Chapter

# 8 Culverts, Bridges, and Wells

## INTRODUCTION

Estimation and costing for **culverts**, **bridges**, and **wells** involve determining the quantities and costs of materials, labor, machinery, and other resources necessary for their construction. Each of these structures has its unique requirements based on size, function, site conditions, and design specifications. Proper estimation is crucial for planning, budgeting, and executing projects within financial constraints while ensuring safety and structural integrity.

### Estimation and Costing of Culverts

Culverts are structures that allow water to pass beneath roads, railways, or trails. They are typically made of reinforced concrete, steel, or stone masonry, and their design depends on the volume of water flow and site conditions.

**1. Types of Culverts**

- **Pipe culverts:** Circular or elliptical pipes used for smaller water flow.
- **Box culverts:** Rectangular culverts typically used for larger water flow.
- **Arch culverts:** Semi-circular structures that are used when the roadbed has low clearance.
- **Slab culverts:** Concrete slabs laid over the water channel, used in areas where the flow is low.

**2. Components of Culvert Construction**

- **Excavation and earthwork:** Preparing the site by removing or filling soil.
- **Foundation:** Laying a solid foundation to support the culvert structure.
- **Culvert barrel:** The main water passage structure, which could be a pipe or box.
- **Headwalls and wingwalls:** Structures at the culvert ends to prevent erosion and provide support.
- **Backfilling:** Filling the soil around the structure for stability.
- **Drainage work:** Ensuring proper drainage to avoid waterlogging.

**3. Steps in Estimating Culvert Work**

**a. Site survey and design**

- Assess the water flow, width of the road, and terrain to select the appropriate culvert type.
- Prepare detailed designs with dimensions for the selected culvert type.

**b. Material estimation**

- **Excavation:** Calculate the volume of soil to be removed.
- **Concrete:** Estimate the quantity of concrete required for the foundation, barrel, headwalls, and wingwalls.
- **Steel reinforcement:** Estimate the weight of steel needed for reinforcement.
- **Pipes (for pipe culverts):** Calculate the length and diameter of pipes required.

3. **Labor and Equipment Estimation**
   - Skilled labor for excavation, concrete work, and pipe installation.
   - Equipment costs for earthmoving, concreting, and lifting.
4. **Costing Components**
   - Material costs: Concrete, steel, pipes.
   - Labor costs: For skilled and unskilled workers.
   - Machinery costs: Excavators, concrete mixers, cranes (if needed).
   - Overheads and contingencies: Typically, 5–10% of the total cost to cover unexpected expenses.

## CULVERTS

Estimating of bridges and culverts are simpler than that of building, but the beginners find building easier because they are more familiar with the parts of building than they are with those of bridges and culverts. An arched culvert consists of abutments, wing walls, arch, parapets and necessary foundation. Floor and curtain walls may or may not be provided depending on the nature of soil and velocity of flow. Exposed surfaces are usually finished with pointing. An oblique view of a culvert is given below (Fig. 8.1) which shows the different parts of a culvert.

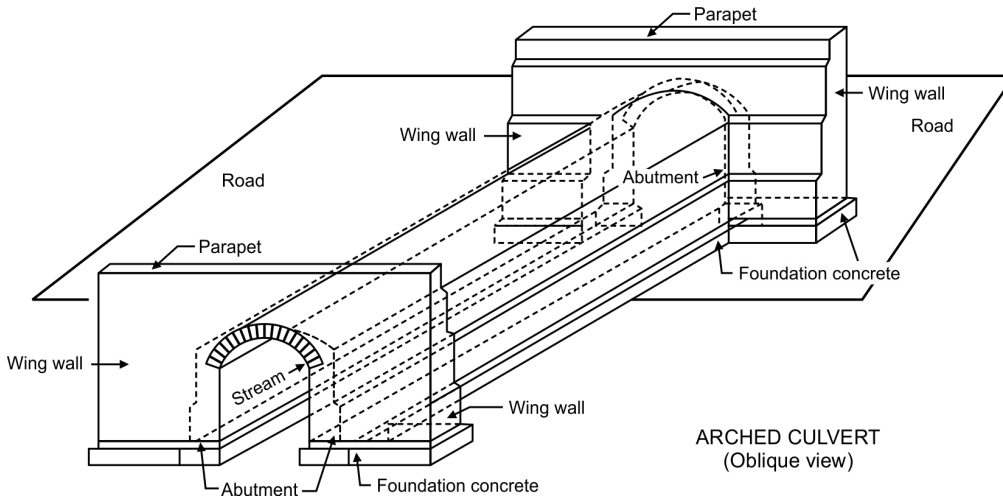



Fig. 8.1

For estimating, the different parts of the culvert should be considered separately. First the two abutments with foundations up to the springing level and then the portions of haunch or spandril above the springing level should be estimated. Then the four wing walls with foundation up to the haunch level should be taken up, and then the parapet walls should be estimated. Arch masonry should be calculated separately. Finishing work of the surfaces is taken up lastly.

Earthwork only for the excavation of foundation is generally taken up with the estimating of culvert. The filling up to the

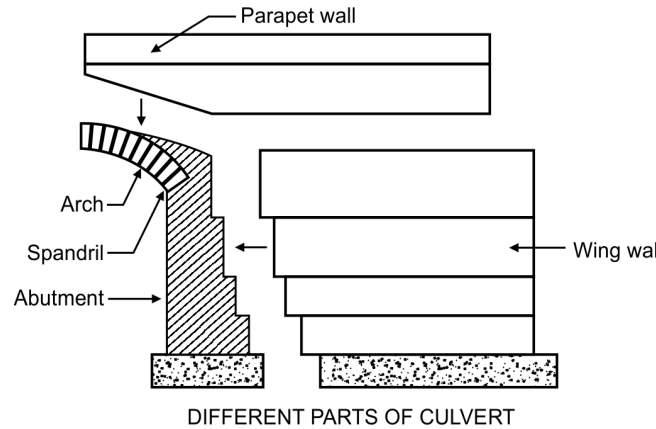



Fig. 8.2

road level after the construction of the culvert is done lateron and is usually taken up together with the earthwork of the road work. If required the earthwork in filling may also be estimated together with culvert:

The abutments are calculated step by step from foundations upward.

The portion from the spring level up to the crown of arch is usually taken as solid rectangular block as shown in Fig. 8.3 and then to get the masonry in the spandrel or haunch filling deduction is made for:

(i) Arch opening,
(ii) Arch masonry work,
(iii) Triangular portion above spandrel.

Spandrel or haunch filling may also be lime concrete or weak cement concrete and may be taken separately.

The wing walls four in number calculated are step by step from foundations upward.

The parapet walls two in number are calculated by taking the whole length and then the triangular portion of special filling are deducted as shown in (Fig. 8.4). Instead of triangular this may be segmental or partly segmental, and deduction may be made as per actual design and drawing.

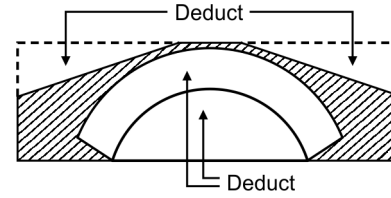


Fig. 8.3

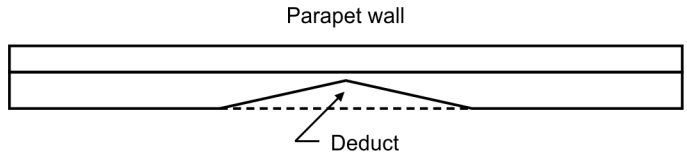


Fig. 8.4

Wing walls may be of different types as straight, curved, splayed, etc. In the case of curved wing walls the centre line length of the wing walls should be determined at every step or mean centre line length may be taken for all steps. If the wing is splayed and sloping then the length of each step should be determined from the drawing and quantities calculated step by step, or the sectional areas of the two ends of wing walls may be calculated and average of those two may be taken as mean sectional area and this mean sectional area multiplied by the mean length will give the quantity of masonry work.

For high bridges or culverts weep holes are provided in the abutment and wing walls for the seepage of water in the soil, but no deduction need be made for these holes.

Foundation work may be of different types depending on the nature of soil, the sub-soil water level, etc. If the sub-soil water level is high, bailing out of water or pumping for dewatering may be required for which extra rates may be provided. Wet or damp earth may be estimated at higher rates. Pile driving, well sinking, coffer dam, etc. may be required depending on the situation, and shall have to be estimated separately.

**Example 1:** Prepare a detailed estimate of a slab culvert of 1.50 metre span and 4.00 metre roadway from the given drawing (Fig. 8.5). The general specifications are as follows:

Foundation concrete shall be of cement concrete 1 : 3 : 6 with stone ballast and coarse sand. Masonry shall be of first class brickwork in 1 : 4 cement coarse sand mortar. Slab shall be of RCC 1 : 2 : 4 with reinforcement as per drawing. Exposed surface of brick masonry shall be cement pointed 1 : 2. Road shall be provided with 10 cm thick wearing coat of 1 : 2 : 4 cement concrete. Assume suitable rates.

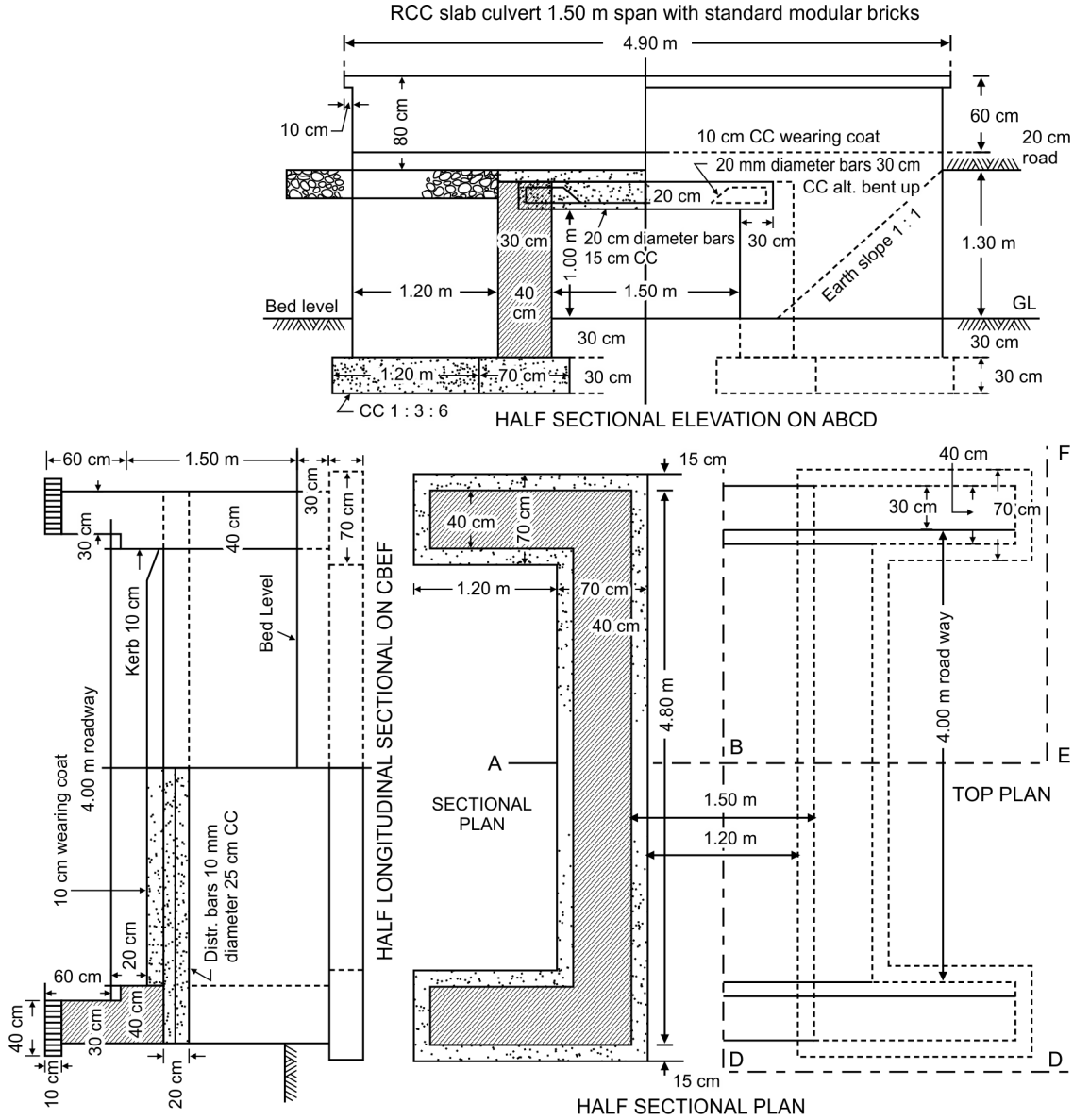

RCC slab culvert 1.50 m span with standard modular bricks
4.90 m
10 cm
80 cm
60 cm
20 cm road
10 cm CC wearing coat
20 mm diameter bars 30 cm CC alt. bent up
20 cm
30 cm
1.00 m
20 cm diameter bars 15 cm CC
30 cm
Earth slope 1 : 1
1.30 m
1.20 m
40 cm
1.50 m
Bed level
GL
30 cm
30 cm
1.20 m
70 cm
30 cm
30 cm
CC 1 : 3 : 6
HALF SECTIONAL ELEVATION ON ABCD
60 cm
1.50 m
30 cm
70 cm
30 cm
40 cm
Kerb 10 cm
Bed Level
4.00 m roadway
10 cm wearing coat
Distr. bars 10 mm diameter 25 cm CC
20 cm
60 cm
40 cm
30 cm
40 cm
10 cm
20 cm
HALF LONGITUDINAL SECTIONAL ON CBEF
15 cm
40 cm
70 cm
1.20 m
70 cm
40 cm
4.80 m
A
SECTIONAL PLAN
1.50 m
1.20 m
15 cm
40 cm
F
30 cm
70 cm
4.00 m road way
B
E
TOP PLAN
D
D
HALF SECTIONAL PLAN

Fig. 8.5

## DETAILS OF MEASUREMENT AND CALCULATION OF QUANTITIES (EX. 1)

| *Item No.* | *Particulars of items of works* | *No.* | *Length* m | *Breadth* m | *Height or Depth* m | *Quantity* | *Explanatory notes* |
|---|---|---|---|---|---|---|---|
| 1. | **Earthwork in excavation** in foundation— | | | | | | |
| | Abutments … | 2 | 5.10 | 0.70 | 0.60 | 4.28 | |
| | Wing walls … | 4 | 1.20 | 0.70 | 0.60 | 2.02 | |
| | | | | | Total | 6.30 | cu m |
| 2. | **Cement concrete** 1 : 3 : 6 in foundation with stone ballast— | | | | | | |
| | Abutments … | 2 | 5.10 | 0.70 | 0.30 | 2.14 | ½ of earthwork in excavation in item 1 |
| | Wing walls … | 4 | 1.20 | 0.70 | 0.30 | 1.01 | |
| | | | | | Total | 3.15 | cu m |
| 3. | **First class brickwork in 1 : 4** cement mortar— | | | | | | |
| | Abutments … | 2 | 4.80 | 0.40 | 1.50 | 5.76 | Up to top of RCC slab |
| | Wing walls … | 4 | 1.20 | 0.40 | 1.50 | 2.88 | |
| | Parapets up to kerb … | 2 | 4.70 | 0.40 | 0.30 | 1.13 | Above RCC slab up to kerb |
| | Parapets above kerb … | 2 | 4.70 | 0.30 | 0.50 | 1.41 | Above kerb excluding coping |
| | Parapet coping … | 2 | 4.90 | 0.40 | 0.10 | 0.39 | |
| | | | | | Total | 11.57 | |
| | **Deduct** Bearing of RCC slab in abutment … | 2 | 4.80 | 0.30 | 0.20 | 0.57 | |
| | | | | Net | Total | 11.00 | cu m |
| 4. | **RCC work 1 : 2 : 4** in slab excluding steel and its bending but including centering shuttering and binding steel … | 1 | 4.80 | 2.10 | 0.20 | 2.016 cu m | No deduction for volume of steel |
| 5. | **Steel bars including bending in RCC work** 20 mm diameter bars— Main straight bars 30 cm CC … | 17 | 2.38 | — | — | 40.46 cu m | L = 2.10 – 2 side covers + 2 hooks = 2.10 – (2 × 4 cm) + (18 × 20 mm) = 2.38 m |
| | $\left(\text{No.} = \frac{4.80}{.30} + 1 = 17\right)$ | | | | | | |

