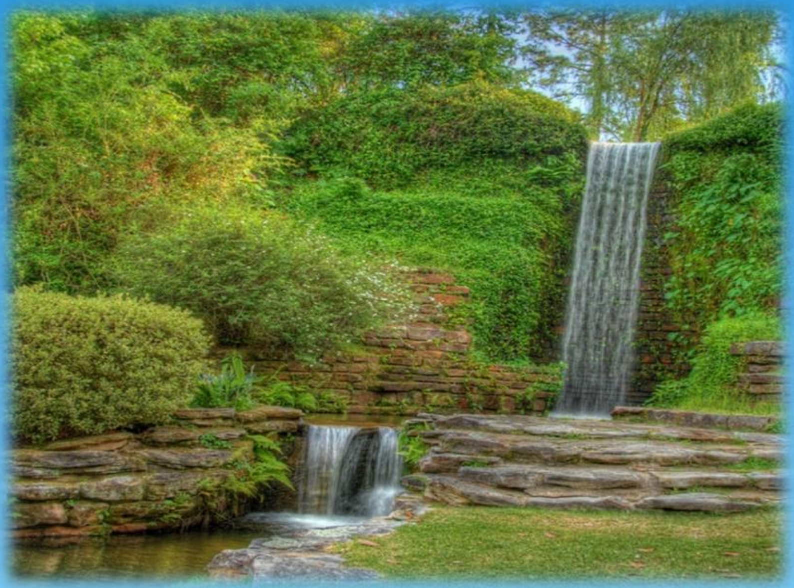

# Diversion Weirs

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# Definition and Classification

Diversion Weirs: Built to raise level and divert water for the purposes of irrigation, hydropower, etc.

The followings should be satisfied in designing any diversion weir:

- Desired amount of water at any time
- No sediments entering into the water intake
- Minimum head losses at the water intake
- Easy flushing of accumulated objects at the water intake

# Differences between Dams and Diversion weirs

**Dams**

- Built on whole valley
- To store water
- Can regulate the flow regime

- Fixed structures
- Can be built certain locations on stream especially Upstream locations

- Dam failure leads catastrophic damages

- Designed according to static forces

- Have large environmental effects

**Diversion weirs**

- Built on river bed
- To rise water
- Can not regulate the flow regime

- Fixed or gated
- Can be built everywhere on stream

- Failure causes comparatively little damages
- Designed according to static and dynamic forces
- Have small environmental effects

# Definition and Classification

* According to Magnitude Of $Q_{100}$
  - Small ($Q_{100} < 100\ m^3/s$)
  - Intermediate ($100\ m^3/s < Q_{100} < 500\ m^3/s$)
  - Large ($Q_{100} > 500\ m^3/s$)

* According to Structural Design
  - Diversion weir with spillway
  - Gated diversion weir

# Definition and Classification

* According to Orientation of Intake
  - with sidewise (lateral) intake
  - with frontal intake
  - with drop (bottom) intake

Diversion Weirs with Sidewise Intakes

- suitable for plain rivers having uniform concentration vertically.
- In Turkey, the 90 % of weirs is of this type.
- See Figure next slide for plan view.
- Similar construction to dams

