A Maintenance System for Waterway Infrastructures

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Summary

The German Waterways Network, including the associated infrastructure facilities such as locks, weirs, culverts, canal bridges and lighthouses, has an assets value of around 40 billion €. To economically maintain such a large infrastructure, an IT based e-maintenance system (EMS) has been implemented. Working with the data obtained from regular inspections and with various mathematical models, the system supplies management with important decision making information. The resulting benefits are:

- reliable predictions of preventive maintenance activities
- cost reduction, transparency and planning security
- sustainability of investments and an increase in traffic safety

Keywords: maintenance system; asset Database; inspection, mathematical models, Markov chains, survival analysis

1. Introduction

The EMS is being developed by the Federal Waterways Engineering and Research Institute (Bundesanstalt fuer Wasserbau, BAW). The components and procedures are described in the following chapters.

2. Asset Database

The Asset Database is a computerised collection of all components of the waterways network. Although the data is spread across various systems, the assets are normalised. This makes it possible to provide all information on individual or groups of assets at the push of a button.

3. Regular Inspections

To gain accurate status information about the waterways, regular inspections are performed. Regular inspections are governed by a German administrative regulation (VV-WSV 2101), which specifies the different types of inspections, frequencies, asset types, inspections formats, inspections output and the competency of the inspectors.

4. Condition Assessment Procedures

Each inspection is performed according to a Condition Assessment Procedure. This procedure is characterised by a detailed damage and condition assessment in accordance to a set of standard criteria. An example of this is that every single damage has to be evaluated separately in terms of its effect on the structural safety and serviceability. The damage also has to be rated on a scale from 1 to 4 (1: good condition; 4: critical condition).

To assist the documentation of the inspections, the electronic tool (WSVPruf) enables the damage report to be linked to the appropriate Waterways Asset and be broken down into the assessment

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criteria: damaged object, damage type, damage grade, damage details like size, place and material. It is also possible to add pictures, comments, etc.

To ensure the quality and standardization of the reports assessment, an extensive inspector training was developed. Moreover, the BAW prepared a guideline for damage classification [1].

5. Reporting

In WSVPruf structural elements are organised into meta-categories. Typical meta-categories are solid structure, steel constructions and equipment. These meta-categories enable data aggregation and reporting from a top-down viewpoint. The meta-categories are also used as the basis for forecasting in EMS.

Another example of their use is the aggregation of all the inspection damage evaluations, to automatically calculate the “condition grade” of each meta-category and the entire structure.

6. Mathematical Models

Maintenance Forecasting is done using mathematical models on the collected data in the EMS. These models are based on the stochastic (random) methods:- Markov Chains and Survival Analysis. The Markov Chains model is being used at the present time to forecast the decay of German waterworks structures where damages have already been reported [1]. To forecast the decay of structures where no damages have been reported, another mathematical model is being used, based on Survival Analysis. For the infrastructure calculations the Herz distribution fits very well, since it has an optimal adaptation to state data [3].

The results of both mathematical models are dependent on the quality of the supplied parameters. To ensure high quality, the necessary parameters should be gained from an analysis of the existing inspection data of the waterways structures i.e. the status of the objects structure. If the information was insufficient, independent specialists helped create the data via interactive interviews using the Delphi method [4].

What helped in the development of the models was the use of real inspection data. The models could thus be verified and be calibrated.

7. Conclusion

The initial driving force for the EMS development was not economics but the need to trigger maintenance based on a quantified and normalised system of what had to be done. However to ensure a continual traffic safety a reliable preventive maintenance system is needed so that repair tasks can be started at the right time. The base for such a system is a consolidated reporting and reliable trigger system.

For the triggers, the mathematical models Survival Analysis and Markov Chains are being used on the waterway infrastructure to predict defects (based on the condition state).

In the next step the maintenance system will quantify the expected development of defects and the necessary maintenance measures, their costs and their impact on associated assets. This should result in a favourable, economical “right work at the right time” trigger.

References

[1] Bundesanstalt für Wasserbau, *Schadensklassifizierung an Verkehrswasserbauwerken,* Karlsruhe, 2009

[2] KLEINER Y, *Scheduling inspections and renewal of large infrastructure assets*, Journal of infrastructure systems, Dec. 2001

[3] HERZ R, *Alterung und Erneuerung von Infrastrukturbeständen – ein Kohortenüberlebensmodell*, Jahrbuch der Regionalwissenschaften, Jahrgang 1993/1994

[4] HAEDER M, *Delphi-Befragung – ein Arbeitsbuch*; Westdeutscher Verlag, Wiesbaden, 2002