A Case study on Water Supply Network in Ward No.17 of Belagavi City.

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Abstract -- **A reliable supply of clean, fresh and safe water is the most critical municipal service that people require. Many people use multiple sources of water. Some will prefer certain sources for drinking water and others for laundry, bathing, watering animals and irrigation. Belagavi district is the fourth largest district in Karnataka and has an average rainfall of about 808 mm usually with a substantial water table. As per the 2011 census, population of Belagavi is about six lakhs and contain 58 wards in total. Ward No. 17 has the population of 10,176 according to the 2011 census obtained from the city municipal commission. The number of houses in this ward is 1650. The people living in this area are middle class people. Present study focuses on water supply pipeline network and head loss in the selected study area. For the determination of head loss, ward No. 17 is divided into three areas: represented as area 1, area 2 and area 3. Total head loss through existing pipeline network in area 1 is 1.788m, similarly area 2 and area 3 has a head loss of 1.355 m and 1.258 m respectively. The existing pipeline network for the selected area is not autonomous, i.e. the pipelines are designed and laid including the demand for neighboring areas.**

I. INTRODUCTION

A reliable supply of clean, fresh and safe water is the most critical municipal service that people require. Developing countries have made great strides in addressing the inadequacy of past provisions for supply of water. Unfortunately the focus on expanding new service provisions is made at the cost of inadequate operation and maintenance. This has resulted in increased levels of losses due to leakage and non-revenue of water. Proper operation and maintenance are indispensable to ensure that capital investment on new infrastructure results in sustainable service provision. Without this, a new water distribution system will soon decline to a point where service provision is compromised, leading to greater financial, water losses and also health risk to consumers. If there is no proper operation and maintenance for a longer duration, there might become a need to change the entire water supply network [1].

Many people use multiple sources of water. Some will prefer certain sources for drinking water and others for laundry, bathing, watering animals and irrigation. Wherever a hazard or the potential for distribution of the water supply, exists, the primary health-care workers or other development personnel should discuss alternative drinking-water sources with the people concerned. Depending on the economic base of the community or neighborhood concerned, the discussion may go on to consider the provision of alternative or reserve water for livestock, small-scale industry or irrigation; however, the first priority should always be water for drinking, cooking and personal hygiene[2].

Belagavi district is the fourth largest district in Karnataka and has an average rainfall of about 808 mm usually with a substantial water table. As per the 2011 census, population of Belagavi is about six lakhs and contains 58 wards in total. Ward No. 17 is selected for the present study and it covers approximately five percent of Belagavi city area. Population in the selected ward is 10,176 and it includes residential area and defense land.

Figure 1 Location of Belagavi in Karnataka and India

II. MATERIALS AND METHEDOLOGY

Types of Water Pipeline Networks

There are mainly 2 types

- Branched configuration
- Looped (grid) configuration

Branched Network

Branched networks are predominantly used for small-capacity community supplies delivering the water mostly through public standpipes and having few house connections, if any. Although adequate, having in mind simplicity and acceptable investment costs, branched networks have some disadvantages

- Low reliability, which affects all users located downstream of any breakdown in the system.
- Danger of contamination caused by the possibility that a large part of network will be without water during irregular situations.
- Accumulation of sediments, due to stagnation of the water at the system ends ("dead" ends) occasionally resulting in taste and odour problems.
- Fluctuating water demand producing rather large pressure variations.

Branched systems are easy to design. The direction of the water flow and the flow rates can readily be determined for all pipes. This is different in looped distribution networks, where consumers can be supplied from more than one direction. Looped networks greatly improve the hydraulics of the distribution system. This is of major importance in the event that one of the mains is out of operation for cleaning or repair[2].

