Abdelhafid Bousouf University Center - Mila

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Drinking water supply

– Lesson 3 –

Chapter 03 : Drinking Water Distribution Network

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Course Objectives 3

This course aims to provide a thorough understanding of drinking water reservoirs, of their role in a water supply and distribution network, as well as design principles and management.

1. Understanding the role of drinking water reservoirs

- Ensure sufficient storage to meet water demand.
- Regulate pressure and compensate for variations in consumption.
- To serve as a backup in case of failure or incident in the network.
- Contribute to water resource management and energy cost reduction.

1. Introduction

The network is a key component of a drinking water supply system. From the reservoir(s), the water is distributed through a network of pipes to which connections are made to supply subscribers.

The network must have a sufficient diameter to ensure maximum flow with ground pressure compatible with the height of the buildings.

In a distribution network, the following conditions must always be checked:

• The Flow Rate

The most accurate possible estimate of the needs of the metropolitan area.

The hydraulic calculation of the pipelines is done using the peak flow rate.

The fire conditions must be verified. The fire flow rate to be anticipated at the most unfavorable point in the network is 60 m^3 /h (17 l/s). Multiple fires occurring simultaneously are taken into account in the case of a large city or in situations of high fire risk.

• Pressure

The networks must meet the following pressure conditions:

A minimum load of 10 m at the highest taps.

A maximum load of 60 m (limiting leakage and noise from water hammer).

If such pressure were to occur, pressure reducers or a staged network should be installed.

- The network must also be designed to provide the following ground pressures: 18 m for one floor, 22 m for two floors

26 m for 3 floors, 36 m for 5 floors, 40 m for 6 floors, 44 m for 7 floors, 31 m for 4 floors

For taller buildings, owners are forced to install in the basement floor of the booster pumps.

Pipelines equipped with fire hydrants must be able to provide a pressure greater than 10 m in the event of a fire.

• Diameter selection

In sections with fire hydrants: Dmin = 100mm

• Speed

Speeds below 0.50 m/s: promote solid deposits in pipes.
Speeds above 1.50: risk promoting leaks, water hammer, and creating cavitation and noises.

In case of fire, it can tolerate a speed of up to 2.5 m/s

- **The pressure**

The water pressure in the network should be in the range of 10 to 40 cubic meters of water. Pressure should be avoided Exceeding 40 cubic meters of water can cause problems (leaks in particular) and certain noises. unpleasant in subscribers' indoor facilities.

2. Classification of the drinking water supply network

Networks can be classified as follows:

2.1 Branched networks

The branched network in which the service conditions do not include any power supply On the return, it has the advantage of being economical, but it lacks security and flexibility in case of rupture. An accident on the main pipeline is cutting off service to downstream subscribers.

Water flows through the sections in only one direction: from the main pipes to the secondary conduits

Advantage: economical

Disadvantage: Lack of safety (in the event of a main pipe rupture, all subscribers located downstream will be deprived of water)

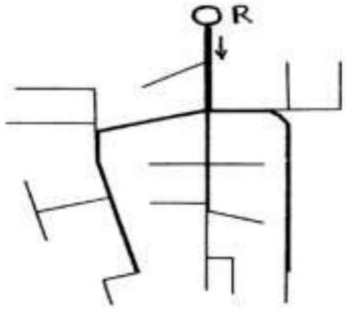


Fig. 3.1 Diagram of the branched network

2.2 Mesh networks

The mesh network, on the other hand, allows for feedback and therefore avoids the drawback of the branching network.

A simple valve operation allows the damaged section to be isolated. It is, of course, more While costly to set up, its security makes it preferable to the network. branched.

Drift of the branched network by connecting the ends of the pipes allowing a return power supply.

Advantage: Increased safety (in the event of a pipe rupture, it is sufficient to isolate it and all subscribers located downstream will be supplied by the other sections) with a more even distribution of pressure and flow rate.

Disadvantage: More expensive and more difficult to calculate.

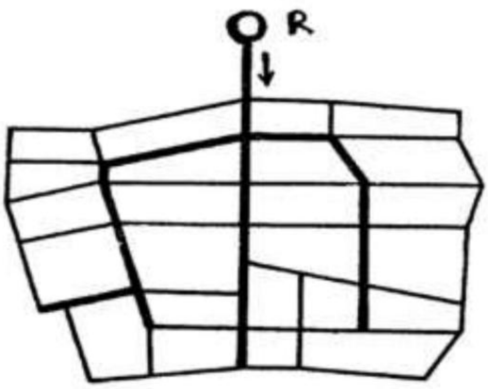


Fig. 3.2. Diagram of the mesh network.

2.3 Mixed networks

This diagram contains two networks: a branched network and a mesh network. This diagram is often chosen for its advantages as an economy and for its safety.

