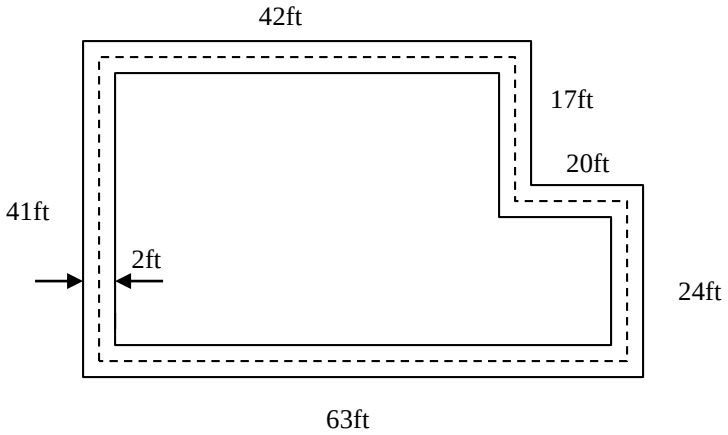
QUANTITY TAKE-OFF

Quantity take off problems are relatively easy to figure out. You just need to know a little bit about geometry and use a little bit of engineering common sense. I will show you a couple tricks of the trade and then some example problems for you to practice to gain experience and confidence.

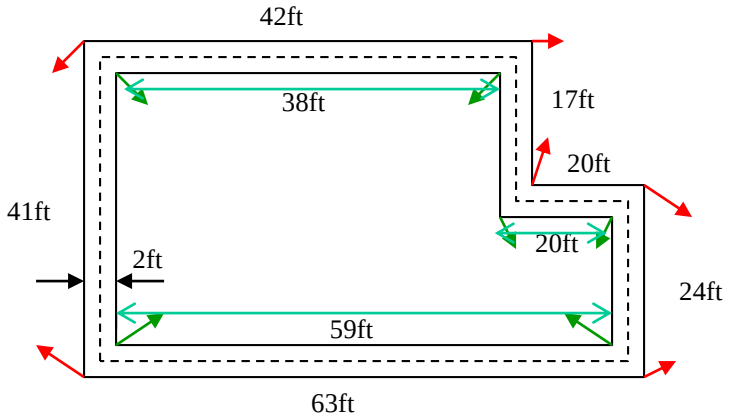
The most likely questions are quantity take off for
1. Soil(excavation, hauling, compacting), 2. Formwork for concrete, 3. Masonry work, and 4. Steel(structural beams, rebar in concrete).

Trick of the Trade #1: To find the length of Excavation – Be careful to fully understand what the given dimension are measuring. The below is the example of a footing plan. If the dimension are given for the centerline or the outer perimeter your calculation is different.



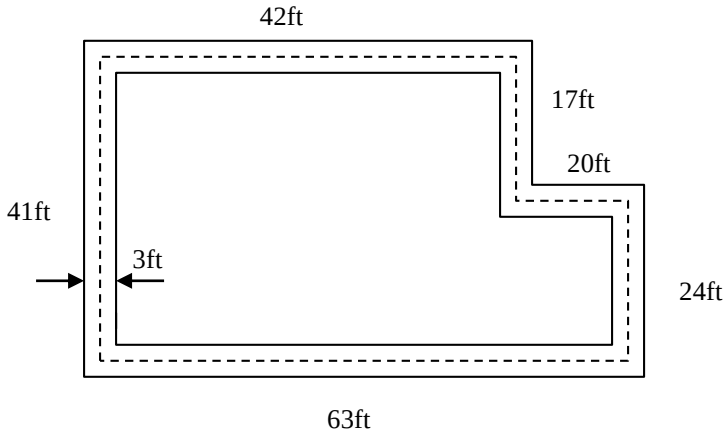
If the dimension are the centerline the calculation are easy.
The Length of Trench equals = 42+17+20+24+63+41 = 207 ft

However if the dimension are the outside perimeter use **Horizontal In-In and Vertical Out-Out Method.** Which just means measure the walls in the Horizontal distance on the inside and in the vertical distance on the outside.
The Length of Trench equals = 38+17+20+24+59+41= 199 ft



QUANTITY TAKE-OFF
EARTHWORK PROBLEM

Question #1:



A contractor is excavating the above trench. He is supposed to dig the trench 5 ft deep x 3 ft wide. The soil was tested to have an approximate swell factor of 15% and a shrinkage factor of 12%. The contractor is placing a 8" water pipe in the trench and then backfilling with the soil that was removed. The above dimensions are on centerline.

