TABLE OF CONTENTS

CHAPTER 1

CONCRETE

1-1 PLAIN AND REINFORCED CONCRETE

Concrete is either Plain or Reinforced. By definition, Plain Concrete is an artificial stone as a result of mixing cement, fine aggregates, coarse aggregates and water. The conglomeration of these materials producing a solid mass is called plain concrete.

Reinforced Concrete on the other hand, is a concrete with reinforcement properly embedded in such a manner that the two materials act together in resisting forces.

The Different Types of Concrete Used in Construction are :

1. The Ordinary Portland cement.
2. The Rapid Hardening Portland Cement which is preferred when high early strength concrete is desired.
3. The Blast Furnace or Sulfate Cement used on concrete structures designed to resist chemical attack.
4. The Low Heat Portland Cement used for massive sections designed to reduce the heat of hydration.
5. The Portland Pozzolan Cement with a low hardening characteristic concrete.
6. The High Alumina Cement.

The High Alumina Cement is sometimes called aluminous cement or cement fundu. Its chemical composition is different from that of Portland cement for having predominant alumina oxide content of at least 32% by weight. The alumina lime is within the limit of 0.85% to 1.3%.

This type of cement has a very high rate of strength development compared with the ordinary Portland cement. Aside from its rapid hardening properties, it can resist chemical attack by sulfate and weak acids including sea water. It can also withstand prolonged exposure to high temperature of more than 1,000°C. Alumina cement however, is not advisable for mixing with any other types of cement.

The Main Composition of Cement are:

1.6	to	65%	Lime
18.0	-	25%	Silica
3.0	-	8%	Alumina
3.0	-	5%	Iron oxide
2.0	-	5%	Magnesia
1.0	-	5%	Sulfur trioxide

AGGREGATES

Aggregates for concrete work are classified into two:

1. **Coarse Aggregate** such as crushed stone, crushed gravel or natural gravel with particles **retained** on a 5 mm sieve.

2. **Fine Aggregate** such as crushed stone, crushed gravel, sand or natural sand with particles **passing** on a 5 mm sieve.

Size of Aggregates. - For coarse aggregate (gravel), the maximum nominal size varies from 40, 20, 14 or 10 mm diameter. The choice from the above sizes depends upon the dimensions of the concrete member more particularly, the spacing of the steel bars reinforcement or as specified.

Good practice demand that the maximum size of coarse aggregate (gravel) should not exceed 25% of the minimum thickness of the member structure nor exceed the clear distance between the reinforcing bars and the form.

The coarse aggregate should be small enough for the concrete mixture to flow smoothly around the reinforcement. This is referred to as workability of concrete.

1-2 THE PRINCIPLES OF CONCRETE MIXING

The purpose in mixing concrete is to select an optimum proportion of cement, water and aggregates, to produce a concrete mixture that will meet the following requirements:

1. Workability
2. Strength
3. Durability
4. Economy

The proportion that will be finally adopted in concrete mixing has to be established by actual trial and adjustment processes to attain the desired strength and quality of concrete required under the following procedures:

1. The water cement ratio is first determined at the very first hour of mixing to meet the requirements of strength and durability.

2. The cement-aggregate ratio is then chosen and established to satisfy the workability requirements. Workability, means the ability of the fresh concrete to fill all the voids between the steel bars and the forms without necessarily exerting much effort in tamping.

Laboratory tests showed that the water-cement content ratio is the most important consideration in mixing because it determines not only the strength and durability of the concrete but also the workability of the mixture.

Concrete mixtures in a paste form, is preferred than those mixtures which are flowing with water.

The ACI Requirements for Concrete are as follows:

1. Fresh concrete shall be workable. Meaning, that fresh con-

crete could freely flow around the reinforcements to fill all the voids inside the form.

2. That, the hardened concrete shall be strong enough to carry the design load.

3. That, hardened concrete could withstand the conditions to which it is expected to perform.

4. That, concrete should be economically produced.

Concrete Mixture may be classified as either:

a. Designed Mixture
b. Prescribed Mixture

Designed Mixture. Where the contractor is responsible in establishing the mixture proportion that will achieve the required strength and workability as specified in the plan.

Prescribed Mixture. Where the designing engineer specify the mixture proportion. The contractor's responsibility is only to provide a properly mixed concrete containing the right proportions as prescribed in the plan.

1-3 THE UNIT OF MEASURE

Prior to the worldwide acceptance of Metrication, otherwise known as System International (SI), materials for concrete structures were estimated in terms of cubic meter although, the components thereof like; cement, sand, gravel and water, are measured in pounds, cubic foot and gallons per bag respectively.

Lately however, under the SI measures, the 94 pounds per bag cement equivalent to 42.72 kilograms was changed and fixed at 40 kilograms per bag. The traditional wooden box used to measure the sand and gravel is 12 inches wide by 12 inches long and 12 inches high, having a net volume of 1 cubic foot.

Today, instead of the traditional measuring wooden box, the empty plastic bag of cement is popularly used to measure the volume of sand and gravel for convenience in handling aggregates during the mixing operations.

TABLE 1-1 CONVERSION FROM INCHES TO METER

Number	Accurate Value	Approximate Value	Number	Accurate Value	Approximate Value
1	.0254	.025	21	.5334	.525
2	.0508	.050	22	.5588	.550
3	.0762	.075	23	.5842	.575
4	.1016	.100	24	.6096	.600
5	.1270	.125	25	.6350	.625
6	.1524	.150	26	.6604	.650
7	.1778	.175	27	.6858	.675
8	.2032	.200	28	.7112	.700
9	.2286	.225	29	.7366	.725
10	.2540	.250	30	.7620	.750
11	.2794	.275	31	.7874	.775
12	.3048	.300	32	.8128	.800
13	.3302	.325	33	.8382	.825
14	.3556	.350	34	8636	.850
15	.3810	.375	35	.8890	.875
16	.4064	.400	36	.9144	.900
17	.4318	.425	37	.9398	.925
18	4572	.450	38	.9652	.950
19	.4826	.475	39	.9906	.975
20	.5080	.500	40	1.016	1.00

The values presented in Table 1-1 could be useful in:

1. Finding the accurate conversion of length from English to Metric measure.

2. Determining the approximate value to be used generally in our simplified methods of estimating.

For Instance :

A) In solving problems, the probability of committing error is substantially high when several digit numbers are being used.

Example:

It is easier to use .10 meter, the approximate equivalent of 4 inches than .1016 it's exact equivalent, be it by multiplication or by division processes.

$\frac{8}{.10}$ = 80 by inspection and analysis

$\frac{8}{.1016}$ = 78.7 by long process of division

B) To memorize the values given in Table 1-1 is a waste of time and not a practical approach in estimating. A simple guide will be adopted so that one could easily determine the equivalent values from English to Metric or vise versa.

Example:

1. To convert Meter to Feet: Divide the length by .30

   Say $\frac{6.00}{.30}$ meters = 20 ft.

2. To convert Feet to Meters: Multiply by .30

   Say, 30 feet x .30 = 9.00 meters

3. To convert Inches to Meter, just remember the following values of equivalent.

1 Inch	=	2.5 cm.	or	.025 meters
2 Inches	=	5.0 cm.	or	.050 meters
3 Inches	=	7.5 cm.	or	.075 meters
4 Inches	=	10.0 cm.	or	.10 meters
5 Inches	=	12.5 cm.	or	.125 meters

Take note that all length in inches is divisible by one or any combination of these five numbers. Thus, it could be easily converted to meters by summing up their quotient equivalent.

Example:

a. What is the meter length equivalent of 7 inches ? By simple analysis, 7 inches could be the sum of 4 and 3, therefore:

   4 Inches = .10 meter
   3 Inches = .075 meter
   Answer = .175 meter

b. How about 21 inches ?

   5 x 4 inches = 20 + 1 = 21 inches

   since 4" = .10 m. and
   1" = .025; multiply

   5 x .10 m. = .50 + .025 = .525 m.

Problem Exercise

Using the foregoing simple guide, convert the following numbers from inches to meters or vise versa.

Inches to Meters		Meters to Inches	
66		2.42	
99		3.35	
113		4.27	
178		4.88	
233		5.19	

1-4 CONCRETE PROPORTION

Proportioning concrete mixture is done in two different ways: by weight or by volume method. The most common and convenient way is by the volume method using the empty plastic bag of cement, or by a measuring box for sand and gravel as

explained in Section 1-3. Measuring the aggregates and water by weight is sometimes used in a concrete batching plant for ready-mix concrete or as specified in the plan.

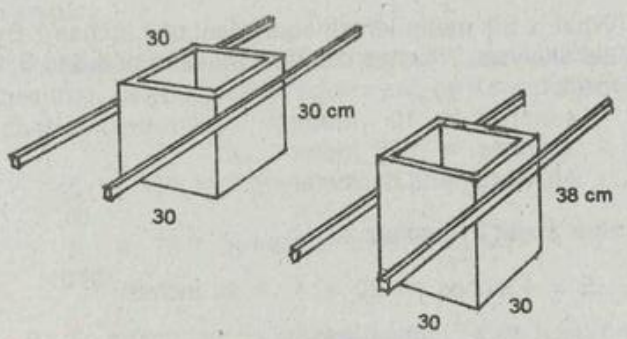


FIGURE 1-1 MEASURING BOX

TABLE 1-2 CONCRETE PROPORTION

Mixture Class	Proportion	Cement in Bag		Sand	Gravel
		40 kg.	50 kg.	cu. m.	cu. m.
AA	1 : 1 ½ : 3	12.0	9.5	.50	1.0
A	1 : 2 : 4	9.0	7.0	.50	1.0
B	1 : 2 ½ : 5	7.5	6.0	.50	1.0
C	1 : 3 : 6	6.0	5.0	.50	1.0

Proportioning concrete by volume method had long been practiced in almost all types of concrete construction. Time has proven it to be effective and successful. However, on construction where space for materials stock piling and mixing does not permit, ready-mixed concrete is the most practical solution.

It is interesting to note in Table 1-2 that the volume of sand and gravel for all classes of mixture is constant at .50 and 1.0 cubic meter respectively. It is true, on the assumption that the cement paste enters the void of the sand and at the same ins-

tance, the composition of these two materials fill the voids of the gravel and thereafter, form a solid mass called concrete equivalent to one cubic meter.

Based on actual concreting work, one cubic meter of gravel plus one-half cubic meter sand mixed with cement and water will obtain a little bit more than one cubic meter solid concrete. The small excess over one cubic meter will be considered as contingency.

Comment :

In actual concreting and masonry work, there are several factors that might affect the accuracy of the estimate. Some of which are enumerated as follows:

1. Inaccurate volume of delivered aggregates which is very common. Delivery truck should be measured to check if the volume of aggregates being delivered is exactly as ordered.

2. Dumping of aggregates on uneven ground surface and grass areas reduces the net volume of aggregates.

3. Improper measuring of the aggregates during the mixing operation. This is common practice when the work is on its momentum where laborers fails to observe the right measuring of aggregates being delivered to the mixer.

4. The cement and fine aggregate for grouting concrete joints are mostly overlooked in the estimating processes.

5. Cement waste due to reckless handling and hauling.

6. The pure cement powder used by mason in plastering operations to prevent the plaster from sliding downward is not considered in estimating.

7. Pilferage of materials. This could be avoided with an effective system of construction management.

Ordering of Coarse Aggregate must be Specific as to:

a. Kind of gravel, either crushed stone or natural gravel from the creek.

b. The minimum and maximum size of the stone must be specified. It should be free from mixed sand because sand is cheaper than gravel.

c.. Natural gravel from the creek requires screening to obtain a well-graded coarse aggregate. Take note that screening of aggregates means additional cost of labor and reduction in the net usable volume of gravel.

1-5 CONCRETE SLAB

The discussions from cement to concrete proportions plus the Tables as presented could be more meaningful and appreciated if accompanied by illustrations of actual applications.

ILLUSTRATION 1-1

A proposed concrete pavement has a general dimension of 10 cm. thick, 3.00 meters wide and 5.00 meters long. Determine the quantity of cement in bags, sand and gravel in cubic meters required using class "C" mixture.

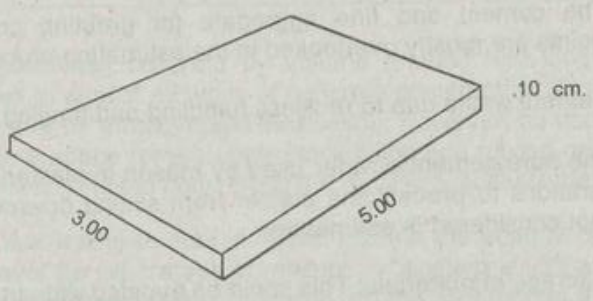


FIGURE 1-2 CONCRETE PAVEMENT

SOLUTION

1. Determine the volume of the proposed concrete pavement.

   Volume = Thickness x Width x Length

   V = .10 x 3.00 x 5.00

   V = 1.5 cubic meters

2. Refer to Table 1-2. Using 40 kg. cement class C mixture; multiply the volume by the corresponding values:

   Cement : 1.5 x 6.0 = 9.0 bags
   Sand : 1.5 x .50 = .75 cu. m.
   Gravel : 1.5 x 1.0 = 1.50 cu. m.

3. Take note that the computation is for a 40 kg. cement. Suppose there is no 40 kilograms cement and what is available are 50 kilograms per bag. How many bags will be ordered using the later?

SOLUTION - 2 (Using a 50 kg. Cement)

1. Knowing the volume to be 1.5 cubic meters, refer again to Table 1-2. Under 50 kg. cement, using class "C" mixture; multiply the volume by the corresponding values.

   Cement : 1.5 x 5.0 = 7.5 bags
   Sand : 1.5 x .50 = .75 cu. m.
   Gravel : 1.5 x 1.0 = 1.5 cu. m.

ILLUSTRATION 1-2

A rural road 6.00 meters wide after base preparation requires concreting of one kilometer long. Find the number of bags cement, sand and gravel required using class "A" concrete if the slab is 6 inches thick.

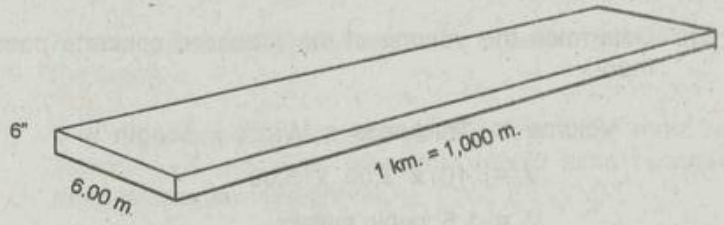


FIGURE 1-3 CONCRETE ROAD

SOLUTION

1. Solve for the volume of concrete pavement, convert 6 inches to meter = .15 m. (see table 1-1)

   V = Thickness x Width x Length

   V = .15 x 6.00 x 1,000 m.

   V = 900 cubic meters

2. Refer to Table 1-2. Using 40 kg. cement, multiply the volume by the corresponding values:

   Cement : 900 x 9.0 = 8,100 bags
   Sand : 900 x .50 = 450 cu. m.
   Gravel : 900 x 1.0 = 900 cu. m.

3. If there is no available 40 kg. cement, a 50 kg. cement will require:

   Cement : 900 x 7.0 = 6,300 bags
   Sand : 900 x .50 = 450 cu. m.
   Gravel : 900 x 1.0 = 900 cu. m.

Take note that the thickness was first converted from inches to meters using the approximate values in Table 1-1.

ILLUSTRATION 1-3

A national highway project as shown in Figure 1-4 specify 25 centimeters thick concrete. Find the number of bags cement, sand and.gravel required using class "A" mixture.

1,000 m.

PLAN

FIGURE 1-4 CONCRETE ROAD

SOLUTION

1. Find the volume of the concrete slab;

   V = Thickness x Width x Length

   V = .25 x 7.20 x 1,000 meters
   V = 1,800 cubic meters

2. Refer to Table 1-2. Using 40 kg. cement class A mixture, multiply the volume by the corresponding values:

   Cement : 1,800 x 9.0 = 16,200 bags
   Sand : 1,800 x .50 = 900 cu. m.
   Gravel : 1,800 x 1.0 = 1,800 cu. m.

3. If 50 kg. cement will be use, we need:

   Cement : 1,800 x 7.0 = 12,600 bags
   Sand and Gravel same as in step 2.

ILLUSTRATION 1-4

The ground floor of a residential house has an area of 200 square meters. The plan specify 4 inches thick concrete floor on fill using class C concrete. List down the materials required.

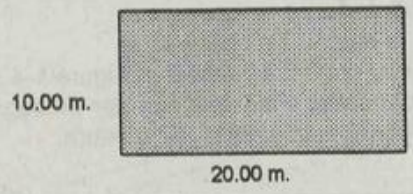


FIGURE 1-5 FLOOR PLAN

SOLUTION

1. Find the volume of the floor slab. Convert 4 inches to meter = .10 m. and then multiply:

   200 x .10 = 20 cubic meters

2. Refer to Table 1-2 under 40 kg. cement along class C mixture, multiply:

   Cement : 20 x 6.0 = 120 bags
   .Sand : 20 x .50 = 10 cu. m.
   Gravel : 20 x 1.0 = 20 cu. m.

Problem Exercise

1. A concrete road 15 meters wide, 5 kilometers long, is designed with a thickness as shown in the following cross section. Specifying class "A" concrete, determine the quantity of 40 kg. cement, sand and gravel required. If there is no available 40 kg. cement, how many bags at 50 kg. would be needed instead?

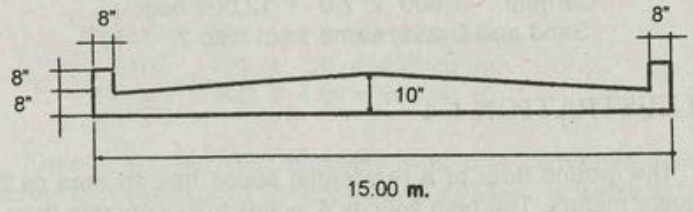


FIGURE 1-6 CROSS SECTION OF THE ROAD

2. From the following figure, solve for cement, sand and gravel using class B concrete if the floor is 5 inches thick.

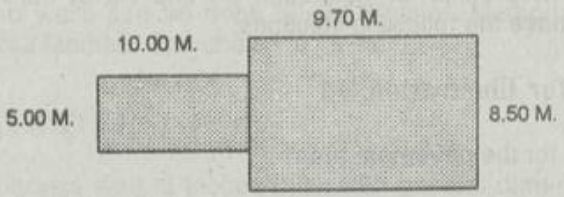


FIGURE 1-7 FLOOR PLAN

1-6 ESTIMATING CONCRETE SLAB BY THE AREA METHOD

Estimating concrete slab by the "Area Method" is much easier than the Volume Method as explained in Sec. 1-5. However, this could be done with the aid of Table 1-3 which readily offer the quantity of cement, sand and gravel per square meter depending upon the required thickness of the slab.

TABLE 1-3 QUANTITY OF CEMENT, SAND AND GRAVEL FOR SLAB AND WALLS PER SQUARE METER AREA

Slab Thickness cm.	Mixture Class						Sand	Gravel
	40 kg. Cement			50 kg. Cement				
	A	B	C	A	B	C	cu. m.	cu. m.
5.0	.450	.375	.300	.350	.300	.250	.0250	.050
7.5	.675	.563	.450	.525	.450	.375	.0375	.075
10.0	.900	.750	.600	.700	.600	.500	.0500	.100
12.5	1.125	.938	.750	.875	.750	.625	.0630	.125
15.0	1.350	1.125	.900	1.050	.900	.750	.0750	.150
17.5	1.575	1.313	1.050	1.225	1.050	.875	.0880	.175
20.0	1.800	1.500	1.200	1.400	1.200	1.00	.1000	.200
22.5	2.030	1.688	1.350	1.575	1.350	1.125	.1125	.225
25.0	2.250	1.875	1.500	1.750	1.500	1.250	.1250	.250
27.5	2.475	2.063	1.650	1.925	1.650	1.375	.1380	.275
30.0	2.700	2.250	1.800	2.100	1.800	1.500	.1500	.300

ILLUSTRATION 1-5

Solving the problem of Illustration 1-1 and 1-2 by the Area Method we have the following solutions:

Solution for Illustration 1-1

1. Solve for the pavement area.

   Area = Width x Length

   A = 3.00 x 5.00 m.

   A = 15 sq. m.

2. Refer to Table 1-3. Along 10 cm. slab thickness under 40 kg. cement class "C" mixture, multiply:

   Cement : 15 x .600 = 9.0 bags
   Sand : 15 x .050 = .75 cu. m.
   Gravel : 15 x .100 = 1.5 cu. m.

3. Compare this quantity to that of Illustration 1-1, the results are the same.

Solution for Illustration 1-2

1. Find the area of the concrete road pavement;

   A = Width x Length

   A = 6.00 x 1,000 meters

   A = 6,000 sq. m.

2. Refer to Table 1-3. Using class "A" concrete for a 15 cm. thick concrete slab, multiply:

   Cement : 6,000 x 1.350 = 8,100 bags
   Sand : 6,000 x .075 = 450 cu. m.
   Gravel : 6,000 x .150 = 900 cu. m.

3. Again, comparing the result with that of Illustration 1-2 the answers are practically the same. Thus, solving the quantity of cement, sand and gravel for concrete pavement and walls can be done by the Volume Method and the Area Method. The choice is yours.

ILLUSTRATION 1-6

A concrete wall, 3 inches thick with general dimensions of 3.00 meters high by 7.00 meters long specify class "B" mixture. Find the number of 40 kg. cement, sand and gravel required.

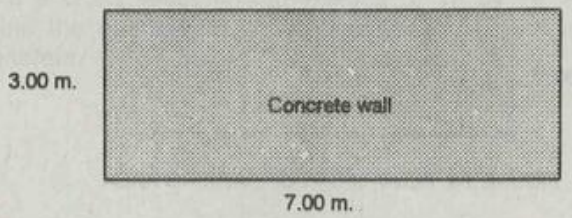


FIGURE 1-8 CONCRETE WALL

SOLUTION

1. Convert 3 inches to centimeters = 7.5 (see Table 1-1)

2. Find the Area of the wall:

   Area = Height x Length
   A = 3.00 x 7.00 m. = 21 sq. m.

3. Refer to Table 1-3. Under slab thickness 7.5 cm. 40 kg. cement class B mixture we obtain the number .563

4. Likewise, under column sand and gravel of Table 1-3 we obtain .0375 and .075 respectively.

5. Multiply the Area by each of these numbers to get the quantity of cement, sand and gravel respectively.

Cement : 21 x .563 = 11.82 say 12 bags
Sand : 21 x .0375 = .79 cu. m.
Gravel : 21 x .075 = 1.57 cu. m.

Problem Exercise

1. By the Area Method, determine the quantity of cement, sand and gravel of the proposed concrete parking area 6 inches thick with a general dimensions of 150 x 120 meters using class "A" mixture.

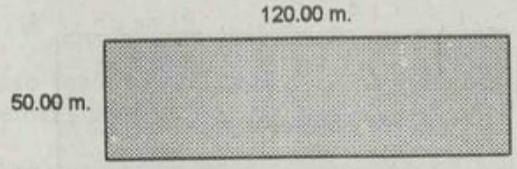


FIGURE 1-9 FLOOR PLAN OF PARKING AREA

2. By the Volume and Area Method, find the quantity of cement, sand and gravel of the concrete pavement 4" thick as shown in Figure 1-10 using class "B" concrete.

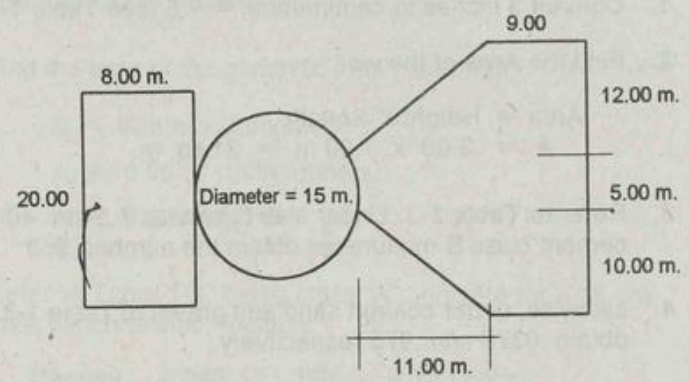


FIGURE 1-10 CONCRETE PAVEMENT PLAN

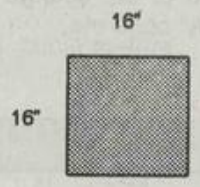
1-7 SQUARE CONCRETE COLUMN

Estimating the quantity of materials for concrete post or column can also be done in two simple ways:

1. By Volume Method and
2. By Linear Meter Method.

ILLUSTRATION 1-7

A reinforced concrete square column is 5.00 meters long with a cross sectional dimensions of 16 by 16 inches. Determine the quantity of cement, sand and gravel using class A concrete.



Cross Section

FIGURE 1-11 SQUARE COLUMN

SOLUTION :

A. By Volume Method

1. Convert first all measurements from inches to meter. 16 inches = .40 meter (See Table 1-1)

2. Solve for the cross sectional area of the column.

   Area : .40 x .40 = .16 sq. m.

3. Find the volume of the column.

V = .16 x 5.00 meters

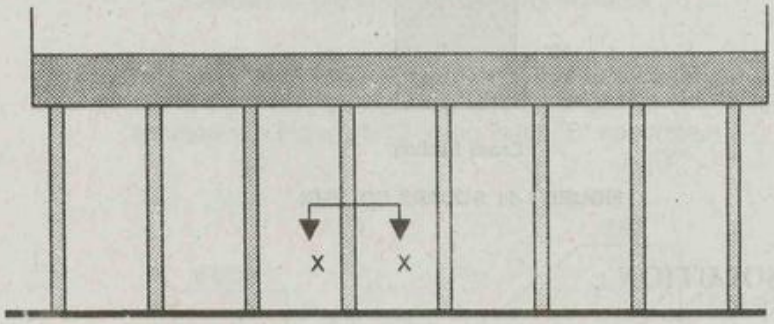
V = .80 cu. m.

4. Refer to Table 1-2, using 40 kg. cement class "A" concrete, multiply:

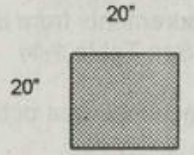
Cement : .80 x 9.0 = 7.2 say 8 bags
Sand : .80 x .50 = 0.4 say 0.5 cu. m.
Gravel : .80 x 1.0 = 0.8 say 1.0 cu. m.

ILLUSTRATION 1-8

A concrete column is 7.00 meters high with a cross sectional dimensions of 20 by 20 inches. Determine the quantity of cement sand and gravel content of the column if there are 8 columns in the row using class "A" concrete.



ELEVATION



CROSS SECTION X-X

FIGURE 1-12 CONCRETE COLUMN

SOLUTION

1. Convert all dimensions from inches to meters. (Refer to Table 1-1, use approximate values).

   20 inches = .50 m.

2. Solve for the volume of one square column.

   V = .50 x .50 x 7.00

   V = 1.75 cu. m.

3. Find the volume of the 8 columns.

   V = 1.75 x 8

   V = 14 cubic meters

4. Refer to Table 1-2. Using a 40 kg. cement class "A" mixture, multiply:

Cement : 14 x 9.0 = 126 bags
Sand : 14 x .50 = 7.0 cu. m.
Gravel : 14 x 1.0 = 14.0 cu. m.

1-8 ESTIMATING SQUARE CONCRETE COLUMN BY LINEAR METER METHOD

Another way of estimating the quantity of materials for concrete column is by the Linear Meter Method.

Under this method, the length of the column is first determined. With the aid of Table 1-4, the materials required are found by multiplying the length by the corresponding values of cement, sand and gravel given in Table 1-4.

ILLUSTRATION 1-9

Solving the problem of Illustration 1-8 Figure 1-12 where there are 8 columns at 7.00 meters high each, we have:

SOLUTION

1. Find the total length of the 8 columns

   8 column x 7.00 m. = 56.00 meters

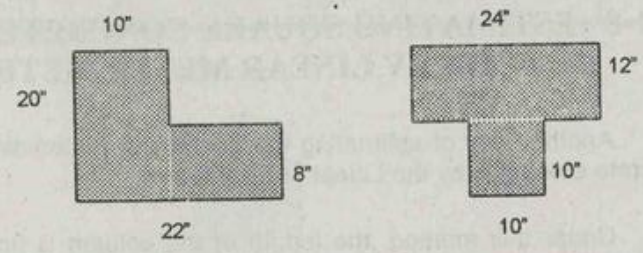
2. Refer to Table 1-4. Along 50 x 50 cm. column, using 40 kg. cement class "A" concrete, multiply:

   Cement : 56.00 x 2.250 = 126 bags
   Sand : 56.00 x .125 = 7.0 cu. m.
   Gravel : 56.00 x .250 = 14.0 cu. m.

3. Comparing the results to that of Illustration 1-7, the answers are the same.

Problem Exercise

1. From the following figure, solve for the quantity of cement, sand and gravel by the Volume Method using (a) class "A" concrete; (b) Class B concrete.



CROSS SECTION **FIGURE 1-13** CROSS SECTION

a.) 6 COLUMN AT 13 M. HIGH b.) 8 COLUMNS AT 16 M. HIGH

TABLE 1-4 QUANTITY OF CEMENT, SAND AND GRAVEL FOR POST BEAM AND GIRDER PER METER LENGTH

Size cm.	Mixture Class 40 kg. Cement A	40 kg. Cement B	50 kg. cement A	50 kg. cement B	Sand cu m.	Gravel cu. m.
15 x 20	.270	.225	.210	.180	.015	.030
15 x 25	.338	.281	.263	.225	.019	.038
15 x 30	.405	.338	.315	.270	.023	.045
15 x 35	.473	.394	.369	.315	.026	.053
15 x 40	.540	.450	.420	.360	.030	.060
20 x 20	.360	.300	.280	.240	.020	.040
20 x 25	.450	.375	.350	.300	.025	.050
20 x 30	.540	.450	.420	.360	.030	.060
20 x 35	.630	.525	.490	.420	.035	.070
20 x 40	.720	.600	.560	.480	.040	.080
25 x 25	.563	.469	.438	.375	.031	.063
25 x 30	.675	.563	.525	.450	.038	.075
25 x 35	.788	.656	.613	.525	.044	.088
25 x 40	.900	.750	.700	.600	.050	.100
25 x 45	1.013	.844	.788	.675	.056	.113
25 x 50	1.125	.938	.875	.750	.063	.125
30 x 30	.810	.675	.630	.540	.045	.090
30 x 35	.945	.788	.735	.630	.053	.105
30 x 40	1.080	.900	.840	.720	.060	.120
30 x 45	1.125	1.013	.945	.810	.068	.135
30 x 50	1.350	1.125	1.050	.900	.075	.150
35 x 35	1.103	.919	.858	.735	.061	.123
35 x 40	1.260	1.050	.980	.840	.070	.140
35 x 45	1.418	1.181	1.103	.945	.079	158
35 x 50	1.575	1.313	1.225	1.050	.088	.175
35 x 55	1.890	1.575	1.470	1.260	.105	.210
40 x 40	1.440	1.200	1.120	.960	.080	.160
40 x 45	1.620	1.350	1.260	1.080	.090	.180
40 x 50	1.800	1.500	1.400	1.200	.100	.200
40 x 55	1.980	1.650	1.540	1.320	.110	.220
40 x 60	2.160	1.800	1.680	1.440	.120	.240
45 x 45	1.823	1.519	1.418	1.215	.101	.203
45 x 50	2.025	1.688	1.575	1.350	.113	.226
45 x 55	2.228	1.856	1.733	1.485	.124	.248
45 x 60	2.430	2.025	1.890	1.620	.135	.270

50 x 50	2.250	1.875	1.750	1.500	.125	.250
50 x 55	2.475	2.063	1.9925	1.650	.138	.275
50 x 60	2.700	2.250	2.100	1.800	.150	.300
55 x 60	2.970	2.475	2.310	1.980	.165	.330
55 x 70	3.465	2.888	695	2.310	.193	.386
55 x 80	3.960	3.300	3.080	2.640	.220	.440
55 x 90	4.455	3.713	3.465	2.970	.248	.495
55 x 100	4.950	4.125	3.850	3.300	.275	.550
60 x 60	3.240	2.700	2.520	2.160	.180	.360
60 x 70	3.780	3.150	2.940	2.520	.210	.420
60 x 80	4.320	3.600	3.360	2.880	.240	.480
60 x 90	4.860	4.050	3.780	3.240	.270	.540
60 x 100	5.400	4.500	4.200	3.600	.300	.600
65 x 60	3.510	2.925	2.730	2.340	.195	.390
65 x 70	4.095	3.413	3.185	2.730	.228	.455
65 x 80	4.680	3.900	3.640	3.120	.260	.520
65 x 90	5.265	4.388	4.095	3.510	.293	.585
65 x 100	5.850	4.875	4.550	3.900	.325	.650
70 x 70	4.410	3.675	3.430	2.940	.245	.490
70 x 80	5.040	4.200	3.920	3.360	.280	.560
70 x 90	5.670	4.725	4.410	3.780	.315	.630
70 x 100	6.300	5.250	4.900	4.200	.350	.700
75 x 70	4.725	3.938	3.675	3.150	.263	.525
75 x 80	5.400	4.500	4.200	3.600	.300	.720
75 x 90	6.075	5.063	4.725	4.050	.338	.675
75 x 100	6.750	5.625	5.250	4.500	.375	.750
80 x 80	5.760	4.800	4.480	3.840	.320	.640
80 x 90	6.480	5.400	5.040	4.320	.360	.720
80 x 100	7.650	6.375	5.950	5.100	.525	1.050
85 x 80	6.120	5.100	4.760	4.080	.340	.680
85 x 90	6.885	5.738	5.355	4.590	.385	.765
85 x 100	7.650	6.375	5.950	5.100	.425	.850
90 x 90	7.290	6.075	5.670	4.860	.405	.810
90 x 100	8.100	6.750	6.300	5.400	.450	.900
95 x 90	7.695	6.413	5.985	5.130	.428	.855
95 x 100	8.550	7.125	6.650	5.700	.475	.950
100 x 100	9.00	7.500	7.000	6.000	.500	1.000

1-9 POST AND FOOTING

Structurally, post is always supported by slab called footing or foundation. Estimating the quantity of materials for these types of structures could be done by:

1. The Volume Method or
2. The Area and Linear Meter Method combined for post and footing.

ILLUSTRATION 1-10

A concrete post 4.00 meters high with cross sectional dimensions of 40 cm. x 40 cm. is supported by a footing slab 20 cm. thick by 1.20 m. square. Using class "A" concrete, find the quantity of cement, sand and gravel if there are 12 posts of the same size.

