Abdelhafid University Center Bousouf - Mila
2024-2025 Semester 1

Hydraulic structures

– Lesson 5 –

Chapter 05 : Preliminary sizing of ancillary structures and construction measures

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Science and Technology	Civil engineering and hydraulics	Bachelor 3	Urban hydraulics

Course objective

The objective of this course is to enable the learner to understand the essential principles of the **basic design of ancillary structures** (such as gutters, ditches, curbs, drainage systems, manholes, etc.) as well as the associated **construction measures** . The student must acquire the necessary foundation to:

- Identify the different ancillary works required according to the type of project.
- Apply the simplified sizing rules adapted to the preliminary stage.
- Incorporate construction measures that guarantee the durability, safety and functionality of the structure.
- Develop a comprehensive vision that allows us to move from basic sizing to detailed design.

Introduction

When a development or construction project is designed, attention is initially focused on the main structures (roads, buildings, major hydraulic works). However, it is often the ancillary structures that ensure the proper functionality, safety, and sustainability of the project.

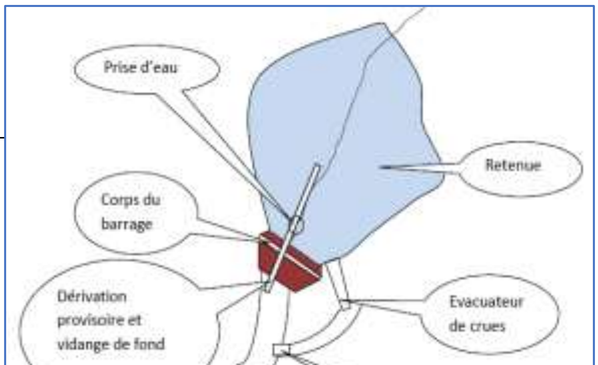
Preliminary sizing of these structures is an essential step from the design phase onward, as it allows for anticipating space, material, and cost requirements. These preliminary estimates guide technical choices and facilitate work planning.

Constructive measures, meanwhile, aim to define the precautions and implementation techniques that ensure the conformity, quality and durability of the works, taking into account the constraints of terrain, climate and use.

Thus, this chapter highlights the importance of ancillary works in the success of a project and presents a methodological approach for their summary sizing, supported by constructive recommendations.

Reservoir dams are generally equipped with ancillary structures that may be permanent or temporary; these structures are usually:

- The flood spillway.



- Temporary diversion.
- Water intake.
- Bottom draining.

The location of these works must be taken into account.

This is taken into account when choosing a site, because generally, they contribute significantly to the cost of constructing the dam.

Figure 01. Main constituent elements of a dam.

V.1- Temporary Derivations

The temporary diversion is an essential structure, which has a role in diverting the waters of the river in order to protect the construction site against any influx of water that could hinder the work during construction and to project the site from flooding.

1. The temporary diversion is accompanied by a tunnel and an upstream cofferdam to allow the diversion works to be carried out without obstruction and to facilitate the flow of water. Another cofferdam is located downstream to prevent backflow.

V.1.1 . Choice of flood for the dimensioning of the tunnel and the cofferdam

In our country, diversion structures are often sized for floods with a return period

- Concrete dams: return period 25-50 years
- Embankment dams: return period 80-100 years

V.1.2 . Flood risk

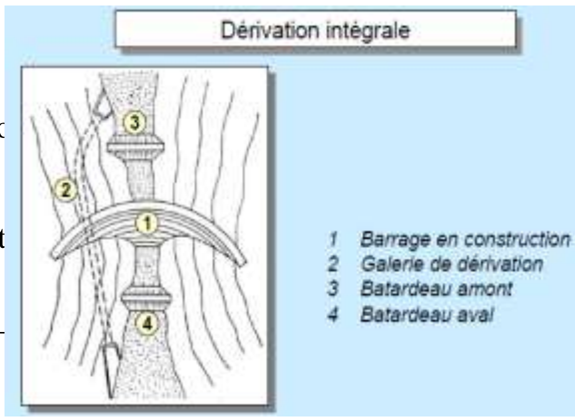
The risk of flooding on a construction site is calculated by:

$$\boldsymbol{r} = \mathbf{1} - (1 - \frac{1}{P})^{n}$$

P: return period of the design flow rate
n : duration of the construction project

V.1.3 . Types of derivations

A. Integral differentiation: integral differentiatic consisting of a bypass gallery and two cofferdams located upstream and downstream of t

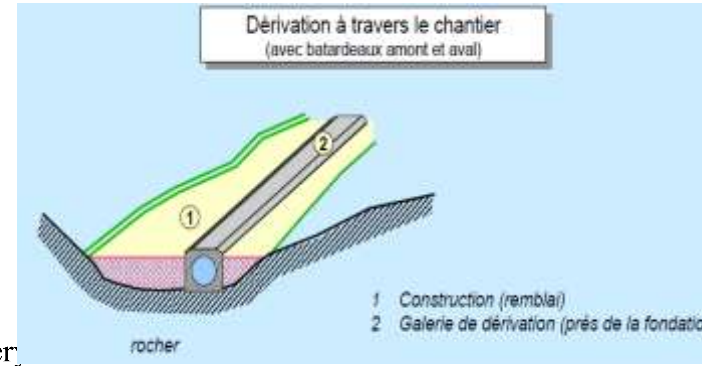


bypass is necessary in the case of a valley

narrow .