Does the contractor have enough soil to backfill the trench, or will he/she have to need more? If he needs more soil, how much does he/she need to bring in. Answer in LCY.

Ans.

a. It fits

b. 14.5 LCY

c. 12.34 LCY

d. 7.25 LCY

QUANTITY TAKE-OFF
SOLUTION 1

Step 1: Find length of trench

Trench = 42ft+17ft+20ft+24ft+63ft+41ft = 207 ft

Step 2: Find the Volume of the soil in the trench

5ft x 3ft x 207ft = 3105 ft^3

Step 3: Find the Volume after compaction

(3105 ft^3)(1-.12) = (3105 ft^3)(.88) = 2732.4 ft^3

Step 4: Find the Volume of the soil needed

Volume of Trench – Volume of Pipe

3105 ft^3 - $\pi(d^2/4)(207ft) = \pi((8/12)^2/4)(207ft)$

3105 ft^3 - 72.25 ft^3 = 3032.75 ft^3

Step 5: Find out if you need more soil

Volume of compacted soil need – Volume of compacted soil available

3032.75 ft^3 - 2732.4 ft^3 = 300.35 ft^3 → <u>So the KTR needs to bring in more soil</u>

Step 6: How much soil does the contractor need to bring in

Volume of compacted soil = (1-Shrinkage factor) x BCF

300.35/.88 = 341 BCF, LCF = BCF x 1.15 = 392/27 = 14.5 LCY

MASONARY QUANTITY TAKE-OFF

There are tables available for estimating the number of bricks required, but for the PE Exam it is relatively easy to just reason out most answers.

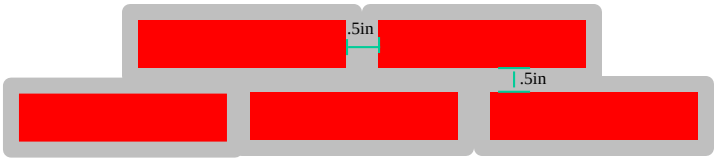
For figuring out the number of bricks required in a wall there is a Five step process.

Trick of the Trade #2: Estimating number of bricks

Step 1: Calculate the net surface area of the wall. (ft^2 or m^2)

- Gross surface Area – openings surface area
- Do not double count area of corners

Step 2: Calculate the surface area of one brick as positioned(including the mortar joint.



- Standard brick size is 8’x2.25’x3.75’
- plus half the joint thickness on each side

Step 3: Divide Net wall area by surface area of the brick.

Step 4: Multiply the number by the number of rows of brinks required.

Step 5: Add an amount for waste (A factor of 2-10% is usually added)

MASONARY QUANTITY TAKE-OFF

If you need to figure out the quantity of mortar required.

Trick of the Trade #3: Quantity of mortar

Step 1: Calculate out the volume of mortar of one brick. (ft^3 or m^3)

- Volume per brick = (t)(w)(L+H+t)

-t = mortar thickness
-w = brick width/depth
- L = brick length
- H = brick height

Step 2: Multiply the mortar required/ brick by the total number of bricks.

Step 3: If more than one row – the volume of mortar needed to fill the gap between rows need to be added. This is volume is the joint thickness times the net area of the wall.

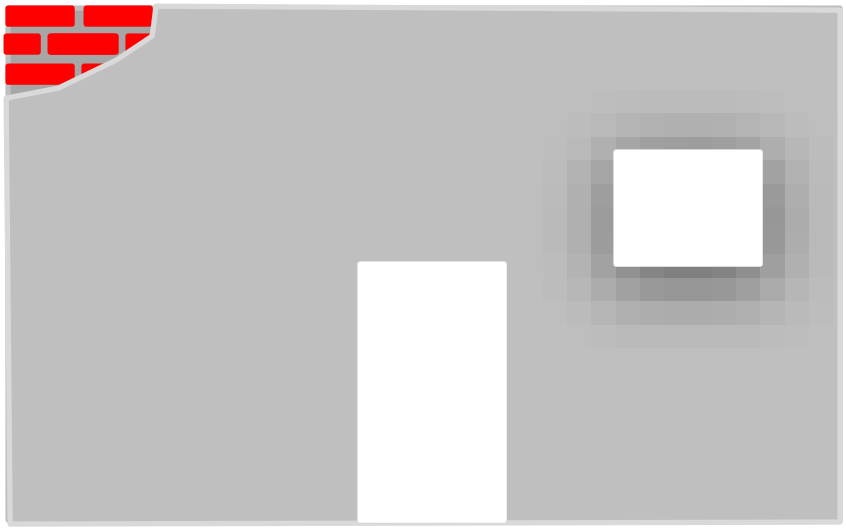
Step 4: Add an amount for waste (A factor of 25% is usually added)