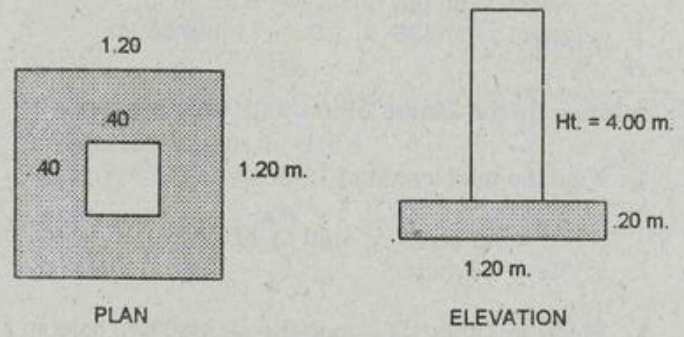


FIGURE 1-14 POST AND FOOTING

SOLUTION

A. By the Volume Method

1. Find the volume of the 12 posts

   Volume = Sectional area x Height x No. of post

Volume = 12 posts x (.40 x .40) x 4.00 m. ht.

V = 7.68 cubic meters

2. Solve for the volume of 12 footing slab

V = 12 (.20 x 1.20 x 1.20)
V = 3.456 cubic meters

3. Find the total volume. Add 1 and 2

Total Volume = 7.68 + 3.456
V = 11.136 cu. m.

4. Refer to Table 1-2. Using 40 kg. cement class "A" concrete, multiply :

Cement : 11.136 x 9.0 = 100.2 bags
Sand : 11.136 x .50 = 5.56 cu. m.
Gravel : 11.136 x 1.0 = 11.136 cu. m.

B. Solution by the Linear Meter and Area Method

1. Find the total length of 12 posts

L = 12 posts x 4.00 m. ht.
L = 48 meters

2. Refer to Table 1-4. Along the 40 x 40 cm. column size class "A" mixture; multiply.

Cement : 48 x 1.440 = 69.12 bags
Sand : 48 x .080 = 3.84 cu. m.
Gravel : 48 x .160 = 7.68 cu. m.

3. Find the area of the footing slab

Area = 12 pcs. (1.2 x 1.2)
= 17.28 sq. m.

4. Refer to Table 1-3, using 40 kg. cement class "A" mixture for 20 cm. thick slab; multiply:

Cement : 17.28 x 1.80 = 31.1 bags
Sand : 17.28 x .100 = 1.72 cu. m.
Gravel : 17.28 x .200 = 3.46 cu. m.

5. Add results of step 2 and step 4.

Cement : 69.12 + 31.1 = 100.2 bags
Sand : 3.84 + 1.72 = 5.56 cu. m.
Gravel : 7.68 + 3.45 = 11.13 cu. m.

ILLUSTRATION 1-11

From Figure 1-15, determine the number of 40 kg. cement, sand and a gravel required using class "A" concrete for the footing and class "C" concrete for the flooring 4" thick.

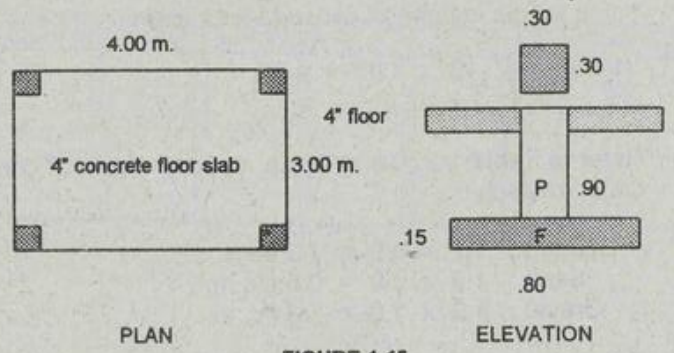


FIGURE 1-15

SOLUTION

A. Footing Slab

1. Solve for the volume of F

Volume = .15 x .80 x .80 = .096 cu. m.

2. Total volume of 4 pieces footing slab

V = .096 x 4 footings 0.384

B. Pedestal

1. Solve for the volume of P
   V_p = .30 x .30 x .90
   V_p = .081 cu. m. x 4 pieces.....0.324

   Total volume..... 0.708 cu. m.

2. Refer to Table 1-2. Using 40 kg. cement class "A" concrete; multiply:

   Cement : .708 x 9.0 = 6.37 bags
   Sand : .708 x .50 = .354 cu. m.
   Gravel : .708 x 1.0 = .708 cu. m.

C. Concrete Floor Slab

1. Solve for the volume of concrete floor slab.

   Volume = .10 x 3.00 x 4.00
   V = 1.2 cu. m.

2. Refer to Table 1-2. Using 40 kg. cement class "C" concrete; multiply:

   Cement : 1.2 x 6.0 = 7.2 bags.
   Sand : 1.2 x .50 = 0.6 cu. m.
   Gravel : 1.2 x 1.0 = 1.2 cu. m.

3. Summary of the materials B and C.

   Cement : 6.37 + 7.2 = 13.57 say 14 bags
   Sand : .354 + 0.6 = .95 cu. m.
   Gravel : .708 + 1.2 = 1.90 cu. m.

Comment:

To a meticulous estimator, the area occupied by the posts will be subtracted from the gross area of the floor although the result is an insignificant amount.

1-10 RECTANGULAR COLUMN

The procedure in estimating rectangular column is practically the same as that of the square column. It could be either by volume method or by the linear meter method as previously explained. The choice of the method however, depends upon the convenience and preference of the estimator.

ILLUSTRATION 1-12

A series of 8 rectangular concrete columns with typical cross sectional dimensions of 40 x 60 cm. is supporting a beam. The column has a clear height of 5.00 meters from the floor line to the bottom line of the beam. Specifying class "A" concrete, determine the quantity of cement sand and gravel required.

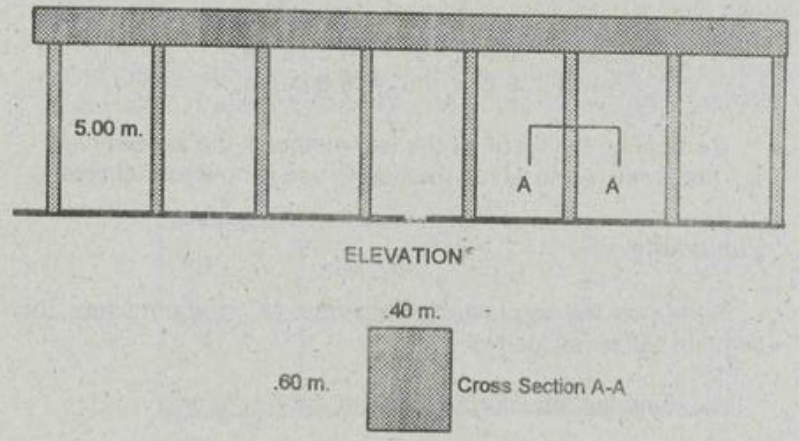


FIGURE 1-16 RECTANGULAR COLUMN

SOLUTION (By Linear Meter Method)

1. Find the total length of the 8 columns.

   Length: 8.00 x 5.00 m. = 40 meters

2. Refer to Table 1-4. Along the 40 x 60 cm. column size under 40 kg. cement class "A" concrete, multiply:

Cement : 40 x 2.16 = 86.4 bags
Sand : 40 x .120 = 4.8 cu. m.
Gravel : 40 x .240 = 9.6 cu. m.

SOLUTION (By Volume Method)

1. Find the volume of the eight columns:

V = .40 x .60 x 5.00 ht. x 8
V = 9.6 cubic meters

2. Refer to Table 1-2. Using 40 kg. cement class "A" concrete, multiply:

Cement : 9.6 x 9.0 = 86.4 bags
Sand : 9.6 x .50 = 4.8 cu. m.
Gravel : 9.6 x 1.0 = 9.6 cu. m.

Comparing the result of the two methods, the answers are the same. As to which method to use is now your choice.

Plastering

If the post will be plastered with class "A" mortar mixture, the solution will be as follows:

1. Find the total surface area of the 8 columns.

Perimeter = 2 (.40) + 2 (.60)
P = 2.00 m.

2. Solve for the surface area of the 8 columns.

Area = P x height x Number of posts
A = 2.00 x 5.00 x 8
A = 80 sq. m.

3. Find the volume of the plaster at 12 mm thick.

V = Area x thickness of the plaster

V = 80 x .012 m. = .96 cu. m.

4. Refer to Table 2-1. Using 40 kg. cement class "A" mixture, multiply:

Cement : .96 x 18.0 = 17.2 bags
Fine Sand : .96 x 1.0 = .96 cu. m.

Plastering is a separate subject matter to be discussed thoroughly in Chapter - 2.

1-11 RECTANGULAR BEAM AND GIRDER

A Beam is defined as a strong horizontal piece of reinforced concrete for spanning and supporting weights. On the other hand, a beam that is carrying or supporting another beam is called girder. Similarly, estimating the materials for these types of structures is either by the volume or the linear meter method.

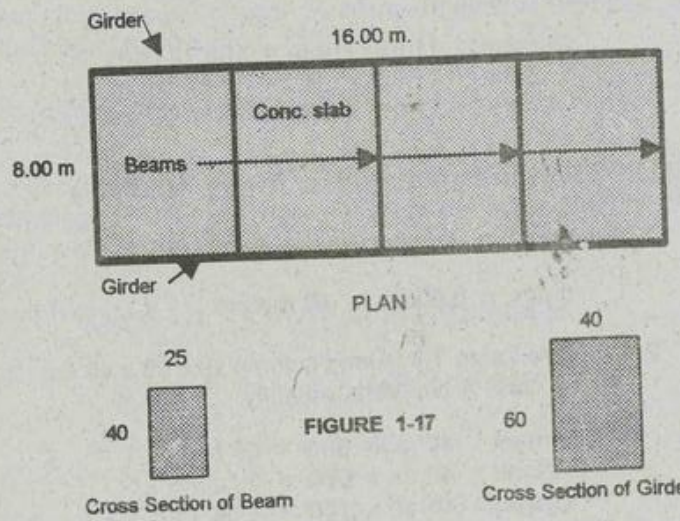


FIGURE 1-17

ILLUSTRATION 1-13

From Figure 1-17, using class "A" concrete, list down the materials required.

SOLUTION (By Volume Method)

1. Find the volume of the beam

   Volume = 5 pcs. x .25 x .40 x 8.00 m. span
   V = 4 cubic meters

2. Solve for the volume of the girder

   Volume = 2 pcs. x .40 x .60 x 16.00 m. span
   V = 7.68 cu. m.

3. Total volume of beam and girder

   Total V = 4 + 7.68
   V = 11.68 cu. m.

4. Refer to Table 1-2. Using 40 kg. cement class "A" concrete; multiply:

   Cement : 11.68 x 9.0 = 105.12 bags
   Sand : 11.68 x .50 = 5.84 cu. m.
   Gravel : 11.68 x 1.0 = 11.68 cu. m.

SOLUTION (By The Linear Meter Method)

1. Find the total length of the Beam

   5 pcs. x 8.00 m. = 40 meters

2. Refer to Table 1-4. Along column size 25 x 40 cm. under 40 kg. class A concrete, multiply:

   Cement : 40 m. x .900 = 36 bags
   Sand : 40 m. x .050 = 2 cu. m.
   Gravel : 40 m. x .100 = 4 cu. m.

3. Find the total length of the Girder

   16 m. x 2 pcs. = 32 meters

4. Refer to Table 1-4 along column size 40 x 60 under column 40 kg class A mixture, multiply:

   Cement : 32 x 2.160 = 69.12 bags
   Sand : 32 x .120 = 3.84 cu. m.
   Gravel : 32 x .240 = 7.68 cu. m.

5. Summarized results of 2 and 4.

   Cement : 36 + 69.12 = 105.12 say 106 bags
   Sand: 2 + 3.84 = 5.84 cu. m.
   Gravel : 4 + 7.68 = 11.68 cu. m.

1-12 CIRCULAR COLUMN

Estimating the materials for circular column is typically the same as the volume method for the square and rectangular columns with the aid of Table 1-2. However, Table 1-5 was also prepared for circular column problems to avail of the linear meter method of estimating.

ILLUSTRATION 1-14

A circular concrete column has a diameter of 60 cm. by 6.00 meters high. Find the concrete materials required if there are 5 columns of the same size in a row.

SOLUTION – 1 (By the Volume Method)

1. Solve for the cross sectional area of the column.

   $A = \pi r^2$ or $A = 0.7854 \times d^2$ (Formula)

   $A = (0.7854 \times .60^2) = .283$ Sq. m.

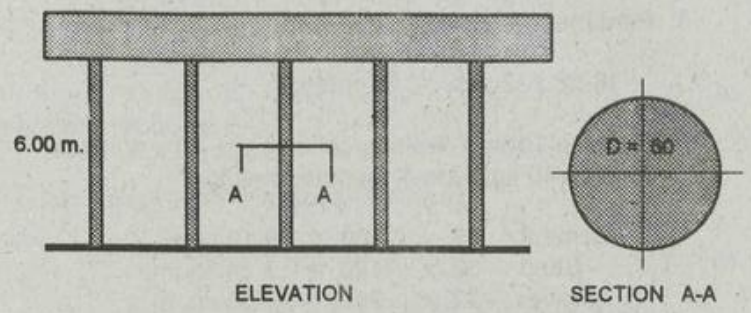


FIGURE 1-18 CIRCULAR COLUMN

2. Find the volume of one column.

   V = .283 x 6 m. ht. = 1.698 cu. m.

3. Solve for the volume of 5 columns.

   Total volume: (1.698 x 5) = 8.49 cu. m.

TABLE 1-5 QUANTITY OF CEMENT, SAND AND GRAVEL PER METER LENGTH OF CIRCULAR COLUMN

Col. Dia. cm.	MIXTURE CLASS				Sand	Gravel
	40 kg. cement		50 kg. cement			
	A	B	A	B	cu. m.	cu. m.
25	.442	.368	.344	.295	.025	.050
30	.636	.530	.495	.424	.035	.070
35	.866	.722	.673	.577	.048	.096
40	1.131	.942	.880	.754	.063	.126
50	1.767	1.473	1.374	1.178	.098	.196
55	2.138	1.782	1.663	1.425	.119	.238
60	2.545	2.121	1.979	1.696	.141	.282
65	2.986	2.488	2.323	1.991	.166	.332
70	3.464	2.886	2.694	2.309	.192	.384
75	3.976	3.313	3.093	2.651	.221	.442
80	4.524	3.770	3.519	3.016	.251	.502
85	5.107	4.256	3.972	3.405	.284	.568
90	5.726	4.771	4.453	3.817	.318	.636
100	7.069	5.890	5.498	4.712	.393	.786

4. Refer to Table 1-2. Using 40 kg. cement class "A" concrete; multiply:

   Cement : 8.49 x 9.0 = 76.4 bags
   Sand : 8.49 x .50 = 4.24 cu. m.
   Gravel : 8.49 x 1.0 = 8.49 cu. m.

SOLUTION – 2 (By Linear Meter Method)

1. Determine the total length of the 5 circular columns.

   L = (5 x 6.00 m ht.) = 30.00 meters

2. Refer to Table 1-5. Along the 60 cm. column diameter under 40 kg. cement, class "A" mixture, multiply:

   Cement : 30.00 x 2.545 = 76.4 bags
   Sand : 30.00 x .141 = 4.23 cu. m.
   Gravel : 30.00 x .282 = 8.46 cu. m.

Problem Exercise

1. From the following figure, List down the concrete materials by any method using class "A" concrete.

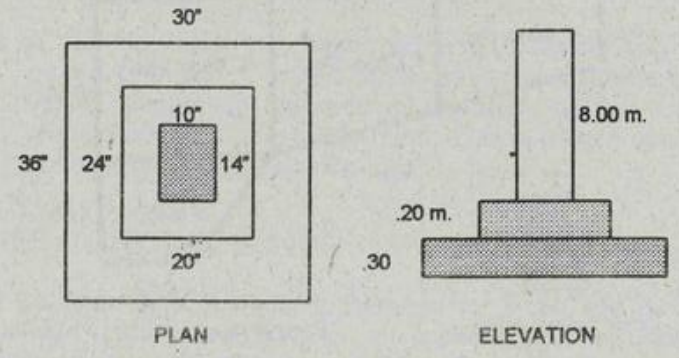
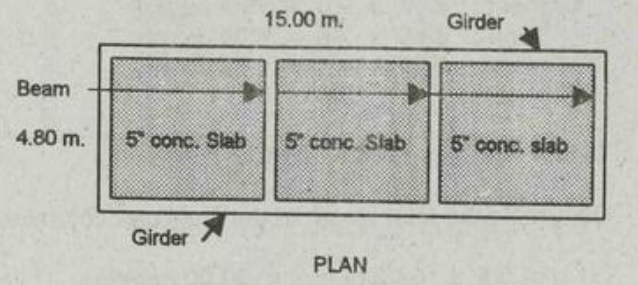


FIGURE 1-19 POST AND FOOTING

2. From the following figures, solve for the concrete materials of slab, beams and girders using class "A" concrete.



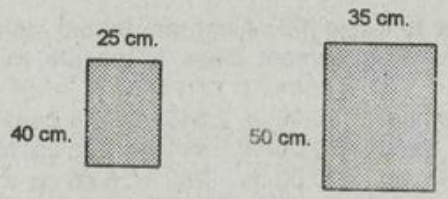


FIGURE 1- 20

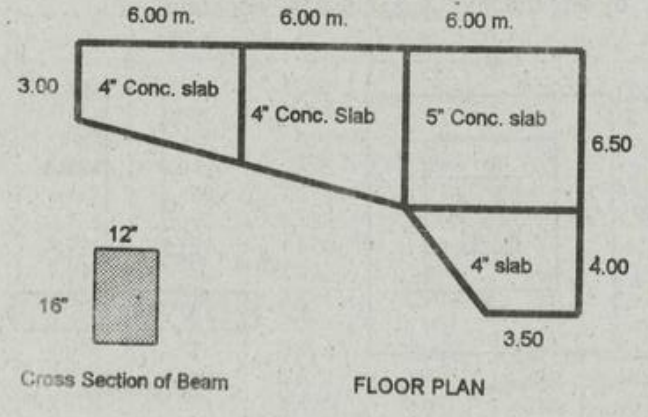


FIGURE 1-21

3. From the following figure, find the concrete materials required for the columns 9.00 meters high each using class A concrete.

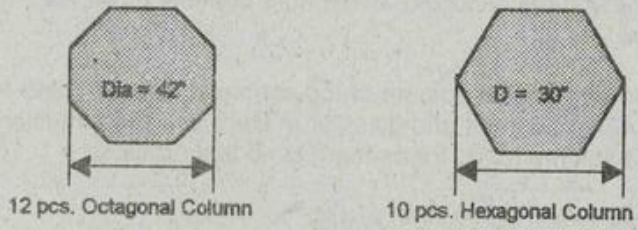


FIGURE 1-22

4. From the following Figure 1-23, find the cement, sand and gravel if there are 8 columns, using class "A" mixture.

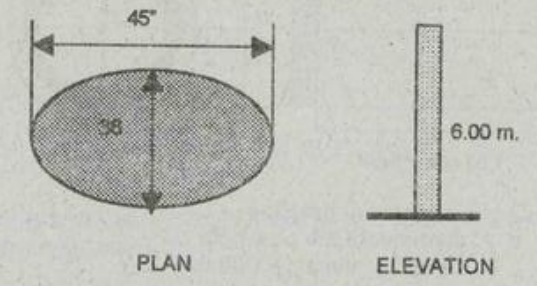


FIGURE 1-23 CROSS SECTION OF ELIPTICAL COLUMN

5. A building design has spiral reinforced concrete column 9 meters high with a general cross sectional diameter of 45 inches. Determine the required materials by the volume method and the linear meter method using class A concrete if there are 6 columns in the plan.

1-13 CONCRETE PIPE

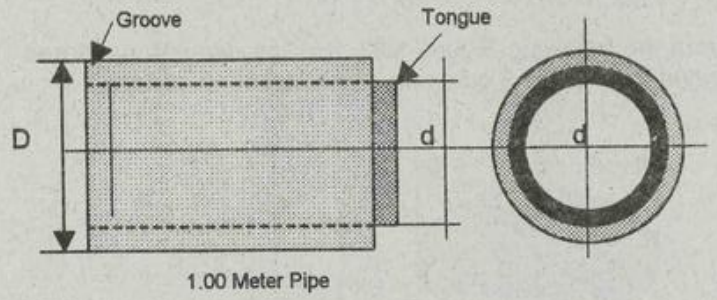
Concrete pipe is much in demand for small and medium drainage construction. The use of concrete pipe as drainage structure materially save cost of forms, time and labor costs as well.

Procedures in Estimating the Materials for Concrete Pipe.

1. Find the net volume of the concrete pipe. That is, by subtracting the volume occupied by the hole from the gross volume of the pipe.

2. Knowing the net volume of the concrete, refer to Table 1-2, under 40 kg. cement and class of mixture specified, multiply by the net volume found for cement, sand and gravel or

3. Use Table 1-6 for final result.



Where: D = Diameter of the Pipe
d = diameter of the pipe hole
L = Length of the pipe 1.00 m.

FIGURE 1-24 CONCRETE PIPE

ILLUSTRATION 1-15

A road construction requires 12 pieces of 90 cm. diameter concrete pipes for drainage purposes. Determine the quantity of cement, sand and gravel needed to manufacture said pipes using class "A" concrete. (excluding reinforcement which will be discussed later in chapter 3).

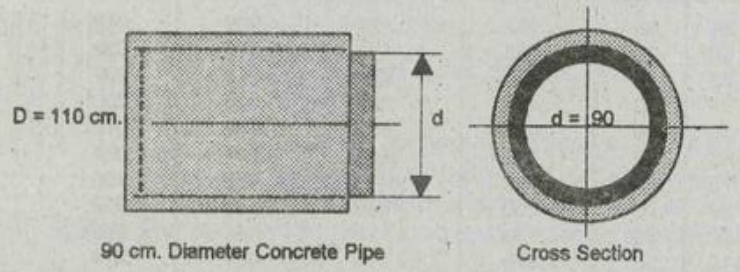
SOLUTION (By Volume Method)

1. Solve for the gross volume of the concrete pipe.

Formula: Volume = $0.7854\ D^2\ h$ Formula

$V = 0.7854 \times 1.10^2 \times 1.00$ m.

$V = .950$ cu. m.



FGURE 1-25 CONCRETE PIPE

2. Solve for the volume of the hole.

$V = 0.7854 \times d^2 h$

$V = (0.7854 \times .90^2 \times 1.00$ length $) = .636$ cu. m.

3. Subtract result of step 2 from step 1 to get the net volume of the concrete pipe.

$V_c = .950 - .636 = .314$

4. Total volume of the 12 pipes.

$V_t = .314 \times 12$

$V_t = 3.768$ cubic meters

5. Refer to Table 1-2. Using 40 kg. cement class "A" concrete; multiply:

Cement : $3.768 \times 9.0 = 33.912$ say 34 bags
Sand : $3.768 \times .50 = 1.88$ say 2.0 cu. m.
Gravel : $3.768 \times 1.0 = 3.77$ say 4.0 cu. m.

TABLE 1-6 QUANTITY OF CEMENT, SAND AND GRAVEL PER CONCRETE PIPE.

Diameter in Centimeter		CEMENT IN BAGS Class of Mixture		Sand	Gravel
D	d	A	B	cu. m.	cu. m.
21	15	.152	.127	.009	.018
26	20	.195	.163	.011	.022
33	25	.328	.274	.018	.037
39	30	.436	.363	.025	.050
50	40	.635	.530	.036	.072
60	50	.779	.650	.044	.088
78	60	1.755	1.463	.098	.196
90	70	2.260	1.883	.126	.252
100	80	2.538	2.115	.141	.282
110	90	2.826	2.355	.157	.314
120	100	3.110	2.595	.173	.346
144	120	4.482	3.735	.249	.498
174	150	5.500	4.583	.306	.612

SOLUTION – 2 (Per Pipe Using Table 1-6)

1. To say 90 centimeters concrete pipe, it refers to the **hole** diameter. And for the purpose of estimating the volume of concrete, we consider the inside diameter of the pipe as presented in the second column **d** of Table 1-6.

2. Refer to Table 1-6. Under d = 90 pipe diameter, class "A" mixture, multiply:

   Cement : 12 x 2.826 = 33.9 say 34 bags

   Sand : 12 x .157 = 1.88 say 2.0 cu. m.

   Gravel : 12 x .314 = 3.77 say 4.0 cu. m.

CHAPTER 2

MASONRY

2-1 CONCRETE HOLLOW BLOCKS

Concrete Hollow Block is popularly known as CHB. It is classified as load bearing and non-bearing blocks. Load bearing blocks are those whose thickness ranges from 15 to 20 centimeters and are used to carry load aside from its own weight.

Non-bearing blocks on the other hand, are blocks intended for walls, partitions, fences, dividers and the like carrying its own weight whose thickness ranges from 7 to 10 centimeters.

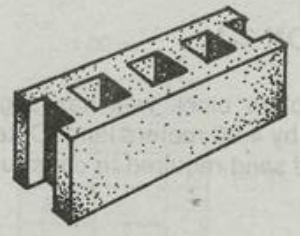


FIGURE 2-1 CONCRETE HOLLOW BLOCK

The standard hollow blocks has three void cells and two half cells at both ends having a total of four. These hollow cells vary in sizes as there are different manufacturers using different types of mold. Hence, it is recommended that concrete hollow blocks with bigger cells be considered in estimating for a more realistic result.

In this study, what we want to know is the quantity of the materials needed for a certain masonry work made of concrete.

hollow block which generally comprises of the following items.

1. Concrete hollow blocks.
2. Cement and sand for block laying.
3. Cement, sand and gravel filler for the hollow core or cell.
4. Cement and fine sand for plastering.
5. Cement sand and gravel for foundation or footing.
6. Reinforcing steel bars and
7. Tie wires.

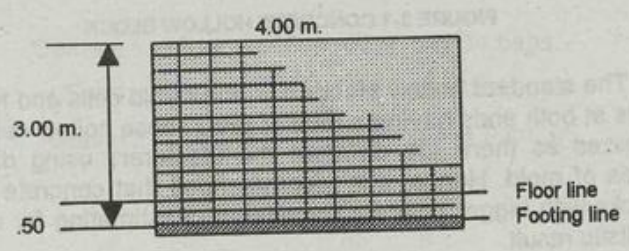
Item 1 to 5 will be discussed in this chapter. The reinforcing steel bars and Tie wires will be presented in Chapter 3 -Metal Reinforcement.

Estimating the materials for masonry work using hollow blocks, could be done in either of the following methods:

By Fundamental methods
By the Area methods

ILLUSTRATION 2-1

A concrete hollow block wall has a general dimension of 3.00 meters high by 4.00 meters long. Determine the number of CHB, cement and sand required to construct the wall.



ELEVATION

FIGURE 2-2 CONCRETE HOLLOW BLOCKS WALL

SOLUTION - 1 (By Fundamental Method)

1. Divide the height of the fence by the height of one block.

   $\frac{3.00}{.20}$ = 15 layers

2. Divide the length of the fence by the length of one block

   $\frac{4.00}{.40}$ = 10 pieces

3. Multiply the result of step 1 by step 2

   15 x 10 = 150 pieces

SOLUTION – 2 (By the Area Method)

Let us examine first how many pieces of CHB can cover up one square meter area.

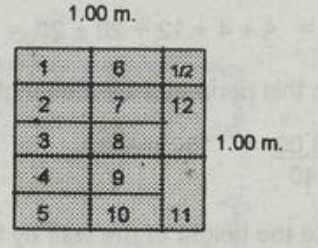


FIGURE 2-3 NUMBER OF CHB PER SQUARE METER

From the above figure it appears, that one square meter area requires 12.5 pieces concrete hollow blocks. Therefore, by multiplying the entire area of the wall by 12.5, we find the total number of CHB required. Thus,

1. Area of the fence; 3.00 x 4.00 m = 12 sq. m.
2. Multiply : 12.00 sq. m. x 12.5 = 150 pieces.

ILLUSTRATION 2-2

From the following Figure 2-4, find the number of 4" x 8" x 16" concrete hollow blocks to construct the fence.

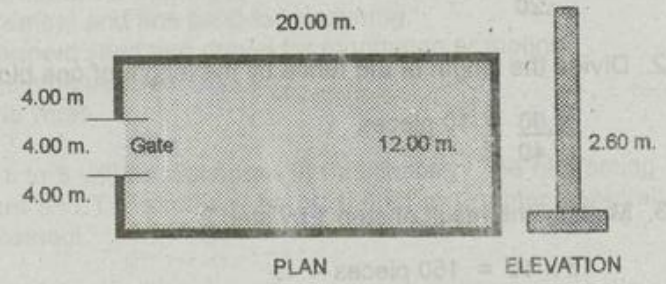


FIGURE 2-4 CHB FENCE

SOLUTION - 1 (By Fundamental Method)

1. Find the Perimeter of the Fence

   P = 4 + 4 + 12 + 20 + 20 = 60.00 meters.

2. Divide this perimeter by the length of one block

   $\frac{60.00}{.40}$ = 150 pieces

3. Divide the height of the wall by the height of one block

   $\frac{2.60}{.20}$ = 13 layers

4. Multiply 2 and 3: 150 x 13 = 1,950 pieces.

SOLUTION - 2 (By the Area Method)

1. Find the area of the wall.

   A = 2.60 x 60.00 m. = 156 square meters.

2. If there are 12.5 blocks in one square meter then, multiply by the area.

   156 x 12.5 = 1,950 pieces.

Comments

1. Comparing the results obtained by the two methods, the answers are practically the same, but for convenience, the solution by the area method is much favored for being simple and direct to the answer.

2. Take note that in the above example, we computed the number of hollow blocks without posts. Suppose that Figure 2-4 was provided with the necessary posts as indicated in Figure 2-5, in this case, the area covered by the post will be subtracted from the total area of the wall, then solve for the CHB adopting the area method for simplicity of the process.

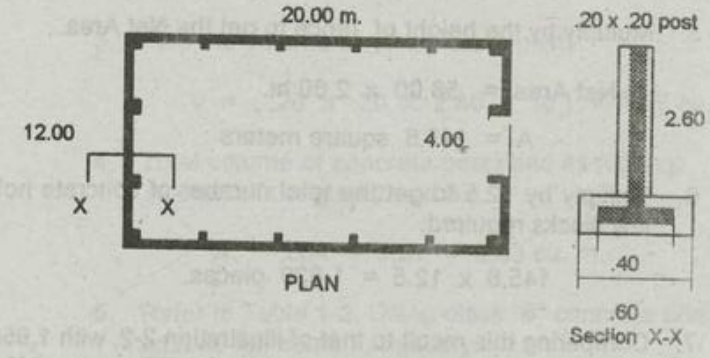


FIGURE 2-5 CHB FENCE

ILLUSTRATION 2-3

From Figure 2-5, using class B mixture find the number of:

a) 10 x 20 x 40 cm. concrete hollow blocks

b) Cement and sand.
c) Concrete for the posts and footings.

SOLUTION – 1 (Finding the CHB)

1. Find the perimeter of the wall.

   P = 20 + 20 + 12 + 8
   P = 60.00 meters

2. Find the space length occupied by the posts

   Along 20 m. (.20 x 6) 2 = 2.40
   Along 12 m. (.20 x 4) 2 = 1.60
   Total space occupied by posts = 4.00

3. Subtract: 60.00 m. – 4.00 m.

   = 56.00 m. net length for CHB.

5. Multiply by the height of fence to get the Net Area.

   Net Area = 56.00 x 2.60 ht.
   A = 145.6 square meters

6. Multiply by 12.5 to get the total number of concrete hollow blocks required.

   145.6 x 12.5 = 1,820 pieces.

7. Comparing this result to that of illustration 2-2, with 1,950 pieces hollow blocks, there is a material difference of 130 pieces because we subtracted the space occupied by the concrete posts.

SOLUTION– 2 (Concrete Posts and its Footing)

1. Find the volume of one concrete footing slab.

Volume = Thickness x Width x Length

V = .15 x .60 x .60
V = .054 cu. m.

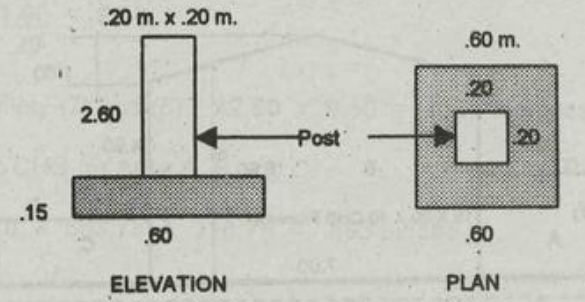


FIGURE 2-6 POST AND FOOTING

2. Find the volume of 16 footings

   V = (.054 x 16) = .864 cu. m.

3. Find the volume of 16 concrete posts

   V = (.20 x .20 x 2.60 x 16) = 1.67 cu. m.

4. Total volume of concrete posts and its footing:
   Add results of step 2 and 3:

   V_t; .864 + 1.67 = 2.53 cu. m.

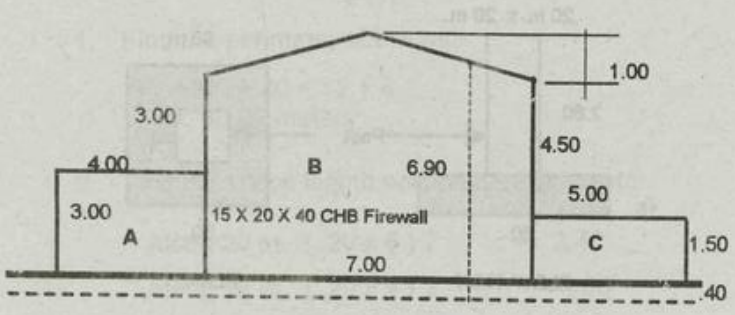
5. Refer to Table 1-2. Using class "B" concrete under column 40 kg. cement, multiply:

   Cement : 2.53 x 7.5 = 19.0 bags
   Sand : 2.53 x .50 = 1.26 cu. m.
   Gravel : 2.53 x 1.0 = 2.53 cu. m.

*** Note:**
Concrete was thoroughly discussed in Chapter - 1

ILLUSTRATION 2-4

From the following Figure, determine the number of 15 x 20 x 40 cm. CHB required to construct the building firewall.



