IMPROVING WATER DISTRIBUTION SYSTEM ROBUSTNESS THROUGH OPTIMAL VALVE LOCATION APPROACH

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ABSTRACT

In the past, water distribution system (WDS) has focused on increasing water penetration rate to more consumers with stable water supply. However, in the present, the importance of resilience, which is the ability to maintain stable water supply capacity, is emerging even in abnormal conditions (i.e., system failure due to the deterioration of the water supply network and rapid changes in climate). Especially, robustness in WDS is defined as the system’s ability to maintain its function to supply customer’s demand under disturbances (e.g., pipe failure and fire flow). In the aspect of water distribution system design and reinforcement, the pipe diameter increasing or additional valves constructing can improve the robustness of water distribution system. If an additional valve is installed at the adequate location, it is possible to supply more stable to the customer by minimizing the space of shut off the water in case of the repair for pipe breakage or maintenance. In this case, the area which is isolated pipes and nodes by closing valves is defined as a segment and the size of the segment is directly related to the range of damage that occurs during water blockage [1].

A segment in WDS consists of a group of pipes and nodes isolated by closing valves in close proximity for repairing a failed WDS components associated in the segment.

A segment can consist only one pipe or node when the valve has covered pipe or node that two valves are located at the end of the pipe or covered around the node. Otherwise, it must close more the neighbor valves to isolate a section of the broken components. In this case, the whole isolated sections of components can be considered as a single segment. With the concept of the segment, the components failure of water distribution system impact can be estimated efficiently. Therefore, in previous studies, there were some studies to reduce the damage in the abnormal condition such as network failure through valve installation of the water distribution system [2], [3], [4], [5].

These previous studies were carried out to quantify these damages when components failure of the water distribution system caused problems in normal system operation. In other word, these studies have been focused on minimize hydraulic damage by installation optimal valve locations in the water distribution system design process. However, the failure of water distribution system causes not only hydraulic damages but also social and economic problems. Therefore, to effectively manage the future water supply system, it is necessary to change focus from only consideration of the hydraulic factor in the past to including social and economic factors.

Therefore, to improve system robustness, additional valves are installed by making large segments smaller and decreasing failure depth. In this study, to improve water distribution system robustness through optimal valve installation applied three concepts: (1) Segment finding algorithm, (2) Critical segment selection technique, and (3) Valve location determination.
Using the segment finding algorithm, the segment and the unintentional isolation can be identified. To select the segments to be divided, a multi-criteria decision technique considering the hydraulic, social, and economic criteria is used as a technique for evaluating critical segment selection technique. And to improve the segment robustness, a new valve location determination technique is proposed as a reinforcement aspect that could replace the engineer's experience approach in the previous study when the additional valve installation location is decided. This technique performed pipe and valve failure analysis for the determination of optimal valve location. To verify the results, a real-world water distribution network is applied. As a result, optimal valve location approach can be confirmed that the damage caused by WDS failure can be significantly mitigated even though supplemental source is not added.

**Keywords:** Water Distribution System; Robustness; Segment;

**Acknowledgement**
This work was supported by a grant from The National Research Foundation (NRF) of Korea, funded by the Korean government (MSIP) (No. 2016R1A2A1A05005306).

**Reference**


