Impact of corrosion on the first immersed concrete tunnel, the Maastunnel

C.B.M. (Kees) BLOM
Consultant Civil Engineer
Public Works Rotterdam, NL
cbm.blom@rotterdam.nl

Kees Blom, born 1972, received his PhD and MsC civil engineering degree from the University of Delft, The Netherlands. He is senior consultant for the engineering department of Public Works Rotterdam and is Assistant Professor at the Technical University of Delft, The Netherlands. His main area of work and research is related to concrete structures.

Summary

The structure of the first immersed concrete tunnel, the Maastunnel in Rotterdam is more than 75 years old and has always been serving well. Recently the tunnel was upgraded to fulfil the increased traffic and fire safety requirements for tunnels. During those construction activities heavy corrosion of structural reinforcement has been observed.

This paper explains the damage that has been observed, the effects on the structural safety, the urgency and impact of the measures to be taken and the plan to refurbish in order to upgrade the tunnel for 50 more years. This project actually shows the consequences when the technical lifetime of a major concrete structure in a main city has been exceeded. Since this is the first immersed concrete tunnel it shows what can be expected in the coming decades worldwide.

Keywords: tunnel, corrosion, safety, repair, refurbish.

1. Corrosion found in the Maastunnel

The Maastunnel is the first immersed concrete tunnel in the world. It has been constructed between 1937 and 1942. In those days vehicle exhaust gasses contained unhealthy substances like lead. A ventilation system was applied in the tunnel to make sure that people were able to pass the tunnel safely. This ventilation system adds fresh air and extracts the polluted air.

During visual inspection of the ventilation tubes it became clear that there was a major concrete damage. The concrete cover was missing on large parts and corrosion was observed of the reinforcement itself (figure 1 and 2). From measurements it became clear that a high chloride concentration had appeared around the reinforcement. The protective passivation of the reinforcement failed and corrosion easily occurred due to highly available water and oxygen. The concrete has been exposed to very hazardous conditions.

Figure 1. Observed corrosion in the ventilation tubes of the Maastunnel

https://doi.org/10.2749/222137813806521496

Figure 2. Corroded reinforcement bar.

2. Impact of the corrosion

The final impact of the corrosion is enormous. The corrosion could result in too little structural safety and closing of the tunnel would be the result. If today the safety is sufficient, the question is how to deal with this safety in the future. To stop the corrosion process repairs have to be executed and this seems to require a closing of the tunnel for about a year. It depends on the chosen repair strategy what the final impact will be. Either way, there will always be serious impact.

It has become clear that a main structure could show heavy corrosion. The immediate question has to be answered whether structural safety is sufficient. A lack of statistically adequate data makes it very difficult to prove accordance with structural safety requirements because conservative basic assumptions have to be applied. Measurements result in desired less conservative basic assumptions, but it takes time to do the measurements.

Statically indeterminate structures might have implicit structural safety by which it could be proven that the structural safety demands are fulfilled. Physical non linear FEM analyses are used to prove the structural safety.

Repair of such corroded structures has a huge impact. This impact is not only technical but also e.g. social, economical and political.

3. Ethical questions and answers

There are ethical answers to be given on major questions like: Would one dare to accept a major decrease in structural safety of such a tunnel structure even if calculations demonstrate that the remaining final structural safety still exceeds the required safety level of the codes? Would one dare to let reinforcement corrode without any attempt to save what is left? On the other hand: would one dare to frustrate society and the economy by closing the tunnel for repair activities?

More structures are getting out of date and finally might expose similar problems. This example shows what can be expected in the future.