ELEVATION

FIGURE 2-7 15 CHB FIREWALL

SOLUTION (By Direct Counting)

1. Find the CHB at **Area A :** $\frac{4.00}{.40}$ = 10 pieces

2. Height of wall A divided by height of one block

   $\frac{3.40}{.20}$ = 17 pieces

3. Multiply: (1) and (2) : 10 x 17 = 170 pieces

4. Find the CHB at **Area B :** $\frac{7.00}{.40}$ = 17.5

5. Average Height of Area B divided by .20 ht. of one block

   $\frac{6.90}{.20}$ = 34.50

6. Multiply (4) and (5) : 17.5 x 34.50 = 603.75 pieces

7. Find the CHB at **Area C :** $\frac{5.00}{.40}$ = 12.50

8. Height of C divided by height of one block

   $\frac{1.90}{.20}$ = 9.50

9. Multiply (7) and (8) 12.50 x 9.50 = 118.75 pieces

Add Total CHB for Area A, B and C.

170 + 603.75 + 118.75 = 893 pieces

Comment:

Take note that in the preceding example solution, fundamental methods of determining the number of blocks were used. The methods had undergone a very long process of finding the quantity by area one at a time. The process must be simplified with the aid of Table 2-2, presented as follows:

SOLUTION - 2 (By the Area Method)

1. Find the Area of A: 3.40 x 4.00 = 13.60 sq. m
2. Find the Area of B: 7.00 x 6.90 = 48.30 sq. m.
3. Find the Area of C: 5.00 x 1.90 = 9.50 sq. m.

   Total Area - - - - - - - - 71.40 sq. m.

4. Refer to Table 2-2. Along 15 x 20 x 40 CHB under column number per square meter; multiply:

   71.40 x 12.50 = 893 pieces.

Reminder

Before estimating the quantity of concrete hollow blocks, be

sure to verify the plan specially the clear height of the wall which is very important in the process. The following questions should be given due consideration for these might affect the result of the estimate.

1. Does the elevation as indicated in the plan specify the height from the first floor to the second floor line, or is it from floor to ceiling? In either case, the depth of the beam has to be considered in the estimate, either added or subtracted.

2. Have you considered the CHB to be installed from the underground foundation to the floor line? This particular portion of the wall is often overlook in the process of estimating especially when there is no detailed plan or cross section detail. Don't ever commit the same mistake experienced by most estimators.

3. See to it that the concrete hollow blocks to be installed are uniform in sizes and in thickness. Have it ordered from one manufacturer or supplier only. Installing different sizes of CHB means additional expenses for cement plaster and labor. If several suppliers cannot be avoided, have their respective blocks installed in a particular phase of work.

2-2 ESTIMATING CEMENT MORTAR

After knowing the number of blocks needed for a particular masonry work, the next step is to find its work partner called cement mortar. Cement mortar is a mixture of cement, sand and water. It is used as bonding materials in installing masonry blocks and other various plastering work. In estimating cement mortar, one has to consider the following items.

a. The mortar to be used in between the layer of CHB.
b. The mortar filler for the hollow core or cell of the blocks. This filler could be pure mortar or mortar with gravel for economy.
c. Fine screened sand for plastering.

ILLUSTRATION 2-5

Continuing the problem of Illustration 2-1 Figure 2-2, determine how many bags of cement and sand needed to install the 150 pieces 10 x 20 x 40 cm. CHB using class "B" mortar.

There are three solutions offered in finding the cement mortar for concrete hollow blocks installation.

1. By volume method.
2. By the Area Method.
3. Per Hundred Block method.

SOLUTION – 1 (By Volume Method)

1. Determine the volume of mortar in between the layer of the blocks, adopting the 12 mm (½") or .012 meters uniform thickness of the mortar.

   Volume = Thickness x Width of CHB x Length

   V = .012 x .10 x 4.00 m.
   V = .0048 cubic meter

2. Take note that 3.00 meters high wall divided by .20 m. height of one block is = 15 layers. Thus, multiply:

   V = 15 layers x .0048
   V = .072 cu. m.

   This is the total volume of the mortar in between the 15 layers of concrete hollow blocks.

3. Aside from the cement mortar used in between block layers, there are 4 hollow cores or cells per block to be filled up with mortar. Find the volume per block.

   Volume = .05 x .075 x .20 x 4 cores
   V = .003 cu. m.

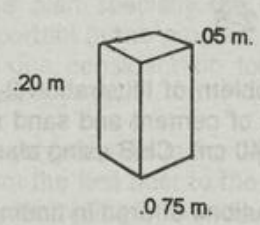


FIGURE 2- 8 HOLLOW CELL OF 4 x 8 x 16 CHB

4. Find the total volume of hollow core for the 150 CHB.

   V = 150 x .003 = .45 cu. m.

5. Total volume; add the results of step 2 and step 4.

   Total Volume : .072 + .45 = .522 cu. m.

6. Refer to Table 2-1. Using class "B" mixture, multiply:

   Cement : .522 x 12.0 = 6.26 bags
   Sand : .522 x 1.0 = .522

TABLE 2-1 QUANTITY OF CEMENT AND SAND FOR MORTAR AND PLASTER IN CUBIC METER

Class Mixture	Proportion	Cement in Bags		Sand
		40 kg.	50 kg.	cu. m.
A	1 : 2	18.0	14.5	1.0
B	1 ; 3	12.0	9.5	1.0
C	1 : 4	9.0	7.0	1.0
D	1 : 5	7.5	6.0	1.0

Another way of finding the mortar for block laying is by the Area Method with the aid of Table 2-2.

SOLUTION – 2 (By the Area Method)

1. Find the area of the wall.

Area : (3.00 x 4.00) = 12 square meters.

2. Refer to Table 2-2. Along 10 x 20 x 40 CHB under class "B" mixture; multiply:

   Cement : 12 x .522 = 6.26 bags
   Sand : 12 x .0435 = .522 cu. m.

TABLE 2-2 QUANTITY OF CEMENT AND SAND FOR CHB MORTAR PER SQUARE METER

Size of CHB in cm.	Number per sq. m	Bags Cement Mixture				Sand cu. m
		A	B	C	D	
10 x 20 x 40	12.5	.792	.522	.394	.328	.0435
15 x 20 x 40	12.5	1.526	1.018	.763	.633	.0844
20 x 20 x 40	12.5	2.260	1.500	1.125	.938	.1250

SOLUTION - 3 (By the Hundred Block Method)

The Hundred Block Method is the third solution offered for a more simpler approach with the aid of Table 2-3

1. Find the number of concrete hollow blocks.

   Area : 3.00 x 4.00 = 12 sq. m.
   12 sq. m. x 12.5 = 150 pieces CHB

2. Convert to unit of 100: $\frac{150}{100} = 1.5$

3. Refer to Table 2-3. Under class "B" mixture for a 10 x 20 x 40 CHB, multiply:

   Cement : 1.5 x 4.176 = 6.26 bags
   Sand : 1.5 x .348 = .522 cu. m.

TABLE 2-3 QUANTITY OF CEMENT AND SAND PER ONE HUNDRED BLOCKS

Size of CHB	Cement in Bags 40 kg. Mixture				Sand cu. m.
	A	B	C	D	
10 x 20 x 40	6.336	4.176	3.152	2.624	0.348
15 x 20 x 40	12.150	8.104	6.072	5.064	0.675
20 x 20 x 40	18.072	12.000	9.000	7.504	1.000

Comment:

Comparing the answers of the three methods in finding the materials for cement mortar, the results are practically the same. The estimator now has the choice which method to use, but before using Table 2-2 and 2-3, know first the kind of mixture and the size of CHB to be used because this is where most errors are being committed.

ILLUSTRATION 2-6

Going back to the problem of Illustration 2-2, Figure 2-4, find the quantity of hollow blocks, cement and sand, for mortar using the area method of estimating.

SOLUTION:

1. Find the area of the wall.

   Area = Perimeter x Height

   A = 60.00 m. x 2.60 m.

   A = 156 square meters

2. Find the number of CHB. Refer to Table 2-2, under column number per sq. m. multiply:

   156 x 12.5 = 1,950 pieces

3. Find the cement and sand. Refer again to Table 2-2, using class B mortar; Multiply:

   Cement: 156 x .522 = 81.43 say 82 bags

   Sand: 156 x .0435 = 6.78 say 7 cu. m.

4. Summary of the materials:

   1,950 pieces CHB

   82 bags cement

   7 cubic meters sand.

Take note that the above materials found does not include the cement, sand and gravel for the footing. For this item, refer to Chapter 1 where it was thoroughly discussed.

2-3 CEMENT MORTAR FOR PLASTERING

Aside from the cement mortar for block laying, plastering is another item to consider. Most estimators however, make their estimate of mortar for block laying and plastering through simple guessing and calculation, assuming the quantity of cement and sand without the pain of computation. The reason is simple, they are just in a hurry and has no time to do it. And for this reasons, we offer the following methods accompanied by a simplified tables of equivalent values.

Estimating the cement mortar for plastering can be done by:

1. The Volume Method and
2. The Area Method

ILLUSTRATION 2-7

Continuing the problem of Illustration 2-1, find the cement and sand necessary to plaster two sides of the 3.00 x 4.00 meters wall.

SOLUTION (By Volume Method)

1. Find the two sides area of the wall.

   A = 3.00 x 4.0 x 2 sides
   A = 24 sq. m.

2. Assuming that the plaster is 16 mm (.016 m.) average thickness, determine the volume of the plaster.

   V = 24 sq. m. x .016
   V = .384 cu. m.

3. Solve for the cement and sand. Refer to Table 2-1. Using 40 kg. cement class "B" mixture; multiply:

   Cement : .384 x 12.0 = 4.6 say 5 bags
   Sand : .384 x 1.0 = .384 say fine sand.

TABLE 2-4 QUANTITY OF CEMENT AND SAND FOR PLASTER PER SQUARE METER AREA

Mixture Class	Cement in Bags Thickness of Plaster				
	8 mm	12 mm	16 mm	20 mm	25 mm
A	.144	.216	.288	.360	.450
B	.096	.144	.192	.240	.300
C	.072	.108	.144	.180	.225
D	.060	.090	.120	.150	.188
Sand	.008	.012	.016	.020	.025

SOLUTION – 2 (By Area Method using Table 2-4)

1. Find the area of the wall (two sides)

   Area = 3.00 x 4.00 x 2 sides
   A = 24 sq. m.

2. Solve for the cement and sand. Refer to Table 2-4. Under 16 mm thick plaster class "B" mixture, multiply:

   Cement : 24 x .192 = 4.6 say 5 bags
   Sand : 24 x .016 = .384 cu. m.

Comparing the answers of the two methods, the results are practically the same. As to what method to use depends on your choice and convenience.

ILLUSTRATION 2-8

From the following Figure 2-9, list down the cement and sand necessary to plaster the two faces of the fence at an average thickness of 20 mm. class "C" mixture.

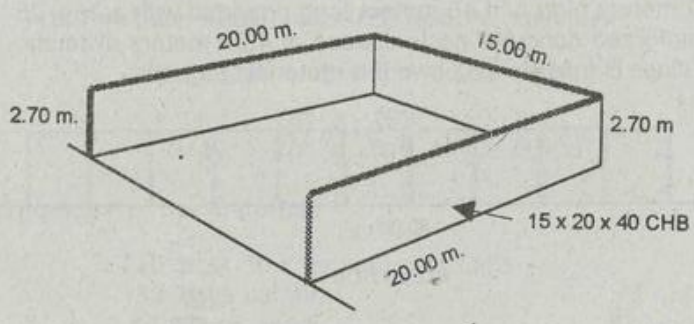


FIGURE 2-9 PLASTERING

SOLUTION (By the Area Method)

1. Find the surface area of the fence.

   Area = Perimeter x Height x 2 faces
   A = 55 m. x 2.70 m. x 2 faces
   A = 297 sq. m.

2. Solve for the area of the front and the top surface of the fence.

A = .15 x (2.70 + 2.70 + 40.00 + 15.00)
A = 9.06 sq. m.

3. Total Area to be plastered add 1 and 2

Total Area = 297 + 9.06 = 306.06 sq. m.

4. Find the cement and sand. Refer to Table 2-4. Under 20 mm thick along class "C" mixture; multiply:

Cement : 306.06 x .180 = 55 bags
Sand : 306.06 x .020 = 6.1 cu. m.

ILLUSTRATION 2-9

The owner of a commercial lot wants to fence the frontage of his lot with 15 x 20 x 40 cm. concrete hollow blocks. The fence is 3.50 meters high and 40 meters long provided with a 25 x 25 cm. reinforced concrete posts spaced at 4.00 meters distance. Using class B mixture list down the materials required.

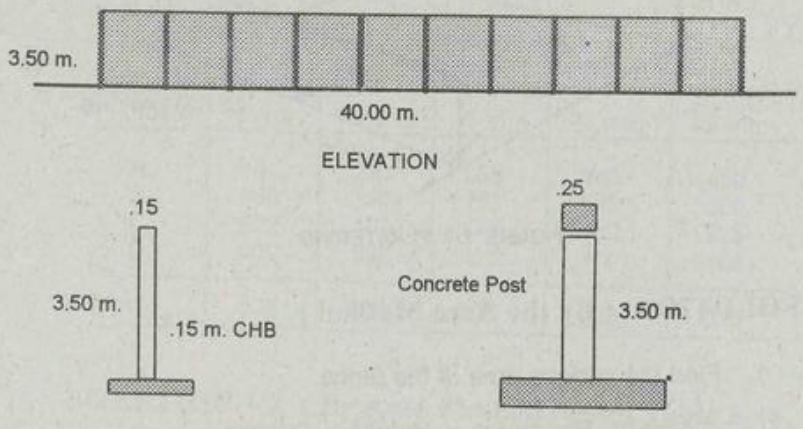


FIGURE 2-10

SOLUTION

1. Solve for the gross area of the fence.

Gross Area = (3.50 x 40.00) = 140 sq. m.

2. Subtract the area occupied by the posts.

Net Area = 140 sq. m. – (.25 x 3.50 ht. x 11 posts.)
A = (140 – 9.625) = 130.4 sq. m.

3. Find the number of CHB. Refer to Table 2-2, multiply:

130.4 sq. m. x 12.5 = 1,630 pieces.

4. Find the cement mortar. Refer to Table 2-2. Using class "B" mixture for a 15 x 20 x 40 CHB; multiply:

Cement : 130.4 x 1.018 = 132.75 bags
Sand : 130.4 x .0844 = 11.0 cu. m.

5. Solve for the cement plaster. Refer to Table 2-4. Using 16 mm thick plaster, class "B" mixture, multiply:

130.4 sq. m. x 2 sides = 261 sq. m.

Cement : 261 x .192 = 50 bags
Sand : 261 x .016 = 4.2 cu. m.

Summary of the Materials

1,630 pcs. 15 x 20 x 40 cm. CHB
183 bags cement
16 cu. m. sand

Comment:

1. Take note that in finding the wall area, the height should be measured from the top of the fence down to the foundation line not just to the floor line only.
2. In the preceding example, two sides of the wall were considered for plastering. The area occupied by the posts was subtracted from the gross wall area. For practical purposes it should not be subtracted because by computing back to determine its area and the plaster required is considerably a waste of time.

3. The area to be plastered is 140 x 2 sides or 280 square meters including the space occupied by the posts.

2-4 CONCRETE HOLLOW BLOCK FOOTING

Concrete hollow block wall, is supported by a continuous wall footing of various thickness and width, depending upon the size of the blocks and the load it has to carry or as indicated in the plan. Table 2-5 was prepared for easy reference in estimating the materials for concrete hollow blocks footing.

TABLE 2-5 QUANTITY OF CEMENT, SAND AND GRAVEL FOR CHB FOOTING PER METER LENGTH

Dimension Centimeters	Cement in Bags Class Mixture			Aggregates Sand	Aggregates Gravel
T x W	A	B	C	cu. m.	cu. m
10 x 30	.270	.225	.180	.015	.030
10 x 35	.315	.263	.210	.018	.035
10 x 40	.360	.300	.240	.020	.040
10 x 50	.450	.375	.300	.025	.050
15 x 40	.540	.450	.360	.030	.060
15 x 45	.612	.510	.048	.034	.068
15 x 50	.675	.563	.550	.038	.076
15 x 60	.810	.675	.540	.045	.090

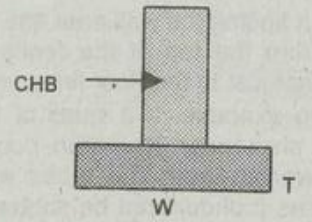


FIGURE 2-11 CROSS SECTION OF CHB FOOTING

ILLUSTRATION 2-10

Continuing the problem of Illustration 2-9, Figure 2-10, if the wall footing is 15 centimeters thick and 50 centimeters wide, determine the quantity of cement, sand and gravel necessary using class "A" concrete.

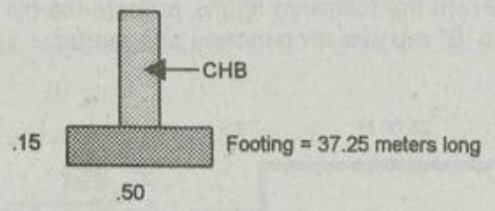


FIGURE 2-12 CHB FOOTING

SOLUTION –1 (By Volume Method)

1. Find the volume of the wall footing. Length minus the space occupied by the posts to get the net length.

   40.00 m. – (.25 x 11 posts)
   40.00 - 2.75 = 37.25 m. net length
   Volume = .15 x .50 x 37.25 m. = 2.79 cu. m.

2. Refer to Table 1-2. Using class "A" concrete; multiply:

   Cement : 2.79 x 9.0 = 25 bags
   Sand : 2.79 x .50 = 1.4 cu. m.
   Gravel : 2.79 x 1.0 = 2.8 cu. m.

SOLUTION – 2 (By the Linear Meter Method)

1. Solve for the Net Length of the CHB wall.

   Net length = 40.00 m. – (.25 x 11 posts) = 37.25 m.

2. Refer to Table 2-5. Along 15 x 50 cm. footing dimension class "A" mixture, multiply:

Cement: 37.25 x .675 = 25.14 bags
Sand: 37.25 x .038 = 1.42 cu. m.
Gravel: 37.25 x .076 = 2.83 cu. m.

ILLUSTRATION 2-11

From the following figure, prepare the bill of materials using class "B" mixture for concrete and mortar.

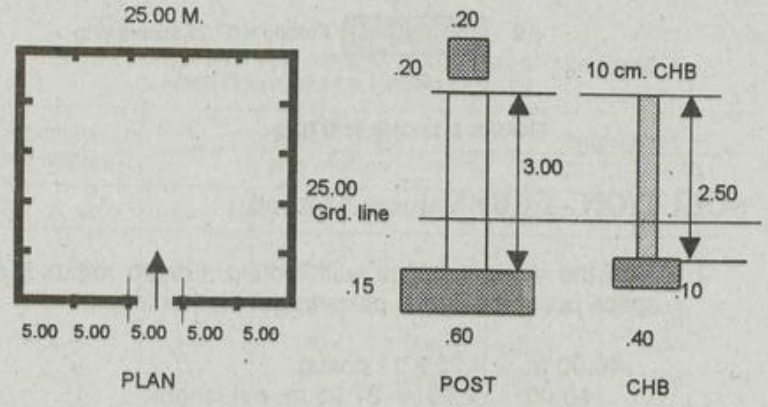


FIGURE 2-13

SOLUTION

A. Solving for CHB

1. Find the Perimeter of the hollow block fence.

   P = 3 (25.00) + 4(5.00)
   P = 95.00 meters.

2. Subtract the length occupied by the posts.

   Length = .20 width x 20 posts (see figure)
   L = 4.00 meters

3. Find the net length of CHB wall

   L = 95.00 - 4.00 = 91.00 m.

4. Find the net area of the CHB wall fence.

   Area = 91.00 x 2.5 m. ht. = 228 sq. m.

5. Find the number of 10 cm. CHB. Refer to Table 2-2, multiply:

   228 x 12.5 = 2,850 pieces

B. Cement Mortar for Block Laying

1. Find the cement and sand for block laying. Refer to Table 2-2. Using class "B" mixture, multiply:

2. Cement : 228 x .522 = 119 bag
   Sand : 228 x .0435 = 9.92 say 10 cu. m.

C. Cement Mortar for Plastering

1. If two sides of the wall will be plastered, then:

   Area = 95.00 m. x 2.00 m. ht. x 2 sides
   A = 380 sq. m. (including the posts)

   Take note that the height of the wall is only 2.00 meters because we do not plaster the wall below the ground line.

2. For plastering, refer to Table 2-4. Using 16 mm thick plaster class "B" mixture; multiply:

   Cement : 380 x .192 = 73 bags
   Sand : 380 x .016 = 6.1 cu. m.

D. Solving for Concrete Post and Footing

1. Materials for CHB footing. The net length of the CHB

wall is 91.00 meters. Refer to Table 2-5. Using a 10 x 40 footing class " B" mixture; multiply :

Cement : 91.00 x .300 = 27.3 say 28 bags
Sand : 91.00 x .020 = 1.8 say 2.0 cu. m.
Gravel : 91.00 x .040 = 3.64 say 4.0 cu. m.

2. Find the volume of the concrete posts.

Volume = 20 posts x (.20 x .20) x 3.00 m. ht.
V = 2.4 cu. m.

3. Find the volume of the footing.

V = 20 footings x (.15 x .60 x .60)
V = 1.08 cu. m.

4. Total Volume of posts and footing. Add step 2 and 3

V = 2.4 + 1.08 = 3.48 cu. m.

5. Refer to Table 1-2. Using class "B" mixture; multiply:

Cement : 3.48 x 7.5 = 26.0 bags
Sand : 3.48 x .50 = 1.74 cu. m.
Gravel : 3.48 x 1.0 = 3.48 cu. m.

6. **Summary:**

2,850 pieces 10 x 20 x 40 cm. CHB
246 bags cement
20 cubic meter sand
7.5 cubic meter gravel

Problem Exercise

1. From the following figures, find the following materials required for its construction.
   a) 15 x 20 x 40 cm. concrete hollow blocks.
   b) Cement, and sand for mortar and plastering.

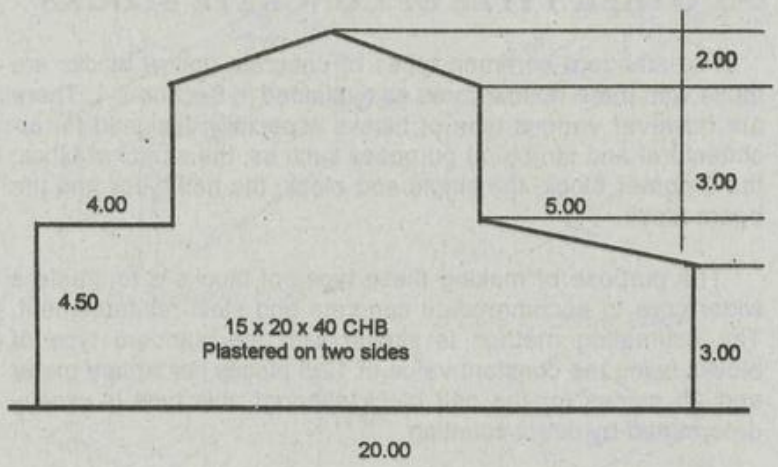
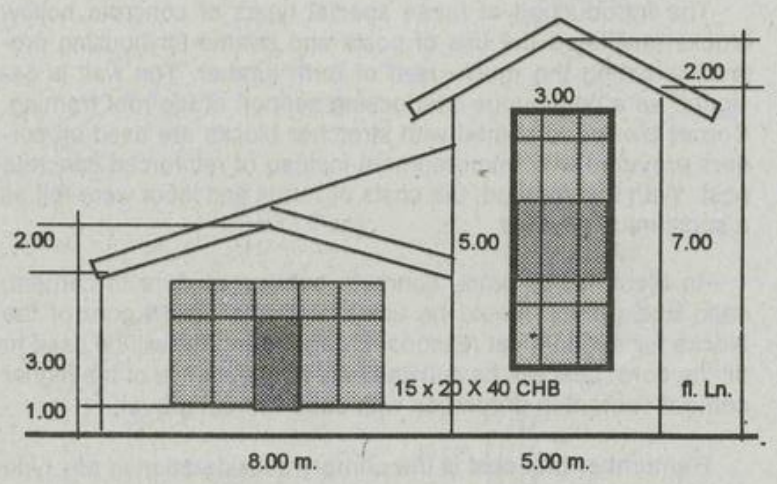


FIGURE 2-14 FIRE WALL



ELEVATION

FIGURE 2-15

2-5 OTHER TYPES OF CONCRETE BLOCKS

The standard common types of concrete hollow blocks are those with three hollow cores as explained in Section 2-1. There are however various type of blocks especially designed for architectural and structural purposes such as; the stretcher block, the L-corner block, the single end block, the half block and the beam block.

The purpose of making these types of blocks is to create a wider core to accommodate concrete and steel reinforcement. The estimating method is similar with the standard type of blocks using the constant value of 12.5 pieces per square meter and 25 pieces for the half block although this type is usually determined by direct counting.

In estimating the quantity of concrete hollow blocks, what is considered is the side portion of the block. The thickness is only used in computing the cement mortar for block laying.

The introduction of these special types of concrete hollow blocks facilitated the use of posts and beams for housing projects avoiding the much used of form lumber. The wall is designed as a continuous interlocking support of the roof framing. Corner blocks combined with stretcher blocks are used on corners provided with reinforcement instead of reinforced concrete post. With this method, the costs of forms and labor were felt as a substantial savings.

In block laying work, concrete being a mixture of cement, sand and gravel should be used to fill the hollow core of the blocks for economical reasons. If cement mortar will be used to fill the core, cost will be substantially high because of the higher cement content in proportion with sand without gravel.

Remember that cost is the primary consideration in any type of construction, and to use pure mortar to fill the hollow core of the blocks is costlier than to use a reinforced concrete walls even if forms are used. One can prove this by applying the principles as explained in chapter-1

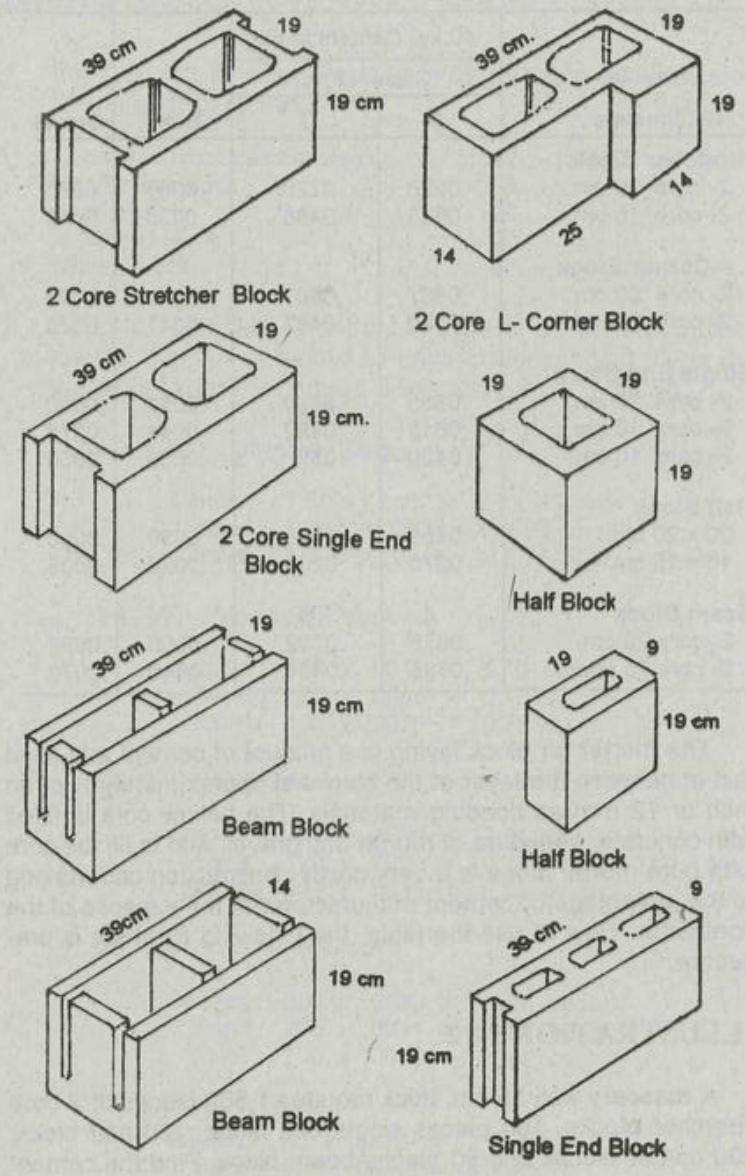


FIGURE 2-16 SPECIAL TYPES OF CHB

TABLE 2-6 QUANTITY OF CEMENT, SAND AND GRAVEL PER BLOCK

Size in Centimeters	40 kg. Cement in bag Class Mixture B	C	Sand	Gravel
Stretcher Block				
2- core 20 cm.	.0920	.0720	.0067	.0085
2- core 15 cm.	.0623	.0488	.0030	.0045
L – Corner Block				
2- core 20 cm.	.0867	.0687	.0060	.0095
2- core 15 cm.	.0590	.0467	.0041	.0070
Single End Block				
2- core 20 cm.	.0885	.0698	.0063	.0090
2- core 15 cm.	.0612	.0482	.0044	.0075
2- core 10 cm.	.0420	.0315	.0035	.0055
Half Block				
20 x 20 cm.	.0400	.0320	.0030	.0050
15 x 15 cm.	.0270	.0215	.0020	.0035
Beam Block	A	B		
2- core 20 cm.	.0878	.0732	.0050	.0098
2- core 15 cm.	.0585	.0488	.0040	.0070

The mortar for block laying is a mixture of cement and sand laid in between the layer of the blocks at approximately ½ of an inch or 12 mm as bonding materials. The hollow core is filled with concrete, a mixture of mortar and gravel. And to fill the core with pure mortar alone is a very costly construction undertaking to the advantage of cement manufacturer at the expense of the contractor. How to use the table, the following example is presented.

ILLUSTRATION 2-12

A masonry wall 15 cm. thick requires 1,500 pieces of 2-core stretcher blocks, 100 pieces single end block, 120 half block, 200 corner blocks and 80 pieces beam block. Find the cement sand and gravel using class "B" mortar mixture.

SOLUTION

1. Itemized the blocks according to its category and indicate the number of pieces.

2-core 15 cm. Stretcher block	1,500	pieces
Single end block	100	
Half block	120	
L-Corner Block	200	
Beam Block	80	

2. Refer to Table 2-6. Under column class "B" mixture, multiply the number of blocks to each corresponding value in the table to get the cement, sand and gravel required.

a.) 1,500 - Stretcher Blocks

Cement : 1,500 x .0623 = 93.45 bags
Sand : 1,500 x .0030 = 4.50 cu. m.
Gravel : 1,500 x .0045 = 6.75 cu. m.

b.) 100 - Single End Block

Cement : 100 x .0612 = 6.12 bags
Sand : 100 x .0044 = 0.45 cu. m.
Gravel : 100 x .0075 = 0.75 cu. m.

c.) 120 - Half Block

Cement : 120 x .0270 = 3.24 bags
Sand : 120 x .0020 = 0.24 cu. m.
Gravel : 120 x .0035 = 0.42 cu. m.

d.) 200 – L Corner Block

Cement : 200 x .0590 = 11.80 bags
Sand : 200 x .0041 = 0.82 cu. m.
Gravel : 200 x .0070 = 1.40 cu. m.

e.) 80 – Beam Block

Cement : 80 x .0488 = 3.90 bags
Sand : 80 x .0040 = 0.32 cu m.
Gravel : 80 x .0070 = 0.56 cu m.

3. Summary of the Materials

1,500 stretcher blocks	100 single end block
120 half block	200 L-corner block
80 beam block	119 bags cement
6.33 cu. m. sand	8.88 cu. m. gravel

2-6 DECORATIVE BLOCKS

Decorative hollow blocks are manufactured from either cement mortar or clay. These types of construction materials had been widely used for ventilation and decorative purposes.

TABLE 2-7 QUANTITY OF CECORATIVE BLOCKS CEMENT AND SAND PER 100 BLOCKS.