B. diversion through the construction site

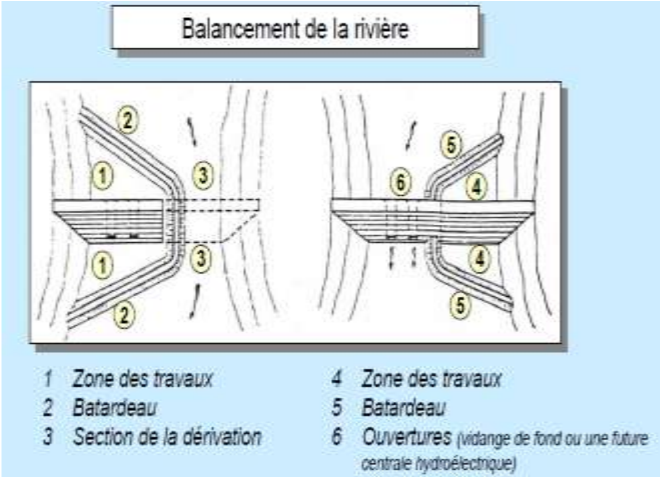
A bypass tunnel parallel to the bed of
The river is built at the foundation level
of the dam. This concrete gallery is built
to the sky and must be built on the rock. This type
the bypass is used in combination with the
embankment dams for fairly wide valleys and
floods that weren't too severe.
The diversion tunnels are often transformed,
at the end of construction, in the bottom drainage gallery
or flood spillway gallery.



C. River swaying

This solution is not feasible for dikes.
than for wide valleys. A bypass
is carried out in several phases:

1. One half of the valley is isolated and drained at the help of cofferdams;
2. The other half of the dam is built with the openings (used at the end of the work such as bottom drain or supply line;
3. River diversion through the openings in the dam by relocation of cofferdams;
4. Closing of openings and filling of the reservoir.



V.1.4 . Elements of the derivation

❖ **Cofferdam**

A **cofferdam** is a dam designed to temporarily retain water at a given location and over a given area. Generally, the cofferdam is used to facilitate activity downstream. It is often constructed using gabions and sheet piles .

The main types of cofferdams are:

- **Cofferdams in embankments:**

Watertight element : - Diaphragm wall or sheet piles

- Zoned, homogeneous dikes

- **Cofferdams with sheet piles:** limited heights (approx. 10m)
- **Submerged cofferdams (** in combination with concrete dams only)

Cofferdams built on embankments as part of dam construction are often designed as submerged cofferdams. Submersion occurs without problems if the downstream face of the cofferdam is reinforced to withstand the erosive force of the water.

This surface protection can be achieved using the following methods:

✓ Riprap

✓ Prefabricated concrete slab

✓ Anchoring the surface of the riprap using reinforcement mesh

✓ Gabions

V.1.5 . Bypass components

A. Diversion gallery

For complete diversion, diversion tunnels are the norm for very narrow valleys.

The largest galleries built to date have a maximum flow rate (Qmax) of 2500 m³/s.

The maximum diameter of the galleries depends on the quality of the rock

- Excellent quality $D_{max} = 16m$
- Good quality $D_{max} = 8\text{-}11m$
- Average quality $D_{max} < 8m$

In general, the galleries are lined with concrete to limit friction losses and prevent abrasion of the rock.

B. Bypass Channels

The solution for diversion canals is interesting when the width of the valley is sufficient and if the floods to be diverted are very large.

C. Opening in the dam

If the flooding to be controlled during construction is too significant, a complete diversion of the river is no longer possible for technical and economic reasons. In this case, diversion through the construction site must be considered, leaving openings in the final structure.

V.2 . Bottom drain

This is a very important structure for a dam; its objectives are:

- Allow for a total or partial draining of the reservoir in the event of an accident likely to damage the dam (fox, for example) and therefore requiring rapid intervention.
- Empty the dead section at the end of the season of use of the water stored for the maintenance of the reservoir.
- To drain some of the water during exceptional floods.
- The removal of sediment deposits to prevent silting up of the dam and water intakes .

The drainage structure is not necessarily designed in isolation; it can be combined either with the flood spillway or with the intake structure.

The most common design involves passing a conduit under the dam body. Operation under pressure is possible , but for relatively large structures , free- flowing designs are adopted .

The drainage system is controlled by valves.

Figure 04. Spillway of a dam in operation.

V.2.1. Design of bottom drains

A. Bottom drainage combined with the dam:

In the case of a concrete dam, bottom drainage can be integrated into the body of the dam.

In order for the valve chamber to also be placed in the dam, its thickness at the base must be a minimum of 18 to 25 m ($Q_{max} \geq 200 m^3/s$).

