Part 4: Estimation of RCC Slab Culvert

4.1 Culvert

Culvert is a small bridge used to carry water from one side to other. It should be covered with embankment and composed of structural material around the entire perimeter. In general culverts are of maximum 3 spans. Maximum span is limited to 5~6 meter. But long span culvert (>40 feet span) was introduced in 1960's.

4.2 Use of Culvert

1. Where natural streams intersect the roadway.
2. For passing surface drainage.
3. Bottom of depression where no natural water course.



Figure 4.1: Various Types of Culverts

4.3 Different Types of Culverts

1. **Arch Culvert:** An arch culvert is normally a low-profile culvert. It can be installed without disturbing the causeway as it will span over the entire drainage width. They are normally made of metal, stone masonry or RCC. They are installed easily, and you don't need to use expensive water diversion structures to install it. Common shapes include semicircular arch, elliptical arch, and concrete box culverts. Another benefit of these type of structure is that the installation process will not take a lot of time, compared to traditional box culverts.



Figure 4.2: Arch Culverts

2. **Slab Culvert:** A slab culvert is made of RCC slab. Masonry arches in culverts have numerous problems, including difficulty in centering, shuttering, less life, more chance of cracks and more dead load. Thus, they have been replaced by simple RCC slab construction. Slab in these culverts may be RCC or stone.



Figure 4.3: Slab Culverts

3. **Pipe culvert:** Pipes culverts are available in different shapes such as circular, elliptical and pipe arches. Although circular pipes are the most common, other shapes might be used depending on site conditions and constraints at the job site. Their prices are very competitive, and they are very easy to install. As with other culvert types, the selection of the culvert will depend on hydraulic design and other factors that might affect their performance and suitability. It is the preferred one on urbanized areas and is the one usually used to manage storm sewer systems.



Figure 4.4: Pipe Culverts

4. **Box culvert:** Box culverts have a concrete (sometimes other materials can be used too) floor allowing the water to flow smoothly through it. Box culverts are usually made up of Reinforced Concrete (RCC). Some box culverts can be built using composite structures and are great when water needs to change direction or when a large flow of water is expected. Box culverts can also be installed in such way that the top of the culvert is also the roadway surface.



Figure 4.5: Box Culverts

5. **Steel girder culvert:** A steel girder culvert has two (2) steel girders running side-by-side to support the main rail path. This type of culvert can only be seen in railways. Two main girders are laid just below the rails. Wooden sleepers are provided between these girders and the rails. Therefore, sometimes these culverts are also called open deck culverts.



Figure 4.6: Steel Girder Culverts

6. **Scupper:** A scupper is an opening in the side walls of an open-air structure, for purposes of draining water. They are usually placed at or near ground level, and allow rain or liquids to flow off the side of the open-air structure, instead of pooling within the walls.



Figure 4.7: Scuppers

4.4 Slab Culvert

Slab culvert is one of the most commonly used culverts in Bangladesh. A total of 18257 culverts have been constructed in Bangladesh until 2017 out of which 3991 culverts (22%) are box culverts (http://www.rthd.gov.bd/bridge_maintenance.php).

Advantages of Slab Culvert

a) Simple in construction
b) Suitable for weak sub grade.
c) Uniform load distribution over a wide area.

4.5 Components of a Typical RCC Slab Culvert

1. **Abutment**

a) Support bridge deck.
b) Retain embankment.
c) Connect approach road to bridge deck.

2. Wing wall

a) Acts as an anchor.
b) Provide smooth movement of water.
c) Prevent spilling of earthen embankment

3. Slab/deck

a) Carries the load of vehicles.



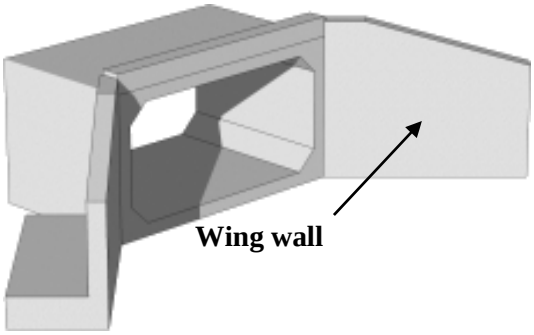




Figure 4.8: Abutment and Wing wall

4.6 Worked Out Problem

Calculate the quantity of the materials required for the construction of the following RCC slab culvert.

