Abdelhafid Bousouf University Center - Mila

2024-2025 Semester 1

Sanitation

– Lesson 4 –

Chapter 4 : Hydraulic calculation of the wastewater drainage network

teaching staff		
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Institute	**Department Year**		**Speciality**
GC **Science and Technology**	License 3	Hydraulics	Urban hydraulics

Course Objectives 4

The main objectives are:

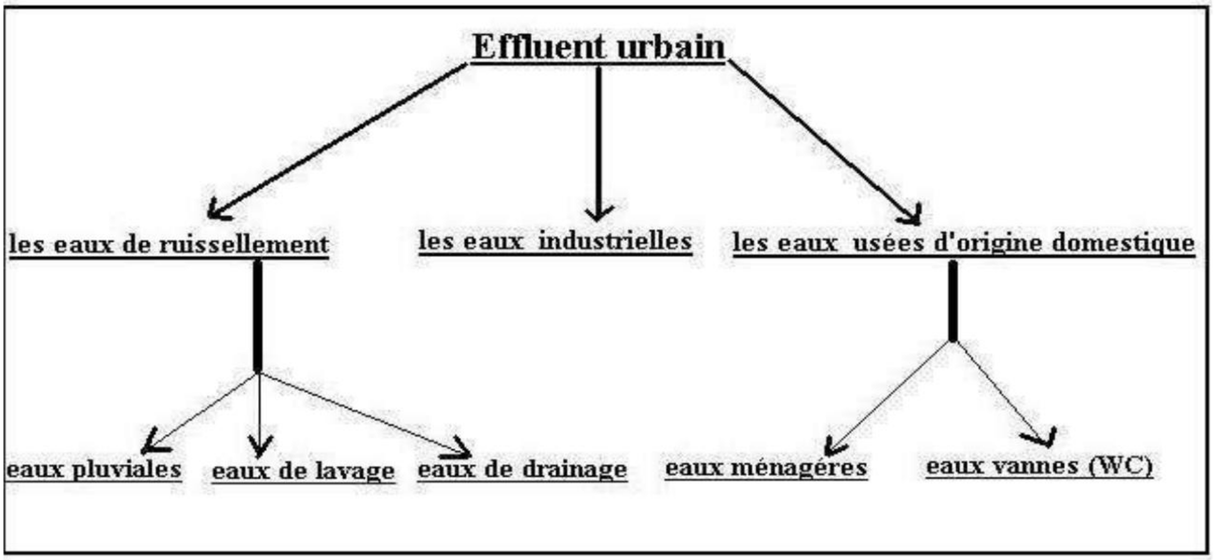
1. **Understand the fundamental principles of hydraulics applied to networks sanitation**
   - o Concepts of gravity and pressure
   - o Pressurized and free surface flow
   - o Pressure losses and transient phenomena
2. **Master the methods for sizing drainage pipes**
   - o Design flow rate and peak coefficients
   - o Calculation of slopes and flow velocities
   - o Minimum diameters and optimization of cross-sections
3. **Analyze the phenomena influencing the functioning of the network**
   - o Effect of variations in flow rate and hydraulic loads
   - o Risks of overloading, clogging and corrosion
   - o Impact of weather conditions and extraneous water
4. **Know the applicable standards and regulations**

- Sanitation code requirements
- Effluent discharge standards and quality
- Good practices in design and operation

1. Introduction

The proper functioning of a network is based on well-controlled calculations; it is necessary to avoid over-calculations. sizing of structures, because it leads to premature investments with risks poor operating conditions during the intermediate periods.

The choice of structural sections will result from the application of hydraulic formulas. flow.



2. Wastewater Transport Conditions

When designing a sanitation network, it is necessary to satisfy a ***free-surface*** gravity ***flow*** and ensuring certain conditions, namely:

2.1. Speed

The velocity of wastewater in the networks is limited both above and below because it must :

- On the one hand, avoid stagnation that could cause deposits and lead to sediments, otherwise there is a risk of pipe blockage and the release of harmful substances. odors due to the decomposition of organic matter.
- On the other hand, prevent erosion of the pipes by solid matter carried by water (sands and gravels) or, where applicable, industrial water.

At low flow rates, a flow velocity must be ensured that prevents deposits from forming.

The minimum speed to be retained, known as the ***self-cleaning speed,*** must be:

- In the case of a single-unit network, the speed equal to or greater than the speed sand entrainment, i.e. **0.6 m/s,** this condition is met for a flow rate to be evacuated equal to 1/10 of the full section flow rate Qps.
- Separate sewer system where there is no storm drain system; the speed must be the order of **0.3 m/s** but ensuring a filling of **2/10D.**

At very high flow rates, and in order to prevent the degradation of the joints of non-structures

For areas open to the public, the water speed must not exceed **4 m/s**

2.2. The slope (installation conditions)

The conditions for self-cleaning are often difficult to achieve in the upstream section or the Flow rates are low. This leads us to look for slopes (0.004 – 0.005); downstream, we can allow minimum slopes (0.003 – 0.002)

2.3. Diameters

The minimum diameter is 300 mm in the case of combined sewer systems, whereas it is 200 mm in the case of separate networks.

