DEFENDING CONCRETE DURABILITY – THE SIGNIFICANCE OF THE CONCRETE COVER

Durable concrete is defined as a concrete that will retain its original form, quality and serviceability when exposed to its environment[1].

Designing a concrete structure that is able to maintain its serviceability and performs according to specifications in a certain environment for the duration of its service life means choosing suitable materials, an appropriate design and detailing, as well as quality control procedures for the production and placement of the concrete.

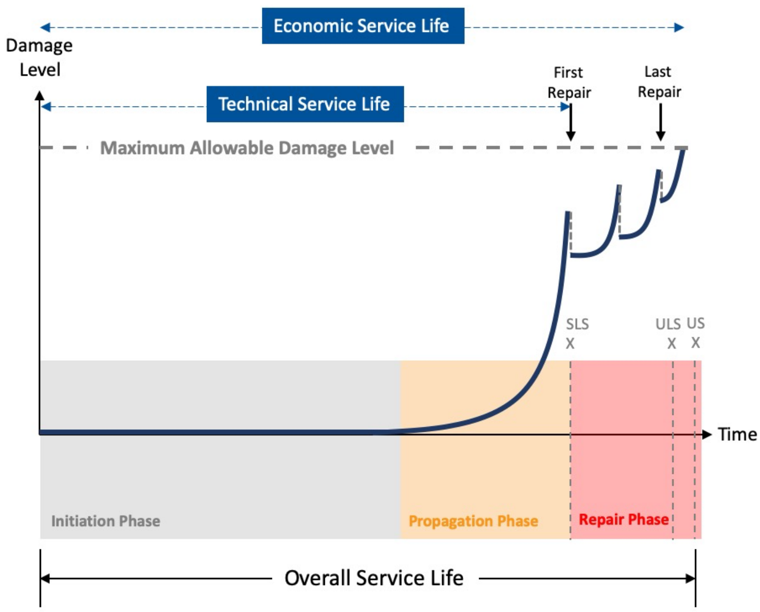
Concrete needs protection from many threats of deterioration associated with chloride ion ingress, carbonation, chemical attacks, freeze-thaw damage, aggregate and alkali-silica reactions, and others. All of these contribute to the deterioration of a structure by increasing the permeability of concrete and causing corrosion of the reinforcement steel, ultimately resulting in a shorter service life.

The service life of concrete can be divided into three phases as follows[2]:

Initiation phase: the structure performs according to specification (designed parameters) and no noticeable weakening of the concrete occurs. Some protective barriers are overcome by carbonation, chloride penetration or sulphate accumulation, but they have a negligible impact on the function and performance of the structure.

Propagation phase: active deterioration proceeds rapidly and exponentially with reinforcement corrosion being one of the most critical forms of propagating deterioration.

Repair phase: when the maximum allowable damage level has been reached and repairs have become necessary to lower the damage and extend the service life of the structure.



[1] ACI 201.2R-01
[2] K. Sakai, "Integrated Design and Environmental Issues in Concrete Technology" (1996), p. 57

The overall service life of a structure is also known as the "Economic Service Life". The economic service life describes the time until the structure is demolished and rebuilt for economic purposes.

On the contrary, the technical service life of a structure consists of the initiation and propagation phase and thus ends when the first repair of the structure is required.

Under the Limit State Design (LSD) approach the end of the initiation phase marks the Limit State. At this point the structure no longer satisfies the design performance requirements (e.g., when the amount of corrosion measured is beyond a point deemed acceptable).

If the service requirements of the structure are no longer met, it has reached its Serviceability Limit State (SLS). Criteria to assess if the Serviceability Limit State has been reached include various stress limits, deformation limits (e.g., deflections), flexibility or rigidity limits, dynamic behavior limits, as well as crack control requirements (crack width) and other arrangements concerned with the durability of the structure or everyday service level[3]. Therefore, the SLS marks the end of the propagation phase and beginning of the repair phase.

