Calculation of the Steel Reinforcement Quantity in Concrete

The quantity of steel reinforcement conducted according to structural drawings with the details of steel reinforcement as shown in Table 1.

Table no.1: Details of Steel Reinforcement

Diameter ϕ (mm)	Weight (kg/m)	Length (m/ton)	Cross Section Area (mm^2)	Available length (m)
10	0.62	1613	79	6,9,12
12	0.90	1124	113	6,9,12
16	1.58	633	201	9,12
18	2.00	500	255	6,9,12
22	3.00	334	380	9,12
25	3.86	260	491	12
28	4.85	207	616	12
32	6.32	159	804	12
36	8.00	125	1018	12
38	8.90	113	1134	12
40	9.87	102	1256	12

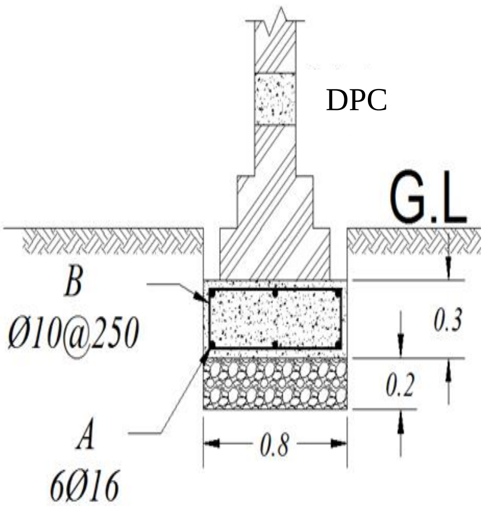
A. Foundations:

1. Wall foundations in construction projects:

<u>Case Study No. 15-1:</u> Calculate the quantity of steel reinforcement for the wall foundations as shown in the figure below for the bearing wall section:

- *If the wall length is **60m**,*
- *concrete cover equal to **5cm**.*

Solution:

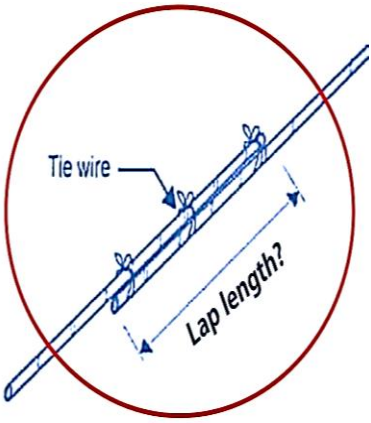


Quantity of steel in long direction (A)

= ***No. of reinforcement bars*** × ***Length*** × ***Weight of a one-meter length***

$= \underline{6} \times \underline{60} \times \underline{1.58} = 568.8\ kg$ + ***Wt. of overlap***

Calculating the weight of overlaps:



Assume the length of the overlaps is 40db

$$\text{No. of overlaps} = \left(\frac{\text{Total lenght of construction member}}{\text{Length of reinforcement bar}}\right)$$

$$\text{No. of overlaps} = \left(\frac{60}{12}\right) = \mathbf{5}$$

Length of a one overlap = 40 × 16 = 640 mm

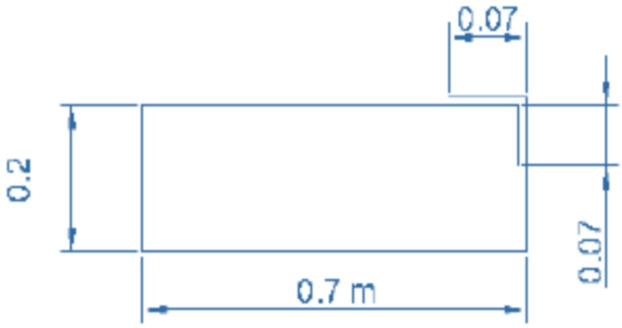
Wt. of overlap = 1.58 × 0.64 × 5×6 = 30.336 kg

Quantity of steel in long direction (A)= 568.8 + 30.336 = ***599.136 kg***

Quantity of steel for Stirrups (B):

Calculate length of each stirrup

= (0.2 + 0.7 + 0.07) * 2 = 1.94 m



Determine the number of stirrups

$$= \left(\frac{60}{0.25}\right) + 1 = 241 \text{ stirrups}$$

Quantity of steel for Stirrups (B)

