Abdelhafid Bousouf University Center - Mila

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Water distribution and collection:

PART II: Sanitation

– Lesson 2 –

Chapter 02 : *Design and sizing of sanitation networks.*

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Institute	**Department**	**Year**	**Speciality**
Science and Technology	GC and hydraulic	2nd year master	Urban hydraulics

Course Objectives 1

- Understand the principles of designing sanitation networks (rainwater and wastewater).

- Know the hydraulic and hydrological parameters necessary for sizing.

- Know how to apply technical standards and recommendations (project flow rates, speeds, slopes, sections).

- Be able to size a rainwater network based on rainfall project and watershed characteristics.

- Be able to size an urban wastewater network according to needs demographics and peak coefficients.

- Master the rules of safety, durability and maintenance in the design of networks.

Introduction

Sanitation is an essential element of urban planning and protection of public health. Sanitation networks ensure the evacuation and treatment of domestic wastewater as well as rainwater management in order to prevent flooding and limit environmental nuisances.

The design and sizing of these networks are based on principles rigorous hydraulic and hydrological, integrating both natural constraints (topography, rainfall, infiltration) and anthropogenic constraints (population density, urbanization, demographic evolution).

This chapter presents the calculation methods and practical rules for dimensioning rainwater and urban wastewater networks, taking into account current standards and local conditions.

II.1 Evaluation of domestic wastewater

The evacuation of wastewater flows mainly concerns the estimation of the quality of discharges liquids from homes and places of activity

II.1.1 Average penalty

• **1st method:** Domestic water constitutes a significant part of the flow to be evacuated, which

flow rate is calculated based on the average flow rate of drinking water.

$$=$$

With :

Qmoyeu: the average flow rate of wastewater.

QmoyAep : the average flow rate of drinking water.

K: coefficient which represents the percentage of consumed water which will be evacuated K = 70 – 80%.

• We take 70% QmoyAep in the case of a rural region.

• We take 80% QmoyAep in the case of an urban region.

The 20-30% represents losses of drinking water in pipes, infiltration, street washing,

watering the gardens….

The flow rate of drinking water is calculated by:

$$= \underline{\quad\quad} \qquad (ÿ)$$

With :

Cmoyj: average daily consumption.

d: the allocation (the water requirement for one inhabitant l/d/inhabitant).

Pf: population future.

•**2nd method:**

The wastewater flow rate can be estimated directly from the average wastewater production (d').

$$= \underline{\quad\quad} \qquad (ÿ)$$

With :

d' : average production of wastewater (l/day/inhabitant) it is given by the following table:

Table 1: Average wastewater production according to the number of inhabitants.

Number of inhabitants	d' (l/d/inhabitant)
>2000	100
2000 – 5000	115
5000 – 10.000	125
10.000 – 20.000	145
20.000 – 100.000	160
< 100.000	190

• **3rd method:**

If we do not have the number of inhabitants, we can use the concept of population density.

So the number of future inhabitants:

$$=$$

With :

d: density (inhabitant/housing/ha)

A: total surface area (ha)

II.1.2 Peak wastewater flow

The flow of wastewater is not constant, it varies according to the seasons, days, hours. For calculate the maximum flow rate passed through the sanitation network, it is therefore appropriate to allocate the flow rate average of a point coefficient.

$$=$$

Generally the peak coefficient is estimated by the relation:

$$= \quad . + \quad \frac{\qquad}{ÿ}$$

II.2 Water transport conditions

1. Speed limit conditions

In order to avoid deposits of solid materials on the one hand and to avoid degradation of the seals and abrasion of the pipes on the other hand, the speeds must be between the limit values suivantes : **0,30** m/ s **<V<4m/** s.

At low flow rates, a flow velocity must be ensured that prevents deposits. minimum to be retained, called *self-cleaning speed* must be:

-In the case of a unitary network, the speed equal to or greater than the sand entrainment speed or **0.6 m/s;** this condition is met for an evacuated flow rate equal to 1/10 of the full section flow rate Qps.

-Separate network where there is no rainwater flushing, the speed must be around **0.3 m/s** but ensuring a filling of **2/10D.**

2. The slope (installation conditions)

Self-cleaning conditions are often difficult to achieve in the upstream section where the flow rates are weak. We are then led to look for slopes (0.004 – 0.005), downstream we can admit slopes minimum (0.003 – 0.002)

3. Diameters

The minimum diameter is 300 mm in the case of unitary networks, while it is 200 mm in the case of separate networks.

