

Design of stilling Basins

1- Introduction

Stilling basins are external energy dissipaters placed at the outlet of a spillway, culvert, chute, or rundown. These basins are characterized by some combination of chute blocks, baffle blocks, and sills designed to trigger a hydraulic jump in combination with a required tailwater condition. With the required tailwater, velocity leaving a properly designed stilling basin is equal to the velocity in the receiving channel. Depending on the specific design, that operated over a range of approach flow Froude numbers, the United States Bureau of Reclamation (USBR) developed several designs of stilling basins based on model studies and evaluation of existing basins.

2- Type of USBR Stilling Basin

A- Type IV Stilling Basin

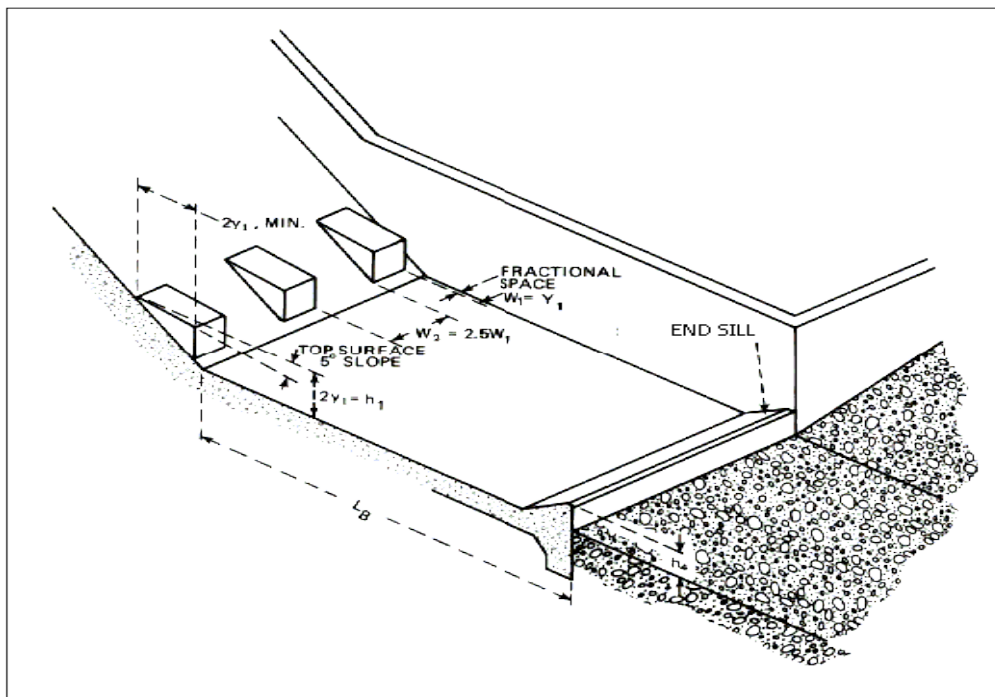


Fig.1: USBR Type IV Stilling Basin ($Fr = 2.5$ to 4.5).

