Tishk International University
Department of Architectural Engineering
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Specifications and Quantities

Quantity Surveying

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Introduction

In a civil engineering activity, the owner promises to pay the contractor an amount for the work that he does; this would then require that the actual works done be somehow estimated or measured for payment purposes. Once a construction project is completed or depending on the form of contract upon completion of certain parts of the work, the contractor must be paid for appropriately completed works.

To estimate how much a civil engineering project may cost, the actual quantities of materials, labor & equipment etc. that is needed for the construction work must be calculated at the beginning of the work. Such work of calculating the amount of materials and other incidentals necessary for the realization of the work is called quantity surveying.

Quantity surveying is a term or processes used in the construction industry to take measurements of civil works, prepare specifications, and estimate the cost of works either for each trade of work or for the whole project.

The term "surveying" means to inspect, study, review, investigate, asses, and hence "to measure" therefore the term "quantity surveying" means "quantity measuring" as applied to civil engineering projects.

Quantity surveying is the application of standard methods of measurement to quantify the amount of various items in a construction project, for the undertaking of valuation, and certifying payments.

The following tasks are covered in quantity surveying:

- Taking measurements of civil works (Taking off quantities and preparing BOQ)
- Preparation of approximate (preliminary) cost estimate at the very early stage of the project
- Preparation of detail cost estimate at different stages (taking as built measurements and preparing payment certificates or approval of payment certificates prepared by taking measurements)
- Valuation of property

Purpose of Quantity Surveying

The purpose of quantity surveying or the preparation of Bill of quantities is:

- To assist the client to have an accurate estimate of the volume of work as well as the required budget.
- To assist in the accurate preparation of tenders, by providing uniform measurement of quantities.
- To give an accurate checklist of work accomplished
- To assist in the certification of payments
- To give insight into the required variation work amounts.

Types of Estimates

1. Conceptual Estimate:

- An estimate prepared while the project is still in a conceptual state. The conceptual estimate is used to study the feasibility of a project or to compare two potential design alternatives (for example, a concrete structure versus a steel structure or three stories versus four stories). These estimates are based on a description of the project or on very limited drawings and as such are the least accurate type of estimate.

Types of Estimates

2. Preliminary Estimate:

- An estimate prepared from a partially completed set of drawings. A preliminary estimate is often performed when the drawings are 35% to 50% complete and is used to check to see if the proposed design is on budget and to identify changes to the design that need to be made to meet the budget. Preliminary estimates may be performed any time before the bid. Preliminary estimates are more accurate than conceptual estimates because more information about the design is available.

Types of Estimates

3. Final or Detailed Estimate:

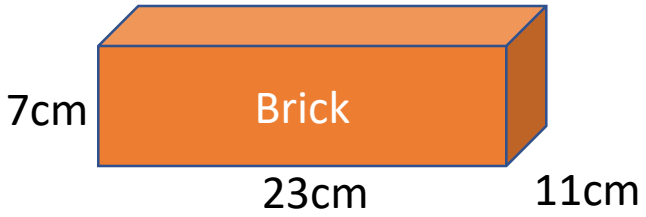
- Are used to prepare bids and change orders, order materials, and establish budgets for construction projects. They are prepared from a complete or nearly completed set of drawings and are the most accurate type of estimate.

Quantity Estimate (Estimating Quantities of materials):

1- Bricks:

Size of Brick as illustrated in the figure is (7*11*23)cm^3.

Joint thickness (cement mortar 1:3) = 1.0 cm.



- If the width of the wall is **36cm** or **more**:

  Size of Brick will be (8*12*24)cm^3

  Number of bricks in 1m^3 of brick masonry work = $$\frac{1m^3}{0.08*0.12*0.24} \approx 435$$

- If the width of the wall is **23cm**:

  Number of bricks in 1m^3 of brick masonry work = $$\frac{1m^3}{0.08*0.12*0.23} = 452.98 \approx 453$$

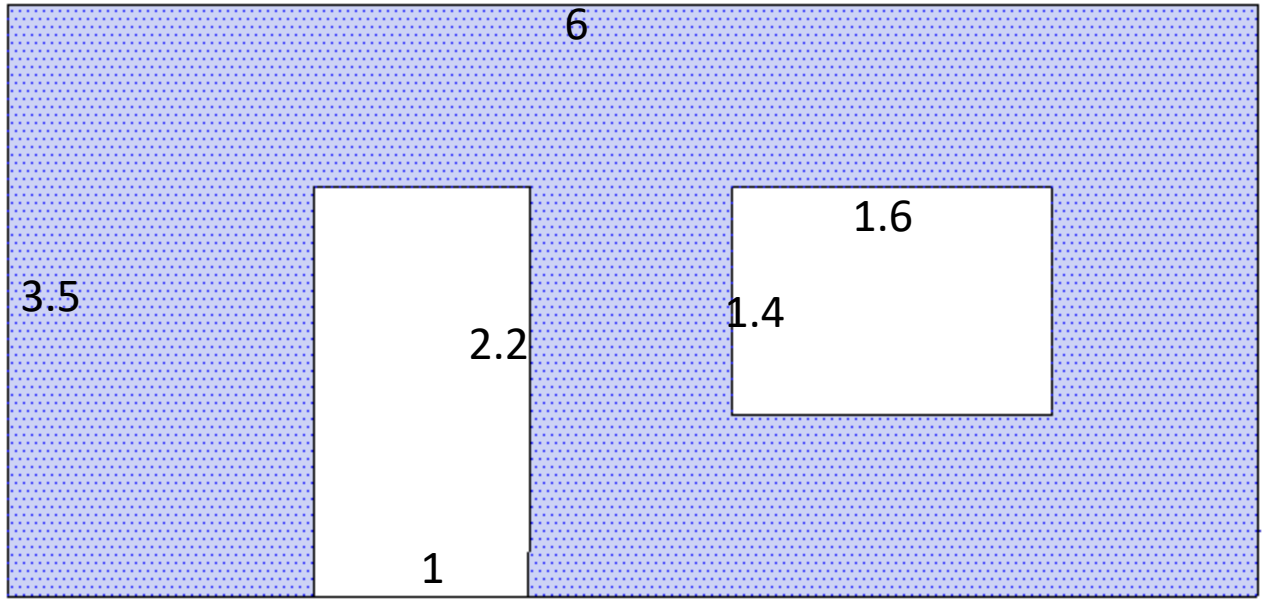
- If the width of the wall is **12cm**:

