Assessment and maintenance plan for 36 structures near Coentunnel - Amsterdam

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Summary

The ring of Amsterdam is ongoing for an enlargement. One of the bottlenecks is the passing below the North Sea canal in Amsterdam. This passing is named the Coentunnel, named by a famous Dutch officer of the Dutch East Indie Company.
Building a new tunnel under the canal now doubles this tunnel. At both sides of the Coentunnel traffic exchangers are build, 36 of this structures needs to be maintained by the Coentunnel construction consortium.
The assessment resulted in to the research on Chloride induced corrosion, Carbonation induced corrosion, Alkali silica reaction, Delayed ettringite formation.
The Chloride induced corrosion was done by measuring the chloride distribution on minimal 3 cores, and concrete cover, resulting is the calculation of the initial chloride content, diffusion coefficient and surface chloride content. With these parameters the remaining lifetime is calculated.

Keywords: chloride distribution, carbonation, petrografic analyses, maintenance plan.

1. Introduction

The congestion problems in the North of the the ring of Amsterdam are mainly due to the limited transport capacity of the Coentunnel. Here the ring road is merged from 3 lanes to 2 lanes. This gives traffic congestion during morning and evening traffic peaks.
The durability assessment is done on the structures before and after the tunnel under the canal. Mainly the structure are passings under the high way for roads, train and (small) canals.

2. On site analyses

2.1 Phase one : initiation phase

The main issue on concrete durability on road bridges and tunnels is chloride induced corrosion of the reinforcement. Therefore the chloride profile of the cores was measured.
The end of the sample was cut off and used for petrografical analyses. The goal of this analyses is to know the cement type (estimation of the slag and fly ash content), the analyses for chemical stability : Alkali silica reaction and Delayed ettringite formation.
The extra core was used to measure the carbonation depth.
The initiation phase ends when ion concentrations pass the critical limit at reinforcement.

https://doi.org/10.2749/222137813806474246

2.2 Phase two : investigation of propagation phase

During the investigation some elements have passed the initiation phase. This mainly by a high chloride threshold in the zone of the reinforcement. The elements in contact with water, coming from leaking expansion joints showed high chloride profiles.
Is this a local phenomenon or is the whole element affected?
In order to see what is the consequence of this high chloride content, on site corrosion potentials are measured. The electric tension is measured using a reference-electrode. The equipment used is Canin+ of the suplier Proceq. The equipment is electrically connected with the reinforcement en measured with a Cu/CuSO4 electrode The resulted voltages give an indication of the corrosion of the reinforcement.
The corrosion potential is done within a grid of 50 cm². This gives a mapping of voltages. Hereunder an example is given of such mapping. The purple zone gives a high risk on corrosion of the reinforcement.

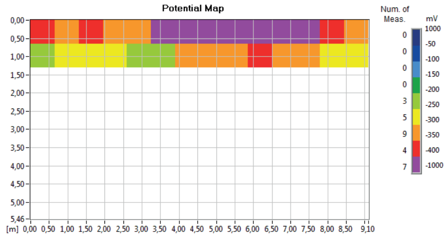

Figure 1: example of mapping of corrosion potential

3. Engineering of the maintenance activities

In total 36 elements where tested. Seven of these element showed in sufficient condition or future condition.
For the same group (see art 2) the similar elements for the other structures in the group where tested (mainly corrosion potential).15 elements where suspect. If concrete cover is contaminated by chlorides or carbonated and the corrosion was already started the concrete cover will not have enough passivation energy to protect the reinforcement. Even when water and oxygen should be blocked from the outside. For these elements the concrete cover needs to be shipped off and replaced by new (sprayed) concrete. If the chloride content or carbonation will be attacking the reinforcement within the end of the maintenance contract, ingress of ions will be stopped. This by applying a coating.

4. Conclusions and Acknowledgements

Making a life time analyses of a big number of structures is possible using validated methods.
Destructive testing gives an accurate overview of the condition of a small part of an element. It should be stipulated that the condition of an element can change within the element.
Local damage cannot be detected by this method. At the contrary local chloride profiles can give a wrong view on the global condition of the structure.
In this type of analyses it is hard to keep things simple, so that maintenance contractors understand what will be the job to do.
A combination of destructive (chloride profile, carbonation) and non destructive (corrosion potential, electric resistivity, concrete cover) methods gives a quite accurate view on the general condition of a structure.

Further research on non destructive methods is needed to simplify this type of life time assessment.