QUANTITY TAKE OFF – MASONRY

PRACTICE PROBLEM #2

Find the quantity of standard size bricks(8inx3.75inx2.25in) you should have delivered to your project if the following conditions are given:

-Wall is 8 ft high, 14 ft wide
- two opening, one 48in x 72in, one 32in x 48in
- Mortar joints are .5in thick
- 2 rows are required
- Allow for 3% brick waste



a. 1275
b. 953
c. 477
d. 982

QUANTITY TAKE OFF – MASONRY
SOLUTION#2

Step 1: Calculate the net surface area of the wall. (ft^2 or m^2)

- Gross surface Area – openings surface area

: $(8ft \times 14ft) - \frac{(48in \times 72in)}{144} - \frac{(32in \times 48\ in)}{144} = 77.33\ ft^2$

Step 2: Calculate the surface area of one brick as positioned(including the mortar joint.

- the thickness of mortar = .5in
- so each side of the brick carries .25in, two side so add .5in to dimension of the brick

Surface area of one brick = $\frac{(8in + .5)(2.25 + .5)}{144} = .1623\ ft^2$

-Step 3: Divide Net wall area by surface area of the brick.

$\frac{77.33\ ft^2}{.1623\ ft^2} = 476.5$ = number of bricks

Step 4: Multiply the number by the number of rows of brinks required.

(476.5)(2 rows) = 952.9 bricks

Step 5: Add an amount for waste (A factor of 2-10% is usually added)

(952.9 bricks)(1.03) = 982 bricks

QUANTITY TAKE OFF – MASONRY

PRACTICE PROBLEM #2A

Estimate the quantity of mortar required in problem #1. The joint thickness between rows is ½in thick. Assume 25% waste.

a. 20.5 ft^3
b. 18.3 ft^3
c. 14.6 ft^3
d. 11.4 ft^3

SOLUTION #2A

Step 1: Calculate out the volume of mortar of one brick. (ft^3 or m^3)

- Volume per brick = (t)(w)(L+H+t)
- Volume per brick = (.5)(3.75)(8.0+2.25+.5) = .01166 ft^3

Step 2: Multiply the mortar required/ brick by the total number of bricks.

- Volume of mortar = (.01166 ft^3/brick) x (982 bricks) = 11.4 ft^3

Step 3: Volume between rows = (.5/12)(77.33) = 3.2 ft^3

Step 4: Mortar Req. = 1.25(11.4+3.2) = 18.3 ft^3

QUANTITY TAKE OFF – BOARD FEET

Board Feet is a measurement of lumber volume. A board foot is equal to 144 cubic inches of wood. Actually it's easy to calculate using the following formula:

→(Thickness(in) x Width(in) x Length(in)/144 = Board Feet
Or
→ # piece of lumber (P) x (Thickness(in) x width(in))/12 x Length = Board Feet

Note: Lumber is specified by its rough size. This is why a 1" x 4" board is actually ¾" thick and a 2" x 4" board is actually 1-1/2" thick.

When you are figuring up board feet, keep in mind a waste factor. If you purchase good clear material add about 15% for waste, if you elect to use lower grade material you will have to allow for defects and more wasted material add about 30%.

Ex. What is the board feet for one 2x4 that is 10 feet long?

Solution: 1 x (2inx4in)/12 x 10ft = 5 2/3 board feet

QUANTITY TAKE-OFF
REBAR

As everyone knows rebar is added to concrete in order to provide tensile strength since concrete is very weak in tension.

The following are tables for rebar, and wire fabric which are required to know for quantity take so you can know pounds of steel required.