  Number of bricks in 1m^2 of brick masonry work = $$\frac{1m^2}{0.08*0.24} = 52.08 \approx 53$$

- If the width of the wall is **8cm**:

  Number of bricks in 1m^2 of brick masonry work = $$\frac{1m^2}{0.12*0.24} = 34.7 \approx 35$$

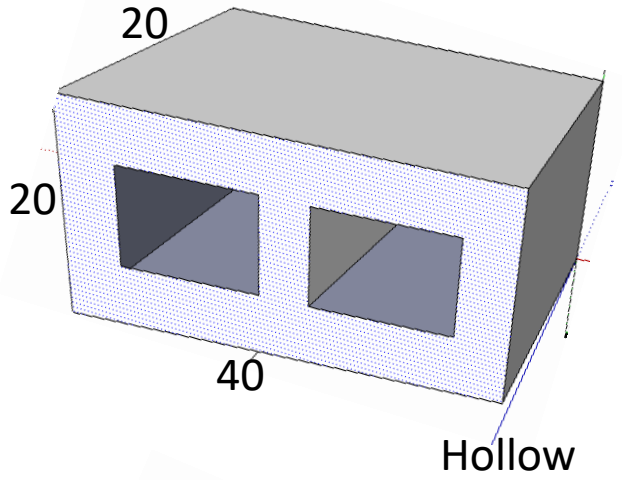
Example: find the number of bricks for the following wall for thickness; 40cm, 23cm, 11cm and 7cm.



2- concrete Blocks:

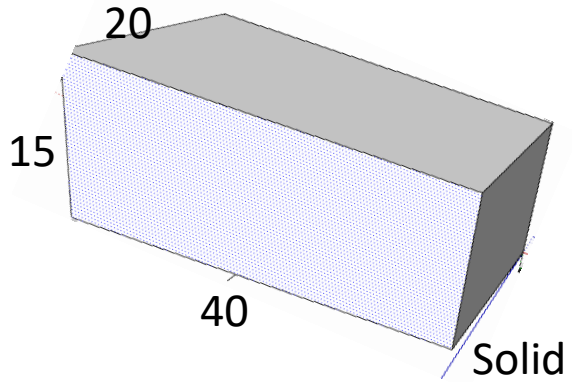
Size of Blocks as illustrated in the figure is:

- (20*20*40)cm^3 (Hollow type)
- (15*20*40)cm^3 (Solid type)
- (10-12*20*40)cm^3 (Hollow type)



Hollow

Joint thickness (cement mortar 1:3) = 1 to 3.0 cm.(use 1 cm)



Solid

- If the width of the wall is **20cm** :

  Size of Block will be (20*21*41)cm^3

  Number of blocks in $1m^3$ = $$\frac{1m^3}{0.2*0.21*0.41} = 58.07 \approx 59$$

- If the width of the wall is **40cm**:

  Size of Block will be (21*21*40)cm^3

  Number of blocks in $1m^3$ = $$\frac{1m^3}{0.4*0.21*0.21} = 56.7 \approx 57$$

- If the width of the wall is **12cm** :

Number of blocks in $1m^3$ = $\frac{1m^3}{0.12*0.21*0.41}$ $= 96.78 \approx 97$

If quantities of block required in m^2 of wall;

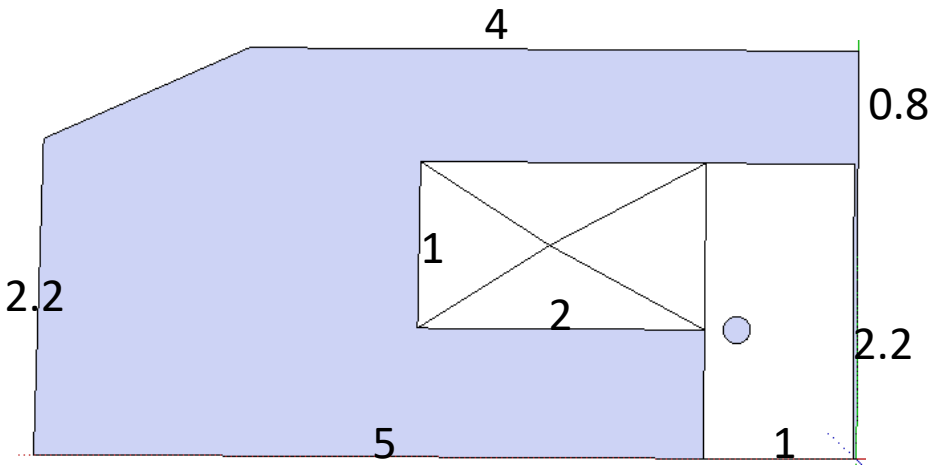
- If the width of the wall is **20cm** :