Size in cm.	Cement in Bag at 40 kg. Number per sq. m.	Class Mixture A	Class Mixture B	Sand per 100 blocks
5 x 10	200	.180	.120	.010
5 x 15	133	.270	.180	.015
5 x 20	100	.360	.240	.020
5 x 25	80	.450	.300	.025
10 x 20	50	.720	.480	.040
10 x 25	40	.900	.600	.050
10 x 30	33	1.080	.720	.060

TABLE 2-8 QUANTITY OF CEMENT AND SAND FOR VARIOUS TYPES OF BRICKS PER 100 BLOCKS

Size in Centimeters T H L	Number per sq. m.	Cement in Bag 40kg Mixture Class A	Cement in Bag 40kg Mixture Class B	Sand per. 100 blocks
6 x 12 x 19	38.5	.346	.230	.019
10 x 14 x 19	33.3	.612	.408	.034
10 x 14 x 23	27.8	.684	.456	.038
10 x 24 x 24	16.0	.882	.588	.049
10 x 14 x 39	16.7	.972	.648	.054
10 x 19 x 39	12.5	1.062	.708	.059

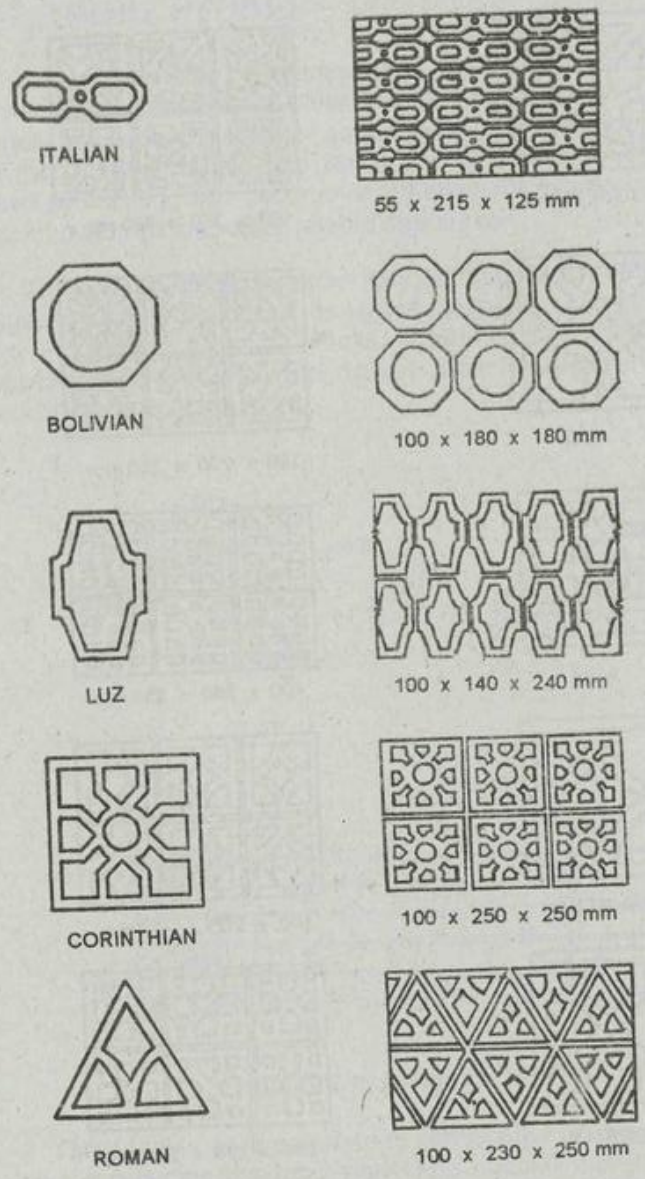


FIGURE 2-17 DECORATIVE BLOCKS

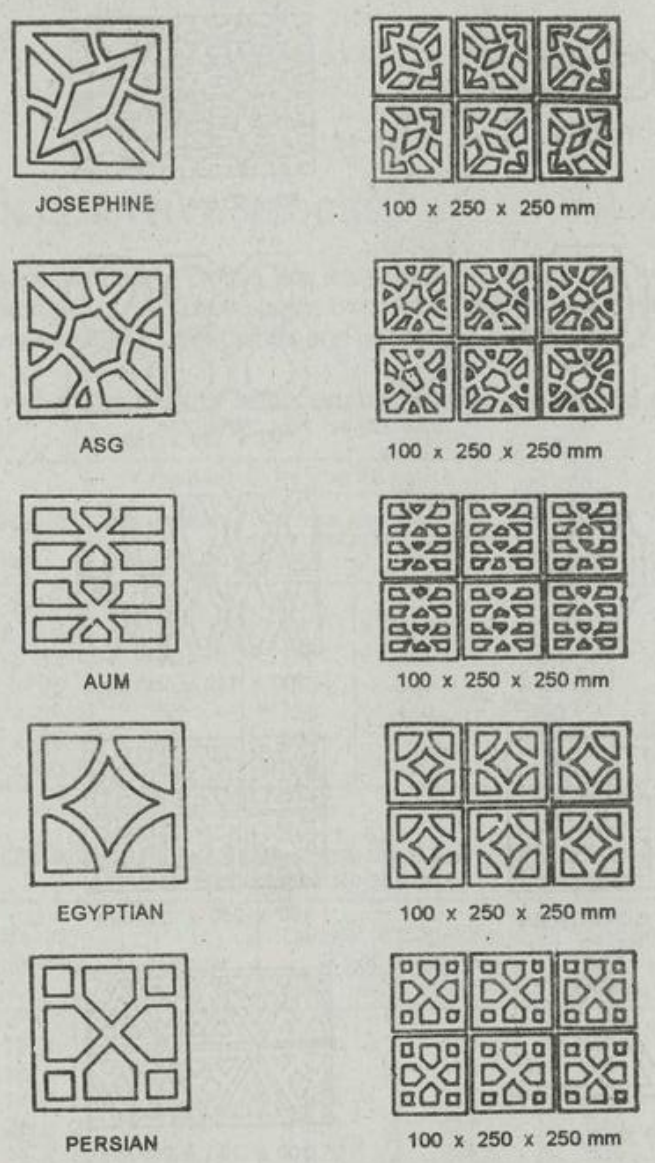


FIGURE 2-18 DECORATIVE BLOCKS

2-7 ADOBE STONE

Adobe Stone is commonly used for fencing materials as substitute to concrete hollow blocks for economic reasons. Lately however, the used of adobe stone was no longer limited to the ordinary zocalo and fencing work but also extensively used as finishing and decorative materials for exterior and interior of buildings and other related structures.

The use of adobe stone for fences, buttresses, cross- footings, and stairs minimizes the use of mortar filler unlike in working with concrete hollow blocks. Plastering is sometimes not applied specially when the design calls for exposure of the natural texture of the stone.

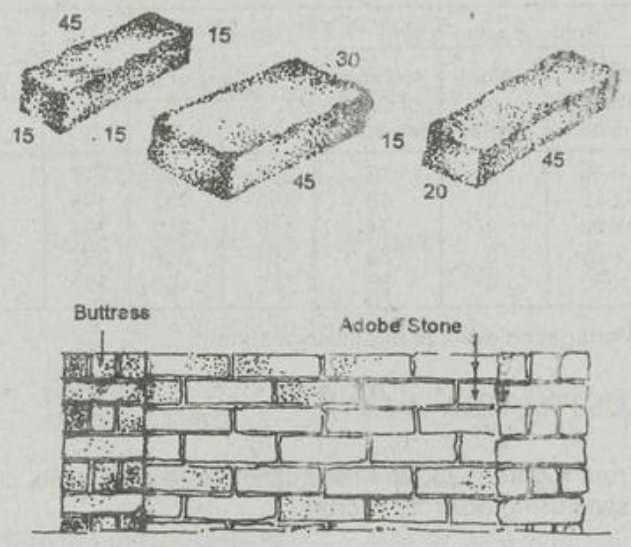


FIGURE 2-19 ADOBE STONE

Three tables were prepared to simplify the process of obtaining the quantity of adobe stone and cement mortar for stone laying and plastering.

TABLE 2-9 QUANTITY OF CEMENT AND SAND FOR ADOBE MORTAR PER SQUARE METER.

Commercial Size in cm.	No. per sq. m.	40 kg. Cement in Bags Class of Mixture			Sand cu. m.
		B	C	D	
15 x 15 x 45	14.8	.173	.130	.108	.015
15 x 20 x 45	11.0	.132	.099	.083	.011
15 x 30 x 30	11.0	.088	.066	.055	.007
15 x 30 x 40	8.3	.089	.067	.056	.008
15 x 30 x 45	7.4	.091	.068	.057	.008

* Mortar at an average thickness of 16 mm.

TABLE 2-10 QUANTITY OF ADOBE STONE CEMENT AND SAND FOR BUTRESSES AND FOOTINGS

Buttress and Footing			Cement per Meter Ht. Class of Mixture			Sand
Buttress Cross Section	No. of course	Number of stone per. M. ht.	A	B	C	cu. m.
30 x 45	2	12	.233	.156	.117	.013
45 x 45	3	18	.350	.233	.175	.019
45 x 60	4	24	.468	.312	.234	.026
45 x 75	5	30	.583	.389	.292	.032
45 x 95	6	36	.702	.468	.351	.039

* Mortar at an average thickness of 16 mm.

ILLUSTRATION 2-13

From Figure 2-20, find the quantity of adobe stone, cement and sand using class "B" mortar.

SOLUTION

A. Solving for Adobe Stone Wall

1. Determine the length of the fence minus the space occupied by the buttresses.

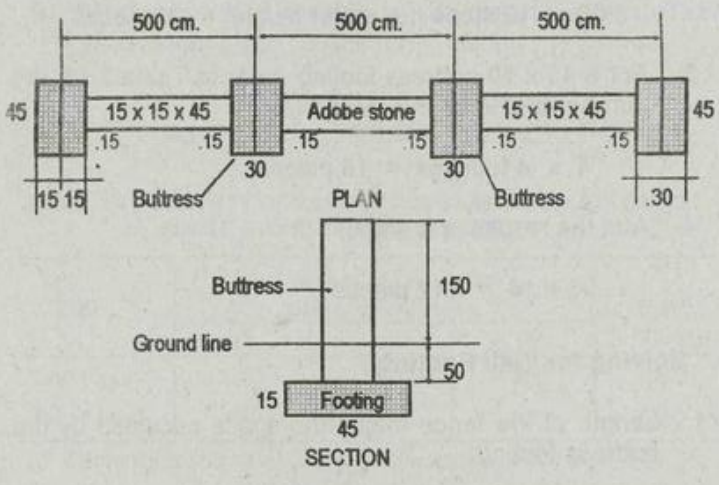


FIGURE 2-20 ADOBE FENCE

Length = 15.00 - (.30 x 3 posts)
(2 post plus the two 1/2 side posts = 3)

L = 14.10 meters

2. Solve for the net area of the wall.

Area = 14.10 x 2.00 m.
A = 28.20 sq. m.

3. Refer to Table 2-9. Using a 15 x 15 x 45 cm. adobe stone, multiply:

28.20 x 14.8 = 418 pieces

B. Solving for Buttresses

1. Find the total length of the post

2.00 m. x 4 posts = 8.00 meters

2. Refer to Table 2-10. Using a 30 x 45 buttress, multiply:

8.00 x 12 stone per meter height = 96 pieces.

3. For a 45 x 60 buttress footing refer to Table 2-10, the number of course is 4. Multiply:

   4 x 4 footings = 16 pieces

4. Add the results of 2 and 3.

   96 + 16 = 112 pieces

C. Solving for Wall Footing

1. Length of the fence minus the space occupied by the buttress footing.

   15.00 m. – (.45 x 3) = 13.65 m.

   3 is the 2 center posts plus the two 1/2 at the sides.

2. Multiply by 6 stones per meter length. The adobe stones are laid crosswise the wall, see figure 2-19.

   13.65 m. x 6 = 82 pieces.

D. Solving for the Cement Mortar

1. The area of the fence is 28.20. Refer to Table 2-9. Using class "B" mortar, multiply:

   Cement : 28.20 x .281 = 8.0 bags
   Sand : 28.20 x .024 = .68 cu. m.

2. For buttresses and footing = 112 pieces stone. Refer to Table 2-10. Along 30 x 45 buttress class "B" mixture multiply:

   Cement : 112 x .027 = 3.0 bags
   Sand : 112 x .0023 = .26 cu. m.

3. **Mortar for wall footing** = 82 pieces. Refer to Table 2-10, using class "B" mixture; multiply:

   Cement : 82 x .027 = 2.2 bags
   Sand : 82 x .0023 = .19 cu. m.

TABLE 2-11 QUANTITY OF CEMENT AND SAND FOR PLASTERING ADOBE STONE PER SQUARE METER *

Side	Cement in Bag 40 kg. Class of Mixture			Sand cu. m.
	B	C	D	
One Face	.240	.180	.150	.020
Two Faces	.480	.360	.300	.040

* Cement Plaster at an average thickness of 20 mm

D. Solving for Cement Plaster

1. Find the total surface area of the wall and the buttresses to be plastered. (one face)

   Length = 15.00 + 2 (.15) + (.15 x 6) = 16.2 m.
   Area = 16.2 x 1.50 ht. = 24.3 sq. m.

2. The height is only 1.50 because we do not plaster the wall below the ground line. Refer to Table 2-11. Using class "B" mixture, multiply:

   Cement : 24.3 x .240 = 5.83 say 6 bags
   Sand : 24.3 x .020 = .49 cu. m.

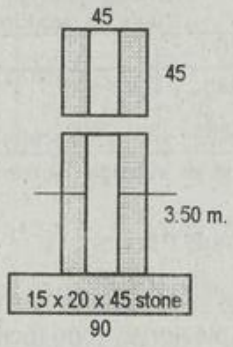
3. This is for one side plaster only. If two sides will be plastered, double the quantity.

Summary of the Materials

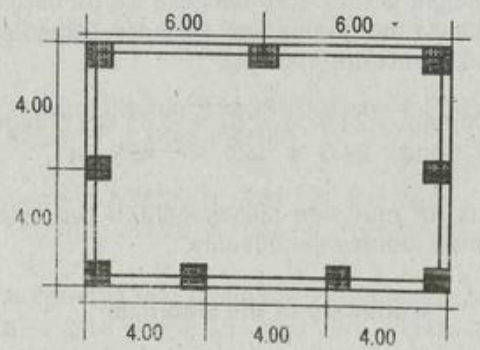
612 pieces. 15 x 15 x 45 cm. adobe stone
20 bags Portland cement
2.0 cubic meters sand

Problem Exercise

From the following figure, find the number of 15 x 20 x 45 cm. adobe stone, the cement and sand required to construct the fence using (a) Class A mixture; (b) Class C mixture. The plan specify plastering both sides of the wall using class B mixture.



SECTION



PLAN

FIGURE 2-21

2-8 RETAINING WALL

The practical use of gravity retaining wall is controlled by height limitations. Indeed, the required wall cross section increases with heights due to the effect of the triangular soil pressure distributed behind the retaining wall.

If the ground water level rises into the backfill behind a retaining wall due to either changing ground water condition or percolating water surface, the lateral pressure against the wall is also changed. The combined effect of soil and water pressure causes overturning moments and sliding forces. This is greater than the condition where there is no water.

To avoid the rise of water that is building up behind the retaining wall, a weep hole or collector drainage system or both are provided as part of the design construction. Weep holes should be at least 3 inches in diameter provided with a granular soil filter fabric at the wall to prevent backfill erosion. The horizontal spacing ranges from 120 to 300 centimeters apart.

For taller walls, two or more rows of weep holes may be provided with a typical vertical spacing of 150 centimeters.

A Satisfactory Retaining Wall Design must Satisfy the Following Criteria

1. The base and stem of the retaining wall must be capable of resisting the internal shear and bending moments developing as a result of soil and other loadings.
2. The wall must be safe against overturning.
3. The wall structure must be safe against sliding
4. The bearing capacity of the foundation material supporting the wall must not be exceeded.

2-9 RIP-RAP AND GROUTED RIP-RAP

Rip-Rap is either with or without grout, with or without filter backing. Stones intended for rip-raping shall consist of rocks

which are nearly rectangular in section as possible. The stone shall be tough, durable and dense. It shall be resistance to the action of air and water and suitable in all aspects for the purpose intended. Adobe stone shall not be used unless specified.

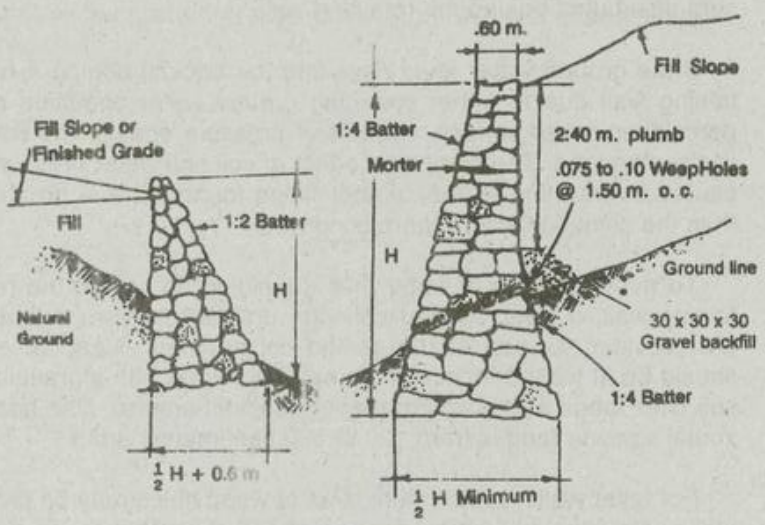


FIGURE 2-22 CROSS SECTIION OF RUBBLE RETAINING WALL

Class of Stone for Rip Raping

Class A - Stone ranging from 15 to 25 kilograms with at least 50% of the stones weighing more than 20 kilograms

Class B - Stone ranging from 30 to 70 kg. With at least 50% of the stones weighing more than 50 kilograms.

Class C - Stones ranging from 60 to 100 kg. With at least 50% of the stones weighing more than 80 kilograms.

Class D - Stones weighing from 100 kg. to 200 kg. with at least 50% of the stones weighing more than 150 kgs.

Excavation and Placing

The bed for rip-rap is excavated down to the required depth and properly compacted, trimmed and shaped. The rip-rap foundation is laid below the depth of the scour filling the toe trench with stone of the same class as specified.

Each stone is laid with its longest axis perpendicular to the slope in close contact with adjacent stone. The rip-rap is thoroughly rammed into place and the finished stones are laid to an even tight surface. Intersections between stones are filled with small broken fragments firmly rammed into place.

The stones are placed by hand or individually laid by machine. Spaces between stones are then filled with cement mortar sufficient enough to completely fill all the voids except the face surface of the stones left exposed.

Cement grout is placed starting from the bottom to the top of the surface and then swept with a stiff broom. After grouting, the surface is cured like structural concrete for a period of at least 3 days after the installation.

TABLE 2-12 QUANTITY OF CEMENT AND SAND ON A STONE RIP-RAP PER CUBIC METER

Stone Class	Cement in Bags			Sand
	Grout Mixture			
	A	B	C	cu. m.
Class - A	2.574	1.716	1.287	.143
Class - B	2.448	1.620	1.214	.135
Class - C	2.232	1.488	1.116	.124
Class - D	1.944	1.296	0.972	.108

ILLUSTRATION 2-14

A stone rip-rap retaining wall 50 meters long as shown in Figure 2-23 specify the use of Class B stone with class C grout

mixture. List down the materials required including the weep hole drain pipe and the gravel backfill as granular soil filter.

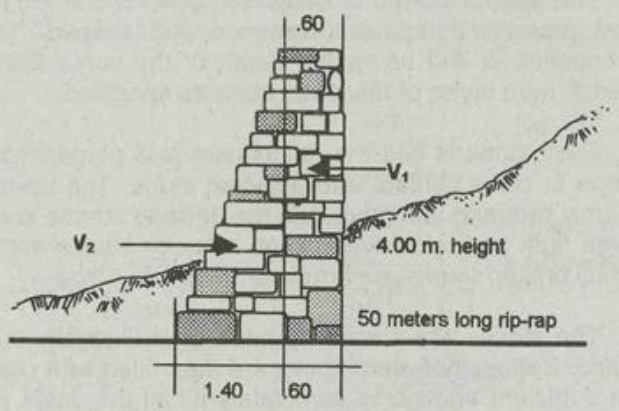


FIGURE 2-23

SOLUTION

1. Solve for the volume of the proposed riprap.

   Volume = Width x Height x Length

   V_1 = .60 x 4.00 m x 50 m. = 120 cu. m.

   V_2 = $(\frac{1.40}{2} \times 4.00) \times 50$ m. = 140 cu. m.

   Total volume..... = 260 cu. m.

2. Refer to Table 2-12. Using Class B stone and Class C grout mixture, multiply

   Cement : 260 x 1.214 = 315.64 say 316 bags
   Sand : 260 x .135 = 35.1 cubic meters

3. Length of the riprap divided by the weep holes at 2.00 meters spacing distance;

   $\frac{50.00 \text{ m.}}{2.00}$ = 25 pieces 3" dia. pipe at 2.00 m. spacing

4. For 2 layers weep hole, add 25 pieces 3" at 1.00 m.

   Total: 25 pcs. 3" diameter at 1.50 m. long.
   25 pcs. 3" diameter at 1.00 m. long

5. Find the volume of the granular soil (gravel) filter.

   V = .30 x .30 x 50.00 m.
   V = 4.5 say 5 cubic meters

6. Summary of the materials

   260 cubic meters Class B stone
   316 bags Portland cement
   35 cubic meters sand
   5 cubic meters gravel
   21 pieces 3" x 3.00 m. PVc pipe

7. For back filling, add 20% to volume for compaction.

2-10 CONCRETE RETAINING WALL

An existing stable earth slope can experience significant movement called slope failure or landslide due to changes in its natural condition or man-induced changes. There are instances where the materials in cut banks slip down to the roadway or carrying portion of the shoulder of the road. This pattern of failure is common in fills or cut slopes of homogenous non-granular materials.

ILLUSTRATION 2-15

A gravity wall 50 meters long has the following dimensions as shown in figure 2-24, list down the materials required using class A concrete.

SOLUTION

1. Find the volume of stem.

V = (.15 + .30) x 4.00 x 50.00 = 90 cu. m.

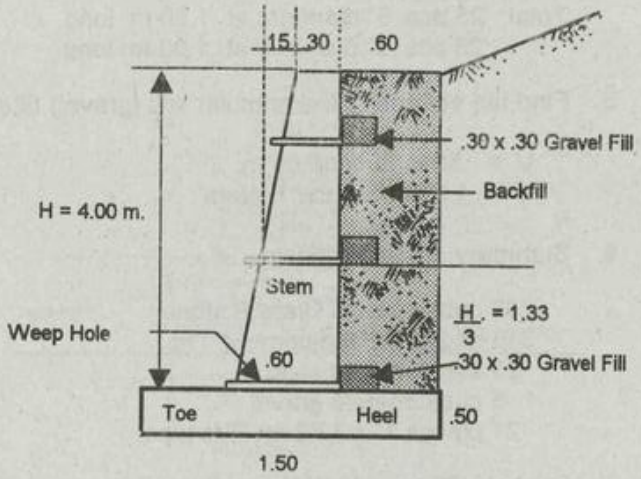


FIGURE 2-24 CROSS SECTION OF RETAINING WALL

2. Find the volume of the footing.

   V = .50 x 1.50 x 50.00 = 37.5 cu. m.

3. Total volume of 1 and 2.

   V = 90 + 37.5 = 127.5 cubic meters

4. Refer to Table 1-2. Using class A mixture, multiply:

   Cement: 127.5 x 9.0 = 1,148 bags
   Sand: 127.5 x .50 = 64 cu. m.
   Gravel: 127.5 x 1.0 = 128 cu. m.

5. For Reinforcement, see plan and refer to Chapter-3

6. For Weep Hole pipe, divide length by 2.00 meters.

   $\frac{50.00}{2}$ = 25 pieces at .60 m. 1st layer

25 pieces at .50 m. 2nd layer
25 pieces at .40 m. 3rd layer

7. Find the volume of Gravel Filter Filler.

   V = .30 x .30 x 50 m. x 3 layers = 13.5 cubic meters

8. Find the volume of backfill materials.

   V = .60 x 4.00 x 50.00 = 120 cubic meters

8. Add 20% for compaction; 120 + 24 = 144 cu. m

10. Summary of the Materials

    1148 bags cement
    64 cu. m. sand
    128 cu. m. gravel
    7 pcs. 3" x 6.00 Pvc pipe
    14 cu. m. gravel
    144 cu. m. back fill materials.

2-11 GABIONS AND MATTRESS

Gabions and Mattresses are used to give permanent protection and support to sea walls, river banks , culverts, reservoirs, road bridges and many other structures in civil engineering works. Gabions are box shaped containers made of tough woven hexagonal netting strengthened by selvedges of heavier wires. To further strengthen the container, diaphragms are added to divide the gabion into 1 m compartments

Recommended Uses

When filled with quarried stone on site, Gabions and Mattresses prove to be excellent materials for construction of retaining and anti-erosion structures. Major applications include:

1. Slope stabilization for embankment and cutting
2. Prevention of erosion in river embankments.

TABLE 3-1 STANDARD WEIGHT OF PLAIN OR DEFORMED ROUND STEEL BARS IN KILOGRAM

Diam.	Length of Steel Bars in Meters						
	5.00	6.00	7.50	9.00	10.50	12.00	13.50
8 mm	1.98	2.37	2.96	3.56	4.15	4.74	5.33
10 mm	3.08	3.70	4.62	5.54	6.47	7.39	8.32
12 mm	4.44	5.33	6.66	7.99	9.32	10.66	11.99
13 mm	5.21	6.25	7.83	9.38	10.94	12.50	14.07
16 mm	7.90	9.47	11.84	14.21	16.58	18.95	21.32
20 mm	12.33	14.80	18.50	22.19	25.69	29.59	33.29
25 mm	19.27	23.12	28.90	34.68	40.46	46.24	52.02
28 mm	24.17	29.00	36.25	43.50	50.75	58.00	65.25
30 mm	27.75	33.29	41.62	49.94	58.26	66.59	74.91
32 mm	31.57	37.88	47.35	56.82	66.29	75.76	85.23
36 mm	39.96	47.95	59.93	71.92	83.91	95.89	107.88

TABLE 3-2 DEFORMATION REQUIREMENTS

Nominal Diameter	Max Average Spacing of Lugs	Height Minimum	Tolerance Maximum	Max. Value Summation Of lugs gap
8	7.0	0.3	0.6	5.5
10	7.0	0.4	0.8	7.8
12	8.4	0.5	1.0	9.4
13	9.1	0.6	1.2	10.2
16	11.2	0.7	1.4	12.6
20	14.0	1.0	2.0	15.7
25	17.5	1.2	2.4	19.6
28	19.6	1.4	2.8	22.0
30	21.0	1.5	3.0	13.6
32	22.4	1.6	3.2	25.1
36	24.5	1.8	3.6	27.5

TABLE 3-3 MECHANICAL PROPERTIES OF STEEL BARS

Class	Grade	Yield Strength Mpa mm²	Tensile Strength Mpa mm²	Specimen mm	Elongation in 200 mm Percent mm	Bending Angle degree Specimen	Diameter of pin d= nominal dia. at
Hot Rolled	230	230	390	D < 25	18	180	3d
				D > 25	16		4d
Non weldable def. steel bar	275	275	480	D < 25	10	180	4d
				D > 25	8		5d
	415	415	620	D < 25	8	180	5d
				D > 25	7		6d
Hot Rolled Weldable Deformed or plain	230	230	390	D < 25	20	180	3d
				D > 25	18		4d
	275	480	480	D < 25	16	180	4d
				D > 25	14		5d
	415	415	550	D < 25	14	180	5d
				D > 25	12		6d

TABLE 3-4 AREAS OF GROUPS OF REINFORCING STEEL BARS

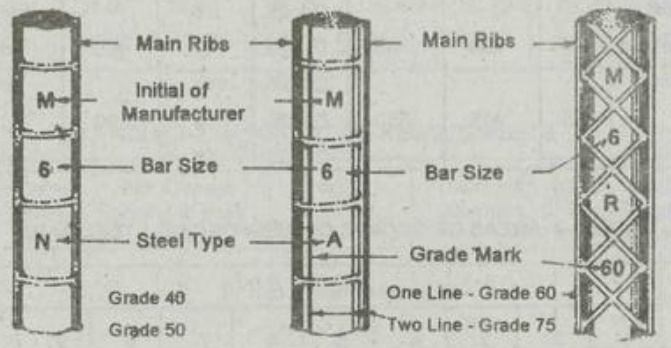
Bar Dia. mm.	Number of Bars (mm²)									
	1	2	3	4	5	6	7	8	9	10
6	28	57	85	113	141	170	198	226	254	283
8	50	101	151	201	251	302	352	402	452	503
10	79	157	236	314	393	471	550	628	707	785
12	113	226	339	452	565	679	792	905	1017	1131
16	201	402	603	804	1005	1206	1407	1608	1809	2011
20	314	628	942	1257	1571	1885	2199	2513	2827	3142
24	491	982	1473	1963	2454	2945	3436	3927	4418	4909
32	804	1608	2412	3216	4021	4825	5629	6433	7237	8042
40	1256	2513	3769	5026	6283	7539	8796	1005	1131	1257

In order to provide a higher degree of sufficient bond between the concrete and the reinforcement, steel bars were provided with a surface deformation in various forms and designs.

3-2 IDENTIFICATION OF STEEL BARS

Steel reinforcing bars are provided with distinctive markings identifying the name of the manufacturer with its initial brand and the bar size number including the type of steel bars presented as follows:

N = For Billet
A = For Axle
Rail Sign = For Rail Steel



STEEL BARS MARKING SYSTEM

FIGURE 3-2

3-3 BAR SPLICE, HOOK AND BEND

In estimating the quantity of steel reinforcing bars, one has to consider the additional length for the hook, the bend and the splice whose length varies depending upon the limitations as prescribed by the National Building Code.

HOW TO DETERMINE SPLICING LENGTH OF STEEL BARS

Types of Reinforcement	Minimum Splice Length
1. Tension Bars	25 x Bar size + 150 mm
2. Compression Bars	20 x Bar size + 160 mm.

ILLUSTRATION 3-1

Determine the length of the splice joint for a 16 mm and 20 mm steel bars under the following conditions:

a.) Tensile reinforcement of a beam
b.) Compressive reinforcement of a column

SOLUTION (For 16 mm steel bars)

a.) Classification of the reinforcement is under tension. Multiply:

25 x 16 mm + 150 mm = 550 mm or 55 cm.

b.) For the reinforcement under compression, multiply:

20 x 16 mm + 150 mm = 470 mm or 47 cm.

Therefore, the splice joint for a 16 mm tension bar is 55 centimeters long and 47 centimeters for a compression bars.

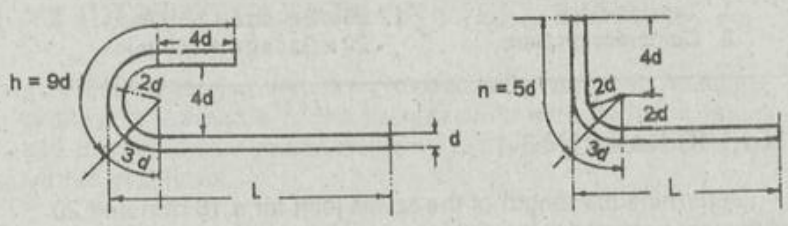
SOLUTION (For 20 mm steel bar)

a. Length of splice for tension bar.
25 x 20 mm + 150 mm = 650 mm. or 65 cm.

b. Length of splice for compression bars.
20 x 20 mm + 150 mm = 550 mm or 55 cm.

MILD STEEL MINIMUM HOOK AND BEND ALLOWANCE

Hook Length = L + h

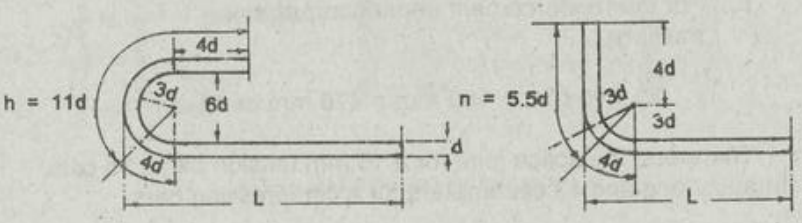


Hook Length = L + h for hook

HOOK BEND

HIGH YIELD BARS MINIMUM HOOK AND BEND ALLOWANCE

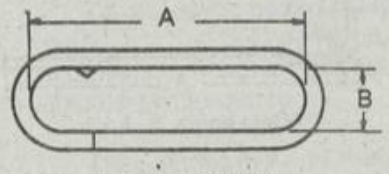
Hook Length = L + n



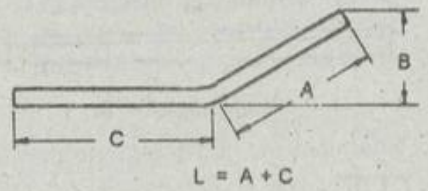
Hook Length = L + n for Bend

HOOK BEND

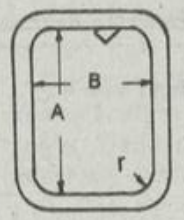
FIGURE 3-3 HOOK AND BEND ALLOWNCE



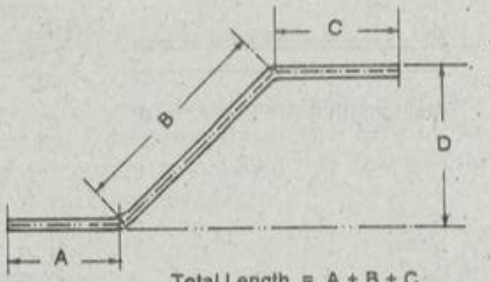
L = 2A + 3B +22d



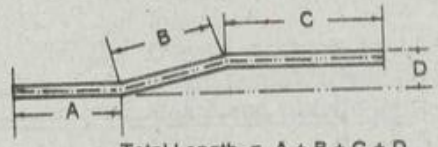
L = A + C



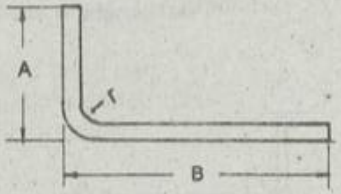
L = 2 (A + B) + 20d



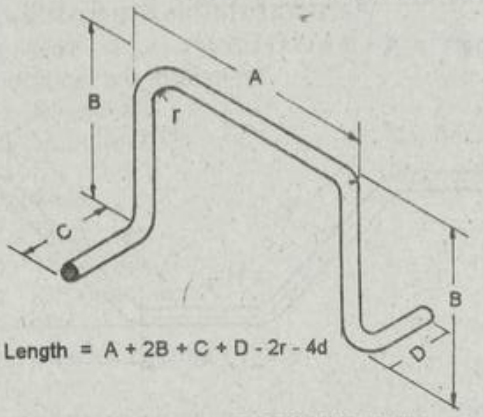
Total Length = A + B + C



Total Length = A + B + C + D



Total Length = A + B - 1/2 r - d



Length = A + 2B + C + D - 2r - 4d

FIGURE 3-4 LENGTH OF HOOK AND BEND

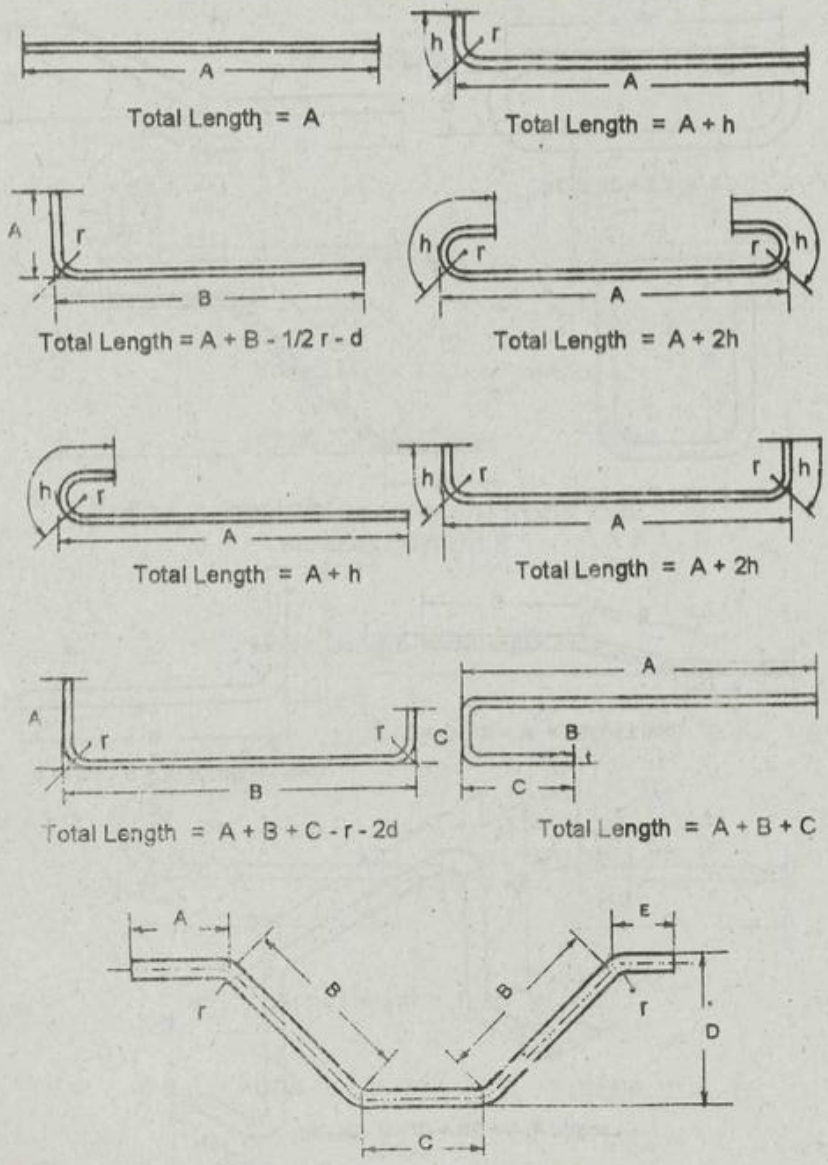


FIGURE 3-5 LENGTH OF HOOK AND BEND

To those who have not yet been exposed to detailed drafting work or actual field construction of reinforced concrete, will find it difficult to make a detailed estimate of the various types of reinforcement required.