Table 12–1 ASTM standard reinforcing bar sizes

Size Number	Metric Size Number	Weight		Diameter		Section Area	
		lb/ft	*kg/m*	*in.*	*mm*	*sq in.*	*mm²*
3	10	0.376	0.560	0.375	9.52	0.11	71
4	13	0.668	0.994	0.500	12.70	0.20	129
5	16	1.043	1.552	0.625	15.88	0.31	200
6	19	1.502	2.235	0.750	19.05	0.44	284
7	22	2.044	3.042	0.875	22.22	0.60	387
8	25	2.670	3.973	1.000	25.40	0.79	510
9	29	3.400	5.059	1.128	28.65	1.00	645
10	32	4.303	6.403	1.270	32.26	1.27	819
11	36	5.313	7.906	1.410	35.81	1.56	1006
14	43	7.650	11.384	1.693	43.00	2.25	1452
18	57	13.600	20.238	2.257	57.33	4.00	2581

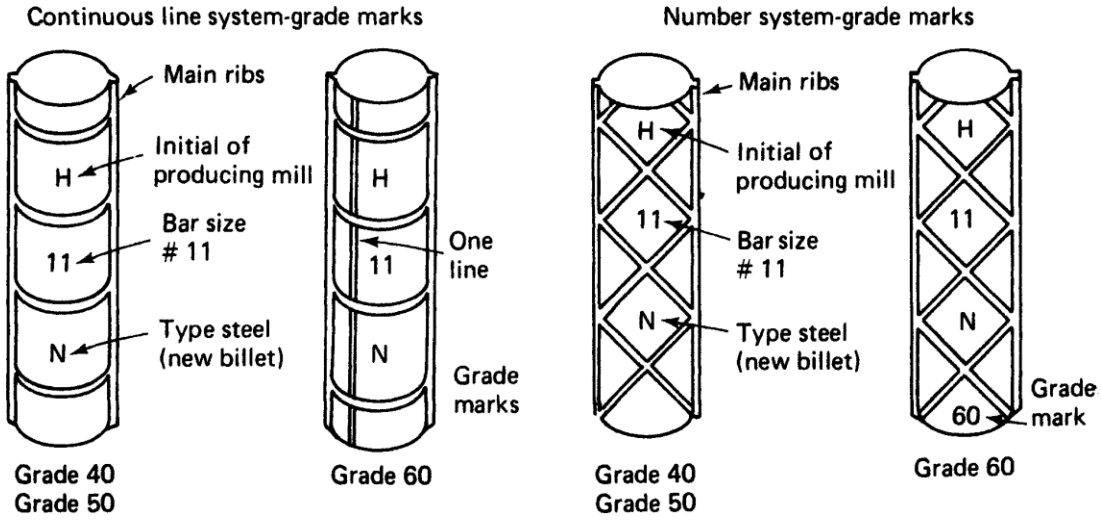


Figure 12–28 Reinforcing bar identification marks. (Courtesy of Concrete Reinforcing Steel Institute)

QUANTITY TAKE-OFF
REBAR

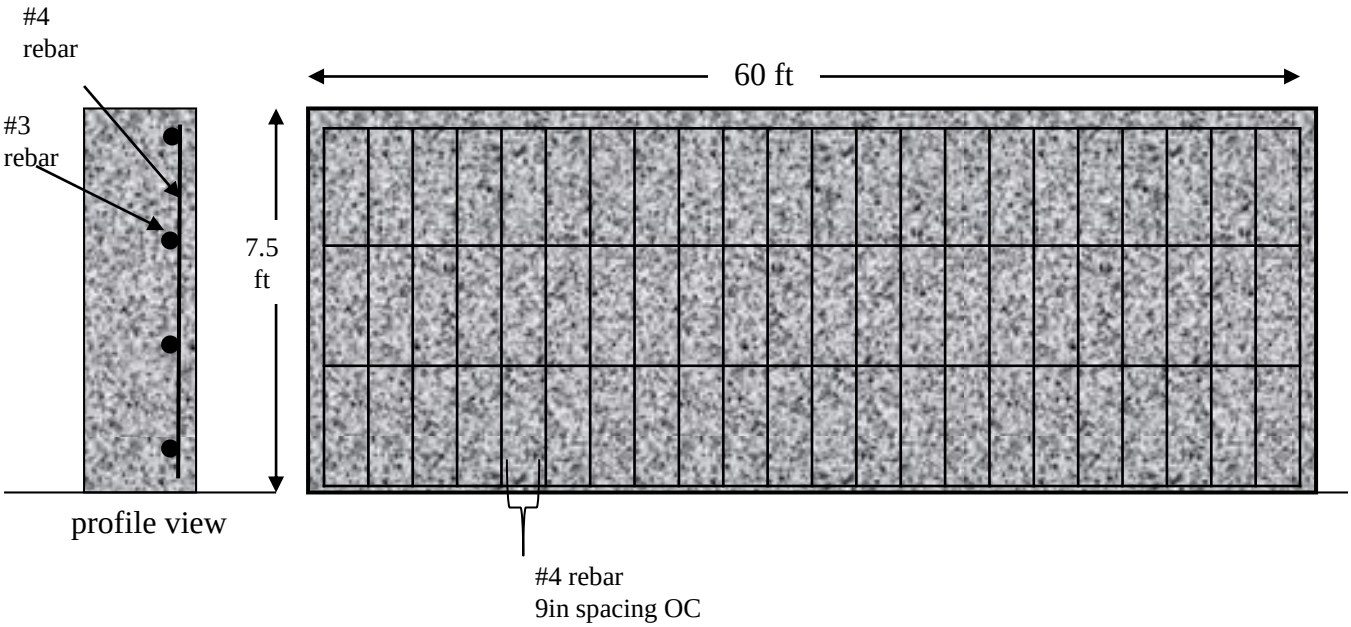
Table 12–2 Steel wire data for welded wire fabric

