OVERCOMING PRESSURE DEFICIENCY IN SUNGAI RENGIT WATER DISTRIBUTION SYSTEM

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ABSTRACT: The increasing levels of urbanization and demand for water lead to problems such as insufficient discharge to meet the existing demand and low-pressure levels in the network. Thus, the decision and process for rehabilitation or upgrading of existing components to meet current and future demands constitute a subject of great interest. Improvements in a distribution system performance can be achieved through rehabilitation of some pipes or other components such as new pump, new balancing tank, etc to the existing network. The main purpose of this study is to analyze the problem of pressure deficiency in Sungai Rengit water distribution system area and propose some improvement measures for overall distribution network. The hydraulic model simulation software EPANET is used to perform hydraulic analysis for the water distribution system. Two model alternatives of hydraulic simulation have been developed to improve nodal pressures at the area concern. By proposed of new booster station at Kg. Bukit Pelali to re-booster water source from Felda Adela reservoir to Bukit Raja reservoir will be improved slightly the nodal pressure from 83% to 125% compared to proposed new pipeline from Bukit Gelugur to Sungai Rengit with 450mm ND (normal diameter) mild steel pipe for a distance about 5.1 km will improve of nodal pressure only from 40% to 58%. Accordingly, the study proposes to Johor Water Authority the several recommendations to improve hydraulic reliability for Sungai Rengit water distribution system.

Keyword – Distribution networks, Pressure, Demand, Simulation.

1.0 INTRODUCTION

A water distribution system consists of transmission, distribution and reticulation pipelines, balancing and service reservoirs and, where required, booster pumping stations. Transmission pipelines carry treated water from a treatment plant or a pumping station to a reservoir as well as treated water from a reservoir to another reservoir. Reticulation pipelines are the pipelines that distribute treated water within the water demand areas. Distribution pipelines are pipelines that distribute water to the reticulation pipeline from the service reservoir, a treatment plant or booster station. The main objective of a water distribution system is to supply potable water, at sufficient pressure and quantity, to the consumers.

2.0 PROBLEM STATEMENT

Recently, water from Adela 2 reservoir has not been sufficient to keep up the water level at Bukit Raja reservoir. In effect, the downstream area of Bukit Raja reservoir has experienced low water pressure especially during holiday seasons. SAJ Holdings Sdn Bhd (SAJHSB) which holds the water supply concession for State of Johor, has identified particularly from Sungai Rengit town to Sungai Kapal (Pengerang) area and from Sungai Rengit town to Teluk Ramunia area currently facing water shortage and low pressure. These problems need to be addresses as soon as possible and improvement measures be identified to overcome them. Currently, SAJHSB have no develop of any proper network model to analyze the existing data and information on the water distribution system. As temporary action, they used rezoning manner where the water in the distribution system are isolate by pipe by-pass to serve the area facing low pressure. But this method is not slightly improving the overall pressure in the water distribution system.
3.0 OBJECTIVE OF STUDY

Recently, water from Adela 2 reservoir has not been sufficient to keep up the water level at Bukit Raja reservoir. In effect, the down stream area of Bukit Raja reservoir has experienced low water pressure especially during holiday seasons. The main objective of this study is to analyze the problem of existing water flow distribution system in that area and propose some improvement measures for overall distribution network. In addition, this study will provide model simulation analysis of water distribution system from downstream of Bukit Lebam balancing reservoir to Bukit Raja service reservoir, Sungai Rengit, Kota Tinggi, Johor.

4.0 SCOPE OF STUDY

The study site is located at Sungai Rengit, Kota Tinggi, Johor. Bukit Raja service reservoir is main contributor of water supply to various areas, especially Sungai Rengit, Pengerang and Teluk Ramunia. Figure 1.1 shows the location of the study area. The study of water demand will be focussed on this area based on existing demand recorded by Johor water authority.

Adela 2 balancing reservoir is located at Felda Adela, Kota Tinggi. The tank with a capacity of 2.272ML receives water supply by pumping from Sening suction tank where by it receives water from Bukit Lebam balancing reservoir. Adela 2 reservoir then supplies water to Bukit Raja service reservoir of capacity 0.909ML. The existing pipeline from Adela 2 reservoir to Bukit Raja reservoir is through 450 mm diameter mild steel pipe with two tees off to Sebana Cove and Kg. Bukit Gelugur respectively. Figure 1.2 shows the cascade drawing of Kota Tinggi District, with supply from Sungai Lebam water treatment plant.

Figure 1.1: The Location of Study Area
5.0 LITERATURE REVIEW

5.1 Water Distribution System

Water distribution system consists of transmission, distribution and reticulation pipelines, balancing and service reservoir and, where required, booster pumping stations. Transmission pipeline are carry treated water from a treatment plant or a pumping station to a reservoir as well as treated water from a reservoir to another reservoir. Reticulation pipelines are the pipelines that distribute treated water within the water demand area. Distribution pipelines are pipelines that distribute water to the reticulation pipeline from the service reservoir, a treatment plant or booster station. The objective of a water distribution system is to supply potable water, at sufficient pressure and quantity, to customers.

5.2 Design Of Distribution Network

Water distribution system function to move water from treatment plants to homes, offices, industries, and other consumers. The major components of a water distribution system are pipelines, pumps, storage facilities, valves and meters. The primary requirements of a distribution system are to supply each customer with a sufficient volume of water at adequate pressure, to deliver safe water that satisfies the quality expectations of customers, and to have sufficient capacity and reserve storage for fire protection and emergency conditions. In analyzing a water supply distribution and networks, it is very important to obtain the most accurate analysis possible within the constraints imposed by time, future water demand and cost. Two formulas widely used to calculate flow in pipes are the Hazen-Williams equation and the Colebrook-White formula.