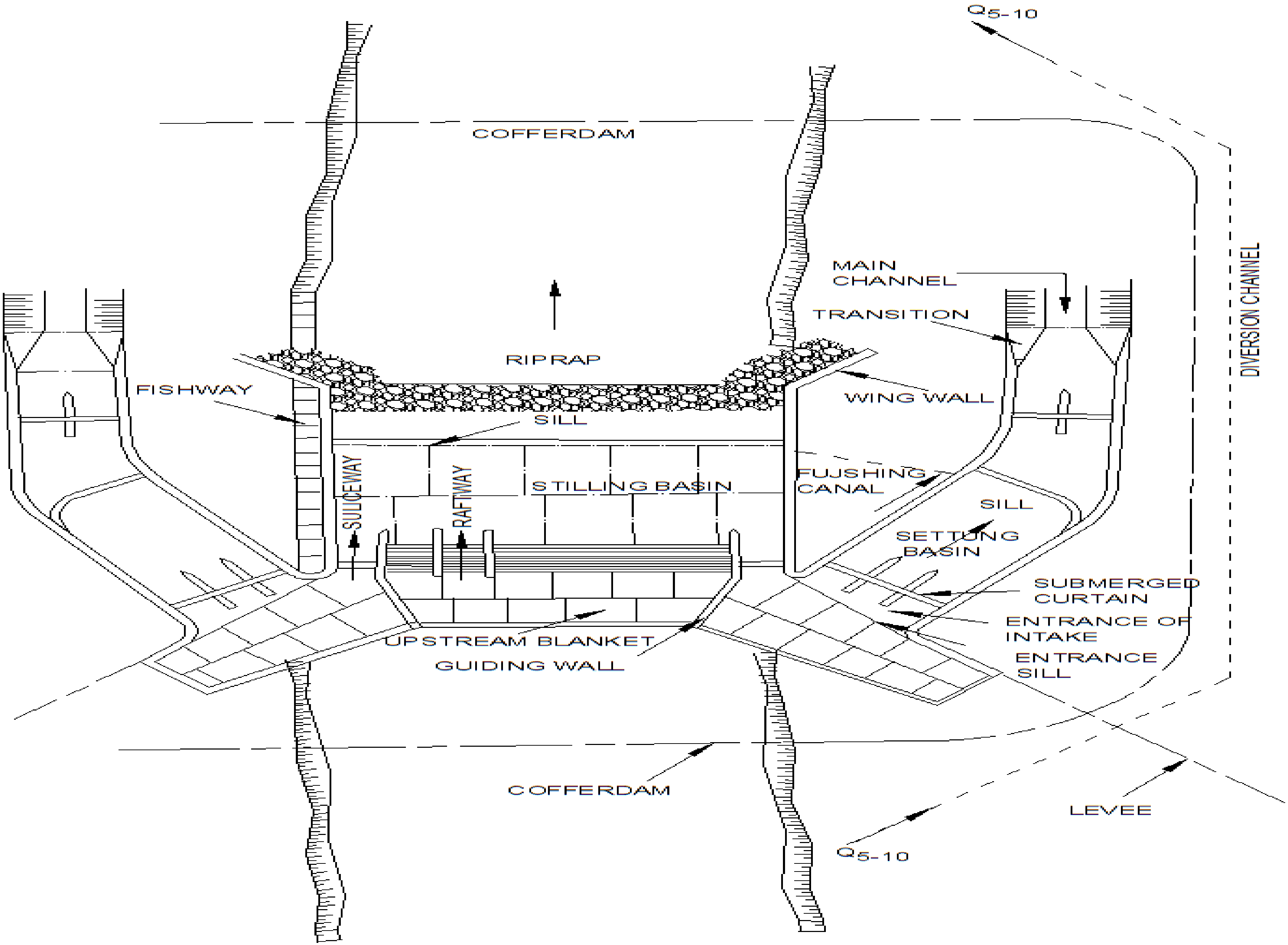
