ASSESSMENT OF VARIATIONS IN NODAL DEMAND SATISFACTION OF WATER DISTRIBUTION NETWORKS

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The objective of a protected water supply system is to supply safe and clean water in adequate quantity, conveniently and as economically as possible. Water Distribution Network (WDN) is one of the components of Water Supply System, which need to be designed and operated more carefully to have a safe and satisfactory supply of water to the consumers. In many of the developing countries, drinking water supplies are inadequate to meet the consumers' needs. Reasons for this may be rapid growth of population, lack of sufficient quantity of water in the source, lack of funds, improper planning, inadequate fund allocation etc. Hence many of the water supply systems are designed and operated as intermittent systems. The pressure head available at all nodes is not same. Outlets are uncontrolled and based on head available at that node discharge through the outlet will be more or less than the designed discharge. In case of intermittent supply, or limited period supply due to shortage of water, the duration of supply is fixed and during the same period some nodes discharge more quantity of water and other nodes may discharge less water.

Reliability is one of the aspects that is gaining importance in design and operation of any system. Different people have defined reliability of water supply systems in different ways and they have also tried to estimate it using different procedures. Reliability was considered as probability of a node being connected to the network with the assumption that once a node is connected to the network it gets required quantity of water with sufficient pressure. In strict sense, the reliability of a water supply system should take into account all possible factors like variations in demand, availability of water at source, failure of components such as pumps, treatment units, valves, pipes etc. and the effect of these factors on performance of water supply system in terms of quantity, pressure, quality etc. Depending on the situation one or more of these factors may become prominent. In case of intermittent supplies, where water is supplied for fixed duration, and when there is shortage of water, people tend to collect water as long as there is supply and hence variations in demand will not be important while assessing intermittent system of supply.

In the present work reliability is defined as supply ratio or demand satisfaction, which is calculated as the ratio of total water supplied and total demand. The ratio of total supply at the node to total demand of the node is taken as Supply Ratio (SR). The program developed here can also predict supply ratios of different nodes at different times and from

these SR for the entire system is calculated.

Demand Driven Analysis (DDA) of water distribution networks has been in practice since a long time. In DDA the demand is assumed to be satisfied irrespective of the head available at nodes. Many modifications were proposed to correct the discharges calculated in DDA based on head available at node or at source. In these modifications their emphasis was mainly on nodes having lesser head with the assumption that discharge at other nodes is greater than demand and hence their level of satisfaction is more than one. In case of deficit supplies and intermittent system of supply where a limited quantity of water is supplied to the entire area, certain nodes get higher quantity of water while nodes with lesser head may get much less quantity than their proportionate share. This is a most common situation in many water supply systems of most of the developing countries. To have a more realistic estimation of demand satisfaction, discharges should be corrected at all nodes. Tanyimboh et.al (2001) used equation (1) to modify the discharges at nodes. Same relation is used in this study also to correct discharges based on source head. They assumed $Q_j = Q_{jreq}$ when H_{sj} is greater than H_{sjdes} In this paper Q_j is assumed to increase with H_{sj} beyond Q_{jreq} also. An iterative procedure is developed where nodal discharges (Q_j) are corrected based on source head.

$$Q_{jnew} = \left((H_s - H_{sjmin})/(H_{sjdes} - H_{sjmin}) \right)^{1/2} Q_{jold} \qquad (1)$$

To quantify the variations in node supply ratios, a new parameter Uniformity Coefficient (UC) is introduced. This is calculated using node supply ratios as given below.

Average supply ratio for the system (ASR) is calculated as mean of node supply ratios. Deviation in supply ratio of each node is taken as modulus of difference between ASR and supply ratio of that node. Average deviation (ADEV) is calculated from these deviations. Using Average deviation and average supply ratio Uniformity Coefficient is calculated from (2).

$$U.C. = 1 - (ADEV/ASR) \qquad (2)$$

When all the nodes have equal demand satisfaction, the value of UC would be one. The objective in design and operation of water supply systems should be to maintain the value of Uniformity Coefficient as one or Supply Ratio of each and every node should be more than one.

From the results it is observed that for given node elevations and demands UC mainly depends on layout of the network and diameters of pipes. Mere increase in diameter may not help in improving the uniformity of supply. This program is to be linked with some optimization tool to develop a network that is optimum in terms of uniform distribution of supply and cost. UC may be included as one of the criteria in the design of Water Distribution Networks.

REFERENCE:

Tanyimboh, T.T., Tabesh, M., and Burrows 2001 "Appraisal of source head methods for calculating reliability of water distribution networks" *J. Water Resour. Plng. and Mgmt.* ASCE 127(4), 206-213.