B- Type III Stilling Basin

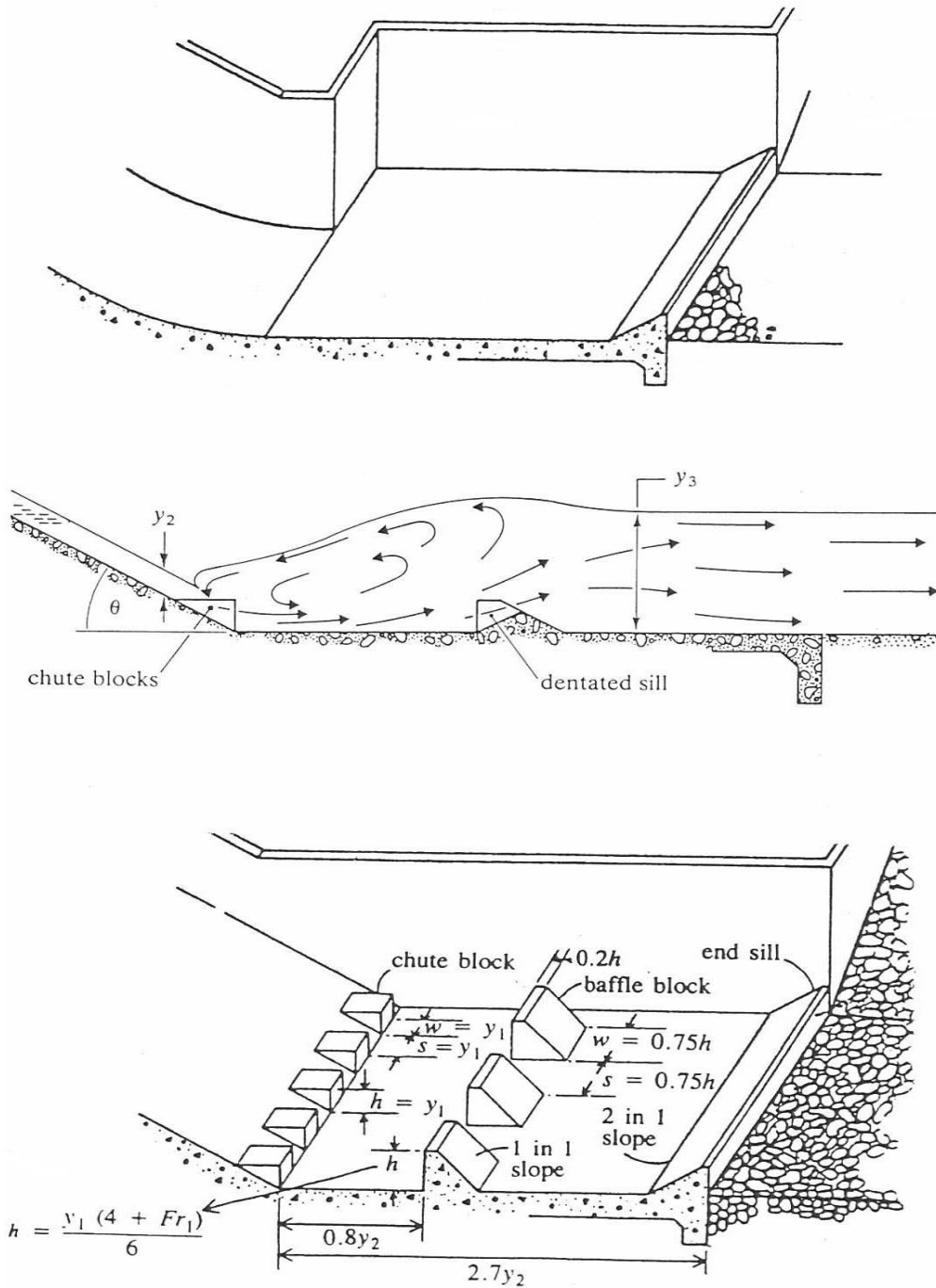


Fig.2: USBR Type III Stilling Basin ($Fr = 4.5$ to 17).

