## Notes by-

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## Energy dissipators

* By creating hydraulic jump
* By using different types of buckets

**Hydraulic jump** :- When supercritical flow meets subcritical flow sudden and turbulent passage of water is created called as hydraulic jump.

It is most effective way of energy dissipation. But amount of energy dissipation depend on type of jump.

Types of jump depend on Froude number of the incoming flow

$$F_{1r} = \frac{V_1}{\sqrt{g y_1}}$$

$V_1$ = mean vel. before jump

$y_1$ - Prejump depth.

$F_1 = 1$ - critical flow no jump, but nil highly unstable flow.

$F_1 = 1$ to $1.7$ - undular jump 5%

$F_1 = 1.7 - 2.5$ - Weak Jump 20%

$F_1 = 2.5$ to $4.5$ Oscillating jump 25% 45%

$F_1 = 4.5$ to $9.0$ Steady jump 70%

$F_1 > 9$. strong jump 85%

**Jump height and tail water rating curves**

$$y_2 = \frac{y_1}{2}\left[\sqrt{1 + 8F_1^2} - 1\right] \longrightarrow (1)$$

$$F_1 = \frac{V_1}{\sqrt{g y_1}} \qquad V_1 = \sqrt{2g H_1}$$

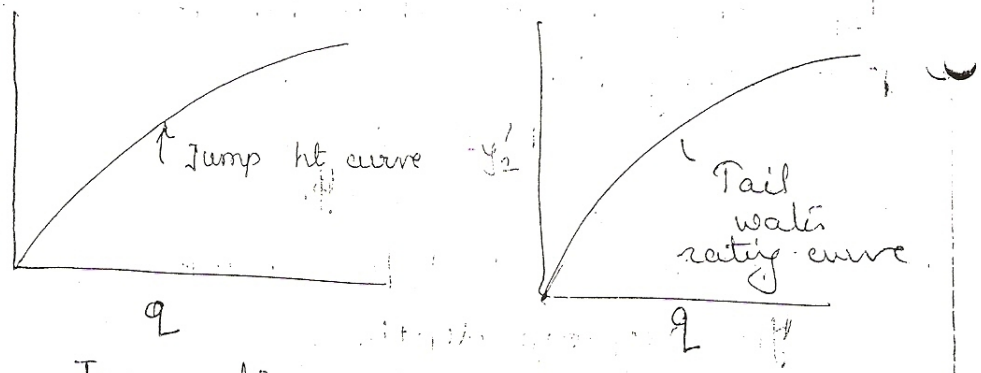
$$\boxed{y_1 = \frac{q}{V_1}}$$ q - discharge / unit length

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$\therefore$ $y_1$ is fixed for given value of q.

if jump should be developed for any value of q $y_2$ should be confirming to that value which eq$^n$ (1) gives.

Plot of $y_2$ Vs q calculated by eq$^n$ (1) is called jump ht. curve. (JRC)




Jump rating curve.

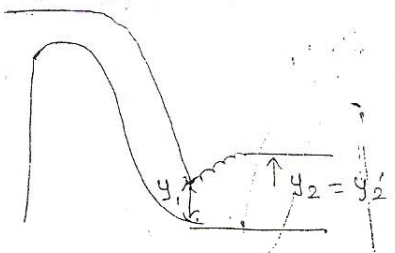
The actual tail water depth ($y_2'$) to any discharge intensity q may not be same as $y_2$ it will depend on hydraulic conditions d/s as well as channel on d/s side.

The plot of $y_2'$ (actual depth) for different values of discharges is called tail water rating curve (TWRC)

## Jump Location

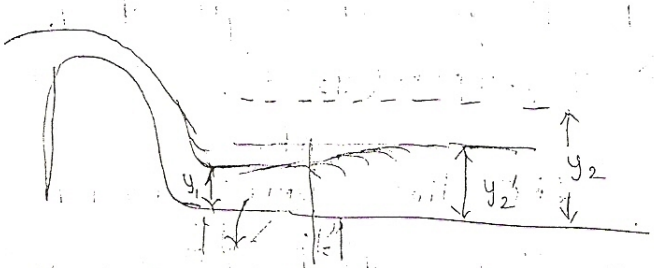
For given q & $y_1$ if jump is developed on d/s side, location of jump purely depends on $y_2'$ & $y_2$ (actual depth & sequent depth)

Case I : $y_2' = y_2$




ideal.

Case II $y_2' < y_2$

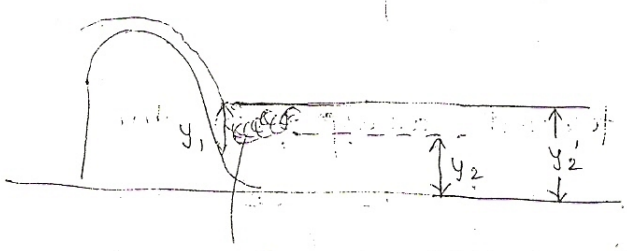



Severe erosion. Jump location

must be avoided

Case III

$y_2' > y_2$




Jump location but drowned or submerged.

must be avoided as no less energy dissipation.

Case IV This analysis is for given value of $q$. if $q$ varies $y_2'$ varies. and location of jump we have to carryout compritive study IRC & TWRC For this IRC & TWRC are plotted on same paper. According 5 conditions arise.

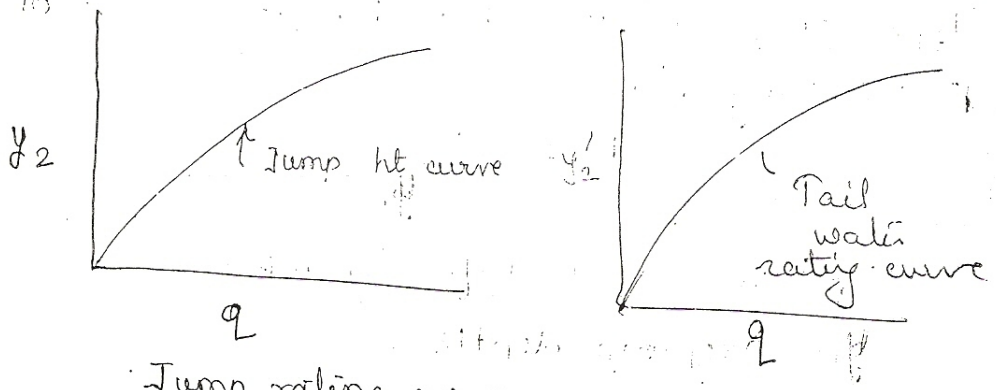
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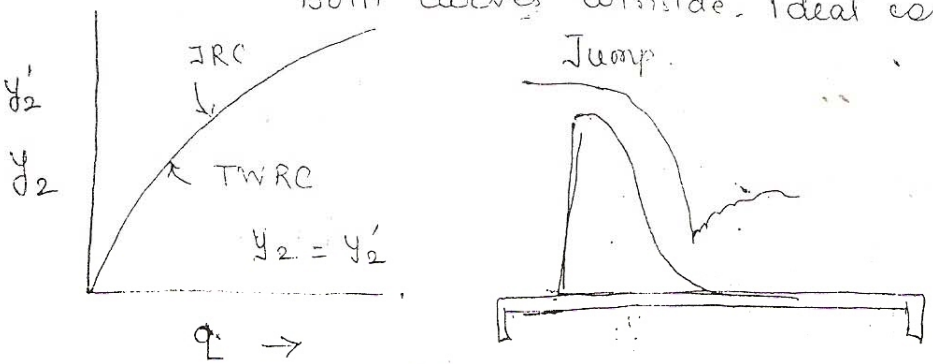
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## Comparitive study of IRC & TWRC

