Development of a Data Filtration Method for Strategic Data Acquisition in Sewer Rehabilitation Planning

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ABSTRACT

International research is already dealing with different aspects of sewer rehabilitation planning. Today several strategies, techniques and tools are available. But due to their complexity many of the available approaches are not applied in practice. In Austria no standardised approach regarding sewer rehabilitation planning is currently available. Therefore several sewer operators have developed “in-house” strategies. This complicates the comparison of different utilities and thus the internal and external evaluation of a specific rehabilitation strategy. In a three years research co-operation between universities and sewer operators, besides other topics, suggestions about standardised performance requirements (performance indicators and service levels) for sewer rehabilitation will be worked out. To support the practical application of the performance requirements a data filtration method will be developed as well. This method shall enhance strategic data acquisition procedures. On the one hand the paper describes the basic idea of the data filtration method. On the other hand first results regarding the definition of different performance indicators will be given.

1 INTRODUCTION

In the last 40 years about 22 billion Euros have been invested in construction and extension of public sewer systems in Austria. Today these works are considered to be widely accomplished. In the future the main focus in urban drainage will concern rehabilitation activities to maintain long-term functioning and value of sewer systems.

International research already deals with different aspects of rehabilitation planning (Milojevic et al., 2005; Le Gauffre et al., 2007; Ugarelli et al., 2007; Dirksen and Clemens, 2008; Alegre and Covas, 2009). Besides integrated rehabilitation planning strategies, publications mainly focus on conservation of the value of sewer systems or modelling of pipe deterioration. Several software applications for decision support are available. An overview of different modelling techniques for sewer deterioration is given in Ana and Bauwens (2010). However, in daily sewer system management practice the mentioned strategies, techniques and tools still seem to be rarely used. According to Ana and Bauwens (2007) a possible reason for the lack of practical applications can be found in the rather rigid and complex architecture of today's techniques and tools. Additionally most of these (theoretical) modelling and decision support approaches require extensive datasets, which often are not available at utility level.

Due to the lack of standardised planning procedures at national level several Austrian sewer operators have started to develop "in-house" sewer rehabilitation strategies. These strategies are based on the data commonly available in sewer practice. However, various planning approaches complicate the comparison of different utilities and thus the internal and external evaluation of a certain rehabilitation strategy. A standardised approach would help solving this problem. Additionally it could serve as a planning guideline especially for small and medium-size utilities, which often have not started rehabilitation planning so far.

EN 752 (2008) is considered to be a useful basis for the development of a national perspective regarding integrated sewer rehabilitation planning.

2 STRATEGIC DATA ACQUISITION

FUNCTIONAL AND PERFORMANCE REQUIREMENTS

According to EN 752 (2008) drain and sewer systems have four different objectives (public health and safety, occupational health and safety, environmental protection, sustainable development). Functional requirements, in total 13, shall ensure that, whilst taking into account sustainable development, drain and sewer systems convey and discharge their contents without causing unacceptable environmental nuisance, risk to public health, or risk to personnel

working therein. To enable the evaluation of the performance of a system it is necessary to determine measurable performance requirements. EN 752 (2008) does not define any performance requirements but refers to different national organisations in the countries of the European Union.

In Austria a research project dealing with strategic sewer rehabilitation planning is currently carried out. The duration of the project is from January 2010 to December 2012. The project consortium comprises three Austrian Universities as well as five of the largest Austrian sewer operators. One major objective of the project is to suggest measurable performance requirements and related service levels which can be used on a national scale in accordance with EN 752 (2008). On international level performance indicators are already discussed in Ashley and Hopkinson (2002) as well as in Matos et al. (2003). However, on the one hand performance indicators shall be structured in a rather simple way. On the other hand they shall only depend on input data commonly available or at least easily accessible in sewer practice.

In a first working step the sewer operators participating in the project identified those functional requirements quoted in EN 752 (2008) most relevant for their daily practice:

- Protection from flooding;
- Protection of groundwater;
- Structural integrity and design life;
- Maintaining the flow;
- Protection of surface receiving waters;
- Inputs quality.

Furthermore the sewer operators defined an additional functional requirement:

- Minimisation of operational efforts.

The next step and the current focus of the project work is to check the availability and applicability of existing national (and international) standards related to the different functional requirements mentioned above. If a standard is available and considered appropriate to a certain functional requirement, it can be applied directly. In this way the related performance requirements (performance indicators and service levels) are already defined by the existing standard.