Looped Network

A looped network usually has a skeleton of secondary mains that can also be in a form of branch, one loop ('ring'), or a number of loops. From there, the water is conveyed towards the distribution pipes and further to the consumers. The secondary mains are connected to one or more loops or rings. The network in large (urban) distribution systems will be much more complex; essentially a combination of loops and branches with lots of interconnected pipes that requires many valves and special parts. To save on equipment costs, over-crossing pipes that are not interconnected may be used but at the cost of reduced reliability[2].

Figure 2 Branched Network

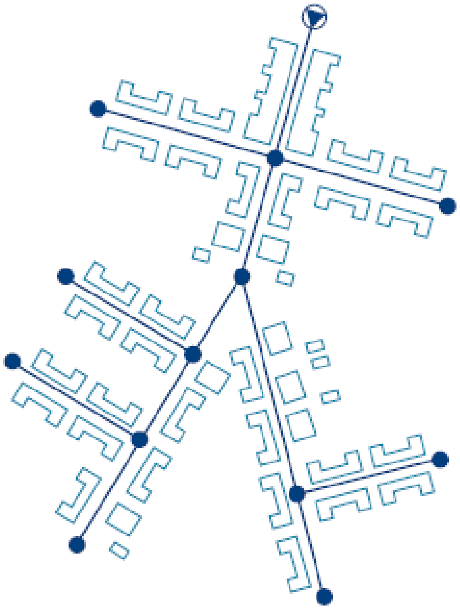
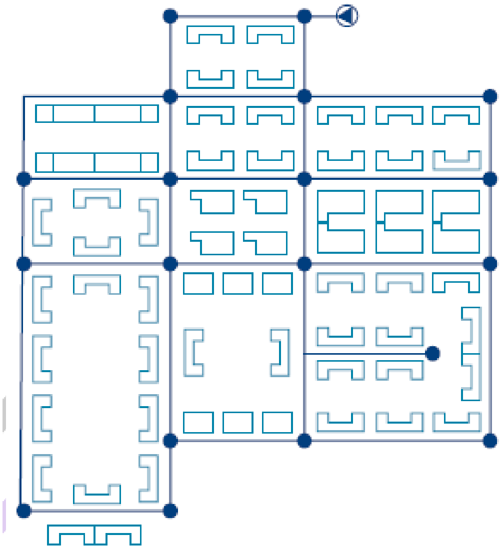


Figure 3 Looped Networks



Losses in Pipe

It is often necessary to determine the head loss, h_L, that occur in a pipe flow so that the energy equation, can be used in the analysis of pipe flow problems. The overall head loss for the pipe system consists of the head loss due to viscous effects in the straight pipes, termed the major loss and denoted $h_{L\text{-major}}$.
The head loss in various pipe components, termed the minor loss and denoted $h_{L\text{-minor}}$. i.e.

$$h_L = h_{L\text{-major}} + h_{L\text{-minor}}$$

The head loss designations of "major" and "minor" do not necessarily reflect the relative importance of each type of loss.
For a pipe system that contains many components and a relatively short length of pipe, the minor loss may actually be larger than the major loss [4].

Major Losses

The head loss, $h_{L\text{-major}}$ is given as ;

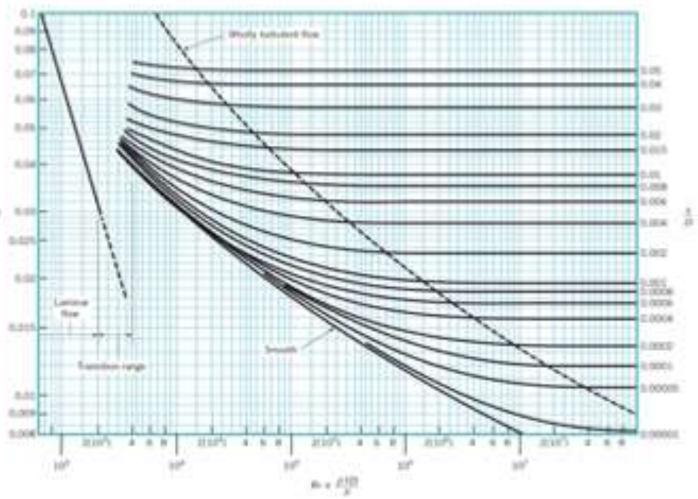
$$HL = \frac{f * L * v^2}{2 * g * d}$$

where *f* is friction factor.
Above mention equation is called the *Darcy-Weisbach* equation. It is valid for any fully developed, steady, incompressible pipe flow, whether the pipe is horizontal or on hill
Friction factor for laminar flow is:

