BANGLADESH WATER DEVELOPMENT BOARD

GUIDELINE FOR DESIGN OF A REGULATOR (1 VENT)

PREPARED BY: DESIGN CIRCLE-8, BWDB.

Design Procedures of A Regulator

Definition of A Regulator:

Hydraulic structure constructed to control/regulate the flow of water.A drainage regulator is usually Constructed at outfall of a khal for drainage purpose from an area.

Types of Regulator:

1)Based on purpose:

a.Drainage Regulator

b.Flushing Regulator

c.Drainage cum Flushing Regulator

2)Regulator Based On Location:

a)Outfall Regulator: Located at outfall of a khal/river
b)Head Regulator: Located at starting point of an irrigation canal
c)Cross Regulator: Located at Intermediate point.

Design of A Regulator

Steps:-

1)Hydrologic Design

2)Hydraulic Design

3)Structural Design

4)Foundation Design

1)Hydrologic Design:

In Hydrologic design,the things to be finded at

a)Design ‘Q’

b)Design head ‘H’

c) Number and size of vents.

a)Design’Q’

Amount of water to be passed through the regulator would be found in this step.To calculate ‘Q’ the methods described below are used.

i)C.I.A method

Q=C.I.A[‘Q’in cfs]

‘C’=Constant and the value is 27

‘I’=intensity of rainfall(inch/day)

‘A’=Area(sq.mile)

(C=27 means that if 1inch rainfall excess passes over 1sq.mile then discharge Q will be 27cfc).We use 10 days,10 years recurrence period.(Reference:CIDA1987,Page vi-13)

The other methods are:

#IECO method

#Drainage method

These methods are described in CIDA manual 1993

Page:4-1,4-2,4-8,4-9

ii)Design ‘H’(head)

To calculate design ‘H’ the facts described below should be considered.

>5%-7% of the cothchment area to be remain inundolea

>For beels which water be drained 2 water must be remained for maintaining ecological balance.

>Beels shall not be completely drained

>For rural area as well as for irrigation purpose 72 hours of retention of water is allowed.

To find the design ‘H’a graph used described in CIDA manual 1993 page 4-88,figure 8-11.For using this graph two parameters should be known-height and width of regulator and design ‘Q’.

Normally we use=Arg Ground level+ft(0.3m)

iii)No and size of vents

a)Lump sum attemption:BWDB selected nominal size

(>For Tidal area-3.35 sq mile>iv(1.5*1.8)

>For Non-Tidal:5 sq mile>iv

Ref)

From monograph described at page VI- 14,we can find capacity ‘Q’ per vent ;Therefore number of vents=Design”Q”/”q” obtained from monograph.

The other methods are: #IECO Method

#Drainage Method

These methods are described in CIDA manual 1993, page: 4-1,4-8, 4-9.

Design”H”

To calculate design “H” the facts described below should be considered.

-5%-7% of the catchment area to be remained inundated.

-For beels which waterto be drained; 2feet water must be remained to maintain ecological balance. Beels shall not be fully drained.

- For rural area as well as for irrigation purpose 72 hours of retention of water is allowed.

To find Design”H” a graph used described in CIDA manual 1993, page-4-88, figure 8-11. For using this graph two parameters should be known:

