Dealing with uncertainty in sewer condition assessment: Impact on inspection programs

Bardia Roghani\textsuperscript{a}, Frédéric Cherqui\textsuperscript{b}, Mehdi Ahmadi\textsuperscript{c}, Pascal Le Gauffre\textsuperscript{b}, Massoud Tabesh\textsuperscript{d,}\textsuperscript{*}

\textsuperscript{a} School of Civil Engineering, College of Engineering, University of Tehran, Tehran, Iran
\textsuperscript{b} INSA-Lyon, DEEP, 69621 Villeurbanne, France
\textsuperscript{c} SINTEF, Oslo, Norway
\textsuperscript{d} Center of Excellence for Engineering and Management of Civil Infrastructure, School of Civil Engineering, College of Engineering, University of Tehran, Tehran, Iran

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ABSTRACT

Sewer condition prediction is a fundamental element of proactive maintenance programs. The prediction relies mostly on the assessed condition of inspected segments, generally based on CCTV reports. However, several sources of uncertainty affect the condition assessment and may lead to inefficient maintenance. The present article focuses on three main questions. 1. What is the impact of uncertainty in assessed condition on the prediction model? 2. Considering uncertainties in the assessed condition, is it necessary to collect data on the characteristics of many segments, or are a small number of influential variables enough to build the condition prediction model? 3. Is it better to overestimate (false positive) or underestimate (false negative) the deterioration of a segment? These questions were evaluated on a semi-virtual asset stock and the results confirm that uncertainties affect the inspection efficiency negatively. Results also show that errors leading to the over-estimation of the deterioration have less negative impact. The study suggests that data from a small number of influential segments is adequate to inform the prediction model.

1. Introduction

Asset management requires managing infrastructure assets to minimize the total cost of owning and operating them, while delivering the desired service levels to customers [1]. Nowadays, water and wastewater utilities face several serious obstacles in the management of their assets; among others, the most important being a limitation of available budget. According to the US EPA [2] 51 billion dollars are in immediate need for sewer segments rehabilitation in the USA. Consequently, utilities need to adopt proactive asset management programs in order to prioritize sewer segments for inspection, maintenance and rehabilitation activities, with the aim of making best use of the limited funds available [3].

One of the most important steps in each proactive sewer asset management is to determine the condition of segments, usually by visual inspection [4]. A sewer segment refers to a length of several tens of meters of segment and is generally located between two successive manholes [5]. The main purpose of such an inspection is to determine the current condition of an asset and, therefore, evaluate the progression of any deterioration to make informed decisions about complementary investigations, maintenance, repair or potential replacement [6]. Currently, the most common technology for condition assessment is the closed-circuit television (CCTV) inspection system, which is widely used to locate and recognize disorders in sewer segments [7]. Van Riel et al. [8], by analysing the information sources of 150 sewer replacement projects in the Netherlands, expressed that in 60% of the cases, operators used CCTV reports as their main information source. Although many other techniques have emerged in recent decades, such as acoustic instrumentation [9,10], laser profiling [11], radar [12], or core sampling [13]; the CCTV remains more prevalent because of its very low cost (for example less than 10 euros per linear meter of segment inspected in France) and the existence of accepted standards for its use [14].

By using a specific coding system such as the European standard EN 13508-2 [15] or PACP in North America [16], CCTV outputs can be an inventory of observed reported defects. In the next step, the observed defects are quantified, and a condition is assigned to each segment based on the condition grading protocol [17]. However, application of CCTV to assess the condition of segment has been called into question due to concerns about reliability [14,18–20]. To the best knowledge of the authors, today, no other inspection techniques is fully ready (in terms of cost, standard and market) to replace the CCTV. Thus, there is...