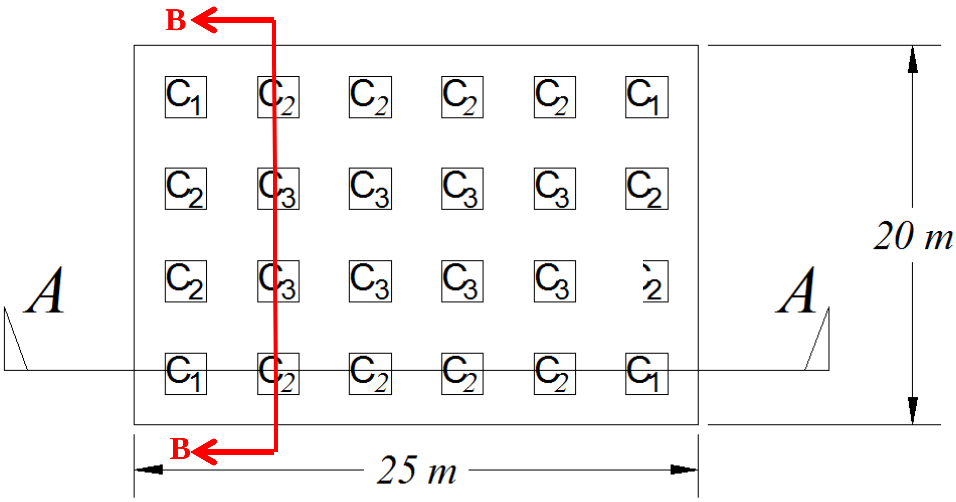
= No. of stirrups × Length of a one stirrup × Weight of a one-meter length

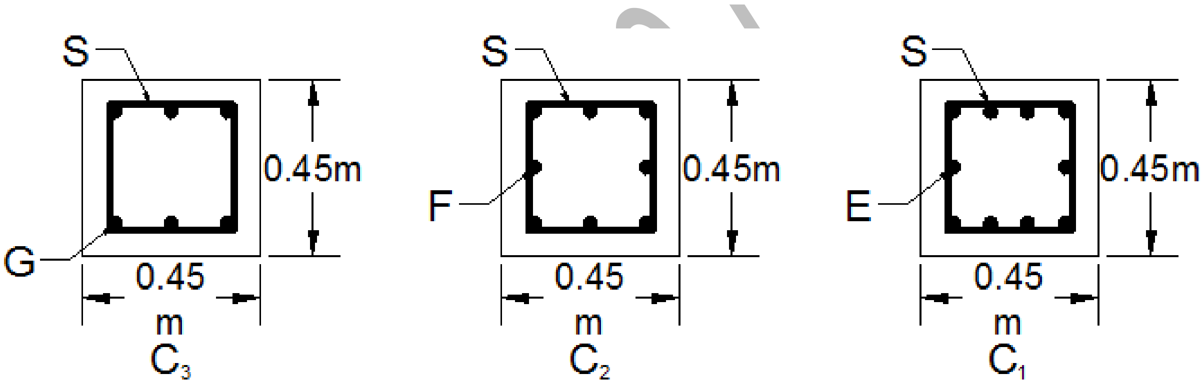
= 241* 1.94 * 0.62 = 289.87 *kg*

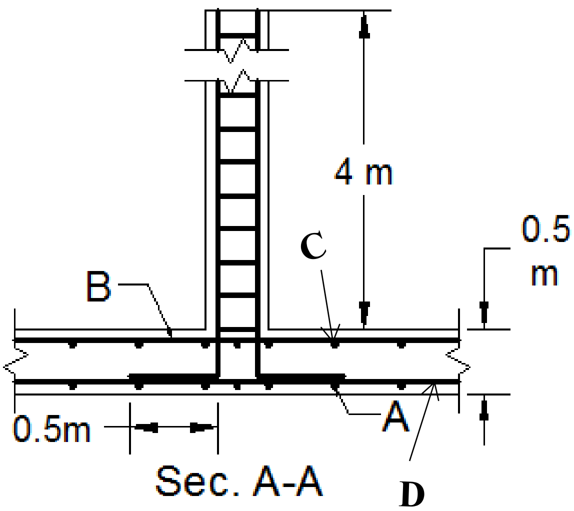
Steel Bars	Unit	Quantity	Number of bars	Length of Bar
ϕ 16mm	*ton*	0.6	30	12.0m
			6	3.2m
ϕ 10mm	*ton*	0.29	241	1.94m