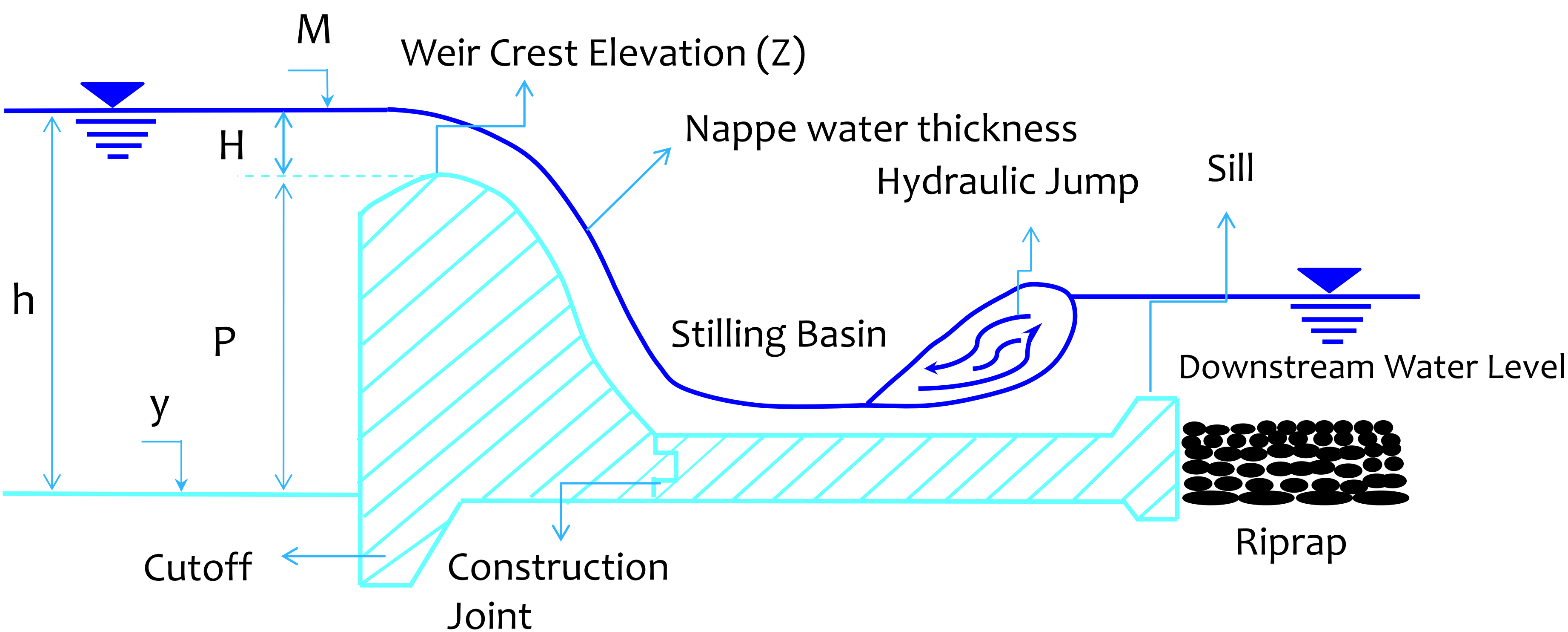