(*Contd…*)

| *Item No.* | *Particulars of items of works* | *No.* | *Length* m | *Breadth* m | *Height or Depth* m | *Quantity* | *Explanatory notes* |
|---|---|---|---|---|---|---|---|
| | Main bent up bars 30 cm CC … | 16 | 2.54 | — | — | 40.64 m | Adding one depth, 16 cm for two bent ups |
| | $\left(\text{No.} = \frac{4.80}{.30} = 16\right)$ | | Total | 81.10 m | at 2.47 | kg m = 200.32 kg | L = 2.38+.16 = 2.54 m |
| | 10 mm diameter bars— Distributing bottom bars 25 cm CC … | 9 | 4.90 | — | — | 44.10 m | L = 4.80—2 end covers + 3 hooks = 4.80 — (2 × 4 cm) + (18 × 10 mm) = 4.90 m |
| | Distributing top bars … | 4 | 4.90 | — | — | 19.60 m | |
| | | Total | 63.70 m | at .62 kg | = | 39.49 kg | |
| | | | Total of steel | | | 239.81 kg | 2.398 quintal |
| 6. | **Cement concrete 1 : 2 : 4 wearing coat** … | 1 | 4.00 | 2.30 | 0.10 | 0.92 cu m | In between parapets |
| 7. | **Cement pointing 1 : 2 in walls** Face wall from 10 cm below GL up to bottom of coping … | 2 | 4.70 | — | 2.10 | 19.74 | |
| | Inner side of parapet excluding coping … | 2 | 4.70 | — | 0.80 | 7.52 | Ht. = (20 + 10 + 50) = 0.80 mm |
| | Coping (inner edge, top, outer edge and outer and side) … | 2 | 4.90 | 0.70 | — | 6.86 | B = (10 + 40 + 10 + 10) cm = 0.70 m |
| | Ends of parapet … | 4 | | 0.40 | 0.20 | 0.32 | Up to kerb |
| | Ends of parapet … | 4 | | 0.30 | 0.50 | 0.60 | Above kerb |
| | Ends of coping … | 4 | | 0.40 | 0.20 | 0.32 | Edge and under side |
| | | | | | Total | 35.36 | |
| | **Deduct** Rectangular opening | 2 | 1.50 | | 1.30 | 3.90 | Including 10 cm below GL and edge of RCC slab |
| | Triangular portion below earth slope | 2 | (½ × 1.30 × 1.30) | | | 1.69 | |
| | | | Total of deduction | | | 5.59 | |
| | | | | Net | Total | 29.77 | sq m |

## SLAB CULVERT

## ABSTRACT OF ESTIMATED COST (EX. 1)

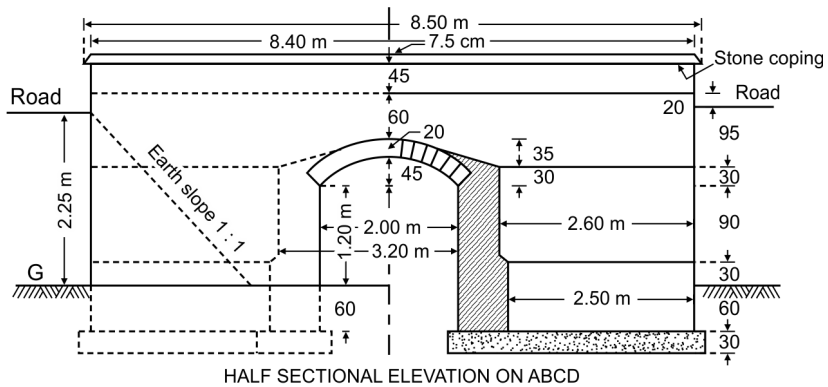
| *Item No.* | *Particulars of item of work* | *Quantity* | *Unit* | *Rate* ₹ *P.* | *Per* | *Rate* ₹ *P.* |
|---|---|---|---|---|---|---|
| 1. | Earthwork in excavation in foundation ... | 6.30 | cu m | 15000 | % cu m | 945.00 |
| 2. | Cement concrete 1 : 3 : 6 in foundation with stone ballast ... | 3.15 | cu m | 9000 | cu m | 28350.00 |
| 3. | First class brickwork in 1 : 4 cement mortar ... | 11.00 | cu m | 7000 | cu m | 77000.00 |
| 4. | RCC work 1 : 2 : 4 in slab excluding steel and its bending but including centering, shuttering and binding steel ... | 2.016 | cu m | 13000 | cu m | 26208.00 |
| 5. | Steel bars including bending in RCC work ... | 2.398 | quintal | 6000 | quintal | 14388.00 |
| 6. | Cement concrete 1 : 2 : 4 in wearing coat ... | 0.92 | cu m | 9000 | cu m | 8280.00 |
| 7. | Cement pointing 1 : 2 in wall ... | 29.77 | sq m | 134 | sq m | 3989.18 |
| | | | | | Total ... | 159160.18 |
| | Add 5% (3% for contingencies and 2% for work charged establishment) | | | | ... | 7958.00 |
| | | | | | Grand Total ... | 167118.18 |

Rate per running metre of span = $\frac{\text{Total cost}}{\text{Span}} = \frac{167118.8}{1.5}$ = ₹111412.12 per metre.

## ESTIMATE OF TWO METRE SPAN ARCHED CULVERT

**Example 2:** Prepare a detailed estimate for an arched culvert of two metre span and 5 metre clear roadway from the given drawings (Fig. 8.6). The general specifications are as follows:

Foundation shall be of cement concrete 1 : 4 : 8 with overburnt brick ballast and local sand. All masonry shall be of first class brickwork in 1 : 5 cement and local sand mortar, except arch work which shall be of 1 : 3 cement and coarse sand mortar. Exposed surface shall be pointed with 1 : 2 cement and local sand mortar.




HALF SECTIONAL ELEVATION ON ABCD

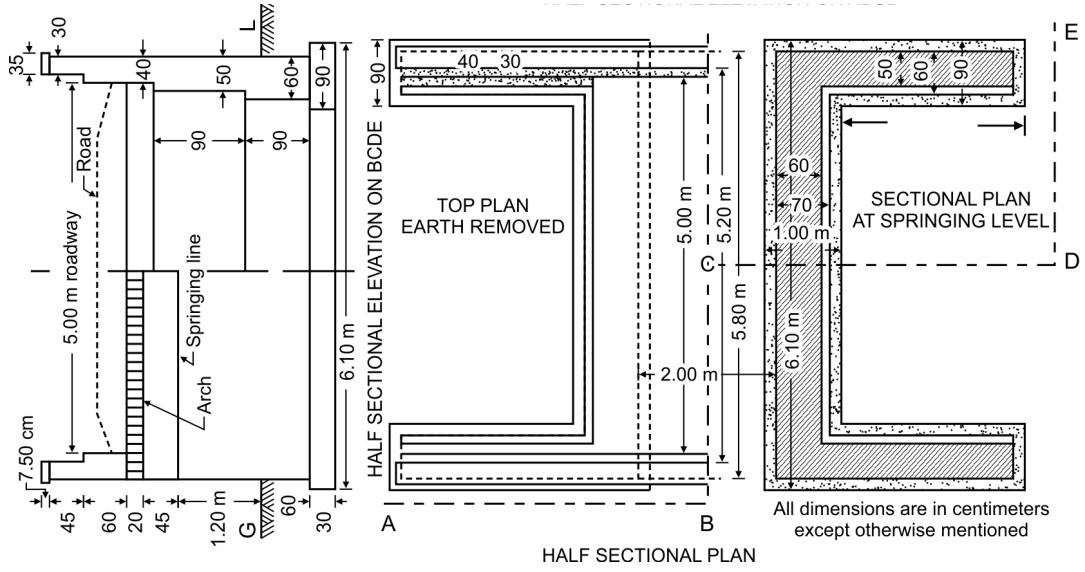



Fig. 8.6

*For the beginners to form clear conception isometric views of different parts of the culvert detached from one another are given in Fig. 8.7 in page 392. The dimensions in the solution of this example may be compared with the dimensions in the isometric view.*

## ARCHED CULVERT

## DETAILS OF MEASUREMENT AND CALCULATION OF QUANTITIES (EX. 2)

| *Item No.* | *Particulars of items and details of works* | *No.* | *Length* m | *Breadth* m | *Height or Depth* m | *Quantity* | *Explanatory notes* |
|---|---|---|---|---|---|---|---|
| 1 | **Earthwork in excavation** in foundation— | | | | | | |
| | Abutments … | 2 | 6.10 | 1.00 | 0.90 | 10.98 | |
| | Wing walls … | 4 | 2.50 | 0.90 | 0.90 | 8.10 | |
| | | | | | Total | 19.08 cu m | |
| 2. | **Cement concrete 1 : 4 : 8** with overburnt brick ballast in foundation— | | | | | | |
| | Abutments … | 2 | 6.10 | 1.00 | 0.30 | 3.66 | *1/3 of earthwork in excavation in item 1.* |
| | Wing walls … | 4 | 2.50 | 0.90 | 0.30 | 2.70 | |
| | | | | | Total | 6.36 cu m | |

(*Contd...*)

| *Item No.* | *Particulars of items and details of works* | *No.* | *Length* m | *Breadth* m | *Height or Depth* m | *Quantity* | *Explanatory notes* |
|---|---|---|---|---|---|---|---|
| 3 | **First class brickwork in** 1 : 5 cement local sand mortar—abutments— | | | | | | |
| | 1st step … | 2 | 5.80 | 0.70 | 0.90 | 7.31 | |
| | 2nd step up to springing level … | 2 | 5.80 | 0.60 | 0.90 | 6.26 | |
| | Above springing level as rectangular solid up to top of crown … | 1 | 5.80 | 3.20 | 0.65 | 12.06 | *Segmental opening, arch masonry, and upper triangle portion to be deducted, see Fig. 8.4 page 384.* |
| | Wing walls— | | | | | | |
| | 1st step … | 4 | 2.50 | 0.60 | 0.90 | 5.40 | |
| | 2nd step up to spandrel level … | 4 | 2.60 | 0.50 | 1.20 | 6.25 | |
| | Parapet up to kerb as solid (whole length) … | 2 | 8.40 | 0.40 | 0.95 | 6.38 | *Triangular portion to be deducted, see Fig. 8.4 page 384.* |
| | Parapet above kerb | 2 | 8.40 | 0.30 | 0.45 | 2.27 | |
| | | | | | Total | 45.93 | |
| | **Deduct** | | | | | | |
| | Arch opening segmental portion … | 1 | 5.80 | (2/3 × 2.00 × .45) | | = 3.48 | Area = 2/3 span × rise. |
| | Arch masonry … | 1 | Same as for item | | (4) | = 2.82 | *For deduction Figs 8.3 and 8.4, page 384 may be seen.* |
| | Triangular portions above abutment … | 2 | 5.80 | (½ × 3.20× .35) | | = 6.50 | |
| | Triangular portions above parapet … | 2 | (½ × 3.20 × .35 × .40) | | | = 0.45 | *Area of triangle × breadth of wall.* |
| | | | Total of deduction | | | 13.25 | |
| | | | | Net | Total | 32.68 | cu m |
| 4. | **First class brickwork in arch** in 1 : 3 cement, coarse sand mortar | 1 | 5.80 | 2.43 | 0.20 | 2.82 cu m | *Arch calculation is given as follows:* |

(*Contd…*)

| *Item No.* | *Particulars of items and details of works* | *No.* | *Length* m | *Breadth* m | *Height or Depth* m | *Quantity* | *Explanatory notes* |
|---|---|---|---|---|---|---|---|
| | Arch calculation: $r = \frac{h}{2} + \frac{s^2}{8h} = \frac{.45}{2} + \frac{2^2}{8 \times .45} = 1.336$ m; $r_m = r + \frac{\tau}{2} = 1.336 + \frac{.20}{2} = 1.436$ m<br>$b = \sqrt{a^2 + h^2} = \sqrt{1^2 + (.45)^2} = 1.096$; $l = \frac{8b - 2a}{3} = \frac{8 \times 1.096 - 2 \times 1.00}{3} = 2.256$ m<br>$l_m = l \times \frac{r_m}{r} = 2.256 \times \frac{1.436}{1.336} = 2.43$ m; $Q = L \times l_m \times t = 5.80 \times 2.43 \times .20 = 2.82$ cu m | | | | | | |
| 5. | **Cut stone work** laid with 1 : 3 cement coarse sand mortar in coping | 2 | 8.50 | 0.35 | 0.075 | 0.45 cu m | |
| 6. | **Cement pointing 1 : 2** in exposed surface including 10 cm below ground— Face wall from 10 cm below GL up to top of parapet | 2 | 8.40 | — | 3.00 | 50.40 | *Rectangular and segmental opening to be deducted.* |
| | Inner face of parapets above road level … | 2 | 8.40 | — | 0.75 | 12.60 | Ht = .20 + .114 + .45 = .764 m |
| | Ends of parapets … | 4 | — | 0.40 | 0.20 | 0.32 | |
| | Ends of parapets … | 4 | — | 0.30 | 0.45 | 0.54 | |
| | | | | | CO | 63.86 | |
| | | | | | BF | 63.86 | Including 10 cm below GL |
| | Inner face of abutments … | 2 | 5.80 | — | 1.30 | 15.08 | |
| | Soffit or arch … | 1 | 5.80 | 2.256 | — | 13.08 | B = *l* = 2.256 |
| | | | | | Total | 92.02 | |
| | **Deduct** | | | | | | |
| | Rectangular opening | 2 | 2.00 | — | 1.30 | 5.20 | |
| | Arch opening segmental portion … | 2 | (⅔×2.00 | × 0.45) | | 1.20 | 2/3 span × rise |
| | Triangular portion below earth slope in face walls … | 4 | (½×2.35 | × 2.35) | | 11.04 | Area = ½ base × ht |
| | | | Total of deduction | | | 17.44 | |
| | | | | Net | Total | 74.58 | sq m |

## ABSTRACT OF ESTIMATED COST (ARCHED CULVERT) (EX. 2)

| *Item No.* | *Particulars of items or works* | *Quantity* | *Unit* | *Rate* ₹ *P.* | *Per* | *Amount* ₹ *P.* |
|---|---|---|---|---|---|---|
| 1. | Earthwork in excavation in foundation | 19.08 | cu m | 15000 | % cu m | 2862.00 |
| 2. | Cement concrete 1 : 4 : 8 with overburnt brick ballast in foundation ... | 6.36 | cu m | 9000 | cu m | 57240.00 |
| 3. | First class brickwork in 1 : 5 cement sand mortar ... | 32.68 | cu m | 7000 | cu m | 228760.00 |
| 4. | First class brickwork in arch in 1 : 3 cement sand mortar ... | 2.82 | cu m | 8700 | cu m | 24534.00 |
| 5. | Cut stone work laid in 1 : 3 cement sand mortar in coping ... | 0.45 | cu m | 12000 | cu m | 5400.00 |
| 6. | Cement pointing 1 : 3 in exposed surface of brickwork ... | 74.58 | sq m | 134 | sq m | 993.72 |
| | | | | | Total ... | 328789.72 |
| | Add 5% (3% for contingencies and 2% for work charged establishment) ... | | | | | 16439.48 |
| | | | | | Grand Total ... | 345229.20 |

**Rates per metre of span** = $\frac{\text{Total cost}}{\text{Span}} = \frac{345229.20}{2}$ = ₹172614.60 per metre of span.