2. *Raft foundation:*

Case Study No. 15-2: A raft foundation of dimensions (**25*20**) m, and thickness of (**0.5** m) as shown in Figures below. Calculate the quantity of reinforcing steel needed to construct foundation and columns, then arrange the quantities in a table according to length and diameter, so that the length of the column is **4.0m**. The thickness of the concrete cover for the foundation and columns is **5.0cm** and **2.5cm** respectively.







A=Ø16@200mm
B=Ø25@175mm
C=Ø16@250mm
D=Ø16@200mm
E=10Ø16
F=8Ø16
G=6Ø16
S=Ø10@200mm

Solution:

Calculation the steel reinforcement for raft in both directions:

Total weight of steel bars used = Weight of design reinforcement steel bars + Weight of overlap

Total weight of steel bars used $= \left(\frac{Length\ or\ width\ of\ foundation}{Spacing\ distribution\ for\ reinforcement}\right) \times$ ***(Length or width of foundation+ Length of overlaps – Concrete cover) × Weight of a one meter length***

Quantity of steel in bottom layer for long direction (A) $= [\left(\frac{25}{0.2}\right) + 1] \times (20+0.75-0.1) \times 1.58 = 4111$ *kg Φ16 mm*

Quantity of steel in bottom layer for short direction (D) $= [\left(\frac{20}{0.2}\right) + 1] \times (25+0.75-0.1) \times 1.58 = 4094$ *kg Φ16 mm*

Quantity of steel in top layer for long direction (C) $= [\left(\frac{25}{0.25}\right) + 1] \times (20+0.75-0.1) \times 1.58 = 3296$ *kg Φ16 mm*

Quantity of steel in top layer for short direction (B) $= [\left(\frac{20}{0.175}\right) + 1] \times (25+0.75-0.1) \times 3.86 = 11415$ *kg Φ25 mm*

Total weight of specific steel bars used $= \sum Sum\ quantities\ of\ detials\ with\ similar\ bars\ diameter$

Total weight of steel bars used Φ16 mm = 4111 + 4094 + 3296 = 11501 kg

Total weight of steel bars used Φ25 mm = 11415 kg

Quantities of steel bars used $= \sum Quantities\ of\ different\ details$????????? **kg**

Calculation the steel reinforcement for columns:

First step:

A common rule of thumb for L_d is $40d_b$ *to* $50d_b$, which should be verified against the governing building code *ACI 318-14*. Furthermore, the length of the steel dowels for the column bases is calculated, where the connection length must not be less than diameter of bar *40.

Length of overlap = 40 × diameter of bar = 40×16 = 640 mm ≈ using 0.75m

Length of steel dowels in column *= [Dowel length + Raft thickness + Length of bent part - (Concrete cover + diameter of bar in long direction + diameter of bar in short direction)]*

Length of steel dowels in column = [0.75 + 0.5 + 0.5 - (0.05+0.016+0.016)] = 1.666 =1.7 m

Steel dowels quantity in column = No. of reinforcement bars * Dowel Length * Weight of a one-meter length

Quantity of steel dowels in columns type (C_1) = (**10**×**1.7**×**1.58**)×**4** = 107.45 *kg Φ16 mm*

Quantity of steel dowels in columns type (C_2) = (**8**×**1.7**×**1.58**)×**12** = 258 *kg Φ16 mm*

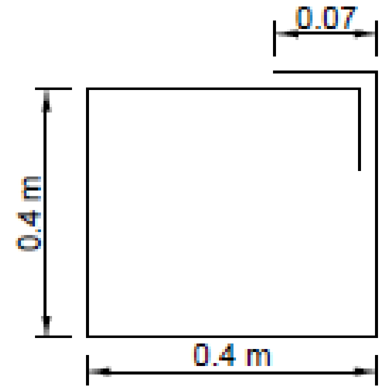
Quantity of steel dowels in columns type (C_3) = (**6**×**1.7**×**1.58**)×**8** = 129 *kg Φ16 mm*