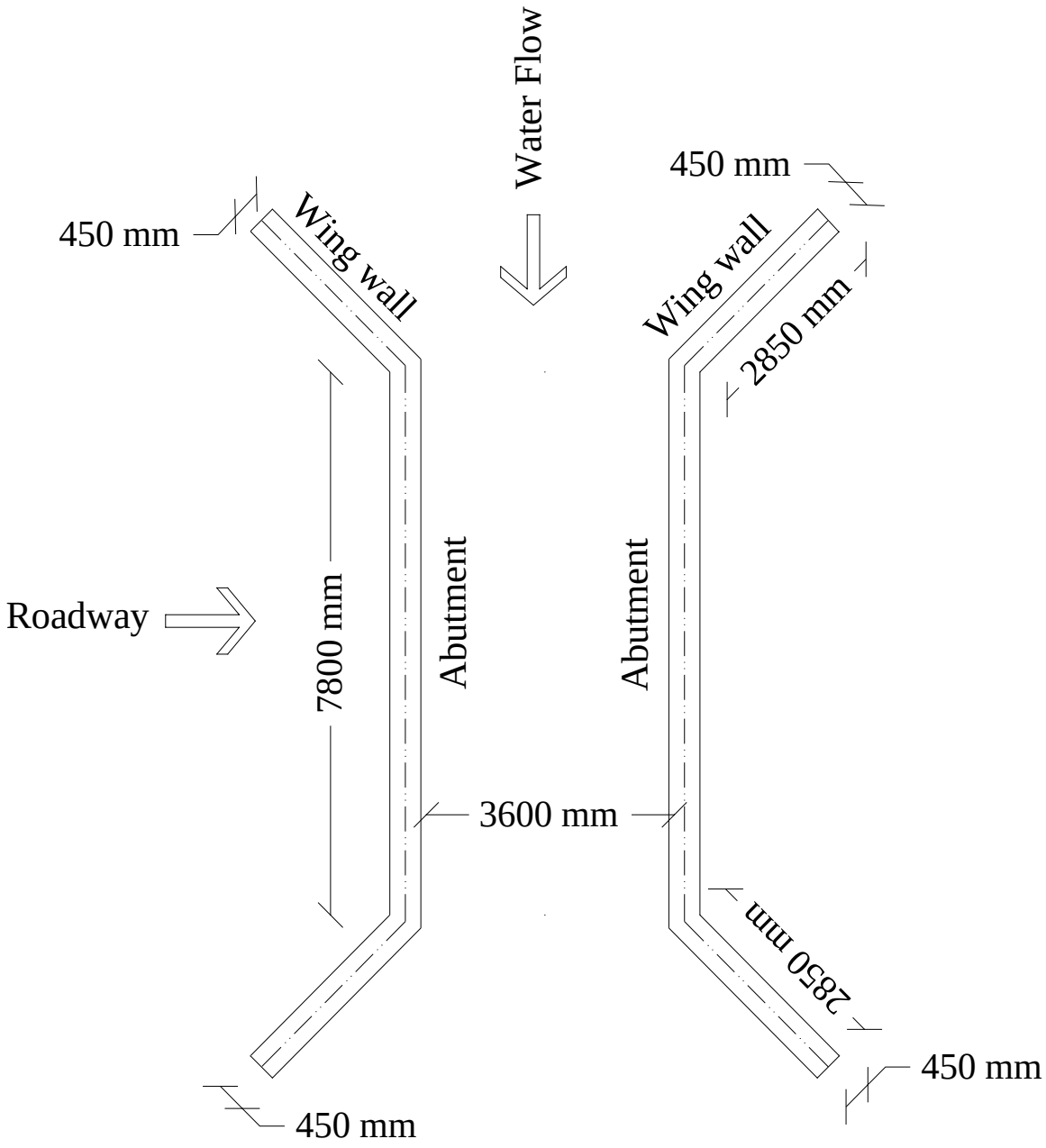


Figure 4.9: Plan of the Culvert.