## ARCHED CULVERT ISOMETRIC VIEW—PARTS DETACHED (EX. 2)

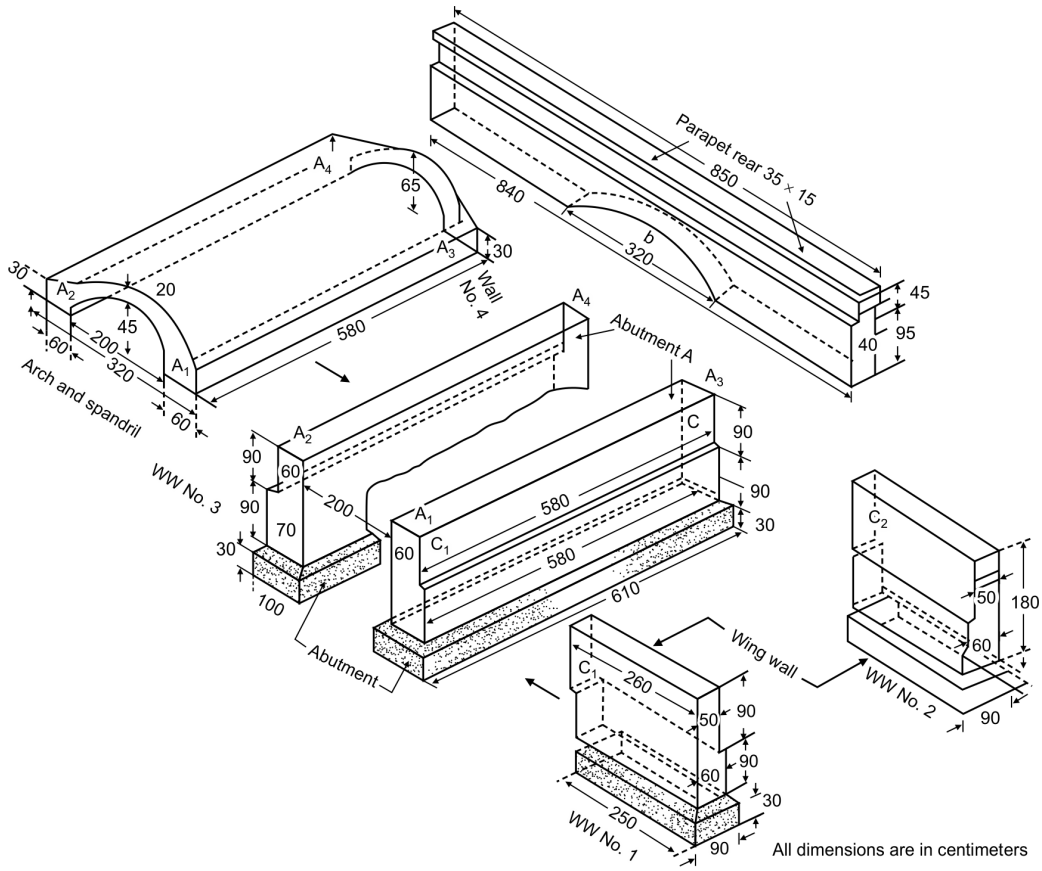



Fig. 8.7

**Example 3:** Prepare a detailed estimate for a 3 metre span arched culvert for 10 metre wide roadway from the drawings given in Figs 8.8 and 8.9. The general specifications and rates are as below:

Foundation will be of lime concrete, masonry work in abutments, wing walls and parapets will be of first class brickwork in cement sand mortar 1 : 4.

Arch masonry will be of first class brickwork in cement sand mortar 1 : 3.

Floor will be of brick-on-edge in cement mortar 1 : 3 over lime concrete. Exposed surface will be cement pointed 1 : 2.

## RATES

| | | |
|---|---|---|
| 1. Earthwork in excavation in foundation | ... | ₹15000.00% cu m |
| 2. Lime concrete in foundation | ... | ₹3600.00 per cu m |
| 3. First class brickwork in cement mortar 1 : 4 | ... | ₹7000.00 per cu m |
| 4 First class brickwork in arch in cement mortar 1 : 3 | ... | ₹8700.00 per cu m |
| 5. First class brick-on-edge floor in cement mortar 1 : 3 including pointing | ... | ₹870.00 per sq m |
| 6. Cement pointing 1 : 2 | ... | ₹134.00 per sq m |

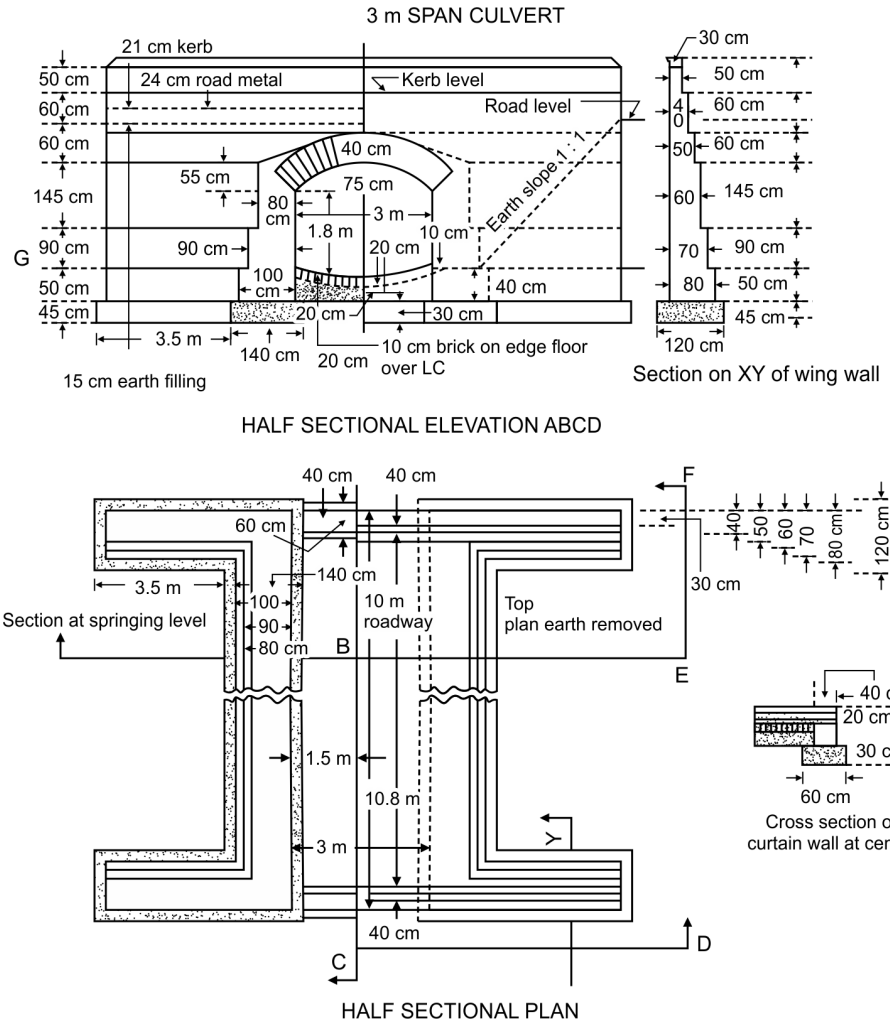



Fig. 8.8

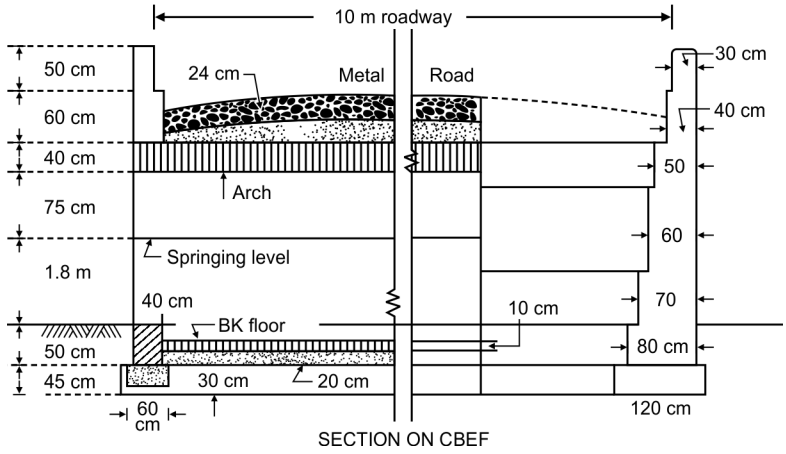



Fig. 8.9

## DETAILS OF MEASUREMENT AND CALCULATION OF QUANTITIES (EX. 3)

| *Item No.* | *Name of items and details of works* | *No.* | *Length* m | *Breadth* m | *Height or Depth* m | *Quantity* | *Explanatory notes* |
|---|---|---|---|---|---|---|---|
| 1. | **Earthwork in excavation** in foundation | | | | | | |
| | Abutments … | 2 | 11.20 | 1.40 | .95 | 29.80 | L = 10.00 + 2 × .40 + 2 × .20 = 11.20 m |
| | Wing walls … | 4 | 3.50 | 1.20 | .95 | 15.96 | |
| | Curtain walls … | 2 | 2.60 | .60 | .80 | 2.50 | |
| | Floor in between abutments … | 1 | 9.80 | 2.60 | .50 | 12.74 | |
| | | | | | Total | 61.00 cu m | |
| 2. | **Lime concrete in foundation** | | | | | | |
| | Abutments … | 2 | 11.20 | 1.40 | .45 | 14.11 | |
| | Wing walls … | 4 | 3.50 | 1.20 | .45 | 7.56 | |
| | Curtain walls … | 2 | 2.60 | .60 | .30 | 0.94 | |
| | Floor … | 1 | 10.00 | 3.00 | .30 | 9.00 | Average thickness |
| | | | | | Total | 31.61 cu m | $= \frac{.40 + .20}{2} = .30$ m |
| 3. | **First class brickwork in** cement mortar 1 : 4 **Abutments**— | | | | | | |
| | 1st step … | 2 | 10.80 | 1.00 | .50 | 10.80 | |
| | 2nd step … | 2 | 10.80 | 90 | .90 | 17.50 | |

(*Contd...*)

| *Item No.* | *Name of items and details of works* | *No.* | *Length* m | *Breadth* m | *Height or Depth* m | *Quantity* | *Explanatory notes* |
|---|---|---|---|---|---|---|---|
| | 3rd step up to spring level … | 2 | 10.80 | .80 | .90 | 15.55 | |
| | | | | | CO | 43.85 | |
| | Abutment above spring level as solid | | | | BF | 43.85 | |
| | including arch … | 1 | 10.80 | 4.60 | 1.15 | 57.13 | Segmental opening, arch masonry, upper triangular portions to be deducted. |
| | **Wing walls** | | | | | | |
| | 1st step … | 4 | 3.50 | .80 | .50 | 5.60 | |
| | 2nd step … | 4 | 3.60 | .70 | .90 | 9.07 | |
| | 3rd step … | 4 | 3.70 | .60 | 1.45 | 12.88 | |
| | 4th step up to crown of arch … | 4 | $\frac{3.70+6.00}{2}$ | .50 | .60 | 5.82 | Average length |
| | Parapet above arch— | | | | | | |
| | *(i)* … | 2 | 12.00 | .40 | .60 | 5.76 | |
| | *(ii)* … | 2 | 12.00 | .30 | .50 | 3.60 | |
| | Curtain wall … | 2 | 3.00 | .40 | .40 | 0.96 | Av. ht. = $\frac{.50+.30}{2}$ = .40 m |
| | **Deduct** | | | | Total | 144.67 | Area of segment |
| | Arch opening (segmental portion) | 1 | 10.80 × | (⅔ × 3.00 | × 75) + | $\frac{75^2}{2\times3.0}$ | = $\frac{2}{3}$ sh + $\frac{h^2}{2s}$ |
| | | | = 10.80 | × 1.57 | (area) = | 16.96 | where s = span, h = rise |
| | Arch masonry … | | Same as for item (4) | | | 30.78 | |
| | Triangular portion above abutment … | 2 | 10.80 | 2.30 | ½ × .60 | 14.90 | L = 10.80 m<br>Area = (½ × 2.30 × .60) |
| | | | Total of deduction | | | 62.64 cu m | |
| | | | | Net | Total | 82.03 cu m | |
| 4. | **First class brickwork** in arch in cement mortar 1 : 3 … | 1 | 10.80 | 3.80 | .75 | 30.78 cu m | b = $l_m$ = 3.80 m as per calculation below: |

$r = \frac{h}{2} + \frac{s^2}{8h}$ $\qquad$ $r_m = r + \frac{t}{2}$

$= \frac{.75}{2} + \frac{3.00^2}{8 \times .75} = 1.875$ m $\qquad$ $r_m = 1.875 + \frac{.40}{2} = 2.075$ m

**Note:** *For deduction of the segmental portion of the arch, in item 8, the area may be taken approximately 2/3 span × rise, $h^2/2s$ may be neglected.*

| *Item No.* | *Name of items and details of works* | *No.* | *Length* m | *Breadth* m | *Height or Depth* m | *Quantity* | *Explanatory notes* |
|---|---|---|---|---|---|---|---|
| | | | | $b = \sqrt{a^2 + h^2} = \sqrt{1.5^2 + .75^2} = 1.66$ m | | | |
| | | | | $l_m = \frac{8b - 2a}{3} = \frac{8 \times 1.66 - 2 \times 1.5}{3} = 3.43$ m | | | |
| | | | | $l_m = l \times \frac{r_m}{r} = 3.43 \times \frac{2.075}{1.875} = 3.80$ m | | | |
| 5 | **First class brick-on-edge** floor, 10 cm thick in cement mortar 1 : 3 including pointing … | 1 | 10.00 | 3.03 | — | 30.30 sq m | L = 10.8—2 × .4 = 10.00 m<br>b = 3.03 |
| | $l = \frac{8b-2a}{3}$,<br>$b = \sqrt{1.5^2 + .2^2} = 1.51$<br>$l = \frac{8 \times 1.51 - 2 \times 1.5}{3}$<br>= 3.03 m | | | | | | LC taken separately in item 2 |
| 6. | **Cement pointing 1 : 2—** | | | | | | |
| | Face wall from GL up to top parapet … | 2 | 12.00 | — | 4.05 | 97.20 | Opening and earth cover to be deducted |
| | Top and inside of parapet above road … | 2 | 12.00 | | 1.11 | 26.64 | Ht. = 30 + 50 + 10 + 21 = 111 cm = 1.11 m |
| | Ends of parapet— | | | | | | |
| | (*i*) … | 4 | .30 | — | .50 | 0.60 | |
| | (*ii*) … | 4 | .40 | — | .21 | 0.34 | |
| | Inside face of abutment … | 2 | 10.80 | — | 1.80 | 38.88 | |
| | Soffit of arch … | 1 | 10.80 | 3.43 | — | 37.04 | b = 1 = 3.43 m |
| | Top of curtain wall … | 2 | 3.20 | .40 | — | 2.56 | |
| | | | | | Total | 203.26 | |
| | **Deduct** | | | | | | |
| | Rectangular opening … | 2 | 3.00 | — | 1.80 | 10.80 | |
| | Segmental portions of each opening … | 2 | ⅔ × 3.00 | × .75 | — | 3.00 | Area = 2/3 span × rise |
| | Triangular portions below earth filling slope 1 : 1 … | 4 | 3.10 | — | ½ × 3.10 | 19.22 | Area × ½ base × ht.<br>Ht. = 3.10 m<br>Base = 3.10 m |
| | (Height up to road level, i.e. up to 15 cm earth fill.) | | | | Total | 33.02 | |
| | | | | Net | Total | 170.24 sq m | |

