Stilling Basins:

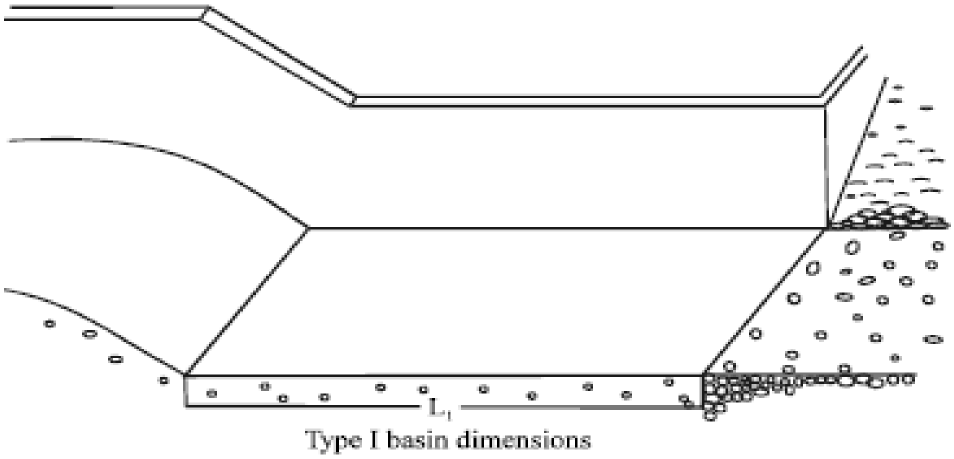
A stilling basin is a basin-like structure in which all or a part of the energy is dissipated. The positioning of a hydraulic jump on an unobstructed horizontal surface is very sensitive to the close match of sequent depths. If the downstream depth matches the sequent depth y_2, the hydraulic jump will occur as desired on the apron. If the downstream depth is less than y_2, $y_3<y_2$, the jump will occur downstream from the apron (a swept-out jump), and the river will become exposed to high scouring velocities. If the downstream depth is greater than y_2, $y_3>y_2$, the jump will be submerged. Although a submerged jump is preferable to a swept-out jump, much of the initial kinetic energy remains in the form of a submerged jet, which alone can result in considerable scour. A carefully designed stilling basin will not only improve the dissipation characteristics of a hydraulic jump, it will shorten its length and stabilize the position of the jump so that it is not sensitive to fluctuations in tailwater levels. In a stilling basin, the kinetic energy causes turbulence and it is ultimately lost as heat energy. The stilling basins commonly used for spillways are of the hydraulic jump type, in which dissipation of energy is accomplished by a hydraulic jump. A hydraulic jump can be stabilized in stilling basin by using appurtenances (or accessories such as chute blocks, basin blocks and end sill.

Types of Stilling Basin:

Because stilling basin block arrangements are difficult to design analytically, their design must be based on experimental methods. Standard designs have been developed through both observations of existing installations and a systematic series of model studies. Four types of stilling basins are developed by the U.S. Bureau of Reclamation are explained in the following:

Type I (1.7<Fr_1<2.5)

It is a rectangular stilling basin with a horizontal bottom, no chutes, no baffles or sills, which include a classical hydraulic jump. Because of high costs that come from the basin length is large as well as the hydraulic jump is sensitive to downstream level variation and effects on safety, it is not recommended.