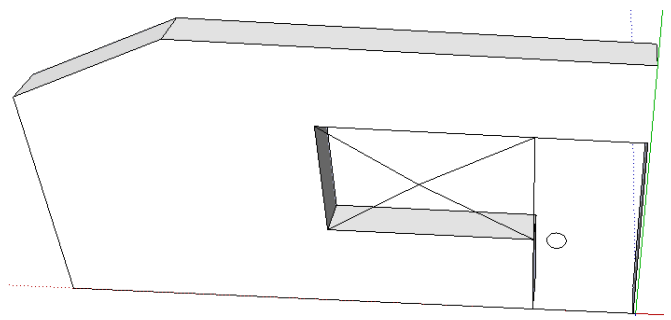
Number of blocks in $1m^2$ = $\frac{1m^2}{0.21*0.41}$ $= 11.61 \approx 12$

- If the width of the wall is **12cm** :

Number of blocks in $1m^2$ = $\frac{1m^2}{0.21*0.41}$ $= 11.61 \approx 12$

Example: find amount of block required in (m^2 and m^3) to build the following wall, if the thickness of wall is; 20cm, 40cm, or 12cm.





isometric

3- Cement, Sand and Gravel:

- ***Cement** mortar **in** **Brick** works:* $V = 0.75 (C + S)$

Volume of Bricks in $1m^3$ of brick work = volume of one Brick * Number of Bricks

= (0.07 * 0.11 * 0.23) * 435 = $0.77\ m^3$

Volume of Mortar in 1m3 of brick work = 1 - 0.77 = $0.23\ m^3$

Then, Cement (C) and Sand (S) quantities can be calculated as follows:
if C : S equal to 1 : 3, means: C=1, S=3
V= 0.75 (C+S) , when $V=0.23m^3$ as obtained before;
0.23=0.75 (C+3C) ⟹ $C = 0.077\ m^3$, $S = 3 * 0.077 = 0.231\ m^3$
Each $1m^3$ of cement = 1400 kg
The weight of cement = 0.077 * 1400 = 107.8 kg

- ***Cement and Sand quantities in** 1m² of Cement Plastering:*

Thickness of plastering = 2 cm

Volume of cement mortar in $1m^2$ of plastering = 0.02 * 1 = $0.02\ m^3$

0.02=0.75 (C+3C) ⟹ $C = 0.0067\ m^3$, $S = 3 * 0.0067 = 0.0201\ m^3$
The weight of cement = 0.0067 * 1400 = 9.4 kg

- ***Cement, Sand, and Gravel in concrete mixes:***

$$V = 0.67 (C + S + G)$$

Cement (C), Sand (S), and Gravel (G) quantities can be calculated as follows:
if proportion is (C : S : G) equals to (1 : 2 : 4) , means: C=1, S=2, and G=4
V= 0.67 (C+S+G) , when V=1m^3 of Mixed material;
1=0.67(C+2C+4C) → C = 0.213 m^3 ,
S = 2 * 0.213 = 0.426 m^3
G = 4 * 0.213 = 0.852 m^3
The weight of cement = 0.213 * 1400 = 298.2 kg ≈ 300 kg

if proportion is (C : S : G) equal to (1 : 1.5 : 3) , means: C=1, S=1.5, and G=3
V= 0.67 (C+S+G) , when V=1m^3 of Mixed material;
1=0.67(C+1.5C+3C) → C = 0.271 m^3 ,
S = 1.5 * 0.271 = 0.4065 m^3
G = 3 * 0.271 = 0.813 m^3
The weight of cement = 0.271 * 1400 = 379.4 kg ≈ 380 kg

if proportion is (C : S : G) equal to (1 : 4 : 8)
V= 0.67 (C+S+G) , when V=1m^3 of Mixed material;
1=0.67(C+4C+8C) → C = 0.115 m^3 ,
S = 4 * 0.115 = 0.46 m^3
G =8 * 0.115 = 0.92 m^3
The weight of cement = 0.115 * 1400 = 161 kg

4- Tiles: Joint= 3.0 mm

- **Glass Tiles**

for size of **15cm * 15cm** :

Number of Tiles in $1m^2$ = $\frac{1m^2}{0.153*0.153} = 42.719 \approx 43$

for size of **20cm * 25cm** :

Number of Tiles in $1m^2$ = $\frac{1m^2}{0.203*0.253} = 19.471 \approx 20$

- **Floor Tiles**

For size of **30cm * 30cm** :

Number of Tiles in $1m^2$ = $\frac{1m^2}{0.303*0.303} = 10.89 \approx 11$

For size of **40cm * 40cm** :

Number of Tiles in $1m^2$ = $\frac{1m^2}{0.403*0.403} = 6.16 \approx 7$

For size of **50cm * 50cm** :

Number of Tiles in $1m^2$ = $\frac{1m^2}{0.503*0.503} = 3.95 \approx 4$

Detailed estimates

- A detailed estimate of the cost of a project, is prepared by determining the costs of materials, construction equipment, labor, overhead, and profit. Such estimates are almost universally prepared by contractors prior to the submitting of bids or the entering into contracts for important projects.
- When preparing a detailed estimate for a given project, the estimator should divide the project into many operations (items) as required. There are two types of detailed estimate.

1. Long and Short Wall Method

The length of longer wall is measured in longitudinal direction end to end and the short wall is measured inside to inside of long walls at every change of step or section. Multiply these lengths by breadth and depth or height to arrive at these quantity.

