

A Study on Analysis of Cross Drainage Work

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Abstract - Present paper deals analysis of aqueduct and siphon aqueduct hydraulic structures. An attempt is made to design aqueduct and siphon aqueduct manually and results are observed with given loading condition.

In an Aqueduct, the canal bed level is above the drainage high flood level (HFL).

In a Siphon aqueduct, the canal bed level is below the drainage high flood level (HFL).

Key Words: Aqueduct, Siphon aqueduct, Super passage, Siphon super passage, Level crossing, Outlet and Inlet crossing.

1. INTRODUCTION

When a natural drain crosses or intercepts an irrigation canal, it becomes necessary to construct some suitable structure to carry forward the canal safely. As these works are constructed for crossing the drainage, these structures are known as Cross Drainage Works (CD Works).

Canals are generally aligned on the watershed so that they meet minimum number of drain. However, before watershed is reached, they usually cross a number of drainage lines. At the watershed itself cross a number of local drainage. A canal system taking off from a large river may irrigate area comprising a number of do-abs or area between different streams.

In this paper we are discussed the analysis of cross drainage works.

2. TYPES OF CROSS DRAINAGE WORKS

There are four following types of cross drainage works:

(i). When the irrigation canal over the drainage

This is further divided into;

- a. An aqueduct
- b. A siphon aqueduct

(ii). When the drainage over the canal.

This is further divided into;

- a. A super passage
- b. A siphon.

(iii). When drainage and canal at same level

This is further divided into;

- a. A level crossing
- b. An inlet and outlet crossing

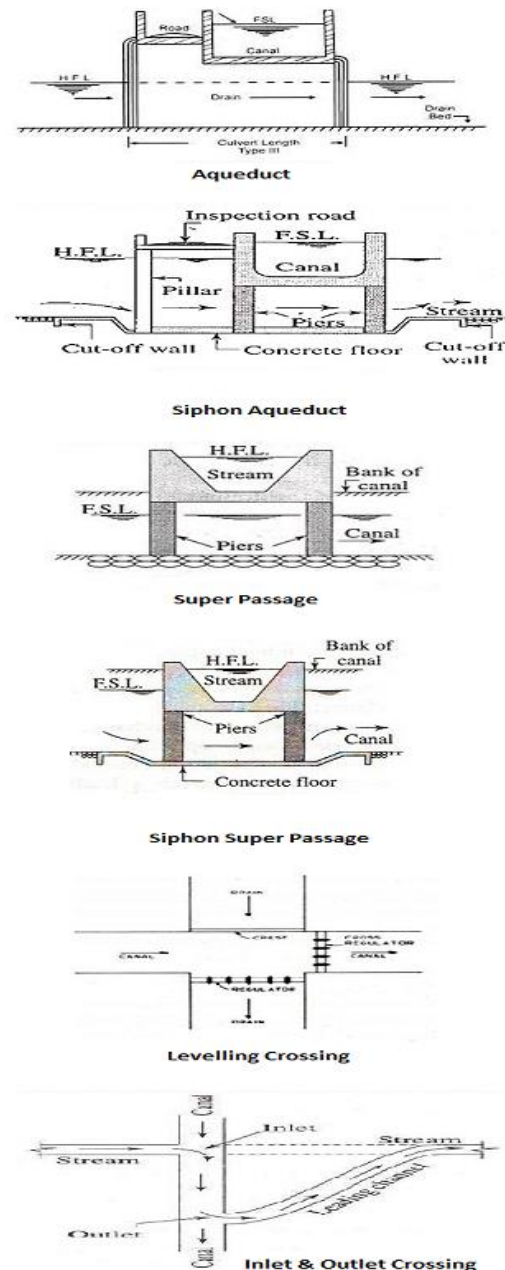


Figure -1

3. STRUCTURAL DESIGN APSECTS

- a) For the construction of various components of an aqueduct prestressed concrete or reinforced cement concrete or masonry or a combination of these may be used depending upon the desired ease of construction and relative economy.
- b) A suitable arrangement for supporting the section of the aqueduct may be decided depending upon the nature of

foundation, difference between HFL of the drain and bed of canal and height between bed of canal and bottom of stream/drain and the afflux allowable in the drain. An economical span can be worked out by a judicious combination of the substructure and superstructure of the aqueduct. Multi-duct canal sections can also be adopted.