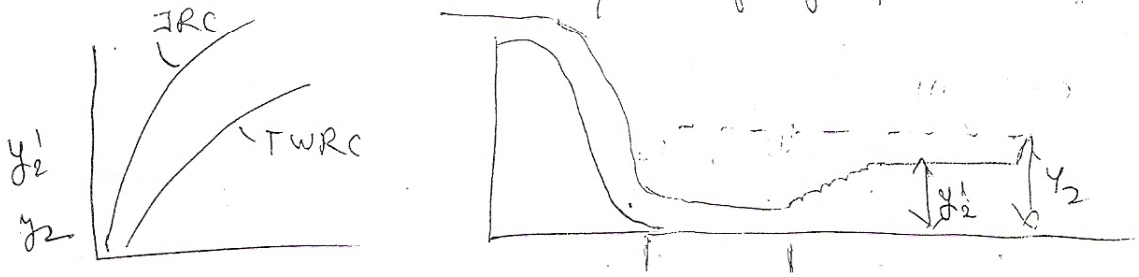
① **Condition I** for all q $y_2 = y_2'$

Both curves coinside. Ideal condition




Horizontal apron with length of apron equal to length of jump $= 5(y_2 - y_1)$

② **Condition II** IRC lies ~~below~~ above TWRC for all 'q'. Thus available tailwater depth is $y_2 > y_2'$ lesser than the depth required for jump

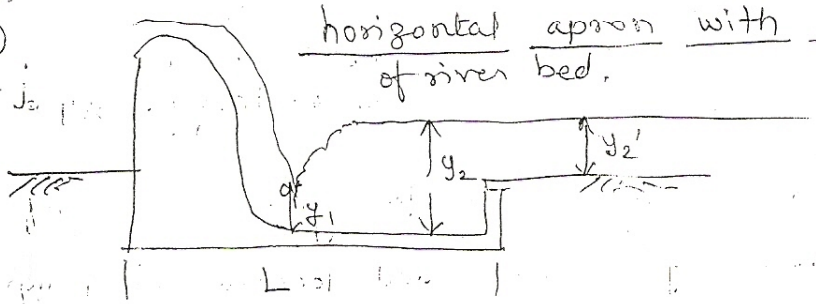



Jump will be formed away from toe.

**protection** - Jump should be at toe.

tail water depth is increased by

① horizontal apron with excavation of river bed.



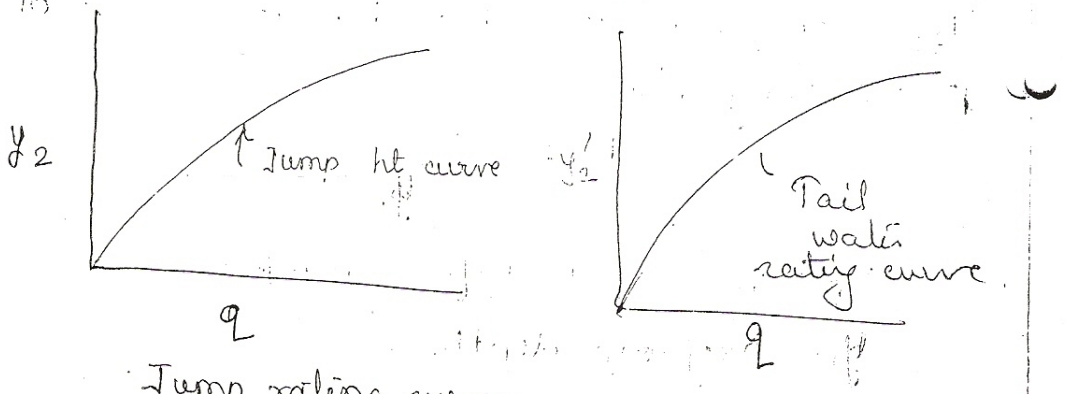

L should be such that for all q jump occurs within the stilling basin.

$$y_1 = \frac{q}{V_1}$$ q - discharge / unit length

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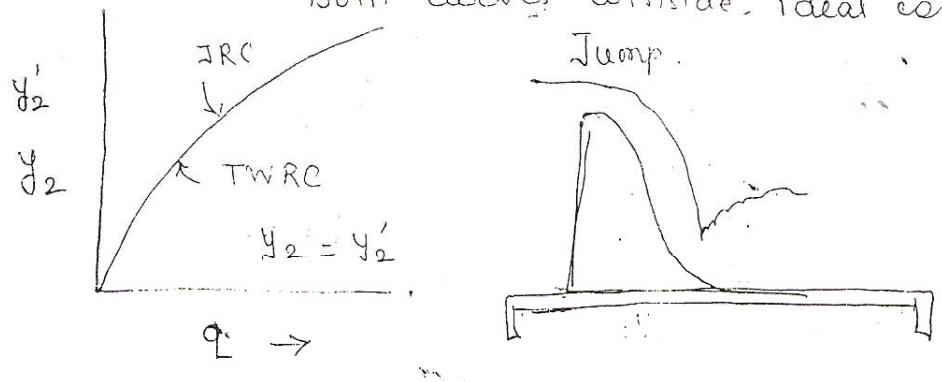
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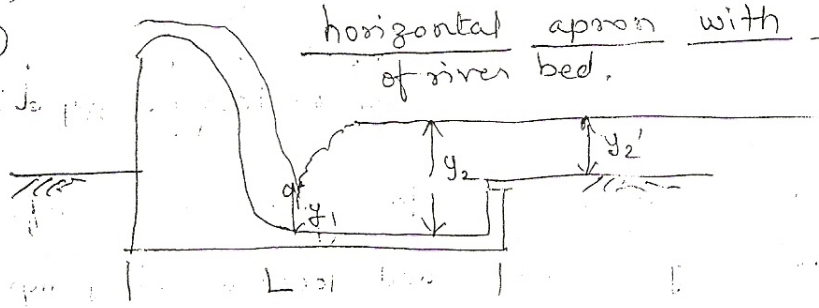



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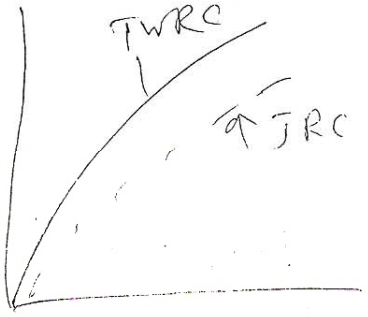
① horizontal apron with excavations of river bed.