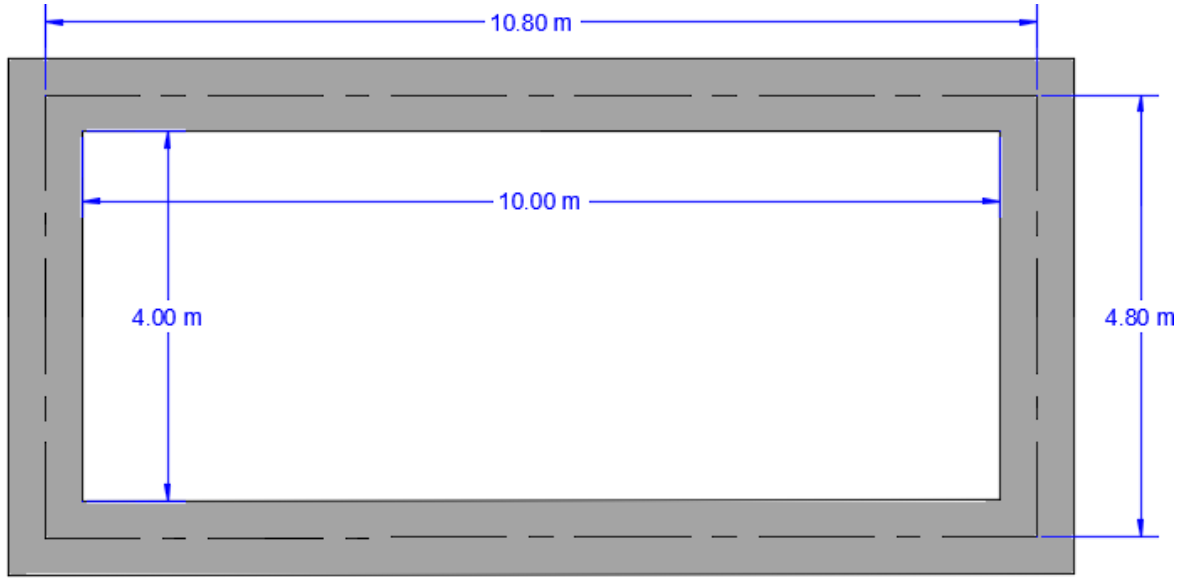
Example:

Estimate excavated material quantity using long and short wall method for the foundation shown its plan in figure below. Assume B = 80 cm and D = 80 cm.

Long walls = (10.0 + (2x0.8)) x 2 = 23.2 m.l
Short walls = 4x2 = 8.0 m.l

Total = 31.2 m.l

Excavation = L x B x D
= 31.2 x 0.8 x 0.8 = 19.97 m3



2. Center Line Method

Center to center distances of long and short walls having similar section are measured and total of the length is obtained.

Quantity = net total length of center line of wall (L) x width (B) x depth (H)

$$= [\,(TL) - (n \times (0.5 \times B))] \times B \times H$$

Where TL = total length of center line of wall dimension

n = number of junctions

B = breadth or width

H = height or depth

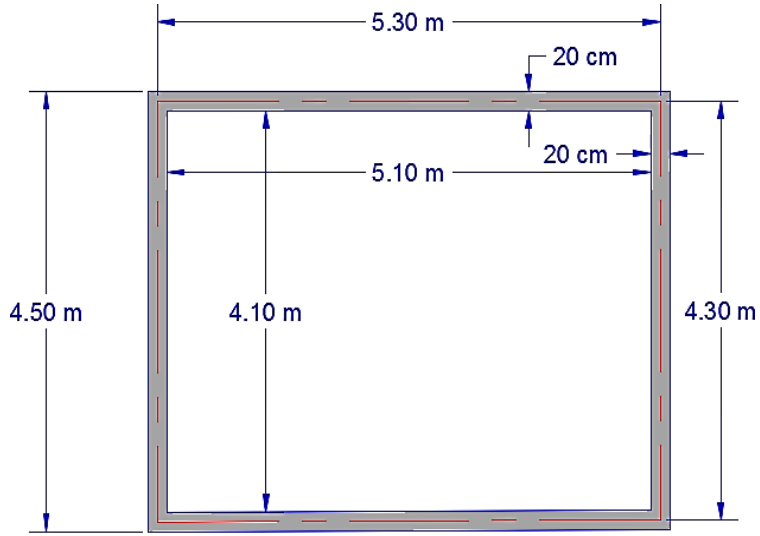
This method is quick but requires special attention and consideration at the junctions, meeting points of partition or cross walls, etc.

For buildings having cross or partition walls, for every junction or partition or cross walls with main walls, special consideration shall have to be made to find the correct quantity.

Example:

Estimate by center line method the quantities of following items of a single room building 4.1 m x 5 .1 m.

1. Excavation,
2. Concrete in foundation,
3. Brickwork in foundation.



-width of walls**=20 cm** above DPC

-width and depth of excavation are **70** cm,

-concrete depth of foundation**= 25** cm,

- Masonry work cross sections are:

60 cm width and **30** depth of 1st step

50 cm width and **30** cm depth of 2nd step

40 cm width and **60** cm depth of 3rd step

Solution

Total center line length = (5.3 + 4.3) x 2 = 19.2 m.l

1. Excavation = 19.2 x 0.70 x 0.70 = **9.408 m^3**

2. Concrete = 19.2 x 0.70 x 0.25 = **3.36 m^3**

3. Masonry work

1st step = 19.2 x 0.60 x 0.30 = 3.456 m^3
2nd step = 19.2 x 0.50 x 0.30 = 2.88 m^3
3rd step = 19.2X 0.40 x 0.60 = 4.608 m^3
Total = **10.944 m^3**