## ABSTRACT OF ESTIMATED COST (EX. 3)

| | | | |
|---|---|---|---|
| 1. Earthwork in excavation in foundation | ... | 61.00 cu m at ₹15000% cu m | = ₹ 9150.00 |
| 2. Lime concrete in foundation | ... | 31.61 cu m at ₹3600 per cu m | = ₹113796.00 |
| 3. First class brickwork in cement mortar 1 : 4 | ... | 82.03 cu m at ₹7000 per cu m | = ₹574210.00 |
| 4. First class brickwork in arch in cement mortar 1 : 3 | ... | 30.78 cu m at ₹8700 per cu m | = ₹267786.00 |
| 5. First class brick-on-edge floor 10 cm thick in cement mortar 1 : 3 including pointing 1 : 2 | ... | 30.30 sq m at ₹870 per sq m | = ₹26361.00 |
| 6. Cement pointing 1 : 2 | ... | 170.24 sq m at ₹134 per sq m | = ₹22813.16 |
| | | Total | ₹101405.16 |
| Add 5% contingencies and work charged establishment | | | ₹50705.75 |
| | | Grand Total | ₹1064820.91 |

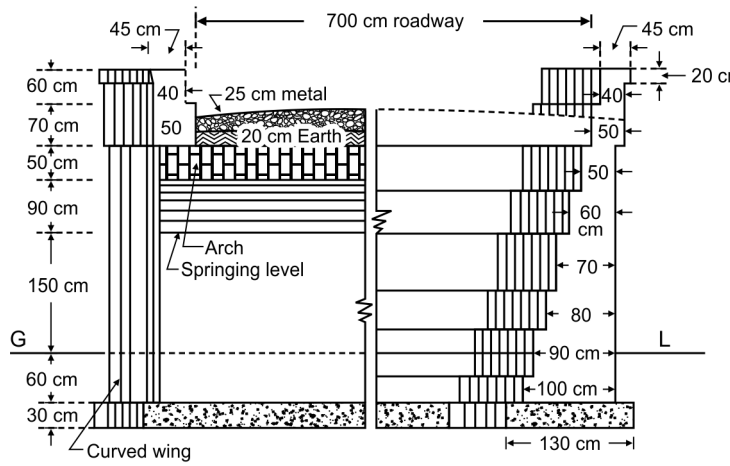
**Rate per running metre of span for 10 metre roadway** = $\frac{\text{Total cost}}{\text{Span}}$

$= ₹\frac{1064820.91}{3}$ = 354940.30 per running metre of span.

## CULVERT WITH CURVED WING WALL

**Example 4:** From the drawing (Figs 8.10 and 8.11) estimate the quantities of the following items:

(*i*) Earthwork for foundations, (*ii*) cement concrete 1 : 4 : 8 in foundations, (*iii*) first class brickwork in 1 : 6 cement mortar up to springing level, (*iv*) arch masonry work in 1 : 4 cement mortar, (*v*) cement pointing 1 : 2 on parapets. (*Roorkee OSQ 1957, Modified.*)




SECTION ON CBEF

Fig. 8.10

*The wing walls of the culvert are curved and curvatures have been indicated by close vertical lines in elevations. Curved wing walls give easy approach to the culvert. For culvert with small roadway in village road the curved wing walls suit better.*

## ARCHED CULVERT 360 cm SPAN WITH CURVED WING WALLS

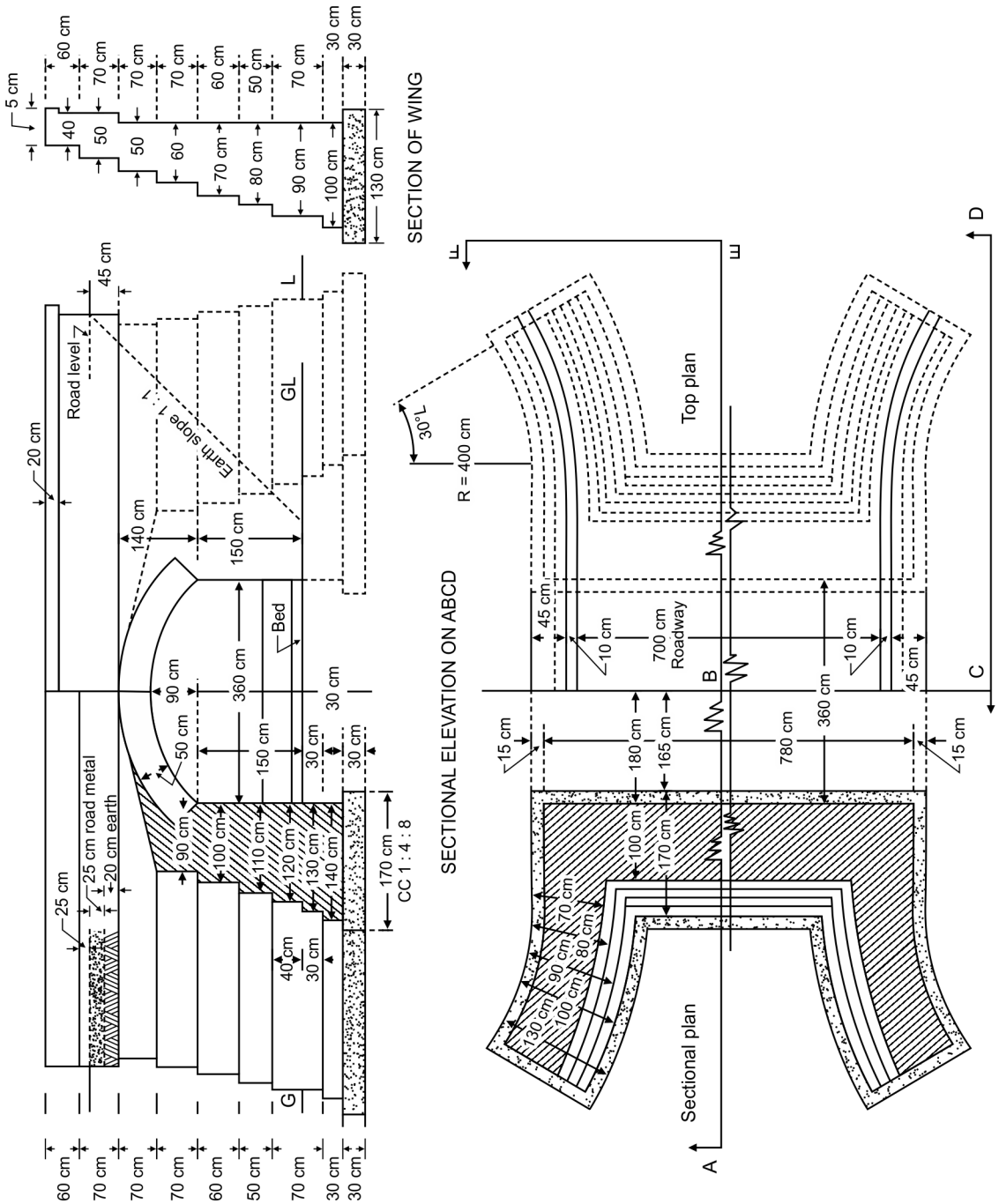



Fig. 8.11

## DETAILS OF MEASUREMENT AND CALCULATION OF QUANTITIES (EX. 4)

| *Item No.* | *Name of items and details of works* | *No.* | *Length* m | *Breadth* m | *Height or Depth* m | *Quantity or Contents* | *Explanatory notes* |
|---|---|---|---|---|---|---|---|
| 1 | **Earthwork in excavation** in foundation | | | | | | |
| | Abutments … | 2 | 7.90 | 1.70 | .90 | 24.16 | Length as in page 402 |
| | Wing walls … | 4 | 2.59 | 1.30 | .90 | 12.12 | |
| | | | | | Total | 36.28 cu m | |
| 2 | **Cement concrete in** foundations | | | | | | |
| | Abutments … | 2 | 7.90 | 1.70 | .30 | 8.05 | 1/3 of earthwork in excavation in item 1 |
| | Wing walls (length same as above) … | 4 | 2.59 | 1.30 | .30 | 4.04 | |
| | | | | | Total | 12.09 cu m | |
| 3 | First class brickwork in 1 : 6 cement mortar | | | | | | |
| | **Abutment** | | | | | | |
| | 1st step … | 2 | 7.80 | 1.40 | .30 | 6.55 | |
| | 2nd step … | 2 | 7.80 | 1.30 | .30 | 6.08 | |
| | 3rd step … | 2 | 7.80 | 1.20 | .40 | 7.49 | |
| | 4th step … | 2 | 7.80 | 1.10 | .50 | 8.58 | |
| | 5th step up to springing level … | 2 | 7.80 | 1.00 | .60 | 9.36 | |
| | Above springing level up to crown (upper) of arch as rectangular solid … | 1 | 7.80 | 5.40 | 1.40 | 58.96 | For deduction *see* next page |
| | **Wing walls** | | | | | | |
| | 1st step … | 4 | 2.59 | 1.00 | .30 | 3.11 | Length of wing wall calculated correctly in page 402 at different steps, but approximate mean length may be taken for practical purposes, *see* page 403. |
| | 2nd step *(i)* … | 4 | 2.66 | .90 | .30 | 2.87 | |
| | *(ii)* … | 4 | 2.76 | .90 | .40 | 3.97 | |
| | 3rd step | 4 | 2.85 | .80 | .50 | 4.56 | |
| | 4th step up to springing level | 4 | 2.91 | .70 | .60 | 4.89 | |
| | | | | | CO | 116.42 | |

(*Contd…*)

| *Item No.* | *Name of items and details of works* | *No.* | *Length* m | *Breadth* m | *Height or Depth* m | *Quantity or Contents* | *Explanatory notes* |
|---|---|---|---|---|---|---|---|
| | | | | | BF | 116.42 | |
| | 5th step up to outer top edge of abutment … | 4 | 2.98 | .60 | .70 | 5.01 | |
| | 6th step up to crown (upper) of arch … | 4 | 4.31 | .50 | .70 | 6.03 | Average length as marked in page 402 |
| | 7th step above crown … | 2 | 11.40 | .50 | .70 | 7.98 | |
| | 8th step parapet … | 2 | 11.36 | .40 | .40 | 3.64 | } Total length |
| | 9th parapet coping … | 2 | 11.42 | .45 | .20 | 2.06 | |
| | | | | | Total | 141.14 | *Total of wing walls and parapet = 44.12 cu m* |
| | **Deduct** | | | | | | |
| | Segmental portion … | 1 | 7.80 × | 2.23 sq m | (area) | 17.39 | Area of segment $= 2/3\ sh + \frac{h^2}{2s} = 2/3 \times 3.6 \times .9 + \frac{.9^3}{2 \times 3.6}$ = 2.23 sq m |
| | Triangular portion (½ base × alt.) × length… | 2 | 7.80 | (½ × .70 | × 2.70) | 14.74 | Base = height = .70 m Alt. = ½ breadth |
| | Arch masonry work … | | Same as | for item | (4) | 18.02 | = 1.8 + .9 = 2.70 m |
| | | | | | Total | 50.15 | |
| | | | | Net | Total | 91.09 | cu m |
| 4. | **Arch masonry work in** 1 : 4 cement mortar … | 1 | 7.80 | 4.62 | .50 | 18.02 cu m | Calculation of mean curve length $l_m$ given below: |
| | $a^2 = h(d - h)$<br>$1.8^2 = .9(d-.9)$<br>$\therefore d = 4.50$<br>$r = \frac{d}{2} = \frac{4.5}{2} = 2.25$<br>$r_m = r + \frac{t}{2}$<br>$= 2.25 + \frac{.5}{2} = 2.50$ | | | | | | $b = \sqrt{a^2+h^2}$<br>$= \sqrt{1.8^2+9^2} = 2.01$<br>$l = \frac{8b - 2a}{3}$<br>$= \frac{8 \times 2.01 - 2 \times 1.8}{3} = 4.16$<br>$l = 1 \times \frac{r_r}{r} = 4.16$<br>$\times \frac{2.50}{2.25} = 4.62$ |

(*Contd…*)

| *Item No.* | *Name of items and details of works* | *No.* | *Length* m | *Breadth* m | *Height or Depth* m | *Quantity or Contents* | *Explanatory notes* |
|---|---|---|---|---|---|---|---|
| 5 | **Cement pointing with 1 : 2 mortar—** | | | | | | |
| | Face walls above GL … | 2 | 11.40 | — | 4.35 | 99.18 | L = Same as parapet<br>Ht. = Full ht. + two outer offsets = (1.50 + 1.40 + .70 + .60) + .10 + .05 = 4.35 m |
| | Inner face of parapet above road level … | 2 | 11.40 | — | .95 | 21.66 | Ht. = .25 + .10 + .60= .95 m |
| | Top of parapet … | 2 | 11.42 | — | .45 | 10.28 | |
| | Ends of parapet (*i*) | 4 | — | .40 | .40 | .64 | |
| | (*ii*) | 4 | — | .45 | 0.20 | .36 | |
| | Inner face of abutment | 2 | 7.80 | — | 1.50 | 23.40 | |
| | Soffit of arch … | 1 | 7.80 | 4.16 | — | 32.45 | |
| | | | | | Total | 187.97 | |
| | **Deduct** | | | | | | |
| | Rectangular portions | 2 | 3.60 | — | 1.50 | 10.80 | |
| | Segmental portions | 2 × | 2.26 sq m | (area) | — | 4.52 | Area same as in page 402 |
| | Triangular portions below earth slope … | 4 | 3.35 | — | ½ × 3.35 | 22.45 | Area of triangle = base × ½ ht. |
| | | | | | Total | 37.77 | |
| | | | | Net | Total | 150.20 sq m | |

## ABSTRACT OF QUANTITIES (EX. 4)

| *Item No.* | *Particulars of items* | *Quantity* | *Unit* | *Remarks* |
|---|---|---|---|---|
| 1. | Earthwork in excavation in foundation | cu m | 36.28 | Cost may be worked out if required. |
| 2. | Cement concrete 1 : 4 : 8 in foundations | cu m | 12.09 | |
| 3. | First class brickwork in 1 : 6 cement mortar | cu m | 60.16 | |
| 4. | Arch mosonry work in 1 : 4 cement mortar | cu m | 18.02 | |
| 5. | Cement pointing with 1 : 2 mortar ... | sq m | 150.20 | |