- c) To carry the service/inspection road across the drainage a suitable arrangement may be provided. For economical reason a causeway may also be considered. In case a road bridge is provided over the aqueduct it should be designed for at least IRC class A loading.

4. DESIGN FOR CROSS DRAINAGE WORK:

DATA FOR DESIGN

For working out the design of an aqueduct, the following specific design data should be available.

Hydraulic Data (Canal)

Full supply discharge = 34 m³/sec
Full supply level (R.L.) = 218.5 m
Canal bed level (R.L.) = 216 m
Canal bed width (R.L.) = 20 m
Trapezoidal canal section = 1.5:1 (H: V)
Canal water depth = 1.7 m

Hydraulic Data (Drainage)

High flood discharge = 320 m³/sec
High flood level = 212 m
High flood depth = 3 m
General ground level = 215 m
Clear span between piers = 9 m
Pier thickness = 1.5 m

Solution:

R.L. of canal bed level is higher High Flood Level of drainage. So we adopt aqueduct type cross-drainage work.

Step- I Design of drainage water way

By Lacey's regime perimeter,
 $P = 4.75 \sqrt{Q}$

Where,

Q = high flood discharge (320 m³/sec)
 $P = 4.75 \sqrt{320} = 84.97 \approx 85$ m

Using 10 bays of 9 m each, clear water way = 10x9 = 90 m

Using 9 pier of 1.5 m each, length occupied by piers = 9x1.5 = 13.5 m

Total length of water way = 90+13.5 = 103.5 m

Step- II Design of canal water way

Bed width of canal = 20 m

Let the width flumed to 10.0 m

Providing a splay of 2:1 in contraction,

The length of contraction transition

$= (20-10)/2 \times 2 = 10.0$ m

Providing a splay of 3:1 in expansion,

The length of expansion transition

$= (20-10)/2 \times 3 = 15.0$ m

Length of the flumed rectangular portion of the canal between abutments = 103.5 m

In transitions, the sides slopes of the canal section will be warped in the plan from original slope of 1.5:1 (H: V)

Step – III: Head loss and bed levels at different sections

At Section 4-4:

Where the canal returns to its original section, we have area

of trapezoidal canal section.

Area, $A = (B + 1.5 y) y$
 $= [20 + (15 \times 1.7) \times 1.7 = 38033 \text{ m}^2$.

Velocity, $V_4 = Q / A$

$= 34 / 38.33 = 0.887 \text{ m/sec}$.

Velocity Head $= (V_4)^2 / 2g$

$= (0.887)^2 / (2 \times 9.81)$

$= 0.040$ m.

R.L. of canal bed level = 216.0 m.

R.L. of water surface at section 4-4

$= 216.0 + 1.7 = 217.7$ m

R.L. of T.E.L. at section 4-4

$= 217.7 + 0.040 = 217.74$ m

At Section 3-3

Keeping the same depth of 1.7 m. throughout the channel, we have at section 3-3

Bed width = 10 m.

Area of channel = 10x1.7 = 17m.

Velocity (V_3) = 34/17 = 2.00 m/sec

Velocity head $= (V_3)^2 / 2g = (2.00)^2 / 2 \times 9.81$
 $= 0.203$ m.

Loss of head in expansion from section 3-3 to section 4-4

$= 0.3 [(V_3)^2 - (V_4)^2] / 2g$

$= 0.3 [(2.0)^2 - (0.887)^2] / (2 \times 9.81)$

$= 0.049$ m.

R.L. of T.E.L. at station 3-3

$= \text{R.L. of T.E.L. at 4-4} + \text{Loss in expansion}$

$= 217.74 + 0.049 = 217.789$ m.

R.L. of water surface at station 3-3

$= \text{R.L. of T.E.L. at 3-3} - \text{Velocity head} = 217.789 - 0.203 = 217.586$ m.

R.L. of bed at 3-3 = 217.586 – 1.7

$= 215.886$ m.