The various type of metal reinforcement that an estimator should be familiarized with are:

A. Concrete Hollow Block Reinforcement.

This is the simplest type of vertical and horizontal reinforcement placed in between the layers and the hollow core of the blocks. This type of reinforcement is installed and spliced progressively with the rise of the concrete blocks.

B. Focting Reinforcements

1. Footing slab reinforcement for small and medium size footings.
2. Dowels, cut bars, anchor, and bend bars
3. Beam reinforcement for medium construction
4. Beam and slab for large construction
5. Stirrups

C. Post and Column Reinforcements

1. Main vertical reinforcement
   a. Single or
   b. Bundled bars

2. Lateral Ties
   a. Outer ties
   b. Inner ties
   c. Straight ties

3. Spiral Ties for circular column

4. Dowels for partitions and other future attachments.

D. Beam and Girder Reinforcements

1. Main Reinforcement
   a. Straight bars
   b. Bend bars
   c. Additional cut bars for tension and compression
   d. Dowel bars for future attachment

2. Stirrups
   a. Open stirrups
   b. Closed stirrups
   c. Straight stirrups or ties

3. Cut Bars
   a. Over and across the support
   b. Between supports
   c. Dowels and hangers for ceiling and partition

E. Floor Slab Reinforcement

1. Main reinforcements
   a. Straight main reinforcing bars extending from one beam to the other
   b. Alternate main reinforcing bars with bend between and over the beam support. (see figure floor slab reinforcement)
   c. Main alternate bars over support (beam or girder)

2. Temperature bars tied perpendicular to the main reinforcement.
3. Additional alternate cut bars over the support (beam).
4. Dowels and hangers for ceiling and other attachment.

E. Other Types of Reinforcement

Other special types of reinforcement designed for a particular structure which may be presented in details. Not until after familiarizing with these different parts and types of reinforcement could one make a sound and reliable estimate.

Suggested Procedures in Estimating Steel Bar Reinforcement

1. The main reinforcement of post, column, beam, girder and the like structures, are determined by the simple Direct Counting Method, that is, by counting the number of main vertical reinforcement on one structure then multiplied by the total number of the same type or category in the plan.

2. Do not forget to include the additional length for hook, bend and splices for end lapping joints. The additional length is the one most often overlooked in ordering length of steel bars. In ordering steel bars, always think of minimizing the splices if it cannot be totally avoided.

3. For other reinforcement parts such as lateral ties, stirrups, spirals, dowels, cut bars and the like should be treated or estimated separately one at a time taking into consideration the additional length for the hook, bend, and splicing length.

4. After knowing the length of the lateral ties, stirrups and other similar parts, select the steel bars from the various commercial length of 6.00 to 13.50 meters long where these cut bars could be obtained avoiding or minimizing unnecessary extra cuts. Extra cuts are waste when classified as junk materials.

5. Considering its cost, Tie Wire for reinforcement joints is a big item in large construction work. The length of each tie wire should be cut to the minimum required length based on the diameter of the bars to be tied on. Indiscriminate cutting of tie wire should not be permitted.

3-4 REINFORCEMENT OF CONCRETE HOLLOW BLOCKS

Steel bar as reinforcement is a requirement for all types of concrete and masonry works. The National Building Code has promulgated guidelines on how and what kind of reinforcement

is appropriate for a certain type of work depending upon the purpose for which it is to serve. The size and spacing requirements for concrete hollow block reinforcement must be indicated on the plan or specifications.

Concrete hollow block reinforcement could be determined in three different ways:

1. By the Direct Counting Method
2. By the Area Method
3. By the Unit Block Method

The Direct Counting Method

Under the direct counting method, the vertical and horizontal reinforcements are counted individually in the plan. The length is also determined from the elevation. The hook, bend and lapping splices are imaginably calculated and added to its length because it is very rare to see a plan in a large scale drawing showing this particular requirements of reinforcing steel bars. Thus, estimators must be familiar with the hook, the bend and splicing requirements to be able to work effectively even if the plan is not accompanied with such details.

In the event that estimating by the Direct Counting Method is somewhat difficult, one can use the Area Method with the aid of Table 3-5 prepared for this purpose.

Estimating by the Area Method

The Area Method is the simplest approach in computing the steel bar reinforcement for CHB with the aid of Table 3-5. The values presented in the table include the allowances required for standard bend, hook and lapping splices.

ILLUSTRATION 3-2

From Figure 3-6, determine the number of:
(a) 10 x 20 x 40 cm CHB
(b) Vertical reinforcement spaced at 80 cm.
(c) Horizontal reinforcement at every 3 layers.

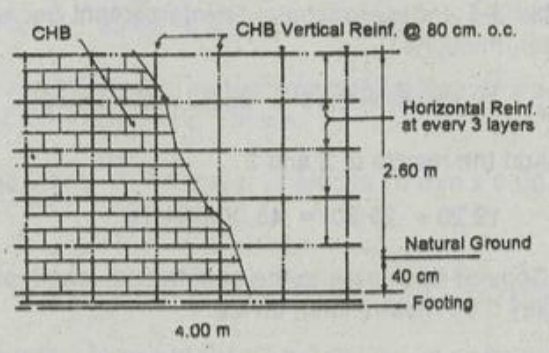


FIGURE 3-6

TABLE 3-5 LENGTH OF REINFORCING BARS FOR CHB IN METERS

Spacing	Vertical Reinforcement Length of bars in meter		Spacing	Horizontal Reinforcement Length of bars in meter	
cm.	Per Block	Per Sq. M.	Layer	Per Block	Per Sq. M.
40	0.235	2.93	2	0.264	3.30
60	0.171	2.13	3	0.172	2.15
80	0.128	1.60	4	0.138	1.72

SOLUTION (By the Area Method)

1. Solve for the Area of the fence

   Area = Length x Height
   A = 4.00 x 3.00 m.
   A = 12 sq. m.

2. For vertical reinforcement spaced at 80 centimeters, refer to Table 3-5. Under column length per sq. m. multiply:

   12 sq. m. x 1.60 = 19.20 m. long

3. Solve for the horizontal bars at every 3 layers. From Table 3-5 under Horizontal Reinforcement per square meter, multiply:

   12 sq. m. x 2.15 = 25.80 meters long

4. Add the results of 2 and 3

   19.20 + 25.80 = 45.00 meters

5. Convert this value to the commercial length of steel bar, say 6.00 meters long, divide:

   $\frac{45.00 \text{ m.}}{6.00}$ = 7.5 order 8 pcs. 10 mm x 6.00 m. long.

SOLUTION (By the Unit Block Method)

Solving the same problem of Illustration 3-2, by the Unit Block Method, we have the following solution:

1. Find the area of the wall.

   Area: = 4.00 x 3.00 m. = 12 sq. m.

2. Determine the number of hollow blocks. Refer to Table 2-2. Multiply:

   CHB: = 12 sq. m. x 12.5 = 150 pieces

3. Refer to Table 3-5.

   a.) Vertical reinforcement at 80 cm. spacing, length of steel bar per block; multiply:

   150 x 0.128 = 19.2 meters long.

   b.) Horizontal bars at every after 3 layers, refer again to Table 3-5. length of steel bar per block; multiply:

   150 x 0.172 = 25.80 meters long.

4. Add the results of (a) and (b)

   19.2 + 25.80 = 45.00 meters long

6. Convert this length to the commercial size of steel bars, say 6.00 meters long. Divide:

   $\frac{45.00 \text{ m.}}{6.00}$ = 7.5 order 8 pieces 10 mm x 6.00 m.

3-5 TIE WIRE FOR CHB REINFORCEMENT

Tie wire refers to gauge No.16 galvanized iron wire popularly known as G.I. tie wire. Tie wire is used to secure the steel bars into its designed position. Ordering tie wire is not by feet nor by meter length but in kilograms or roll. One roll is equivalent to 45 kilograms, or approximately 2,385 meters at 53 meters per kilogram.

The length of each tie wire depends upon the size of the bars to be tied on. Tie wire is cut into length ranging from 20 to 40 centimeters for small and medium size steel bars. For larger steel bars, the length of ties varies depending upon the convenience of the steel man.

This particular item of construction material is always included in the bill of materials but never been computed. The quantity is determined through a more or less calculation. In short, it is a quantity with uncertainty of its accuracy. The only thing that is certain is either it is over estimated or under estimated which is as bad as the other.

Length of Tie Wire Reinforcement

The common size of steel bar reinforcement specified for concrete hollow block work is either; 10 mm, 12 mm or 16 mm diameter depending upon the plan and specifications. For this particular size of reinforcement, a 25 to 40 centimeters long tie wire folded at the center is satisfactory.

TABLE 3-6 No. 16 G.I. TIE WIRE FOR CHB REINFORCEMENT PER SQUARE METER

Vertical Spacing	Horizontal Layer Spacing	Kilograms per Square Meter		
		25 cm. Tie	30 cm. Tie	40 cm. Tie
40	2	.054	.065	.086
40	3	.039	.047	.063
40	4	.024	.029	.039
60	2	.036	.044	.057
60	3	.026	.032	.042
60	4	.020	.024	.032
80	2	.027	.033	.044
80	3	.020	.024	.032
80	4	.015	.018	.024

ILLUSTRATION 3-3

Continuing the solution of illustration 3-2, find the required Tie Wire in kilograms if the reinforcements are spaced at:

1. Vertical bars spaced at 80 centimeters and one horizontal bars at every after 3 layers of the block.
2. Vertical bars at 60 centimeters and one horizontal bar at every after 2 layers of the block
3. Tie wire in kilograms.

SOLUTION - I

1. Solve for the wall area.

   Area = 4.00 x 3.00
   A = 12 sq. m.

2. Refer to Table 3-6. Along 80 cm. vertical spacing and 3 layers horizontal spacing of reinforcement at 30 cm. long tie wire, multiply:

   12 sq. m. x .024 = .29 kgs. # 16- G.I. wire

SOLUTION - 2

1. Find the wall area.

   Area = 4.00 x 3.00 = 12 sq. m.

3. Refer to Table 3-6. Along 60 cm. vertical spacing with one horizontal bar at every after 2 layers of block and using 30 cm. tie wire, multiply:

   12 sq. m. x .044 = 0.53 kilograms # 16 G.I. wire.

More of this Tie Wire will be presented in the succeeding examples on steel reinforcement.

3-6 INDEPENDENT FOOTING REINFORCEMENT

Independent column footing is also referred to as individual or isolated footing. The ACI Code provides that the minimum underground protective covering of concrete to steel reinforcement shall not be less than 7.5 centimeters. The reinforcement for this type of structure is determined by direct counting from the detailed plan under the following procedures:

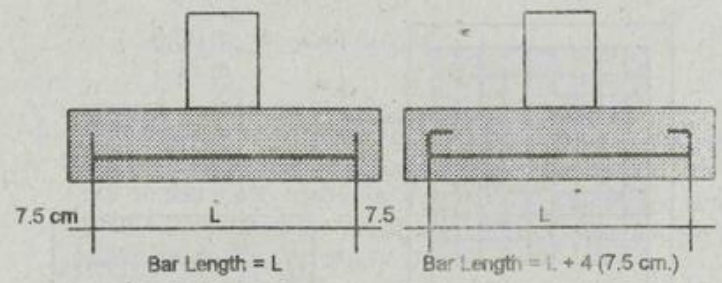


FIGURE 3-7 INDIVIDUAL FOOTING REINFORCEMENT

1. Know the actual dimensions of the footing as to its length and width.

2. Consider the 7.5 cm. minimum underground protective covering of concrete to the steel reinforcement.
3. If the plan does not specify hook or bend of the footing reinforcement, the length of the bar is equal to the length or width of the footing minus the 7.5 protective covering at both ends.
4. If the plan indicate hook or bend of the reinforcement, the bar cut should include the allowances for the hook and band as presented in Figure 3-4 and 3-5.
5. Know the spacing distance of the steel bars both ways to determine the exact number required. As much as possible, select the appropriate commercial length of steel bar which is divisible by the required cut length to avoid unwanted cuts.

One important consideration in estimating steel bar reinforcement is to find the required length and quantity of a particular reinforcement then choose a commercial length bars which when cut into the required sizes will minimize unwanted cuts. For instance, if 5 pieces at 1.20 meters long is needed, the most ideal order is 6.00 meters long steel bar. Likewise, if the work requires 2.50 meters cut length, the order will not be 6.00 meters but 7.50 meters long steel bars.

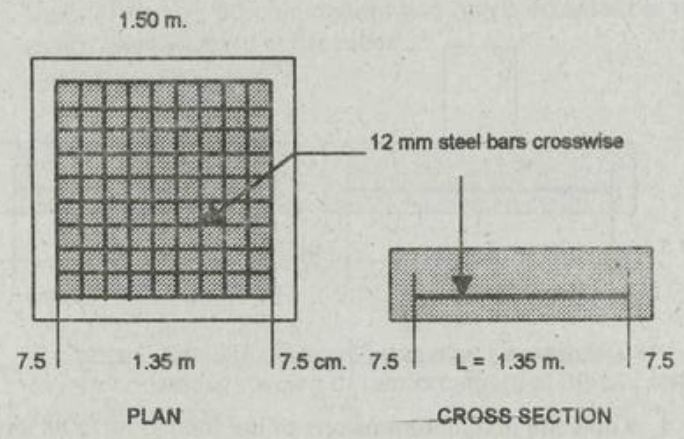


FIGURE 3-8 INDEPENDENT FOOTING REINFORCEMENT

ILLUSTRATION 3-4

From Figure 3-8, find the number of 12 mm steel bars required if there are 24 footings having a general dimensions of 1.50 x 1.50 meters.

SOLUTION

1. Find the net length of one cut reinforcing bar.

   Net Length is = 1.50 m. - 2 (.075)
   L = 1.35 meters.

2. Find the total number of these cut bars in one footing.

   10 x 2 = 20 pieces of 12 mm at 1.35 m. long.

3. Find the total number of cut bars in 24 footings.

   Total cut bars: 24 x 20 = 480 pieces

4. If 6.00 meters long steel bar will be used, we obtain the following cuts.

   $\frac{6.00 \text{ m.}}{1.35 \text{ m.}} = 4.44$ pieces

5. The result simply mean that in one 6 meters long steel bar we could get 4.44 pieces at 1.35 meters long. We will not consider the fractional value of .44 because it is less than 1.35 meters length of one cut bar. Instead, we will only use the whole value 4.0.

6. Divide the result of step 3 by 4.0 to get the number of 6 meters steel bars required.

   $\frac{480}{4.0} = 120$ pieces steel bars at 6 meters long.

N = 6 x 2 (crosswise) = 12 pieces per footing

3. Find the total cut bars for 30 footings.

   12 cut bars x 30 footings = 360 pieces.

4. Find the total length of 360 pcs. cut bars at 1.20 m. long.

   360 x 1.20 = 432 meters

5. Divide by 6.00 m. length of one commercial steel bar

   $\frac{432 \text{ m.}}{6}$ = 72 pieces 12 mm x 6.00 m. steel bars.

Comment :

1. The above solution is correct because in dividing 6.00 m. by 1.20 (length of one cut bar), we got an exact amount of 5.0. Meaning, there is no extra cut in one 6.0 meters steel bar.

2. In step 5, dividing 432 by 6.00 meters, yield an exact number of 72 pieces at 6.00 meters steel bar. Therefore, all cuts are exactly the same without excesses.

Solving the Same Problem by the First Method

1. The net length of one cut bar is 1.20 meters and the total number of bars in 30 footings is 360 pieces.

2. Select a commercial length of steel bar which is divisible by 1.20 without extra cut. Try 6.00 meters long steel bars.

   $\frac{6.00 \text{ m}}{1.20 \text{ m.}}$ = 5 pieces

3. This simply mean that in a 6.00 meter long steel bar, we obtain exactly 5 pieces at 1.20 m. long cut bar. Divide the total cut bars for 30 footings by 5

$\frac{360}{5}$ = 72 pieces 12 mm x 6.00 meters steel bars

The question now is, when to use the first method and when to use the second. The following rules will help in making the right choice.

1. Determine the net length of one reinforcing cut bar
2. Divide 6.00 meters or any chosen commercial length of steel bar by the result of step 1.
3. If the result in dividing the length of one steel bar by the length of one cut bar is a whole number (exact value) use the second procedure.
4. If the result has a fractional value, use the first method.

Estimating The Footing Tie Wire

Estimating the Tie Wire was initially discussed in Section 3-5 under the reinforcement for CHB. Applying the same principles in illustration 3-4 and 3-6, we have the following examples:

A) Solving the Tie Wire for Illustration 3-4

1. Looking at the plan of Figure 3-8 there are:

   10 x 10 = 100 intersections of steel bars to be tied per footing

2. Solve for the total ties of the 24 footings:

   100 x 24 = 2,400 ties.

3. Using a 30 centimeters long ties, multiply:

   2,400 x .30 m. = 720 meters G.I. wire.

4. Convert this length to kilograms. (One kilogram of No. 16 tie wire is approximately 53 meters long.) Divide :

   $\frac{720}{53}$ m. = 13.58 say 14 kilograms # 16 G.I. wire.

B) Solving the Tie Wire for Illustration 3-6

1. Looking at the plan of Figure 3-9. There are 36 steel bar intersections to be tied with G.I wire

   6 x 6 = 36 ties per footing

2. Solve for the total ties of 30 footings.

   36 x 30 = 1,080 ties.

3. If one tie is 30 cm. long, find the total length of 1,080 ties;

   .30 m. x 1,080 = 324 meters long.

4. Convert this length to kilograms. Using the value of 53 meters per kilogram, divide:

   $\frac{324\ m.}{53}$ = 6.1 kilograms # 16 G.I. wire.

3-7 POST AND COLUMN REINFORCEMMENT

The reinforcement of post and column to be considered in this study are: (a.) The main or vertical reinforcement, (b.) The lateral ties or (c.) Spiral ties for circular column.

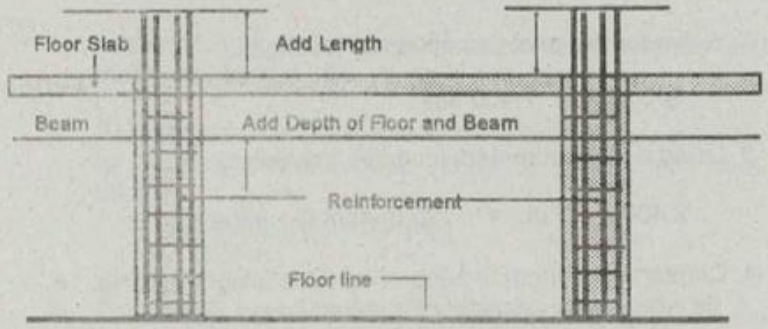


FIGURE 3-10 POST AND COLUMN REINFORCEMENT

The quantity and length of the main reinforcement is determined by the "Direct Counting Method" giving special attention to the additional length for:

a. Lap joints of end splices
b. Allowance for bending and or hook
c. Additional length for beam depth and floor thickness if the height indicated in the plan is from floor to ceiling.
d. Distance from floor to footing slab.
e. Provisions for splices of succeeding floors.

ILLUSTRATION 3-7

From the following figure, list down the main reinforcement from the footing to the second floor using 20 mm if there are 10 columns in the plan.

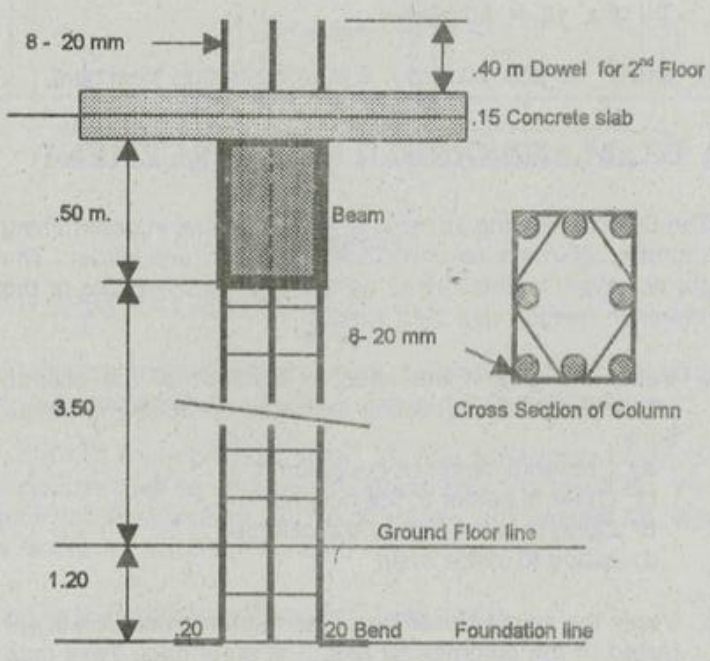


FIGURE 3-11 LENGTH OF MAIN REINFORCEMENT

SOLUTION

1. Determine the total length of the main steel bar reinforcements.

   a. Bend at the base footing ..... .20
   b. Length from footing to ground floor 1.20
   c. Height from ground line to beam..... 3.50
   d. Depth of beam ..... .50
   e. Thickness of the floor slab .... .15
   f. Dowel for second floor (20 x 20 mm) ..... .40
   Total Length of the Reinforcement.... 5.95 M.

2. Select a 6.00 meters long steel bar

3. Multiply by number of bars in one post x 10 post.

   8 x 10 = 80 pieces

4. Order: 80 pcs. 20 mm x 6.00 meters long steel bars.

3-8 BEAM AND GIRDER REINFORCEMENT

The Direct Counting so far is the best method in determining the number of main reinforcement of beam and girder. The length however, is determined by the physical condition of the structures in relation with their support.

1. Verify the plan if the span or distance of the column where the beam is resting indicates the following conditions:
   a) Center to center of the column
   b) Outer to center of the column
   c) Outer to outer side of the column
   d) Inside to inside span

2. Verify the splicing position of the reinforcement if it is adjusted to the commercial length of steel bars. Take note that "the lesser the splice the lesser is the cost".

3. Identify the bars with hook and bend for adjustment of their order length.

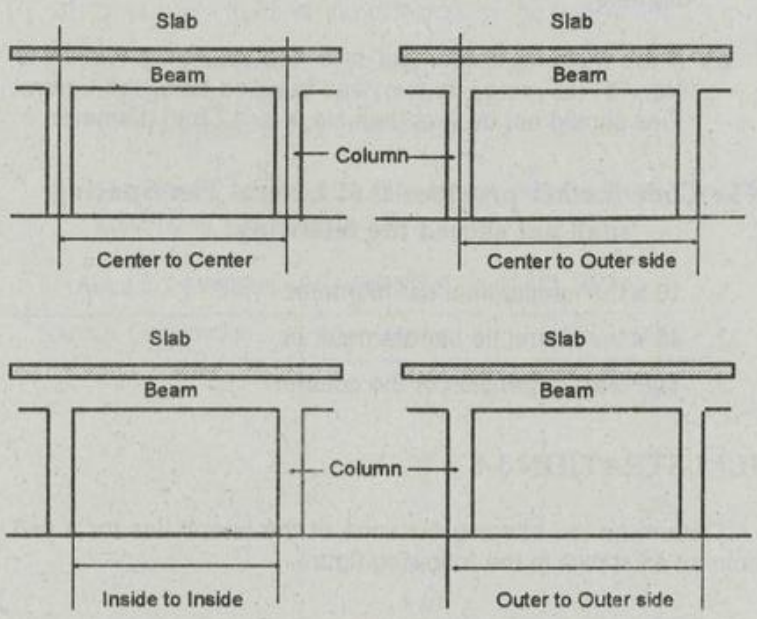


FIGURE 3-12

3-9 LATERAL TIES

Tied column has reinforcement consisting of vertical bars held in a position by lateral reinforcement called lateral ties.

The ACI Code provides that: *"All non pre-stressed bars for tied column shall be enclosed by lateral ties of at least No. 3 in size for longitudinal bars No. 10 or smaller and at least No. 4 in size for No. 11 to 18 and bundled longitudinal bars".*

The Code Provisions Simply Mean that:

a.) If the main longitudinal reinforcement of a tied column is

No. 10 bars or smaller in size (lower than 30 mm), the Lateral Ties should not be smaller than No. 3 bar or 10 mm diameter.

b.) If the main reinforcement of a tied column is No. 11 to No. 18 (35 mm to 66 mm) and bundled bars, the Lateral Ties should not be less than No. 4 or 12 mm diameter.

The Code further provides that Lateral Ties Spacing shall not exceed the following:

1. 16 x the longitudinal bar diameter
2. 48 x the lateral tie bar diameter or
3. The least dimension of the column

ILLUSTRATION 3-8

Determine the spacing distance of the lateral ties for a tied column as shown in the following figure.

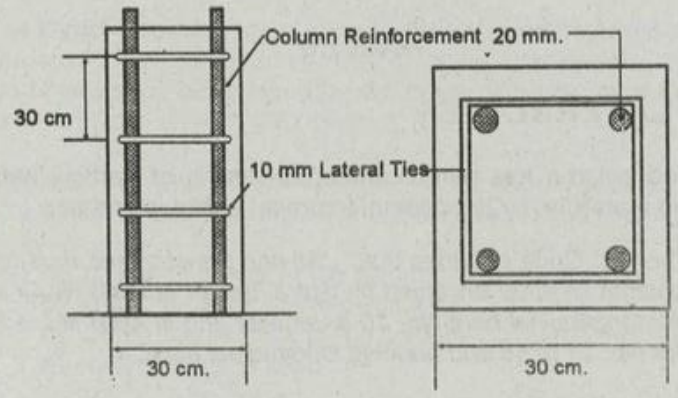


FIGURE 3-13 SPACING DISTANCE OF LATERAL TIES

SOLUTION

1. Determine the spacing distance of the lateral ties.

   a) 16 x 20 mm = 320 mm or 32 cm.
   b) 48 x 10 mm = 480 mm or 48 cm.
   c) The least side of the column is = 30 cm.

2. The lowest value is 30. Therefore, adopt 30 centimeters spacing of the lateral ties

TABLE 3-7 NUMBER AND DIAMETER OF STEEL BARS

Bar No. Designation	Inches	mm.
2	¼	6
3	3/8	10
4	1/2	12
5	5/8	16
6	¾	20
7	7/8	22
8	1.0	25
9	1-1/8	28
10	1-1/4	31
11	1-3/8	35
12	1-1/2	38
13	1-5/8	41
14	1-3/4	44
16	2.0	50
18	2-1/4	65

ILLUSTRATION 3 - 9

A building has 26 square columns 7.00 m. high with cross sectional dimensions of .50 x .50 m. with 8 pieces 20 mm main reinforcement. Find the lateral ties required using 10 mm and the corresponding tie wire.

SOLUTION

1. Determine the spacing of the lateral ties.

   16 x 20 mm. = 320 mm or 32 cm

48 x 10 mm. = 480 mm or 48 cm.

The least dimension of the column is 50 cm.

2. Adopt 32 cm. spacing of the lateral ties being the smallest value.

3. Determine the number of lateral ties in one column.

$$\text{Spacing} = \frac{7.00 \text{ m. ht.}}{.32 \text{ cm.}} = 21.875 \text{ say } 22$$

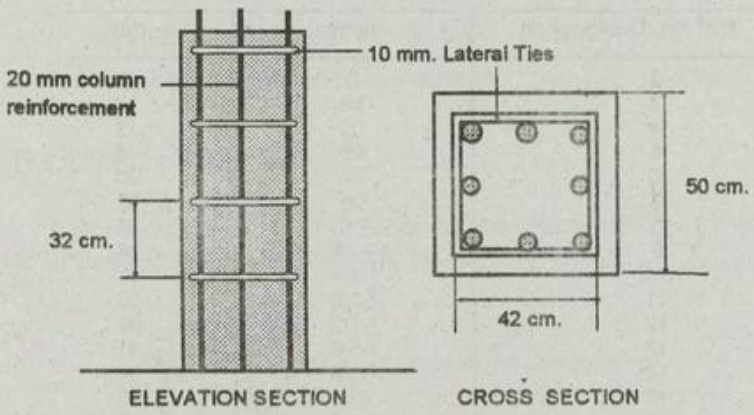


FIGURE 3-14

4. Take note that this 22 is the spacing distance between lateral ties. What we are after is the number of ties in one column height. Add one to get the number of lateral ties.

   No. of Lateral Ties: 22 + 1 = 23 pieces.

5. Solve for the total lateral ties in the 26 columns.

   Total ties: 23 x 26 columns = 598 ties

6. Determine the length of one Lateral Tie. By Inspection, the tie is 180 cm. or 1.80 meters long.

7. Find how many 1.80 meters could be derived from a commercial length of steel bars ranging from 6.00; 7.50 or 9.00 meters long. By trial division we have:

$$\frac{6.00}{1.80} = 3.33 \qquad \frac{7.50}{1.80} = 4.16 \qquad \frac{9.00}{1.80} = 5.0$$

8. From the above results, select 5 for having exact value which means exactly 5 pieces could be derived from a 9.00 meters long steel bar.

9. Divide the total number of ties in step 5 by the values found in step 7 to get the number of steel bars required.

$$\frac{598}{5.0} = 119.6 \text{ say } 120$$

10. Order: 120 pcs. 10 mm x 9.00 meters long steel bars.

Comments:

1. Step 7 is very important because without these trial divisions, cutting could be done on a 6.00 m. or 7.50 m. steel bars making so many extra cuts to be classified later as surplus or junks.

2. In cases where results of the trial divisions does not give an exact quotient, it becomes the estimator's choice to decide which length to use that will not produce excessive waste.

3. In this example, we have learned how to program the buying and cutting of steel bars for lateral ties minimizing if not totally avoiding unwanted cuts.

Solving for the Tie Wire

1. Find the number of main reinforcement in one column multiplied by the number of intersections with the lateral ties.

8 bars x 23 lateral ties = 184 intersections per column

2. Find the total intersections in the 26 columns:

   184 x 26 = 4,784 ties

3. This 4,784 is the total number of Tie Wires. If each tie is 40 cm. long, multiply to get the total length in meters.

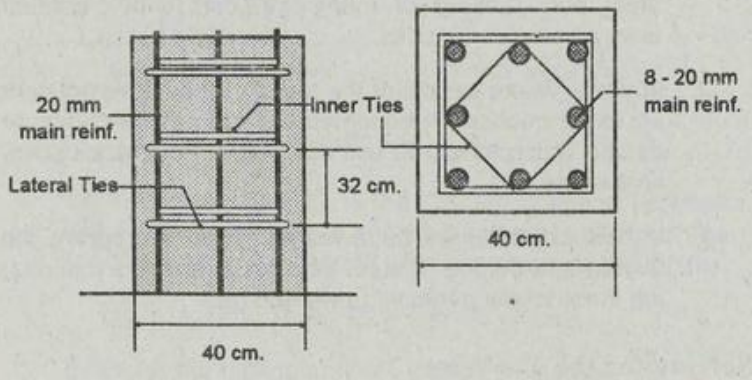
   .40 x 4,784 = 1,914 meters G.I. wire

4. One kilogram of No. 16 G.I. wire is approximately 53 meters, divide:

   $\frac{1,914}{53}$ m. = 36.1 say 37 kilograms

ILLUSTRATION 3-10

From the following figure, find the number of 10 mm. lateral ties if there are 30 columns at 8 meters high each including the tie wire in kilograms.



ELEVATION SECTION CROSS SECTION

FIGURE 3-15

SOLUTION

1. Determine the spacing of the lateral ties

   16 x 20 mm = 320 mm. Or 32 cm.
   48 x 10 mm = 480 mm. Or 48 cm.
   The least dimension of the column is 40 cm.

2. Adopt 32 cm. spacing, the smallest value found.

3. Determine the number of lateral ties in one column.

   Spacing = $\frac{8.00 \text{ m. ht}}{.32 \text{ m.}}$ = 25 pieces + 1 = 26

4. Find the total lateral ties in the 30 columns.

   a.) Inner Ties : 26 x 30 = 780 pieces
   b.) Outer Ties: 26 x 30 = 780 pieces

5. By Inspection, the length of the lateral ties are:

   a.) Inner ties = 100 cm. or 1.00 meter
   b.) Outer ties = 140 cm. or 1.40 meters

6. Find how many 1.00 meter and 1.40 meters could be derived from a commercial length of steel bars. By trial division we have:

   a.) $\frac{6.00}{1.00}$ m. = 6.0 pcs. the result has no fraction.

   b.) $\frac{6.00}{1.40}$ m = 4.28 pcs. with fraction, try another length

   c.) $\frac{7.50}{1.40}$ m = 5.35 pcs. with fraction, try another length.

   d.) $\frac{9.00}{1.40}$ m. = 6.42 pcs. still with fraction.