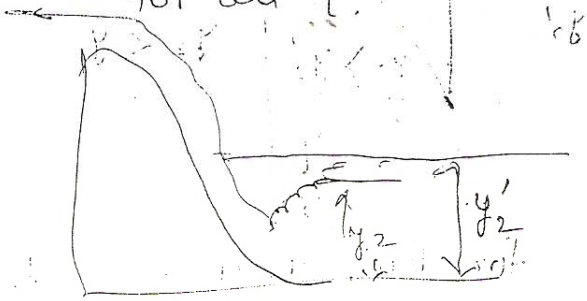



L should be such that for all q jump occurs within the stilling basin.

(2) Stilling basin by providing baffles or end sill
length of stelling basin should be such that jump occurs within basin for all $q_{in}$

3) Condition III - JRC lies below TWRC for all $q$.

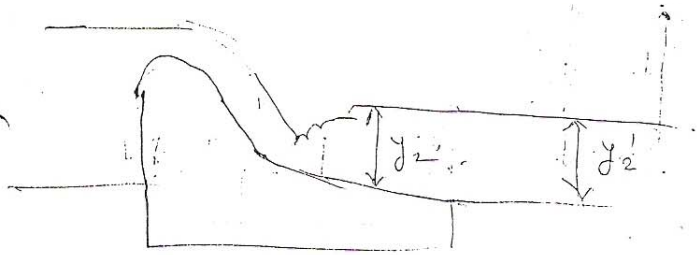


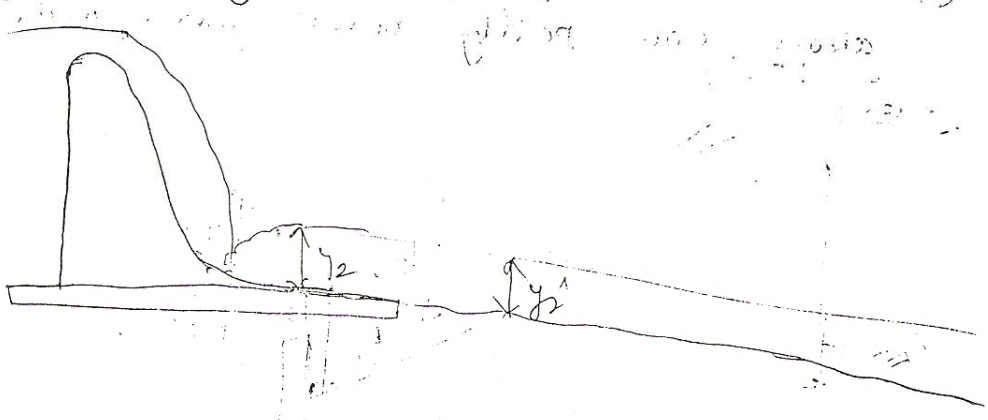

Tail water $y_2 < y_2'$ jump drowns and no energy dissipation.

protection works

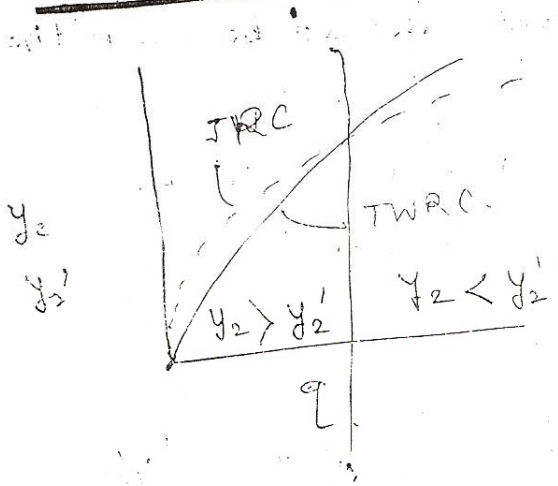
(1) Provide sloping apron over river bed




(2) By providing drop in river bed



## Condition 4.

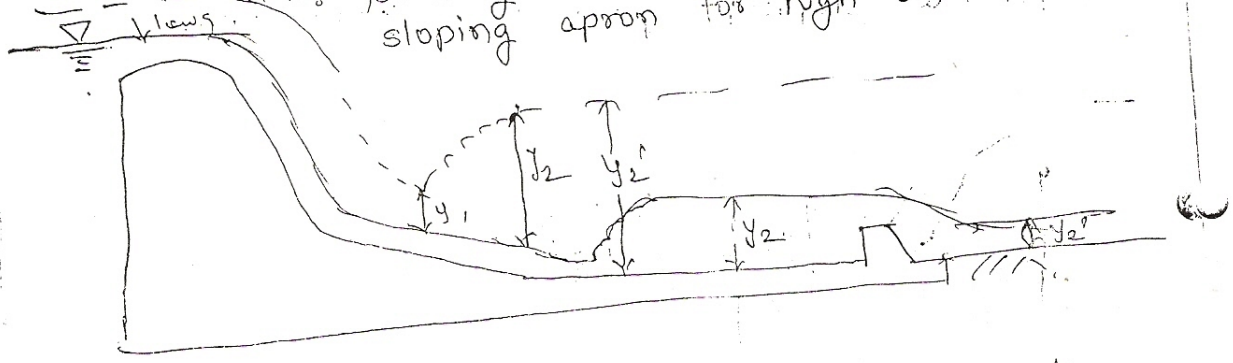



for low discharges $y_2 > y_2'$ jump occurs far away.

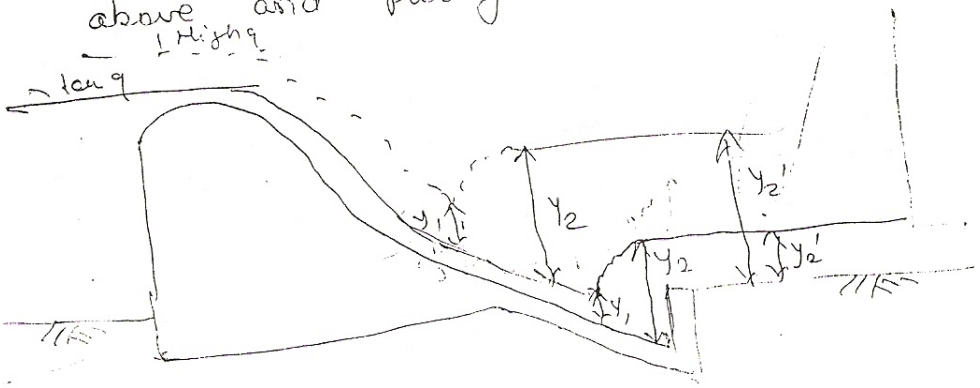
for high discharges $y_2 < y_2'$ jump drowned.

protection work:

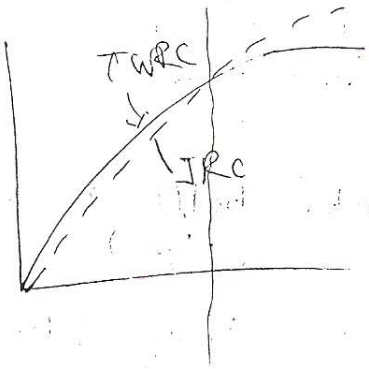
1) ~~Sloping apron from d/s of spillway~~
   - High → stilling basin for low disch.
   - low → sloping apron for high disch.