If there is no standard available for a certain functional requirement, the project team (universities and sewer operators) will work out adequate performance requirements. In the process of compiling representative indicators, the availability of the needed input data is brought into focus as well.

As result a set of SMART performance requirements will be provided to serve as a basis for a standardised evaluation of functional requirements according to EN 752 (2008). Thereby SMART means that the requirements are formulated Simple and Measurable. They should be Accepted all over Austria and Relevant for the utilities. Due to standards increase with increase in prosperity the requirements are Time-oriented. Hence referring to these

requirements comprehensible and comparable sewer rehabilitation planning methods can be adapted.

A crucial point related to performance requirements is the availability of input data needed to determine performance indicators. Prior knowledge of input data requirements is essential for strategic data acquisition and thus for successful practical implementations of certain planning techniques.

DATA FILTRATION METHOD

To support the practical application of the suggested performance requirements in strategic sewer rehabilitation planning a data filtration method will be developed within the current research project. The aim of this method is to enhance strategic data acquisition procedures. As mentioned before, according to EN 752 (2008) performance requirements have to be derived on a national level. However, in this context, from a practical point of view, two different aspects are of importance: On the one hand it is necessary to know exactly what kind of information is gained from a certain performance indicator (allocation to a certain functional requirement). On the other hand it is essential to have preliminary information about input data requirements for the calculation of a specific performance indicator. Based on this information a sewer operator on the one hand can decide whether a certain functional requirement and therewith performance indicator is relevant for his current planning process. On the other hand a sewer operator can assess whether it is possible to calculate a certain performance indicator with the input data available. As a consequence missing data can be collected systematically. Prior to extensive data collection work a cost-benefit-analysis might be advantageous.

The systematic approach of the data filtration method is shown in figure 1. Functional requirements, service levels as well as performance indicators, evaluation methods and input data are the headstones of this method.

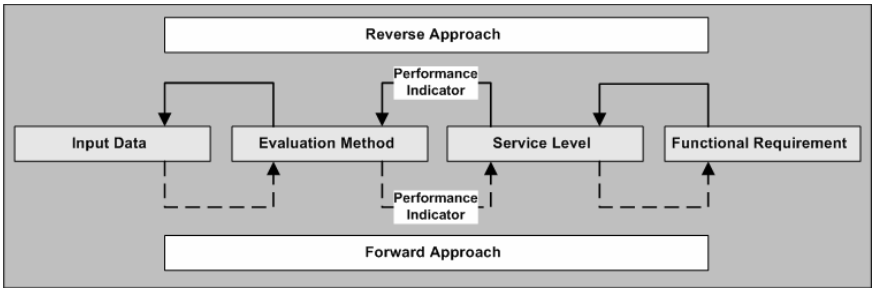

Figure 1. Data filtration method –reverse and forward approach

The data filtration method comprises a reverse and a forward approach: To assess the performance of a system regarding a certain functional requirement one has to focus on the related service level. A service level is used to describe

the degree of target achievement (e. g. accordance with the functional requirement). It defines which performance indicator has to be applied for the assessment. The way how to calculate the performance indicator is given in the evaluation method. Each evaluation method requires a certain and predefined amount of input data. Thus, the data filtration method will directly provide the information on input data requirements for the assessment of a certain functional requirement (reverse approach).

Focusing on the available input data, the data filtration method gives an overview of the applicable evaluation methods and thus performance indicators and service levels to be derived from the existing input data. The "derivable" service levels will give the information which of the functional requirements can be assessed directly from the available input data (forward approach).

For all existing and suggested performance indicators the input data requirements have to be listed. In several cases there will be analogies in the data requirements. However, a summary of all performance indicators including the related input data requirements will be available finally.

3 FIRST RESULTS AND DISCUSSION

In the following, first results, regarding the collection and development of performance indicators, related to the different functional requirements, are presented. The functional requirements are assigned to the four different aspects of integrated sewer management: Structural, hydraulic, environmental and operational performance (EN 752 2008). The detailed description of service levels is not part of this paper.