4. Ventilation

The need to transport domestic effluents requires that the sewers be ventilated structures. This ventilation limits fermentation, the absence of O2 in the pipes causes the formation hydrogen sulfide and methane which decomposes and leads to corrosion of the concrete walls of the sewers.

II.3 Method for calculating a sanitation network

Before proceeding with the hydraulic calculation of the sanitation network, we consider the following assumptions:

1· The flow is uniform at free surface, the hydraulic gradient of pressure loss is equal to the slope of the raft;

2· The pressure loss generated is a potential energy equal to the difference in the plane dimensions of water upstream and downstream.

The flow in collectors is a free surface flow governed by the continuity formula:

$$=$$

With :

Q: flow rate carried m3 /s

V: flow velocity m/s

S: wet section m2

To calculate the flow velocity, the formula is used:

II.3.1 Formule de CHEZY

The formula for flow velocity given by **CHEZY** is:

$$= ÿ \quad \overline{\quad}$$

With :

V: Flow velocity in m/s

R: Hydraulic radius with R = S/P

S: wet section in m²

P: wetted perimeter in m

I: Slope of the structure in m/m

C: CHEZY coefficient we adopt that given by the BAZIN formula

$$= \frac{\quad}{+ \frac{}{\ddot{y}}} = \frac{\ddot{y}}{+ \ddot{y}}$$

ÿ: is a flow coefficient which varies according to the materials used and the nature of the water

transported

ÿ = 0.25 in the case of pipes transporting wastewater

ÿ = 0.46 in the case of pipes that transport rainwater.

II.3.2 MANNIN G STRICLER formula

$$= \quad \ddot{y}\,\ddot{y}$$

With :

K = Manning – Strickler coefficient depends on the roughness of the pipes K = (20 – 102)

Manning – Strickler proposed the relation for the CHEZY coefficient: C = K R1/6

II.3.3 Calculation of a separate wastewater network

The Bazin coefficient ÿ can be taken equal to **0.25.** C can therefore be represented

approximately by the expression:

$$\textbf{C=70.R}^{1/6}$$

Speed: = $\ddot{y}\,\ddot{y}$

The flow rate: = $\ddot{y}\,\ddot{y}$

II.3.4 Calculation of a separate rainwater network

It should be taken into account that deposits are likely to form, which leads to

admit a flow on semi-rough walls.

The Bazin coefficient ÿ can be taken as **0.46.** C can therefore be approximately represented by

the expression:

$$\textbf{C=60.R}^{1/4}$$

Speed: =   ÿ ÿ ÿ

The flow rate: =   ÿ

1) Calculation of a unitary and separate network

The hydraulic calculation of sanitation networks is based on the use of several charts

which are established by the formulas of MANNING STRICKLER or BAZIN *Abacus 4a and Abacus 5a.*

1. The diameter in (mm) is taken from the abacus **(4a);** depending on the flow rate and the slope.

Slope of the raft = $\dfrac{(\qquad)ÿ(\qquad)}{(\qquad)}$

2.   the full section speed (m/s); Calculated by the formula:

Vps=60R3/4 ÿI (separate rainwater network and combined network)

$$= ÿ\,ÿ \text{ (Separate wastewater network)}$$

With : *R=D/4*

3. Calculate the flow rate at full section:

$$=$$

With: S=ÿD2 /4

4. Calculation of the flow rate ratio (rQ)ÿ

$$= \underline{\quad}$$

5. Calculation of the height ratio (rH) deduced from the abacus **(5a).**

6. Filling height (m):

$$H = D * rH$$

7. Calculation of the speed ratio (rV). Deduced from the abacus **(5a).**

8. Flow velocity Ve:

$$Ve=rv*vps$$

9. Self-healing speed (m/s):

$$Worth = 0.6 \ Vps$$

If the self-cleaning conditions are not verified, c at dv 0.6 m/s; We can give the proposals

following to avoid these problems:

1. Changed the slope of the pipe and redo the calculation with the new slope.

2. Do not change the characteristics of these sections but introduce a specific management system

of these sections:

-Periodic cleaning of the manholes in these sections.