The Ultimate Limit State (ULS) is an agreed computational condition just below the elastic limit of the structure and below the real ultimate point. The idea of the ULS is – as long as the design criteria under repetitive loadings are fulfilled – to ensure the safety and reliability of the structure.

Once the structure is characterized by excessive deformations that will result in an imminent collapse or it is exceeding pre-agreed values, it has reached the Ultimate State (US).

Because it is widely accepted that deterioration of the concrete begins once corrosion of the reinforcement is initiated, protection of the steel reinforcement is of significant importance. In this context the concrete cover – as the only barrier between the reinforcement and the concrete surface – plays a critical role. Unfortunately, higher proneness to cracking and higher porosity (due to poor or no curing) makes the concrete cover the weakest link of the concrete structure.

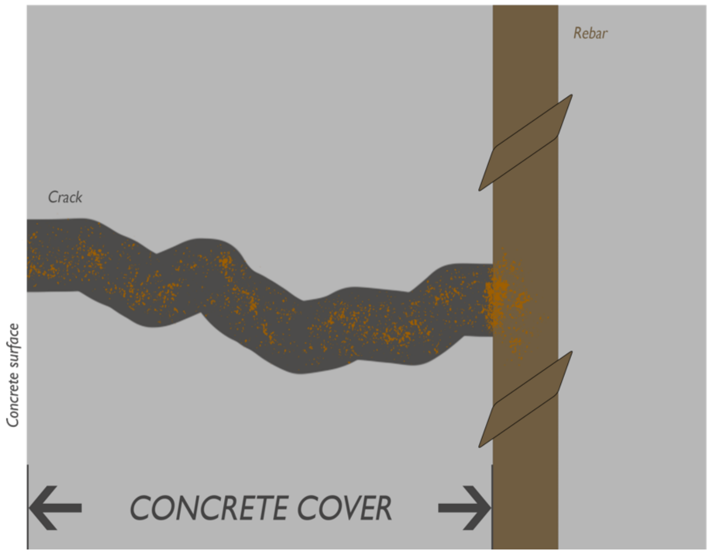


Figure 1 Chloride penetration of the concrete cover and initiation of rebar corrosion

[3] Wikipedia (https://en.wikipedia.org/wiki/Limit_state_design)

Water-borne contaminants such as chlorides migrate through the pores, capillaries and microcracks of the concrete cover and towards the reinforcement. Once the chloride threshold around the reinforcement surpasses a certain value (usually between 0.2-0.4% of chlorides by mass), corrosion begins. This process is slow and takes years or decades depending on the thickness of the concrete cover (usually between 4-7cm) and environmental conditions the concrete is subjected to. The thinner and more permeable the concrete cover is, the faster chlorides can reach the reinforcement and induce corrosion. A more permeable concrete is therefore directly associated with a shorter service life.

In other words, the service life of concrete can be extended by employing measures to reduce its permeability and – in this context – particularly the permeability of the concrete cover.

PENETRON ADMIX reduces permeability of concrete and the concrete cover with up to 100% by sealing microcracks pores and capillaries with insoluble, crystalline formations bridging cracks up to 0.5mm. Being a hydrophilic product it provides concrete with self-healing capabilities throughout the service life, that will seal future cracks in the structure as soon as water enters. PENETRON ADMIX has been proven to seal concrete even under high water pressure and is therefore classified as a permeability-reducing admixture for hydrostatic conditions (PRAH).

Due to the low permeability achieved with PENETRON ADMIX, the risk of corrosion in areas where the concrete cover is lower than average is significantly reduced. This ultimately provides concrete designers greater assurance in achieving service life design requirements even in cases where bad workmanship or sub-standard work may occur.

Independent tests have shown a considerably reduced chloride diffusion coefficient of PENETRON AMDIX-treated concrete. This resulted in a service life extension of up to 60 years in critical environments when compared to untreated control mixes.