(2) provide sloping apron which lies partly above and partly below river bed.



Conditions : IRC

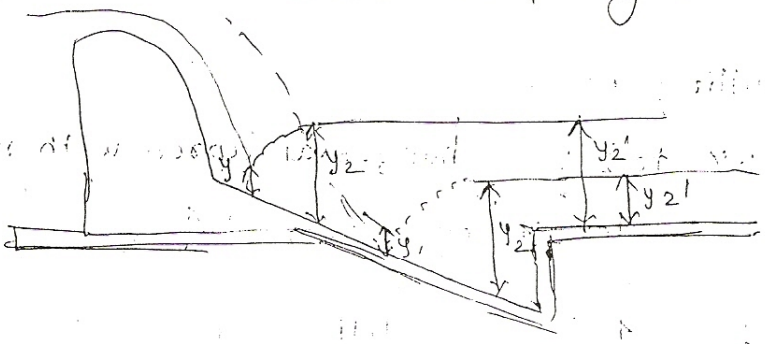



for low discharges
for high discharg

low q $y_2 < y_2'$ jump drawn

hig q. $y_2 > y_2'$ jump occurs far away

protection ① By sloping apron partly below and partly abov river bed.




② " stilling basin with baffles
low disch less troublesome

* Too expensive
* not effective in stabilizing jump
* Stilling basin designed

## Stilling Basins

- Structure in which Hydraulic jump used for energy dissipation is confined partly or entirely.

Accessories - chute blocks, baffle blocks (floor) or sills. end sills.

to reduce length of jump & cost of stilling basin. also improve dissipation action and stabilize the jump.

Type of stilling basin → type of hydraulic jump

$F_1$

USBR stilling basins

① $F_1$ = 1.7 to 2.5 - horizontal apron with no accessories. length of apron $5(y_2)$.

② $F_1$ = 2.5 - 4.5 - stilling basin type I (oscillating jump) chute blocks optional end sill.

| $F_1$ | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| $4\ y_2$ | 4.3 | 5.3 | 5.8 | 6. |

To dampen the waves of oscillating jump floor of basin should be such set that $y_2$ in the basin is 10% > $y_2$

$F_1$

$4/y_2$

$h_3/y$

$h_4/y$

(6)

③ $F_1 > 4.5$ (Stable, well balanced jump)

ⓐ $V < 15$ m/s. Type II stilling basin

chute blocks
baffle blocks
end sills

| $F_1$ | 5 | 6 | 8 | 10 | 12 | 14 | 16 |
|---|---|---|---|---|---|---|---|
| $4/y_2$ | 2.3 | 2.5 | 2.6 | 2.7 | 2.8 | 2.8 | 2.8 |
| $h_3/y_1$ | 1.5 | 1.7 | 2.0 | 2.3 | 2.7 | 3.0 | 3.3 |
| $h_4/y_1$ | 1.2 | 1.3 | 1.5 | 1.6 | 1.7 | 1.8 | 1.9 |

$y_1$ - initial depth $y_2$ - sequent depth

L - considerably reduced by.
dissipation - hydraulic jump
impinging action of incoming flow against these blocks.
Baffle blocks should by properly anchored.

ⓑ $V > 15$ m/s. Type III stilling basin

chute blocks.
dentated end sill.
No baffle blocks

high impact of velocity
-ve pressure on dissipation
length less than type I

| $F_1$ | 5 | 6 | 8 | 10 | 12 | 14 |
|---|---|---|---|---|---|---|
| $4/y_2$ | 3.85 | 4.0 | 4.2 | 4.3 | 4.3 | 4.3 |

Floor of basin is so set that TWD. is 5% greater than $y_2$ to check sweeping jump.

## IS stilling basins IS 4997 : 1968

(1) Stilling basins with horizontal apron
(2) Stilling basin with sloping apron.

I] With horizontal apron :- For IRC ≅ TWRC

① IS stilling basin type I
② IS stilling basin type II

① IS stilling basin type I :- $F_1 < 4.5$ weirs & barrages. chute blocks, basin / baffle blocks, or dentated end sills.

- Type I USBR - size, spacing, and location of chute blocks.

- Type II USBR. ht & top thickness of baffle (2)
  ht. of block = width & spacing of baffle block

- size of dentated end sill - Type III USBR (1) (2)

Length L

| $F_1$ | 2 | 3 | 4 | 4.5 |
|---|---|---|---|---|
| $L/y_2$ | 3.15 | 4.0 | 4.75 | 5.0 |

② IS stilling basin II $F_1 > 4.5$ medium & high dams chute blocks, baffle blocks, dentated end sill

if $V_1 < 15$ m/s baffle blocks are provided otherwise no.

~~floor of basin~~
$> 15$ m/s no baffle blocks. floor of basin kept at depth = $y_2$ below TWRC.

* size, spacing, location - Type II or Type III USBR of chute block.

* size spacing and location of the basin blocks.

— Type II USBR

* dentated end sill — Type III USBR

| L | | | | | |
|---|---|---|---|---|---|
| $F_1$ | 5 | 6 | 8 | 10 | 12 |
| $L/y_2$ | 2.9 | 3.2 | 3.7 | 3.9 | 4.0 |

(2) Stilling basin with sloping apron

when $y_2'$ is very large compared $y_2$

$$y_2' >> y_2$$

① Is stilling basin Type III (TWRC above TRC for all q) — sloping apron for ending

② Type IV

TWRC $\gg y_{2c}$ for maxi q.

$\geq y_2$ low dis.

partly sloping & partly horizontal apron.

Both these are provided with solid or dentated end sill.

## Bucket Type Energy Dissipators

It consists of upturned bucket provided at the toe of the spillway to deflect water flowing over spillway.
Used in case of only overflow spillway. Economic if $F_1$ exceeds 10 because $y_1$ & $y_2$ are differed by very large for which very large and long stilling basin will be required. Stiff rock bed river Can be used for any tailwater conditions.

1) Solid roller bucket
2) Slotted roller bucket } tail water depth too large ~ $y_2$,
3) Ski - jump (flip - trajectory)

Solid - slotted Bucket - remain submerged in water also called as submerged bucket

### Solid Roller

Concave circular profile of large radius and deflector lip. Water leaving bucket lip forms two elliptical rollers.



① On the surface of bucket anticlockwise (Bucket Roller)
② other on ground surface clockwise (ground roller)

dissipation of energy

* loose material may get deposited in bucket
* erosion of d/s river bed.

