Experiences with a non-failure based condition survey of ductile iron pipes in the water supply system of Vienna

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ABSTRACT

Water distribution pipe condition information is mainly collected during the repair process of reported or detected leaks. In the contrary, less is known about the deterioration processes themselves. A reason for this is, that data collection of different stages of deterioration either is technically impossible (e.g. inside inspection of small diameter pipes) or expensive (e.g. inside inspection of large diameter pipes). For ductile iron (DI) pipes, the main failure cause is outside corrosion. Corrosion is a process that can be easily observed if the pipe is subsequently uncovered. In 2009 Vienna Water Works therefore started a condition survey based on a questionnaire, which was filled each time a DI pipe is uncovered because of (small) construction sites. As Vienna's water distribution, system consists of 60% ductile iron pipes with 3 different coating systems the condition evolution of theses pipes is of high interest for future rehabilitation planning. So far, 754 condition records were collected and statistically analysed. The results of the significance tests have shown that a specific condition state of a pipe is by chance with less than a 5% probability for pipes with different coating systems, for pipes with previous failure and for pipes at different ages. This means these factors are statistically highly significant and hence were incorporated into the model building process. Although it is well known that the surrounding conditions can have significant influence on corrosion, the collected data in Vienna did not allow to derive any interrelationships between surrounding material and the deterioration state so far. At the moment the model allows to predict the percentage of ductile iron pipes with different coating systems and with or without previous failure being in a specific condition state at specific ages. For Vienna the model has shown that at an age of 40 years 45% of bitumen coated pipes but only 25 % of zinc bitumen coated pipes are expected to be of class 3 (strong corrosion) if they belong to the category "pipes with previous failure". In a next step it is planned to implement information from soil investigations into the analyses as well. Such soil investigations are made in the fore field of many construction sites in Vienna and are collected by the municipality. The continuous analysis of non-failure based condition data helps Vienna Water Works to improve rehabilitation prioritization, especially because the analyses have shown that pipes, with previous failure nearby, have a high probability to be in a bad condition as well.

INTRODUCTION

Water distribution pipeline condition information is mainly collected during the repair process of reported or detected leaks. The analysis of such data focuses on predicting the probability of a failure event at a specific age. Several model approaches have been developed in this context. Liu et al. (2012) give a comprehensive review of such models. In the contrary less is known about the deterioration processes themselves. A reason for this is, that data collection of different stages of deterioration either is technically impossible (e.g. inside inspection of small diameter pipes) or expensive (e.g. inside inspection of large diameter pipes). Further state of the art inspection techniques do not exist for all kinds of pipe materials. For ductile iron (DI) pipes the main failure cause is outside corrosion. Corrosion is a process that can be easily observed if the pipe is subsequently uncovered.

MATERIALS AND METHODS

Vienna's water distribution system consists of 60% ductile iron pipes with 3 different coating systems. Hence the condition evolution of theses pipes is of high interest for Vienna Water Works. In 2009 Vienna therefore started a condition survey based on a questionnaire, which was developed by both engineers and skilled workers of Vienna Water Works and of Tiroler Rohre GmbH, an Austrian pipe manufacturer. The purpose was to fill the questionnaire each time a DI pipe is uncovered because of (small) construction sites, like house connection renewal or valves renewal. The questionnaire is kept simple to be easily interpretable at the construction site. The water works employees visually classify in "no corrosion", "light corrosion", and "strong corrosion". Examples for these condition states are given with pictures and verbal description. The surrounding conditions are classified in two different categories "back-fill material" or "excavation material". It was decided to neglect soil interpretations as the focus was set on a systematic easy to handle quantitative data collection. From the existing GIS system, information about the year of construction and about already occurred failures within a radius of 50m are allocated to the datasets. The change of the coating systems was defined the following: from 1968 to 1980 (tar) from 1981 to 1995 (duplex system: zinc and bitumen) from 1996 to present (duplex system: zinc and polyurethane).

So far 750 datasets of pipes at different ages and with different coating systems were available for a statistical analysis. Aim of the statistical analyses was to derive how the improvements of the coating systems extend lifetime expectancy. Therefore an ordinal regression analysis was applied to derive the significant influencing factors on the deterioration process and predict future condition class probabilities for Vienna's DI pipes.