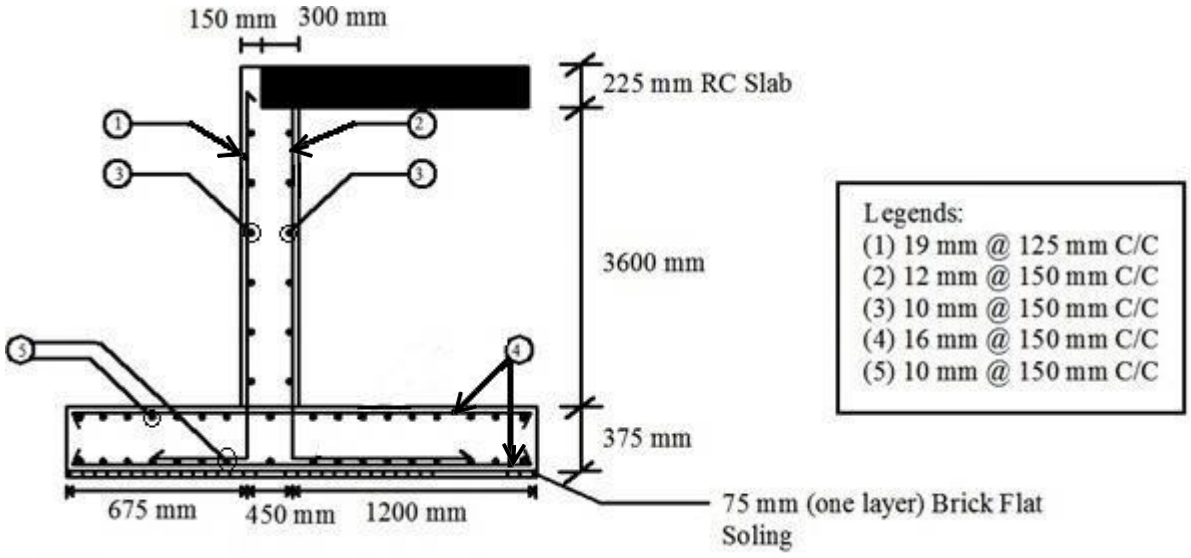


Figure 4.10: Sectional Elevation through Abutment

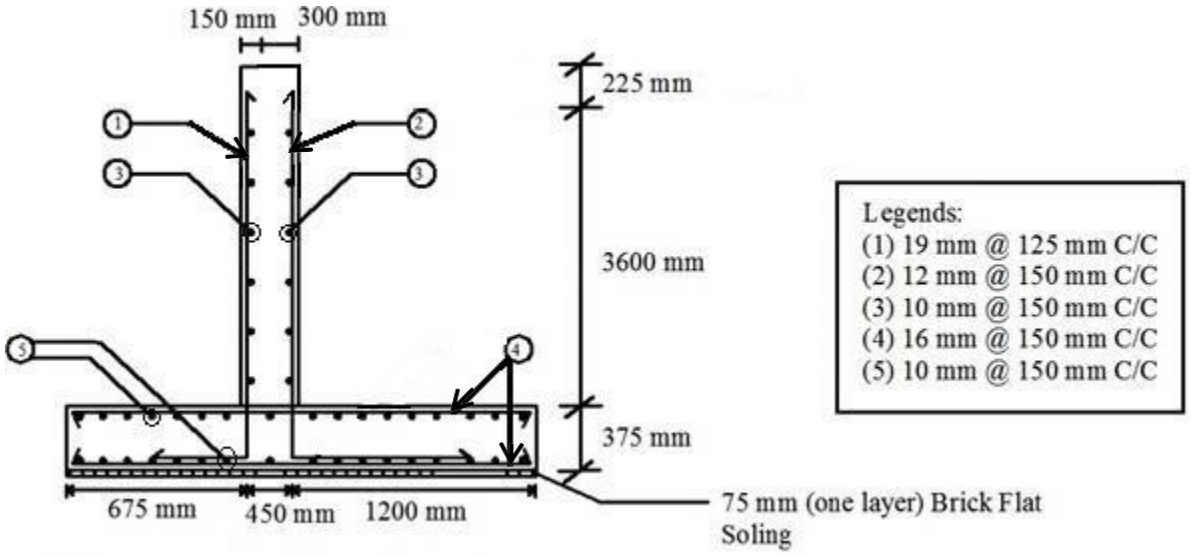


Figure 4.11: Sectional Elevation through Wing Wall

Concrete Estimation

Table 4.1: Calculation of Estimation of Concrete for the Workout Problem of Slab Culvert