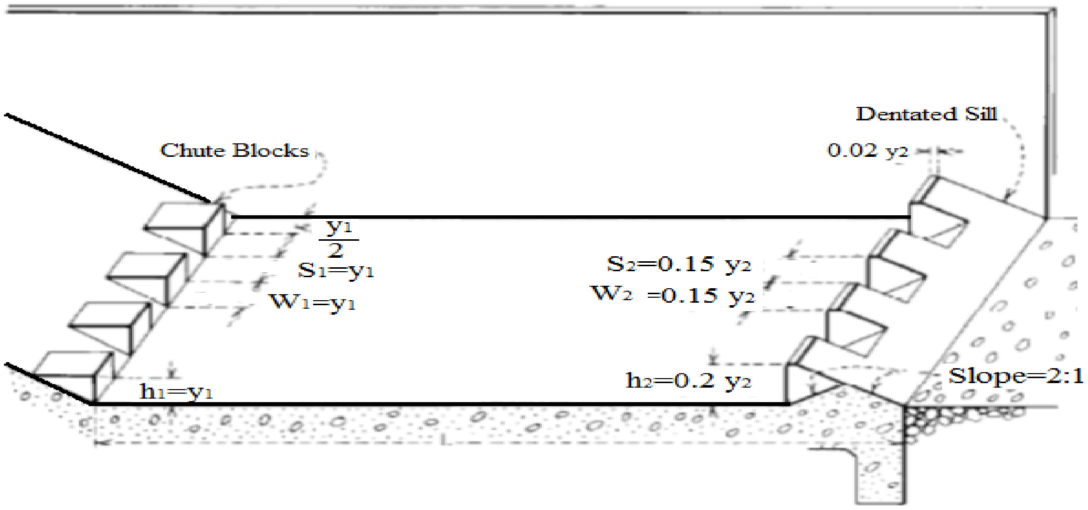
Stilling Basin Type I

Type II (Fr_1> 4.5; V_1 > 18 m/s)

The Type II basin is designed for use on high dams, earth dam spillways for Froude numbers greater than 4.5. The chute blocks and end sill help reduce the basin length by 33%. The design includes blocks and dentate end sill. The end sill has a stabilizing effect and dissipative reason. The length of stilling basin calculates from the following equations:

$L_{II} = y_2[4.0 + 0.055(Fr_1 - 4.5)]$ for $4.5 < Fr_1 < 10$

$L_{II} = 4.35 y_2$ for $Fr_1 > 10$



Type II Stilling Basin

Type III (Fr_1> 4.5; V_1 < 18 m/s)

The Type III basin reduces the length by 45-60 % with the addition of chute blocks, baffle piers, and an end sill. This structure is also used for Froude numbers greater than 4.5, but its use is restricted to small spillways where the upstream velocity is less than 15-18 m/sec. It was developed for gravity dam, earth dam spillways. With the inclusion of baffles, the inflow velocities are restricted to avoid cavitation damage to the concrete surface and reduce the impact force to the blocks. The length of stilling basin can also calculate from the following equation:

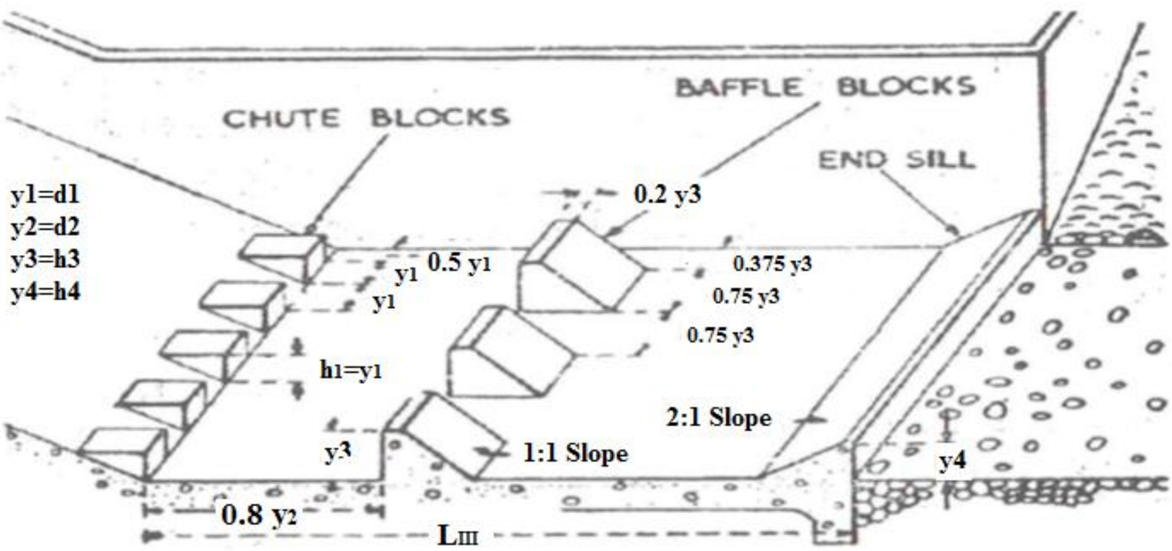
$L_{III} = y_2[2.4 + 0.073(Fr_1 - 4.5)]$ for $4.5 < Fr_1 < 10$