Long and short wall method L = (5.3 -t0.70) x 2 = 12 ml

S = (4.3-0.70) x 2 = 7.2 ml

Total= 19.2 ml the same length as in center line method

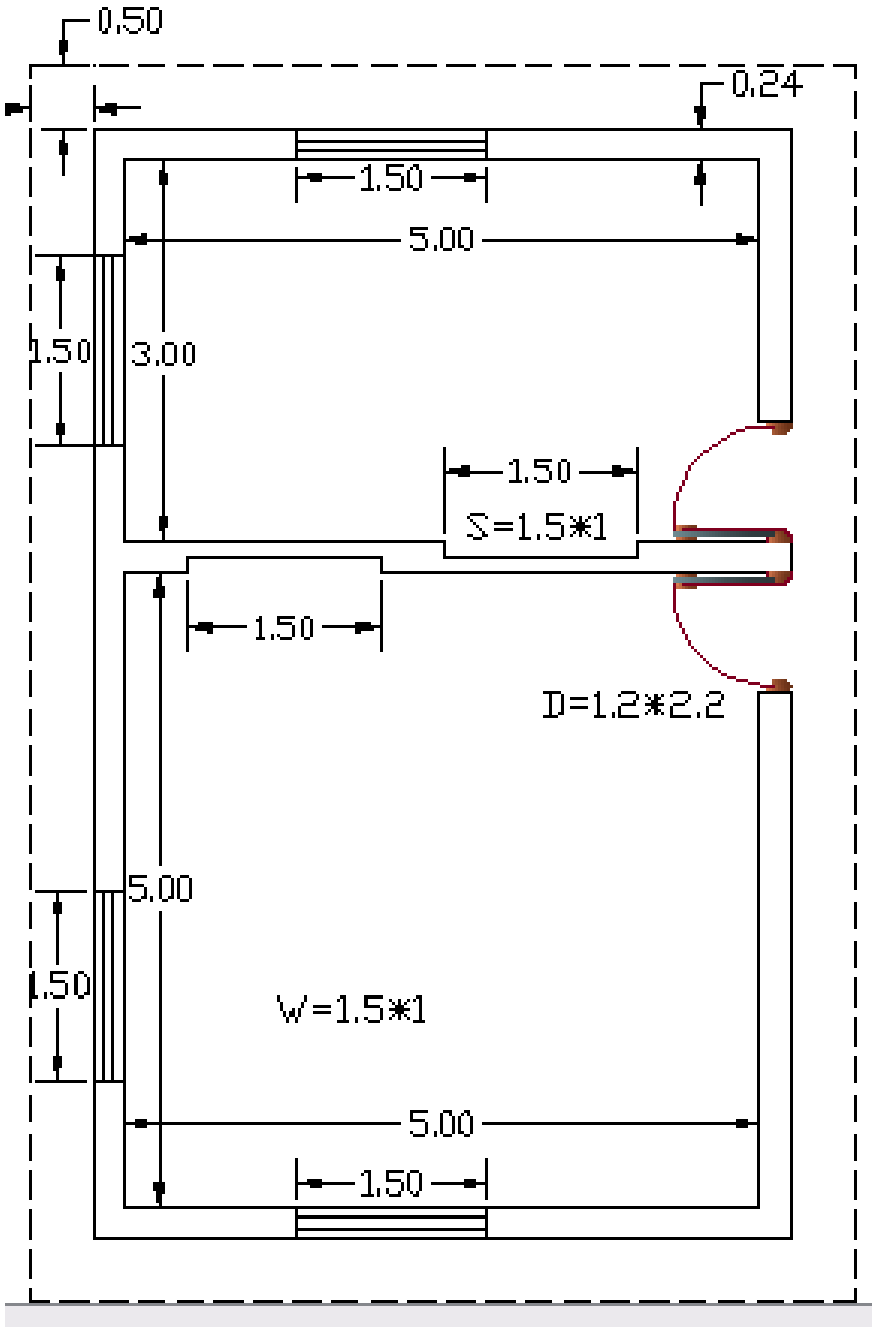
3. Detailed Estimate:

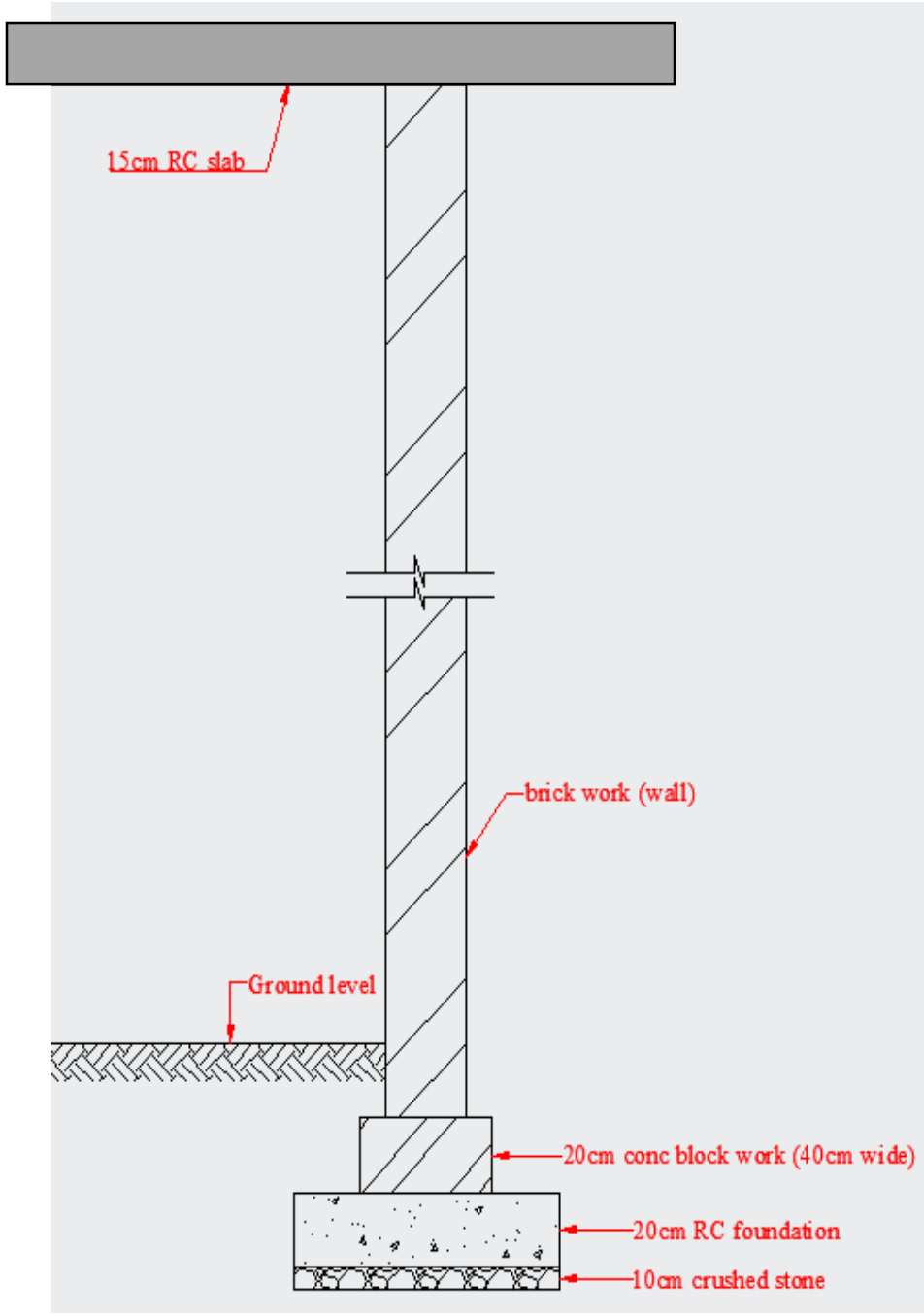
Ex.: Estimate the quantities and cost of the following items of a two roomed building from the given plan and section in figure below.