### Slotted roller Bucket

:- A bucket like apron with a concave circular profile of large radius. but it has a slotted deflector lip.

It overcomes the deposition of material

inside bucket
small discharge - two rollers
large discharge - three

## Ski - Jump Bucket :-

Tailwater depth is less than IR depths and river bed is stiff rock.

## Spillway Gates

1) Flashboards (1) temporary (2) permanent
2) Stoplogs and Needles
3) Vertical lift gates
   - (1) sliding gates
   - (2) fixed wheel gates
   - (3) slonley gates
4) Tainter gates or radial gates
5) Roller gates / Rolling gates
6) Drum gates
7) Bear Trap gates

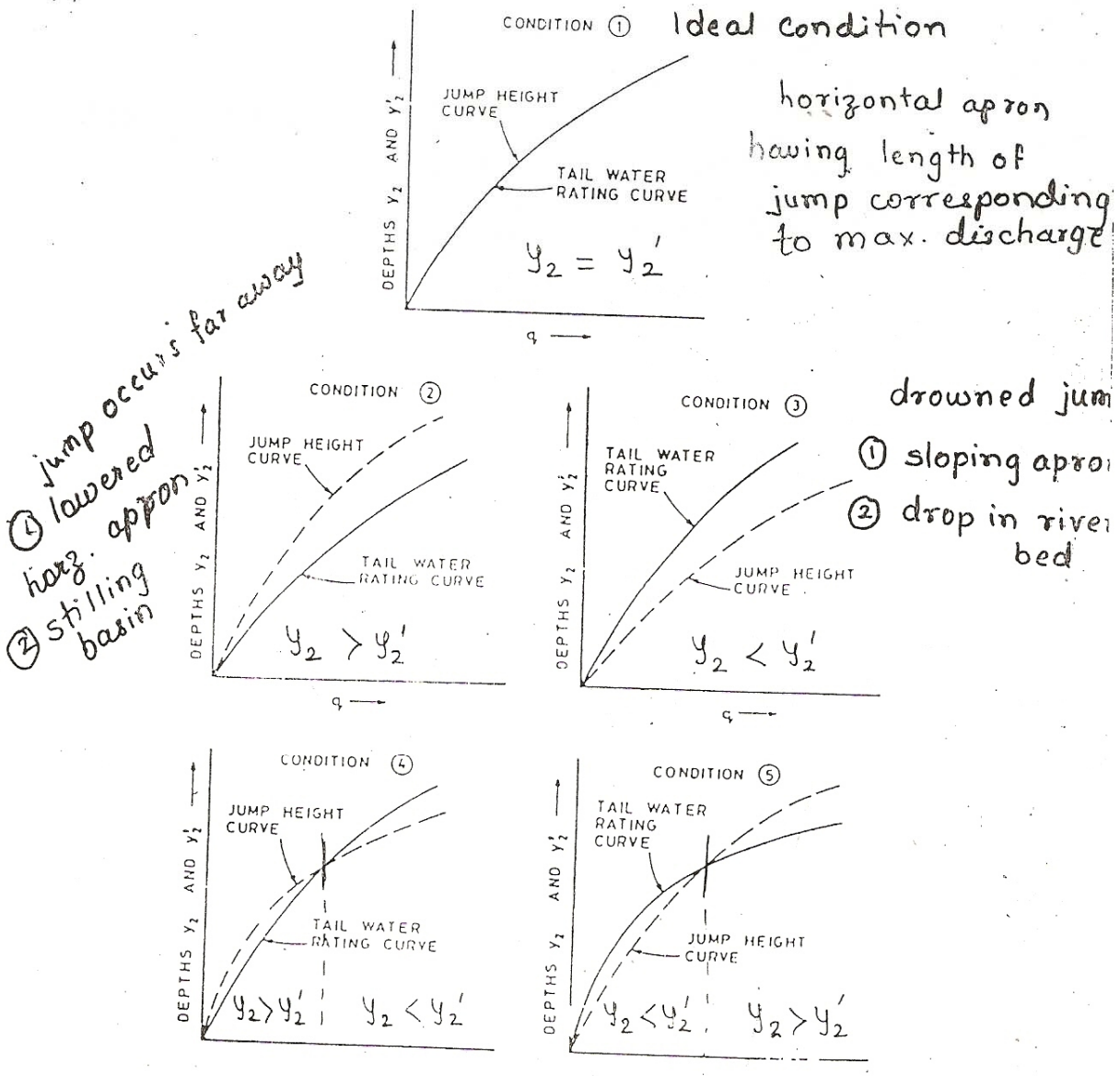



Fig. 12·26 Tailwater conditions for the design of scour protection works.

low dis --- jump occurs far
high Q ---- jump is drowned

① stilling basin with sloping apron
② sloping apron partly above ~~partly below the river bed~~

low Q - jump is drowned
high Q - jump occurs far

① sloping apron partly under river bed
② stilling basin

14. Students are permitted to use calculators but programmable calculators are not allowed in the examination.

*CANAL OUTLET :- Outlet is a device through which water is released from a distributing channel into water course or field channel. A part of head regulator for a water course which supplies water to the field. It is also a connecting link between the field govt. staff & cultivators who use water. Discharge through an outlet is less than 0.085 cumecs usually.

* REQUIREMENTS OF GOOD OUTLET :-

(i) It should be simple in design, construction & working.

(ii) It should not be easily tampered by the cultivator & if tampered should be detected easily.

(iii) It should perform best for even less working head.

(iv) Outlet should draw its fair share of silt from parent channel.

(v) It should be strong with no movable parts which are susceptible to damage & require periodic attention & maintenance.

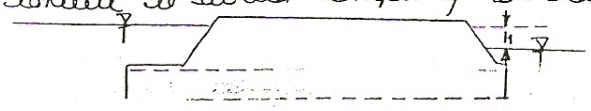
(vi) From cultivator point of view. It should work & give constant discharge for any head. But from distributor point of view it draw proportionally less or more discharge with varying supply in distributary channel.

(vii) Cost of the outlet should not be high.

* TYPES OF OUTLETS :-

| (A) NON-MODULAR | (B) SEMI-MODULAR Semi Modulus flexible Modules. | (C) MODULAR OUTLETS (Rigid Modules Modules). |
|---|---|---|
| (i) Q depends on difference between point of offtaking field channel & difference between water levels of parent channel & field channel. | (i) Q varies with variation of the water level in the distributing channel but is independent of water level in field channel as water course provided min working head is available. | (i) With reasonable working limits outlets maintain constant discharge irrespective of variation of the water level of parent as well field channel water course. |

(A) NON-MODULAR OUTLETS :- It is just a rectangular or circular opening with a pavement at submerged pipe. Fig shows submerged pipe outlet. Pipe is laid on light concrete foundation to prevent uneven settlement and consequent leakage. Pipes are horizontal and ⊥ᵉ to centerline of distributing channel. Inlet and exit are fixed in concrete to avoid tampering. Discharge through pipe outlet.