7. The results dictate that we use 6.00 meters steel bars.

a) For Inner Ties: $\frac{780}{6}$ = 130 pieces

b) For outer Ties : $\frac{780}{4.28}$ = 195 (disregarding .28)

8. Add (a) and (b) = 325 pcs. 10 mm x 6 m. steel bars.

TABLE 3-8 NUMBER OF LATERAL TIES IN ONE STEEL BAR AND QUANTITY PER METER LENGTH OF COLUMN

Lateral Ties Spacing	Number of Lateral ties per M. ht.	Length of Ties with Hook & Bend	Number of Cut in One Steel Bar Length				
			5 M.	6 M.	7.5 M.	9 M.	12 M.
15	6.70	60	x	10	x	15	20
		70	7	x	x	x	17
20	5.15	80	6	x	x	11	15
		85	x	7	x	x	14
25	4.13	90	x	x	8	10	13
		95	5	x	x	x	x
30	3.43	100	5	6	x	9	12
		105	x	x	7	x	x
35	3.00	110	x	x	x	8	x
		115	x	5	x	x	x
40	2.64	120	4	5	x	x	10
		125	4	x	6	x	x
45	2.36	130	x	x	x	x	9
		135	x	x	x	x	x
50	2.14	140	x	4	x	x	x
		145	x	4	5	6	x
55	1.96	150	x	4	5	6	8
		160	3	x	x	x	x
60	1.81	170	x	x	x	5	7
		180	x	x	4	5	x
		190	x	3	x	x	6
		200	x	3	x	x	6

X – Not advisable length for economical reasons.

Solving for the Tie Wire

1. Find the number of intersections between the main reinforcement and the lateral ties.

No. of Ties : 8 x 26 x 30 columns = 6,240 ties

2. Using .40m. long Tie Wire, find the total length of the wire.

.40 x 6,240 m. = 2,496 meters.

3. Convert to kilograms. $\frac{2,496}{53}$ = 47 kilograms

Table 3-8 was prepared to simplify further the estimate of column lateral ties and stirrups for beam and girder. The x – entry simply mean that such length of steel bars, is not recommended for economical reasons.

The table will guide the estimator in selecting reinforcing bars whose commercial length when divided by the length of each Lateral Tie or Stirrups will minimize extra cut of unwanted length. To use the table, consider the following example:

ILLUSTRATION 3-11

A building has 20 columns with cross sectional dimensions of 30 x 40 cm. each with a clear height of 7.00 meters. Find the number of 10 mm steel bars for lateral ties using Table 3-8.

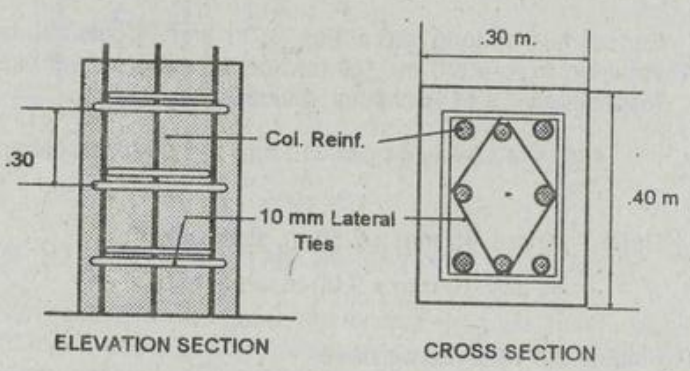


FIGURE 3-16

SOLUTION

1. By Inspection, there are two types of lateral ties.

   a.) Outer ties = 125 cm. with hook

   b.) Inner ties = 80 cm. with hook

2. Find the total length of the 20 columns.

   7.00 x 20 column = 140 meters.

3. Refer to Table 3-8. Under spacing of lateral ties at 30 cm. distance, there are 3.43 pieces per meter height. Multiply:

   140 m. x 3.43 = 480 pcs. outer ties

   480 pcs. of Inner ties.

4. Refer again to Table 3-8. Under length of ties along 125 centimeters, 4 and 6 pieces could be derived from a 5.0 and 7.50 meters steel bars respectively. If 6 cuts is chosen, divide:

   $\frac{480}{6}$ = 80 pcs.-10 mm x 7.50 m. steel bars

5. For the 80 cm. long lateral ties, 6; 11 and 15 cuts can be obtained from a 5.0 m., 9.0 m. and 12 meters steel bars respectively. If 11 is chosen, divide:

   $\frac{480}{11}$ = 43.6 say 44 pcs.-10 mm x 9.00 m. steel bars

6. Order: 80 pcs. 10 mm x 7.50 m. steel bars

   44 pcs. 10 mm x 9.00 m. steel bars

7. Finding the Tie Wire we have:

   480 lateral ties x 8 main reinforcement = 3,840 ties

8. If the length of each tie is 40 cm. find the total length:

   3,840 x .40 = 1,536 meters

9. Convert to kilograms, divide by 53 m.

   $\frac{1,536}{53}$ m. = 28.9 say 29 kilograms.

Problem Exercise

From the following figure, find the number of 10 mm lateral ties and tie wire if there are 36 columns with cross sectional dimensions of 60 x 90 cm. at 12.00 meters long per column.

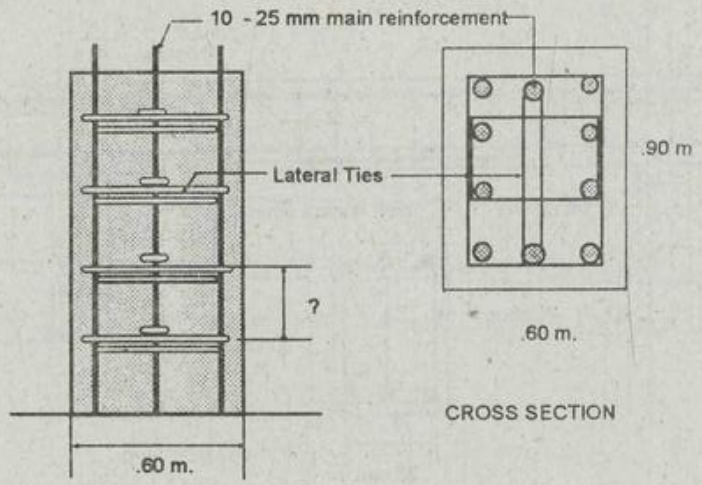


FIGURE 3-17

3-10 STIRRUPS FOR BEAM AND GIRDER

Stirrup is the structural reinforcing member that holds or binds together the main reinforcement of a beam or girder to a designed position. The two types of stirrup commonly used are the open stirrups and the closed stirrups.

The procedures adopted in estimating the number of stirrups for beam and girder is the same as that of the lateral ties as explained using Table 3-8. However, the spacing distance of the stirrup requires special consideration because they are gradually becoming closer towards the support. Hence, it is important to get the average number of stirrups per span or by direct counting from the detailed plan.

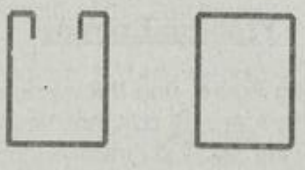


FIGURE 3-18 OPEN AND CLOSED STIRRUPS

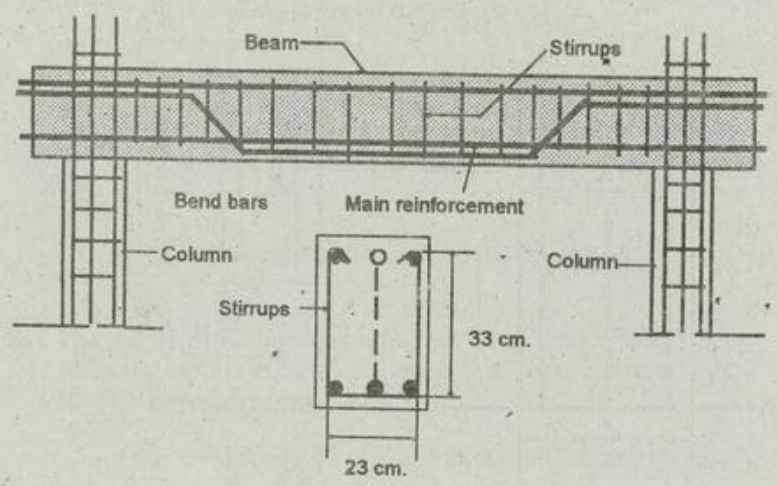


FIGURE 3-19 STIRRUPS ON BEAM

ILLUSTRATION 3-12

A reinforced concrete beam with a cross-sectional dimensions as shown above specify the use of 10 mm open stirrups

spaced as shown in Figure 3-19. If there are 16 beams of the same design, find the materials required for the stirrups.

SOLUTION

1. By direct counting, there are 17 stirrups at 99 cm. long say 1.00 meter.

2. Find the total number of stirrups

   17 x 16 beams = 272 pieces.

3. Refer to Table 3-8. For a 1.00 m. long stirrup the choice is either 6.0 m.; 9.0 m.; or 12 meters long steel bar. For easy handling use 6.0 meters long. Divide:

   $\frac{272}{6}$ = 45.3 say 46 pcs. – 10 mm x 6.00 meters

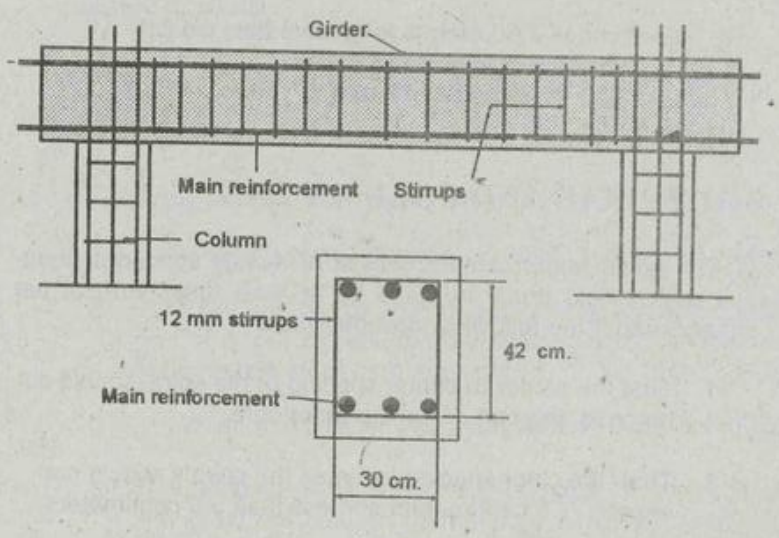


FIGURE 3-20 STIRRUPS ON GIRDER

ILLUSTRATION 3-13

From Figure 3-20, compute the number of 12 mm stirrups required if there are 12 girder of the same design.

SOLUTION

1. By direct counting, there are 15 stirrups per span, if there are 12 girders; multiply :

   15 x 12 girders = 180 stirrups

2. By inspection the length of one stirrup is 150 cm. Refer to Table 3-8, along 150 cm. length of ties, 4, 5, 6 and 8 cuts could be derived from 6.00; 7.50; 9.00 and 12 meters steel bars respectively. If we chose 6.00 m. long.

   $\frac{180}{4}$ = 45 piece 12 mm x 6.00 m. steel bars.

3. If we chose 7.50 meters long steel bars we get:

   $\frac{180}{5}$ = 36 pieces 12 mm x 7.50 m.

3-11 SPIRAL AND COLUMN TIES

The spiral reinforcement consist of evenly spaced continuous spirals held firmly in place by at least three vertical bar spacers under the following considerations

1. That the center to center spacing of the spiral should not exceed 6th part of the diameter core.
2. That, the clear spacing between the spirals should not exceed 7.5 centimeters nor less than 5.0 centimeters.
3. That the clear spacing between the spirals be less than 1-1/2 times the biggest size of the coarse aggregate.

ILLUSTRATION 3-14

A spiral column with a cross sectional diameter of 50 cm. requires 10 mm spiral reinforcement as shown in the following figure. If there are 14 columns at 7.00 meters high, find the number of 10 mm steel bars needed for a 5 cm. pitch spirals.

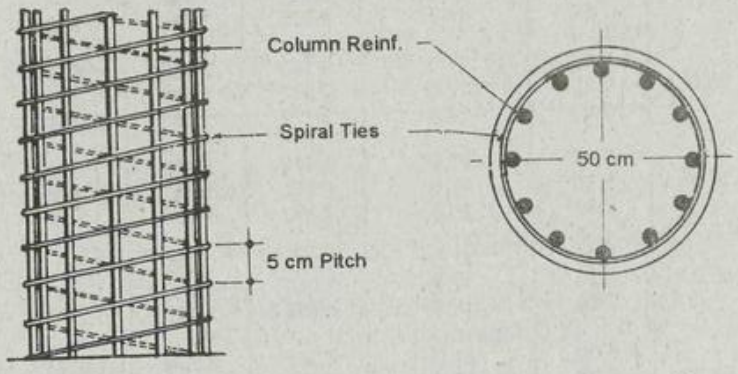


FIGURE 3-21 SPIRAL COLUMN

SOLUTION

A. Solving the Spiral Reinforcement

1. Total length of 14 columns: 7.00 m. x 14 = 98 meters.
2. Find the number of 10 mm bar spirals. Refer to Table 3-9. For a 50 cm. column diameter, 5.0 cm. pitch using a 6.00 meters steel bars, multiply:

   98 m. x 4.919 = 482.1 say 483 x 10 mm x 6.00 m.

3. If 9.00 meters will be used as spiral, from Table 3-9. along 50 cm column diameter, 5 cm. pitch under 9 m. steel bars the entry is 3.223. Multiply:

   98 m. x 3.223 = 316 pieces. 10 mm x 9.00 m.

TABLE 3-9 NUMBER OF SPIRAL REINFORCING BARS PER METER HEIGHT

Column Dia. cm.	Pitch cm.	No. of Turn per Meter ht.	Number of Steel Bars from a 6.00 m.	9.00 m.	12.00 m.
30.0	5.00	21.0	2.604	1.706	1.269
	6.25	17.0	2.108	1.381	1.027
	7.50	14.3	1.778	1.165	0.866
32.5	5.00	21.0	2.894	1.896	1.410
	6.25	17.0	2.342	1.535	1.141
	7.50	14.3	1.975	1.294	0.962
35.0	5.00	21.0	3.183	2.085	1.550
	6.25	17.0	2.577	1.688	1.255
	7.50	14.3	2.172	1.423	1.058
37.5	5.00	21.0	3.472	2.275	1.692
	6.25	17.0	2.811	1.842	1.393
	7.50	14.3	2.370	1.524	1.154
40.0	5.00	21.0	3.762	2.465	1.833
	6.25	17.0	3.045	1.995	1.484
	7.50	14.3	2.567	1.682	1.251
42.5	5.00	21.0	4.051	2.654	1.974
	6.25	17.0	3.281	2.149	1.598
	7.50	14.3	2.765	1.812	1.347
45.0	5.00	21.0	4.340	2.844	2.115
	6.25	17.0	3.513	2.302	1.712
	7.50	14.3	2.962	1.940	1.443
47.5	5.00	21.0	4.630	3.033	2.256
	6.25	17.0	3.748	2.455	1.826
	7.50	14.3	3.159	2.070	1.539
50.0	5.00	21.0	4.919	3.223	2.397
	6.25	17.0	3.982	2.609	1.940
	7.50	14.3	3.357	2.199	1.635
55.0	5.00	21.0	5.498	3.602	2.678
	6.25	17.0	4.525	3.017	2.253
	7.50	14.3	3.752	2.524	1.888
60.0	5.00	21.0	6.077	3.981	2.960
	6.25	17.0	4.919	3.223	2.396
	7.50	14.3	4.146	2.717	2.020

70.0	5.00	21.0	7.234	4.740	3.524
	6.25	17.0	5.856	3.837	2.853
	7.50	14.3	4.936	3.234	2.405
80.0	5.00	21.0	8.391	5.498	4.088
	6.25	17.00	6.793	4.451	3.310
	7.50	14.3	5.726	3.752	2.790
90.0	5.00	21.0	9.549	6.256	4.652
	6.25	17.0	7.730	5.064	3.766
	7.50	14.3	6.366	4.171	3.101
100.0	5.00	21.0	10.706	7.014	5.216
	6.25	17.0	8.667	5.678	4.222
	7.50	14.3	7.137	4.676	3.477

B. Finding the Tie Wire

1. Find the number of vertical bars per column = 12 pieces
2. Refer to Table 3-9. Under 50 cm. column diameter, 5 cm pitch, the number of turn per meter height is 21. Multiply:

   12 x 21 = 252 Ties per meter height
3. Total Ties for 14 column at 7.00 m. high is:

   252 x 7.00 x 14

   = 24,696 ties
4. Total length of the wire at .30 m. long per tie:

   24,696 x .30

   = 7,409 meters.
5. Convert to kilograms. Divide by 53.

   $\frac{7,409}{53}$ = 139.8 say 140 kilograms

3-12 ONE WAY REINFORCED CONCRETE SLAB

One of the most commonly used concrete floor systems is the solid slab that is continuous over parallel supports. The supports may consist of bearing walls of masonry or a set of evenly spaced concrete beams. The principal reinforcement runs in one direction parallel to the slab span and perpendicular to the supports. One method used in finding the number of steel bars for a one-way reinforced concrete slab is either by the direct counting or by the area method.

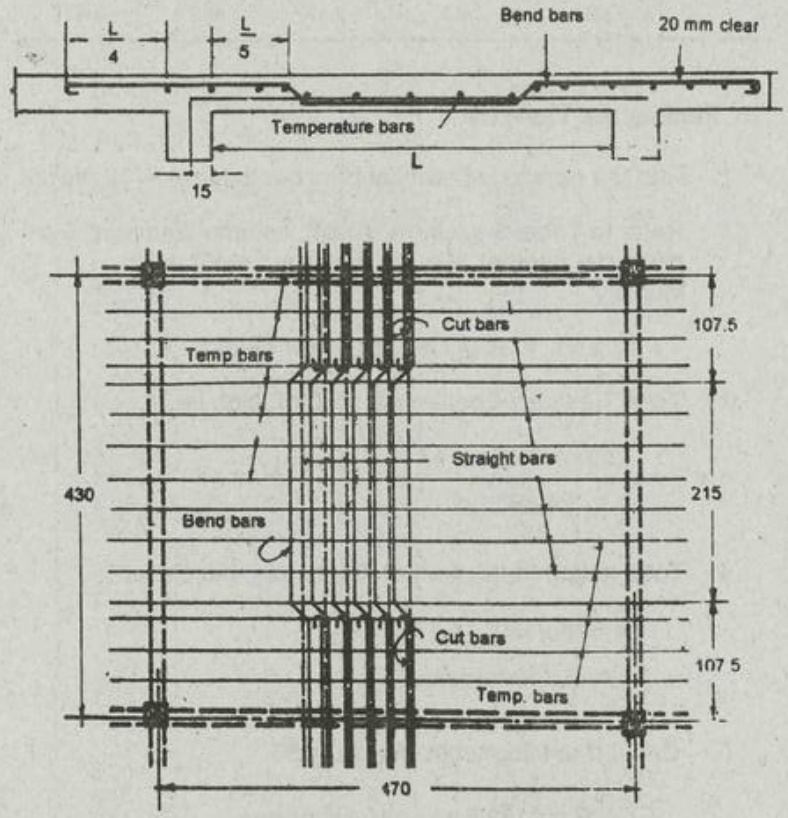


FIGURE 3- 22 ONE WAY SLAB REINFORCEMENT

ILLUSTRATION 3-15

From Figure 3-22 of a one-way reinforced concrete slab, determine the number of 12 mm. steel bars including the tie wire required.

A. SOLUTION (By Direct Counting)

Given Data:

Spacing of main reinforcement	= 15 cm.
Temperature bar spacing	= 30 cm.
Size of the reinforcement	= 12 mm diameter
Type of reinforcement	= One way

1. Find the number of main reinforcements at .15 m. spacing

$$\frac{5.70}{.15} = 38 \text{ pieces}$$

2. This 38 is the spacing between bars, and to get the number of steel bars add 1

38 + 1 = 39 pieces x 6.00 m. main reinforcement.

This 39 bars are the alternate straight and bend bars.

3. Find the number of cut bars in between the bent bars.

$$\frac{5.70}{.30} + 1 = (20 \times 2 \text{ sides}) = 40 \text{ pcs. at } 1.40 \text{ m.}$$

4. Using a 6.00 meters steel bar, divide by 1.40 to get the number of cut in one steel bar.

$$\frac{6.00 \text{ m.}}{1.40} = 4.28 \text{ cuts (use 4 disregarding .28)}$$

5. Divide the result of step 3 by this 4 cuts

$$\frac{40}{4} = 10 \text{ pieces at 6.00 m. steel bars}$$

6. Find the main reinforcement; add step 2 and step 5.

   39 + 10 = 49 pieces 12 mm x 6.00 m.

Finding the Shrinkage and Temperature Bars

1. Across the main reinforcement, divide by .30 spacing

   $\frac{5.50}{.30}$ + 1 = 19.33 say 20 pieces x 6.00 m.

2. Along the 1.40 m. span top bars.

   $\frac{1.40}{.30}$ + 1 = 5.6 say 6 pieces at 6.00 meters.

3. Since there are 2 sides at 1.40 m. multiply:

   6 x 2 sides = 12 pieces at 6.00 meters long

4. Add the results of step I and step 3.

   20 + 12 = 32 pieces

5. **Summary** :

   Main reinforcement: 39 + 10 = 49 pcs. 12 mm x 6.00 m.
   Temperature bars: 20 + 12 = 32 pcs. 12 mm x 6.00 m.
   Total ..... 81 pcs. 12 mm x 6.00 m.

It will be noted that the preceding, solution by Direct Counting Method is some what complicated considering that there are three different items of reinforcement involved:

a) The main reinforcement composed of straight and bend bars;
b) The cut alternate bars between the bend bars and
c) The shrinkage and temperature bars.

Table 3-10 was prepared for a more simplified solution in finding the reinforcement of a one way slab by the so called Square Meter Area Method.

TABLE 3-10 QUANTITY OF REINFORCING STEEL BARS IN A ONE-WAY REINFORCED CONCRETE SLAB

Bar Spacing cm.	Number of Steel Bars per Square Meter			
	6.00 M.	7.50 M.	9.00 M.	12.00 M.
10.0	3.764	2.937	2.421	1.769
12.5	3.062	2.381	1.934	1.427
15.0	2.584	2.004	1.636	1.197
17.5	2.232	1.726	1.407	1.033
20.0	1.980	1.528	1.258	0.914
22.5	1.786	1.369	1.109	0.810
25.0	1.627	1.250	1.014	0.736

* The ACI Code provides that the center to center bar spacing must not be greater than five times the slab thickness.

TABLE 3-11 QUANTITY OF TIE WIRE ON A ONE WAY REINFORCED CONCRETE SLAB IN KILOGRAMS PER SQUARE METER

Bar Spacing in Centimeters	Length of Steel Bars							
	6.00 M		7.50 M		9.00 M		12.00 M	
	.30	.40	.30	.40	.30	.40	.30	.40
10.0	.474	.632	.462	.616	.460	.614	.448	.598
12.5	.316	.422	.307	.409	.295	.394	.293	.391
15.0	.228	.303	.217	.289	.214	.285	.207	.276
17.5	.168	.224	.162	.216	.158	.210	.153	.204
20.0	.132	.175	.126	.168	.125	.167	.120	.160
22.5	.110	.147	.102	.135	.099	.132	.095	.126
25.0	.089	.118	.086	.114	.081	.108	.077	.103

B. SOLUTION (By the Area Method)

1. Determine the floor area.

   Area: 5.70 x 5.50 = 31.35 square meters

2. Refer to Table 3-10. Using a 6.00 meter long steel bars at 15 cm. spacing distance, multiply:

31.35 x 2.584 = 81 pieces 12 mm x 6.00 meters.

Solving the Tie Wires at . 30 cm. long

Refer to Table 3-11, along bar spacing at 15 cm. using a 30 cm. tie wire, multiply:

31.35 x .228 = 7.15 say 8 kg. # 16 G.I. wire.

ILLUSTRATION 3-16

From the following floor plan, find the quantity of steel bars and the tie wire required using 12 mm x 7.50 meters steel bars.

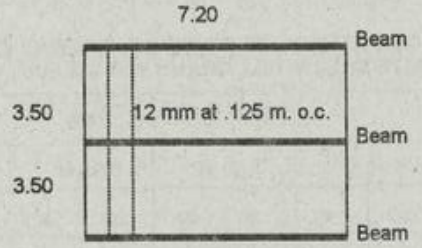


FIGURE 3-23 REINFORCED CONCRETE FLOOR PLAN

SOLUTION

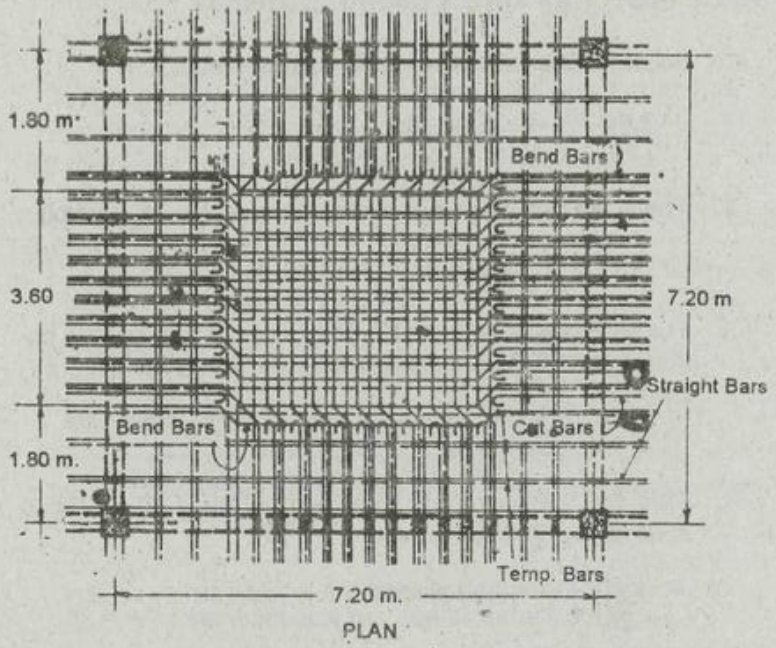
1. Solve for the Area of the floor: 7.20 x 7.00 = 50.40 sq. m.
2. Refer to Table 3-10 along 12.5 spacing, under 7.50 m. steel bars, multiply:

   50.40 x 2.381 = 120 pieces 12 mm x 7.50 m.
3. For tie wire, refer to Table 3-11. using a .30 m. long multiply

   50.40 x .307 = 15.5 kilograms

3-13 TWO-WAY REINFORCED CONCRETE SLAB

A two-way reinforced concrete slab consists of a multiple bays of solid two-way spanning slab supported by beams or girders.



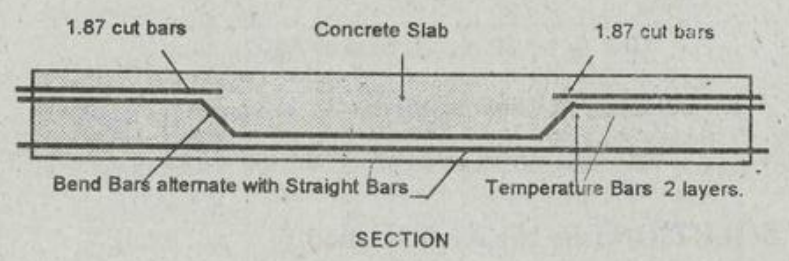


FIGURE 3-24 REINFORCEMENT OF TWO WAY CONCRETE SLAB

ILLUSTRATION 3-17

From Figure 3-24, determine the number of 12 mm steel bars spaced at 10 cm. on center including the tie wire required.

SOLUTION (By Direct Counting Method)

1. Solve for the number of main reinforcement.

   $\frac{3.60}{.10} + 1 = 37$ pieces

2. There are two cross run of main reinforcement, multiply:

   37 x 2 = 74 pieces

3. For additional cut bars at 1.80 m. long, 4 cuts can be obtained from a 7.50 m. steel bars. Divide

   $\frac{74}{4} = 18.5$ say 19 pcs 12 mm x 7.50 m. steel bars

4. Find the Temperature bars across the 1.80 m. span spaced at .20 m. on center.

   $\frac{1.80}{.20} + 1 = 10$ pieces

5. Multiply by 4 sides at 2 layers, one at the bottom and one at the bend bars. (see figure 3-24)

   10 x 8 = 80 pieces bars at 7.50 m. long

6. Summary of steel bars from step 2, 3 and 5.

   74 + 19 + 80 = 173 pieces 12 mm x 7.50 m.

SOLUTION (By the Area Method)

1. Find the area of floor slab

Floor Area = 7.20 x 7.20 = 51.84 sq. m.

2. Refer to Table 3-12. Using a 7.50 m. steel bars at 10 cm. spacing of main reinforcement, multiply:

   51.84 x 3.337 = 173 pieces 12mm x 7.50 meters

TABLE 3-12 QUANTITY OF STEEL BARS IN A TWO WAY REINFORCED CONCRETE SLAB PER SQUARE METER

Bar Spacing in Centimeters	Number of Steel Bars per Square Meter			
	6.00 M	7.50 M	9.00 M	12.00M
10.0	4.369	3.337	2.772	2.022
12.5	3.603	2.662	2.245	1.635
15.0	3.221	2.296	1.921	1.382
17.5	2.647	2.025	1.650	1.196
20.0	2.360	1.775	1.461	1.056
22.5	2.168	1.601	1.312	0.907
25.0	1.977	1.466	1.217	0.862

* The ACI Code provides that the center to center spacing of temperature bars must not be greater than five times the slab thickness.

TABLE 3-13 TIE WIRE IN A TWO-WAY REINFORCED CONCRETE SLAB IN KILOGRAMS PER SQUARE METER

Bar Spacing in Centimeters	Length of Steel Bars							
	6.00 M		7.50 M		9.00 M		12.00 M	
	.30	.40	.30	.40	.30	.40	.30	.40
10.0	.592	.896	.648	.863	.648	.864	.596	.794
12.5	.416	.554	.420	.560	.431	.574	.421	.561
15.0	.350	.466	.307	.409	.257	.343	.297	.396
17.5	.247	.330	.231	.308	.223	.298	.206	.275
20.0	.174	.232	.171	.227	.173	.231	.163	.217
22.5	.168	.224	.150	.200	.148	.198	.130	.173
25.0	.142	.189	.134	.178	.114	.152	.116	.155

Solving for the Tie Wire

1. Refer to Table 3-13, along 10 cm bar spacing and 30 cm. long tie wire, multiply by the area:

   51.84 x .648 = 33.6

2. Order 37 kilograms of No.16 G.I. wire.

3-14 CONCRETE PIPE REINFORCEMENT

ILLUSTRATION 3-18

From the following Figure, determine the quantity of 10 mm steel bars and the tie wire required.

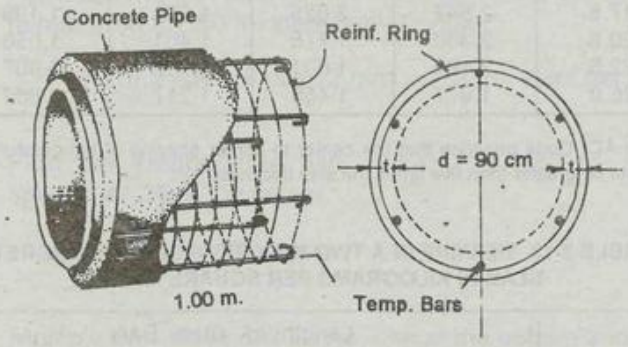


FIGURE 3-25

SOLUTION

1. Solve for the circumference of the circle at midpoint of the concrete thickness " t "

   $C = \pi d$

   C = 3.1416 x (.90 + .10) = 2.1416 m.

2. Total length of one ring plus .15 m. splice.

   3.1416 + .15 = 3.29 meters

3. Find the total number of ring at 15 cm. spacing distance.

   $\frac{1.00}{.15}$ m. = 6.7 number of spacing distance

4. Add one to get the number of ring: 6.7 + 1 = 7.7 say 8 pieces at 3.29 meters.

5. Find the number of shrinkage and temperature bars at say .20 m. on center.

   $\frac{3.29}{.20}$ = 16.45 say 17 pieces

6. Summary of the Reinforcements

   8 pcs. 10 mm. x 3.29 m. long

   17 pcs. 10 mm. x 1.00 m. long

Solve for the Tie Wire

1. Total number of ring multiplied by the number of shrinkage and temperature bars.

   8 x 17 = 136 ties x .30 cm. long per tie = 41 meters

2. Convert this length to kilograms. Divide by 53.

   $\frac{41}{53}$ = .77 say 1.0 kilograms # 16 G.I. wire

Problem Exercise

1. A road construction requires 75 pieces concrete pipe at 60 centimeters diameter. Compute the number of 8 mm steel bars, tie wires and the concrete required using class A mixture.

2.) A flood control project requires 80 and 50 pieces concrete pipes with 120 and 90 centimeters diameter respectively. Compute for the following:

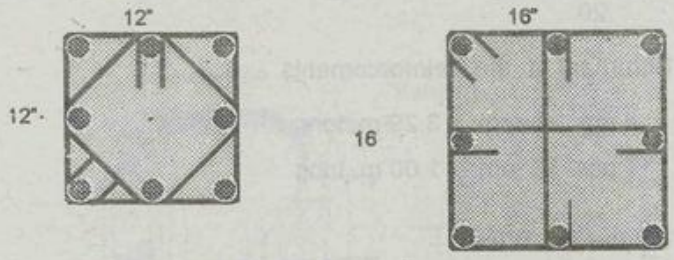
a) 10 mm reinforcement for the 120 cm. pipe

b) 8 mm reinforcement for the 90 cm. pipe

c) Tie wire

d) Concrete using class A mixture

3.) From the following figure, find the main and lateral ties steel reinforcement for 20 columns each with a height of 15 meters.



COLUMN A COLUMN B

FIGURE 3-26

Column A	Column B
Main Reinforcement = 16 mm	Main Reinforcement = 20 mm
Lateral Ties = 10 mm	Lateral Ties = 10 mm
Number of column = 20	Number of column = 20
Height = 16 meters	Height = 24 meters

Suggested Estimating Procedures

a. For accuracy of the lateral ties cut length make a full scale drawing then measure the actual length.

b. Check the length of your tie wire from the actual size of main steel bars and the lateral ties.

c. Remember the additional length for hook and bend.