$$f = \frac{64}{\mathrm{Re}}$$

Friction factor for turbulent flow is based on *Moody* chart.
It is because, in turbulent flow, Reynolds number and relative roughness influence the friction.
Reynolds number,

$$Re = \frac{\rho * V * D}{\mu}$$



The *Moody* chart is universally valid for all steady, fully developed, incompressible pipe flows.

Minor Losses

The additional components such as valves and bend add to the overall head loss of the system, which is turn alters the losses associated with the flow through the valves.
Minor losses termed as:

$$HL = KL\frac{V^2}{2g}$$

where *KL* is the loss coefficient.
Each geometry of pipe entrance has an associated loss coefficient.
Entrance flow conditions and loss coefficient.

Figure 4 Entrance flow conditions

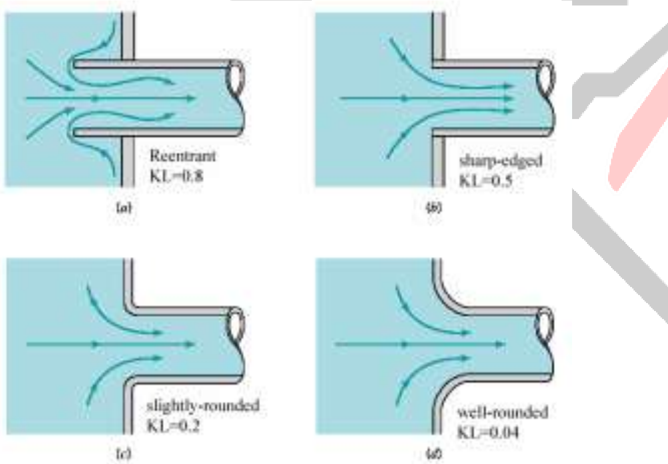
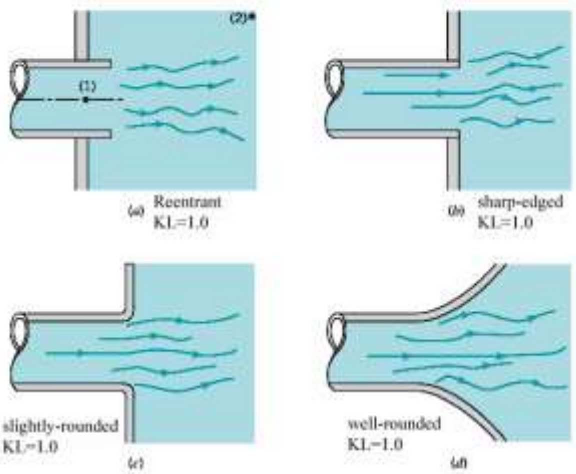