Total = 494.5 kg Φ16 mm

Overall quantities of steel bars used in constructing the raft foundation = 22.916 + 0.495 = 23.411 ton

Second step:

- *Columns above the raft foundation:*



Quantity of steel in columns type (C_1) = (10×4×1.58)×4 = 252.8 kg

Quantity of steel in columns type (C_2) = (8×4×1.58)×12 = 606.72 kg

Quantity of steel in columns type (C_3) = (6×4×1.58)×8 = 303.4 kg

Total = ***1162.92 kg Φ16 mm***

- *Quantity of stirrups:*

Length of stirrups = (0.4 + 0.4 + 0.07) ×2 = 1.74

No. of stirrups = [(4 - 0.1)/0.2)] +1 = 21

Quantity of stirrups = (21×1.74×0.62) ×24 = **544 kg**

Total quantity of steel in columns = *1162.92*+544.00 = ***1661 kg= 1.661 ton***

Table no.2: The quantities of steel reinforcements

Bar	Φ mm	No.	Length m	shape
A	16	126	12 & 8.65	Straight
B	25	115	12+12 & 2.65	Straight
C	16	101	12 & 8.65	Straight
D	16	101	12+12 & 2.65	Straight
E	16	10	1.7 & 4	Dowel & Straight
F	16	8	1.7 & 4	Dowel & Straight
G	16	6	1.7 & 4	Dowel & Straight
S	10	504	1.74	Stirrup

Case Study No. 15-3: *For the previous case, calculate the total cost for constructing work, if the mix proportion for foundation is (**1:2:4**) and for column is (**1:1.5:3**), the cost of each construction material is: Cement 125×10³ IQD/ton, gravel 40×10³ IQD/m³, sand 30×10³ IQD/m³, steel reinforcement 800×10³ IQD/ton, cost of 1 m² wood formwork 10×10³ IQD/m² (work only), cost of 1 ton steel reinforcement (work) 100×10³ IQD, cost of cast 1m³ concrete 25×10³ IQD.*

Solution:

1. *Cost of raft foundation:* For mix ratio (1:2:4)

Volume of raft = $25\times20\times0.5 = 250\ m^3$

Weight of cement = $0.213\times250\times1400 = 74.6$ ton

Volume of sand = $0.213\times2\times250=106.5\ m^3$

Volume of gravel = $0.213\times4\times250=213m^3$

Total quantity of steel in Raft = 22.193 + 0.495 = 22.68 ton

Cost of materials: Cost of cement=$74.6\ ton\times125\times10^3$ ID/ton = 9.325×10^6 IQD

Cost of sand =$106.5\times30\times10^3 = 3.195*10^6$ IQD

Cost of gravel = $213\times40\times10^3= 8.52*10^6$ IQD

Cost of steel reinforcement=$22.68\times800\times10^3=18.144\times10^6$ IQD

Cost of forms: Cost of form = $(20+25)\times2\times0.5\times10\times10^3=0.450\times10^6$ IQD

Cost of works: Cost of steel reinforcement Work = $22.68\times100\times10^3 = 2.268\times10^6$ IQD

Cost of casting the concrete = $250\times25\times10^3 = 6.25*10^6$ IQD

Total cost of raft *= Cost of materials + Cost of forms + Cost of works =* ***48,152,000*** *IQD*

2. *Cost of columns:* For mix ratio (1:1.5:3)

Volume of column = $0.45\times0.45\times24\times4 = 19.44m^3$

Weight of cement = $0.271\times19.44\times1400 = 7.4$ ton

Volume of sand = $0.271\times1.5\times19.44 = 7.9m^3 = 8m^3$

Volume of gravel = $0.271\times3\times19.44=15.8m^3$

Cost of materials: Cost of cement = $7.4\ ton\times125\times10^3$ IQD /ton = 925×10^3 IQD

Cost of sand = $8\times30\times10^3 = 240\times10^3$ IQD

Cost of gravel = $15.8\times40\times10^3= 632\times10^3$ IQD

Cost of steel reinforcement = $1.661\times800\times10^3 = 1328.8\times10^3$ IQD

Cost of forms: Cost of form = $(0.45+0.45)\times2\times4\times24\times10\times10^3 = 1728\times10^3$ IQD

