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Estimations of safety degree of water distribution system

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Abstract

The relatively weak pipe or area of water distribution can be estimated by calculating the probability of pipe break and thickness index. And safety degree of area in water distribution system can be estimated by thickness index which is introduced in this study. Thickness index is the ratio of estimated thickness of pipe and real used thickness of pipe. Thickness index can express the safety degree of each pipe or each area of water distribution system. In the present study, water hammer pressure which can be appear in two test beds of water distribution system is considered for the estimation of pipe thickness. Estimated thickness of pipe was used to estimate the thickness index of each area of water distribution system. Thickness index and probability of pipe break were estimated for a small block and water distribution system. From the results, it was found that thickness index and probability of pipe break can be used to determine the weakest link of water distribution system. And it can be used to determine the priority rank of pipe in water distribution system for the repair or replacement.

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Keywords: Water distribution system; Pipe breakage; Thickness index; Surge pressure; Safety degree

1. Introduction

Water distribution system is the essential link which delivers the enough and safe water to the citizen. However, safety of water distribution system has been issued recently for so many reasons. For example, breakage of water

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main can cause the state of system failure, then it is necessary to analyze the causes of system failure as the uncertainties using the reliability analysis.

Mailhot et al. (2000) suggested the method that can estimate the coefficients of stochastic models for the city water distribution system which contains the short history of pipe breakage. And it showed the application method to the city water distribution system which has real history of pipe breakage. Watson et al. (2004) suggested Bayesian method that can express the uncertainties rely on engineering experiences to the management and the various decision making of water distribution system. Kwon and Lee (2008a) performed the reliability analysis to determine whether water distribution system secure the water supply. And Kwon and Lee (2008b) estimate the probability of pipe breakage using the results of unsteady analysis for the water distribution system. Kwon and Lee (2009) performed the reliability analysis for the friction coefficient which has intimate relation with the probability of pipe breakage using AFDA method.

In this study, unsteady analysis performed for the Ho Chi Minh City small block water distribution system located in south area of Vietnam. Reliability analysis has been performed using the results of unsteady analysis. Therefore, the probability of each pipe breakage has been quantitatively calculated and compared with the pipe thickness index which is one of the management indexes and suggested in the present study.

2. Unsteady analysis of a small block water distribution system (HCM1 network) in Ho Chi Minh city

Ho Chi Minh city small block water distribution system (HCM1 network) has 889 hydrants, 1 distributing reservoir which is located on 15 meter elevation supplying the treated water of 0.009m^3/sec (802.83m^3/day). Fig. 1 shows the HCM1 network which has 1 reservoir, 148 junctions, and 162 pipes. Furthermore, it was divided by 4 areas to analyze the safety degree of each area.

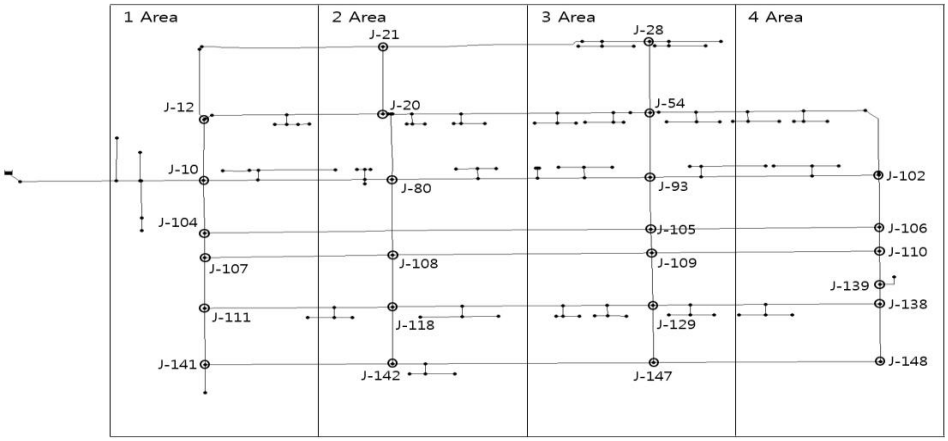

Fig. 1. Plan view of HCM1 network

In this study, the method of characteristics has been used for the unsteady analysis. First of all, unsteady analysis was performed by assumptions of quick valve closure. It was assumed that shut off valve at the distributing reservoir is linearly closed in 1 second and opened in next 1 second. And as shown in Fig. 1, it was assumed that the demand at each junction is closed in 1 and 2 seconds. For the unsteady analysis, relations of $\Delta t = 0.0008\sec$, $\Delta x = 1m$, and wave speed c=1250m/sec were used for the conditions of numerical analysis. And the same value of Darcy-Weisbach friction coefficient for the distribution system was used as 0.04 which is estimated by field observation.