A Development of Model for Evaluating Block Leakage Using Simulated Annealing

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Introduction

Due to difficulties in developing new water sources compared to increasing demand for water recently in Korea, there has been an enhanced interest regarding leaks. Accordingly, in order to reduce leakage, revenue water ratio was increased to 5.0% by investing a total of 7.1053 trillion won from 1999 to 2003. But from 2004 to 2008, although the cost was similar to that of before in 7.3936 trillion won but revenue water ratio only rose by 3.3% (2008 water supply statistics, Ministry of Environment). That is, as revenue water ratio becomes higher, there is a problem that it costs more to increase the ratio. As a result, when revenue water ratio exceeds a certain point, benefit received by leak reduction is overshadowed by the large cost to reduce the leak and may cause a negative effect instead to the management of the water supply business. Therefore, decision standard for leak reduction that considers economic efficiency becomes needed. As an alternative, Infrastructure leakage index (ILI) or Economic level leakage (ELI) developed by the IWA Task Force must be proposed. But because such methods do not take into consideration of Korea's pipe net characteristic, water usage configuration, and block and region, there is a problem of appropriate evaluation not being accomplished when applied directly. Therefore, this research will consider economic efficiency suitable for the circumstances of Korea to develop a leakage evaluation model in order to propose the goal for leakage management and assist management condition evaluation.

Study Method

This research consists of 3 stages: block leak estimation equation development, block economic suitable leakage proposal, and block leak evaluation.

Block leak estimation equation development

This research selects 66 blocks in Korea's city S as the research target region and based on GIS and operation data, regression analysis is used after classifying pipe type regarding leakage by block and pipe age as standards to develop a pipe net leakage estimation equation according to the pipe type from the pipe net. In addition, although Properties correspond more to individual than the public domain, recent properties of Korea have shown an growing interest in reducing leak and since improvement is difficult with just individuals' efforts, public intervention is becoming required. In this research, regression is used according to characteristic of properties including leak management of properties with such enhanced interest to develop leakage estimation equation for the properties. This equation

is combined with the previously developed pipe net leakage estimation equation to develop the block leak estimation equation.

Block economic suitable leakage proposal

Block economic suitable leakage is proposed after economic consideration of the four main factors of leak management in the form of pipe materials management, pressure management, active leakage control, and speed and quality of repairs and consideration of leak reduction of properties.

First, regarding pipe materials management, cost and leak reduction rate is estimated when pipe is replaced in the previous pipe net leak estimation equation. Then in regards to pressure management, leak reduction rate and needed expenses due to adjustment of water pressure are estimated. For active leakage control, economic efficiency is considered for leak detection and for speed and quality of repairs, direct and indirect damage cost and change in construction cost due to shortening of repair time regarding burst occurrence are considered. And then for properties, leak reduction construction cost and its effects are analyzed. Evaluation of cost occurs according to the cost-benefit curve.

The above 5 factors are integrated to make it possible for the development of a model estimating cost for leak reduction and its corresponding benefits. However, as the number of variables for economic efficiency increase, the equation becomes more complex making it more difficult to propose the appropriate leakage so even though it requires more time than other methods, simulated annealing which is effective in finding global optimum value is used to propose the appropriate leakage.

Block leak evaluation

For block leak, the current leakage and economic suitable leakage are compared to evaluate current management standard and future management goals.

Results

As a result of applying the model developed through this study to blocks 49 and 50 of S city ,the existing method of leak evaluation index (ILI) showed an allowable leak amount of 31,044 ㎥/yr and appropriate revenue water ratio of 98.9%, while the evaluation using economic extent of leak (ELL) resulted in 86,284 ㎥/yr and 97.1%, respectively. This is uneconomical since the goals are too high. However, in this model, the block's adequate maximum allowed leak amount was calculated to be 631,791 ㎥/yr and the adequate revenue water ratio to be 82.07%, thus having a larger allowable leak amount than that of the existing ILI, ELL and ELI methods. Thus, this model was verified to be more reasonable from an economic viewpoint as it can provide a realistic alternative to leakage management.

Table.1 Compare between developed model and existing method

	Present	ILI	ELI	Developed model (Adjusted ELI)
Revenue water(㎥/yr)	2,890,963			
Acceptable leakage(㎥/yr)	925,108	31,044.00	86,284	631,791
Inflow(㎥/yr)	3,816,071	2,922,007	2,977,247	3,522,754
Goal of revenue water ratio(%)	75.76%	98.94%	97.10%	82.07%
Evaluation		29.8	10.72	1.46

Conclusion

Through this research, a model was developed to evaluate block leak, this model proposes a larger allowance possibility for leakage compared to the existing method. Such results emerged because of more strict consideration of economic efficiency and Korean-specific factors such as high population density and Korea's block characteristic where many small blocks are present are considered.

This research does not propose a simple index but by inserting data needed for a model pertaining to a region with various characteristics, the study is able to propose an estimation equation and leakage suitable and taking into account of the region characteristics and is more useful compared to the existing method. Also, the research does not simply propose evaluation and management goal for current circumstances regarding block but by applying various reduction methods to the model, the study can help select the appropriate leak management method and develop the optimal application sequence.

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