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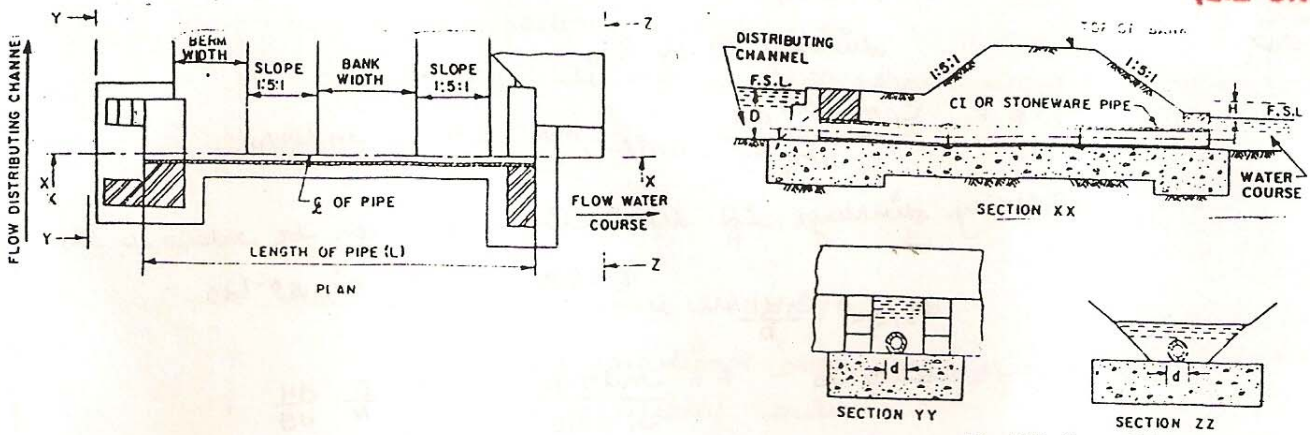



Fig. 18.1 Pipe outlet

H = entry loss + (exit loss) + residual velocity head @ exit + frictional loss.

$$H = 0.505\frac{V^2}{2g} + \frac{fLV^2}{2gd} + \frac{V^2}{2g}.$$

where V = velocity through pipe.
L = length of pipe
d = dia of pipe
f = coeff of friction
g = gravitational constant.

$Q = A \cdot V$

where $V = \sqrt{2gH}\left[\frac{d}{1.5d + fL}\right]^{0.5}$

$$Q = A\sqrt{2gH}\left[\frac{d}{1.5d + fL}\right]^{0.5}$$

A = area of Cs of pipe.

In other words.

$Q = C A \sqrt{2gH}$. where C - coeff of discharge which depends on friction factor, L & d.

$$C = \left[\frac{d}{1.5d + fL}\right]^{0.5}$$

if H is max Q is max.

* Advantage of non-modular outlets is that they can work with very small available heads.

* Drawbacks :- (i) Q depends on difference between water levels of distributing channel and water course and hence it varies with change in level of any channel.

(ii) Discharge capacity unpredictable since proper and equitable distribution of water is very difficult.

(iii) Cs. ration of distributing channels, outlets will vary with max discharge, whereas may failed, hence damage.

(B) SEMI MODULAR OUTLETS :- Behaviour of semi-modular and modular outlets the following terms are used.

* (i) FLEXIBILITY :- $F = \frac{(dq/q)}{(dQ/Q)}$

where F = flexibility, q = discharge through the outlet
Q = discharge of the distributing channel

H = head acting on outlet

then $q = CH^n$ — (i) where C = Constant & n = outlet index

differentiating $dq = q_m H^{m-1} dH$ ——— ②

dividing ② by ①.

$$dq/q = \frac{C_1 m H^{m-1} dH}{C_1 H^m} = m H^{-1} dH = m dH/H.$$

similarly discharge in distributing channel can be related to its depth.

$$Q = CD^n \qquad dQ = Cn D^{n-1} dD.$$

$$\therefore dQ/Q = \frac{n dD}{D}$$

the flexibility is $F = \frac{m dH/H}{n dD/D} = \frac{m}{n} \frac{D}{H} \frac{dH}{dD}$

the change in depth of distributing channel will show equal change in H.

$$\therefore dD = dH.$$

$$\therefore \boxed{F = \frac{m}{n} \frac{D}{H}.}$$

A semi-modular outlet or semi-module possess flexibility then it is called as flexible whereas modular outlet flexibility=0 then it is called as rigid module.

* (ii) PROPORTIONALITY :— If flexibility =1 then outlet is called as proportional outlet.

Thus for proportional outlet rate of change of discharge of the outlet is equal to the rate of change of discharge of distributing channel.

$$F = \frac{dq/q}{dQ/Q} = 1 \qquad \frac{dq}{q} = \frac{dQ}{Q}, \quad F = \frac{m}{n} \frac{D}{H} = 1 \qquad \boxed{\frac{H}{D} = \frac{m}{n}}$$

The ratio $\frac{H}{D}$ is called as setting ratio of depth of the crest level of outlet below F.S.L of distributing channel to full supply depth of distributing channel.

$$\therefore \text{for proportional outlet setting} = \frac{m}{n} = \frac{\text{outlet index}}{\text{channel index}}$$

For a wide trapezoidal channel with slope 0.5:1 $Q \propto D^{5/3}$ (approx)

$$\therefore n = 5/3.$$

For an orifice type outlet $q \propto H^{1/2}$, $m = 0.5$, $F = 0.5/5/3 = \frac{3}{10} = 0.3$.

outlet will be proportional if $H = 0.3D$.

$F > 1$ hyperproportional outlet

$\frac{m}{n} \frac{D}{H} > 1$ discharge of distributing channel changes by certain percentage

$\frac{m}{n} > \frac{H}{D}$ this discharge of outlet changes by larger proportion.

$$\boxed{\frac{H}{D} < \frac{m}{n}}$$

so for hyperproportional outlet setting is less than $m/n$

F<1 supersepaultional outlet

$dq/q < dQ/Q$ discharge of dist channel changes by certain % ge than Q of outlet change by small % ge.

$F<1 \quad \frac{m}{n} \frac{D}{H} < 1 \quad \frac{m}{n} < \frac{H}{D}$ $\boxed{\frac{H}{D} > \frac{m}{n}}$

Value of setting is more than m/n.

for hypersepaultional outlet setting is more than sepaultional outlet
for subsepaultional outlet setting is lower than sepaultional outlet.

*(iii) SENSITIVITY :— Ratio of change of discharge of an outlet to the rate of change in the level of the water surface in the distributing channels. referred to normal depth of the channel.

Gauge be provided for distributing channel which is set to zero when discharge through outlet is zero.

q be the reading on gauge when discharge through outlet is Q

$$S = \frac{dq/q}{dQ/D}$$

where S = sensitivity of outlet.
q = discharge through outlet.
dq = change in discharge through outlet.
dq = change in gauge reading
D = depth of flow in distributing channel.