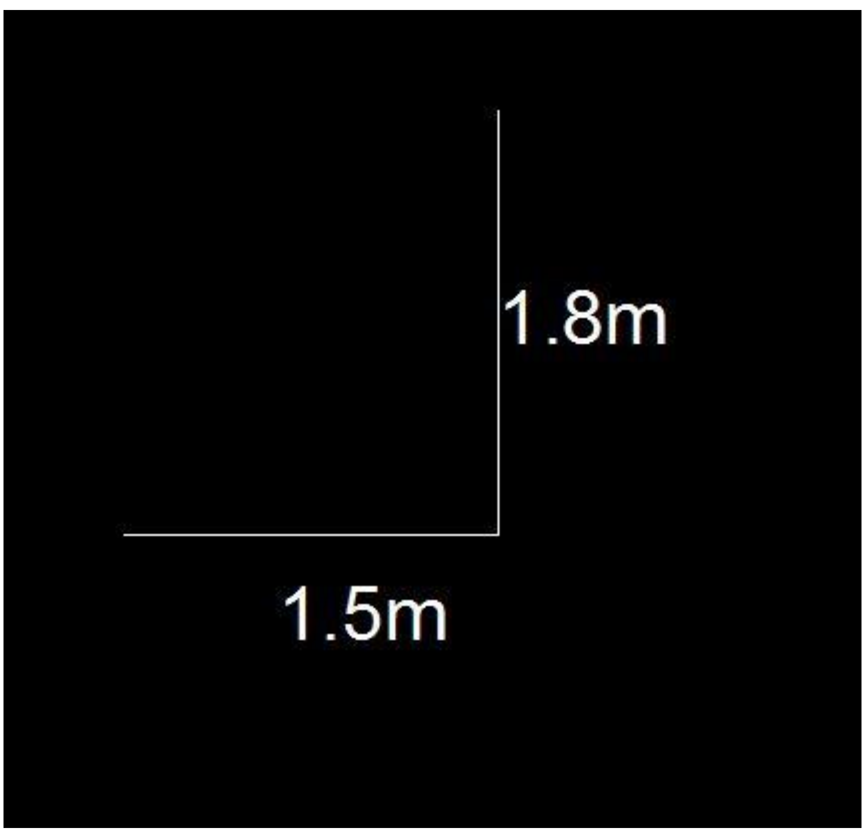
i) Height and width of regulator
ii) Flaring angle of wing wall (normally 5 to 10 degree used)

Normally we use –Avg. Ground level+1ft

No. and Size of Vents:

Lump sum assumption: For non tidal area 3-3.5sp. miles 1vent is sufficient and for tidal area 5sq. miles for 1 vent.

(BWDB conventional vent sizes are 1.5mX1.8m)



From monograph described at Page VI-14 we can find capacity “q” per vent; therefore

No. of vents=(Design”Q”)/(capacity ”q” per vent)

Hydraulic Design:

We have to find out the shape and size of the structure in this portion. Crest level, Crest width, Invert level, Wing wall, Length of wing wall, Width of wing wall Return wall height etc. are fixed in this portion. To fix the invert level of the structure the facts should be considered are:

-For only Drainage purpose, invert level of the structure must be above/equal to the lowest water level of river.

- For flushing invert level can be fixed below 2feet of the lowest water level of the river.

- Floor length, exit gradient, angle of flair of wing wall all are selected in this portion.

Structural Design:

Thickness of different part of regulator, configuration of steel (i.e. area and spacing of steel) of different part of the regulator are fixed here.

Foundation Design:

The pressure as well as load exerted by the structure is calculated from the structural design. If the SPT value of soil is high enough to support this load, no soil treatment is necessary otherwise the traditional method used here is sand pile treatment.

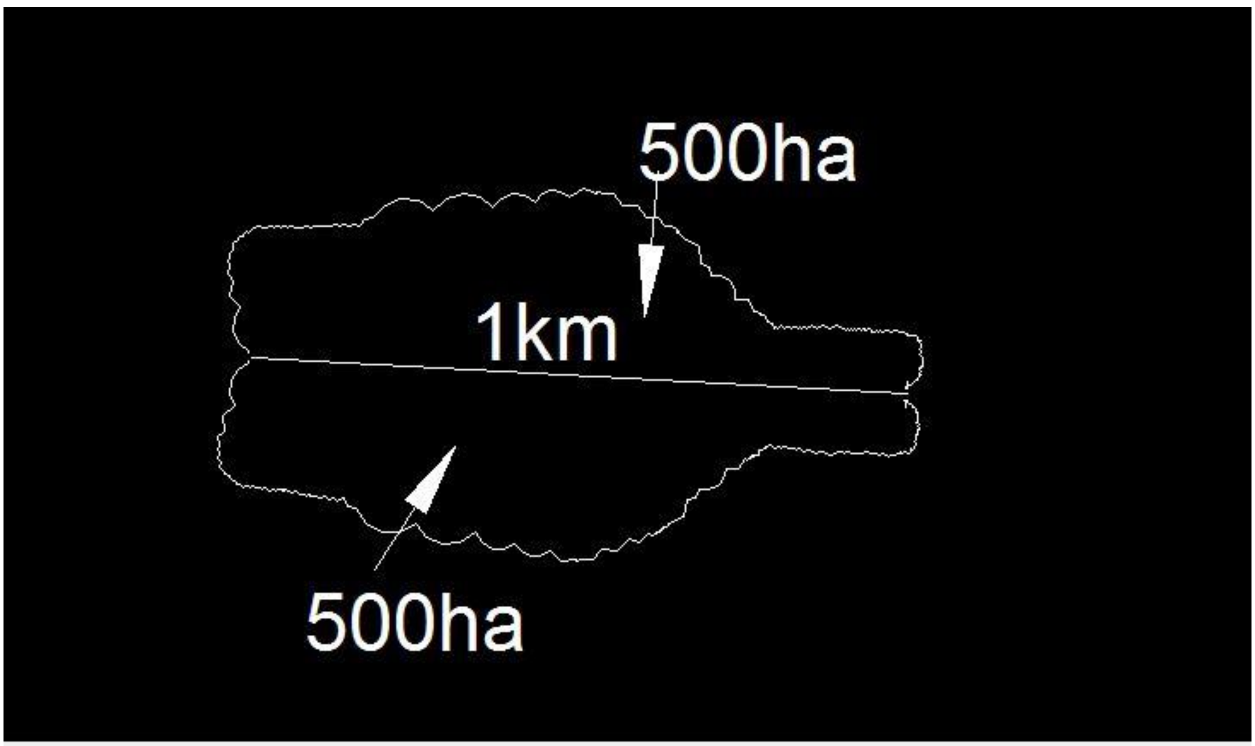
EXAMPLE: DRAINAGE CUM FLUSHING REGULATOR