3. From the following circular column, determine the spiral reinforcement and the tie wires required under the following specifications:

a. Spiral reinforcement = 10 mm
b. Pitch of spiral = 5 cm.
c. Number of columns = 12
d. Height of each column = 5.00 m.
e. Diameter of the column = 55 centimeters
f. Number of main reinforcement 16 – 16 mm

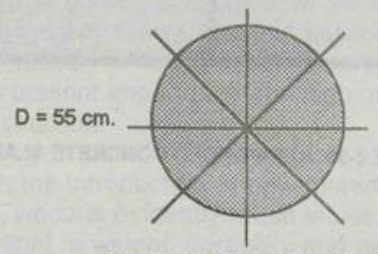


FIGURE 3- 27 SPIRAL COLUMN

4. Determine the required reinforcement and tie wire of a one way reinforced concrete slab using 12 mm steel bars designed as follows:

a.) Main reinforcement 12 mm at 5 inches on center.
b.) Temperature bars 12 mm at 10 inches on center.

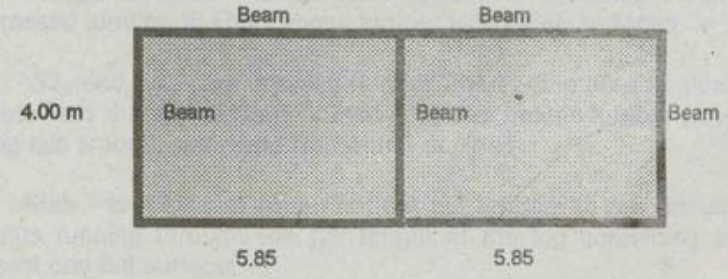


FIGURE 3-28 ONE WAY CONCRETE SLAB

5. A two way reinforced concrete slab will be reinforced by 12 mm steel bars space at 7 inches and the temperature bars at 14 inches on center. List down the metal reinforcement required including the tie wire.

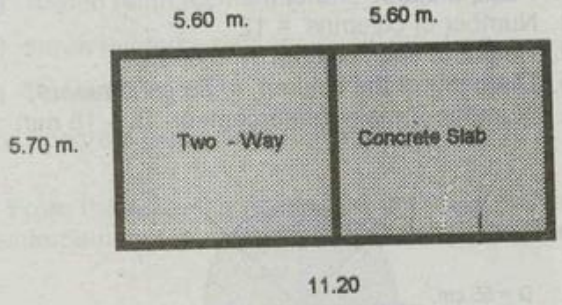


FIGURE 3-29 REINFORCED CONCRETE SLAB

CHAPTER 4

LUMBER

4-1 WOOD

Wood is that fibrous substance which composes the trunk and the branches of a tree that lies between the pith and the bark. The versatility of using wood in every construction has lifted it to its present importance and high demand in almost all types of construction.

Even with the introduction of new materials and methods of construction, wood is evidently much in use. Wood, because of its strength, light in weight, durability and ease of fastening become one of the most important building materials.

4-2 DEFINITION OF TERMS

Lumber - is the term applied to wood after it has been sawed or sliced into boards, planks, timber etc.

Rough Lumber - is the term applied to unplaned or undressed lumber. In short, those lumber with rough surfaces.

$S2_S$ and $S4_S$ - are dressed lumber wherein the number connotes the smooth sides. For instance, S2s means lumber having two smooth sides and S4s with four sides.

Slab - is a kind of rough lumber cut tangent to the annual rings running through the full length of the log containing at least one flat surface.

Surface or Dressed Lumber - is a planed lumber having at least one smooth side.

Timber - is a piece of lumber five inches or larger in its smallest dimension.

Plank - is a wide piece of lumber from 4 to 5 inches thick.

Board - is a piece of lumber less than 4 centimeters thick with at least 10 centimeters wide.

Flitch - is a thick piece of lumber.

Fine Grained - when the annual rings are small, the grain or marking which separates the adjacent rings is said to be fine grained. When large, it is called **Coarse Grained**.

Straight Grained - Is a term used when the direction of the fibers are nearly parallel with the side and edges of the board.

Crooked or Cross Grained - is a lumber taken from a crooked tree.

4-3 CLASSIFICATION OF WOOD

Wood that are used in building constructions are those which grows larger by addition of a layer on the outer surface each year known to botanists as EXOGENS.

Wood is Classified According to:

1. **Mode of Growth**

   a. **Indigenous** - are those trees that grows from the inside. These kind of trees has a soft center core and are not preferred for lumbering.

   b. **Exogenous** - are those outward growing trees preferred for lumbering.

2. **With Respect to Density** - It is either:
   a. Soft
   b. Hard

3. **With Respect to Leaves** - is either:
   a. Needle shape
   b. Broad shape

4. **With Respect to Shades or Colors**
   a. White
   b. Yellow
   c. Red
   d. Brown
   e. Black, etc.

Cross Section of a Tree

FIGURE 4-1

5. **With Respect to the Grain**
   a. Straight
   b. Cross
   c. Fine
   d. Coarse

6. **With Respect to the Nature of Surface when Sawed**

a. Plain
b. Grained
c. Figured or Marked

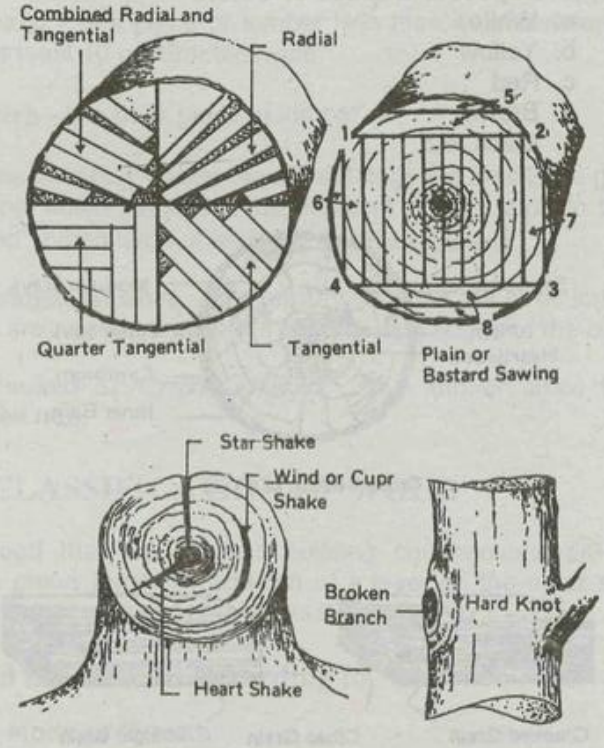


FIGURE 4-2 METHODS OF LOG SAWING

4-4 METHODS OF LOG SAWING

Lumbering is the term applied to the operations performed in preparing the wood for commercial purposes. Logging is the process or operations from cutting of trees, hauling and delivery to the sawmill for sawing. Sawing on the other hand is the operation of cutting logs into commercial sizes of lumber.

The Methods and Manner of Log Sawing

1. Plain or Bastard Sawing
2. Quarter or Rift Sawing
   a. Radial
   b. Tangential
   c. Quarter Tangential
   d. Combined Radial and Tangential

4-5 DEFECTS IN WOOD

The term defect refers to irregularities found in wood. And the most common defects in wood are:

1. Caused by Abnormal Growth Such as:

a. **Heart Shakes** are radical cracks in wood originating from the heart of the logs. Heart shake is commonly found in old trees.

b. **Wind Shakes or Cup Shakes** are cracks or breaks across the annual rings of the wood during its growth caused by excessive bending of the tree due to strong wind.

c. **Star Shakes** are composed of several heart shakes radiating from the center of the log in a star like manner.

d. **Knots** - occurs at the starting point of a limb or branch of the tree.

2. Due To Deterioration

a. **Dry Rot** - is caused by fungi in a seasoned lumber due to the presence of moisture.

b. **Wet Rot** - takes place sometime in the growth of the tree caused by water saturation.

4-6 SEASONING OF LUMBER

By nature, trees contain moisture in their cell layers. This moisture has to be expelled thoroughly to preserve the wood from shrinkage or decay. Experiments proved that wood immersed in water immediately after cutting is less subject to splitting and decay. It reduces warping but become brittle and less elastic. Soaking of wood in liquid is the oldest method of seasoning lumber introduced and practiced by the ancient Roman builders.

Methods of Seasoning Lumber

1. The Natural Sunlight or Air- Seasoning Process is considered as one of the best method used in seasoning of wood although the period involved is relatively longer.

2. The Artificial Seasoning is a process where lumbers are stacked in a drying kiln and then exposed to steam and hot air. Under this method, lumber undergoes a quick drying process.

The Artificial Methods of Seasoning Wood are:

1. By Forced Air Drying
2. By Kiln Drying
3. By Radio Frequency Dielectric Drying

Good seasoning is the primary consideration for successful preservation of wood. Wood does not decay naturally through age, nor will it decay if it is kept constantly dry or continuously submerged in water.

The Common Causes of Decay in Wood are:

1. Alternate moisture and dryness
2. Fungi or molds
3. Insects and worms
4. Heat and confined air

The Process of Preserving Wood are:

1. **External Process.** The wood is coated with preservative applied as paint to penetrate the fibers of the wood.
2. **Internal process.** A chemical compound is impregnated at a prescribed pressure to permeate the wood thoroughly

4-7 THE UNIT MEASURE OF LUMBER

Board Foot is the unit of measure used in computing the volume of lumber. Despite the adoption of the Metric System (SI), board foot for lumber is still in use for convenience and practical use. One board foot simply mean, one square foot by one-inch thick lumber or an equivalent of 144 cubic inches. The width and thickness of commercial lumber are expressed in inches while the length is in feet of even numbers.

Board foot is found by dividing the product of the thickness, the width and the length by 12.

ILLUSTRATION 4-1

Find the total board feet of 5 pieces 2" x 6" x 14" ft. lumber.

SOLUTION

$$\text{Board foot} = \frac{5 \times 2 \times 6 \times 14\text{ ft.}}{12} = 70 \text{ bd. ft.}$$

Finding the board foot of a commercial size lumber is as simple as the above illustration. But the question is how to find the net board foot of a round log or a standing tree knowing its diameter and height? This question can be answered using the following formula:

$$\text{Bd. Ft. Volume} = \frac{(D-4)^2 \times L}{16}$$

Where: D = The smaller diameter of the log
L = The length of the log
4 = Constant as reduction factor

ILLUSTRATION 4-2

Determine the total board foot lumber which could be derived from a round log 28 inches diameter by 6.00 meters (20') long as shown in Figure 4-3.

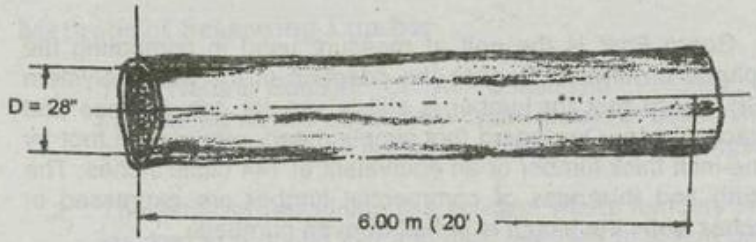


FIGURE 4-3 NET BOARD FOOT IN A LOG

SOLUTION

1. Substitute given data in the formula:

$$\frac{(28-4)^2 \times 20 \text{ ft.}}{16} = 720 \text{ bd. ft.}$$

In solving board foot of lumber, convert first all measurements from Metric to English. Take note that the thickness and width are in inches and length in feet.

Manner of Payment in Sawing or Slicing Lumber

There are two methods of computing payment for slicing or sawing lumber.

1. By board foot or
2. By meter length

The board foot method is simply computing the total board foot of sawed lumber then multiplied by the agreed price per board foot. On the other hand, the meter length method is multiplying the width in inches by the length in meter times the agreed unit price per meter run.

ILLUSTRATION 4-3

How much will it cost to slice a 6" x 6" x 3.00 meters wood to produce a 2 x 6 lumber if the unit price is P2.00 per board ft.

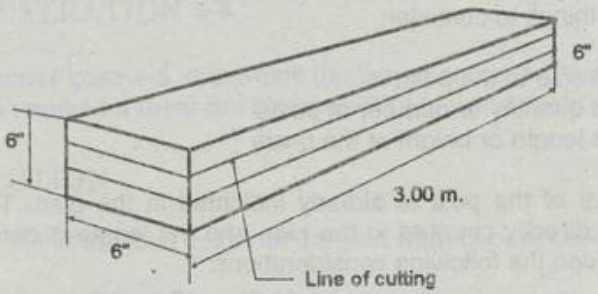


FIGURE 4-4

SOLUTION (By Board Foot Method)

1. Find the total board foot of lumber

$$\frac{6" \times 6" \times 10 \text{ ft}}{12} = 30 \text{ bd. ft.}$$

2. Multiply by the unit price say P 2.00

30 x 2.00 = P60.00

SOLUTION (By Inch-Meter Method)

1. Multiply the width by the length

6" x 3.00 = 18

2. Multiply by number of cut

   18 x 2 = 36 Inch - Meter

3. Multiply by the unit cost

   36 x 1.65 = P 59.40

4-8 WOOD POST

In estimating wooden post for building structure, there are only three things to consider:

1. The size of the post
2. The quantity or number of posts
3. The length or height of the posts

The size of the post is already indicated in the plan. The quantity is directly counted in the plan and the length is determined through the following considerations:

1. For one story building, verify if the elevation height indicates from floor to ceiling. If the ceiling is below the girts add the depth of the girts including the bottom chord or the rafters to the height of post.

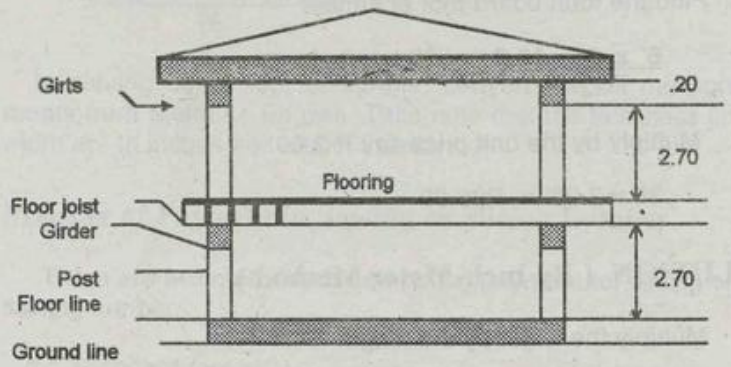


FIGURE 4-5

2. For a two story building, verify if the height indicates from floor to floor. If so then consider the additional depth of the girder, the floor joist and the flooring. And for the second floor, add the depth of the girts, bottom chord or rafters to the height of the post.

3. Take note that the commercial length of lumber is always of even number. If the computed length is odd number adjust the order to the next even number length.

ILLUSTRATION 4-4

From Figure 4-5, determine the length and board foot of the posts required if there are 8 pieces 6" x 6" wood posts.

SOLUTION

1. Find the total height of the post from floor to ceiling

   2.70 + 2.70 = 5.40 m.

2. Determine the depth of the girder, floor joist, flooring and the girts.

   Girder = .20
   Floor joist = .15
   Flooring = .025
   Girts = .20
   .575 m.

3. Add results of 1 and 2 to get the total length.

   L = 5.40 + .575
   = 5.975 meters

4. Convert to feet: $\frac{5.975}{.30}$ = 20 ft

5. Order: 8 - 6" x 6" x 20' = 480 board ft.

4-9 GIRDER

Girder is the structural member of a building that carries the floor joist and the flooring. It is determine by Direct Counting Method based on the framing plan of the building. The length however, is subject to the following considerations:

1. If the span or distance of the post is indicated from center to center, the length of the girder is equal to the span plus one side width of the post (Figure 4-6).

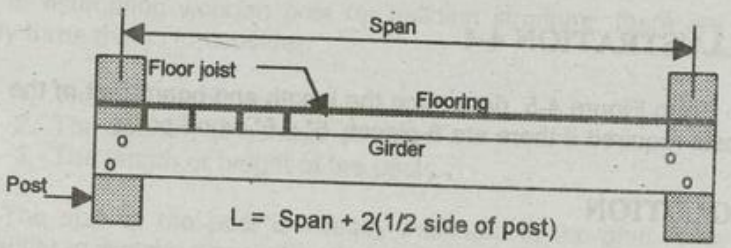


FIGURE 4-6 CENTER TO CENTER SPAN

2. If the span of the post indicates from outer to outer side of the post, the girder length is equal to the span of the post.

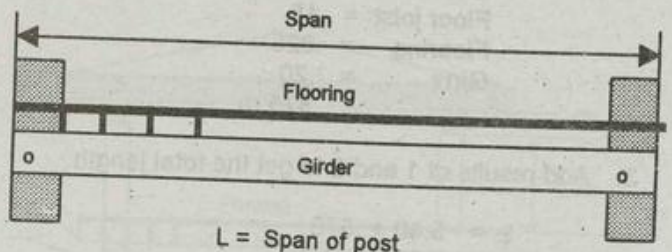


FIGURE 4-7 OUTER SPAN

3. If the span of the post indicates from center to outer side of the posts, the length of the girder is equal to the span plus one half the width of one post.

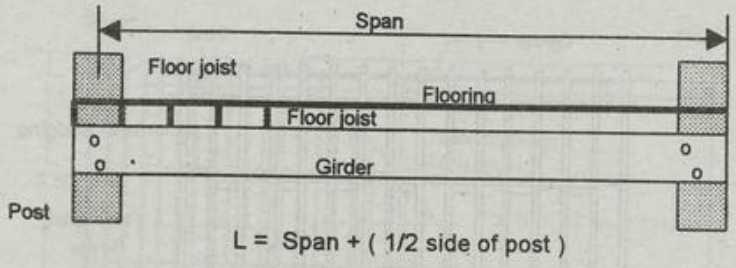


FIGURE 4-8 CENTER TO OUTER SPAN

4. If the span or distance of the post indicates inside measurement, the length of the girder is equal to the span plus two width of the post. (Figure 4-9).

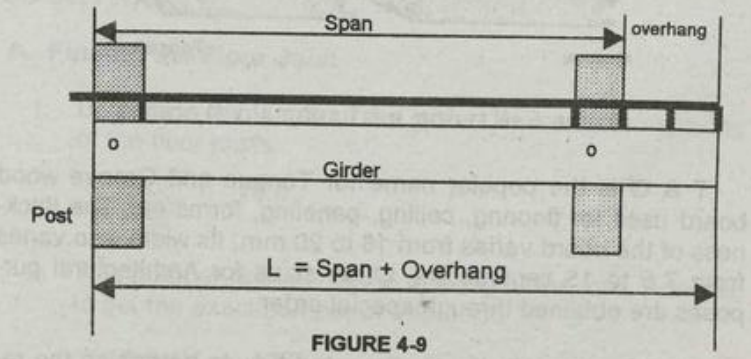


FIGURE 4-9

5. If the second floor has overhang, wherein the girder has to carry the floor joist, the girder length is equal to the span plus the overhang (Figure 4-9).

4-10 FLOOR JOIST AND WOOD FLOORING

Floor Joist is the structural member of a building that supports the wood flooring. Floor joist is estimated by direct counting method based on the floor framing plan. However, in the absence of a detailed plan, estimating could also be done if the spacing and length of the girder is known

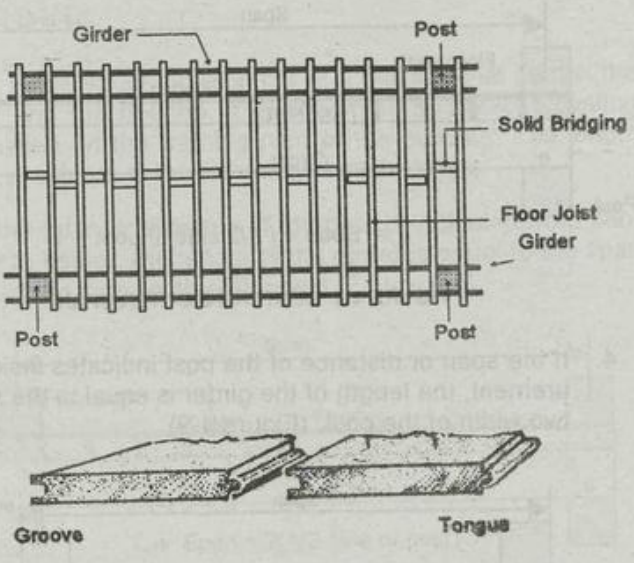


FIGURE 4- 10 FLOOR JOIST AND T & G FLOORING

T & G is the popular name for Tongue and Groove wood board used for flooring, ceiling, paneling, forms etc. The thickness of the board varies from 16 to 20 mm. Its width also varies from 7.5 to 15 centimeters. Other sizes for Architectural purposes are obtained through special order.

There are two methods presented how to determine the required number of pieces and board foot of T&G for a known floor area.

1. By Direct Counting method or
2. By Board Foot per square meter

ILLUSTRATION 4-5

From the floor framing plan as shown in Figure 4-11, determine the number and board foot of floor joist and the T & G flooring required.

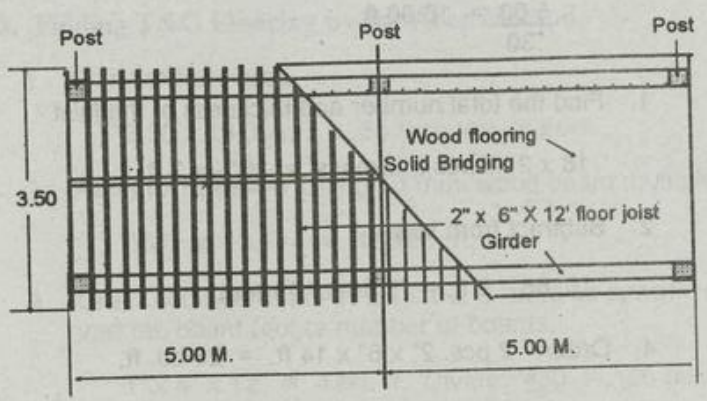


FIGURE 4-11 FLOOR JOIST AND WOOD FLOORING

SOLUTION

A. Finding the Floor Joist

1. Determine the length of the girder. Divide by the spacing of the floor joists.

$$\frac{5.00}{.30} = 16.6$$

2. This number represents the spacing of the joist. Add one to get the exact number of floor joist.

   16.6 + 1 = 17.6 say 18 pieces

3. For two span, multiply: 18 x 2 = 36 pieces.

4. Determine the length of the floor joist in feet.

$$\frac{3.50}{.30} = 11.66 \text{ say } 12 \text{ feet.}$$

   Order: 36 pieces 2" x 6" x 12 ' = 432 board foot

B. Solid Bridging

1. Find the length of the girder in feet:

$\frac{5.00}{.30}$ = 16.66 ft.

1. Find the total number and thickness of the joist

   18 x 2 inches thickness = 36" or 3 ft.

2. Subtract from step - 1

   16. 66 – 3 ft. = 13.66 or 14 feet

4. Order: 2 pcs. 2" x 6" x 14 ft. = 28 bd. ft.

TABLE 4-1 QUANTITY OF WOOD FLOORING AND SIDING BOARD PER SQUARE METER AREA

Size of Board In Inches	Effective Width in Meter	Board Foot per Sq. M.
1" x 3"	.0625	14.400
1" x 4"	.0875	13.714
1" x 5"	.1125	13.333
1" x 6"	.1375	13.091

C. Finding T&G Flooring By Direct Count

1. Find the length of the floor joist = 3.50 m.
2. Using 4" T&G, divide by the effective width.

   $\frac{3.50}{.0875}$ = 40 pieces x 2 span = 80 pieces.

3. Length of girder is 5.00 m. or 18 feet.
4. Order: 80 – 1" x 4" x 18 ft = 480 board foot.
5. If 18 ft. is not available: order 120 - 1" x 4" x 12 ft.

D. Finding T&G Flooring by the Area Method

1. Find the floor area.

   3.50 x 10.00 m. = 35.0 square meters

2. Refer to Table 4-1,Using 10 mm. wood board multiply:

   35.0 x 13.714 = 480 bd. ft.

3. Order 480 board foot 1" x 4" T & G. or to be specific convert the board foot to number of boards.

   1" x 4" x 12" = 4 bd. ft. Divide: $\frac{480}{4}$ = 120 pieces

4-11 SIDING WOOD BOARD

The common types of commercial siding wood boards are:

1. Stone cut
2. Double Stone Cut
3. V- Cut
4. BCB Cut
5. Weather cut

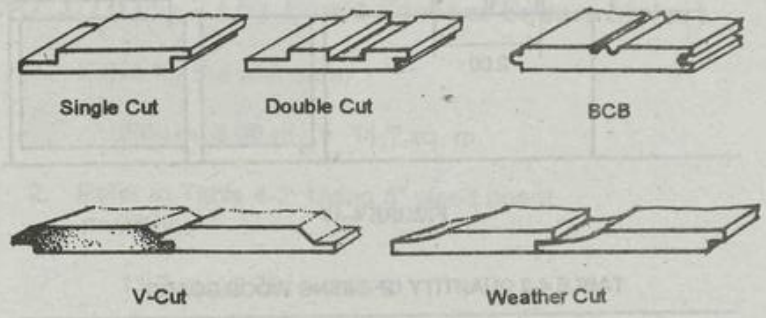


FIGURE 4-12 SIDING WOOD BOARD

The thickness of siding wood board varies from 16, to 20 mm. Likewise, the width ranges from 15 mm (6") to 20 mm (8") of even length from 8 to 16 feet. The quantity is estimated under the following considerations:

1. The area of the opening such as windows, doors and the like are subtracted from the gross area of the wall to be covered by the siding wood boards.
2. Consider the additional depth length for the girts, flooring, floor joist and the girder.
3. The length of the siding wood board must be specified to avoid joints in between the heights.

ILLUSTRATION 4-6

From the following Figure, find the number of 8 inches Double Stone Cut siding wood board.

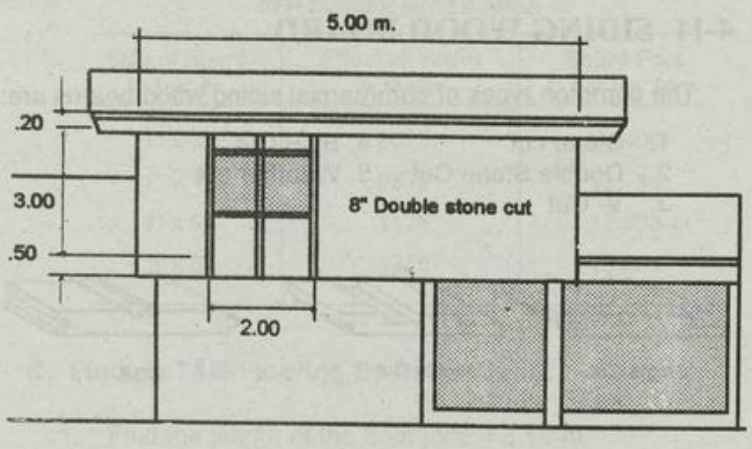


FIGURE 4-13

TABLE 4-2 QUANTITY OF SIDING WOOD BOARD

Size of Wood Board		Number per	Approx. Board Ft.
Inches	Centimeter	Meter Run	per Sq. Meter
6	15	7.27	17.40
8	20	5.33	12.76

SOLUTION

1. Determine the total length of the wall board

   Floor to ceiling 3.18
   Depth of girts .25
   Flooring and joist .17
   Depth of girder .30
   3.90 m. = 13 ft.

   Order length ..... 14 ft.

2. Length of the wall = 5.00 – 2.00 window = 3.00 m.

3. Refer to Table 4-2 for an 8" or 20 cm. wood board, multiply:

   3.00 x 5.33 = 16 pieces.

4. Order: $\frac{16 \text{ pcs. } 1" \times 8" \times 14'}{12}$ = 149.3 board ft.

SOLUTION - 2 (By Board Foot per Square Meter)

1. Solve for the wall area:

   3.90 x 3.00 m. = 11.7 sq. m.

2. Refer to Table 4-2. Using 8" wood board, multiply:

   11.7 x 12.76 = 149.3

3. If 6" wood board will be used then from Table 4-2, multiply:

   11.7 x 17.40 = 203.58 board ft.

4. Order: 204 board ft. 1" x 6" x 14 ft.

4-12 ROOF FRAMING

Roof framing comprises the girts, bottom chord, rafters, purlins collar plate, center post, strut and blocks are computed by direct counting method. Shorter parts like collar plates, king post, strut and wood blocks are determined according to their sizes combined together and adjusted to the commercial length of lumber. For accuracy of estimating these items, a detailed drawing indicating their sizes and length should be made as basis in finding the unit length of every parts.

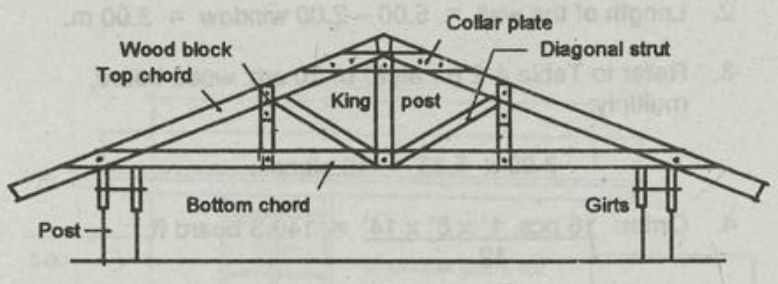


FIGURE 4-14

4-13 STUD

Stud is the structural member in building construction wherein the sidings or partition boards are fastened. It is sometimes referred to as the ribs of wooden walls or partitions. Lumber intended for studs should be straight and uniform in width of either S2s or S4s for uniformity of wall thickness.

Advantage of Using S2s and S4s Lumber

1. Good quality, straight and uniform in thickness.
2. It is economical in terms of labor cost.
3. The work progress is not affected or delayed.

There are two methods presented on how to find the quantity of studs at a given vertical and horizontal spacing.

1. By Direct Counting Method
2. By the Square Meter Method

By **Direct Counting Method** is simply counting the number of vertical and horizontal member from a detailed plan. In the absence of a detailed drawing plan, an imaginary counting through arithmetical calculation will do.

By the **Area or Square Meter Method** is simply finding the wall area multiplied by the values given in Table 4-2 corresponding to the size and spacing of the studs.

TABLE 4-3 NUMBER OF BOARD FOOT OF STUDS AND NAILING JOIST PER SQUARE METER

Lumber size in Inches	Spacing in Centimeters (Center to Center)				
	30 x 30	30 x 60	40 x 40	40 x 60	60 x 60
1 x 2	4.103	3.147	3.189	2.686	2.268
2 x 2	8.198	6.293	6.379	5.373	4.594
2 x 3	12.284	9.440	9.569	8.060	6.898
2 x 4	16.414	12.592	12.758	10.746	9.195

ILLUSTRATION 4-7

A wall partition 5.80 meters long and 3.40 meters high specify the use 2" x 3" studs spaced at 60 centimeters on center both ways. Find the total board foot required.

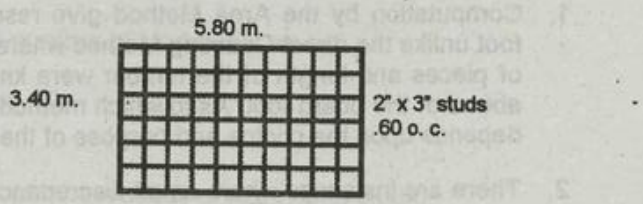


FIGURE 4 – 15 WALL STUDS

SOLUTION –1 (By Direct Counting)

1. Find the number of Vertical Studs

   $\frac{5.80}{.60}$ = 10 (rounded) Number of spacing

2. Add 1 to get the number of studs.

   10 + 1 = 11 at 3.40 m or (12 ft.)

3. Find the number of Horizontal Studs.

   $\frac{3.40}{.60}$ + 1 = 7 at 5.80 m. or (20 ft.)

4. Order: Vertical Studs 11 - 2" x 3" x 12' = 66
   Horizontal Studs 7 - 2" x 3" x 20' = 70
   Total... ... 136 bd. ft.

SOLUTION –2 (By The Area Method)

1. Find the area of the wall partition.

   Area: 5.80 x 3.40 = 19.72 sq. m.

2. Refer to Table 4-2 Using 2" x 3" at .60 x .60 m. spacing multiply

   19.72 x 6.898 = 136 bd. ft. 2" x 3" lumber.

Comment

1. Computation by the Area Method give results in board foot unlike the direct Counting Method where the number of pieces and length of the lumber were known outright ahead of the board foot. As to which method will be used depends upon the choice and purpose of the estimator.

2. There are instances where small discrepancies arise between the results of the two methods. This is due to the adjustment of lumber from odd to even length.

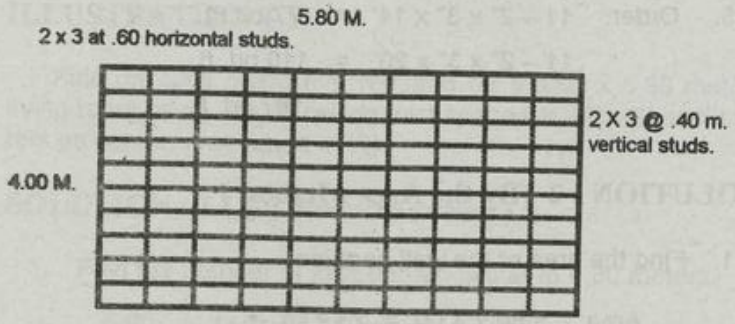


FIGURE 4-16

ILLUSTRATION 4-8

A wall partition of Figure 4-16 measures 5.80 meters long by 4.00 meters high specify 2" x 3" wood studs spaced at 60 centimeters for vertical and 40 centimeters for horizontal center to center distance. Find the number of board foot required.

SOLUTION –1 (By Direct Counting)

1. Find the number of vertical studs

   $\frac{5.80}{.60}$ = 9.7 say 10 spacing

2. Add 1 to get the number of vertical studs:

   10 + 1 = 11 pcs. 2 x 3 x 5.80 m. or (14 ft.)

3. Find the number of Horizontal studs.

   $\frac{4.00}{.40}$ = 10

4. Add 1 to get the number of Horizontal studs.

   10 + 1 = 11 pieces 2" x 3" x 5.80 m. or (20 ft.)

5. Order: 11 – 2" x 3" x 14' = 77 bd. ft.
   11 – 2" x 3" x 20' = 110 bd. ft.
   187 bd. ft.

SOLUTION - 2 (By the Area Method)

1. Find the area of the wall partition

   Area: 5.80 x 4.00 = 23.2 sq. m.