Items:

1. Earth work in excavation at \$1.0 per m^3.
2. Crushed stone at \$0.25 per m^2.
3. Cement Concrete 1:2:4 in foundation at \$40 per m^3.
4. Brick work and cement mortar (1:3) in foundation at \$50 per m^3.
5. Brick work and cement mortar (1:3) in super structure (wall) at \$80 per m^3.
6. Aluminum window with all accessories at \$100 per m^2.
7. Steel door at \$75 per m^2.
8. Concrete floor at \$35 per m^3.
9. Reinforced concrete roof at \$150 per m^3.
10. Cement plastering at \$3 per m^2.
11. Gypsum plastering at \$3 per m^2.
12. Floor tile at \$15 per m^2.
13. Emulsion paint at \$0.75 per m^2.
14. Oil paint at \$1.0 per m^2.

Plan and Section of 2 roomed building.





Detail of measurements and calculation of quantities

Item No	Description	No	Length m	Width m	Height m	Unit	Quantity
1	Excavation •Long side •Short side	 2 3	 9.28 4.44	 0.8 0.8	 0.6 0.6	m3	 8.909 6.394 ∑ = 15.302
2	Crushed stone (10 cm) •Long side •Short side	 2 3	 9.28 4.44	 0.8 0.8	 -- --	m^2	 14.848 10.656 ∑= 25.504
3	Concrete 1:2:4 •Long side •Short side	 2 3	 9.28 4.44	 0.8 0.8	 0.2 0.2	m^3	 2.969 2.131 ∑= 5.101
4	Block work •Long side •Short side	 2 3	 8.88 4.84	 0.4 0.4	 0.2 0.2	m^3	 1.42 1.162 ∑= 2.582

Item No	Description	No	Length m	Width m	Height m	Unit	Quantity
5	Brick work (wall) •Long side •Short side •Doors •windows	 2 3 2 4	 8.72 5.00 1.20 1.00	 0.24 0.24 0.24 0.24	 3 3 2.2 1.5	m^3	 12.557 10.800 **-1.267** **-1.440** ∑ = 20.649
6	Aluminum windows	4	1.0	--	1.5	m^2	6.0
7	Steel doors	2	1.2	--	2.2	m^2	5.28
8	Concrete floor 1:2:4 •Room 1 •Room 2	 1 1	 5.0 5.0	 5.0 3.0	 0.1 0.1	m3	 2.5 1.5 ∑ = 4.0
9	Reinforced concrete slab	1	9.72	6.48	0.15	m^3	9.448
10	Cement plastering •Front &back facing •Sides facing •Under slab projection Long side Short side	 2 2 2 2	 8.72 5.48 9.72 5.48	 -- -- 0.5 0.5	 3.0 3.0 -- --	m^2	 52.32 32.88 9.72 5.48

	•Facing of Slabs front &back: sides: •Around doors •Around windows •Doors •Windows	 2 2 4 2 8 8 2 4	 9.72 6.48 -- 1.2 -- 1.0 1.2 1.0	 -- -- 0.07 0.07 0.07 0.07 -- --	 0.15 0.15 2.2 -- 1.5 -- 2.2 1.5		 2.916 1.944 0.616 0.168 0.84 0.56 **-5.28** **-6.00** ∑ = 96.164
11	Gypsum plastering					m^2	
	Room1: Walls	2	--	3	2.85		17.1
		2	5	--	2.85		28.4
	•ceiling	1	5	3	--		15
	Room 2: walls	4	5	--	2.85		57
	•Ceiling •Around doors •Around shelves •Doors •Windows	1 4 2 4 4 2 4	5 1.2 1 1.2 1.0	5 0.07 0.07 0.12 0.12	-- 2.2 1.5 2.2 1.5		25 0.616 0.168 0.72 0.48 **-5.28** **-6.00** ∑ = 133.3

Item No	Description	No	Length m	Width m	Height m	Unit	Quantity
12	floor tile •Room 1 •Room 2 •Under door	 1 1 2	 5 5 1.2	 3 5 0.24	 -- -- --	m^2	 15 25 0.576 $\sum = 41$
13	Emulsion paint “on gypsum plastering”						$\sum = 133.3$
14	Oil paint					m^2	$\sum = 0$