Wire Size Number		Diameter		Area		Weight	
Smooth	*Deformed*	*in.*	*mm*	*sq in.*	*mm²*	*lb/ft*	*kg/m*
W31	D31	0.628	16.0	0.31	200	1.054	1.568
W28	D28	0.597	15.2	0.28	181	0.952	1.417
W26	D26	0.575	14.6	0.26	168	0.934	1.390
W24	D24	0.553	14.1	0.24	155	0.816	1.214
W22	D22	0.529	13.4	0.22	142	0.748	1.113
W20	D20	0.505	12.8	0.20	129	0.680	1.012
W18	D18	0.479	12.2	0.18	116	0.612	0.911
W16	D16	0.451	11.5	0.16	103	0.544	0.810
W14	D14	0.422	10.7	0.14	90	0.476	0.708
W12	D12	0.391	9.9	0.12	77	0.408	0.607
W11	D11	0.374	9.5	0.11	71	0.374	0.557
W10	D10	0.357	9.1	0.10	65	0.340	0.506
W9.5		0.348	8.8	0.095	61	0.323	0.481
W9	D9	0.338	8.6	0.09	58	0.306	0.455
W8.5		0.329	8.4	0.085	55	0.289	0.430
W8	D8	0.319	8.1	0.08	52	0.272	0.405
W7.5		0.309	7.8	0.075	48	0.255	0.379
W7	D7	0.299	7.6	0.07	45	0.238	0.354
W6.5		0.288	7.3	0.065	42	0.221	0.329
W6	D6	0.276	7.0	0.06	39	0.204	0.304
W5.5		0.265	6.7	0.055	35	0.187	0.278
W5	D5	0.252	6.4	0.05	32	0.170	0.253
W4.5		0.239	6.1	0.045	29	0.153	0.228
W4	D4	0.226	5.7	0.04	26	0.136	0.202
W3.5		0.211	5.4	0.035	23	0.119	0.177
W2.9		0.192	4.9	0.029	19	0.099	0.147
W2.5		0.178	4.5	0.025	16	0.085	0.126
W2		0.160	4.1	0.02	13	0.068	0.101
W1.4		0.134	3.4	0.014	9	0.048	0.071

QUANTITY TAKE-OFF
REBAR

Trick of the Trade #3: When calculating the number of bars required find the total length Divided by the spacing of the bars and add 1.

Example: You are building a 60 ft x 7.5ft concrete wall. The design is the diagram Below with 9 inch spacing of vertical rebar. Figure out the lbs of rebar required.



Step 1: Figure out the steel in the horizontal direction.

- it is given that there are 4 #3 bars = .376 lbs/ft
- it is given that the horizontal distance is 60 ft
- American Concrete Institute recommends concrete cover for slabs, joints, walls NOT exposed to ground 3/4 in

lbs of #3 rebar = (4)(60ft-((2)(3/4in)/12))(.376lbs/ft) = 90 lbs

Step 2: Figure out the steel in the vertical direction.