(PROPOSED FOR 1VENT-1.50mX1.80m)

<u>GIVEN DESIGN DATA:</u>

-Catchment Area-200ha(existing length of khal 2.2km)

Next it was modified 500ha assuming 1km khal carries 50+50=100ha both sides

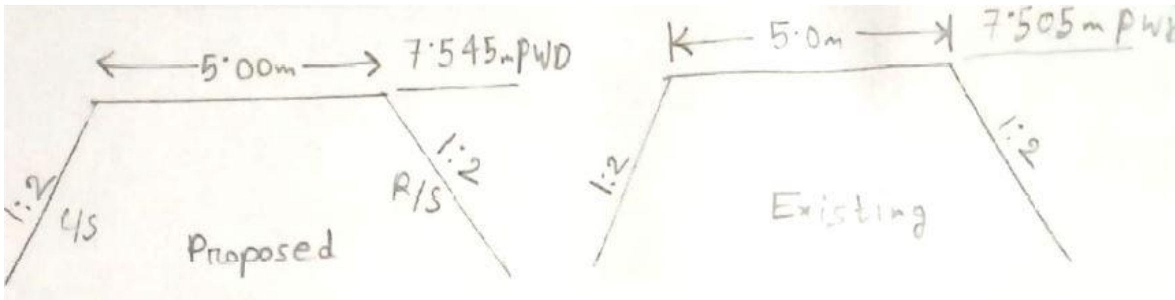


Average HWL of outfall River: (+)4.83mPWD

Average LWL of outfall River: (+)0.50mPWD

Avg. ground level was taken 5.2m PWD (both for C/S and R/S) from cross section of Khal.

Embankment Information:



-Existing structure: Invalid(Sill+3.1mPWD)

-Nearby Structure: Sill level (+)0.90m PWD. Outfall. (3v-1.50mX1.80m)

-Proposed vent no. and size 1V-1.50mX1.80M

Selected Parameters:

Sill level=(+)0.20mPWD

(selected considering the flushing condition for avg. LWL 0.50m PWD and the sill/Invert level is 1' below the avg. LWL)

Crest Level-7.60m PWD

Crest width-6.0m

Return wall top (C/S)-5.20mPWD(AVG. Ground level)

Return wall top (R/S)-5.20mPWD

Apron Level-(-)0.55mPWD, Therefore

Drop Δ z =0.75m(for C/S; 1:3 slope; called glacier)

Drop Δ z =0.60m(for R/S; 1:2 slope; called glacier, rest 0.15m/6" is used for tightening the flap gate)(Details in drawing)

Head selected by this parameters H1=(5.31+0.3-0.2)

(avg. Ground level+1ft –sill level)=5.41m

Considering this too high and floor length will be much larger; we consider Δh=2.5m

Hydrologic Design:

Q=C.I.A

=27X1.87X(500/259) cfs

(I= 16 for days from raincurve, taken I=16/10(per day)+10% = 1.87)

=98 cfs

= 2.76cumec

Discharge capacity taken from monograph described earlier.