**Note:** *For the answer of the question paper the quantities of items required may be picked up.*

## CALCULATION OF LENGTHS OF WING WALLS (EX. 4)

| *Particulars* | *Mean radius,* $R_m = R + \frac{\text{Breadth}}{2}$ m | *Mean length of curvature* $\frac{L_m}{2\pi R_m} = \frac{30°}{360°}$, $L_m = \frac{1}{6}\pi R_m$ m | *Total mean length by adding offsets* m |
|---|---|---|---|
| Foundation excavation and concrete — | $4.00 + \frac{1.30}{2} = 4.65$ | $\frac{1}{6} \times \frac{22}{7} \times 4.65 = 2.44$ | 2.44 + .15 = 2.59 m |
| 1st step | $4.15 + \frac{1.00}{2} = 4.65$ | $\frac{1}{6} \times \frac{22}{7} \times 4.65 = 2.44$ | 2.44 + .15 = 2.59 m |
| 2nd step | $4.15 + \frac{.90}{2} = 4.60$ | $\frac{1}{6} \times \frac{22}{7} \times 4.60 = 2.41$ | 2.41 + .15 + .10 = 2.66 m<br>(i) 2.41 + .15 + .10 +.10 = 2.76 m (ii) |
| 3rd step | $4.15 + \frac{.80}{2} = 4.55$ | $\frac{1}{6} \times \frac{22}{7} \times 4.55 = 2.40$ | 2.40 + .15 + .10 + .10 + .10 = 2.85 m |
| 4th step | $4.15 + \frac{.70}{2} = 4.50$ | $\frac{1}{6} \times \frac{22}{7} \times 4.50 = 2.36$ | 2.36 + .15 + .10 + .10 + .10 + .10 = 2.91 m |
| 5th step | $4.15 + \frac{.60}{2} = 4.45$ | $\frac{1}{6} \times \frac{22}{7} \times 4.45 = 2.33$ | 2.33 + .15 + .10 + 10 + .10 + .10 + .10 = 2.98 m |
| 6th step | $4.15 + \frac{.50}{2} = 4.40$ | $\frac{1}{6} \times \frac{22}{7} \times 4.40 = 2.31$ | 2.31 + .15 + .10 + .10 + .10 + .10 + .10 = 2.96 m |
| 7th step above crown | $4.05 + \frac{.50}{2} = 4.30$ | $\frac{1}{6} \times \frac{22}{7} \times 4.30 = 2.25$ | 2.25 + .15 + .10 + .10 + .10 + .10 + .10 + .10 = 3.00<br>Total length above crown = (2 × 3.00) + (3.60 + .90 + .90) = 11.40 m |
| 8th step parapet | $4.05 + \frac{.40}{2} = 4.25$ | $\frac{1}{6} \times \frac{22}{7} \times 4.25 = 2.23$ | 2.23 + .15 + .10 + .10 + .10 + .10 + .10 + .10 = 2.98<br>Total length = (2 × 2.98) + (3.60 + .90 + .90) = 11.36 m |
| 9th step parapet coping | $4.00 + \frac{.45}{2} = 4.225$ | $\frac{1}{6} \times \frac{22}{7} \times 4.225 = 2.21$ | 2.21 + .15 + .10 + .10 + .10 + .10 + .10 + .10 + .05 = 3.01 m<br>Total length = (2 × 3.01) + (3.60 + .90 + .90) = 11.42 m |
| Average length for the portion above abutment (6th step of wing wall). | — | — | $\frac{2.96 + (2.96 + .90 + 1.80)}{2}$ = 4.31 m |

**Approximate estimate of wing walls and parapet**

**Note:** The wing walls and parapet may be estimated approximately by taking the mean length which may be taken as the length of the 3rd step which is equal to 2.85 m, and this mean length multiplied by the breadth and the height of the different steps will give the quantities. The length column will remain same. The length of one middle step of the wing wall can be found easily in the same method as given in the previous page, without much labour and time. The quantities of masonry work in wing walls and parapets may thus be calculated as:

| *Details of work* | *No.* | *L* m | *B* m | *Ht.* m | *Qty.* $m^3$ |
|---|---|---|---|---|---|
| **Wing walls** | | | | | |
| 1st step … | 4 | 2.85 | 1.00 | .30 | 3.42 |
| 2nd step … | 4 | 2.85 | .90 | .70 | 7.18 |
| 3rd step … | 4 | 2.85 | .80 | .50 | 4.56 |
| 4th step … | 4 | 2.85 | .70 | .60 | 4.79 |
| 5th step … | 4 | 2.85 | .60 | .70 | 4.79 |
| 6th step … | 4 | ½ (2.85 + 2.85 + .90 + 1.80) = 4.20 | .50 | .70 | 5.88 |
| 7th step above crown full length … | 2 | 2(2.85 + .10) + (3.60 + .90 + .90) = 11.30 | .50 | .70 | 7.91 |
| 8th step parapet full length … | 2 | 11.30 (same as 7th step) | .40 | .40 | 3.62 |
| 9th step parapet coping … | 2 | 11.30 + (2 × .05) = 11.40 | .45 | .20 | 2.05 |
| | | | Total | 44.20 | cu m |

The quantity of wing walls and parapets as calculated corrected in pages 401-402 works out us 44.12 cu m. The difference in between the correct quantity and approximate quantity comes to 44.20 – 44.12 = 0.08 cu m. For practical purposes to save labour and calculations approximate method may be adopted.

**Example 5:** Estimate the cost of RCC T-beam decking including beam for a bridge of one span of 6 metre section is given (Fig. 8.12). Assume 45 cm bearing on either abutment. The mild steel reinforcements are 2.5% in beam and 1% in slab and post. Density of mild steel is 78.5 quintal per cu m (7.85 $g/cm^2$).

Assume suitable rates.

RCC T-beam decking

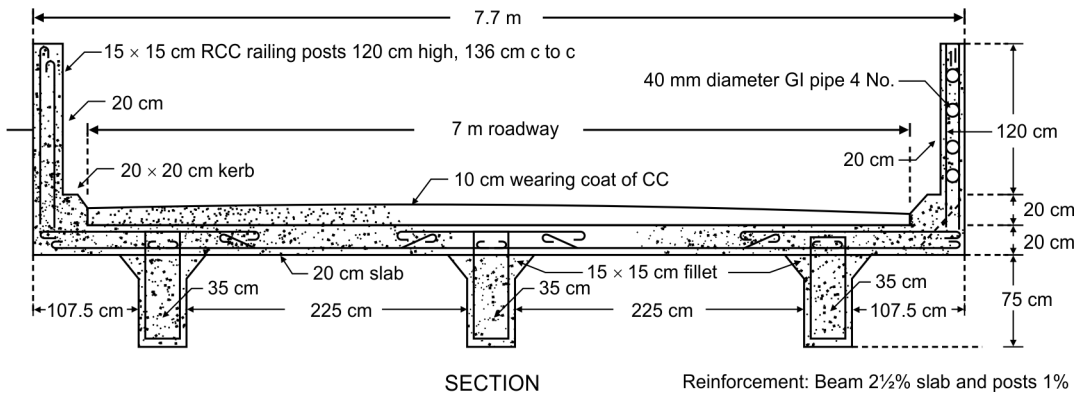



Fig. 8.12

## DETAILS OF MEASUREMENT AND CALCULATION OF QUANTITIES (EX. 5)

| *Item No.* | *Particulars of items and details of works* | *No.* | *Length* m | *Breadth* m | *Height or Depth* m | *Quantity* | *Explanatory notes* |
|---|---|---|---|---|---|---|---|
| 1. | RCC work 1 : 2 : 4 excluding steel and its bending but including centering and shuttering and binding of bars— | | | | | | Length of beams = clear span + 2 bearings = 6.00 + 2 × .45 = 6.90 m |
| | T-beam ribs … | 3 | 6.90 | .35 | .75 | 5.434 | 45 cm bearings |
| | Fillets … | 3 × 2 | 6.90 | ½ (.15 × | .15) | 0.466 | Triangular |
| | Deck slab … | 1 | 6.90 | 7.70 | .20 | 10.626 | |
| | Railing posts … | 6 × 2 | .15 | .15 | 1.20 | 0.324 | 6 posts each side |
| | Kerbs … | 2 | 6.90 | .35 | .20 | 0.966 | |
| | | | | | Total | 17.816 cu m | |
| 2. | RCC 1 : 2 : 4 in wearing coat … | 1 | 6.90 | 7.00 | .10 | 4.83 | 10 cm average thickness |
| 3. | 40 mm diameter GI pipe in railing … | 2 × 4 | 6.90 | — | — | 55.20 r m | |
| 4. | Steel reinforcement bars including binding— | | | | | | |
| | Beam at 2½% … | 3 | × 6.90 × | .35 × 95 | $\frac{2.5}{100}$ | 78.5 = 13.50 q | Full depth including slab thickness |
| | Slab at 1% | | 10.626 | × $\frac{1}{100}$ | 78.5 = | 8.34 q | |
| | Railing posts at 1% | | 0.324 | × $\frac{1}{100}$ | 78.5 = | 0.26 q | |
| | | | | | Total | 22.10 q | |

## ABSTRACT OF ESTIMATED COST (EX. 5)

| *Item No.* | *Particulars of items of works* | *Quantity* | *Unit* | *Rate* ₹ P. | *Per* | *Amount* ₹ P. |
|---|---|---|---|---|---|---|
| 1. | RCC work 1 : 2 : 4 excluding steel and its bending but including centering and shuttering and binding of bars … | 17.816 | cu m | 13000 | / cu m | 231608.00 |
| 2. | CC 1 : 2 : 4 in wearing coat … | 4.83 | cu m | 9000 | / cu m | 43470.00 |

| *Item No.* | *Particulars of items of works* | *Quantity* | *Unit* | *Rate* ₹ P. | *Per* | *Amount* ₹ P. |
|---|---|---|---|---|---|---|
| 3. | 40 mm diameter GI pipe in railing … | 55.20 | r m | 230 | / r m | 12696.00 |
| 4. | Steel reinforcement bars including bending | 22.10 | quintal | 5800 | /q | 128180.00 |
| | | | | Total | ... | 415954.00 |
| | Add 5% for contingencies and work charged establishment | | | | ... | 20797.70 |
| | | | | Grand Total | ... | 436751.70 |

**Note:** *For fillets and kerbs no reinforcement have been taken into account.*

## CULVERT WITH SERIES OF SPANS

When there are number of span and arches, the two abutments and four wing walls can be estimated in the same manner as for a single span culvert. The, piers shall have to be calculated separately and

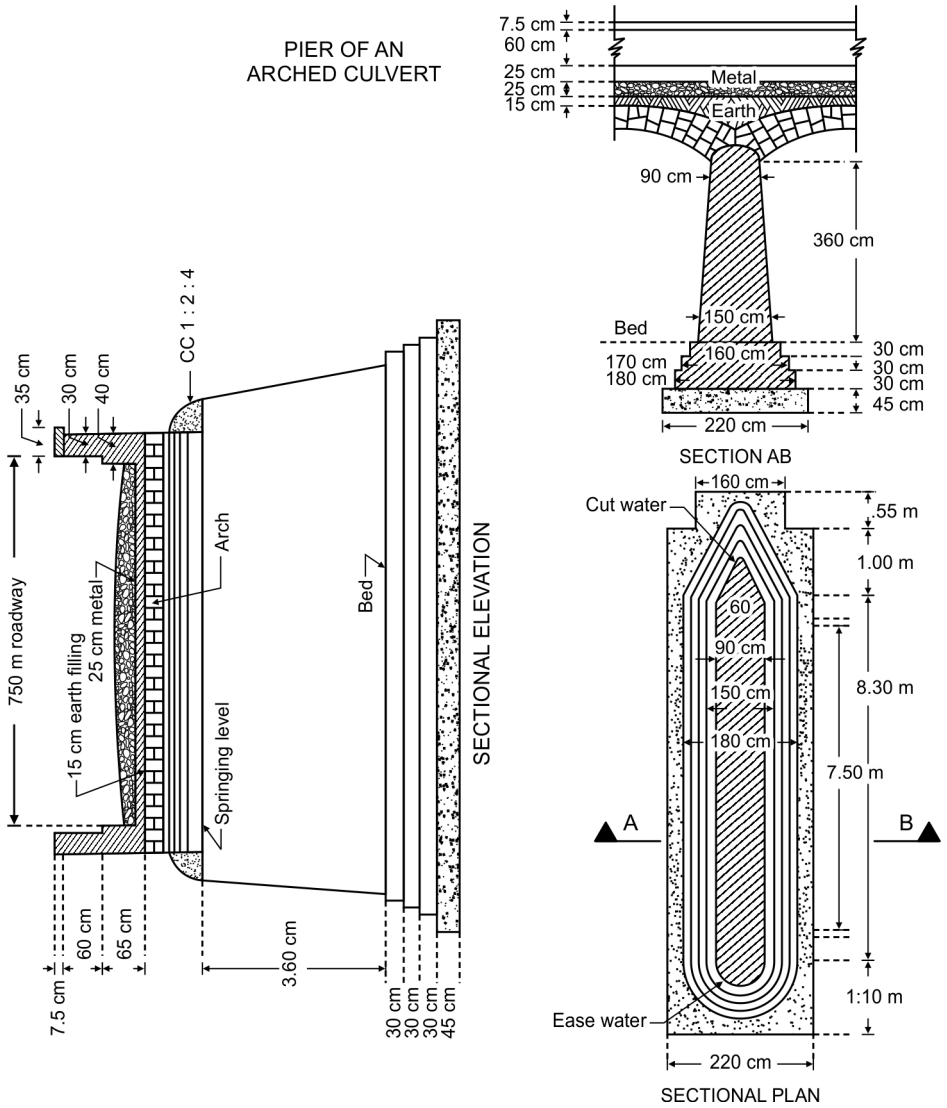



Fig. 8.13

multiplied by the number of piers if they are similar, to get the total quantity. Similarly, one arch can be calculated and multiplied by the number of arches. The spandrel and the portion above the springing point should be calculated as solid rectangular block for one span and necessary deduction made and then multiplied by the number of span.

## ESTIMATE OF PIER

**Example 6:** Estimate the quantities of different items of a pier of an arched culvert up to the springing level for 7.50 metre roadway from the given plan and sectional drawings (Fig. 8.13).

## DETAILS OF MEASUREMENT AND CALCULATION OF QUANTITIES (EX. 6)

| *Item No.* | *Particulars of items* | *No.* | *Length* m | *Breadth* m | *Height or Depth* m | *Quantity* | *Explanatory notes* |
|---|---|---|---|---|---|---|---|
| 1. | **Earthwork** in excavation in foundation | | | | | | |
| | Pier … | 1 | 10.40 | 2.20 | 1.35 | 30.88 | |
| | Cut-water end … | 1 | 0.55 | 1.60 | 1.35 | 1.19 | |
| | | | | | Total | 32.07 | cu m |
| 2. | **Cement concrete 1 : 4 : 8** in foundation | ⅓ of earth work in excavation = ⅓ × 32.07 | | | | 10.70 cu m | Q = $\frac{.45}{1.35}$ = 1/3 of earthwork |
| 3. | **First class brickwork** in 1 : 5 cement mortar— Pier— | | | | | | |
| | 1st footing … | 1 | 8.30 | 1.80 | .30 | 4.48 | |
| | 2nd footing … | 1 | 8.30 | 1.70 | .30 | 4.23 | |
| | 3rd footing … | 1 | 8.30 | 1.60 | .30 | 3.98 | |
| | Above footing up to springing level … | 1 | 8.30 | $\frac{1.5 + .9}{2}$ | 3.60 | 35.86 | Average breadth. |
| | Above springing trapezium portion | 1 | 8.30 | $\frac{.9 + .5}{2}$ | .40 | 2.32 | Upper breadth = 50 cm Ht. = 40 cm |
| | Ease-water end— | | | | | | |
| | 1st footing … | 1 | $\frac{1}{2}\left(\frac{22}{7} \times \frac{1.8^2}{4}\right)$ | | .30 | 0.38 | Area of semicircle × ht. |
| | 2nd footing … | 1 | $\frac{1}{2}\left(\frac{22}{7} \times \frac{1.7^2}{4}\right)$ | | .30 | 0.34 | |
| | 3rd footing … | 1 | $\frac{1}{2}\left(\frac{22}{7} \times \frac{1.6^2}{4}\right)$ | | .30 | 0.30 | |
| | Above footing up to springing level … | 1 | $\frac{1}{2}\left(\frac{22}{7} \times \frac{1.2^2}{4}\right)$ | | 3.60 | 2.05 | Diameter at middle section = $\frac{1.5 + .90}{2}$ = 1.2 m |
| | Cut-water end— | | | | | | |
| | 1st footing … | 1 | ½(1.8 × | 1.8 × .866) | .30 | 0.42 | Area of triangle × ht. |
| | 2nd footing … | 1 | ½(1.7 × | 1.7 × .866) | .30 | 0.37 | |