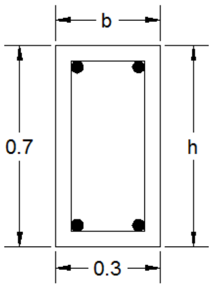
Cost of works: Cost of steel reinforcement Work = $1.661\times100\times10^3 = 166.1\times10^3$ IQD

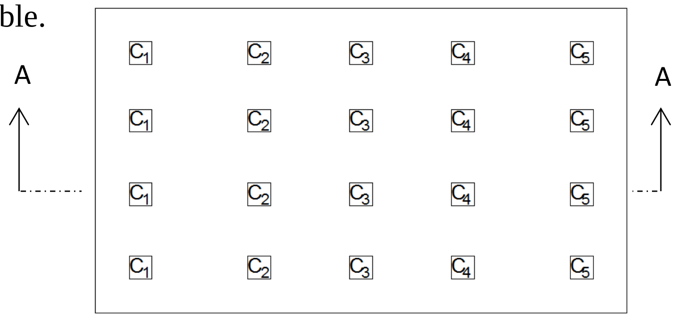
Cost of casting the concrete = $19.44\times25\times10^3 = 486\times10^6$ IQD

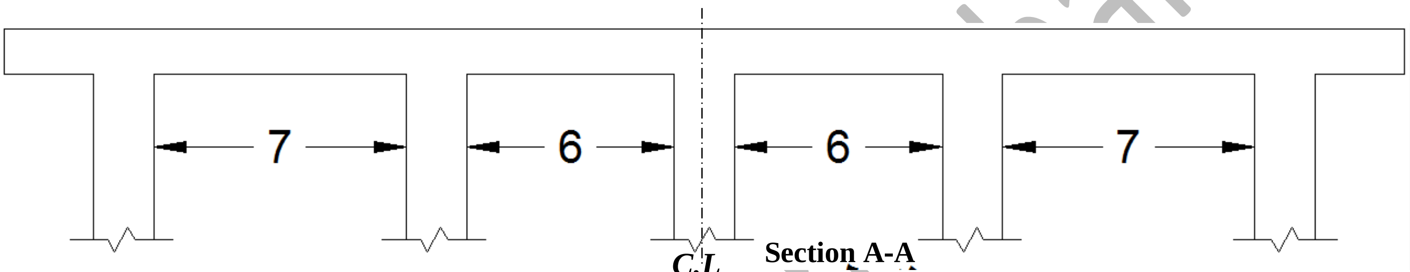
Total cost of columns = *Cost of materials + Cost of forms + Cost of works =* ***5508600 IQD***

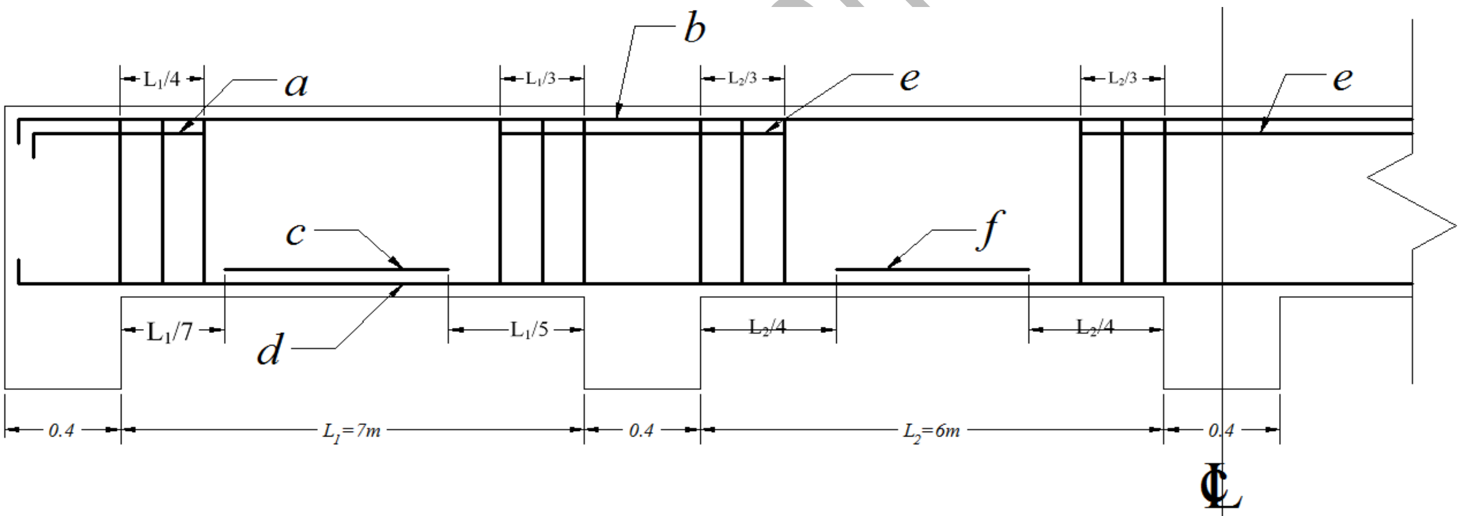
B. Beams and Girders:

