



Reducing plastic shrinkage cracking in slabs

Concrete remains the most widely used engineering material in the world due to its versatility, availability and durability. Concrete is especially strong in compression, but not in tension. To overcome this, concrete is often reinforced with steel bars to resist tensile stresses caused by applied loads such as wind, traffic, self-weight and also restrained shrinkage. However, these steel bars are only effective once the concrete has hardened, leaving the concrete vulnerable to any tensile loads while it is still in the plastic phase. The plastic phase only lasts for a few hours after the concrete has been cast. During this phase the concrete is often exposed to conditions with high evaporation rates which are mostly associated in South Africa with warm, sunny, dry and windy conditions. The evaporation of pore water from the still plastic concrete causes a negative capillary pore pressure within the concrete which results in shrinkage of the concrete. If this shrinkage is restrained, by for example the same steel bars added to provide tensile strength in the hardened concrete, cracks are likely to occur and are typically referred to as plastic shrinkage cracks.

These cracks mainly occur in concrete elements with large exposed surfaces such as slabs, bridge decks and pavements. In most cases, plastic shrinkage cracks also interact with plastic settlement cracks. These cracks occur if the uniform settlement of solid particles in the fresh concrete mix is disrupted by inclusions such as reinforcing steel bars or a non-uniform slab depth. This results in differential settlement which causes both a shear and surface crack above the restraint as shown in the Figure 1. The surface crack is often only visible from the side and not at the surface, while the shear crack is only visible from the side. These cracks can therefore be present even if not visible at the surface and when present in combination with plastic shrinkage cracking can lead to sudden and severe cracking. Figure 2 shows the plastic shrinkage cracking that occurred when tested with and without a reinforcing steel

bar with a cover depth of 20 mm and therefore with and without the influence of plastic settlement cracking.

Preventing these plastic cracks remains a problem in practice due its complexity, even though there are several effective precautionary measures that can be taken. These measures are mostly external and aimed at reducing the water loss due to evaporation by for example using a fog spray above the concrete surface, applying a curing agent and even erecting sunshades and/or windbreaks. Although effective, these measures are often expensive, impractical and also difficult to apply at the appropriate time, especially for large slabs that are placed over several hours. Furthermore, these cracks are often hidden or closed at the surface due to finishing operations such as floating and trowelling as shown in Figure 3. The figure shows a plastic shrinkage crack that was closed at the surface by trowelling, while the crack remains present below the surface. This crack appears at the surface after a day or two, often leading to confusion regarding the origin of the crack due to its apparent appearance in the hardened concrete.

The only current internal preventative measure that has proven to provide protection against plastic shrinkage cracking is the addition of a low volume of polymeric micro fibres to the concrete. These fibres reduce the crack widening by both increasing the strain capacity of the concrete as well as by bridging the crack once formed. A typical dosage of 0.6 to 1 kg/m³ is added and proved to be effective in minimising plastic cracks. Higher dosages can also be added, although this could influence concrete properties such as workability and therefore trial mixes should be conducted. It should also be noted, that fibres do not provide 100 % crack reduction and therefore do not justify neglecting of the application of external preventative measures.

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

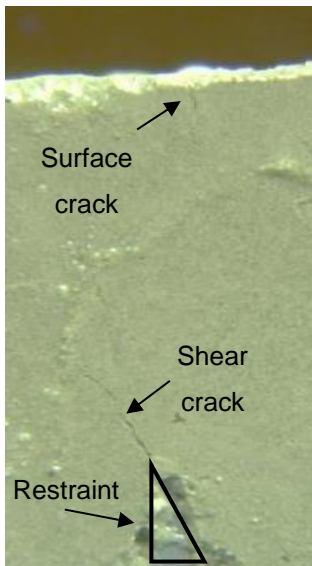


Figure 1. Plastic settlement cracks above restraint as viewed from the side

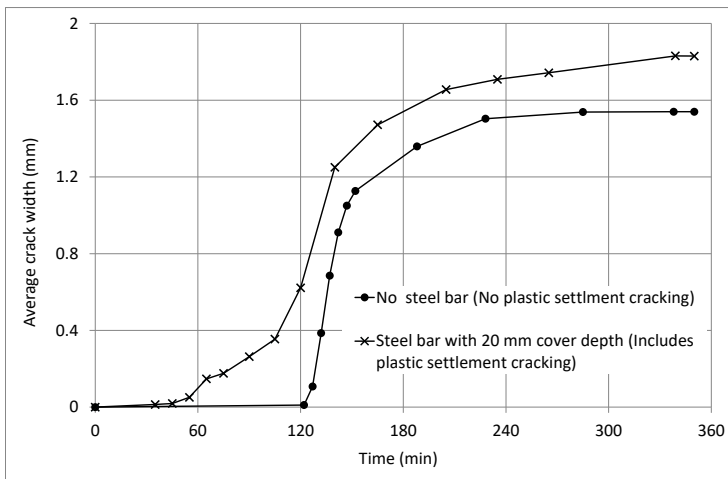


Figure 2. Crack widths without the influence of plastic settlement cracking

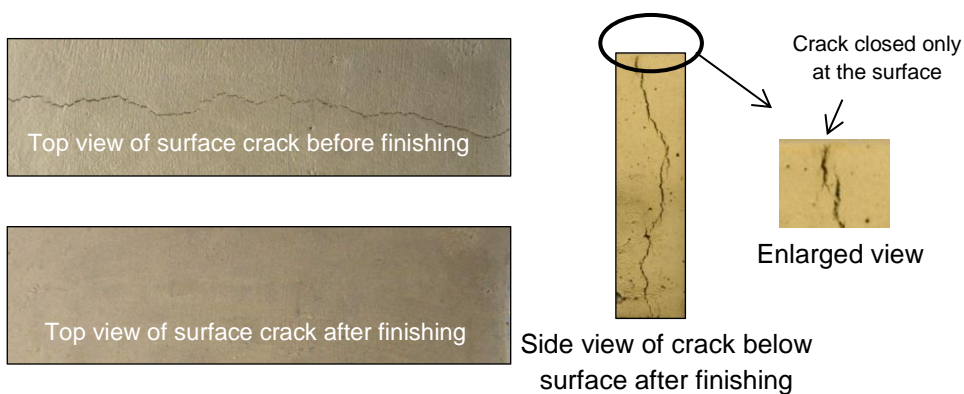


Figure 3. Influence of finishing operation on cracking

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