(*Contd…*)

| *Item No.* | *Particulars of items* | *No.* | *Length* m | *Breadth* m | *Height or Depth* m | *Quantity* | *Explanatory notes* |
|---|---|---|---|---|---|---|---|
| | | | | | CO | 54.73 | Area of triangle<br>= ½ B × alt.<br>= ½ B × B × .866 |
| | | | | | BF | 54.73 | |
| | 3rd footing … | 1 | ½(1.6 × | 1.6 × .866) | .30 | 0.33 | Area of triangle × ht. |
| | Above footing up to springing level … | 1 | ½(1.2 × | 1.2 × .866) | 3.60 | 2.24 | Breadth at middle sec<br>$= \frac{1.5 + .9}{2}$<br>= 1.2 m |
| | | | | | Total | 57.30 cu m | |
| 4. | **Cement concrete** 1 : 2 : 4 at the upper ends of pier— | | | | | | |
| | Ease-water end … | 1 | ¼ × $\frac{4}{3}$ × | $\frac{22}{7} \times \left(\frac{.9}{2}\right)^3$ | = | .094 | Q = Quarter of a sphere<br>= ¼ ($\frac{.4}{3}$ πr³) |
| | Cut-water end … | 1 | ½ (.9 × .9 | × .866) × | $\left(\frac{1}{3} \times \frac{.9}{2}\right)$ | = 0.052 | Q = Volume of triangular pyramid = Area of base × ⅓<br>Ht.= $\frac{.9}{2}$ |
| | | | | | Total | 0.146 cu m | |
| 5. | **Cement pointing** 1 : 2 in exposed surface— | | | | | | |
| | Pier … | 2 | 8.30 | — | 3.60 | 59.76 | Two faces |
| | Ease-water end … | 1 | $\frac{22}{7} \times \frac{1.2}{2}$ | — | 3.60 | 6.78 | Radius at middle sec $\frac{1.2}{2}$ |
| | Cut-water end … | 1 | (1.2 × 1.2) | — | 3.60 | 5.18 | Two sides of triangle at middle section |
| | | | | | Total | 71.72 sq m | |

## ABSTRACT OF QUANTITIES (EX. 6)

| | | | |
|---|---|---|---|
| 1. Earthwork in excavation in foundation | ... ... ... | 32.07 | cu m |
| 2. Cement concrete 1 : 4 : 8 in foundation | ... ... ... | 10.70 | cu m |
| 3. First class brickwork in 1 : 5 cement mortar | ... ... ... | 57.30 | cu m |
| 4. Cement concrete 1 : 2 : 4 at upper ends of pier | ... ... ... | 0.146 | cu m |
| 5. Cement pointing | ... ... ... | 71.72 | sq m |

## PIPE CULVERT

Pipe culverts are provided when discharge of Nala stream is small or when sufficient headway or height is not available. Number and size of pipes depend on the discharge and height of bend. Diameter of pipe for pipe culvert should not be less than 30 cm as smaller diameter pipe is likely to be chocked. The wing walls may be straight with face walls but it is better to make wing walls splayed for easy approach of water.

**Example 7**: Prepare a detailed estimate of hume pipe. Culvert of three pipes, each of 60 cm diameter, from the given plan and elevations (Fig. 8.14). Foundation concrete shall be of 1 : 4 : 8 cement concrete and brickwork shall be of first class in 1 : 6 cement sand mortar. Exposed surfaces shall be pointed with 1 : 2 cement sand mortar. Assume suitable rates.

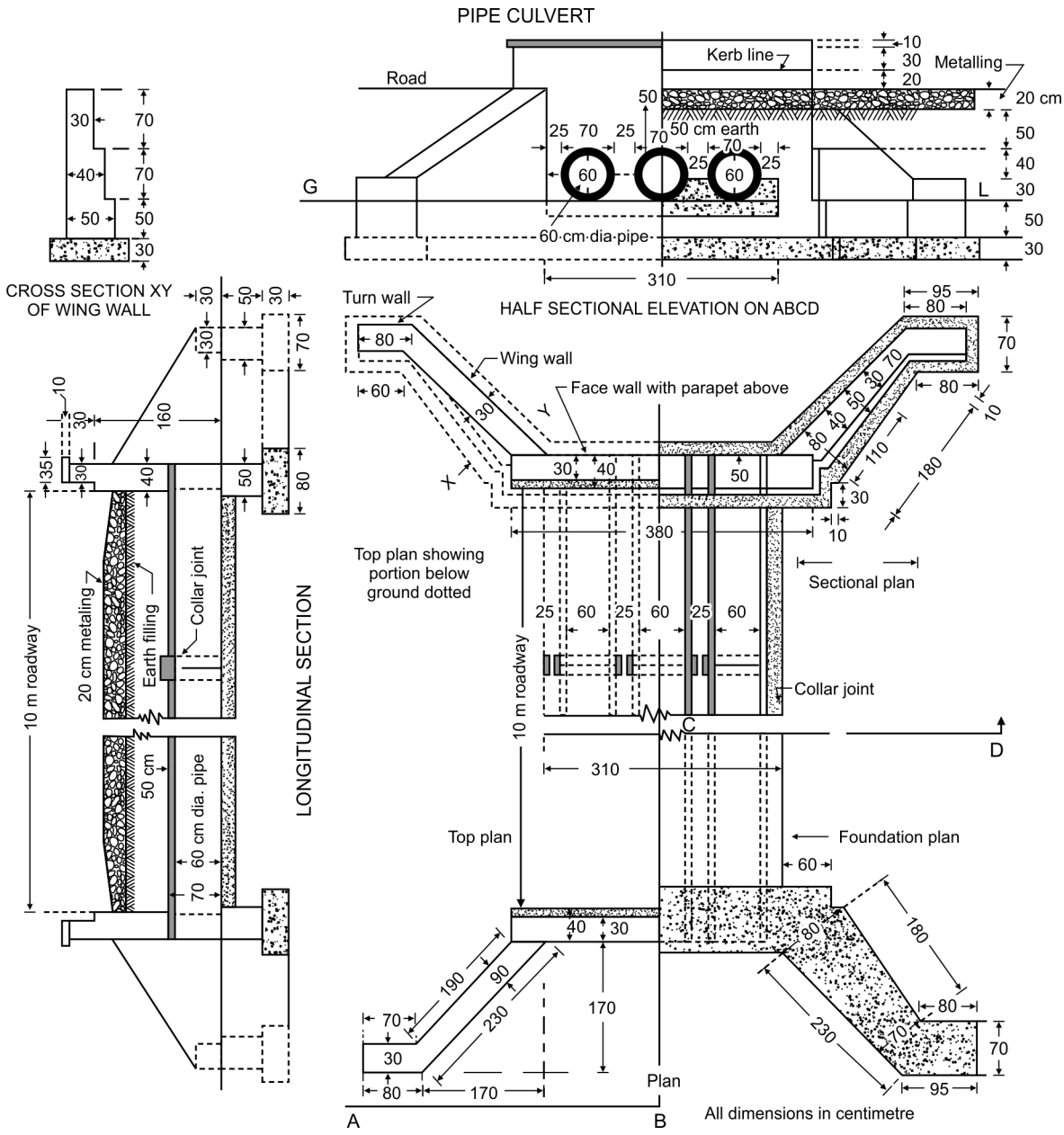



Fig. 8.14

## DETAILS OF MEASUREMENT AND CALCULATION OF QUANTITIES (EX. 7)

| *Item No.* | *Particulars of items* | *No.* | *Length* m | *Breadth* m | *Height or Depth* m | *Quantity* | *Explanatory notes* |
|---|---|---|---|---|---|---|---|
| 1. | Earthwork in excavation in foundation— | | | | | | |
| | Face walls … | 2 | 3.10 | .80 | .80 | 3.97 | |
| | Wing walls inclined portion … | 4 | $\frac{2.3 + 1.8}{2}$ | $\frac{.8 + .7}{2}$ | .80 | 4.92 | Average length and average breadth |
| | Wing walls triangular corner … | 4 | (½ × .6 | × .8) | .80 | 0.77 | Area of triangle |
| | Turn walls … | 4 | $\frac{.95 + .80}{2}$ | .70 | .80 | 1.96 | Average length |
| | Under pipe … | 1 | 9.80 | 3.10 | .15 | 4.56 | |
| | | | | | Total | 16.18 cu m | |
| 2. | Cement concrete 1 : 4 : 8 in foundation | | | | | | |
| | Face walls … | 2 | 3.10 | .80 | .30 | 1.49 | |
| | Wing walls inclined portion … | 4 | $\frac{2.3 + 1.8}{2}$ | $\frac{.80 + .70}{2}$ | .30 | 1.85 | |
| | Wing walls inclined portion … | 4 | (½ × .6 | × .8) | .30 | 0.29 | |
| | Turn walls … | 4 | $\frac{.95 + .80}{2}$ | .70 | .30 | 0.74 | |
| | Upper pipe and in between pipe up to half height … | 1 | 9.80 | 3.10 | .50 | 15.19 | Thickness = $15 + \frac{70}{2}$ = 50 cm = .50 m |
| | | | | | Total | 19.56 | |
| | **Deduct** half of pipes … | 3 | 9.80 × ½ | $\frac{\pi \times .7^2}{4}$ | | 5.66 | |
| | | | | | Total | 13.90 cu m | |
| 3. | First class brickwork in 1 : 6 cement sand mortar—face walls— | | | | | | |
| | Footing—50 cm breadth | 2 | 4.00 | .50 | .50 | 2.00 | Breadth means thickness of wall |
| | Above footing—40 cm breadth … | 2 | 3.80 | .40 | 1.60 | 4.86 | |
| | | | | | CO | 6.86 | |

(*Contd…*)

| *Item No.* | *Particulars of items* | *No.* | *Length* m | *Breadth* m | *Height or Depth* m | *Quantity* | *Explanatory notes* |
|---|---|---|---|---|---|---|---|
| | | | | | BF | 6.86 | |
| | Parapet—30 cm breadth | 2 | 3.80 | .30 | .30 | 0.68 | |
| | Coping—35 cm breadth | 2 | 4.00 | .35 | .10 | 0.28 | |
| | Wing walls— | | | | | | |
| | 1st step—40 cm breadth | 4 | 1.10 | $\frac{.5 + 0}{2}$ | .50 | 0.55 | |
| | 2nd step—40 cm breadth— | | | | | | |
| | (*i*) Straight portion … | 4 | 1.80 | .40 | .30 | 0.86 | |
| | (*ii*) Sloping portion … | 4 | 1.80 | .40 | $\frac{.40 + 0}{2}$ | 0.58 | Average height |
| | 3rd step—30 cm breadth | 4 | 1.90 | .30 | $\frac{.70 + 0}{2}$ | 0.80 | |
| | Turn wall—40 cm breadth | 4 | $\frac{.8 + .7}{2}$ | .40 | .50 | 0.60 | |
| | Turn wall—30 cm breadth … | 4 | $\frac{.80 + .75}{2}$ | .30 | .30 | 0.28 | |
| | | | | | Total | 11.49 | cu m |
| 4. | Cement pointing 1 : 2 in exposed surfaces above GL | | | | | | |
| | Face walls outer sides … | 2 | 3.10 | — | 1.40 | 8.68 | Up to road level<br>Above road level including coping |
| | Face wall parapet outer side | 2 | 3.80 | — | .65 | 4.94 | Ht. = 20 + 30 + 10 + 5 = 65 cm = .65 m |
| | Parapet inner faces | 2 | 3.80 | — | .70 | 5.32 | Including kerb offset of 10 cm |
| | Wing walls vertical face | 4 | 2.30 | — | $\frac{1.40 + .50}{2}$ | 8.74 | Average height |
| | Wing walls top … | 4 | 2.30 | .30 | — | 2.76 | |
| | Turn walls vertical face three sides … | 4 | 1.80 | — | .30 | 2.16 | L = Perimeter<br>= 80 + 30 + 70<br>= 180 cu m<br>= 1.80 m |

(*Contd...*)

| *Item No.* | *Particulars of items* | *No.* | *Length* m | *Breadth* m | *Height or Depth* m | *Quantity* | *Explanatory notes* |
|---|---|---|---|---|---|---|---|
| | Turn walls lop | 4 | $\frac{.8 + .7}{2}$ | .30 | — | 0.90 | |
| | | | | | Total | 33.50 | sq m |
| 5. | Hume pipe heavy type 60 cm diameter including collar joint | 3 | 10.80 | — | — | 32.40 | L = 10 + .4+ .4 = 10.8 m |
| | … | | | | | | |

## ABSTRACT OF ESTIMATED COST (EX. 7)

| | | |
|---|---|---|
| 1. Earthwork in excavation in foundation | 16.18 cu m at ₹15000% cu m | = ₹2427.00 |
| 2. Cement concrete 1 : 4 : 8 in foundation brick ballast | 13.90 cu m at ₹9000 per cu m | = ₹125100.00 |
| 3. First class brickwork in 1 : 6 cement mortar | 11.49 cu m at ₹7000 per cu m | = ₹ 80430.00 |
| 4. Cement pointing 1 : 2 in exposed surfaces | 33.50 cu m at ₹134 per cu m | = ₹4489.00 |
| 5. Hume pipe heavy type 60 cm diameter including collar joint | 32.40 m at ₹800 per cu m | = ₹25920.00 |
| | | Total ₹238366.00 |
| Add 5% for contingencies and work charged establishment | | ₹11918.30 |
| | | Grand Total ... ₹250284.30 |

## STEEL BRIDGES

Steel bridges may be of various types, may be of i-beams, plate girders, latticed or trussed girders, etc. supported over abutments and piers of masonry. The steel work may be estimated on the same principles of steel roof trusses and steel stanchions. The length of individual members can be found from the drawings, and the weight with the help of steel table.

*The estimate of a RCC T-beam bridge is given at the end of this chapter.*

## MASONRY WELL

Masonry wells are constructed for drinking water purposes, for irrigation water supply, and for the foundation of bridges. Usually excavation is done up to the sub-soil water level or spring level, a curb is then laid and masonry constructed up to a height of about 3 mm (10 ft.) above ground level and the sinking operation is done. When one portion of about 3 m (10 ft.) is sunk then another 3 m (10 ft.) of masonry is constructed and sunk, and the operation is repeated up till the required depth is reached. Vertical steel tie rods and horizontal flat iron rings are provided in the masonry steining of well to prevent cracks during sinking. Vertical tie rods and horizontal rings are usually provided up to the sub-soil water level but may also be extended up to the whole height of wall. The rate of sinking varies according to depth and diameter, and rates are usually fixed per metre for every 3 m (10 ft.) depth. Flat rate per running metre (r m) for the whole depth of sinking may also be provided. For excavation of pit up to sub-soil water level, different rates are allowed for every 1.5 m (5 ft.) depth. (*For rates see Schedule of Rates given at the end of the book*.)

When soil is bad, soft and sandy excavation of pit may be done only up to a shallow depth, up to which the digging can be done without slip and then curb may be laid and masonry constructed, and then sinking operation is done, the excavation inside the well up to sub-soil water level is done by entering into the well.

## ESTIMATING OF WELL

**Example 8:** Prepare a detailed estimate of a masonry well of 2 metre diameter and 14 metre deep exclusive the curb from the drawing given (Fig. 8.15). the soil water level being 3.80 m below GL. The steining of well is of 30 cm thick of first class brick masonry in 1 : 6 cement mortar. The inside and exposed surfaces shall be pointed with 1 : 2 cement mortar. The well should be raised 60 cm above GL and an apron of 4 cm CC over 7.5 cm LC 1 metre wide shall be provided all round the well. The curb shall be of RCC with 75 × 75 × 6 mm angle iron cutting edge.

Assume suitable rates.