Item Description	No	Length(m)	Width (m)	Height/ thickness (m)	Area (m^2)	Volume (m^3)	Remarks
(1)75mm brick flat soling in foundation							
Abutment	2	7.80	2.325	---	36.27	---	
Wing wall	4	2.85	2.325	---	26.51	---	
				Total =	62.78		
(2) Reinforced cement concrete in foundation (including reinforcement); 1:2:4							
Abutment	2	7.80	2.325	0.375	---	13.60	
Wing wall	4	2.85	2.325	0.375	---	9.94	
					Total =	23.54	
(3) Reinforced cement concrete in superstructure (including reinforcement); 1:2:4							
Abutment	2	7.80	0.45	3.825	---	26.852	
Deduction due to slab bearing	2	7.80	0.30	0.225	---	-1.053	
Wing wall	4	2.85	0.45	3.825	---	19.622	
					Total =	45.421	
(4) RCC in slab; 1:1.5:3	1	7.80	3.60	0.225	---	6.318	
					Total =	6.318	

1. 75mm BFS [one layer]

Size of one brick = 240 mm × 115 mm × 70 mm

Area of one brick = 0.24 m × 0.115 m = 0.0276 sqm

No of bricks = $\frac{62.78}{0.0276}$ = 2275 Nos.

Sand volume required per 10 sqm area of BFS = 0.1 cum

Volume of sand = 0.1 × $\frac{62.78}{10}$ = 0.628 cum

2. Reinforced cement concrete in Foundation (1:2:4)

Final volume (hard concrete) = 23.54 cum

Initial volume (before mixing) = 23.54 × 1.5 = 35.31 cum

Mix ratio = 1:2:4

Cement = 35.31 × $\frac{1}{7}$ = 5.044 cum = 143 bags

[One bag cement = 50 kg = 112 lb. = 1.25 cft = 0.035423256 cum]

Sand = 35.31 × $\frac{2}{7}$ = 10.1 cum

Brick chips/ Khoa = 35.31 × $\frac{4}{7}$ = 20.2 cum

No. of bricks = 20.2 × 300 = 6060 Nos.

[One cum brick chips required 300 Nos. of full-size brick]

3. Reinforced Cement Concrete in Superstructure (1:2: 4)

Final volume (hard concrete) = 45.42 cum

Initial volume (before mixing) = 45.42 × 1.5 = 68.13 cum

Mix ratio = 1:2:4

Cement = 68.13 × $\frac{1}{7}$ = 9.7 cum = 275 bags

[One bag cement = 50 kg = 112 lb. = 1.25 cft = 0.035423256 cum]

Sand = 68.13 × $\frac{2}{7}$ = 19.5 cum

Brick chips/ Khoa = 68.13 × $\frac{4}{7}$ = 38.93 cum

No. of bricks = 38.93 × 300 = 11680 Nos.

[One cum brick chips required 300 Nos. of full-size brick]

4. RCC in Slab (1:1.5:3)

Final volume (hard concrete) = 6.32 cum

Initial volume (before mixing) = 6.32 × 1.5 = 9.48 cum

Mix ratio = 1:1.5:3

Cement = $9.48 \times \frac{1}{5.5}$ = 1.72 cum = 49 bags

[One bag cement = 50 kg = 112 lb. = 1.25 cft = 0.035423256 cum]

Sand = $9.48 \times \frac{1.5}{5.5}$ = 2.58 cum

Brick chips/ Khoa = $9.48 \times \frac{3}{5.5}$ = 5.17 cum

No. of bricks = 5.17 × 300 = 1551 Nos.

[One cum brick chips required 300 Nos. of full-size brick]

Total volume of cement = [143 + 275 + 49] = 467 bags

Total volume of sand = [0.628 + 10.3 + 19.5 + 2.58] =33 cum

Total number of bricks = [2275 + 6060 + 11680 + 1551] =21566 Nos.

