Chloride transport in concrete

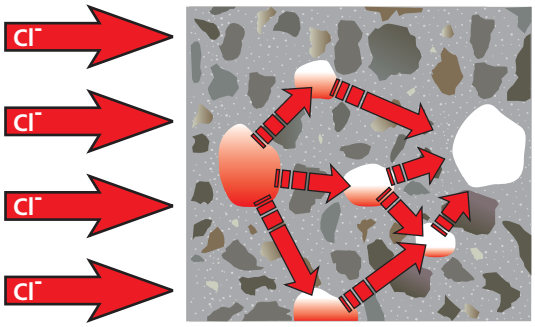
FORMTEX®
Controlled Permeability Formwork (CPF) liner

Chloride contamination of concrete can come from several sources. Marine environments, de-icing salts, contaminated aggregates, contaminated water, airborne salts, salts in chemicals in contact with the concrete surface, salts in ground water etc. The main transport mechanisms are:

- Diffusion (driven by concentration difference)
- Permeation (driven by pressure difference)
- Capillary rise (driven by capillary suction)
- Migration (driven by voltage difference)

Diffusion

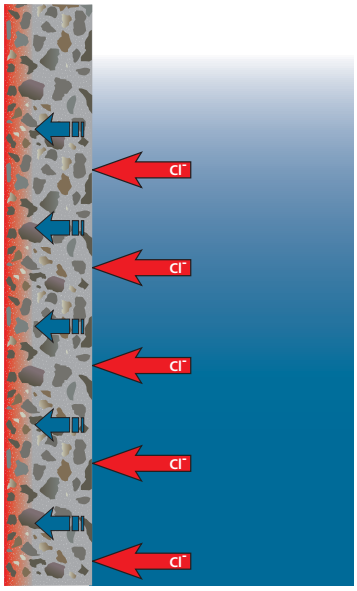
When the concrete surface is exposed to chlorides, diffusion will always be an active transport mechanism. This is because the driving force is the concentration difference between the contaminated surface and the non-contaminated concrete.



The rate of ingress will depend on the chloride concentration at the surface, and the diffusion coefficient of the concrete. The diffusion coefficient is a material property describing the speed of diffusion through the concrete. The size of the diffusion coefficient is highly dependent on the pore-structure and the denseness of the concrete and therefore mainly varies with the w/c-ratio, cement content, pozzolan content, presence of micro-cracks and curing conditions.

Permeation and capillary rise

Chloride ingress by permeation occurs when concrete is subject to a one-sided pressure from water containing chlorides. In this case there will be a flow of chloride contaminated water through the concrete to the side without pressure. The chlorides will be transported with the water all the way through the concrete, and will accumulate at the non-pressure surface as the water evaporates. This creates the highest concentration of chlorides at the non-pressure surface opposite the exposed surface.



As in other porous materials capillary rise is also a transport mechanism. This is best understood by thinking of what happens when a sugar lump is held only with its lower part in a fluid. The fluid will rise through pores of the sugar lump until it is saturated. The speed of permeation and capillary rise is dependent on the denseness of the concrete.

Migration

Transport by electro migration occurs after active corrosion of the re-bars has started. The corroding areas of the reinforcement create an electric current, and will attract the negatively charged chloride ions (Cl^-). This will worsen the situation at the corroded areas considerably.
As is the case for diffusion and permeation the speed of the electro migration is highly dependent of the pore-structure and the denseness of the concrete.

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