2.4. Ventilation

The need to transport domestic wastewater requires that sewers be...
Ventilated structures. This ventilation limits fermentation and the absence of O2 in the pipes. generates the formation of hydrogen sulfide and methane which decompose and lead to the corrosion of the concrete walls of sewers.

3. Method for calculating a sanitation network

Knowing the flow rates to be evacuated and the slope of the structures at each point, the choice of The number of sections will be deduced from the adopted flow formula. Flow in the networks The sanitation process takes place in a free surface, therefore the flow rate conveyed by the pipes is given by the continuity equation.

$$\boldsymbol{Q = V\,S}$$

With :

Q: flow rate conveyed m3 /s

V: flow velocity m/s

S: wetted section m2

The following formula is used to calculate the flow velocity:

3.1 CHEZY Formula

The formula for the flow velocity given by **Chezy** is:

$$\boldsymbol{V = C\sqrt{R\,I}}$$

With :

V: Flow velocity in m/s

R: Hydraulic radius with R = S/P

S: wetted cross-section in m^2

P: wetted perimeter in m

I: Slope of the structure in m/m

C: CHEZY coefficient, we adopt the one given by BAZIN's formula

$$C = \frac{87}{1 + \frac{\gamma}{\sqrt{R}}} = \frac{87\sqrt{R}}{\gamma + \sqrt{R}}$$

ÿ: is a flow coefficient that varies depending on the materials used and the nature of the water transported

ÿ = 0.25 in the case of pipes that transport wastewater

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

3.2 MANNIN G STRICLER Formula

$$V = K\, R^{2/3}\sqrt{I}$$

With :

K = Manning-Strickler coefficient depends on the roughness of the pipes

K = (20 – 102).

Manning-Strickler proposed the following relationship for the Chezy coefficient: C = K R1/6

3.3 Calculation of a separate wastewater network

A greasy film forms in the works which improves the conditions of flow. Also, the Bazin coefficient ÿ can be taken as **0.25.** C can therefore be represented approximately by the expression $C=70.R^{1/6}$.

Speed: $$V = 70\, R^{2/3}\sqrt{I}$$

The flow rate: $$Q = 70\, R^{2/3}\sqrt{I}\; S$$

3.4 Calculation of a separate rainwater drainage network:

It should be noted that deposits are likely to form, which leads to to allow flow over semi-rough walls.

Bazin's coefficient ÿ can be taken to be **0.46.** C can therefore be represented approximately by the expression $C=60.R^{1/4}$.

Speed: $$V = 60\, R^{3/4}\sqrt{I}$$

The flow rate: $$Q = 60\, R^{3/4}\sqrt{I}\; S$$

3.5 Calculation of a unit network

The calculation will be carried out in the same way as for the stormwater network in a separate system, given the relative importance of wastewater flow compared to that of rainwater.

The hydraulic calculation of wastewater networks is based on the use of several abacuses which are established by the formulas of MANNING STRICKLER or BAZIN ***Abacus 4a and Abacus 5a.***

All the results obtained are summarized in the table containing the following columns:

1. Basin number in question.
2. Section number.
3. Partial area (ha).
4. Cumulative area (ha)…

Conclusion

The hydraulic calculation of wastewater drainage networks is a step essential in the design of sanitation infrastructure. It allows for the sizing properly the pipes, ensure efficient gravity flow and avoid the problems of water clogging, overloading or stagnation.

Thanks to hydraulic principles and modeling tools, it is possible to optimize flow management, minimize flood risks and ensure proper long-term functioning of networks.

However, the system's performance also depends on maintenance. regular and adaptation to urban and climatic changes.

Thus, the design and operation of wastewater drainage networks must to be considered within a comprehensive approach, integrating both technical considerations, environmental and economic factors to ensure effective and sustainable sanitation.

Links

- https://youtu.be/cZ50CB5Bd-w?list=PLMak1gCtEGQx5KhyEuZsh8qg8WNwyzzWp
- https://youtu.be/XCQuMWxQyk0
- https://youtu.be/03krfVNi4Xo
- https://youtu.be/-hJaWIxgAVU

References

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2. https://ofctp.com/question/hydraulique-en-reseau-nombre-dhabitants-pouvant-etres-desservis-via a wastewater pipe with a diameter of 200mm/
3. https://staff.univ-batna2.dz/sites/default/files/khelif-abdelkarim/files/chapitre_vi_calcul_hydraulique_des_reseaux_dassainissement.pdf?m=1668983177
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6. https://www.thermexcel.com/french/ressourc/evacuation.htm
7. https://elearning.centre-univ-mila.dz/a2025/mod/resource/view.php?id=53626
8. https://num.univ-msila.dz/DWE/public/attachements/2022/11/28/dimensionnement-dun-reseau-dassainissement-et-la-station-de-relevage-de-ghzal-wilaya-de-msilapdf-yhrebmqz1669634111.pdf