For a given size or full Q there is large change in discharge of outlet, larger is sensitivity

For rigid module $dq = 0$. sensitivity = 0.

$$F = \frac{dq/q}{dQ/Q} = \frac{dq/q}{n\,dD/D} \qquad F = S/n \Rightarrow \boxed{S = nF}$$

*(iv) EFFICIENCY :— Ratio of head recovered to head lost in means of conveyation of head.

*(v) DRAWING RATIO :— Ratio between the depth of water level on the upstream and d/s & u/s side of the outlet.

*(vi) MINIMUM MODULAR HEAD :— Minimum head required for the function of an outlet min Modular loss.

*(vii) MODULAR LIMITS & MODULAR RANGE :— The Modular limits are the upper & lower of any of main factor beyonds which a module as semi-module ceases to function as a module or semi module.

range of various factors within which module or semi-module works as designed.

*(viii) ADJUSTABILITY :- Capacity for modification of the outlet to take into account changed condition such as silting or growing of the distributing channels. Necessity to increase or decrease outlet discharge due to a change in the command

TYPES OF SEMI-MODULAR OUTLETS :-

(i) PIPE OUTLET
(ii) KENNEDYS GUAGE OUTLET
(iii) OPEN FLUME OUTLET
(iv) ORIFICE SEMI MODULE

*(i) PIPE OUTLET :- If pipe outlet is set in such a way that it discharges fully in atmosphere, the discharge through it becomes independent of water level in water course. $Q \propto \sqrt{H}$. The outlet is proportional if it is set at 0.30 m depth below the water surface in the distributing channels, however pipe outlet is generally set lower than this hence it become subproportional efficiency is high, silt condition is good.

*(ii) KENNEDY'S GUAGE OUTLET :- Kennedy (1906)

* mouth-iron bell mouthed orifice for entry.
* from orifice jet of water discharge into a chamber. to which a vertical vent pipe is connected which is in touch with air below. Vent pipe extends above the water level in the distributing channel and thus allows free circulation of air around jet. This arrangement enables jet to flow as if it is flowing fully in atmosphere air and make discharge independent of its condition.

After leaving air chamber jet enters in expanding pipe connected to the air chamber, having dia slightly larger than orifice. Expanding pipe is usually 3m long. [Cast iron or sheet steel as per] conical pipe extension is added through which water is discharged into the water course. $Q = C_d \sqrt{2gH_0}$

where $H_0$ = dist from centre of orifice to water surface level of distribution chamber.

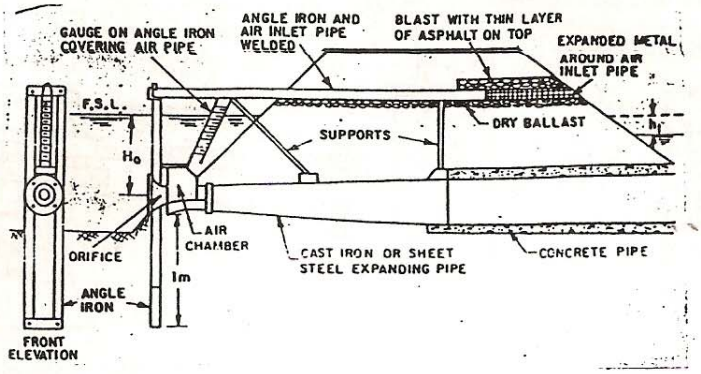
Loss due to friction, eddies is about $0.22H_0$ hence minimum working head. $H = WL$ in distributing - WL in RE channel.

$H \geq 0.22 H_0$

As long as this condition is satisfied Q is calculated by above eqn whether

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outlet is submerged or not.




* DRAWBACK :- This outlet can easily tampered by closing all vents of air pipe. Irrigation Kennedy 1915 introduced a "Modified and tamper proof Gauge Outlet" But its tampering was possible and its high cost all this type of outlet.

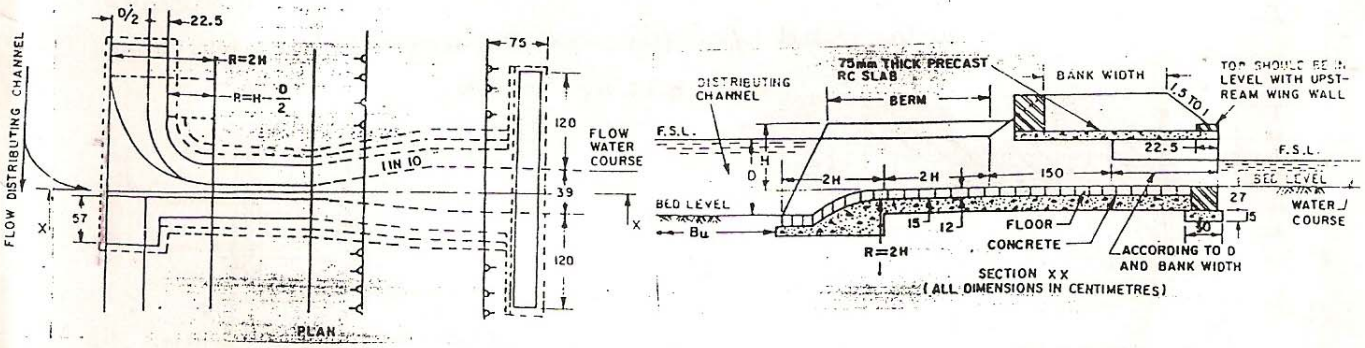
* (iii) OPEN FLUME OUTLET :- (PUNJAB) :-

(i) smooth well with constricted throat to ensure hyper critical velocity.

(ii) length of throat is such that controlling section remains within its throat at all discharges.

(iii) A gradually expanding flume is provided below its throat to ensure formation of hydraulic jump in this portion and thus obtain max recovery of head. The formation of hydraulic jump makes its discharge through outlet independent of water level of water course.

Entire work on brick masonry but except controlling section is provided with RCC bed & check walls.




discharge through open flume outlet

$Q = K B_t H^{3/2}$

$B_t$ = width of throat.

H = HI of water surface to floor of outlet

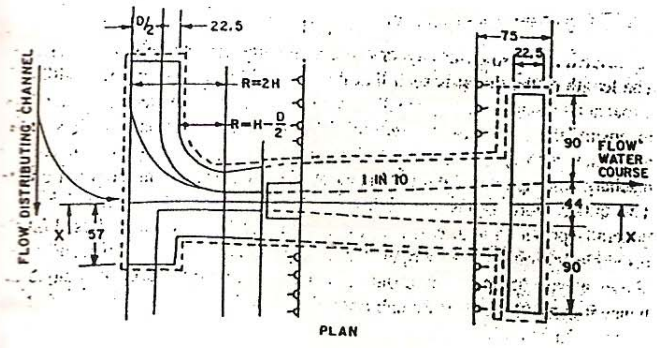
k = coeff of discharge

| Throat width | K |
|---|---|
| 0.06m to 0.09m | 1.60 |
| 0.09m to 0.12m | 1.64 |
| over 0.12m | 1.66. |

outlet will be proportional if throat is @ 0.9 times D. higher than this hyperproportional.

lower than this - super proportional.