capacity “q”=260 cfs

(Taken H/D=2.5/1.8=1.4; D=1.8m or 6’)

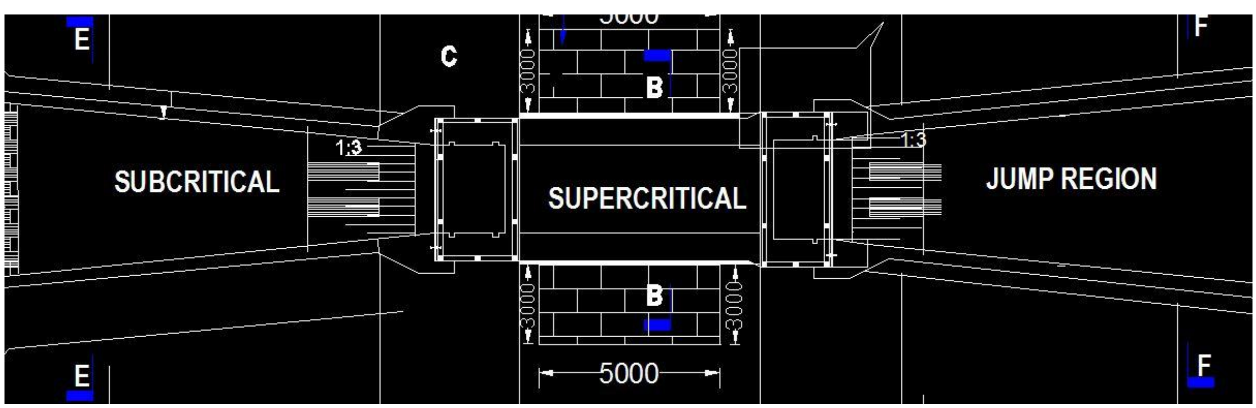
From thumb rule; for non tidal zone 5sq.miles is needed for 1 vent.

Here A=1.93sq miles.

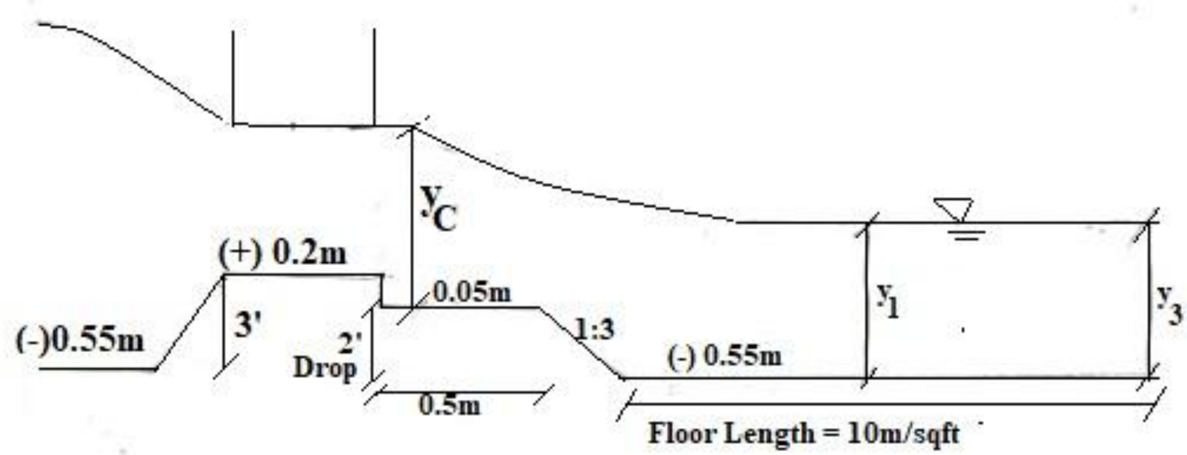
no of vents = 1.93/5=0.4

so, 0.4 no of vent is required with size 1.5mX1.8m. So 1 vent is sufficient.