Figure 4.1. Plan view of a diversion weir with sidewise intake

# Diversion Weir

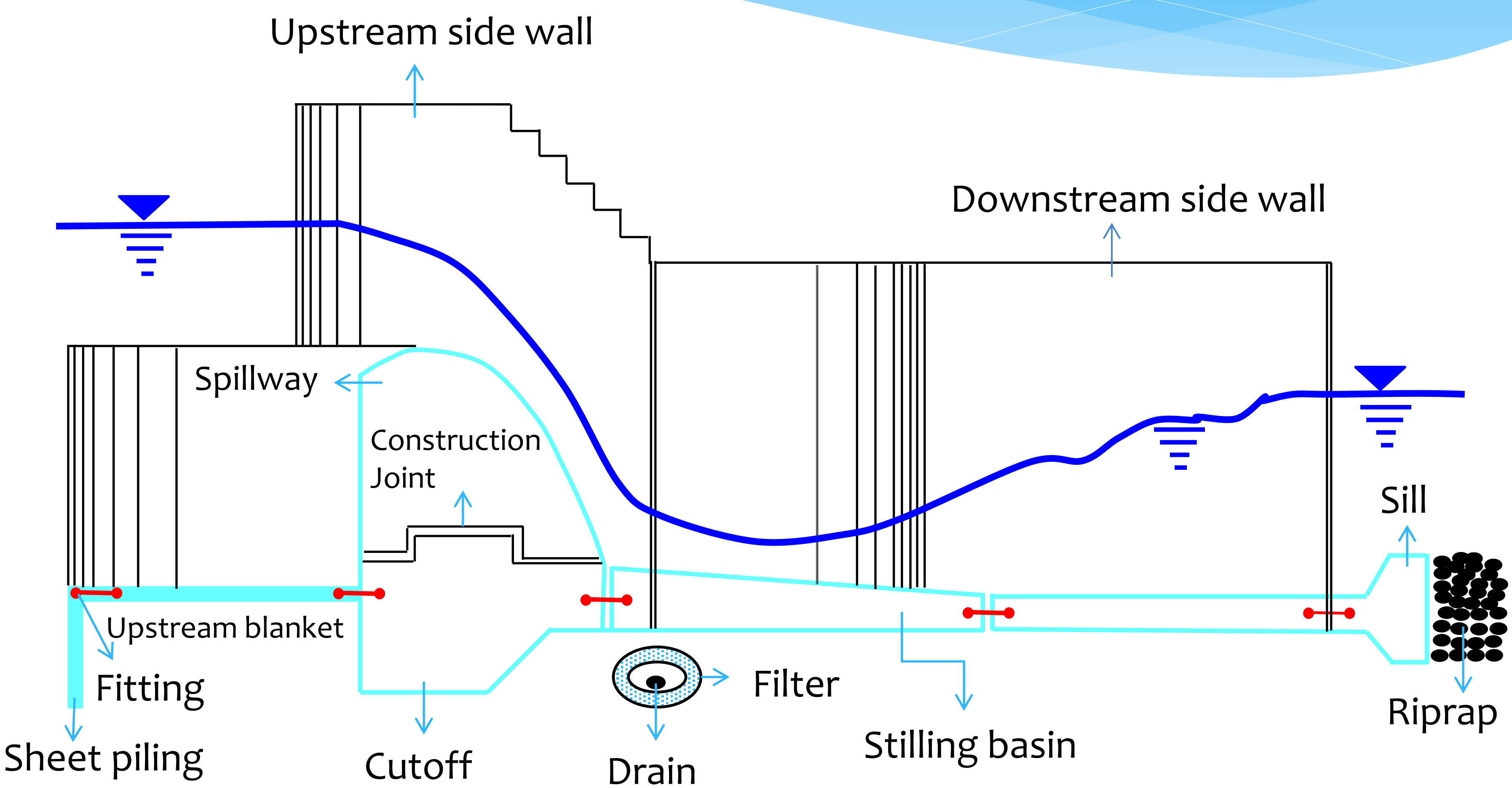


# Diversion Weir

- H: Overflow Head
- P: Weir Height
- Z: Weir Crest Elevation
- $M_{max}$: Maximum Raised Water Elevation
- $H_{min}$: Minimum Overflow Head
- y: River thalweg elevation
- M: Raised Water Elevation
- $H_{max}$: Maximum Overflow Head

