THEORETICAL ISSUES IN ADVANCING INFRASTRUCTURE ASSET MANAGEMENT PROGRAMS

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ABSTRACT: Asset management has been truly a buzz word in recent years for infrastructure management professionals as a promising framework to achieve the optimal use of financial resources and to find smart and carefully crafted decision making processes on maintenance, rehabilitation and replacement activities. This paper addresses major theoretical issues that must be answered in order to advance the infrastructure asset management programs with potential solutions. Underground infrastructure assets are used as case studies.

Keywords: *Infrastructure Management, Asset Management, Deterioration Model, Clustering Approach*

Extended Abstract

The U.S. government agencies and municipalities have made significant efforts to ensure an adequate level of infrastructure service to the public. However, the nation's water and wastewater infrastructure networks are continuously deteriorating. The infrastructure grade for drinking water and wastewater is almost a failure grade, D-. However, the agencies are operating under constant pressure of serious financial constraints. Asset management is considered as a promising framework for achieving the optimal use of financial resources through carefully crafted decision making processes.

The authors believe that the two most fundamental and theoretical issues that the academia can help for the successful implementation and advancement of asset management systems are *a) identifying realistic deterioration processes of assets to develop reliable deterioration models, and b) discovering and creating logical risk models for the assets*. These two models are key for most decisions made through asset management programs. Along with the three major types of input values (asset inventory, asset history and current conditions, and level of service), these two deterioration and risk models are equally critical in producing reliable decisions. Deterioration models help infrastructure agencies predict future maintenance, rehabilitation, or replacement timing of assets. The risk models help agencies prioritize the assets for the activities and allocate their budget. Thus, the quality of asset management decisions is highly dependent upon the quality of these two theoretical elements that are fed into the asset management process.

The authors have noticed three inherent problems in existing deterioration models that create fundamental skepticisms for these models to be employed by utilities; a) failure to address and differentiate two primarily different needs of deterioration models, b) oversight of critical locations and soil factors in developing deterioration models, and c) failure to deal with issues in developing models for the entire network level. This presentation will discuss a new approach in developing robust deterioration models that are expected to overcome these three major

limitations.

The authors have discovered that there are two fundamentally different purposes of deterioration models. One is to use a deterioration model for planning new pipeline construction projects and the other is to use a deterioration model for making decisions for inspection, maintenance, rehabilitation and replacement activities on the already installed pipe assets. The latter case can use and benefit actual condition assessment data of the specific asset for accurate decisions and customized prediction of future conditions while the former can only rely on collective aging pattern of a similar type of pipes in operation as the asset has not been installed yet. The discovery of the two primarily different purposes of deterioration models is significant because it justifies the need to develop dual deterioration models. Previous researchers in developing deterioration models apparently failed to recognize these two different usages of a deterioration model. The deterioration models that will be discussed in the presentation will be dual models for group and individual prediction.

Another important problem that existing deterioration models have is the inability to handle the effect of maintenance activities in estimating the expected life of a pipe. Clearly, rigorous maintenance activities will extend the expected life of a pipe than poor maintenance activities. Thus, individual prediction models should be dynamic to reflect both the actual condition change of an asset over time and the effect of maintenance activities in estimating the expected life of the asset.

Previous studies have made significant contributions to explaining the affecting attributes of underground pipe deterioration. Some of them clearly indicated that pipeline deterioration processes might be more specific to location than generic to all different environments, given the fact that location markers, such as proximity to roadway, railway, etc., climate and soil corrosivity, significantly affect pipe deterioration. This presentation will discuss how these location-related attributes significantly affect the deterioration process of underground assets.

Most of previously developed deterioration models for sewer pipes take small data samples (ranging from 1.8% up to 6% of the entire data set) from pipeline networks, develop a prediction model, and use that model to estimate the rest of the network. This approach has led water and wastewater utilities to rely on models that treat pipeline network populations as homogenous and to neglect the critical differences in the pipeline networks. One prominent approach to this problem is to group individual assets using clustering techniques and develop different deterioration models for each cluster. Cluster analysis is an exploratory data analysis tool which attempts to sort different objects into groups in a way that the degree of association between two objects is maximal if they belong to the same group and minimal otherwise. The clustering process creates a virtual grouping of observations using prior knowledge. This presentation will also discuss the need of rigorous clustering approaches before developing deterioration models and its effectiveness over the conventional methods.