Hydraulic Design:



At barrel portion supercritical flow may occur. Stilling basin is provided to dissipate the jump energy by following procedure



H/D=5.6/1.8=3.11 greater than 1.5 (Type 3, CIDA 1993, 5-16)

From CIDA 1987, VI-44 we take Cq=0.51

q=CqD√(2gΔh)cfs/per width

=0.51*6*√(2*32.2*2.5*3.28)

=70.32cfs/per width

Q=q*B=70.32*5=352cfs

Q=352cfs=352/35.2=10cumec

Taking Q=10cumec

b=1.5m, D=1.80m, q=Q/b=10/1.5=6.67cumec/m

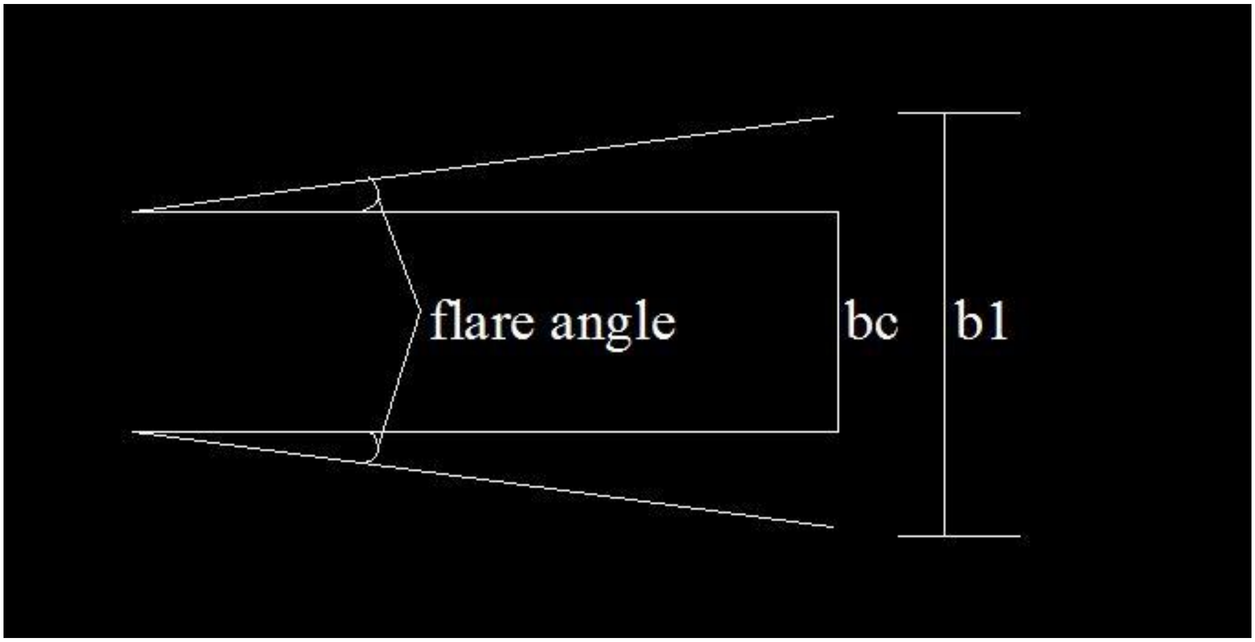
bc=width at section C-C

= 5'+(6"/12)*2 (This 6" used for tightening of flap gate)

=6'

b1= width at section 1-1

=bc+(drop*slope(1:3)+0.5*3.28)*(tangent of flare angle)*2(for both side)



b1=6'+((2*3+0.5*3.28)*tan7®)*2=7.87'

qc=Q/bc=352/6=58.67cfs/ft

yc=(qc^2/g)^(1/3)

=(58.67^2/32.2)^(1/3)

= 4.74'

Applying Bernaulis equation at sec C-C and sec 1-1 we can find

qc+(vc^2/2g)+z=y1+(v1^2/2g).........(1)

(vc^2/2g)= qc/2, z=2' v1=(Q)/(B1Y1)

so the above no 1 equation simplifies as

4.74+(4.74/2)+2=y1+((352/7.87)^2/(2*32.2*y1^2)

It will be a cubic equation. Solving this equation 2 values of y1 will be obtained. Fromthose one negative, one larger value should be omitted. Taking y1=2.1’

y1<yc(ok)

v1=(352)/(2.1*7.87)=21.3fps

F1=v1/√(gy1)=21.3/√(32.2*2.1)=2.6>2.5(ok)

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

Putting the values y1 and F1 we find y2=6.74’

Now length of jump,

1)L=220*y1*tanh((F1-1)/22) from this equation,

L=33’=10.22m

2)L=6.9(y2-y1)

=6.9(6.74-2.1)

= 32’=10m

3)L/y2=5.3 (figure-23,1987 manual page VI-70)

L=5.3*6.74=35.72’=10.89m.