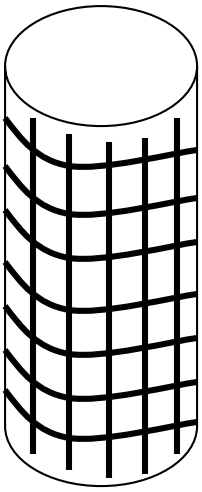
- it is given there are #4 = .668 lbs/ft
- using the above trick of trade, ((60ft)(12in/ft)/9in) = 80 bars + 1 = 81 bars required
- ACI recommends concrete cover for concrete exposed to the ground of 1.5 inchs, so you should estimate 1.5in off the ground and .75in on top of wall.
- So the total length on one #4 rebar is 7.5ft-((1.5/12)-(.75/12)) = 7.31ft

lbs of #4 rebar = 81(7.31ft)(.668lbs/ft) = 396 lbs

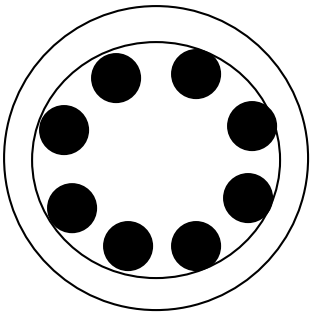
Step 3: Find the total lbs of rebar

- 90lbs+396lbs = 486 lbs

QUANTITY TAKE-OFF
REBAR



Question #3: Find the weight of the steel rebar in concrete filled drilled shaft which is 35 ft deep. The design calls for 8 vertical #10 rebars, and the ties every 5ft are #4 rebar. The diameter of the cylinder is 2 ft. Disregard any concrete cover offset for steel length.



Answer #3:

Step 1: Find pounds of steel in the vertical direction.

- given 8 vertical bars = 8
- Total length of vertical bars = 35ft/bars x 8 bars = 280 ft
- weight of #10 = 4.303 lbs/ft
- total weight in the vertical direction = (4.303 lbs/ft)(280ft) = 1,205 lbs of #10 rebar

Step 2: Find pounds of steel in the horizontal direction.

- Find number of ties, using trick of trade #3, 35/5 +1 = 8 ties
- Find length of ties = circumference of the circle = Pi(2ft) = 6.283 ft
- Total length = (6.283 ft)(8) = 50.3 ft
- Weight of #4 rebar = .668lbs/ft
- Total Weight of #4 rebar = (.668lbs/ft)(50.3ft) = 33.6lbs

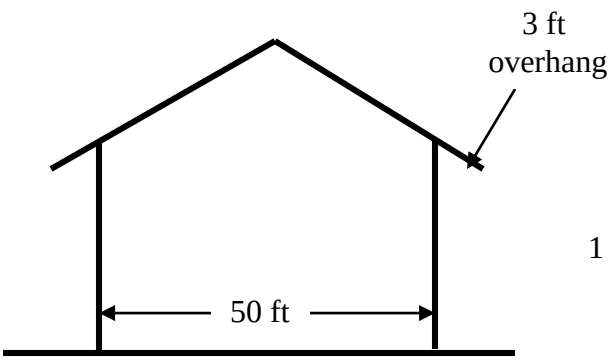
Step 3: Find total weight of Rebar.

- 1205lbs + 33.6lbs = 1238.6lbs

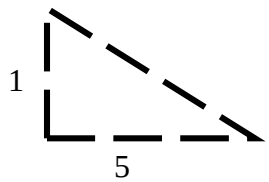
QUANTITY TAKE-OFF
ROOFING

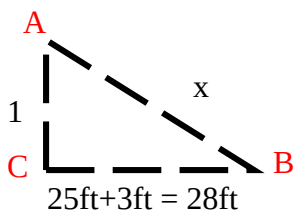
Roof material quantity take-off are pretty easy trig problems, but I will go over it quick to make sure you get it, because most likely a question will be on the PE exam.

Trick of the Trade #4: When thinking of roof problems you just need to worry about three things.
1.The angle of the roof, or the rise/run of the roof
2.The width of the house plus the overhang of the roof
3.Always remember to add in all sections of the roof and multiply by length of rafters and by the length of the house



Example: Find the Roofs area if the roof has a 1/5 rise over run angle with a 3ft overhang. The length of the house is 75ft. The width of the house is 50 ft.