-Remove sediment surrounding the surface of the sections.

-Periodic hydro-cleaning, which allows cleaning or unblocking under water pressure.

II.4 Choice of materials and type of pipe

There are different types of pipes in the sanitation sector. Their choice depends on

of several factors, the main ones of which can be listed as follows:

• Nature of the water to be transported (corrosion, fouling);

• Volume of effluents;

• Quality of materials used and manufacturing methods;

• Location (under roadway or under sidewalk);

• Resistance to statistical and dynamic loads as well as internal pressure;

• Resistance to chemicals;

• Dimensional homogeneity;

• Slope of the land (speed and erosion);

• Nature of the subsoil (instability, corrosion, water ingress);

• Respect for the environment.

II.5 Design of a sanitation network

1. Choice of sanitation method

2. Choice of network type

3. Location of discharge points

4. Installation of treatment facilities

5. Network plan layout

6. Sizing

II.6 Factors influencing the design of the sanitation project

Natural data

• Rainfall

• Topography

• Hydrography

• Geology

Characteristics of the agglomeration

• Importance and nature

• Land use methods

• Sanitation already in place

• Future development of the agglomeration

Sanitation constraints

• Conditions for transporting wastewater

• Ease of operation

• Reduction of nuisances

II.7 Procedure

1. network layout plan

2. cutting into sections of approximately 300 m

3. delimitation of the watershed drained by each section

4. calculation of the peak flow generated by this basin

• peak wastewater flow rate

• peak rainwater flow

5. calculation of the dimensions of the pipeline according to its slope

6. plotting the longitudinal profile of the pipeline

7. Checking for proper operation

II.8 Elements of a sanitation network

1- the looks

These are reinforced concrete structures, they are watered on the ground equipped with a frame and a cover,

designed to withstand the thrust of the earth and that generated by the passage of rolling loads.

1.1-Type of look

a- Inspection window

The role of the inspection chamber is to ensure:

- sewer ventilation

- network access for cleaning equipment (See figure 01).

Figure 01. Inspection window

They are installed at:

- each change of direction

- each change in diameter

- distance between two successive views is 30 to 50 m, except in special cases.

b- Drop manholes: this type of manhole is very necessary in the case of very uneven terrain, they have the role of lowering steep slopes. (See figure 02).
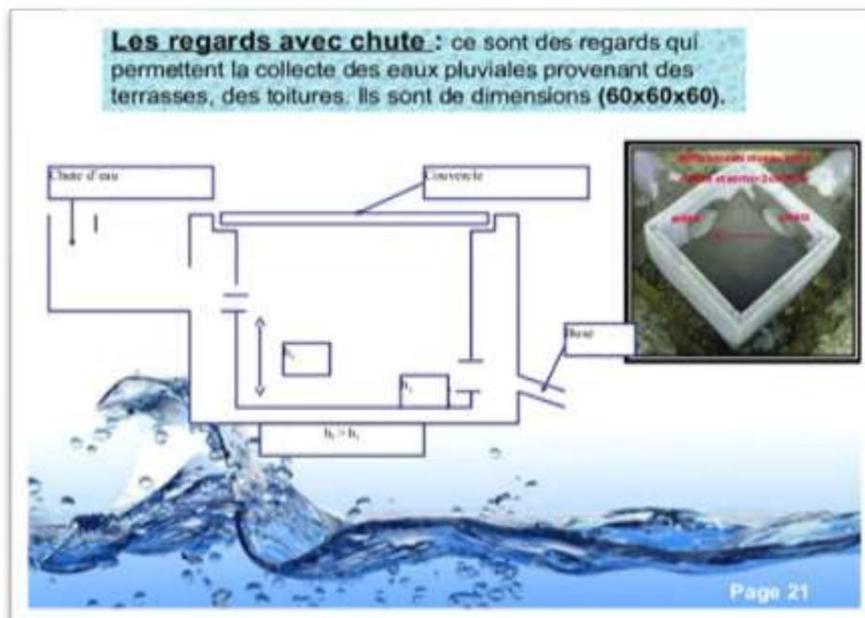

**Figure 02. Drop manhole**

c- Flush manhole: this type of manhole is installed at the network head to deal with waste, if the self-cleaning conditions are not verified.

d- the outlet: this is the last work delivered by the projector on plan. (See figure 01).

