Chloride transport and chloride threshold values

Studies on concretes and mortars with Portland cement and limestone blended cement

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Reinforced concrete is one of the most widely used building materials and if it is properly designed and produced, it is an extremely durable material with a service life up to 100 years. However, under certain environmental conditions the service life of reinforced concrete structures is more limited. Deterioration of concrete structure is in most cases caused by the penetration of aggressive media from the surrounding environment. Chloride initiated reinforcement corrosion is one of the major causes of deterioration of concrete structures. One conflicting issue is how replacing Portland cement with mineral additions influences chloride initiated reinforcement corrosion. This issue is of immediate interest, as there is a steady growth in the use of cement blended with mineral additions, such as blast-furnace slag, fly ash and limestone filler. This is done by the cement and concrete industry to reduce the CO_2 emissions linked to Portland cement manufacturing, by limiting the use of clinker in the cement.

The main objective of this work has been to further clarify the role of limestone filler as partial substitute to Portland cement on the two main decisive parameters for chloride induced reinforcement corrosion: chloride ingress rate and chloride threshold values. In the first part of this work the chloride ingress was studied both with accelerated laboratory methods and also after field exposure. The initial focus for the second part of the study was to determine the chloride threshold values for the binders investigated in the first part, so a comprehensive view of the effect of limestone addition on chloride initiated corrosion could be presented. However, during the work the need for the development of a practice-related method for determining the chloride threshold values was identified and the focus of the research was redirected to meet that need.

The efficiency of limestone filler concerning chloride ingress showed to be dependent on replacement ratio, time (age) and on the test method. It was not possible to draw any rigid conclusion of the limestone filler's efficiency regarding chloride ingress. But part of the inconsistency in the results was identified to be that limestone filler has two opposite effects on chloride ingress, on one hand contribute to a refinement of microstructure and on the other hand diminishing the chloride binding.

The steel surface condition was shown to have a strong effect on the corrosion initiation, and can likely be one of the most decisive parameters attributing to the variability in the reported chloride threshold values obtained in laboratory experiments. The chloride threshold value for the sulphate resistant Portland cement from the laboratory experiments was estimated to be about 1% by weight of binder. For the concrete with limestone blended cement (CEM II/A-LL 42.5R) tested in this work the chloride threshold value was at the same level as for the sulphate resistant Portland cement. From the field study but with a somewhat different definition of chloride threshold value, a chloride threshold value of about 1% by weight of binder was also estimated for ordinary Portland cement and sulphate resistance Portland with 5% silica fume exposed to marine environment.

Key words: Cement, Mortar, Concrete, Corrosion, Reinforcement, Chloride ions

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