Residual Life and Reliability Assessment of underground RC pipelines under uncertainty

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20STUTA25

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Tran-SET

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$112,001

Assesing new methodologies in reinforced concrete sewer pipeline inspections and repairs

Due to little financial resources and the urgent need for pipeline maintenance/repair projects, the prioritization of funding to these projects is a major issue that all municipalities encounter, especially Region 6. One way to optimize the limited resources allocated to operation and management of sanitary sewers is to consider probabilistic performance assessment, which provides a complete characterization of structural elements and systems' performance. The most common probabilistic performance indicator is reliability, a measure of failure probability relative to a particular limit state (e.g., ultimate strength or serviceability). Reliability methods can be used to identify which pipeline sections in a particular system require the most serious inspections. To apply the proposed approach to the Reinforced Concrete Pipes (RCPs) in Houston, the research team will work thoroughly with the Center for Structural Engineering Research/Simulation and Pipeline Inspection at the University of Texas at Arlington (UTA) to obtain filtered, Light Detection and Ranging (LIDAR) data. From this LIDAR data, a probability distribution representative of wall thickness loss during inspection will be estimated. Next, this derived probability distribution will be integrated within a serviceability limit state that defines failure as the complete loss of concrete cover. With this limit state and a prescribed probability of exceedance threshold, a reliability-based prediction of the leftover service life will be determined. Advanced statistical techniques will also be used to ascertain these predictions. Finally, an asset management report outlining locations of the most vulnerable pipeline sections will be created. This report will provide decision makers crucial information about the state of their city's pipelines. Although the approach developed can be applied to any municipality's pipeline network, the potential of the developed methodology will be explained by its application in Houston sanitary sewers.

Problem Statement

Funding pipeline repair projects is a serious issue that municipalities encounter everywhere, especially in Region 6. To optimize narrow

resources allocated to operation and management of sanitary sewers is to consider probabilistic performance assessment, which provides a complete characterization of performance of structural elements and systems. The most widely used probabilistic performance indicator is reliability, a measure of probability of failure relative to a particular limit state (e.g., ultimate strength or serviceability). Reliability methods can be used to identify which pipeline sections within a particular system require urgent repairs. Inspection results, in the form of LIDAR data, were previously collected for about 2 miles of pipe in Houston, TX. Using this data, the UTA research team will determine the remaining life of these pipeline systems. The results derived from this study can eventually help officials make informed choices regarding the allocation of funds by providing a comprehensive performance assessment. Moreover, an asset management report for the 2 miles of pipeline in Houston will be developed; the report may help city engineers and planners identify and understand the critical pipeline infrastructures in the region. The methodology developed may be applied to RCPs in any region and assist decision makers by providing information regarding the remaining life of sanitary sewers.

Objectives

The main goal of this study is to estimate the remaining life of reinforced concrete pipes, using field data collected via multi-sensor inspection. The specific objectives are listed below:

- Create reliable analysis methodologies for RC sanitary sewer systems.
- Perform probabilistic performance prediction to estimate residual life.
- Facilitate informed, economical decision making, in addition to mitigating detrimental environmental and societal impacts of pipeline failure.

Figure 1: RC Sewer pipeline being inspected

Intended Implementation of Research

Workforce Development, Education, and Outreach: This study will provide a systematic methodology to evaluate the reliability of civil infrastructure in Region 6. More specifically, a specialized and customizable decision support tool will be developed for asset managers and engineers involved with the operation and maintenance of sanitary sewer networks. In practice, an asset management report summarizing the findings of the reliability study will be available for engineers and pipeline managers so that they make informed decisions regarding the infrastructure under their jurisdiction. Also, The PI will work with graduate and undergraduate students at UTA to develop outreach modules for high school students interested in engineering careers. The PI is the faculty advisor to the student Steel Bridge team; this platform outreach high school students. The PI will develop (with the help of the Steel Bridge team) an hour-long interactive learning module that will be shared at a local high school within the Arlington, TX independent school district. Moreover, the results of this study could be integrated within a graduate level course that the PI teaches at UTA. The graduate class, "Structural Reliability," taught in the Civil Engineering Department at UTA, equips students with fundamental concepts about structural safety and risk, within a life-cycle context. Students will develop semester-long projects and their results can be used in making their final project.

Anticipated Impacts/Benefits of Implementation

The findings of this study will help government officials make informed choices about city fund allocation and provide a comprehensive information manual about the status of the city's sanitation sewers. The main deliverables of this project are as follows.

1) A technical paper published in a refereed journal

2) Conference presentation(s) and proceeding(s) (including the TranSET 2021 conference)

3) A customized asset management report that supports decision-making with respect to lifetime management of RCPs.

Web links

- Tran-SET's website https://transet.lsu.edu/research-in-progress/

Tran-SET

Tran-SET is Region 6's University Transportation Center. It is a collaborative partnership between 11 institutions (see below) across 5 states (AR, LA, NM, OK, and TX). Tran-SET is led by Louisiana State University. It was established in late November 2016 "to address the accelerated deterioration of transportation infrastructure through the development, evaluation, and implementation of cutting-edge technologies, novel materials, and innovative construction management processes".

Learn More

For more information about Tran-SET, please visit our website, LinkedIn, Twitter, Facebook, and YouTube pages. Also, please feel free to contact Dr. Momen Mousa (Tran-SET Program Manager) directly at transet@lsu.edu.