One functional requirement concerns the structural condition assessment of sewers: "Structural Integrity and Design Life" EN 752 (2008), amongst other aspects, specifies that sewers have to be maintained to ensure structural integrity. Sewer inspection is a common practice to observe the structural condition of sewers (and to a certain extent the hydraulic and environmental condition as well). Today, apart from different national and international standards (e. g. RLOOE 1992, DWA M 149-2 2006), EN 13508-2 (2008) is used as a visual inspection coding system in Austria. Further, EN 13508-2 (2008) will replace all national standards in the EU countries in near future. For the assessment of sewer conditions different national and international standards are available (e. g. ISYBAU 2006, DWA M 149-3). Most of the current methods are already based on EN 13508-2 coding system. Methods for structural assessment as well as input data requirements are given by the available standards. Regarding service levels all standards have four to five structural condition grades representing the priority of sewer rehabilitation measures. However, from a practical point of view in sewer rehabilitation planning it might be more appropriate only to use two structural condition grades (short-term rehabilitation measures needed or not). Sewer operators would also recommend the implementation of some kind of "rehabilitation grade" performance indicator including appropriate service levels to be used in

combination with sewer condition grade assessment. In this new performance indicator the design life of a sewer pipe might be considered as well. Matos et al. (2003) present a full listing of performance indicators for wastewater services. Here certain performance indictors are related to sewer system rehabilitation (e. g. wOp21 to wOp23 [sewer rehabilitation, renovation, replacement in % per year]).

Another functional requirement concerns the hydraulic performance of sewers: Referring to "Protection from Flooding" EN 752 (2008) states that flooding events shall be limited to nationally prescribed frequencies. Matos et al. (2003) define flooding related performance indicators (e. g. wOp37 to wOp39 [floodings/100 km sewer*year]). In the Austrian guideline OEWAV RB 11 flooding frequencies are already defined and categorised according to local boundary conditions (rural areas, domestic areas, city centres, transport facilities, etc.). Hydrodynamic models have to be adopted to prove compliance with prescribed frequencies. Data requirements are defined by the applied model. Currently another guideline dealing with sewer maintenance (OEWAV RB 22) is under preparation. In this guideline five hydraulic condition grades (service levels) shall be defined. From a practical point of view two hydraulic condition grades (compliance or non-compliance with the prescribed flooding frequency) again seem to be sufficient for sewer rehabilitation planning. Hence public pressure to immediately solve hydraulic problems (flooding) is high.

Two functional requirements concern the environmental performance of sewers: The most reliable way to confirm "Protection of Groundwater" is to test the tightness of sewer pipes. Therefore the functional requirement "Protection of Groundwater" is considered to be on a par with the functional requirement "Watertightness". EN 1610 (1998) and the Austrian standard OENORM B 2503 (2004) define all required methods and related input data. Currently both standards are being revised. However, EN 752 (2008) states, only new sewers have to be in accordance with testing requirements of EN 1610 (1998). Watertightness of existing sewers shall be in accordance with local or national testing requirements. This is a very important point, as conventional tightness testing according to EN 1610 (1998) and OENORM B 2503 (2004) is a very difficult task in operating sewer pipes. Information about the water tightness of sewer pipes can also be gained through indirect methods such as visual inspection (optical tightness), quality measurements in the groundwater (residues of pharmaceuticals) and tracer measurements. Fenz et al. (2004) for instance describe the monitoring of concentrations of the anticonvulsant carbamazepine to quantify sewer leakage. These indirect methods seem to be very appropriate tools and thus shall be part of the new national guideline dealing with sewer maintenance (OEWAV RB 22). Quality and tracer measurements can be connected with additional and complex work (groundwater modelling, sampling, etc.), but as a result direct statements regarding the groundwater quality can be made. From a work expenditure point of view visual inspection to prove optical tightness of sewer pipes seems to be more favourable (excluding water protection areas) as it can be combined with the observation of the structural integrity. Obviously high inspection data

quality is of tremendous importance. Additional data such as groundwater level, hydraulic conductivity or type of circumjacent soil can also support the evaluation process (e. g. risk analysis). Regarding service levels a two graded scale is considered to be sufficient for sewer rehabilitation planning (sewer tightness confirmed or not). In Matos et al. (2003) this functional requirement is address in performance indicators wOp30 to wOp33 (inflow, infiltration, exfiltration [m³/km sewer*year]).