Case Study No. 15-4: For the beams plan shown below, with mix ratio of concrete (1:1.5:3), by using the same price of construction materials listed in previous example. Calculate the following points: (1) The quantity of steel reinforcement. (2) The total cost of the work. (3) The cost of $1m^3$ of reinforced Concrete, if the following information are available.









Span length m	*Section (b*h)m*	*a*	*b*	*c*	*d*	*e*	*f*	*g*	*Stirrups spacing*
L_1	*0.3*0.7*	*3Φ16 mm*	*2Φ16 mm*	*2Φ25 mm*	*2Φ16 mm*	*3Φ25 mm*	---	*2Φ12 mm*	*Φ10@200mm*
L_2	*0.3*0.7*	---	*2Φ16 mm*	---	*2Φ16 mm*	*3Φ25 mm*	*3Φ16 mm*	*2Φ12 mm*	*Φ10@200mm*

Solution:

- *Quantity of steel reinforcement*

Quantity of steel reinforcement (a)= 3 × [(7/4) + 0.35 + 0.2] ×1.58 = 10.9 kg

Quantity of steel reinforcement (b)= 2 × [0.2 + 0.35 + 7 + 0.4 + 6 + 0.2] × 1.58 = 44.714kg

Quantity of steel reinforcement (c)= 2 × [7 - (7/7) - (7/5)] × 3.86 = 35.52 kg

Quantity of steel reinforcement (d)= 2 × [0.2+0.35+7+0.4+6+0.2] × 1.58 = 44.714 kg

Quantity of steel reinforcement (e)= 3 × [(6/3) + 0.4 + (7/3) + (6/3) + 0.2] × 3.86 = 80.288 kg

Quantity of steel reinforcement (f)= 3 × [6-(6/4) × 2] × 1.58 = 14.22 kg

Quantity of steel reinforcement (g)= 2 × 0.9 × [0.2 + 6 + 0.4 + 7 + 0.35] = 25.11kg

