APPLICATIONS OF THE LOG-LINEAR AND THE POWER LAW PROCESS ROCOF TO WATER MAIN FAILURE DATA

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Decisions regarding continual repair or replacement of deteriorating pipes in water distribution systems involve assessment of the failure patterns and economical efficiency of replacement. Since the failure patterns of the pipes in water distribution systems varies considerably, modeling of the failure phenomena should be focused at an individual pipe level to save overall maintenance costs. Based on recorded failure times or observed number of failures in non-overlapping time intervals, a suitable ROCOF (the rate of occurrence of failure) can be used in modeling the failure pattern and in estimating economically optimal replacement time of a water main.

This paper presents applications of the log-linear ROCOF and the power law process to model failure rate and to estimate optimal replacement time of individual pipes in a water distribution system in the U.S. The performance of the two ROCOFs in the assessment of the failure rate is examined by using the maximum likelihood method for different modeling approaches, in which each recorded failure time or number of failures in non-overlapping time intervals is used, in relation to varying data types, in which truncated or complete data are available. The optimal replacement time equations for the two ROCOFs are developed by applying the methodology of Loganathan et al. (2000) for the case in which rescaled failure times are used to aid convergence in the parameter estimation processes.

The performance of the log-linear ROCOF and the power law process for the 'faire-time-based' and the 'failure-number-based' method is compared by using the maximized log-likelihoods for the 92 individual pipes that have more than 5 recorded failures. For about 96% of the pipes, which is 88 out of the 92 pipes, the maximized log-likelihoods for the log-linear ROCOF were greater than the power law process for the 'failure-time-based' method. Therefore, for the 'failure-time-based' method, it was determined that the log-linear ROCOF better represented the pipe failure patterns of the case study area than the power law process.

For the 'failure-number-based' method, about 82% of the pipes, which is 75 out of the 92 pipes, had greater maximized log-likelihoods for the power law process than for the log-linear ROCOF. The average and the standard deviation of the difference between the maximized log-likelihoods of the two ROCOFs for the 75 pipes, whose maximized log-likelihoods of the power law process were greater than the log-linear ROCOF, were about 0.39 and 0.36, respectively. Meanwhile, the average and the standard deviation of the difference between the maximized log-likelihoods of the two ROCOFs for the 17 pipes, whose maximized log-likelihoods of the log-linear ROCOF were greater than the power

law process, were about 0.84 and 1.39, respectively. Therefore, for the 'failure-number-based' method, it was not reasonable to distinguish a better ROCOF over the other for the pipes under study. The summary of the comparisons are shown in Table 1.

Comparison for overall performance of the 'failure-time-based' and 'failure-number-based' method showed that all of the maximized log-likelihoods of the 92 pipes calculated by using the 'failure-time-based' method were greater than the ones obtained from the 'failure-number-based' method for both of the two ROCOFs,

Table 1. Comparison Chart for the Performance of the ROCOFs

CRITERIA / METHOD	ROCOF	Number of Pipes Better Modeled	Difference of the Maximized Log-Likelihood	
			Average	Standard Deviation
Failure Time Based	Log-Linear	88	3,529	3,099
	Power Law Process	4	708.8	984.9
Failure Number Based	Log-Linear	17	0.84	1.39
	Power Law Process	75	0.39	0.36

REFERENCES

Loganathan, G. V., Park, S., and Sherali, H. D. (2002). "A Threshold Break Rate for Pipeline Replacement in Water Distribution Systems," *Journal of Water Resources Planning and Management, ASCE*, vol. 128, no. 4, pp. 271-279.