0.06 = Bt min value to avoid choking.



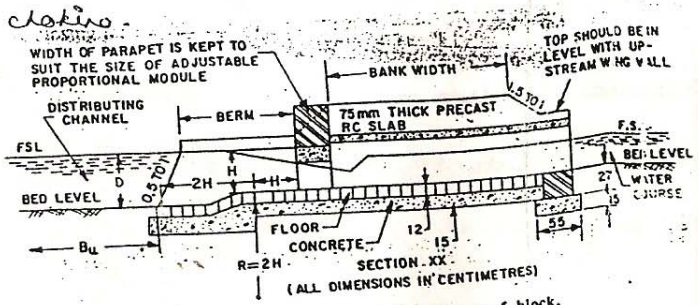




Fig. 18·4. Open flume outlet with roof block.

* DRAWBACKS :- · open flume outlet are not easily adjustable, To change discharge dismantling is required.

*(iv) ORIFICE SEMI - MODULE :- · Orifice provided with a gradually expanding flume and a sill. Flow through orifice is supercritical which results in the formation of hydraulic jump in expanding flume.

* Crumps adjustable proportional module (Crumps A.P.M.)

* Adjustable orifice semi module (A·O·S·M)

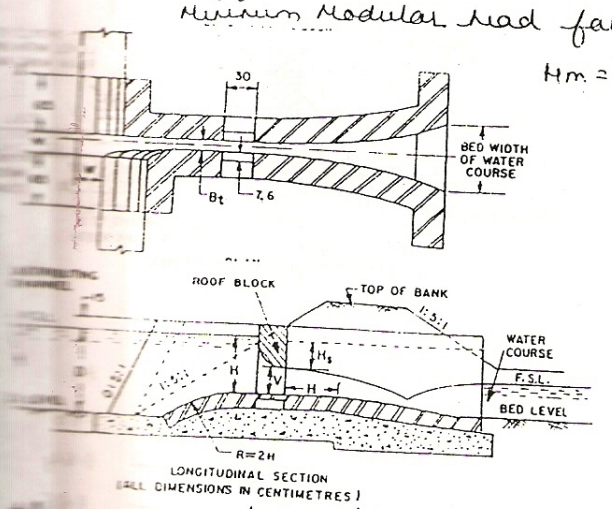
A·O·S·M :- It consists of a cast iron roof block a cast iron base plate and check plate.

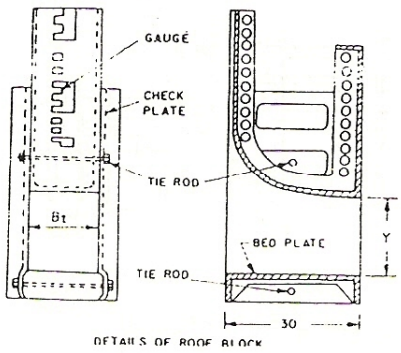
$$q = 4.03\, Bt\, Y \sqrt{Hs}.$$ Bt - width of orifice

Y = H of the orifice at smallest section in m, Hs = head measured from the water surface in the distributing channels to the lowest point of the roof block in m

Minimum Modular head for this outlet is given by

$$Hm = 0.82\, Hs - 0.5\, Bt.$$




USAGE :- · * can be conveniently at adjustable @ small cost * tampering is easily detected.

* TYPES OF MODULAR OUTLETS OR RIGID OUTLETS :- Rigids modules are outlets when discharge is constant & independent of water level of both channels. *Ex. the module where

$F = dq/q / dQ/Q = 0$ means $dq = 0$. Here they are not varying, here the flow is rigid. Many of the rigid modules have moving parts which are generally expensive & lead to failure as require periodic maintenance. Hence these outlets are not very popular because of the cost & maintenance.

Two common types of rigid modules which do not have moving part are as follows.

(i) GIBB'S MODULE:- (i) Evolved by A.S. Gibbs, (ii) Bell mouthed inlet pipe & its is laid in the eddy chamber through the sides pipe in which full water flow is developed.

(iii) In water flow for any filament product of $V \times i$ = Constant.

(iv) In eddy chamber a no of baffles are provided in such a way that it is fixed suspended from roof & their lower ends sloping against the direction of flow.

(v) water bank in @ outlet fall, collides on baffles are round between two successive baffle and finally drops on the ascending stream of water thus dissipating excess energy and keeping the discharge as constant.

$$q = s_0 \sqrt{2g} (d_4 + h_0)^{1.5} \left\{ \frac{m^2-1}{m^3} \log_e m + \frac{1}{m} (\log_e m) - \frac{m^2-1}{2m^2} \right\}.$$

where $q$ = discharge of outlet, $s_0$ = radius of outlet circumference of eddy chamber, $s_4$ = inner radius circumference of eddy chamber, $m = s_0/s_4$, $d_4$ = depth of water @ inner circumference, $h_0$ = head of water at outlet circumference. This formulae is applicable for $m = 2$, $h_0/D = 1/7$ where $D$ = min water level in distribution channel & flow of eddy

* DRAWBACK:- Silt condition of chamber. Gibbs module is however not good and also the outlet is comparatively costly.

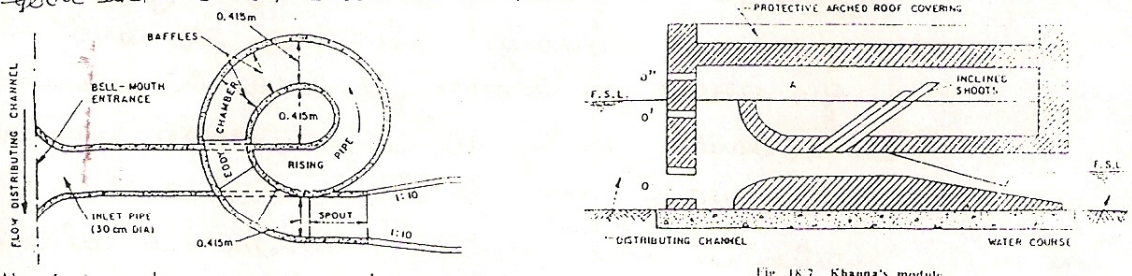



Fig. 18.7 Khanna's module

(ii) KHANNA'S MODULE:- (i) It is same as Gibbs semi-modular outlet except two ranges of inclined shoots. (ii) Prime aim of rigid module is to keep discharge constant (iii) In addition to main opening orifice there are two small openings 0', 0'' situated at higher levels than main openings (iv) upper openings is at level which joins a chamber in which the inclined shoots are situated at the different levels & slope 1:2. (v) Shoots have roofing since silt carrying is present (vi) If canal supply level outlet behaves as semi module (vii) Even if shoots are choked, outlet behaves as semi module Not commonly used.