B. Bottom drainage combined with dam foundation

The bottom drainage of embankment dams must never penetrate the dam body, and especially the watertight core, for the following reasons:

- Differential settlement (concrete gallery, much more rigid than backfill).
- Preferred percolation paths along the concrete gallery (risk of internal erosion),
- Delicate compaction in the vicinity of the concrete gallery.

In some cases, it has been possible to integrate the bottom drainage into the embankment dam foundation.

C. Combined bottom drainage with bypass gallery

A common solution is to locate the bottom outlet in the diversion tunnel. Upon completion of construction, the diversion tunnel is converted into a bottom outlet. This conversion requires modifying the inlet, constructing the valve chamber, modifying the tunnel downstream of the valves, and building a discharge structure.

The location of the valve chamber is determined by the position of the sealing screen.

V.3. Flood spillways

V.3.1. Purpose and objectives:

A spillway is a safety device that prevents the uncontrolled overflow of a reservoir and protects the dam and related structures against spillage that could cause damage due to erosion and instability.

Definition :

The term "flood spillway" or "spillways" refers to structures that complement reservoir structures and allow the release of excess flood flows downstream of the dam.

Of paramount importance for the safety of the dam, the spillways must be able to prevent water from overflowing above the dam and the occurrence of erosion downstream of the dam in the discharge zone into the wadi.

V.3.2 *Different types of flood spillway*

Flood spillways can be classified into two groups according to their hydraulic operating methods:

- Surface drains.
- The evacuators are in charge.

V.3.2.1 Surface drains

This is the most commonly used and also the most reliable type. The surface spillway begins with a weir, which discharges into a gently sloping channel that carries the water downstream of the dam. The water then flows through the channel, the gradient of which compensates for the difference in elevation between the reservoir level and the riverbed downstream. The channel empties either directly into the river or into a retention basin.

Figure 05. Surface drains.

The surface drain is positioned according to the topographical and geological conditions:

- Laterally to the dam on one of the banks (*lateral spillway*).
- In the middle part of the dam (*front spillway*).

V.3.2.1 Pressurized Evacuators

They can be in a well or a siphon.

- Well drain

It is a circular concrete structure; it evacuates water via a vertical drop into an underground pipe, which opens downstream of the dam into a dissipation basin.

- Siphon drain

This is a simple pipe whose operation must be initiated; this pipe can be incorporated into the dike or, preferably, laid in a lateral trench dug into the bank.

Figure 06. Pressurized evacuators.

V.3.2. Choice of weir type

The choice between a surface weir and a pressurized weir depends on:

- The importance of the flow rates to be evacuated
- The difference in elevation between the highest water level and the level of the wadi bed in the downstream discharge zone,
- The nature of the terrain crossed by the structure, in particular by the canal or channel

(Making the coating necessary or not).

In all cases, it is recommended to design the flood spillway as simply as possible in order to keep costs within reasonable limits.

It should be noted that pressurized weirs have, compared to surface weirs:

- a much smaller safety margin, due to variations in flow rate depending on the significantly lower load ($\mathbf{H}^{1/2}$ and $\mathbf{H}^{3/2}$).

- A higher implementation cost

V.4. Water intake structure

A water intake is a structure built into the dam or its surroundings, designed to **draw water from the reservoir** for:

- The drinking water supply,

- Irrigation,
- Energy production (hydroelectric power plants),
- Or other industrial and domestic needs (See figure 07).

Figure 07. The water intake tower.

V.4.1 Composition and main elements

A water intake typically consists of:

1. **Suction orifice** : located at a certain depth to capture good quality water and avoid sediments.
2. **Penstock** or tunnel: transports water under pressure downstream or towards the turbines.
3. **Guard valves** (or isolation valves): allow the passage to be closed for maintenance or in case of emergency.
4. **Protective grids** : prevent the entry of floating debris or fish.
5. **Intake chamber** : regulating space where water enters before being conveyed.

V.4.2 Role and importance

- **Safety** : control of the volume of water taken to avoid sudden emptying.
- **Quality** : possibility of capturing water at different levels to select the best quality (for example, avoiding surface water that is too hot or water loaded with mud at the bottom).
- **Functionality** : ensures water availability for all uses without compromising the stability of the dam.

V.4.3 Different types of water intake

There are different types of water intake with two modes of water intake:

- Gravity-fed water supply.
- Water pumping.

We find:

1. Floating water intake.
2. Water intake tower.
3. Water intake without a turn.

In our dam the water intake is fixed at the bottom of the reservoir, it is a tower water intake.

Figure 08. Floating water intake.

Conclusion

The preliminary sizing of ancillary structures is not a mere secondary step: it constitutes an essential technical and economic foundation for the success of a project. By integrating simplified calculation principles and appropriate construction measures from the outset, the risks of defects, cost overruns, and subsequent malfunctions are significantly reduced.

This chapter therefore enables students to acquire a clear methodology for analyzing needs, proposing appropriate solutions, and ensuring the quality of the work. The transition to detailed sizing then occurs more naturally, within a framework of optimization and sustainability.

Useful links

https://youtu.be/xNYdzLIBlEM

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