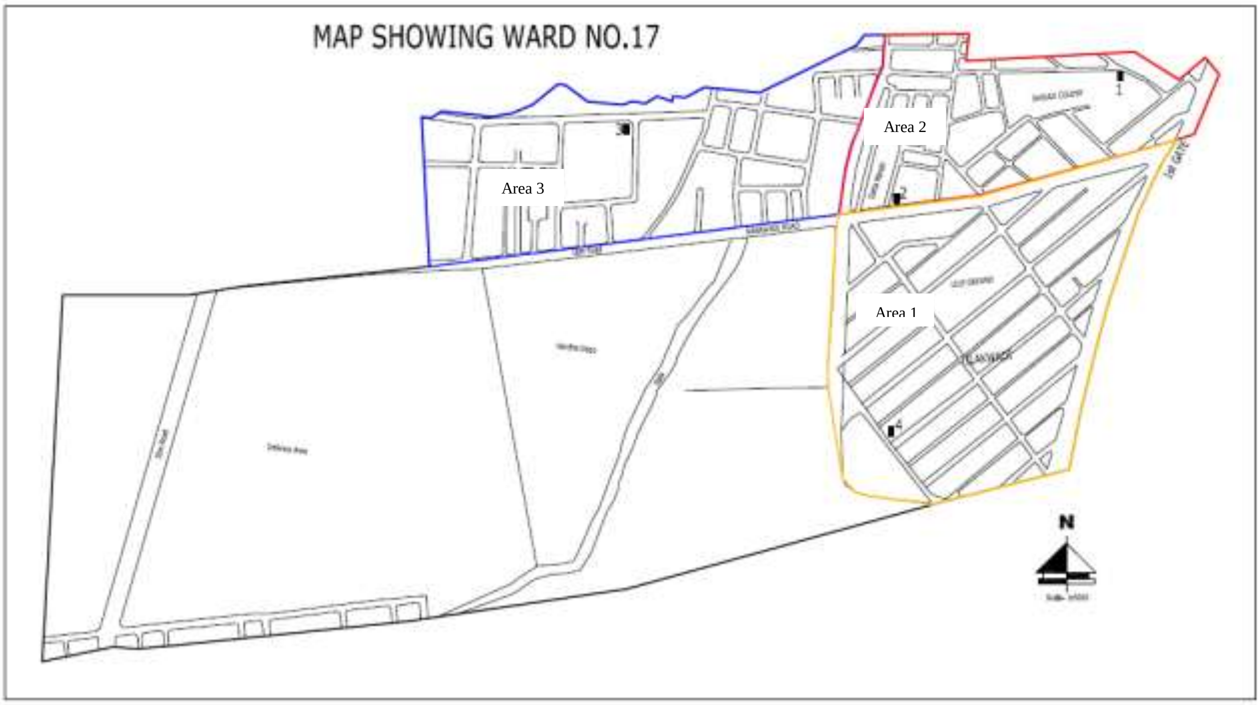
Figure 5 Exit flow conditions



III. RESULTS AND DISCUSSION

Out of the 58 wards from the Belagavi city the ward taken under the consideration for the case study is the ward no-17. It consists mainly five percent of the Belagavi's area. It has the population of 10,176 according to the 2011 census obtained from the city municipal commission. The number of houses in this ward is 1650.The people leaving in this area are middle class people.
The map shows the detailed plan for the selected area for study. Four houses were selected for the determination of discharge from outlets. The positions of the houses are selected in such a way that, it gives a representative values for the entire area. The selected houses are represented as House No.1: S.P. Hosmani, House No.2: M.K. Patil, House No.3: A.S. Taware and House No.4: S.K. Desai.