RESULTS:

The results of the significance tests have shown that being in a specific condition state is by chance with less than a 5% probability for pipes with different coating systems, for pipes with previous failure and for pipes at different ages. This means these factors are statistically highly significant and hence were incorporated into the model building process. Although it is well known that the surrounding conditions can have significant influence on corrosion the collected data in Vienna did not allow to derive any interrelationships between surrounding material and the deterioration state so far. Figure 1 shows first results of the regression model, for example according to the predictions 45% of tar coated pipes and 25.5% of zinc bitumen coated pipes are expected to be of class 3 (strong corrosion) at an age of 40 years if they belong to the category “pipes with previous failure”.

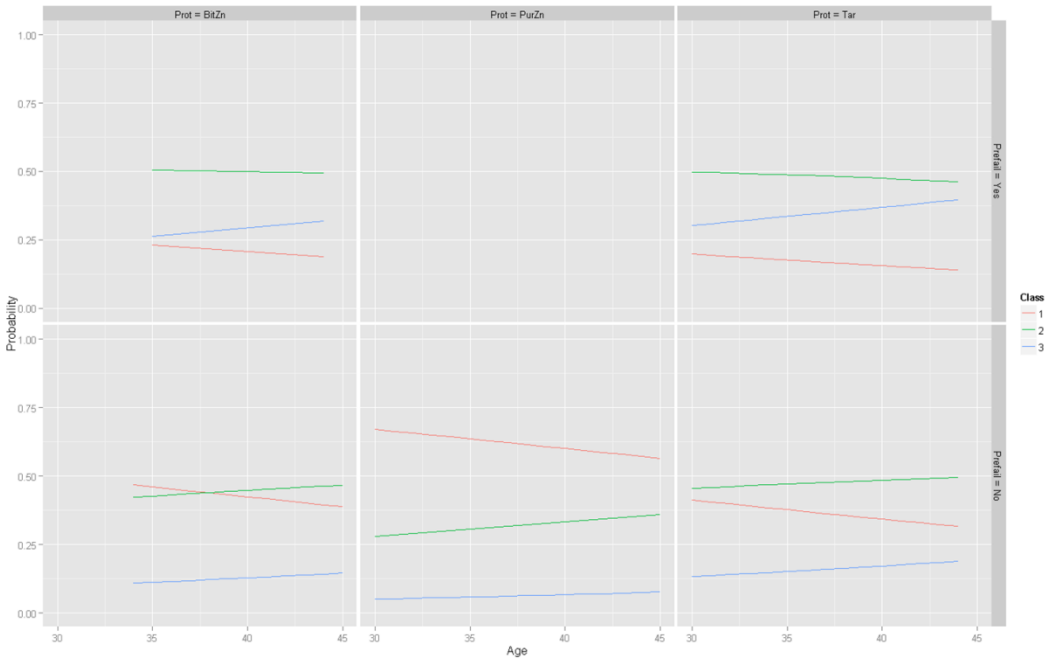

Figure 1: Percentage of pipes in condition classes 1, 2 or 3 for different coating systems per age (forecasted for BitZn nad PurZn) for as well pipes with previous failure as without previous failure derived from an ordinal regression model of 750 non failure based condition data.

CONCLUSIONS AND OUTLOOK

The statistical analyses have shown that it is possible to build a regression model and predict the probability of pipes being in a specific condition class based on the data of the survey. However, so far only 3 factors have shown a statistical significance. In a next step it is planned to implement information from soil investigations into the analyses as well. Such soil investigations are made in the fore field of many construction sites in Vienna and are collected by the municipality.
The continuous analysis of such non-failure based condition data helps to improve maintenance planning and rehabilitation prioritization, especially because the analyses have shown that pipes, with previous failure nearby, have a high probability to be in a bad condition as well.
The first feedback according to work load and feasibility among the employees, which fill out the questionnaire, was asked for by the management board of Vienna Water Works. As the reactions were mainly positive Vienna plans to go on with the survey, making amendments of the questionnaire resulting from this first employee feedback and problems with the statistical analyses.

REFERENCES

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