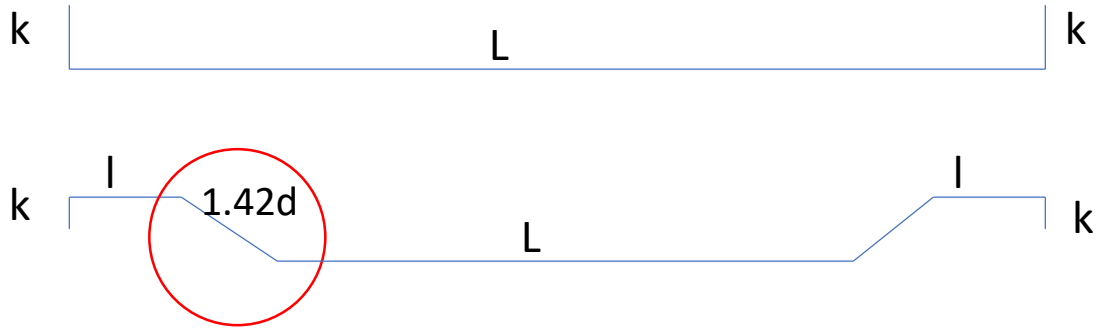
5- Steel Reinforcement:

$$\frac{D^2}{162} = kg/1m(D = \phi_{mm})$$

d=ϕ	10	12	16	20	22
Kg/m	0.617	0.888	1.58	2.469	2.987
in	3/8	4/8	5/8	6/8	7/8
12mBar/ton	135	93	53	34	28

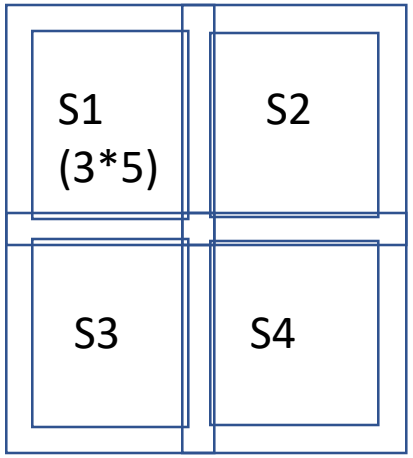
Slab:

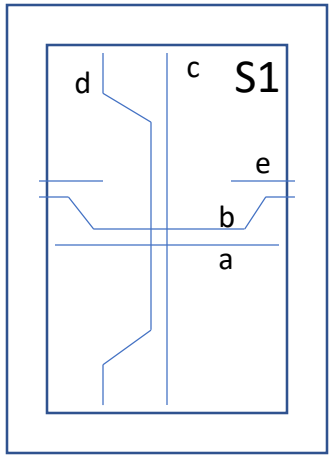
- Straight bars: (L+2K)
- Bent bars: (L+2K+2l+2.84d)



Example: For the following reinforcement plan, estimate the quantity of the steel required.

Where;
a= ϕ12@25c/c
b= ϕ12@25c/c
c= ϕ10@30c/c
d= ϕ10@30c/c
e= ϕ10@30c/c (1.5m)





- Main bars (in short span):

1. Straight bars:

   length=4-0.04 = 3.96

$$\text{Number of bars} = \frac{span(long) - cover(both)}{space(c/c)} + 1$$

$$= \frac{5 - 0.04}{0.25} + 1 = 20.84 \approx 21 bars \phi 12$$

21 No. Φ12 with length of 3.96m

2. Bent bars:

   length=(4-0.04)+0.84d

   = 3.96+0.84*0.11=4.052m

$$\text{Number of bars} = \frac{5 - 0.04}{0.25} + 1 = 20.84 \approx 21 bars \phi 12$$

21 No. Φ12 with length of 4.05m

3. Additional bars:

length=1.5m

Number of bars $= \frac{5-0.04}{0.30}+1 = 17.5 \approx 18(oneSide)$

36 No. Φ10 with length of 1.5m

- Secondary bars (Long Span):