A mixed network is calculated after separating the network into two networks, one branched and the other meshed. is calculated separately for each one.

2.4 Tiered Network

The stepped network is characterized by very significant differences in elevation. This makes the Water distribution from the reservoir results in high pressures at the lowest points (standards of pressures are not respected). Indeed, these systems require the installation of a tank intermediate, supplied by the first which allows to regulate the pressure in the network.

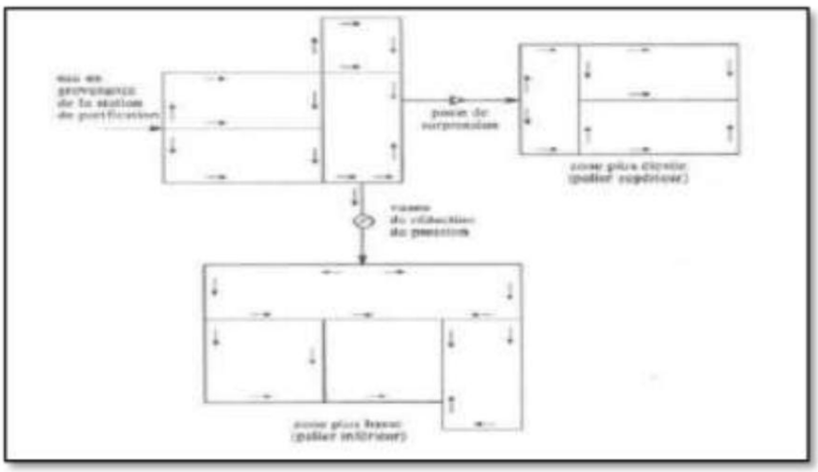


Fig.3.3. Diagram of the tiered network.

Generally, a **mesh network** is used to supply **an urban area** and a **branched network** to supply **a rural area.**

The choice of the type of consumption network depends on:

- Master urban development plan for the metropolitan area (PWD).
- Master plan of the urban area.
- The position of large consumers.

Node = meeting point of several pipes

Section = portion of pipe between two successive nodes

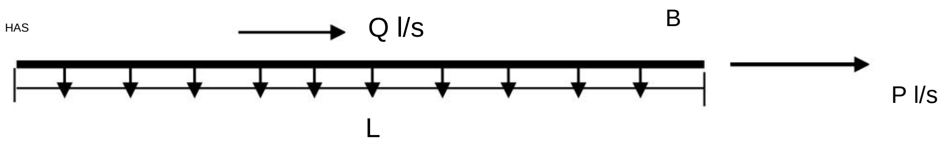
3. Hydraulic calculation of the branched network

When it comes to the branched network, the pipe, in addition to an end flow rate, must be able to distribute water to subscribers along its route via the numerous connections attached to it:

That's the flow rate in progress.

The throughput is calculated based on the number of users to be served at peak times. and assuming this flow is evenly distributed along the street.

Indeed, Q is the flow rate thus distributed along a pipe AB of length L, in thus admitting that it must, on the one hand, distribute a uniform flow rate along its path, and on the other hand ensure a flow rate P at its end.



Furthermore, the flow rate of the pipe is calculated using the following formula:

$$q = P + 0.55\,Q$$

With :

q: flow rate of the section.

P: downstream flow rate.

Q: flow rate in transit.

Example :

The ABC section, which is supplied in the AC direction, provides en route services with flow rates Ask: Q = 20 l/s, P = 13 l/s, and are respectively the needs of sections AB and BC. What are What are the proposed flow rates for calculating sections AB and BC?

Section BC: $q = P + 0.55\,Q = 0 + 0.55 * 13 = 7.15\ l/s$

Section AB: $q = P + 0.55\,Q = 13 + 0.55 * 20 = 24\ l/s$

3.1 Determine the specific flow rate

There are three methods for determining this flow rate:

a- Length method:

$$Q_{sp} = \frac{Q'}{\sum L} \text{ With } Q' = Q_p - Q_{éq}$$

With :

Qsp : the specific flow rate.

Qp : the peak flow rate.

Qéq : the flow rate of the equipment.

ÿL : the sum of the lengths of the network.

SO : $$le\ débit\ de\ route = Q_{sp} L_i + Q_{éq}$$

b- Surface method:

$$Q_{sp} = \frac{Q'}{S_t}$$

St : total area.

If : surface corresponds to segment i

SO : $$le\ débit\ de\ route = Q_{sp} S_i + Q_{éq}$$

c- Method based on population:

$$Q_{sp} = \frac{Q'}{N_p}$$

Np: number of inhabitants.
If : number of inhabitants who are connected to section i

SO : $$le\ débit\ de\ route = Q_{sp} N_{pi} + Q_{éq}$$

4. Hydraulic calculation of the meshed network

The calculation of a meshed network is carried out by successive approximations according to the method of HARDY CROSS.

