



From measurements to prediction of moment of intervention during the (remaining) lifetime

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Henk Voogt has started his career in the design and construction of quay walls and has since 2001 worked as asset manager marine structures at the Port of Rotterdam. He is in this position among others from the beginning involved in investigating and solving the problem of corrosion in Rotterdam as well as in the development of the asset management tool KMS.

Summary

The Port of Rotterdam has put considerable investment into the development of models that can identify the best time to initiate remedial intervention to ensure maximum longevity for steel-concrete quay infrastructures that are in constant use

Keywords: port infrastructure; risk assessment; corrosion; asset management; KMS.

1. Introduction

Much research has been done worldwide to find the causes and effects of accelerated (low water) corrosion. In the Port of Rotterdam this research has been extended to find a correlation between the lab / in situ coupon tests and the actual loss of material on the substructures of the quay walls. By validating the test results, it was possible to draw up a model that is capable to predict the safety factor on both strength of structure and soil retention over the remaining lifetime of a quay wall and if needed to present the ultimate moment to start maintenance. As most of the substructures of quay walls are made of steel structure and superstructures are made of concrete, a similar method is being used to predict the aging of concrete. The results of these simulations are used in the Port of Rotterdam's new asset management tool KMS, which gives the asset manager the possibility to prioritize maintenance measures. Apart from the simulations a risk assessment is implemented in KMS to identify and rank the risks on the structures. After that the business value of an asset is being used to make the final prioritisation and are the remaining risks after maintenance made visible.

2. General

The port of Rotterdam is the largest port in Europe and one of the largest ports in the world. It's currently at the forefront of world-class asset management for port- and maritime structures. The maritime assets add enormous value to ports, but due to the function these structures serve as well as their location in the marine environment these assets are relatively costly to construct and maintain.

The capital invested in such maritime civil engineering structures is quite substantial too. The typical service life for these port- and maritime structures is approximately 50 years. A large proportion of these assets will be nearing the end of their service life span in the coming decades. In order to effectively and efficiently manage these assets it is critical to have a system in place to track the yearly required maintenance as well as forecast the near and distant costs of keeping these structures in service. Finally the consequences of the recent economic recession and the subsequent credit crisis also play a role: port- and maritime organizations are being forced to think – from an integrated approach – more about which assets they put their money into.

3. Quay wall modelling system

The KMS (the Dutch abbreviation for Quaywall Modelling System) is a unique asset management tool for the port- and maritime market sector. It provides the asset owner and asset manager a tool to efficiently manage a portfolio of quay walls or other maritime civil engineering structures. The KMS is a system that objectively supports decisions, with respect to the budget and schedule, for the required maintenance of quay walls. In addition, it clarifies the risks and consequences, both short and long term, in case this required maintenance is postponed. The KMS aims to improve at predicting, simulating, analysing, prioritising, budgeting and planning the required maintenance to quay walls.

A quay wall's remaining lifetime is mainly determined by the quality of the sub- and superstructure. With the aid of its highly advanced deterioration models, KMS can predict when the lower safety limit for a quay wall will be reached, how the inspection regime must then be detailed and what maintenance measures must be done in order to meet the asset owner's required functionalities (such as availability for use, or asset lifetime).

KMS simulates various maintenance strategies, on the basis of the inspection results, so that the most efficient and cost-effective inspection regime and maintenance scenario for the quay wall in question can be selected and applied.

It'll also provide insight into the consequences – such as reduction in remaining service life or availability of the structure – of postponing specific maintenance measurements. Furthermore, it'll determine the consequences or advantages of different alternative maintenance measures.

The system contains the possible risks and causes that endanger the quay wall (or parts of it) relating to availability, structure safety, sustainability and aesthetics so it ranks the risks associated with retaining the desired functionality, then presents the financial consequences of postponing required maintenance for budgetary or economic reasons.

KMS prioritises the maintenance tasks to be carried out, on a multi-criteria basis. Required maintenance tasks are ranked by a quality mark: this is made up of various factors – commercial importance, availability requirement and end of contract term.

By using this quality-marking system in conjunction with the level of risk to be covered, it's possible to create a prioritised list of all maintenance measures to be executed over the next 12 months. A high quality mark combined with a top-ranked risk gives a maintenance action the highest priority. A low quality mark with a bottom-ranked risk gives it the lowest priority.

KMS also creates an overall budget for a structure's prioritised work, based on the sum of individual maintenance actions. The system performs this task for the upcoming calendar year and also for the prescribed maintenance period of the structure, which for the Port of Rotterdam Authority, is when the commercial contract on the quay wall ends.

If the next calendar year's necessary maintenance work is delayed (for example, due to budgetary constraints), KMS will translate the consequences of this directly into the maintenance budget for subsequent years. In effect, it translates the risks of not performing a certain maintenance task into a budgetary dollar-cost for the coming years.

Once the asset manager finalises the prioritised required maintenance on each structure, KMS can create an efficient, effective work schedule. Compiling work packages for multiple structures containing similar tasks means these packages can then be procured under one contract, in order to reduce installation time and cut costs.

So this prioritisation of maintenance tasks, based on multi-criteria analysis, ensures that expenditure and maintenance is performed on those structures that are the most economically important to the Port of Rotterdam Authority – and where the safety risks are highest.