Figure 6 Map of ward No. 17



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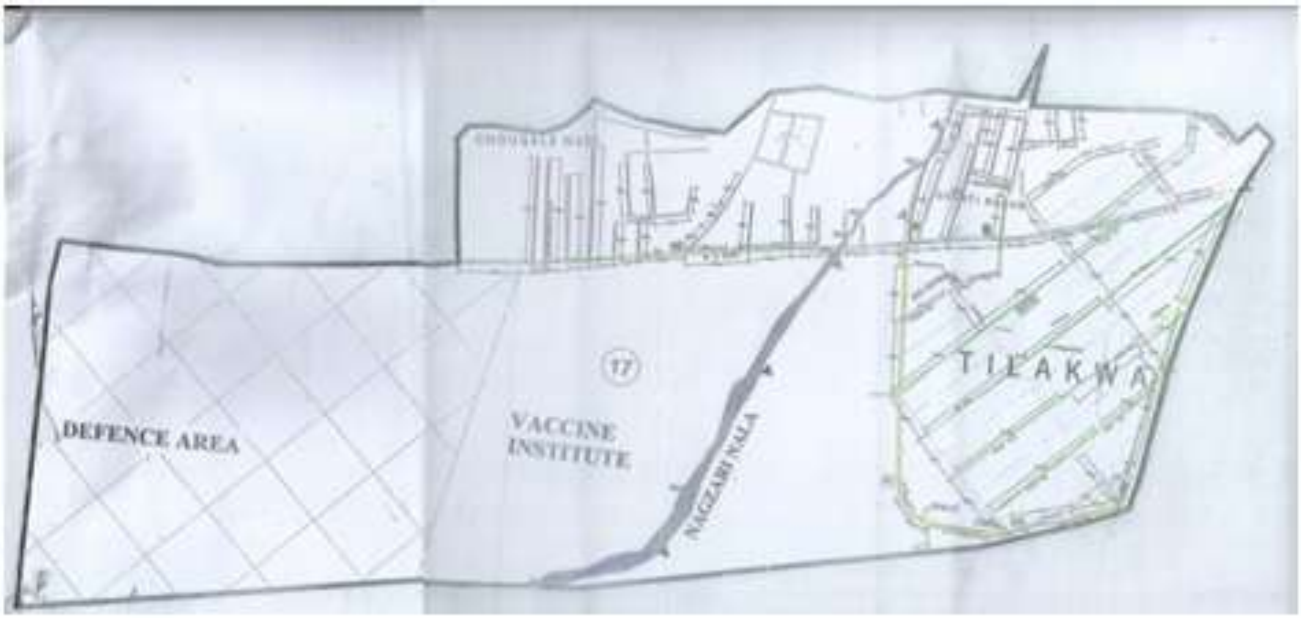

The discharge was recorded after 30min interval and the average value for the supply period is recorded as follows:

Table 1 Details of the Discharge determination

Sl. No.	House No.	Date of discharge determination (l/sec)		
		25.03.2016	30.03.2016	05.04.2016
1.	House No.1	0.322	0.323	0.293
2.	House No.2	0.280	0.289	0.274
3.	House No.3	0.235	0.165	0.241
4.	House No.4	0.163	0.165	0.159
	Average Discharge	0.252	0.252	0.241

From the above table

Total Average = (0.252+0.252+0.241) / 3

= 0.248 l/sec

Average population in house is 5 so

Q = 0.248/5

Q = 0.0496 l/sec

Total discharge for the selected area

Q = 0.0496*10176 (Population)