At Section 2-2:

From section 2-2 to 3-3, the cross section is same so area and velocity of sections are same. But from section 2-2 to 3-3 which may be calculated by Manning's formula as equal to

$$H_L = (n^2 V^2 L) / R^{4/3}$$

Where, n = rugosity co-efficient

$= 0.016$ for concrete trough

L = length of trough

$= 103.5$ m.

V = velocity on trough

$= Q/A$

$= 34/17$ [Where, $A = (10 \times 1.7 = 17)$]

$= 2$ m/sec

$R = A/P = 17/13.4 = 1.27$ m.

[Where, $P = 10 + (2 \times 1.7) = 13.4$ m]

Hence, $H_L = [(0.016)^2 \times (2)^2 \times 103.5] / (1.27)^{4/3}$
 $= 0.077$ m.

R.L. of T.E.L. at station 2-2

$= \text{R.L. of T.E.L. at 3-3} + \text{Friction loss in trough}$
 $= 217.586 + 0.077 = 217.663$ m.

R.L. of water surface at station 2-2
= R.L. of T.E.L. at 2-2 – Velocity head
= 217.663 – 0.203 = 217.46 m.
R.L. of bed at 2-2 = 217.46 – 1.7
= 215.76 m.

At Section 1-1:

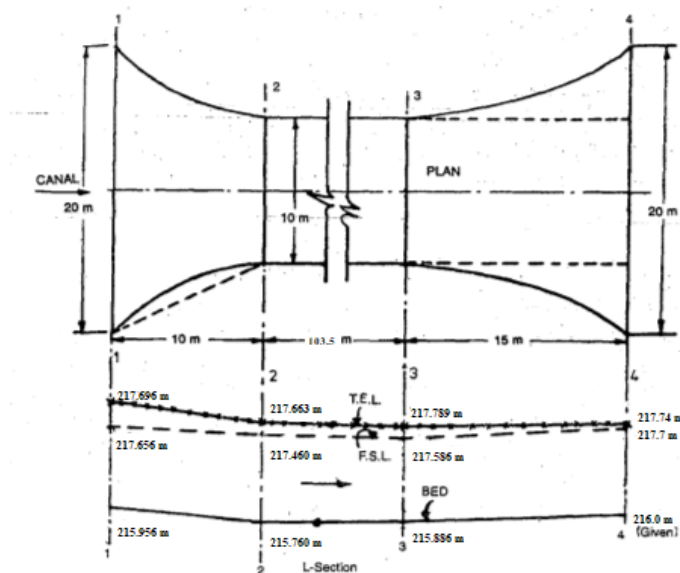
Loss of head in contraction transition from 1-1 to 2-2 section

$$= 0.2 [(V_2)^2 - (V_1)^2] / 2g$$

$$= 0.2 [(2)^2 - (0.887)^2] / (2 \times 9.81)$$

$$= 0.033 \text{ m.}$$

R.L. of T.E.L. at station 1-1
= R.L. of T.E.L. at 2-2 + Loss in contraction
= 217.663 + 0.033 = 217.696 m.
R.L. of water surface at station 1-1
= R.L. of T.E.L. at 1-1 – Velocity head
= 217.663 – 0.040 = 217.656 m.
R.L. of bed at 1-1 = 217.656 – 1.7
= 215.956 m.



Plan and Section of Canal Trough

Figure – 2

Step-IV Design of Transitions

a. Contraction Transition

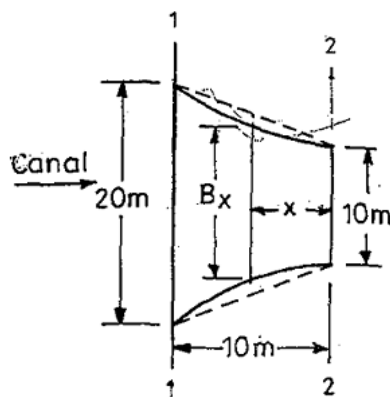


Figure – 3

By using Mitra's hyperbolic transition equation, we can be designed the width of transition

$$B_x = (B_n \cdot B_f \cdot L_f) / [L_f B_n - x (B_n - B_f)]$$

Where, $B_n = 20 \text{ m}$,
 $B_f = 10 \text{ m}$ and
 $L_f = 10 \text{ m}$

Putting the above values in equation, we can find

$$B_x = (20 \times 10 \times 10) / [200 - x (20 - 10)]$$

B_x is depend on the values of x as mentioned above figure, the values of x varies from 0 to 10 m right to left.