1. Straight bars:

length=5-0.04 = 4.96

Number of bars $= \frac{span(short)-cover(both)}{space(c/c)}+1$

$= \frac{4-0.04}{0.30}+1 = 14.2 \approx 15 bars\phi 10$

15 No. Φ10 with length of 4.96m

2. Bent bars:

length=(5-0.04)+0.84d

= 3.96+0.84*0.11=5.052m

Number of bars $= \frac{4-0.04}{0.30}+1 \approx 15 bars\phi 10$

15 No. Φ10 with length of 5.05m

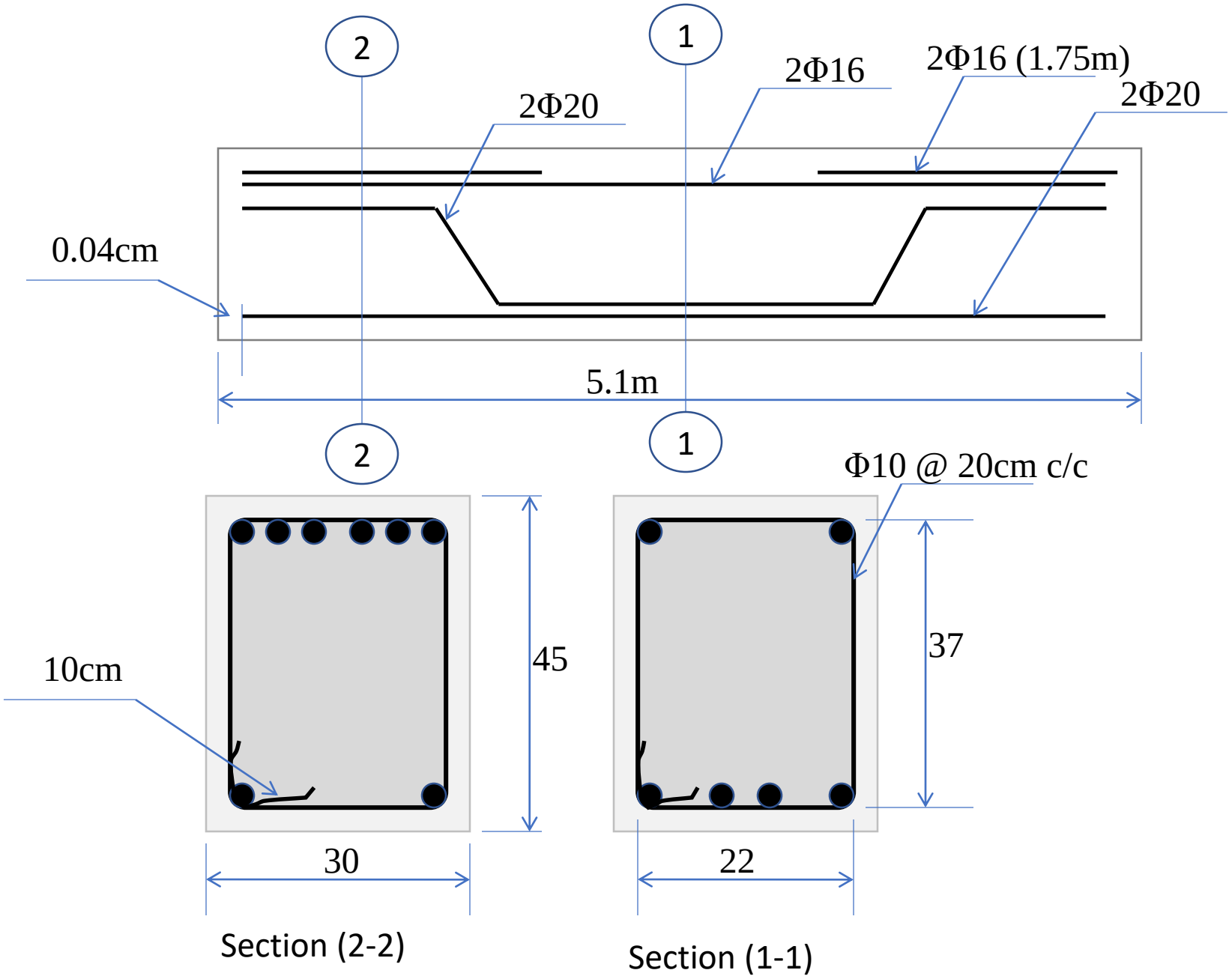
Note: tabulate the required amount of steel per each size separately as follows.
Following table represent the amount of steel for (S1).

Item No.	Description	No	length	Weight / m	Quantity(kg)
1	Main Bars				
	a (st. bars ϕ12)	21	3.96	0.86	74.01
	b (bent. Bars ϕ12)	21	4.05	0.86	75.694
					Φ12: $\sum \approx 150$kg
	c (add. Bars ϕ10)	36	1.5	0.62	33.48
2	Secondary Bars				
	c (st. bars ϕ10)	15	4.96	0.62	46.128
	d (bent. Bars ϕ10)	15	5.05	0.62	46.965
					Φ10: $\sum \approx 127$kg

Thus; total amount of steel required per each slab :
Φ12: $\sum \approx 150$kg
Φ10: $\sum \approx 127$kg

total amount of steel :
Φ12: $\sum \approx 600$kg
Φ10: $\sum \approx 508$kg

Beam:


2
1
2Φ16
2Φ16 (1.75m)
2Φ20
2Φ20
0.04cm
5.1m
2
1
Φ10 @ 20cm c/c
10cm
45
37
30
22
Section (2-2)
Section (1-1)

- **Bottom bars:**

1. Straight bars:

length=5.1- (2*0.04) = 5.02

Number of bars = 2

2 No. Φ20 with length of 5.02m

2. Bent bars:

length=(5.02)+0.84d

= 3.96+0.84*0.37=5.33m

Number of bars = 2

2 No. Φ20 with length of 5.33m

- **Top bars:**

1. Straight bars:

2 No. Φ16 with length of 5.02m

2. Additional bars:

2 No. Φ16 with length of 1.75m

- **Stirrups:**

Number of stirrups $= \frac{5.1-0.08}{0.2}+1 = 26.1 \approx 26$

length $= (0.22+0.37)*2+0.1 = 1.28 \approx 1.3m$

26 No. Φ10 with length of 1.3m

Item No.	Description	No	length	Weight / m	Quantity(kg)
1	Bottom bars				
	(st. bars ϕ20)	2	5.02	2.47	24.79
	(bent. Bars ϕ20)	2	5.33	2.47	26.33
					$\Phi 20: \sum \approx 52kg$
2	Top bars				
	(st. bars ϕ16)	2	5.02	1.58	15.86
	(add. Bars ϕ16)	2	1.75	1.58	5.53
					$\Phi 16: \sum \approx 22kg$
3	stirrups				
	ϕ10	26	1.3	0.62	20.96
					$\Phi 10: \sum \approx 21kg$

- Sanitary and Water supply involves the following items:

Item	Unit	Specifications and requirements
Septic tank	no.	Number of user, type of construction material, required plan and section….etc
Pit Latrine	no.	Depth, location, section…etc
Pan or (WC)	no	
Urinal	no.	
CC pipe	m.l	Precast pipe thickness, slope, concrete line, section and diameter..
CI pipe	m.l	Cast iron pipe diameter and mechanical specification.
Manholes	no.	Size, sectional detail of construction for large manholes.
Kitchen sink	no.	Type of material
Wash basin	no.	Antibacterial or traditional
Flushing cistern	no.	

Item	Unit	Specifications and requirements
GI (Galvanized Iron Pipe)	m.l	diameter
Valve	no.	
PPR-pipe	m.l	diameter
Water Tanks	no.	
Boilers	no.	