The summary of quantity of materials is provided below:

Table 4.2: Summary of Quantity of Materials:

Materials	Quantity
Cement	467 bags
Sand	33 cum
Brick	21566 Nos.

Reinforcement estimation:

Deformed bar is used; each bar is hooked in each end.

Hook length = nine times bar diameter = $9d_b$

Cover = 75 mm = 3 inch

Development length for vertical reinforcement in abutment and wing wall = 12 inch = (12×25) mm

Reinforcement in one wing wall:

(1) Vertical rod in wall (outside face)

19 mm dia @ 125 mm c/c

$$= \left[\frac{2850 - 75}{125}\right] \times [3600 + 225 - 75 + 375 - 75 + (12 \times 25) + (10 \times 19 \times 2)]$$

(2) Vertical rod in wall (inside face)

12 mm dia @ 150 mm c/c

$$= \left[\frac{2850 - 75}{150}\right] \times [3600 + 225 - 75 + 375 - 75 + (12 \times 25) + (10 \times 12 \times 2)]$$

(3) Horizontal rod in wall (both face)

10 mm dia @ 150 mm c/c

$$= \left[\frac{3825 - 75}{150} + 1\right] \times [2850 - 75 + (10 \times 10)] \times 2 \text{ (Two Face)}$$

(4) Horizontal rod in footing (both layer)

16 mm dia @ 150 mm c/c

$$= \left[\frac{2850 - 75}{150}\right] \times [675 + 450 + 1200 - 75 - 75 + (10 \times 16 \times 2)] \times 2 \text{ (Two Layer)}$$

(5) Horizontal rod in footing (both face)

10 mm dia @ 150 mm c/c

$$= \left[\frac{675 + 450 + 1200 - 75 - 75}{150} + 1\right] \times [2850 - 75 + (10 \times 10)] \times 2 \text{ (Two Face)}$$

Reinforcement in one abutment:

(1) Vertical rod in wall (outside face)

19 mm dia @ 125 mm c/c

$$= \left[\frac{7800}{125} + 1\right] \times [3600 + 225 + 375 - 75 - 75 + (12 \times 25) + (10 \times 19 \times 2)]$$

(2) Vertical rod in wall (inside face)

12 mm dia @ 150 mm c/c

$$= \left[\frac{7800}{150} + 1\right] \times [3600 + 375 - 75 - 75 + (12 \times 25) + (10 \times 12 \times 2)]$$

(3a) Horizontal rod in wall (outside face)

10 mm dia @ 150 mm c/c

$$= \left[\frac{3600 + 225 - 75}{150} + 1\right] \times [7800]$$

(3b) Horizontal rod in wall (inside face)

10 mm dia @ 150 mm c/c

$$= \left[\frac{3600 - 75}{150} + 1\right] \times [7800]$$

(4) Horizontal rod in footing (both layer)

16 mm dia @150 mm c/c

$$= \left[\frac{7800}{150} + 1\right] \times [675 + 450 + 1200 - 75 - 75 + (10 \times 16 \times 2)] \times 2 \text{ (Two Layer)}$$

(5) Horizontal rod in footing (both face)

10 mm dia @150 mm c/c

$$= \left[\frac{675 + 450 + 1200 - 75 - 75}{150} + 1\right] \times [7800] \times 2 \text{ (Two Face)}$$

Table 4.3: Calculation of Reinforcement in Two Abutments

Bar	No.	Total Length [For one abutment] (m)	Weight per meter (kg/m)	Weight (kg)
19mm	2			
16mm	2			
12mm	2			
10mm	2			

Table 4.4: Calculation of Reinforcement in Four Wing Walls

Bar	No.	Total Length [For one Wing Wall] (m)	Weight per meter (kg/m)	Weight (kg)
19mm	4			
16mm	4			
12mm	4			
10mm	4			

Table 4.5: Calculation of Reinforcement in two Abutments and Four Wing Walls

Bar	Reinforcement		Total (kg)
	Two abutments (kg)	Four wing walls (kg)	
19mm			
16mm			
12mm			
10mm			