Q = 504.729 liters per sec

Q = 0.504 m^3/sec

1] To determine the Economical Diameter of the main pipeline

d = 0.98 to 1.22 √Q

d = 1.15 √0.504

d = 0.81 meter

2] To determine the Discharge Velocity

Q = A*V

A = π $(d/2)^2$

A = π $(0.81/2)^2$

A = 0.515m^2

V = Q/A

V = 0.504/0.515

V = 0.978 m/sec

Area wise calculation

1) Area 1

L_1= 497.48m, L_2 = 498.12m

Population of area 1 = 5270

$$Hf1 = \frac{f' * L * v^2}{2 * g * d}$$

$$Hf1 = \frac{0.025 * 497.48 * 0.978^2}{2 * 9.81 * 0.81}$$

$Hf1$=0.748 meter

Average population in house is 5, Hence

Q=0.236 l/sec per person

Total discharge for the selected area

Q = 0.000236 m^3/sec

Q =0.000236*5270

Q =1.243

Q =1.243/5

Q = 0.248 m^3/sec

1] To determine the Economical Diameter of the main pipeline

d =0.98 to 1.22 √Q

d =1.15 √0.248

d = 0.572 meter

2] To determine the Discharge Velocity

Q=A*V

A= π $(d/2)^2$

A= π $(0.572/2)^2$

A =0.256 m^2

V= Q/A

V=0.248/0.256

V=0.968 m/sec

$$Hf2 = \frac{f' * L2 * v2^2}{2 * g * d}$$

$$Hf2 = \frac{0.025 * 498.12 * 0.968^2}{2 * 9.81 * 0.572}$$

$Hf2$ =1.04 meter

Total head loss = Hf= Hf1+Hf2
= 0.748+1.04
Hf= 1.788 meter

2) Area 2

L_1= 497.48m, L_2 = 227.33m
Population of area 2 = 2378

$$Hf1 = \frac{f' * L * v^2}{2 * g * d}$$

$$Hf1 = \frac{0.025 * 497.48 * 0.978^2}{2 * 9.81 * 0.81}$$

$Hf1$=0.748 meter

Average population in house is 5 so
Q=0.312 l/sec per person
Total discharge for the selected area
Q = 0.000312 m³/sec
Q =0.000312*2378
Q =0.741 m³/sec
Q =0.741/5
Q = 0.148 m³/sec

1] To determine the Economical Diameter of the main pipeline
d =0.98 to 1.22 √Q
d =1.15 √0.148
d = 0.44 meter

2] To determine the Discharge Velocity
Q=A*V
A= π (d/2)²
A= π (0.44/2)²
A =0.154m²
V= Q/A
V=0.148/0.154
V=0.961 m/sec

$$Hf2 = \frac{f' * L2 * v2^2}{2 * g * d}$$

$$Hf2 = \frac{0.025 * 227.33 * 0.961^2}{2 * 9.81 * 0.44}$$

$Hf2$ = 0.607 meter

Total head loss = Hf= Hf1+Hf2
= 0.748 + 0.607
Hf= 1.355 meter

3) Area 3

L_1= 1256.767 m, L_2 = 185.10m
Population of area 2 = 2528

$$Hf1 = \frac{f' * L * v^2}{2 * g * d}$$

$$Hf1 = \frac{0.025 * 1256.767 * 0.978^2}{2 * 9.81 * 0.81}$$

$Hf1$= 1.890 meter

Average population in house is 5, Hence

Q=0.162 l/sec per person

Total discharge for the selected area

Q = 0.000162 m^3/sec

Q =0.000162*2528

Q =0.410

Q =0.410/5

Q = 0.082 m^3/sec

1] To determine the Economical Diameter of the main pipeline

d =0.98 to 1.22 √Q

d =1.15 √0.082

d = 0.329 meter

2] To determine the Discharge Velocity

Q=A*V

A= π $(d/2)^2$

A= π $(0.329/2)^2$

A =0.085m^2

V= Q/A

V=0.082/0.085

V=0.964 m/sec

$$Hf2 = \frac{f' * L2 * v2^2}{2 * g * d}$$

$$Hf2 = \frac{0.025 * 185.10 * 0.964^2}{2 * 9.81 * 0.329}$$

$Hf2$ = 0.666 meter

Total head loss = Hf= Hf1+Hf2

= 1.890 + 0.666

Hf = 1.258 meter

IV. CONCLUSION

Total population of ward No. 17 is 10176 and it is a area comprising of residential area and defense land. As per the observations made during the study it is clear that, as the lateral waterlines move away from the main line, head loss increases and intern the discharge varies. It is evident from the discharge calculated from the selected houses. House No. 1 has an average discharge of 0.312 l/sec, House No. 2 has an average discharge of 0.281 l/sec, House No. 3 has an average discharge of 0.236 l/sec and House No. 4 has an average discharge of 0.162 l/sec. The existing pipeline network for the selected area is not autonomous, i.e. the pipelines are designed and laid including the demand for neighboring areas. The diameters of the existing pipelines vary from 80 mm to 110 mm. For the determination of head loss, ward No. 17 is divided into three areas: represented as area 1, area 2 and area 3. Total head loss through existing pipeline network in area 1 is 1.788m, similarly area 2 and area 3 has a head loss of 1.355m and 1.258m respectively.

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