C- Type II Stilling Basin

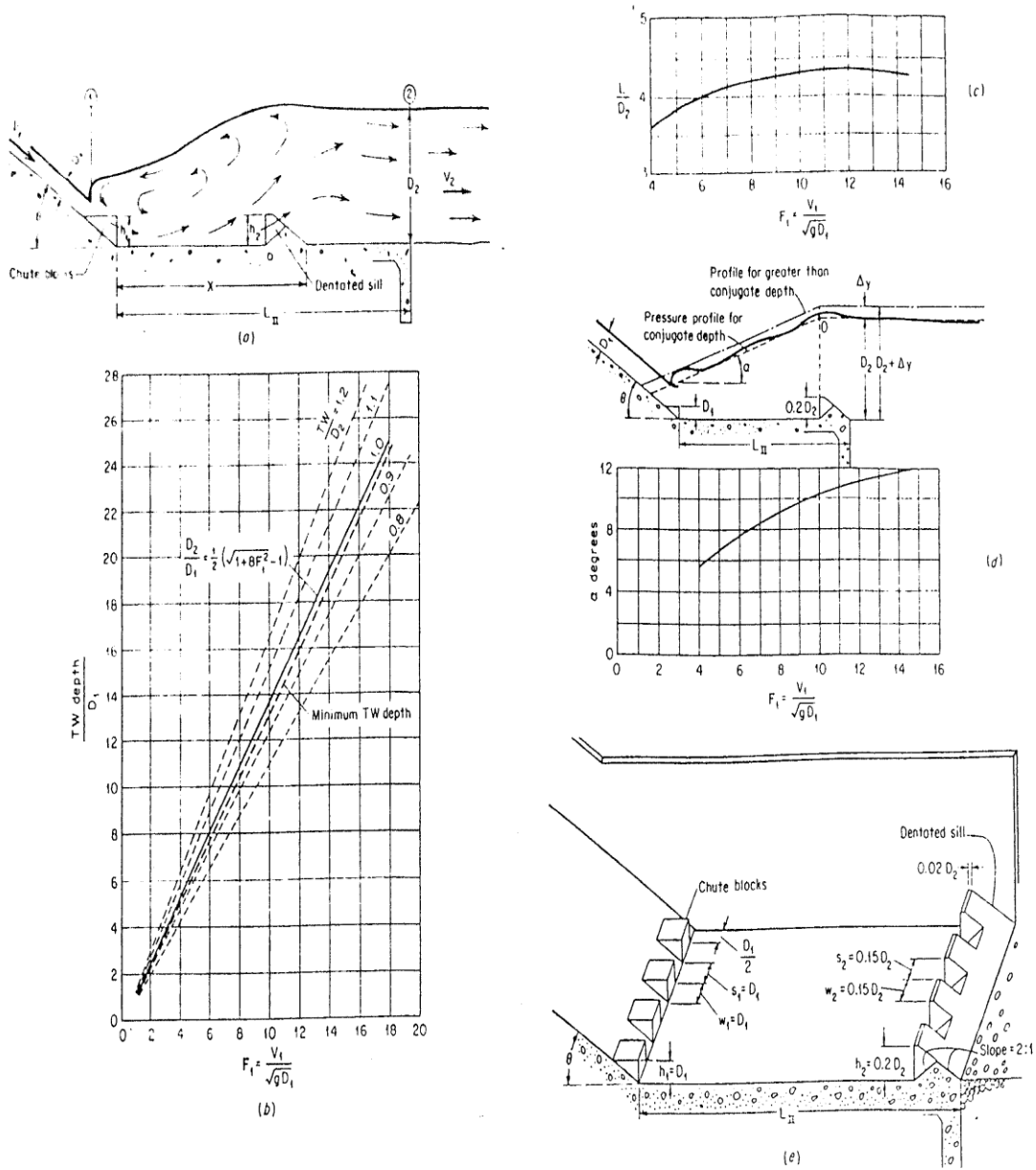


Fig. 14. Design curves and proportions of USBR basin II. (a) Definition of symbols; (b) minimum tailwater depths; (c) length of hydraulic jump; (d) approximate water surface and pressure profiles; (e) recommended proportions.

Fig.3: USBR Type II Stilling Basin.

Design Example

Proportion a USBR stilling basin Type II for the overflow spillway designed in previous example. The tailwater elevation is at El = 920.

Solution

Start the design from the Fig.13 with:

a head of $H_d = 17.7$ ft & a total fall $Z = 120$ ft

So, the actual velocity will be $V = 79$ ft / s (from the Fig.13)

So $A = Q / V = 75000 / 79 = 949.37$ ft²

But $A = b \cdot y_1$ or $y_1 = A / b = 949.37 / 250 = 3.797 \approx 3.8$ ft

So, $Fr = V / (g y_1)^{0.5} = 79 / (32.2 \times 3.8)^{0.5} = 7.13$

Now, from the (Fig.3 of USBR Type II Stilling Basin) with $Fr=7.13$ yields:

1- $T_w / D_1 = 9.7$ from the solid curve

So $T_w = 9.7 \times D_1 = 9.7 \times 3.8 = 36.9$ ft = $D_2 = y_2$

2- From the line of minimum T_w the figure gives:

$T_w / D_1 = 9.2$, So

$T_w = 9.2 \times D_1 = 9.2 \times 3.8 = 35$ ft

Note that this $T_w = 35$ ft now $\neq (D_2 = y_2)$, which is a very important note.

Now, for purposes design adding 8 % to this value the T_w will be:

$T_w = 35 \times 1.08 = 37.8$ ft ($> D_2$ and it is equal to $1.024 D_2$)

So, the EL. of the basin floor of the tailwater = $920 - 37.8 = 882.2$

Now, the length of the basin can be obtained by entering the curve in Fig. 3c with $Fr=7.13$. Thus,

$$***L/D_2 = 4.16 \text{ So, } L = D_2 * 4.16 = 4.16 * 36.9 = 154 \text{ ft}***$$

Also, the height, width and spacing of the chute blocks as recommended by the design of type II, will be such that:

$$***h_1 = W_1 = S_1 = D_1 = 3.8 \text{ ft (say 3 ft and 10 inches)}***$$

The height of the dentate sill is $0.2 D_2 = 0.2 * 36.9 = 7.38 \text{ ft}$

The width and spacing of the dentate is:

$$***0.15 D_2 = 0.15 * 36.9 = 5.54 \text{ ft}***$$