Life Cycle Cost Model For A Wastewater System With Infiltration

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Abstract

The study was focused on developing a model to estimate the Life Cycle Cost (LCC) for operating a wastewater sewer system. A spreadsheet model has been developed, which is based on population and average household occupancy. Essential components of a wastewater system have been identified and divided into sectors with housing, commercial, educational and recreational facilities. Life cycle cost includes treatment, transportation, maintenance and rehabilitation of a wastewater system to control infiltration over a period of 30 years. The model can be used to compare different rehabilitation and maintenance scenarios and identify the most cost effective approach. The model is being calibrated with published data.

1. Introduction

It is estimated that there are over 4.2 billion feet of wastewater pipelines in the U.S with an estimated value of $1.0 trillion [2]. The anticipated rehabilitation needs to upgrade this system exceeds $34 billion, where as the current annual spending for wastewater rehabilitation is approximately $1.0 billion [2]. One of the main reasons for this dilemma is because till the 1980s sanitary sewer rehabilitation were primarily limited to replacement by parallel construction and very little rehabilitation work was done. This made the rehabilitation cost prohibitive. Due to the advancement in technology new cost effective methods have been developed for inspection and rehabilitation of wastewater systems, which have made the rehabilitation and maintenance a cost effective alternative to replacement/new construction. The model can be used to compare various rehabilitation and maintenance plans and new construction cost. There are number of models used for wastewater system design but most if not all of these models have not incorporate the LCC or infiltration [1]. Hence there is need for developing new models to overcome some of these shortcomings.

2. Objective

The objective of this study is to develop a model to determine the LCC due to infiltration in wastewater systems. The specific objectives are as follows:

1. To identify the important parameters that influences the cost of a wastewater system due to infiltration.
2. To develop a LCC model for a period of 30 years
3. To incorporate the various rehabilitation and maintenance methods to identify the most cost effective plan.

Various steps being followed in developing the model are:

- Estimate the various components of the sanitary sewer system based on the population and the service area.
- Quantify the amount of wastewater flow based on infiltration in an existing sanitary sewer system.
- Developing Life Cycle Cost Analysis (LCCA) for a wastewater system with infiltration.
- Estimate infiltration cost, wastewater treatment cost, transportation cost associated with the wastewater system.

- Estimate rehabilitation cost associated with various rehabilitation activities.
- Perform parametric study with various factors of the sanitary sewer system and identify the most important cost contributing factors.
- Compare various rehabilitation alternatives and perform break-even analysis with operation cost of the wastewater system.

3. Case Study

Various case studies have been documented for cities with different populations. One such example is Norfolk, Virginia. The population of this city is 260,000 [3]. A study on the infiltration problem was conducted based on the data provided by the city. Information on the treatment and transportation cost ware $1.40/1000 gallons and $1.29/1000 gallons respectively [4]. Based on the census data the household occupancy was 2.5 per unit [4] and the model was used to generate the data for a period of 30 years and various analyses were performed.