5.3 EPANET Network Model

In order to quantify water distribution system reliability, hydraulic simulation of the system is required. Several commercial simulation models are available, but in this study EPANET will be used to perform hydraulic simulation. It was selected because it fulfills the requirement of calculating nodal pressures, and also its source code is available free of cost in the public domain, and can be applied to large water distribution networks with unlimited pipe numbers. EPANET uses the same numerical engines as WaterCAD® (2001) and other commercially available software and therefore results of hydraulic simulation obtained from them are expected to be similar. Although it lack features such as links to SCADA systems and GIS, for ordinary hydraulic modeling it is suitable to use EPANET.

6.0 RESULTS, ANALYSIS AND DISCUSSION

Input data for downstream Bukit Lebam area was collected from existing district metering zone (DMZ) provided by the water utility (SAJHSB) that will use for develop the water distribution system model. Geographic condition of the model network were determined using GPS equipment provide by water utility to obtain land surface elevation data for each district metering zone (DMZ).
6.1 Existing Model Simulation

From existing pressure simulation result as shown in Figure 5.31, 5.32 and 5.33, the typical day for node 33, 38 and 41, water used is lowest at night between 12.00 a.m to 5.00 a.m. Water use rises rapidly in the morning from 5.00 a.m to 8.00 a.m followed by moderate usage through midday 12.00 p.m to 2.00 p.m. Use the increases in the evening approximately from 5.00 p.m to 8.00 p.m and drops rather quickly around 9.00 p.m. Some locations may not have the sufficient pressure. Pressure dropped below a reference level setup by water utility, so-called reference pressure for supplying 100% of desired demand or reference demand. Every junction pressure are affected by fluctuate water demand especially at peak hour. For instance based on existing model simulation for node 38, the nodal demand is met at the range pressure of 12 meter head, as shown in Figure 5.34. It is noticed that any of the pipes along the critical segment is out of service, it will cause a dramatic pressure drop. Under peak-demand conditions, the area of node 33 (Teluk Ramunia), node 38 (Sungai Rengit) and node 41 (Sungai Kapal) having the problem of low pressure as modelled.

![Figure 5.31: Existing Pressure Simulation for Node 33 (Teluk Ramunia)](image)

![Figure 5.32: Existing Pressure Simulation for Node 38 (Sungai Rengit)](image)
6.2 Alternatives Approach

To overcome the problem of water deficiency pressure, two alternatives method had been proposed to improve water distribution system for downstream Bukit Lebam reservoir. The alternatives had been modelled are:

a. Proposed new pipeline from Bukit Gelugur (node 25) to Sungai Rengit (node 29) with 450mm ND (normal diameter) mild steel pipe for a distance about 5.1 km.

b. Proposed new booster station at Kg. Bukit Pelali to re-booster water source from Felda Adela reservoir to Bukit Raja reservoir.

6.3 Comparison Result Between Alternative 1 and 2

By comparing the reliability pressure between alternative 1 and 2 as shown in Figure 5.44, 5.45 and 5.46, it is observed that pressure for downstream Bukit Raja reservoir area are continuously improve by alternative 2 especially at peak demand between 6.00 a.m to 12.00 p.m and 6.00 p.m to 10.30 p.m. Pressure in the distribution system (downstream Bukit Raja reservoir) are maintained over than 20 meters due to sufficient pressure to keep up the water level at Bukit Raja reservoir as shown in Figure 5.43. This is most critical hours where the existing pressure for downstream Bukit Raja reservoir always facing pressure deficiency and not complies with minimum water utility pressure requirement (SAJ Holdings Sdn Bhd) due to peak demand.
Figure 5.44: Model Comparison (Alternative 1 & 2) Pressure Simulation for Node 33

Figure 5.45: Model Comparison (Alternative 1 & 2) Pressure Simulation for Node 38

Figure 5.46: Model Comparison (Alternative 1 & 2) Pressure Simulation for Node 41
7.0 CONCLUSION

The main purpose of this research was to calculate the hydraulic analysis simulation of a water distribution system from Bukit Lebam balancing reservoir to Bukit Raja service reservoir which requires extensive improvement in order to overcome pressure deficiency problem at Sungai Rengit water distribution system. Based on comparison data as shown in Figure 5.44, 5.45 and 5.46 in Chapter 5, installation of booster station at Bukit Pelali will fulfil the minimum pressure head requirements at all the junctions of the network so that consumers can meet their adequate pressure at all time.

After performing the hydraulic simulation of Sungai Rengit water distribution system, it was found that the main cause of low pressure in the network are increasing levels of demand and the failure of main pipes which are connected directly to the reservoirs and tanks. Therefore, in order to improve the reliability it is necessary to provide precautionary measures by providing alternative pipes leading to the sources so that in case of failure these alternate pipes could be used immediately. It is also suggested to properly maintain the pipes which are directly connected to the reservoirs and tanks and if necessary they should be replaced.

The results of this study can contribute greatly in assessing the hydraulic analysis of water distribution methods by two different approaches i.e to predict pressure deficiency at all time due to some modification in the water distribution system. In addition, it will help the Water Authorities, to set guidelines for establishing reliability levels with respect to the pressure head requirements of the consumers that would be useful for satisfying the water requirements of the consumers, as presently there are no proper guidelines available in the literature to establish the reliability levels.
Figure 1.2: Cascade Drawing of Kota Tinggi District, Supply from Sungai Lebam Water Treatment Plant.
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