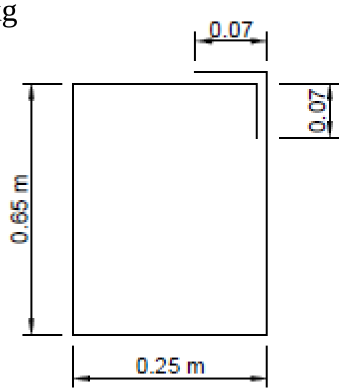
- *Quantity of stirrups*

  Assume the concrete cover = 25mm

  Length of stirrup = (0.25 +0.65 + 0.07) × 2 = 1.94m

  No of stirrups = [(7/0.2) +1] + [(6/0.2) +1] = 67

  Quantity of stirrups =67 × 1.94 × 0.62 = 80.58 kg

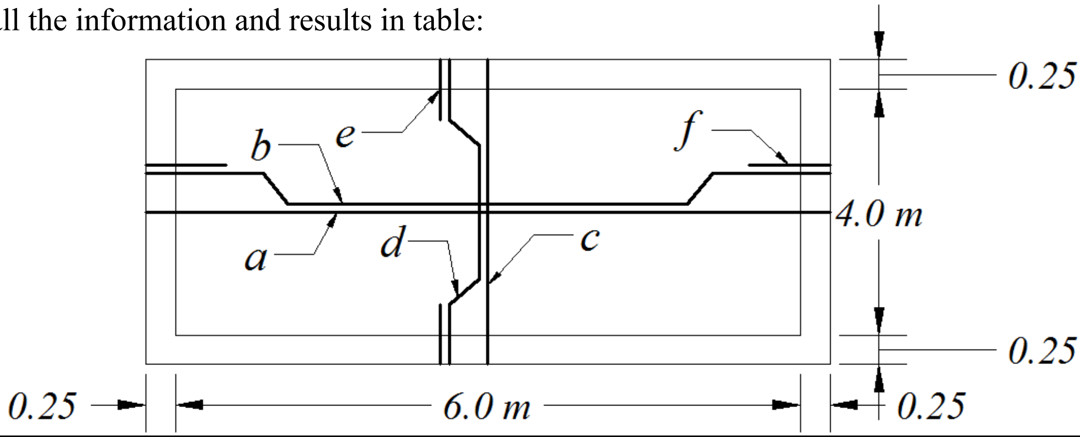


✓ *Total quantity of steel reinforcement (for half of the beam line)* = 10.9 + 44.714 + 35.52 + 44.714 + 80.288 + 14.22 + 25.11 + 80.58 = 336.32 kg + *Wt. of overlap*

- Concrete volume = 0.3 × 0.7 × (0.2+6+0.4+7+0.4) = 2.94 m^3(for half the beam)
- Concrete for all beams = 2.94×2×4 = 23.52 m^3
- Steel for all the beams = 336.32×2×4 = 2690.56 kg = 2.7 ton. + *Wt. of overlap*
- Steel for 1m^3 of Concrete = 2700/23.52=114.79 kg/m^3 + *Wt. of overlap*

C. Slabs:

Case Study No. 15-5: Calculate the quantity of steel reinforcement for the slab shows in plan below, then arrange all the information and results in table:



Slab	E or I	(L*B) m	a	b	c	d	e	f
A	E	6*4	Ø12@450 mm	Ø12@450 mm	Ø10@250 mm	Ø10@250 mm	Ø16@150 mm	Ø16@150 mm

Solution:

$$a = (\frac{4.5}{0.45} + 1) \times 6.45 \times 0.9 = 63.86 \ kg$$

$$b = (\frac{4.5}{0.45} + 1) \times (6.45 + 0.15) \times 0.9 = 65.34 \ kg$$

$$c = (\frac{6.5}{0.25} + 1) \times (4.45) \times 0.62 = 74.49 \ kg$$

$$d = (\frac{6.5}{0.25} + 1) \times (4.45 + 0.15) \times 0.62 = 77 \ kg$$

$$e = (\frac{6.5}{0.15} + 1) \times (\frac{4}{3} + 0.25) \times 1.58 \times 2 = 221.8 \ kg$$

$$f = (\frac{4.5}{0.15} + 1) \times (\frac{6}{3} + 0.25) \times 1.58 \times 2 = 220.4 \ kg$$

Bar index	Bar Dia.	No.	L (m)	Shape	Details
a	12	11	6.45		straight @450mm c/c
b	12	11	6.6		bent @450mm c/c
c	10	27	4.95		straight @250mm c/c
d	10	27	5.10		bent @250mm c/c
e	16	90	1.58		straight @150mm c/c
f	16	62	2.25		straight @150mm c/c

Case Study No. 15-6: Calculate the quantity of reinforced concrete required to constructed the stair shown below:

Solution:

Volume of reinforced concrete for stair:

Foundation of stair = $0.6\times0.25\times1.0 + 0.3\times0.6\times1.0 = 0.33\ m^3$

Reinforced concrete of stair = $(0.15\times2.5\times1.0)\times 2 + [(0.19\times0.3/2)\times1]\times14 = 1.149 m^3$

Plate form of stair = $[1.45\times0.19\times3.0]\times 2 = 1.653\ m^3$

Total = $0.33+1.149+1.65 = 3.129\ m^3$