This method is based on the following two laws:

First law : at any node of pipes, the sum of the flow rates arriving at that node is equal to the sum of the flows that leave it.

$$\sum Q\ entre = \sum Q\ sort$$

2nd law: the log of a directed and closed path, the algebraic sum **of** the head losses is zero.

$$\sum \Delta H = 0$$

4.1 Principle of the HARDY CROSS method

The HARDY CROSS method consists of:

We choose a direction for the water to flow.

Distribution of flow rates in order to satisfy the 1st law.

In each mesh, the law of pressure losses is applicable according to the 2nd law.

Ordinarily, this equality is not verified on the first try and it is necessary to modify the Initial assumed distribution of flow rates according to the following formula:

$$Q_1 = Q_0 + \Delta Q_0$$

With :

Q1 : corrected flow rate.

Q0 : assumed flow rate.

ÿQ0 : the corrective flow rate, it is calculated using the following formula:

$$\Delta Q = -\frac{\sum \Delta H}{2 \sum \frac{\Delta H}{Q}}$$

ÿÿH: the algebraic sum of the pressure losses in a mesh

ÿÿH/Q: the sum of the percentage of pressure loss of each segment of the mesh relative to at the flow rate of this section.

The pressure losses are proportional to the square of the flow rates, so we can write:

$$\Delta Q = -\frac{\sum r\, Q^2}{2 \sum r\, Q}$$

With : $\Delta H = J\, L = \frac{\lambda\, V^2}{2\, g\, D}\, L = \frac{8\, \lambda\, Q^2}{\pi^2\, g\, D^5}\, L = r\, Q^2$

r: the resistance of the pipe over the length L (L equivalent length).

Each mesh is calculated separately; the corrections made to the flow rates are of two types:

Correction specific to the mesh considered with the sign ÿQ.

Correction specific to the adjacent mesh with the appositive sign of ÿQ.

4.2 Calculation of nodal flow rates

There are several methods for calculating nodal flow rates:

4.2.1 Length Method

The nodal flow rate of a node is given by the following formula:

$$Q_n = \frac{\sum Q_{tri}}{2} = \frac{\sum(q_{sp} L_{tr(i)} + Q_{moy\ j\ maj\ équipement})}{2}$$

With :

Qn : flow rate of node (i) l/s.

qsp : the specific flow rate (calculated by the length method) (l/s/ml).

ÿLtri/2 : the sum of half the lengths of the segment connected to the node (m).

Qmoy j equipment : the flow rates of equipment connected to node (i) (l/s).

This method is not precise because sometimes a very long pipeline and the number of inhabitants

The length of the connected section is small. Therefore, in the calculation, we use equivalent lengths instead of the length.

real by introducing equivalent coefficients (C).

Table 3 – 6: Values of the equivalent coefficient C.

Type of operation of the section	Geometric length Lg	Equivalent coefficient	Equivalent length Leq
Building on both sides of the section	LG	2	2 Lg
House on both sides of the section	LG	1.5	1.5 Lg
The distribution on only one side of the section	LG	1	1 Lg
The houses are at the end of the section	LG	0.5	0.5 Lg
No house on the log section	LG	0	Lg **0**

4.2.2 Surface Method

The principle of this method is to divide the total surface into partial surfaces, each of them surrounded by a knot.

$$Q_n = \frac{\sum Q_{tri}}{2} = \frac{\sum(q_{sp} S_i + Q_{moy\ j\ maj\ équipement})}{2}$$

With :

Qn : flow rate of node (i) l/s.

qsp : the specific flow rate (calculated by the surface area method) (l/s/ha).

If : the area occupied by node (i) (ha)

Qmoy j equipment : the flow rates of equipment connected to node (i) (l/s).

The drawback of this formula is that it does not take into account the distribution of inhabitants across the total surface area, one can have a large surface area node supplying water to a small number of inhabitants.

4.2.3 Method based on population size

This is the most accurate method compared to other methods.

$$Q_n = \frac{\sum Q_{tri}}{2} = \frac{\sum(q_{sp}N_{ptri} + Q_{moy\ j\ maj\ équipement})}{2}$$

With :

Qn : flow rate of node (i) l/s.

qsp : the specific flow rate (calculate per inhabitant) (l/s/inhabitant).

ÿLtri/2 : the sum of half the number of inhabitants connected to the node (hab).

Qmoy j equipment : the flow rates of equipment connected to node (i) (l/s).

Conclusion

Drinking water networks are essential to ensure reliable access to drinking water.

a combination of efficient management, infrastructure modernization and the use of

Advanced technologies are needed to improve their performance and meet current challenges.

related to sustainability and water quality.

Useful links

https://youtu.be/4imD-10lDIM

https://youtu.be/RKaFLdWCaKk

https://youtu.be/Zqk4YES0dKw

References

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