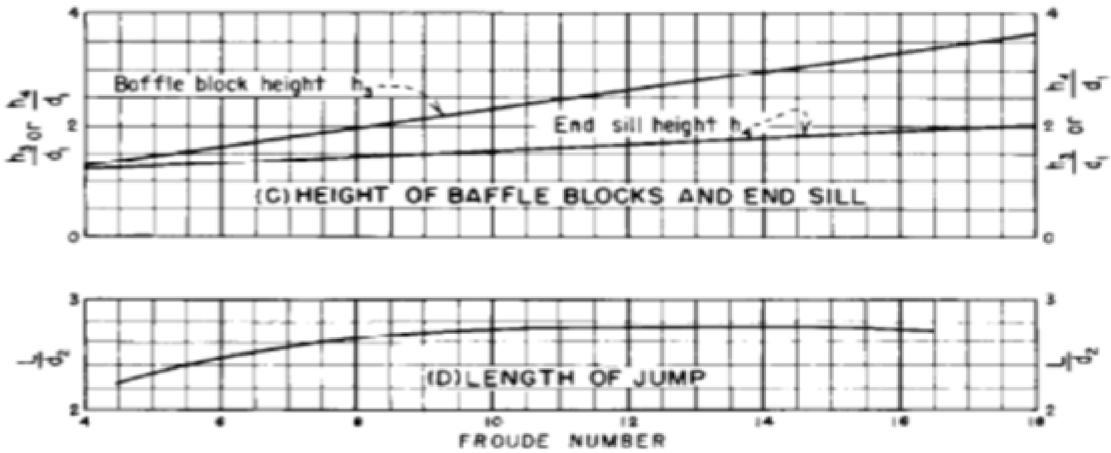
$L_{III} = 2.8 y_2$ for $Fr_1 > 10$

For the Type III stilling basin, the dimensions h3(y3) and h4(y4) are given by,

$h_3 = y_1[1.3 + 0.164(Fr_1 - 4.0)]$

$h_4 = y_1[1.25 + 0.056(Fr_1 - 4.0)]$



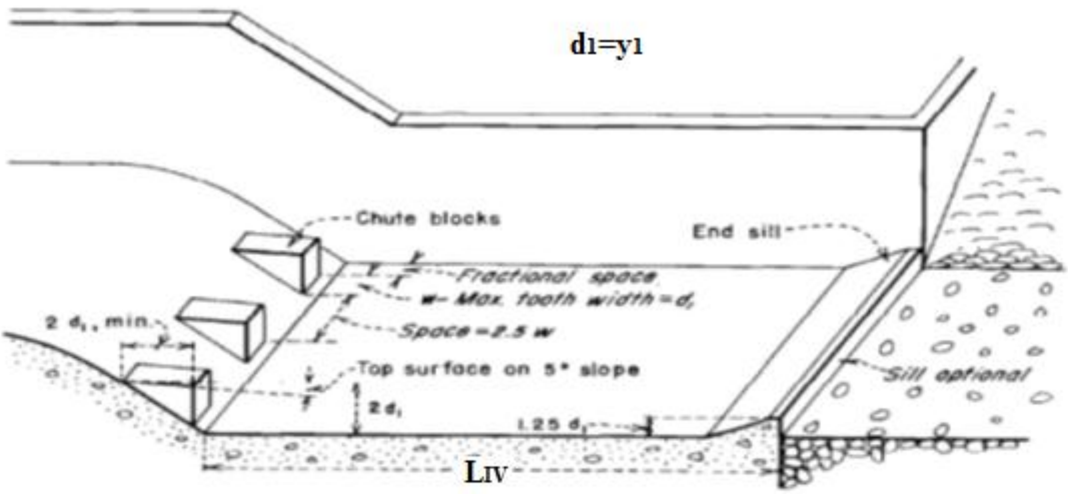


Characteristics of Stilling Basin III

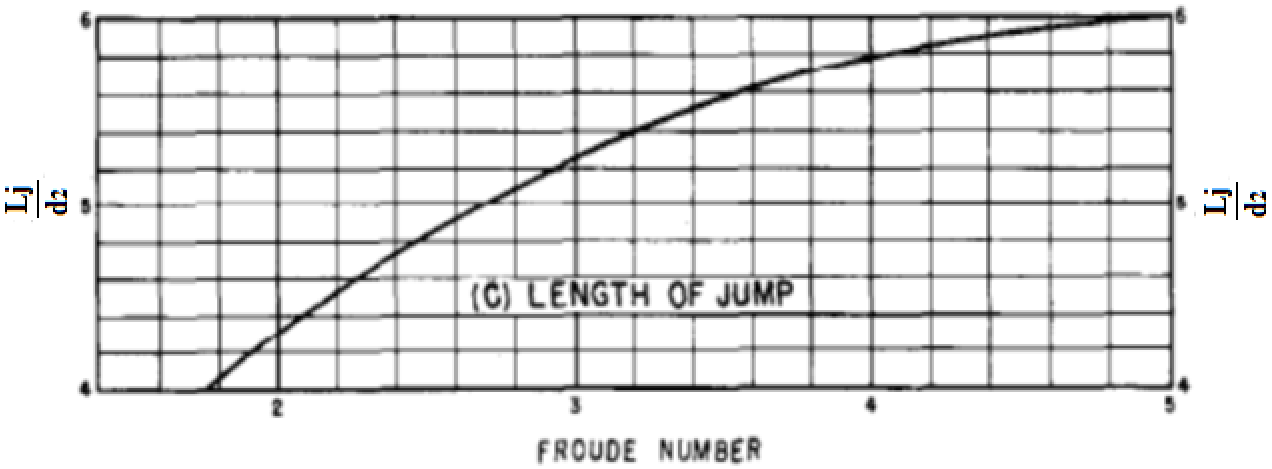
Type IV (2.5<Fr1 <4.5)

The Type IV basin is used for Froude numbers 2.5-4.5, and thus is used primarily for oscillating hydraulic jump on canal structures and diversion canals. **It includes chute deflector blocks to reduce the instability of the oscillating jump and continuous end sill. The length of the stilling basin calculates from the following equation:**

$L_{IV} = y_2[5.2 + 0.40(Fr_1 - 2.5)]$



Type IV Basin Dimension



Characteristics of Stilling Basin IV

Problems

Q (1): A horizontal rectangular stilling basin is used at the outlet of a spillway to dissipate energy. The spillway discharges 13m^3/s and has a uniform width of 12m. At the point where the water enters the basin, the velocity is 10m/s, compute:

- **The sequent depth of the hydraulic jump,**
- **The length of the stilling basin,**
- **The energy loss in the jump,**
- **The efficiency of the jump (the ratio of specific energy after to the specific energy before the hydraulic jump,**
- **If the thickness of the basin is 0.75m, and the sieve analysis for the site soil indicate the d50 is 0.05mm, are the requirements of scour design satisfied or not?**

Q (2): A spillway carries a discharge of 22.5m^3/s with the outlet velocity of 15m/s at a depth of 0.2m. Design the stilling basin and determine the jump efficiency?

Q (3): An increase in discharge through the spillway in Q (2) to 45m^3/s will increase the outlet depth to 0.25m. Design the stilling basin and determine the jump efficiency?