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Autor(en): **Brühwiler, Eugen / Mivelaz, Pierre**

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From Corrosion of Existing to Durability of New Concrete Structures

Eugen BRÜHWILER
Professor, Civil Engineer
Swiss Fed. Inst. of Techn.
Lausanne, Switzerland

Eugen Brühwiler received his civil engineering and doctoral degrees from the Swiss Federal Institutes of Technology (ETH) in Zurich and Lausanne. He is currently the professor for the Maintenance, Construction and Safety of Structures Institute at ETH Lausanne and the chairman of the IABSE Publications Committee.

Pierre MIVELAZ
Dr. Civil Engineer
Swiss Fed. Inst. of Techn.
Lausanne, Switzerland

Pierre Mivelaz received his civil engineering and doctoral degrees from the Swiss Federal Institute of Technology (ETH) in Lausanne. He is a part time research associate at ETH Lausanne in the domain of durability of concrete structures and co-director of ESM Consulting Engineers.

Summary

The problem of reinforcement corrosion in new concrete structures can be avoided if measures are taken to increase the corrosion initiation time. These measures include providing adequate concrete cover thickness, ensuring a low permeability of the cover concrete, and limiting early age concrete cracking. As adequate concrete cover is normally not a problem, this paper highlights the findings of two studies that focus on the latter two measures. The first study investigated chloride ingress under given climatic conditions and evaluated the feasibility of measuring the permeability of concrete cover in situ. The second study used numerical models to investigate the effects of early age cracking and determine measures to be taken to limit their development during construction. The principal findings of both studies are given herein. It is concluded that permeability measurements should be conducted for quality control of the cover concrete of new structures and that early age cracking due to the hydration of young concrete may be limited by reducing the difference between concrete and ambient temperature.

Introduction

Reinforced concrete structures have generally shown satisfactory performance in terms of strength and durability. Under certain climatic conditions, however, reinforced concrete structures have suffered from corrosion damage of steel reinforcement (rebar) resulting in premature and expensive repair work.

Damage to concrete structures is the result of the interaction between the material and the environment. Gas, liquid and ionic transport mechanisms play a major role in the concrete deterioration. The nature of the damage can be chemical, such as rebar corrosion or sulfate and acid attacks on cement paste, and physical, such as abrasion or freeze-thaw cycles (Fig.1). Both the quality of cover concrete and the presence of cracks (especially those which allow water seepage) have a predominant influence on the durability of a concrete structure. Concrete not only has a load bearing function, but also acts as a protective coating for the steel reinforcement.

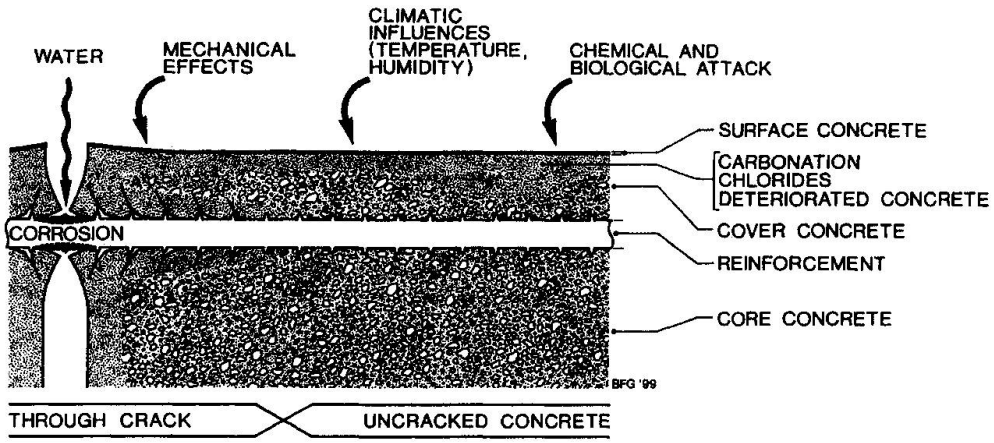

Fig. 1 Vulnerability of reinforced concrete

The majority of research on the deterioration phenomena affecting reinforced concrete has concentrated on material behaviour. The ultimate limit states for structural safety and serviceability, however, are based on structural considerations. These aspects must be combined. With this combination it is important to analyse the deterioration mechanisms considering both the observable steady state and a time evolutionary point of view.

This paper investigates measures to reduce the risk of occurrence of rebar corrosion that may be used in the construction of durable and low maintenance concrete structures for the future. After a review of the relevant aspects of rebar corrosion, this paper investigates:
- the roles of the permeability of cover concrete and
- early age crack formation in delaying the onset of corrosion.

Conclusions

1. The objective of measures to reduce the risk of rebar corrosion should be to increase the corrosion initiation time until it is greater than the service life of the structure. Three methods to reduce this risk are (1) to provide sufficient concrete cover thickness, (2) to provide dense surface and cover concrete of low permeability, and (3) to limit early age cracking of concrete. These measures depend on the climatic exposure of the structural element.

2. Numerical models allow approximate prediction of the initiation phase for rebar corrosion and early-age cracking of concrete elements. They are reliable tools to evaluate time evolutionary issues of concrete structures and therefore investigate the effectiveness of measures to ensure durable new concrete structures.

3. Permeability measurements should be conducted for quality control of new concrete structures. They are reliable with adequate adjustments for moisture.

4. Cracking due to hydration of young concrete increases concrete permeability and thus its vulnerability to rebar corrosion. Early age cracking may be limited or even avoided by reducing the difference between the temperature of new concrete and ambient temperatures.