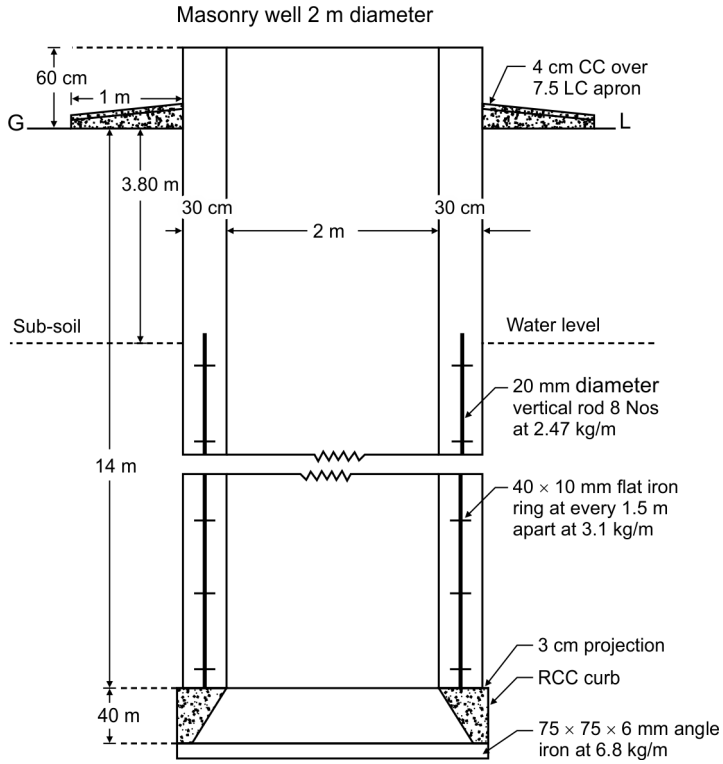



Fig. 8.15

## DETAILS OF MEASUREMENT AND CALCULATION OF QUANTITIES (EX. 8)

| *Item No.* | *Particulars of items and details of works* | *No.* | *Length* m | *Breadth* m | *Height or Depth* m | *Quantity* | *Explanatory notes* |
|---|---|---|---|---|---|---|---|
| 1. | **Earthwork in excavation** up to sub-soil water level | | | | | | Outer diameter = 2.00 + .30 × 2 + .03 × 2 = 2.66 m |
| | (*i*) up to 1.50 m depth … | 1 | $\frac{\pi \times 2.66^2}{4}$ | × | 1.50 | 8.34 cu m | |
| | (*ii*) 1.50 m to 3.00 m depth | 1 | $\frac{\pi \times 2.66^2}{4}$ | × | 1.50 | 8.34 cu m | |
| | (*iii*) 3.00 m to 3.80 m depth | 1 | $\frac{\pi \times 2.66^2}{4}$ | × | 0.80 | 4.45 cu m | |
| 2. | **RCC work in curb** including steel — (sectional area × mean length at (CG) | ½ × | (.33 × .40) | × (π × | 2.44) = | 0.506 cu m | Mean diameter of *CG* of triangular section = 2.00 + 2 × 2/3 × .33 = 2.44 m |
| 3. | **Iron work**—angle iron 75 × 75 × 6 mm at 6.8 kg in curb | 1 | (π × 2.66) | × 6.8 kg | = | 56.84 kg | L = outer circumference 8 No., rods 40 cm extra |
| | Vertical tie rods 20 mm diameter at 2.47 kg | 8 × | 10.60 × 2 | .47 kg | = | 209.45 kg | L = 14 – 3.8 + .4 = 10.6 m |
| | Flat iron ring of 40 × 10 mm at 3.1 kg No. = $\left(\frac{14.0–3.8}{1.5}\right)+1 = 8$ | 8 × | (π × 2.30 | × 3.1) | = | 179.30 kg. | L = Mean circumference = π × 2.30 m |
| | | | | | Total | 445.6 kg = 4.46 q | |
| 4. | **First class brickwork in** well steining in 1 : 6 cement mortar | 1 | (π × 2.30) | .30 | 14.60 | 31.67 cu m | S = Mean circumference = π × 2.30 |
| 5. | **Cement pointing** | | | | | | |
| | **1 : 6**—inside … | 1 | (π × 2.00) | × | 14.60 | 91.80 | |
| | Outside above GL … | 1 | (π × 2.60) | × | 0.485 | 3.96 | Ht. above apron |
| | Top of wall … | 1 | (π × 2.30) | × .30 | = | 2.17 | L = Mean circumference |
| | | | | | Total | 97.93 sq m | |
| 6. | **4 cm CC over 7.5 cm** LC apron (floor) | 1 | (π × 3.60) | × | 1.00 | 11.30 sq m | Mean diameter = 2.6 + 1.0 = 3.60 m |

(*Contd…*)

| *Item No.* | *Particulars of items and details of works* | *No.* | *Length* m | *Breadth* m | *Height or Depth* m | *Quantity* | *Explanatory notes* |
|---|---|---|---|---|---|---|---|
| 7. | **Sinking of well** below springing (sub-soil water) level | | | | | | |
| | (*i*) Up to 1.50 m below springing level | 1 | — | — | 1.50 | 1.50 r m | |
| | (*ii*) 1.50 m to 3.00 m below springing level | 1 | — | — | 1.50 | 1.50 r m | |
| | (*iii*) 3.00 m to 6.00 m below springing level | 1 | — | — | 3.00 | 3.00 r m | |
| | (*iv*) 6.00 m to 9.00 m below springing level | 1 | — | — | 3.00 | 3.00 r m | |
| | (*v*) 9.00 m to 10.20 m below springing level | 1 | — | — | 1.20 | 1.20 r m | |

## ABSTRACT OF COST (EX. 8)

| *Item No.* | *Particulars of items of works* | *Quantity* | *Unit* | *Rate* ₹ *P.* | *Per* | *Cost* ₹ *P.* |
|---|---|---|---|---|---|---|
| 1. | **Earthwork in excavation—** | | | | | |
| | (*i*) Up to 1.5 m depth ... | 8.34 | cu m | 15000 | % cu m | 1251.00 |
| | (*ii*) 1.50 m to 3.00 m depth ... | 8.34 | cu m | 16000 | % cu m | 1334.00 |
| | (*iii*) 3.00 m to 3.80 m depth ... | 4.45 | cu m | 18000 | % cu m | 801.00 |
| 2. | **RCC work including steel in curbs** ... | 0.506 | cu m | 13000 | / cu m | 6578.00 |
| 3. | **Iron work—angle, tie rods and flat iron rings** ... | 4.46 | q | 5400 | / quintal | 24084.00 |
| 4. | **First class brickwork in 1 : 6 cement mortar** ... | 31.67 | cu m | 7000 | / cu m | 221690.0 |
| 5. | **Cement pointing 1 : 2 cement mortar** ... | 97.93 | sq m | 134 | / sq m | 13122.62 |
| 6. | **4 cm CC 1 : 2 : 4 over and including 7.5 cm IC apron** ... | 11.30 | sq m | 1100 | / sq m | 12430.00 |

(*Contd...*)

| *Item No.* | *Particulars of items of works* | *Quantity* | *Unit* | *Rate* ₹ *P.* | *Per* | *Cost* ₹ *P.* |
|---|---|---|---|---|---|---|
| 7. | **Sinking well below sub-soil water level** | | | | | |
| | (*i*) Up to 1.5 m below springing level ... | 1.50 m | r m | 1350 | / r m | 2025.00 |
| | (*ii*) 1.50 m to 3.00 m below springing level ... | 1.50 m | r m | 2200 | / r m | 3300.00 |
| | (*iii*) 3.00 m to 6.00 m below springing level ... | 3.00 m | r m | 3000 | / r m | 9000.00 |
| | (*iv*) 6.00 m to 9.00 m below springing level ... | 3.00 m | r m | 3850 | / r m | 11550.00 |
| | (*v*) 9.00 m to 10.20 m below springing level ... | 1.20 m | r m | 1100 | / r m | 1320.00 |
| | Total | | | | ... | 308335.62 |
| | Add 3% for contingencies | | | | ... | 9250.00 |
| | Add 2% for work charged establishment | | | | ... | 616671.00 |
| | Grand Total ... | | | | ... | 323752.33 |

**Note:** (1) Item 4 may also be calculated as a hollow cylinder, whole volume – inner volume

$$= \left(\frac{\pi \times 2.6^2}{4}\right) - \left(\frac{\pi \times 2.0^2}{4}\right) \times 14.6 = (5.31–3.14) \times 14.6 = 31.68 \text{ cu m}$$

(2) Item 6 may also be calculated by whole area – area of the well.

## ESTIMATE OF WELL FOUNDATION

**Example 9:** Estimate the cost of a well foundation of a bridge. The well is to be circular of 5 metre internal diameter with 90 cm thick wall in 1 : 6 cement and sand mortar. The well is to be founded on a strata 20 metre below bed of river which is dry during the hot weather. Bottom of the well is to be plugged with 1.50 m thick cement concrete 1 : 3 : 6 and the top is to be sealed with 1.00 m thick cement concrete 1 : 3 : 6 and the central portion is to be sand filled.

Take the following rates:

| | | |
|---|---|---|
| Brickwork in 1 : 6 cement sand mortar | ... | ₹7000.00 per cu m |
| Cement concrete 1 : 3 : 6 with stone ballast | ... | ₹9000.00 per cu m |
| Sand filling | ... | ₹170.00 per cu m |
| Cost of RCC with curb including reinforcement steel, cutting angle, tie rods, bars, etc. | ... | ₹40000.00 LS |

Rate of sinking including all charges:

| | |
|---|---|
| 0–1.50 m ₹1350.00 per r m | 9.00–12.00 m ₹4700.00 per r m |
| 1.50–3.00 m ₹2200.00 per r m | 12.00–15.00 m ₹5800.00 per r m |
| 3.00–6.00 m ₹3000.00 per r m | 15.00–18.00 m ₹7000.00 per r m |
| 6.00–9.00 m ₹3800.00 per r m | 18.00–19.00 m ₹8600.00 per r m |

Punjab OSQ—1986 (Modified)

*Breadth of well curb at top = 90 cm.*
*Depth of well curb = 1.00 m.*
*Height of brick masonry from top of curb to bed level = 20 – 1 = 19*
*Height of sand filling = 20 – (1.5 + 1.0) = 17.50 m.*

## DETAILS OF MEASUREMENT AND CALCULATION OF QUANTITIES (EX. 9)

| *Item No.* | *Particulars of items of works* | *No.* | *Length* m | *Breadth* m | *Height or Depth* m | *Quantity* | *Explanatory notes* |
|---|---|---|---|---|---|---|---|
| 1. | **Brick masonry in 1 : 6 cement mortar** | 1 | $\pi \times 5.90$ | .90 | 19.00 | 317.05 cu m | Mean diameter = 5.9 m<br>Mean circumference = $\pi \times (5 + .9) = \pi \times 5.9$ |
| 2. | **Cement concrete 1 : 3 : 6** | | | | | | |
| | Bottom plugging curb portion … | 1 | $\frac{\pi \times 5.9^2}{4}$ | × | 1.00 | 27.35 | For curb portion mean diameter = 5.9 m |
| | Bottom plugging above curb … | 1 | $\frac{\pi \times 5^2}{4}$ | × | 0.50 | 9.82 | |
| | Top plugging … | 1 | $\frac{\pi \times 5^2}{4}$ | × | 1.00 | 19.64 | |
| | | | | | Total | 56.81 cu m | |
| 3. | Sand filling | 1 | $\frac{\pi \times 5^2}{4}$ | × | 17.50 | 343.75 | cu m |
| 4. | **RCC well curb including reinforcement steel, tie rods, bars, etc.** | 1 | — | — | — | 1 Job | |
| 5. | **Sinking of well** | | | | | | |
| | (*i*) 0–1.50 m … | 1 | — | — | 1.50 | 1.50 r m | Total of sinking operation is 19 m |
| | (*ii*) 1.50–3.00 m … | 1 | — | — | 1.50 | 1.50 r m | |
| | (*iii*) 3.00–6.00 m … | 1 | — | — | 3.00 | 3.00 r m | |
| | (*iv*) 6.00–9.00 m … | 1 | — | — | 3.00 | 3.00 r m | |
| | (*v*) 9.00–12.00 m … | 1 | — | — | 3.00 | 3.00 r m | |
| | (*vi*) 12.00–15.00 m … | 1 | — | — | 3.00 | 3.00 r m | |
| | (*vii*) 15.00–18.00 m … | 1 | — | — | 3.00 | 2.00 r m | |
| | (*viii*) 18.00–19.00 m | 1 | — | — | 1.00 | 1.00 r m | |

## ABSTRACT OF COST (EX. 9)

| *Item No.* | *Particulars of items of works* | *Quantity* | *Unit* | *Rate* ₹ *P.* | *Per* | *Cost* ₹ *P.* |
|---|---|---|---|---|---|---|
| 1. | Brick masonry in 1 : 6 cement mortar … | 317.05 | cu m | 7000 | / cu m | 2219350.00 |
| 2. | Cement concrete 1 : 3 : 6 with stone ballast … | 56.81 | cu m | 9000 | /cu m | 511290.00 |
| 3. | Sand filling … | 343.75 | cu m | 170 | / cu m | 58437.50 |
| 4 | RCC well curb including reinforcement steel, tie rods, bars, etc. … | 1 | Job | 40000 | LS | 40000.00 |
| 5 | Sinking of well— | | | | | |
| | (*i*) 0–1.50 m … | 1.50 | r m | 1350 | r m | 2025.00 |
| | (*ii*) 1.50–3.00 m … | 1.50 | r m | 2200 | r m | 3300.00 |
| | (*iii*) 3.00–6.00 m … | 3.00 | r m | 3000 | r m | 9000.00 |
| | (*iv*) 6.00–9.00 m … | 3.00 | r m | 3800 | r m | 11400.00 |
| | (*v*) 9.00–12.00 m … | 3.00 | r m | 4700 | r m | 14100.00 |
| | (*vi*) 12.00–15.00 m … | 3.00 | r m | 5800 | r m | 17400.00 |
| | (*vii*) 15.00–18.00 m … | 3.00 | r m | 7000 | r m | 21000.00 |
| | (*viii*) 18.00–19.00 m … | 1.00 | r m | 8600 | r m | 8600.00 |
| | | | | | Total ... | 2915912.50 |
| Add 3% for contingencies | | | | | ... | 87477.40 |
| Add 2% for work charged establishment | | | | | ... | 58318.25 |
| | | | | | Grand Total ... | 3081708.15 |

## RCC T-BEAM BRIDGE

**Example 10:** Prepare a detailed estimate of a RCC T-beam bridge of 7.5 metre span with 7 metre roadway, for IRC class A loading, from the given drawing Fig. 9.16 (page 417-A). Abutments and wing walls shall be of first cIass brickwork in 1 : 5 cement sand mortar over 1 : 4 : 8 cement concrete foundation. All RCC work shall be of 1 : 2 : 4 cement concrete with steel reinforcements as per drawings. A wearing coat of 10 cm cement concrete 1 : 2 : 4 shall be provided. All exposed surfaces of brickwork shall be cement pointed 1 : 2. In RCC work cement concrete, steel reinforcements and centering and shuttering have to be estimated under separate items.