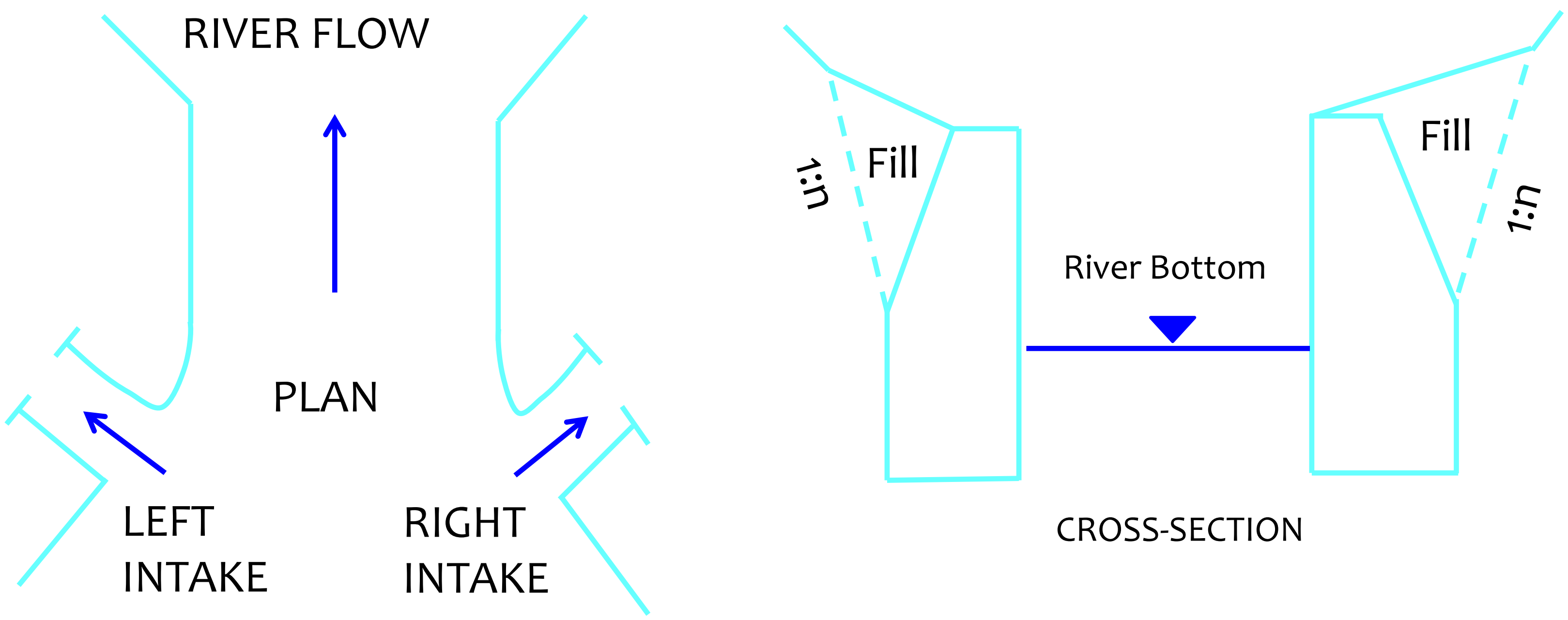
- $M_{max} = Z + H_{max}$
- $H = M - Z$
- $Z = M - H_{min}$
- $P = Z - y$