Regarding the "Protection of Surface Receiving Waters" EN 752 (2008) states that surface waters shall be protected from pollution within nationally prescribed limits. In sewer operation and maintenance (and thus in sewer rehabilitation planning) surface waters will be mainly affected by combined sewer overflow (CSO) spills. The national guideline OEWAV RB 19 (2007) defines operational requirements (efficiencies) for CSOs. According to the wastewater treatment plant design capacity a minimum share of the annual wastewater quantity in a catchment has to be conveyed to the local treatment plant. To prove compliance with the prescribed efficiency rates, hydrological or hydrodynamic models have to be used. Again data requirements are defined by the applied model. However, input data will at least be partially equal to the functional requirement "Protection from Flooding". Regarding service levels for sewer rehabilitation planning here again a two graded scale is considered to be sufficient (efficiency constraints met or not).

Three functional requirements concern the operational performance of sewers:

Generally EN 752 (2008) suggests assessing operational performance by the number of operational incidents or failures. The functional requirement "Maintaining the Flow" is mostly affected by the occurrence of sewer blockages (sewer collapses, sedimentation, etc.). Therefore proactive sewer operation and maintenance is the most appropriate approach to maintain the flow (periodical or demand orientated). In Austria this approach is considered to be state-of-the-art. In international literature the performance indicator "sewer blockages" is cited (e. g. wOp34 [No. of sewer blockages/100 km sewer*year] in Matos et al. 2003). However, in Austria from a sewer operator's point of view any incident or failure in sewer operation shall be avoided. Sewer operators participating in the research project have less than 0.03 blockages/100 km sewer*a. For this reason the use of the "sewer blockages" performance indicator is of only very limited significance. For sewer rehabilitation planning it is most important to know which sewers need high-maintenance. In this context the definition of a novel performance indicator (including data requirements, evaluation method and service levels) as for instance "operating expense" could be more appropriate.

With regard to contents it is obvious that the additional functional requirement "Minimisation of Operational Efforts", defined by the projects participants, is mainly related to "Maintaining the Flow". As mentioned before operational activities, such as sewer cleaning and sewer inspection, are important measures to maintain the proper functionality of the sewer system. If the work carried out is documented appropriately (strategic data acquisition),

essential information for sewer rehabilitation planning can be derived (e. g. cleaning intervals of certain sewers, etc.).

Regarding the functional requirement “Inputs Quality“ EN 752 (2008) states that the quality of non-domestic inputs shall be controlled, so that, apart from further requirements, they do not compromise the integrity of the pipe material. In Austria the national regulation IEV (2006) provides discharge and control requirements for non-domestic wastewater. All sewer operators are requested to assemble a register of all relevant discharges. As certain wastewater qualities can have negative effects on the fabric of the system detailed information about non-domestic discharges can support sewer rehabilitation planning.

4 CONCLUSIONS AND OUTLOOK

International research is already dealing with different aspects of sewer rehabilitation planning. Several strategies, techniques and tools are available. But due to their complexity many of the available approaches are not applied in practice.

In Austria currently there is no standardised approach available regarding strategic sewer rehabilitation planning. Therefore several sewer operators have developed “in-house” strategies. This complicates the comparison of different utilities and thus the internal and external evaluation of specific rehabilitation strategies. In a three years research co-operation between universities and sewer operators, besides other topics, investigations on standardised performance requirements (performance indicators and service levels) regarding sewer rehabilitation (and maintenance) planning will be worked out. Current project work regarding performance requirements shows that for functional requirements regarding the structural, hydraulic and environmental performance of sewer systems national or international standards (including performance indicators, evaluation methods, etc.) are available. However, in specific cases additional and more significant performance indicators and service levels would be appropriate. Regarding the operational performance of sewer systems no suitable national or international standards exist.

Comprehensible strategic sewer rehabilitation planning requires the definition of appropriate structural, hydraulic, environmental and operational service levels and applicable performance indicators.

To support the practical application of incorporating performance requirements into rehabilitation planning processes, a data filtration method is derived, in the first stage of the mentioned research project. This method shall enhance strategic data acquisition. On the one hand a sewer operator shall obtain direct information regarding the kind of input data needed to evaluate the accordance with a certain functional requirement (reverse approach). On the other hand an overview shall be given, indicating which of the functional requirements could be addressed, using only the data available (forward approach). A standardised approach could also serve as a planning guideline for small and medium-size utilities, which often have not started their rehabilitation planning so far.

The upcoming project steps are a further development of the performance requirements (definition of performance indicators and service levels) according to specific functional requirements. Based on the performance indicators and the required input data, the data filtration method will be developed. Subsequently, the applicability of the method will be tested in several case studies in the course of the project.

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