Figure 02. Water drainage in rural areas.

e- Connection inspection chamber: it provides a connection between the buildings' sanitary network and the network external sanitation. (See figure 03).
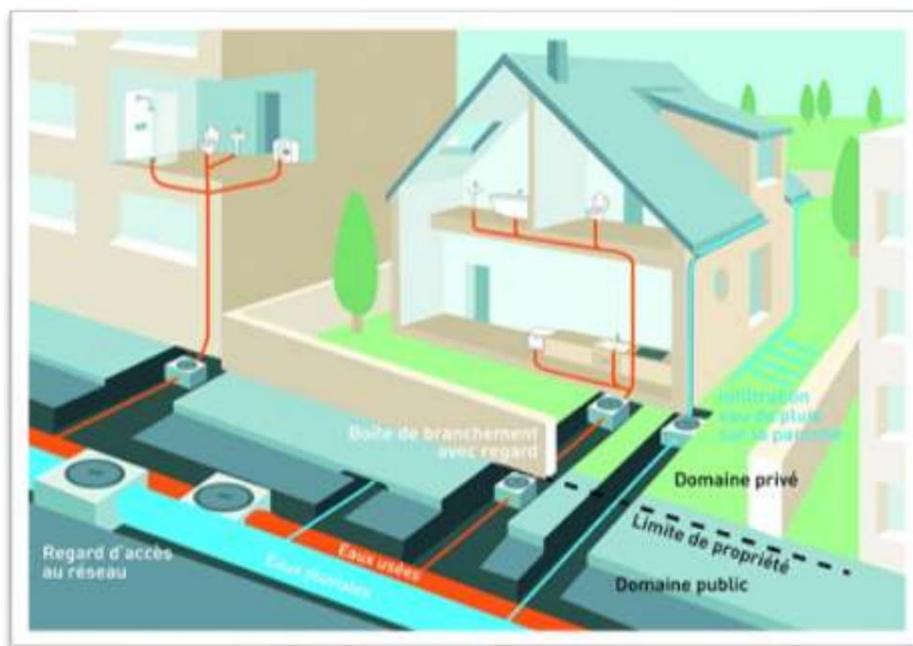
Figure 03. Connection view

f- Drainage manhole (sewer inlet): these are ancillary structures intended to collect water from surface runoff (rain, washing of roads, parking lots, sidewalks, etc.) and to channel them

to the sewer through a pipe, they are installed laterally, it is essential to clean them

after each storm, they can be: grid – selective – filtering. (See figure 01).

Figure 04. Inlet manhole.

2- the pipes

In sanitation, pipes are intended to carry flows to

free surface up to the main collector, we notice the existence of two most common types

used.

a- **circular pipes:** these are the most used, given their simplicity of manufacture and execution. (See figure 04).

Figure 04. Circular pipe.

b- **Ovoid pipes:** prefabricated concrete ovotides, their useful length is at least 1

m, they are joined with a mid-thickness interlock, it facilitates the flow of flows

important. (See figure 01).

Figure 05. Ovoid conduits.

c- **Nature of the pipes:** the choice of materials depends on:

- the nature of the ground

- the chemical nature of the fluid to be evacuated

- its availability on the market and the cost

- resistance under the effect of external loads

3. the joints

They constitute the weak points of the network, they must necessarily and imperatively

meet the technical requirements:

- waterproofness and flexibility

- resistance to hydraulic pressure and effluent attacks

- be protected from attack by plant roots.

For this, we chose cement mortar to make the joints so that they fit

the cement nozzle and for its ease of production and its availability.

4. The spillways

According to the encyclopedia of sanitation, a Storm Overflow (SO) is a "structure allowing

the direct discharge of part of the effluent into the natural environment, when the upstream flow exceeds a certain

value. Storm overflows are generally installed on combined networks, in order to limit

contributions to the downstream network, and in particular the treatment plants, in the event of rain."

Storm overflows help to reduce the load on treatment plants, but on the other hand

On the other hand, they discharge a large quantity of polluting materials from wastewater into the environment

natural in rainy weather.

The calculation of storm overflows relates to:

• At the gallery itself

• At the spill threshold, the level of which determines the operation of the structure.