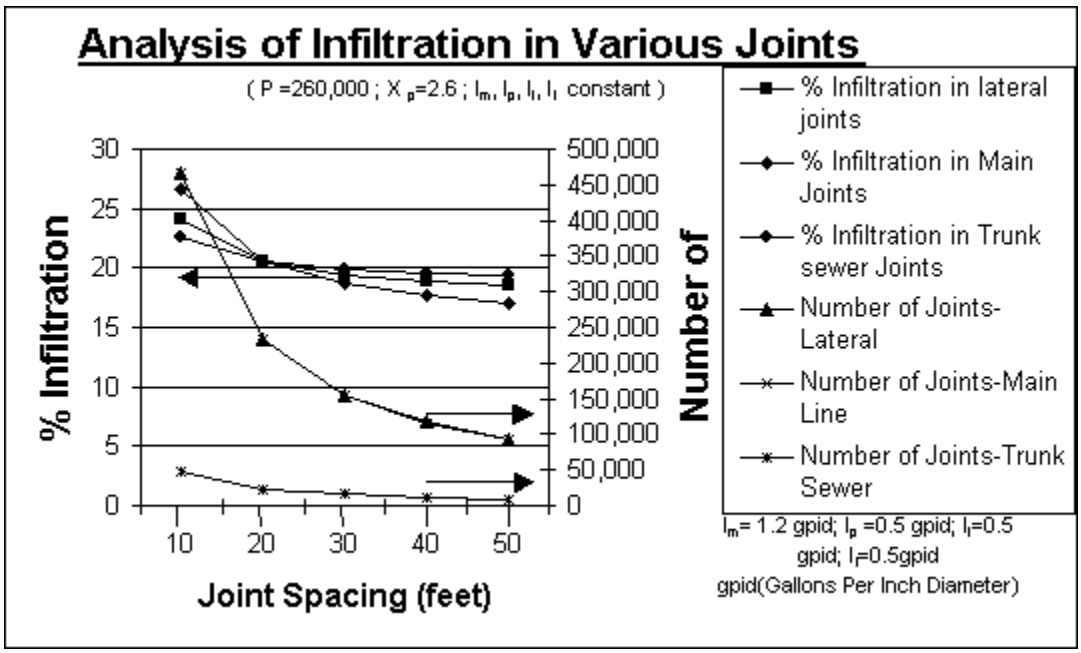

Figure1. Variation in Infiltration with Joint Spacing

Figure 1 shows the results obtained from a parametric study conducted by varying the spacing between pipe joints in the wastewater pipelines. This study shows the changes in the percent infiltration as the spacing between various pipe joints are increased. In Fig. 2, LCC for various infiltration reduction is compared with the repair cost and treatment cost. Based on the cost results, it can be stated that up to 50% reduction in infiltration by repair method is cost effective. Higher reduction in infiltration will result in greater repair cost and greater total cost.

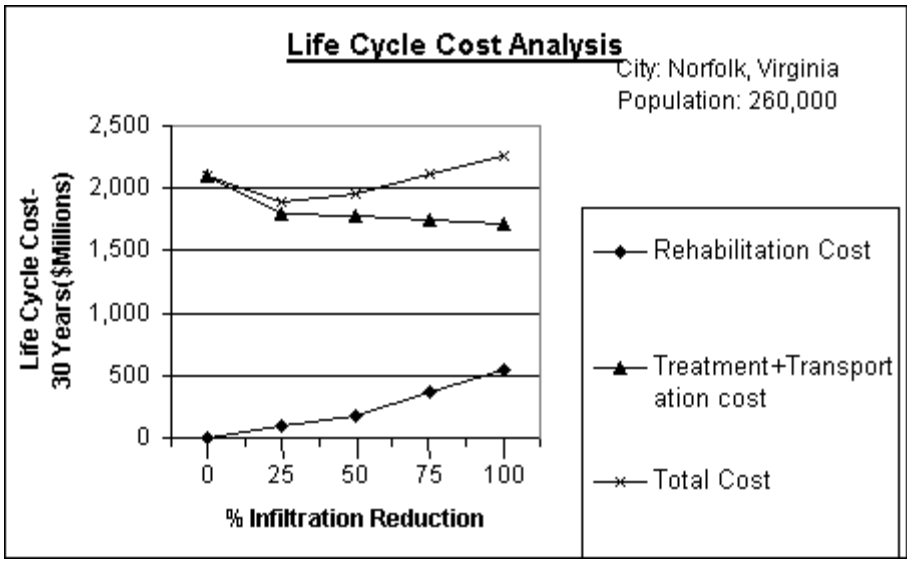

Figure2. Life cycle cost and infiltration reduction

4.Conclusion

The model is based on population and household occupancy of the area that is being designed. The lumped parameter model can be easily used to estimate size of the wastewater system. The model is very flexible, the can be calibrate for specific location by modifying the default values provided. The model parameters are being updated by calibrating the model with published data.

5. Acknowledgements

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6. References

1. Ardit, D., "Life Cycle Cost Analysis(LCCA) in municipal Organization", Journal of Infrastructure Systems Vol. 5, No. 1, March, 1999.

2.Wade, Mark, " Controlling Inflow and Infiltration In Wastewater Collection Systems", http://www.wadeinc.com/articles/asce.htm

3.United States Census Data, www.census.gov

4.Curtis,W Lamont and Anderson, K Gregory, "Determining the cost-effectiveness of sanitary sewer rehabilitation in Norfolk, Virginia",' National Conference on Sanitary Sewer Overflows(SSOs), April 24 - 26, 1995, Washington ,DC.

5.ASTM C 1131-95, "Standard practice for Least Cost (Life Cycle) Analysis of Concrete Culverts, Storm Sewer, and Sanitary sewer systems", Annual Book of ASTM Standards, Vol. 04.07

If you have any questions, please contact **Dr. C.Vipulanandan**