Table -1

x , (meter)	0	2.5	5	7.5	10
$B_x = \frac{(20 \times 10 \times 10)}{200 - x[20 - 10]}$ (meter)	10	11.4	13.3	16	20

The contraction transition can be easily plotted with the help of these values.

b. Expansion Transition

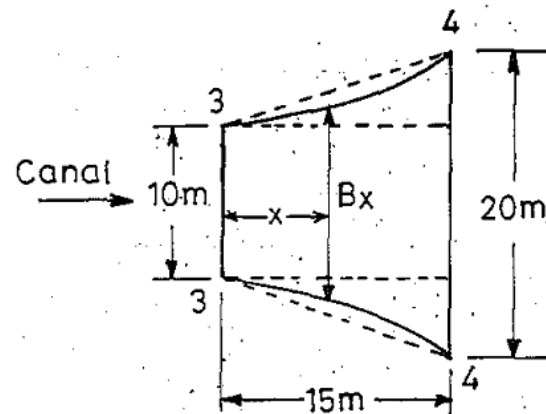


Figure – 4

By using Mitra's hyperbolic transition equation, we can be designed the width of expansion,

$$B_x = (B_n \cdot B_f \cdot L_f) / [L_f B_n - x (B_n - B_f)]$$

Where $B_n = 20 \text{ m}$, $B_f = 10 \text{ m}$, and $L_f = 15 \text{ m}$

Putting the above values in equation, we can find

$$B_x = (20 \times 10 \times 15) / [300 - x (20 - 10)]$$

B_x is depend on the values of x as mentioned above figure, the values of x varies from 0 to 15 m left to right.

Table -2

x , (meter)	0	3	6	9	12	15
$B_x = \frac{(20 \times 10 \times 15)}{300 - x[20 - 10]}$ (meter)	10	11.1	12.5	14.2	16.6	20

The expansion transition can be easily plotted with the help of these values.

Step-V Design of Trough

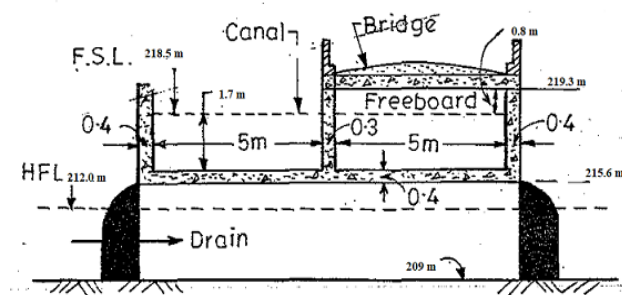


Figure – 5

The trough shall be divided into two equal components of 5m each and separated by an intermediate wall of 0.3 m thickness.

A free board of 0.8 m above the normal water depth of 1.7 m is sufficient; hence bottom level of the road slab over the left component can be kept at $1.7 + 0.8 = 2.5$ m above the bed level of the trough.

The trough section will be constructed in monolithic reinforced concrete and can be designed by structural method.

5. CONCLUSION

From the analysis, for the given data following points are concluded:

- (i). For rectangular cross section, Perimeter is 85 m and total length of water way is 103.5m for the design of drainage water way.
- (ii). In plan section, the length of contraction and expansion are 10 m & 15 m at transition respectively for the design of drainage water way.
- (iii). In this study analysis, we designed the Head losses, R.L. of canal bed level, water surface and T.E.L at different sections as mentioned above in Step III.
- (iv). By using Mitra's hyperbolic transition equation, we calculated the values of width at interval of 2.5 m at the contraction transition and at the interval of 3 m at the expansion transition.

6. ACKNOWLEDGEMENT

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7. REFERENCES:

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