The gallery must be calculated to be able to carry all of the upstream flows. (See figure 06).
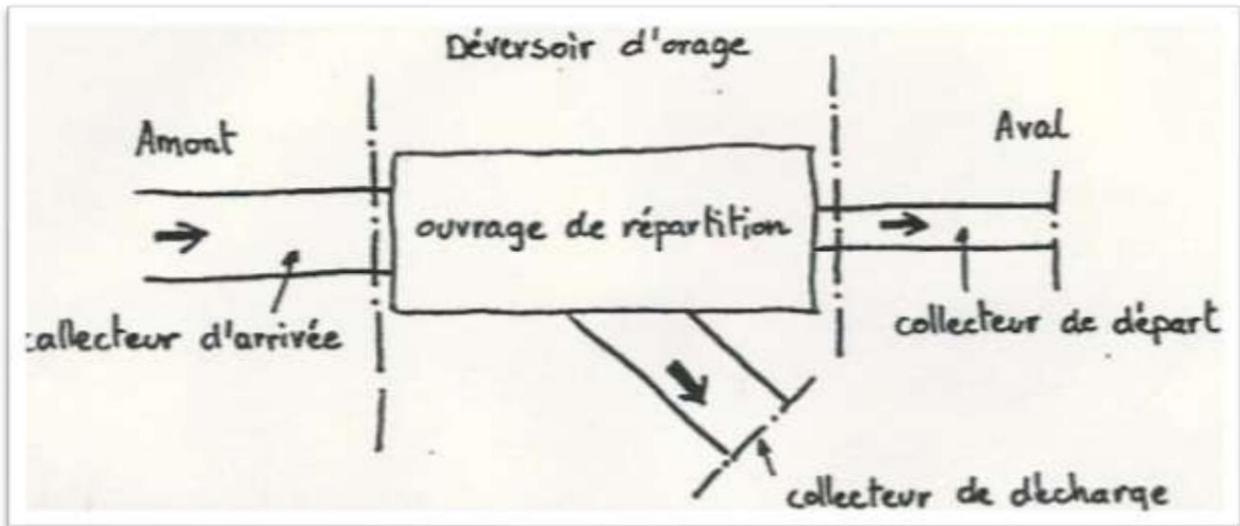

Figure 06. Storm overflow.

5. Retention basins

Retention basins are used when the aim is to reduce the dimensions of the collectors projected downstream by spreading the peak flows over a time imposed by the conditions downstream flow. (See figure 07).

Natural depressions can be used as retention basins, if they are re-lined with sewerage network for the evacuation of runoff flows stored for a certain period time in depression.

These basins are made up of a basin body and a downstream structure made up of a threshold discharge which can be an overflow or an orifice.

Figure 08. Retention basins.

6. Low-point siphons

Their role is to overcome an obstacle at a level higher or lower than that of the main collector. An obstacle can be a watercourse, a canal, a road, a tunnel, a railway track, a trench or a large pipe. (See figure 09).

Figure 09. Low point siphons.

II.9 Execution of the trench and laying of the pipeline

The width of the trench must be at least equal to the outside diameter of the pipe with over-widths of 0.3 m on one side and on the other, if the nature of the joints makes it necessary, their operation must be facilitated by the construction of niches in the bottom and in the walls of the trenches.

The bottom of the trench is normally watered at least 0.1 m above the planned level for the wire water, the laying bed must be made of fine sand.

The pipes must be laid from downstream, the socket, if any, being directed upstream, the temporary wedging of the pipes is carried out using sieved clods of earth at least 0.4 m above of the pipeline, then backfilling is done using the rough run.

Conclusion

The sizing of sanitation networks is a crucial step to ensure the correct operation of urban water drainage systems. Rigorous design allows not not only to meet current needs in terms of sanitation and comfort, but also to anticipate future developments linked to urbanization and climate change.

Mastery of hydraulic principles, taking into account hydrological data and demographics, as well as compliance with technical standards are essential to ensure the sustainability, security and efficiency of networks. Finally, the engineer must always reconcile the imperatives technical, economic and environmental in its design choices.

Useful links

https://youtu.be/cZ50CB5Bd-w?list=PLMak1gCtEGQx5KhyEuZsh8qg8WNwyzzWp

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