# Longitudinal profile of a typical spillway and stilling basin



# Structural Components

1. <u>Sidewalls:</u> Boundaries of structures / Acting like retaining wall




Schematic of sidewall

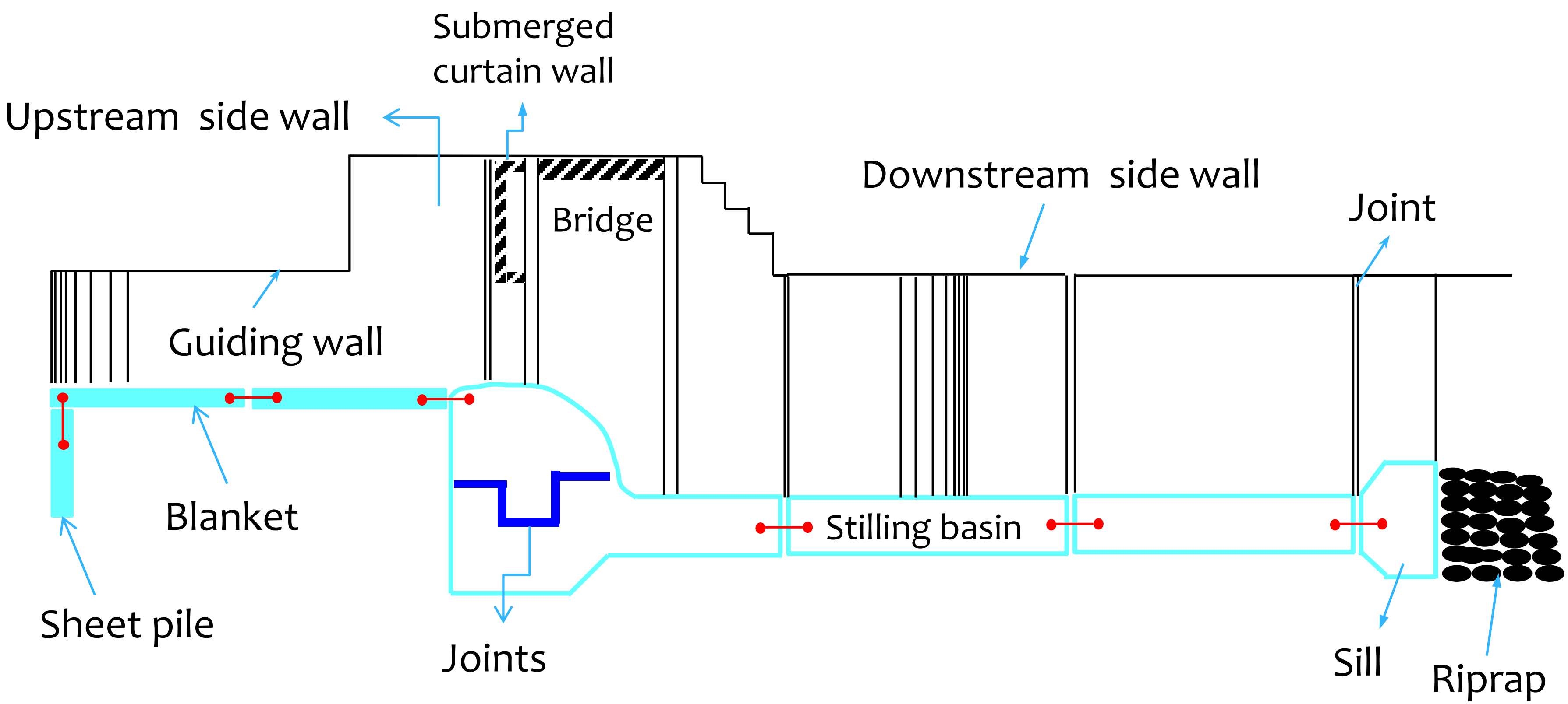
# Structural Components

2. Spillway: Collects, raises and diverts flow to the intake
3. Sluiceway: Prevents the deposition of sediment in front of intake (with square cross section with 2.5x2.5 m)
4. Guiding wall: Deflects sediment towards the sluiceway.
5. Upstream blanket: Retards the seepage path. (4mx4m concrete blocks and 30 thickness)

