evaporation. These include: casting during favourable conditions with low evaporation rates, shielding the concrete from wind and direct sunlight, spraying a fine mist of

water continuously above the concrete surface as well as cooling the concrete aggregates and/or mixing water.

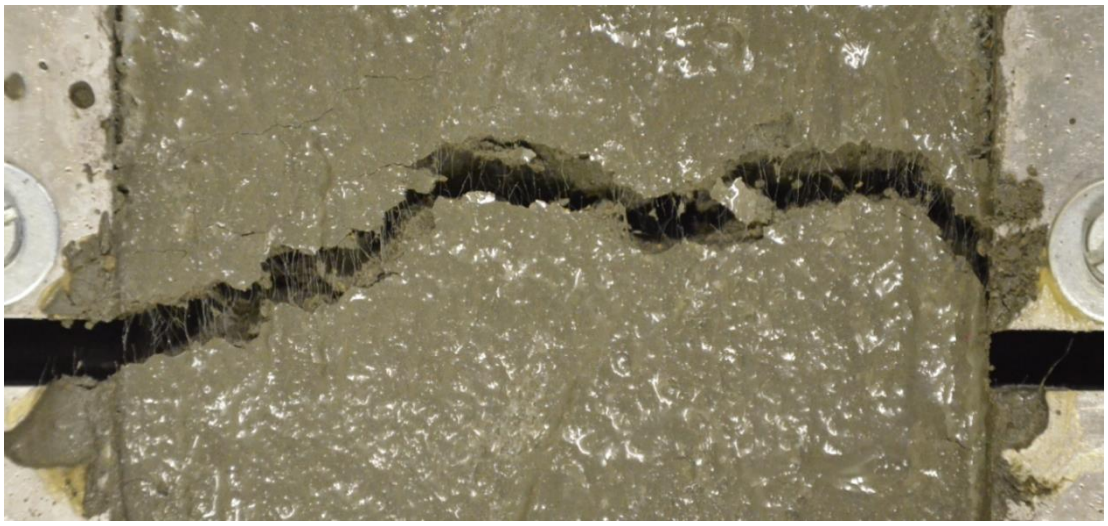
Internal measures influence the internal structure and behaviour of the concrete. The most common and successful internal measure which has been shown to reduce PSC through various tests at Stellenbosch University is the addition of a low volume of polypropylene micro fibres to the concrete. The fibres reduce crack widening by transferring the stress induced by capillary pressure across the crack. The photo shows a direct tensile test on plastic concrete, which clearly shows the fibres bridging the crack even after extensive crack opening. In general, the higher the dosage of fibres the less severe the cracking will be. However, it should be kept in mind that the addition of fibres also influences fresh concrete properties such as bleeding and workability. It is therefore important to conduct trial mixes, especially at higher dosages, although a typical dosage of 0.6 kg/m^3 can be prescribed as a proven dosage that effectively reduces PSC without negatively influencing to workability of the concrete.

Finally, although fibres provide resistance to PSC, they do not always result in a 100 % crack reduction and the addition of fibres do not justify neglecting the application of external preventative measures. Another common and worrying practice in the construction industry is the use of steel mesh to reduce PSC. This is a misconception as the steel mesh may in certain cases even aggravate the PSC of concrete by providing vertical and horizontal restraint. The steel mesh is meant to control cracking due to drying shrinkage which occurs long after PSC has finished.

In conclusion, although PSC remains a problem with concrete slabs, the addition of a low volume of polypropylene micro fibres has proven to be an effective method to reduce the severity of these cracks.



Typical capillary pressure build up before the onset of plastic shrinkage cracking in concrete



Direct tensile test on fresh concrete clearly showing the fibres bridging the crack even after extensive crack opening.

This article was supplied by Prof Billy Boshoff and Riaan Combrinck, Unit for Construction Materials, Stellenbosch University.