## DETAILS OF MEASUREMENT AND CALCULATION OF QUANTITIES (EX. 10)

| *Item No.* | *Particulars of items of works* | *No.* | *Length* m | *Breadth* m | *Height or Depth* m | *Quantity* | *Explanatory notes* |
|---|---|---|---|---|---|---|---|
| 1. | **Earthwork** in excavation in foundation— | | | | | | |
| | Abutment … | 2 | 9.10 | 4.80 | 1.20 | 104.83 | |
| | Wing walls … | 4 | $\frac{13.1+9.75}{2}$ | 2.65 | 1.20 | 145.32 | Average length. |

(*Contd*...)

| *Item No.* | *Particulars of items of works* | *No.* | *Length* m | *Breadth* m | *Height or Depth* m | *Quantity* | *Explanatory notes* |
|---|---|---|---|---|---|---|---|
| | Turn walls … | 4 | $\frac{2.0 + 1.2}{2}$ | 1.30 | 1.20 | 9.98 | Average length. |
| | | | | | Total | 260.13 | cu m |
| 2. | **Cement concrete** 1 : 4 : 8 in foundation with stone ballast … | | ½ of earth in item 1 | work | in excavation | | |
| | | | = ½ × | 260.13 | | 130.06 | cu m |
| 3. | **First class brick masonry** in cement mortar 1 : 5 Abutments— | | | | | | |
| | Below GL … | 2 | 8.80 | 4.40 | 0.60 | 46.46 | |
| | Above GL up to base block … | 2 | $\frac{8.8+7.9}{2}$ | × $\frac{4.4+.9}{2}$ | × 6.00 | 265.53 | Average length and average breadth |
| | Wing walls— Below GL … | 4 | $\frac{12.8+10.0}{2}$ | 2.25 | 0.60 | 61.56 | Average length and average breadth at middle section |
| | Above GL up to top… | 4 | $\frac{12.8+10.0}{2}$ | × $\frac{2.25+.5}{2}$ | 4.25 | = 266.48 | Average length and average breadth at middle section |
| | Turn walls— Below GL … | 4 | $\frac{1.8+1.4}{2}$ | 0.90 | 0.60 | 3.46 | Average length |
| | Above GL | 4 | $\frac{1.8+1.4}{2}$ | × $\frac{.9+.5}{2}$ | × 0.90 | 4.03 | Average length and average breadth |
| | | | | | Total | 647.52 cu m | |
| 4. | **RCC work** 1 : 2 : 4 in beams, slabs, etc. excluding steel and centering and shuttering— | | | | | | |
| | T-beams rib below slab … | 3 | 8.65 | 0.40 | 1.00 | 10.38 | L = 7.50 + (2 × .75) – (2 × .175) = 8.65 m |
| | Slab | 1 | 8.65 | 7.90 | 0.20 | 13.67 | |
| | Railing— Hand rails … | 2 | 7.50 | 0.20 | 0.20 | 0.60 | |
| | Lower portion above kerb … | 2 | 7.50 | 0.20 | 0.20 | 0.60 | |
| | Vertical pillars 20 × 20 cm … | 2 × 7 | 0.20 | 0.20 | 0.50 | 0.28 | |

(*Contd…*)

| *Item No.* | *Particulars of items of works* | *No.* | *Length* m | *Breadth* m | *Height or Depth* m | *Quantity* | *Explanatory notes* |
|---|---|---|---|---|---|---|---|
| | Verticals in between pillars | | | | | | |
| | 10 cm × 7.5 cm … | 2 × 24 | 0.10 | 0.075 | 0.50 | 0.18 | |
| | Kerb | 2 | 7.50 | 0.25 | 0.25 | 0.94 | |
| | Bed block … | 2 | 7.90 | 0.75 | 0.30 | 3.56 | |
| | Retaining wall … | 2 | 7.90 | 0.15 | 1.25 | 2.96 | |
| | End pillars below slab … | 4 | 0.60 | 0.45 | 1.40 | 1.51 | |
| | End pillars above slab … | 4 | 0.75 | 0.45 | 1.20 | 1.62 | |
| | Fillets of beam … | 3 × 2 | 8.65 | (½×.15 | ×.15) | 0.58 | |
| | | | | | Total | 36.88 cu m | |
| 5. | **Cement concrete** (plain) 1 : 2 : 4 in wearing coat | 1 | 9.00 | 7.00 | 0.10 | 6.30 cu m | |
| 6. | **Steel work** (bars) in RCC including bending, binding in position— | | | | | | |
| i. | T-beam— | | | | | | |
| | Straight longitudinal bars at bottom 40 mm dia … | 3 × 3 | 9.30 | | | 83.7 m | L = 8.05 – 2 side covers + 2 hook lengths = 8.65 – 2 × .04 + 18 × .04 = 9.29 = 9.30 |
| i. | Straight longitudinal bars at top 40 mm diameter … | 3 × 3 | 9.30 | — | — | 84.70 m | |
| i. | Bent up longitudinal bars 40 mm diameter (top and bottom cover 4 cm) … | 3 × 3 | 10.38 | — | — | 93.42 m | Additional for 2 bent ups = depth in btwn centres of bars = 1.20 – .08 – .04 = 1.08 m |

(*Contd…*)

**Note:** *For 2 hook lengths add 18 diameter of bars, for 2 bent ups add one depth in between bars.*

| *Item No.* | *Particulars of items of works* | *No.* | *Length* m | *Breadth* m | *Height or Depth* m | *Quantity* | *Explanatory notes* |
|---|---|---|---|---|---|---|---|
| ii. | Stirrups in beams 20 mm diameter (bottom cover 6 cm, top cover 4 cm, side cover 4 cm) | 28 × 3 | 3.39 | — | — | 284.76 m | L = (1.2 – .08)2 + (.4 —.08) 2 + 2 hooks + extras = 2.88 + (18 × .02) + .15 = 3.39 m |
| | **Slab** | | | | | | |
| iii. | Main stirrups bars at bottom 12 mm diameter 7.5 CC No. = $\frac{8.65}{.075} + 1 = 116$ | 116 | 8.04 | — | — | 932.64 m | L = 7.9 – .08 + (18 × .012) = 8.04 m |
| iii. | —Do—at top 12 mm diameter 15 cm CC … | 58 | 8.04 | — | — | 466.32 m | |
| iii. | Main bent up bars (alternate) 12 mm diameter 15 cm CC | 58 | 8.28 | — | — | 480.24 m | Additional for 4 bent ups = 4 × ½ (.20 – .08) = .24 m |
| iv. | Distributing bars 10 mm diameter (*see* details below) | *54 | 8.75 | — | — | 472.50 m | L = 8.65 – (2 × .04) + (18×.01) = 8.75 m |
| | **Bed block—** | | | | | | |
| iv. | 10 mm diameter bars 15 cm CC at top and bottom | 2 × 54 | 0.90 | — | — | 97.20 m | No. in each = $\frac{7.9}{.15} + 1$ = 54 |
| v. | 6 mm diameter longitudinal bars at top and bottom ... | 2 × 6 | 7.93 | — | — | 95.16 m | L = 7.9 – .08 + (18 × .006) = 7.93 m |

(*Contd*...)

**Number of distribution bars*

| | | |
|---|---|---|
| Central bays in between fillets at bottom 20 cm CC | ... | 11 × 2 = 22 Nos |
| Central bays in between fillets at top 40 cm CC | ... | 5 × 2 = 10 Nos |
| Cantilever portions at top 20 cm CC | ... | 5 × 2 = 10 Nos |
| Cantilever portions at bottom | ... | 3 × 2 = 6 Nos |
| Above beam at top | ... | 2 × 3 = 6 Nos |
| | | Total ... 54 Nos |

| *Item No.* | *Particulars of items of works* | *No.* | *Length* m | *Breadth* m | *Height or Depth* m | *Quantity* | *Explanatory notes* |
|---|---|---|---|---|---|---|---|
| | **Retaining wall** | | | | | | |
| iv. | 10 mm diameter outer vertical bars 10 cm CC … | 2 × 80 | 1.725 | — | — | 276.00 m | L = 1.625—.08+(18×.01) = 1.725 m<br>No. $\frac{7.9}{.10}$ = 80 |
| iv. | 10 mm diameter inner vertical bars 20 cm CC … | 2 × 40 | 1.725 | — | — | 138.00 m | |
| v. | 6 mm diameter horizontal bars outer and inner faces … | 2 × 6 | 7.93 | — | — | 95.16 m | |
| iv. | 10 mm dia, inclined bars 15 cm CC … | 2 × 54 | 0.60 | — | — | 64.80 m | |
| | **Railing** | | | | | | |
| iii. | 12 mm diameter vertical bars in 20 × 20 cm pillars 14 Nos … | 4 × 14 | 1.40 | — | — | 78.40 m | 4 Nos vertical bar in each |
| v. | 6 mm diameter lateral ties 10 cm CC in above pillars … | 13× 14 | 0.75 | — | — | 136.50 m | |
| iv. | 10 mm diameter bars in 10 cm × 7.5 cm vertical strips … | 2× 48 | 1.40 | — | — | 134.40 m | 2 Nos vertical bars in each |
| iii. | 12 mm diameter continuous horizontal bars in hand rail and near kerb … | 4 | 7.70 | — | — | 30.80 m | 2 Nos in hand rails and 2 Nos above kerb |
| iii | 12 mm diameter inclined bars 15 cm CC … | 2 × 50 | 0.90 | — | — | 90.00 m | |
| | **End pillars 4 Nos** | | | | | | |
| ii | 20 mm diameter vertical bars 8 Nos in each end pillars | 4 × 8 | 2.80 | — | — | 89.60 m | Embedded in bed block<br>L = 1.3 + 1.2 + .3 = 2.8 mm |

(*Contd…*)

**Abstract of steel bars** *Total of i. ii, iii, iv and v separately*)

| | | |
|---|---|---|
| (*i*) | 40 mm dia. steel bars total length 261.82 m at 9.86 kg/m | = 260.82 × 9.86 = 2581.54 kg. |
| (*ii*) | 20 mm dia. steel bars total length 374.36 m at 2.47 kg/m | = 374.36 × 2.47 = 924.67 kg. |
| (*iii*) | 12 mm dia. steel bars total length 2078.40 m at 0.89 kg/m | = 2078.40 × 0.89 = 1849.78 kg. |
| (*iv*) | 10 mm dia. steel bars total length 1357.70 m at 0.62 kg/m | = 1357.70 × 0.62 = 841.77 kg. |
| (*v*) | 6 mm dia. steel bars total length 326.82 m at 0.22 kg/m | = 326.82 × 0.22 = 71.90 kg. |
| | | Total 6269.66 kg. |
| | | = 62.697 quintal |

| *Item No.* | *Particulars of items of works* | *No.* | *Length* m | *Breadth* m | *Height or Depth* m | *Quantity* | *Explanatory notes* |
|---|---|---|---|---|---|---|---|
| iv | 10 mm diameter lateral ties 15 cm CC … | 4 × 19 | 2.30 | — | — | 174.80 m | L = (.65 + .35) × 2 + .3 = 2.3 m |
| 7. | Steel bars plate 5 mm thick (under beams) at 196.2 kg sq m ... | 3 × 2 | 0.60 | 0.55 | — | 1.98 sq m = 1.98 × 196.2 = 388.48 kg 3.885 q | |
| 8. | **Centering and shuttering** (form work) | | | | | | |
| | **T-beam** | | | | | | |
| | Bottom … | 3 | 7.50 | 0.40 | — | 9.00 | |
| | Vertical sides … | 3 × 2 | 8.65 | — | 0.85 | 44.12 | Ht. = 1.00 – .15 = .85 m |
| | Fillets (triangular sides) … | 3 × 2 | 8.65 | — | 0.21 | 10.90 | Hyp = $\sqrt{.15^2 + .15^2}$ = .21 m |
| | **Slab** | | | | | | |
| | In between beams … | 2 | 7.50 | 2.10 | — | 31.50 | b = 2.4 – 2 × .15 = 2.10 m |
| | Cantilevers … | 2 | 7.50 | 0.80 | — | 12.00 | b = .95 – .15 = .80 |
| | **Railing** | | | | | | |
| | Outer sides … | 2 | 7.50 | — | 1.35 | 20.25 | Ht. = .9 + .25 + .2 = 1.35 m |
| | Inner sides … | 2 | 7.50 | — | 0.90 | 13.50 | |
| | Kerbs … | 2 | 7.50 | — | 0.25 | 3.75 | |

(*Contd*...)

| *Item No.* | *Particulars of items of works* | *No.* | *Length* m | *Breadth* m | *Height or Depth* m | *Quantity* | *Explanatory notes* |
|---|---|---|---|---|---|---|---|
| | **Retaining wall—** | | | | | | |
| | Outer sides … | 2 | 7.90 | — | 1.625 | 25.68 | |
| | Inner sides … | 2 | 7.90 | — | 1.325 | 20.94 | |
| | Ends … | 2 × 2 | — | .15 | 1.625 | 0.98 | |
| | | | | | CO | 192.62 | |
| | | | | | BF | 192.62 | |
| | **Bed block** | | | | | | |
| | Inner sides | 2 | 7.90 | — | 0.30 | 4.74 | |
| | End … | 2 × 2 | — | 0.75 | 0.30 | 0.90 | |
| | **End pillars** | | | | | | |
| | End pillars above slab, 3 faces excluding retaining wall sides … | 4 | — | 1.95 | 1.30 | 10.14 | b=.75 +. 75 + .45 = 1.95 m |
| | End pillars below slab level perimeter (4 faces) … | 4 | — | 2.40 | 1.20 | 11.52 | b=2×.75+2 × .45 = 2.40 m |
| | | | | | Total | 219.92 sq m | |
| 9 | **Ruled cement pointing** 1 : 2— | | | | | | |
| | Abutment inner vertical face … | 2 | $\frac{9.1+7.9}{2}$ | — | 6.10 | 103.70 | Average length |
| | **Wing walls** | | | | | | |
| | Vertical face … | 4 | $\frac{12.8+12.5}{2}$ | — | $\frac{7.625+.9}{2}$ | 215.68 | Average length and average height |
| | Top … | 4 | 12.50 | 0.50 | — | 25.00 | |
| | **Turn walls** | | | | | | |
| | Front face … | 4 | 1.80 | — | 0.90 | 6.48 | |
| | Top … | 4 | 1.80 | 0.50 | — | 3.60 | |
| | Ends … | 4 | $\frac{.5 + .9}{2}$ | — | 0.90 | 2.52 | Average breadth |
| | | | | | Total | 356.98 sq m | |

(*Contd…*)

## ABSTRACT OF ESTIMATED COST (EX. 10)

| *Item No.* | *Particulars of items and details of works* | *Quantity* | *Unit* | *Rate* ₹ *P.* | *Unit* | *Amount* ₹ *P.* |
|---|---|---|---|---|---|---|
| 1. | Earthwork in excavation in foundation … | 260.13 | cu m | 15000 | % cu m | 39019.50 |
| 2. | Cement concrete 1 : 4 : 8 in foundation with stone ballast … | 130.06 | cu m | 2000 | / cu m | 260120.00 |
| 3. | First class brick masonry in 1 : 5 cement mortar … | 647.52 | cu m | 7000 | / cu m | 4532640.00 |
| 4. | RCC work 1 : 2 : 4 in beams, slabs, etc. excluding steel, and centering and shuttering … | 36.88 | cu m | 13000 | / cu m | 479440.00 |
| 5. | Cement concrete 1 : 2 : 4 (plain) in wearing coat … | 6.30 | cu m | 11000 | / cu m | 69300.00 |
| 6. | Steel work (bars) in RCC work including binding and bending in position … | 62.697 | q | 13000 | / quintal | 815061.00 |
| 7. | Steel baseplate … | 3.885 | q | 6000 | / quintal | 23310.00 |
| 8. | Centering and shuttering (form work) … | 219.92 | sq m | 955 | / sq m | 210023.60 |
| 9. | Ruled cement pointing 1 : 2 … | 356.98 | sq m | 134 | / sq m | 47835.32 |
| | | | | | Total … | 16387169.42 |
| | Add 3% for contingencies | | | | … | 491615.08 |
| | Add 2% for work charged establishment | | | | … | 327743.40 |
| | | | | | Grand Total … | 17206527.90 |

$$\text{Cost per running metre of span (for 7 metre roadway)} = \frac{\text{Total cost}}{\text{Span}} = \frac{₹364147.19}{7.5 \text{ m}}$$

= ₹2294203.72 per running mere of span.

## CONCLUSIONS

Accurate estimation and costing are essential for the successful planning and execution of culverts, bridges, and wells. These structures have diverse design requirements, and their costs vary based on materials, labour, and site conditions. By calculating the quantities of materials and resources needed, project managers can ensure that these critical infrastructure projects are completed within budget and according to specifications.