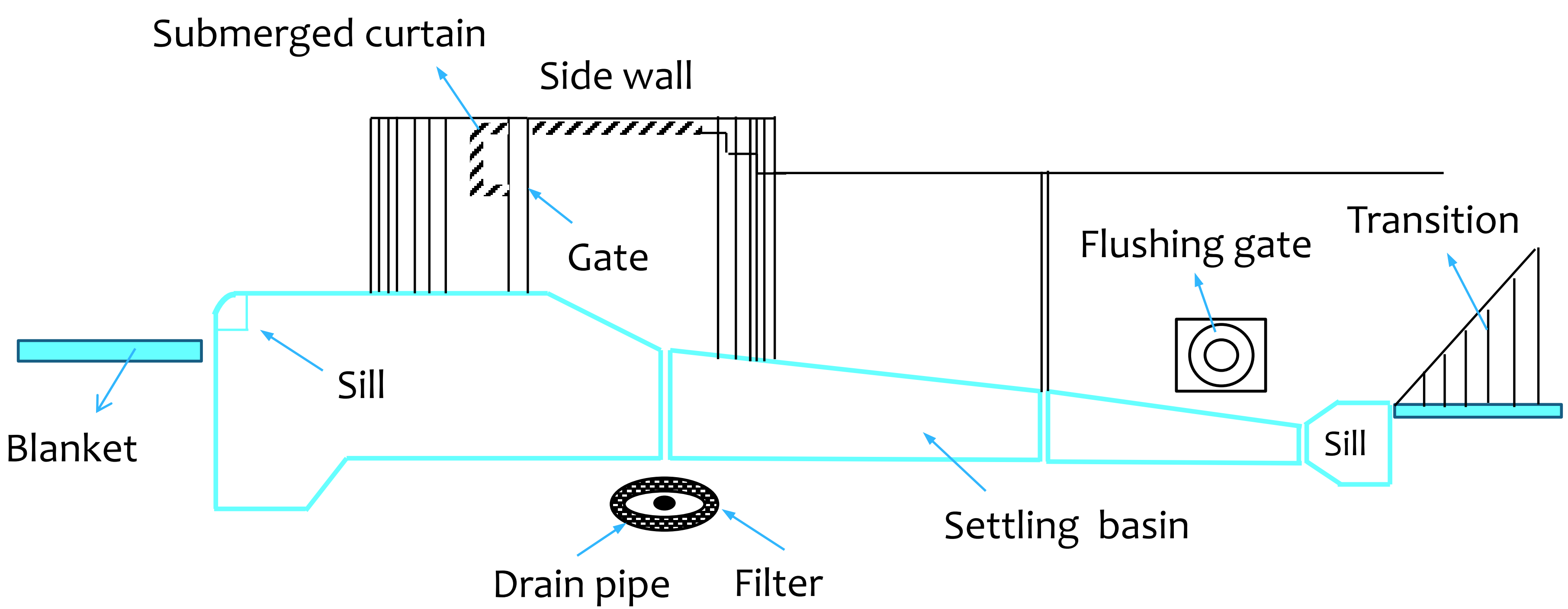
# Structural Components

6. Energy dissipating basin: Prevents the scour of the river bed.
7. Riprap: Follows "energy dissipating basin" to protect the river bed. (stones with 75 cm thick and 10 m long)
8. Fish passage: Provides the passage of fish.
9. Raft passage: Only constructed if log transportation is required.
10. Intake: Takes the required discharge and transmits it to the main channel.

# Longitudinal profile of a typical sluiceway and stilling basin



# Longitudinal profile of an intake



# Structural components of intake

- **Submerged curtain:** to prevent the entrainment of floating objects
- **Screens:** racks at the entrance of intake (in front of the vertical gate) to retard floating objects and coarse sediment
- **Settling basin:** to ensure the settlement of sediment grains up to certain size

# Structural components of intake

- **Flushing canal:** located at the end of the settling basin and used to discharge sediment deposited in the settling basin
- **Transition:** connects the rectangular settling basin to a trapezoidal irrigation channel

# Location of Intake

* Located at narrowest section → "minimum size and cost"
* As upstream depth increases much

  → "excessive seepage and high uplift force"

  In this case; "gated spillway" considered.
* Final solution

  decided based on "economy" and "hydraulic conformity"

# Hydraulic Computation

**Design of Intake**

- Computational direction → downstream to upstream (water surface profile)
- The crest elevation of the overflow spillway = Head losses through the intake structure + water surface elevation at the entrance of the main irrigation channel

# Determination Of Length Of Settling Basin

- Diameter of particle to be settled in the main irrigation channel (with **$Q = Q_{design}/2$**)
- Because irrigation systems are rarely operated with the design discharge

$$D = 10\ R\ S_o$$

- R: Hydraulic radius
- $S_o$: Bed slope of main irrigation channel

# Determination Of Length Of Settling Basin

- Fall velocity (w) of sediment grain with D computed from Eqs. above then
- Length of rectangular settling basin (L):

$$L = \frac{Q}{(B\ w)}$$

  - Width of settling basin

- a value of L larger than the computed one should be selected
- Small particles (i.e., silt, clay) – OK

  Larger particles (i.e., sand) – not OK

# Determination Of Length Of Settling Basin

- $V_{\text{at the end}} < 0.3$ m/s || $V_{\text{at the entrance}} < 0.8\text{-}1.0$ m/s

Bottom Slope = 0.01

Height of Upward $\text{Sill}_{\text{at the end}} > 50$ cm

Height of $\text{Sill}_{\text{at the entrance}} > 50$ cm above the river bed

# Design of Spillway and Sluiceway

- Crest elevation → Elevation $_{\text{at the entrance of irrigation channel}}$ + Head losses
- Freeboard (in front of spillway) → ~ 10 cm (for fluctuation of water)
- Height of spillway → 1.5 – 2.5 m
- Length of spillway → river cross section at the axis of spillway (Piers on the crest – Effective length)