Step 1: Find the length of the roof
- BC = 28ft
- tan ABC = 1/5 = .20
- $\tan^{-1}$ .20 = 11.3°
- AB cos 11.3 = BC
- AB = BC/cos 11.3 = 28/cos 11.3
- AB = 28ft/.9806 = 28.55ft

Step 2: Find the Area of the Roof
- Area = 2 sides x (length of the rafter) x (length of the building)
- Area = 2 x 28.55ft x 75ft

- Area = 4,283ft^2

QUANTITY TAKE-OFF
STEEL

The type of steel used in structural steel is designated by a letter A followed by the ASTM number. Then most common type of steel are;

- A36 Carbon Structural Steel
- A572 High Strength Low-Alloy Structural Steel
- A588 Corrosion-Resistant High Strength Low Alloy Structural Steel

Steel strength is usually designated by the symbol Fy which is the minimum yield point of steel. Ex. Type A36 = Fy = 36Ksi = 36,000lb/sq in

ASTM have also standardized a number of rolled steel shapes. Below are 5 examples

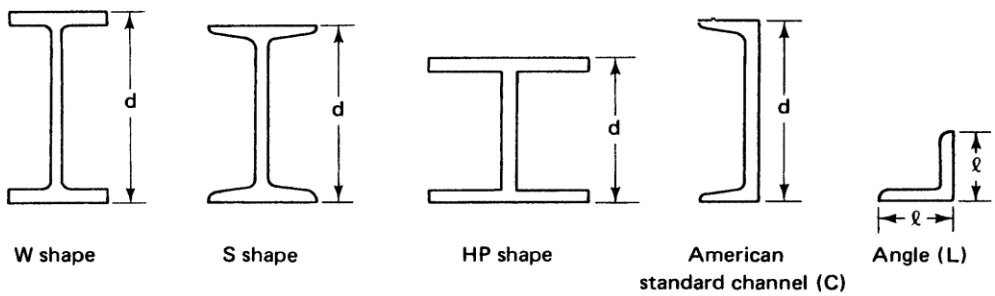
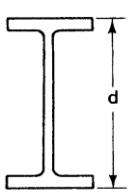


Figure 15–2 Rolled-steel section shapes.

Table 15–2 Rolled-steel shape designations

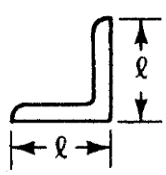
Type of Shape	Example Designation
W shape	W27 × 114
S shape	S20 × 95
M shape	M8 × 25
American Standard Channel	C12 × 30
Miscellaneous Channel	MC12 × 50
HP (bearing pile) shape	HP14 × 89
Equal leg angle	L6 × 6 × ½
Unequal leg angle	L8 × 4 × ½



W shape

W27 x 114

The number 27 Is d=27in and 114 is that the Flange weight 114 lbs/ft This applies to the shapes too except the L-angle.



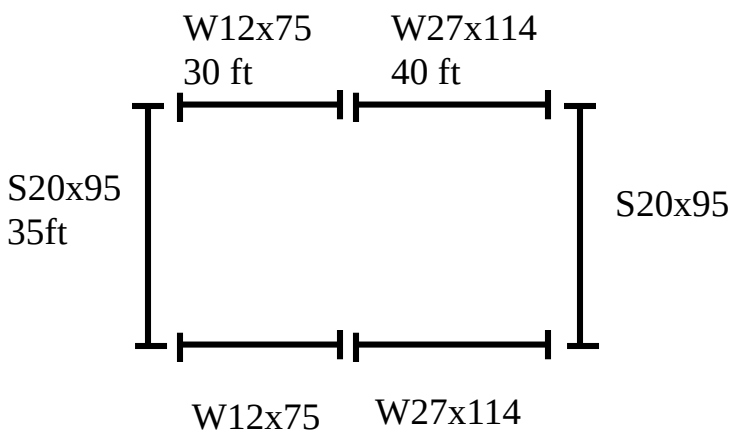
Angle (L)

L8 × 4 × ½

The number 8 is one leg in inches and 4 indicates the other leg in inches and ½ represents the thickness of the section. Weight is obtained from other tables.

QUANTITY TAKE-OFF STEEL PRACTICE PROBLEM

Find the weight of steel in the plan view of the building below.



Step 1: Find the weight of each beam:

S20x95(35ft) = 95lbs/ft x 35 ft = 3,325 lbs
W12x75(30ft) = 75lbs/ft x 30 ft = 2,250 lbs
W27x114(40ft) = 114lbs/ft x 40 ft = 4,560 lbs

Because the other three beams are the same size you can add the three beams and multiply by 2 to get the total weight of steel.

Total weight of the beams = (3,325 + 2,250 + 4,560) x 2 = 20,270 lbs