# Design of Spillway and Sluiceway

- Dimensions of sluiceway → suitable (i.e., 2.5 m x 2.5 m).
- Design Discharge:

$$Q_{100} = Q_{spillway} + Q_{sluiceway}$$

- Discharge components can be calculated from:

$$Q_{spillway} = C\ L\ H_o^{3/2}$$

where

- C: Corrected spillway coefficient
- L: Effective spillway length
- $H_o$: Design spillway head

# Design of Spillway and Sluiceway

$$Q_{sluiceway} = C\ L_e\ (2gy)^{1/2}$$

where

- C: Coefficient from Fig.
- $L_e$: Width of sluice gate
- d: Opening of sluice gate
- y: Upstream water depth

➢ See Fig. 4.10 for notations and flow conditions.

# Design of Spillway and Sluiceway

- For design $Q_{spillway}$ and $Q_{sluiceway}$ :

"an upstream water surface elevation is assumed, then these discharges are computed.

Repeat this until

$$Q_{100} = Q_{spillway} + Q_{sluiceway}$$

is satisfied"

Bottom elevation and Type of stilling basin and Lowering river bed can be determined using computational steps in Ch. 3.

# Stability Requirements

a) Safety against sliding

   i. Whole structure considered

   - SF > 1.5 for the case of "without earthquake "
   - SF > 1.2 for the case of "with earthquake"

b) Safety against overturning

   i. Only spillway considered

   ii. SF > 1.5 for the case of "without earthquake "

   iii. SF > 1.2 for the case of "with earthquake"

# Stability Requirements

c) Safety against uplift

**i. Lane's creep analysis:**

- Determination of minimum creep length adjacent to the structure long enough to prevent "piping" problem which is erosion of finer particles in soil.
- **Creep length** is related to "effective hydraulic head (H)" and "relative permeability (C)". See next slide in Table for the values of C.

# Values of C to be used in creep analysis (Kashef, 1987)

| Foundation Material | C |
|---|---|
| Very fine sand or silt | 8.5 |
| Fine sand | 7.0 |
| Medium sand | 6.0 |
| Coarse sand | 5.0 |
| Fine gravel | 4.0 |
| Medium gravel | 3.5 |
| Coarse gravel including cobbles | 3.0 |
| Boulders with some cobbles and gravel | 2.5 |
| Soft clay | 3.0 |
| Medium clay | 2.0 |
| Hard clay | 1.8 |
| Very hard clay or hardpan | 1.6 |

# Stability Requirements

- **Permeability** of alluvial bed in horizontal direction is 3 times that in vertical direction.
- After determining the creep length; is checked.

$$\sum L \geq C\ H$$

- H: elevation difference between upstream and downstream
- C: the relative permeability of soil.
- L: the creep length

# Stability Requirements

- The field measurements of Lane indicated that the permeability of an alluvial bed in the horizontal direction is about three times the permeability in the vertical direction, which reveal that the seepage force in the vertical direction is three times greater than the seepage force in the horizontal direction.

# Stability Requirements

- When **∑L = C H** ; uplift at point “x” of the structure adjacent to the foundation can be determined from

$$u_x = H_0 - \left( H_x + \frac{L_x}{C} \right)$$

- $u_x$ is the uplift pressure head
- $H_o$ is the upstream water depth
- $H_x$ is the elevation at point x relative to a datum which is usually selected as the river thalweg elevation at the spillway axis
- $L_x$ is the creep length up to point x.

# Stability Requirements

When

$$\sum L \neq \sum CH$$

Uplift pressures can be determined by distributing the available head with respect to the total creep length

Apron is the most critical structure and should satisfy

$$F.S_u = \frac{W_a}{F_u} \geq 1.20$$

d) Foundation stresses: should be within allowable limits.

# TEŞEKKÜRLER

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