2. Refer to Table 4-2. Using 2" x 3" at 40 x 60 cm. multiply:

   23.2 x 8.060 = 187 bd. ft.

4-14 CEILING JOIST

Ceiling joist is the structural member in building construction where the ceiling board is fastened. It is otherwise known as the nailing strip. The common size used for ceiling joist are 1 x 2 ; 1 ½ x 2 ; 2 x 2 and 2 x 3 lumber spaced to suit the size of the ceiling board. In short, the ceiling board dimensions govern the spacing of the ceiling joist for economical reasons.

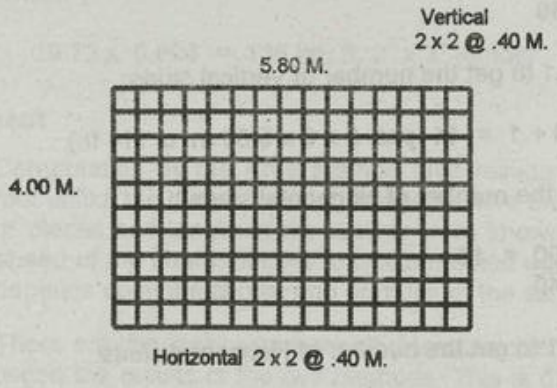


FIGURE 4-17 CEILING JOIST

ILLUSTRATION 4-9

Find the total board foot required for a 4.00 x 5.80 meters living room using 2" x 2" ceiling joist spaced at 40 x 40 centimeters on center. (see figure 4-17)

SOLUTION –1 (By direct counting)

1. Find the number of joist perpendicular to 5.80 meters.

   $\frac{5.80}{.40}$ = 14.5 say 15 spacing of joist

2. Add 1 to get the exact number of joists.

   15 + 1 = 16 pieces at 4.00 m. or (14 ft.)

3. Find the number of joist perpendicular to 4.00 m. span.

   $\frac{4.00}{.40}$ = 10 spacing + 1 = 11 pcs. at 5.80 or (20 ft.)

4. Order: 16 pcs. 2 x 2 x 14 ft. = 74.66
   11 pcs. 2 x 2 x 20 ft. = 73.33
   Total..... 147.99 bd. ft.

5. If 20 feet is not available, the order could be:

   16 pcs. 2 x 2 x 14 ft. = 74.66
   22 pcs. 2 x 2 x 10 ft. = 73.33
   Total ..... 147.99 bd. ft.

SOLUTION - 2 (By the Area Method)

1. Find the area of the ceiling.

   4.00 x 5.80 = 23.2 sq. m.

2. Refer to Table 4-3 Using 2" x 2" at 40 x 40 cm. multiply:

   23.2 x 6.379 = 147.99 bd. ft

4-15 CEILING BOARD

There are numerous kinds of ceiling board of different brand, quality and dimensions available for building construction. However, the simplest way of finding the number of boards required is to divide the total ceiling area by the effective covering of one ceiling board chosen or by the square meter method with the aid of Table 4-3.

ILLUSTRATION 4-10

A bedroom with a general dimensions of 4.00 x 5.00 meters specify the use of 1/4" x 4" x 8" plywood ceiling on a 2" x 2" ceiling joist spaced at 40 x 60 centimeters. Find the number of plywood and the ceiling joist required if there are 5 rooms of the same size.

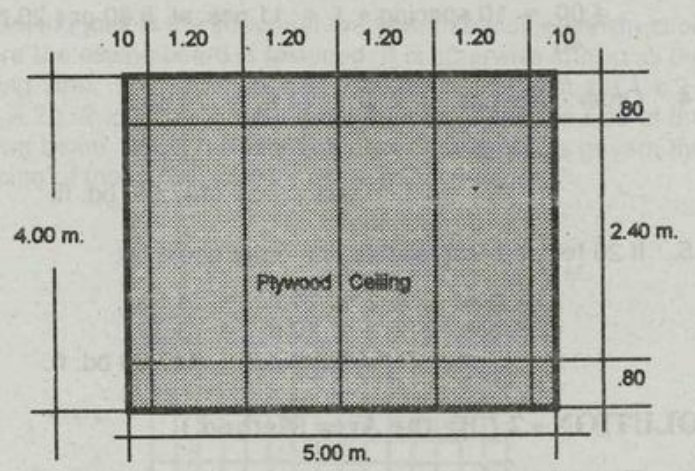


FIGURE 4-18 CEILING PLAN

SOLUTION (By the effective coverage method)

A. Ceiling Joist

1. Find the area of the ceiling; 4.00 x 5.00 = 20 sq. m.
2. See Table 4-3 Using 2 x 2 at .40 x .60 spacing, multiply:

   20 sq. m. x 5.373 = 107.46 bd. ft.
3. For 5 rooms 107.46 x 5 = 537.3 bd. ft. of 2" x 2"

B. Ceiling Board

1. Find the area of ceiling: Area: 4.00 x 5.00 = 20 sq. m
2. Refer to Table 4-4. Using a 1.20 x 2.40 m. plywood, divide:

   $\frac{20 \text{ sq. m.}}{2.88} = 7$ pieces per room
3. For 5 rooms, order 35 - ¼" x 4' x 8' plywood

TABLE 4-4 QUANTITY OF CEILING BOARD PER SQUARE METER

Board Size in Centimeters	Effective Covering per board	Number of pieces per Square Meter
30 x 30	0.09	11.111
40 x 40	0.16	6.250
40 x 60	0.24	4.167
60 x 60	0.36	2.778
60 x 120	0.72	1.389
90 x 180	1.62	0.617
120 x 240	2.88	0.347

ILLUSTRATION 4-11

An office room measures 6.00 x 9.60 meters long specify a 60 x 120 cm. ceiling board, List down the materials required.

SOLUTION-1 (By Effective Area Coverage Method)

1. Find the area of the ceiling.

Area : 6.00 x 9.60 = 57.6 sq. m.

2. Refer to Table 4-3. Using a 60 x 120 ceiling board, divide the area by its effective covering.

$$\frac{57.6}{.72} = 80 \text{ pieces } 60 \times 120 \text{ ceiling board.}$$

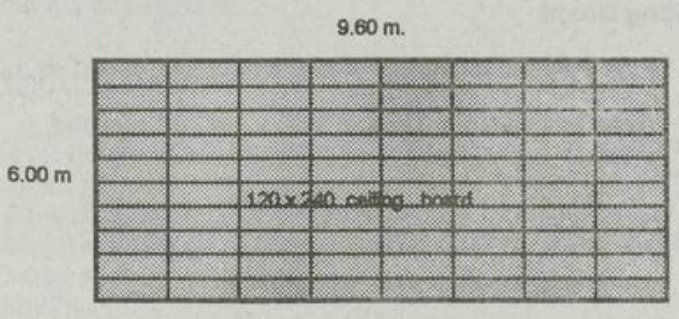


FIGURE 4-19 CEILING PLAN

SOLUTION- 2 (By Direct Counting Method)

1. Find the number of boards along the 6.00 meters.

$$\frac{6.00 \text{ m.}}{.60} = 10 \text{ pieces}$$

2. Find the number of board along the 9.60 meters span.

$$\frac{9.60 \text{ m.}}{1.20} = 8 \text{ pieces}$$

3. Multiply the results of 1 and 2

10 x 8 = 80 pieces 60 x 120 ceiling board.

Comment:

The result of the two methods as presented are correct if the ceiling area falls under the following conditions:

1. That the quotient in dividing the area of the ceiling by the effective area covering of one board yields an exact number or value (no fraction).
2. That the ceiling design is plain and not interrupted by beams, girders, rafters and the like.
3. That the ceiling has no intricate design or decorations that requires more cutting of the ceiling board.
4. When cutting of the board could not be avoided, wastage is also inevitable but could be replenished by an allowance factor of about 2 to 5% depending upon the design.

ILLUSTRATION 4-12

An elementary classroom building has a general dimensions of 6.80 x 8.00 meters specify the use of a 90 x 180 centimeters ceiling board. Find the number of ceiling boards required for a 12 classrooms.

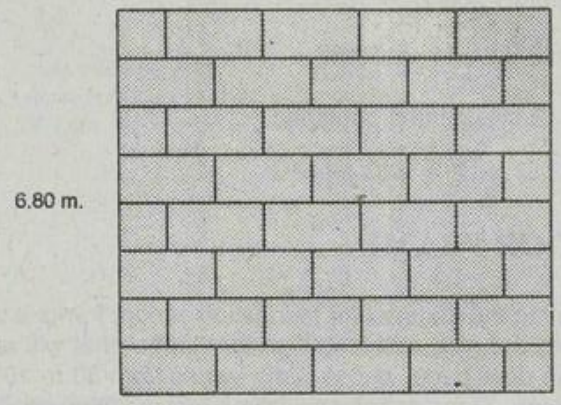


FIGURE 4-20 CEILING PLAN

SOLUTION -1 (By the Effective Area Coverage Method)

1. Find the area of the ceiling.

6.80 x 8.00 = 54.40 square meters

2. Refer to Table 4-4. Using a .90 x 1.80 cm. ceiling board; divide:

$$\frac{54.40}{1.62} = 33.6 \text{ pieces}$$

3. For 12 classrooms: 33.6 x 12 = 403 pieces

SOLUTION –2 (By Direct Counting Method)

1. Find the number of board along the 6.80 meters side.

$$\frac{6.80}{.90} = 7.555 \text{ pieces}$$

2. Find the number of board along the 8.00 meters side.

$$\frac{8.00}{1.80} = 4.44 \text{ pieces}$$

3. Multiply 1 and 2:

7.55 x 4.44 = 33.57

4. For 12 classrooms, multiply:

33.57 x 12 = 403 pieces.

4-16 DOOR FRAME

Estimating the material for fabrication of door frame is simply determining the size and length of the lumber that will accommodate the door panel whose width varies from 60 to 100 centimeters wide. Door panel and frame bigger than one meter width is considered special design and order.

In ordering lumber for door frame, the estimator has two options:

1. Ordering 18 feet long for each door jamb and header or
2. A combination of 7 and 10 feet for jamb and header.

ILLUSTRATION 4-13

A 20 classroom building with 2 doors each specify 3" x 6" door jamb. List down the materials needed for fabrication.

SOLUTION

A. Ordering one length for each jamb.

1. Determine the total length of the jamb.

   Jamb = (7' + 3") x 2 = 14.5 ft.

2. Length of Header: 3' + 6" = 3.5 ft.

   Total length = 18.0 ft.

3. Order: 40 pcs. 3" x 6" x 18' = 1,080 board ft.

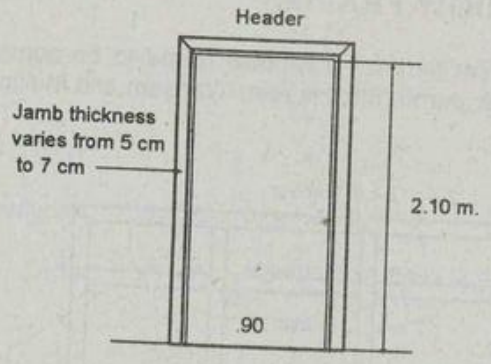


FIGURE 4-21 DOOR JAMB

B. Combination of Jambs and Headers

1. One header is 3' - 6" or..... 3.5 ft.
2. Total length of 4 headers is 14.0 ft.
3. For 40 headers, order 10 pcs. 3" x 6" x 14 ft.
4. For jambs = 7.3" + 3" x 2 sides = 14'-6" or 16 ft.

Lumber length is of even numbers, for 40 jambs order:

40 pcs. 3" x 6" x 16' = 960 bd. ft.
10 pcs. 3" x 6" x 14' = 210 bd. ft.
Total..... 1,170 bd. ft.

Comment:

Comparing the results of the two methods, there is a difference of 90 board feet if the second method is used. However, considering the scarcity of lumber, length from 16 feet and above may not be available in the market and the only choice is to order shorter length from 8 to 12 feet.

The price of lumber varies according to its length and width. The longer the need, the higher is the price.

4-17 WINDOW FRAME

The different parts of a window frame to be considered in estimating are: Jamb, Sill, Header, Transom and Mullions.

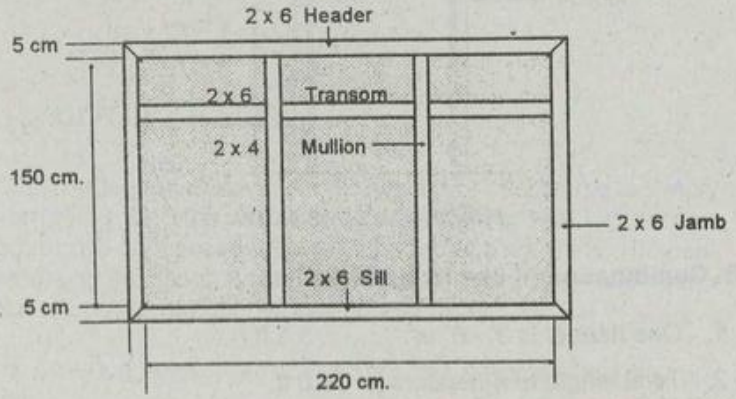


FIGURE 4-22 WINDOW FRAME

ILLUSTRATION 4-14

A low cost housing project requires 50 pieces window frame as shown in figure 4-22. List down the materials needed for fabrication.

SOLUTION

1. Jamb: (150 + 5 + 5) x 2 pcs. = 320 cm. or 12 ft.

   Order: $\frac{\text{50 pcs. 2" x 6" x 12 ft.}}{12}$ = 600 bd. ft.

2. Header and sill: (220 + 10) x 2 = 460" or 16 ft.

   Order: 50 pcs. 2" x 6" x 16 ft. or

   $\frac{\text{100 pcs. 2" x 6" x 8 ft.}}{12}$ = 800 bd. ft.

3. Mullion 100 - 2" x 4" x 1.50 m. or
   50 - 2" x 4" x 3.00 m.

   Order: 50 - 2" x 4" x 10 ft.

4. Transom: 100 - 2" x 6" x (2.20 + 10)

   Order : $\frac{\text{100 - 2" x 6" x 8 bd. ft.}}{12}$ = 800 bd. ft.

Problem Exercise

1. From the following figure, list down the floor framing materials required:

   (a) Girder,
   (b) Floor joist
   (c) Header and bridging
   (d) 1" x 4" T&G wood flooring.

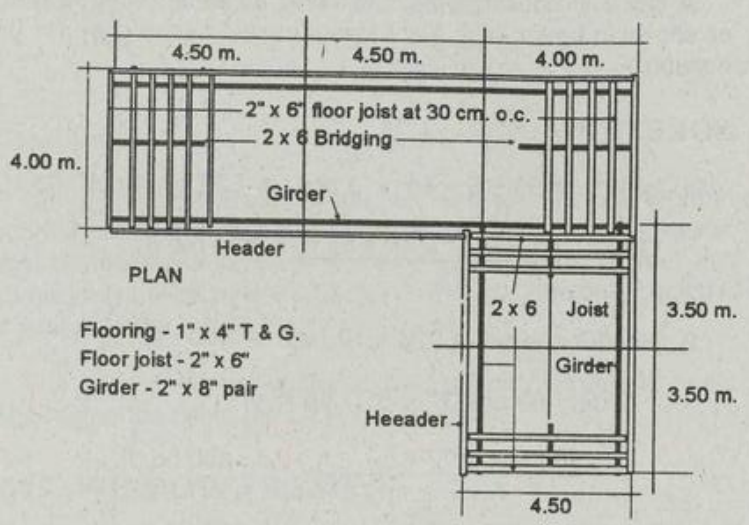


FIGURE 4-23

2. A 10 door apartment 40 meters long by 10 meters wide requires 2 x 6 floor joist and 1" x 6" T&G wood flooring. Find the number of board foot required for floor joist and T&G flooring.

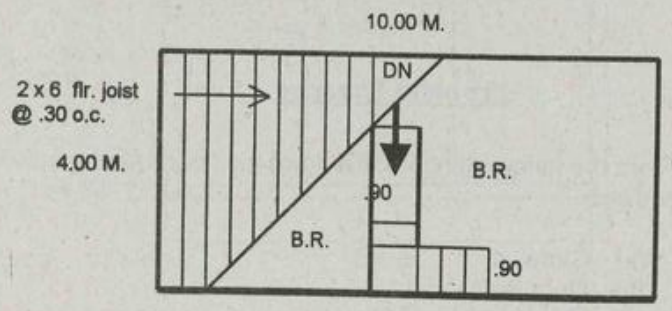


FIGURE 4-24

3. From the following ceiling plan, list down the required materials:

a) 1.20 x 2.40 m. marine plywood
b) 2" x 2" ceiling joists 40 x .60 m. on center.

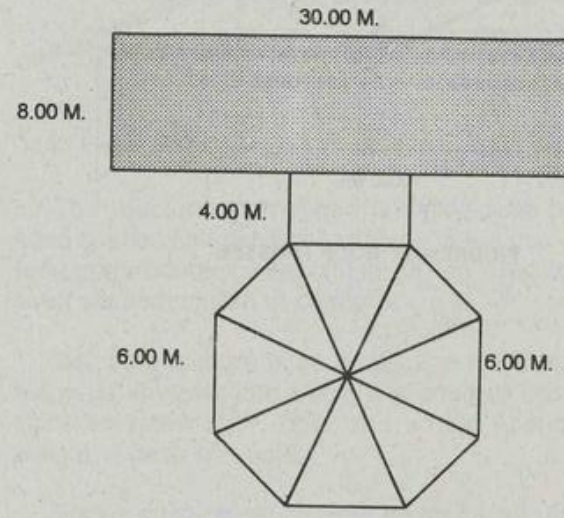


FIGURE 4-25 CEILING PLAN

4. Twenty one roof framing of classroom building specify the use of wood trusses on a concrete beam as shown on Figure 4-24. List down the following materials required: (make an scaled drawing at 1:20 to get the accurate length of every parts)

a.) Bottom chord
b.) Top Chord
c.) Purlins 2" x 4"
d.) King post
e.) Vertical strut
f.) Diagonal strut
g.) Collar plate and blocks.

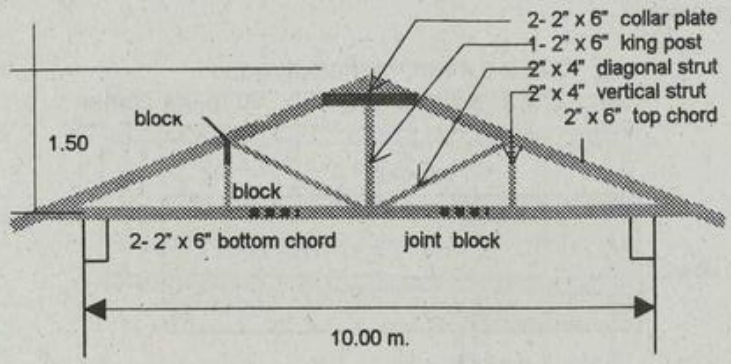


FIGURE 4-26 ROOF TRUSSES

CHAPTER 5

FORM, SCAFFOLDING AND STAGING

5-1 FORMS

The structural members of a building are built-up into its desired shapes and dimensions through the use of form. Form is a temporary boarding, sheathing or pan used to produce the desired shape and size of concrete.

Concrete mixture is generally semi-fluid that reproduces the shape of anything into which it is poured. Thus, concrete forms shall be water tight, rigid and strong enough to sustain the weight of fresh concrete.

Forms must be simple and economically designed in such a manner that they are easily removed and reassembled without damage to themselves or to the concrete.

Selection of Forms are based on:

1. Cost of the materials
2. Construction and assembling cost
3. The number of times it could be used
4. Strength and resistance to pressure and tear and wear.

Classification of Forms:

A. As to Materials

1. Wood
2. Metal
3. Plastic
4. Composite

B. As to Shape
1. Straight
2. Circular, etc.

C. Solid or Hollow Cast
1. Single
2. Double

D. As to Methods of Construction
1. Ordinary
2. Unit

E. As to Uses
1. Foundation
2. Wall
3. Steps
4. Beam and girders
5. Slab
6. Sidewalk, etc.

F. Construction of forms consist of:
1. Retaining board
2. Supporters or studs
3. Braces
4. Spacer
5. Tie wire
6. Bolts and nails

G. Types of Post and Wall form
1. Continuous
2. Full unit
3. Layer unit
   a. Continuous
   b. Sectional

Greasing of Forms

Forms are constantly greased before its use. The purpose of greasing the form is to make the wood waterproof preventing the absorption of water in the concrete which causes swelling and warping. Greasing of forms also prevent the adherence of concrete into the pores of the wood.

Crude oil is the most economical and satisfactory materials for this purpose. The crude oil is mixed with No. 40 motor oil to a proportion of 1:3 mixtures or with varying viscosity depending upon the temperature condition.

A thicker mixture is recommended on warm weather condition. However, greasing of forms should not be allowed after the steel bars have been set to its position. Metal forms also need oil application to prevent rust formation,

5-2 PLYWOOD AS CONSTRUCTION FORM

Plywood is a versatile construction material used as wall partitions, cabinets, and furniture. Plywood is also utilized in boat building as well as forms for reinforced concrete constructions.

Plywood as Form has the following advantages.

1. It is economical in terms of labor cost.
2. It is lightweight and handy
3. It has smooth surface which may not require plastering
4. Less consumption of nails
5. Ease of assembling and disassembling
6. Available

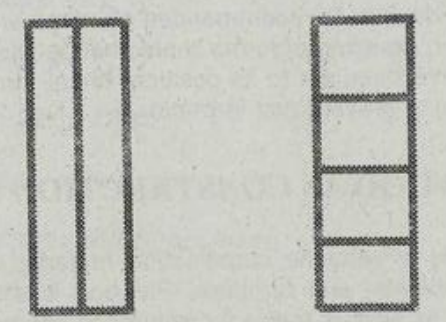
Plywood is manufactured in various thickness ranging from 4; 6; 12; 20 and 25 mm with a standard commercial sizes of .90 x 1.80 and 1.20 x 2.40 meters.

5-3 FORMS FOR SQUARE AND RECTANGULAR COLUMN

In determining the materials for square and rectangular column forms, one has to consider the following:

1. The thickness of the board to be used.
2. The size of the frame
3. Types of framework to be adopted

   a.) Continuous rib type
   b.) Stud type



CONTINUOUS RIB TYPE STUD TYPE

FIGURE 5-1 TYPES OF FORM

Formula in Finding the Materials for Square and Rectangular Column Forms

(1) $$P = 2(a + b) + .20$$

Where: P = lateral perimeter of the column
a = shorter side of the column
b = the longer side of the column
.20 = constant value for the lapping of form joints

(2) Multiply P by the height of one column times the number of columns to get the total area of the forms.

(3) Divide the total area found by 2.88 to get the number of plywood forms.

(4) Multiply the number of plywood found by 29.67 to get the board foot of frame required.

ILLUSTRATION 5-1

Six concrete posts at 4.00 meters high with a uniform cross sectional dimensions of .30 x .30 m. specify the use of 6 mm (1/4") marine plywood on a 2" x 2" wood frame. List down the materials required using a continuous rib type forms.

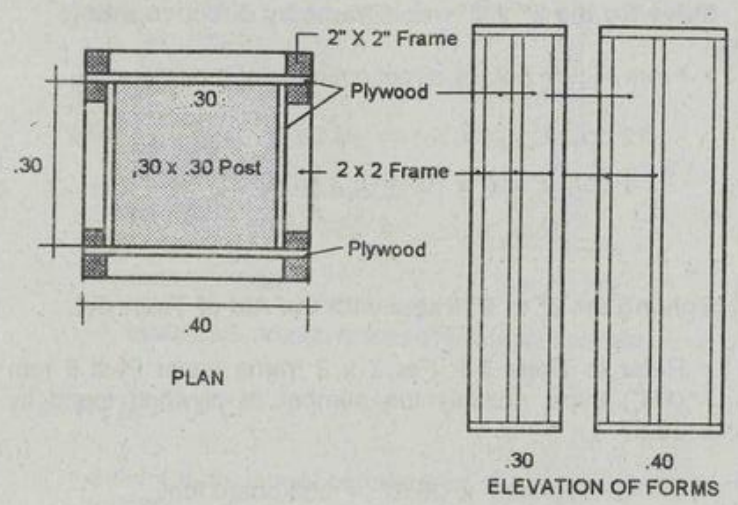


FIGURE 5-2 PLYWOOD FORM ON 2 X 2 FRAME

SOLUTION

A. Solving for the Plywood form

1. Find the lateral perimeter of one column using the formula:

   $P = 2(a + b) + .20$
   $P = 2(.30 + .30) + .20$
   $P = 1.40$ m.

2. Multiply P by the column height and the number of columns to find the total area of the forms.

   Area = 1.40 x 4.00 x 6 columns.
   A = 33.6 square meters.

3. Divide this area by 2.88, the area of one plywood form to get the number of plywood required.

   No. of Plywood : $\frac{33.6}{2.88} = 11.7$ say 12 pieces.

Comment

1. Take note, if 2" x 2" wood frame will be used, the multiplier is 29.67 board foot. On the other hand, If 2" x 3" lumber will be used, the multiplier is 44.50 board foot.

2. If thicker plywood board will be used as form, the spacing of the frame could be increased reducing its board foot by 20% to 30%.

5- 4 FORMS FOR CIRCULAR COLUMN

The plain galvanized iron sheet and black sheets are commonly used as sheeting for circular, oval, elliptical and other similar types considering its versatility in forming any shape of geometrical design.

Metal sheet form is supported by metal frame of either plain bars, angular, tee or circular in cross section or whatever specified in the plan.

Estimating Procedures:

1. Find the circumferential area of the circular column using the formula:

   C = 3.1416 x diameter x Height x No. of columns

2. Divide the area found by the effective area covering of one metal sheet.

3. Count the number of ribs or support classified as to their kind and length then convert to commercial size of steel bars.

4. In estimating materials for any particular work, a detailed plan is imperative. Without a detailed plan, expect a half hazard result even from your brightest estimator.

ILLUSTRATION 5-3

From Figure 5-4, determine the required metal black sheet form for 8 circular columns 4.00 meters high each with a uniform cross-sectional diameter of 60 centimeters.

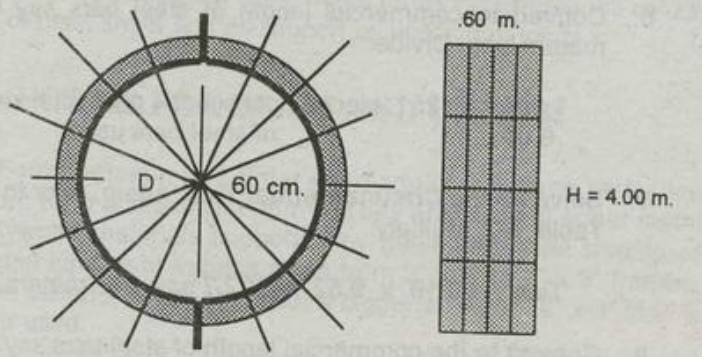


FIGURE 5-4 CIRCULAR COLUMN METAL FORMS

SOLUTION:

1. Solve for the circumference of one column.

   C = 3.1416 x .60 m. = 1.88 meters

2. Multiply by column height to find the surface area.

   Area: 1.88 x 4.00 = 7.52 sq. m.

3. Find the Area of the 8 columns, multiply:

   Total surface Area: 7.52 x 8 = 60.16 sq. m.

4. Find the **Number of Sheet** required. Refer to Table 5-2. Using a 1.20 x 2.40 m. black sheet, multiply:

No. of sheet: 60.16 x .347 = 21 pieces

5. Find the number of **Vertical Support** (ribs) at 15 cm. spacing distance. Refer again to Table 5-2. Multiply:

   Vert. Support: 60.16 x 25 = 1,504 meters

6. Convert to commercial length of steel bars say 6.00 meters long. Divide:

   $\frac{1,504}{6.00}$ = 251 pieces (consult the plan what kind of steel bars used)

7. Solve for the **Circumferential Ties**. Again, refer to Table 5-2. Multiply:

   Ties: 60.16 x 9.52 = 572.7 say 573 meters

8. Convert to the commercial length of steel bars say 6.00 meters. Divide:

   $\frac{573.00}{6.00}$ = 95.5 say 96 pieces (consult the plan what kind of bars used)

TABLE 5-2 QUANTITY OF METAL FORM FOR CIRCULAR COLUMN

Size of Metal Sheet in Meters	No. of Sheet per Sq. Meter	Length of Vert. Ribs in M. Spacing in Centimeters		Length of Circumferential Ties in Meter
		15 cm.	20 cm.	
.90 x 2.40	.462	25.0	18.0	9.52
1.20 x 2.40	.347	25.0	18.0	9.52

Comment:

1. The kind of steel bars for vertical support (ribs of the form) depends upon the design. The illustrated solutions showed how to find the quantity of materials such as: the plain sheet, the vertical support and the circumferential ties.

2. In addition to the materials as computed, the estimator has to consider the locking devices and the welding rod necessary for assembling the forms. The number of locking bolts depends upon the spacing as indicated in the plan which could be determined by direct counting.

3. The advantage of using metal forms maximizes the utilization of plain sheet and its support by welding of joints.

5-5 FORMS FOR BEAM AND GIRDER

Form for beam and girder are made of only three parts; one bottom form and two side forms. They are made of either metal or plywood materials supported by galvanized pipe staging or wooden lumber of varying sizes from 2" x 2" to 2" x 3" frames. When coconut lumber is used, a bigger size from 2" x 3" to 2" x 4" are used.

Wooden forms are rigidly supported with sufficient vertical and diagonal bracing to carry the heavy load of concrete weighing approximately 65 kilograms per cubic foot.

The ease of dismantling is the primary consideration in the assembling of forms. The freedom from pain and difficulty in removing the form depends on how it was fastened.

Formula in Finding the Materials for Beam and Girder Forms

(1) $P = 2(a + b) + .10$-

Where: P = Perimeter of two sides form
d = the two side forms
b = the bottom form
.10 = constant value for the lapping of form

(2) Multiply P by the length and number of beams to get the total area of the forms.

(3) Divide the total area found by 2.88 to get the number of plywood forms.

(4) Multiply the number of plywood found by 22 get the board foot of frame required.

ILLUSTRATION 5-4

Ten concrete beams with cross sectional dimensions of .30 by .60 meter has a uniform clear span of 4.50 meters. Using ¼" 4' x 8' plywood form on 2" x 2" lumber frame, List down the materials required.

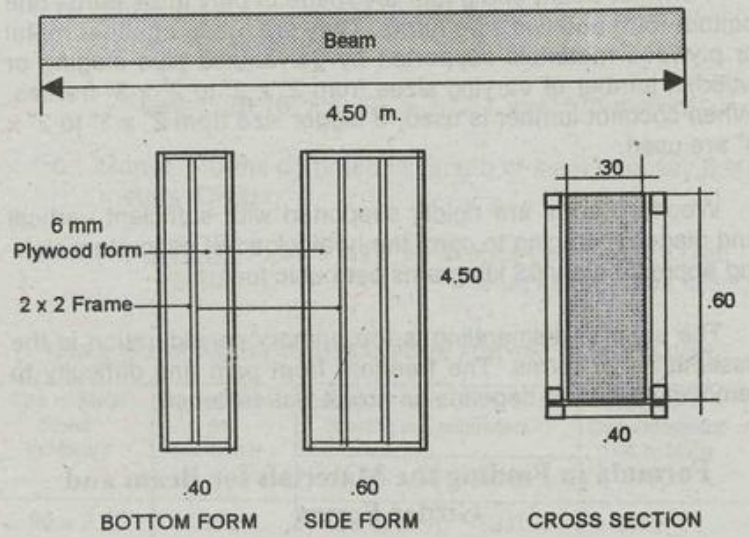


FIGURE 5-5 CONCRETE BEAM

SOLUTION

A. Finding the Plywood Form

1. Find the lateral perimeter of the beam.

$$P = 2(d) + b + .10$$

2. Substitute data in the formula:

$$P = 2(.60) + .30 + .10 = 1.60 \text{ m.}$$

3. Multiply P by the length and number of beams to get the area of the forms.

Area : 1.60 x 4.50 m. x 10 columns

A = 72 sq. m.

4. Divide by 2.88 to get the number of plywood required.

$$\text{No. of Plywood} : \frac{72}{2.88} = 25 \text{ pieces}$$

B. Solving for the 2" x 2" Wood Frame

1. Refer to Table 5-1. Under column beam using 6 mm ¼" thick plywood on 2" x 2" frame, multiply:

25 x 25.06 = 626 bd. ft.

2. Order: 25 pieces ¼" x 4' x 8' plywood form

626 board ft. 2" x 2" lumber

ILLUSTRATION 5-5

Ten concrete girder with a general dimensions of .35 x .50 meter has a uniform clear span of 6.00 meters. If 12 mm. (½") marine plywood will be used on a 2" x 3" lumber find the materials required.

SOLUTION

1. Find the area of the form using the formula:

$$P = 2(d) + b + .10$$

$$P = 2(.50) + .35 + .10 = 1.45 \text{ m.}$$

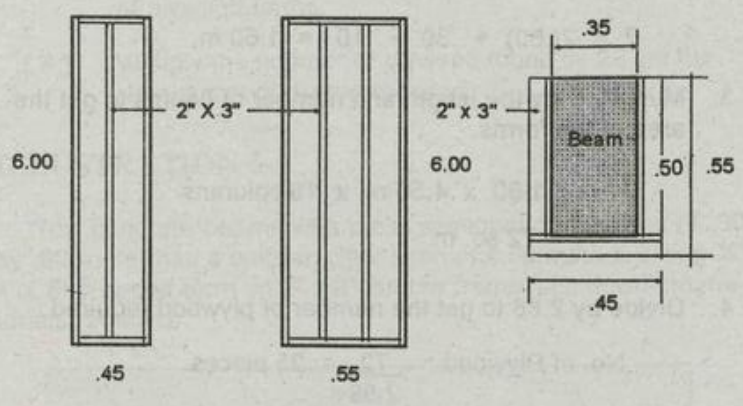


FIGURE 5-6 GIRDER FORM

2. Total area of 10 forms at 6.00 m. long.

   Area = 1.45 x 6 x 10 = 87 sq. m.

3. Divide by the area of one plywood (2.88)

   $\frac{87}{2,88}$ = 30.2 say 31pieces.

4. Refer to Table 5-1. Under Beam 12 mm (½") thick board on 2" x 3" wood frame, multiply:

   31 plywood x 28.00 = 868 board foot 2" X 3"

5. Order: 31 pcs, ½" x 4" x 8" plywood
   868 bd. ft 2" x 2" lumber form

5-6 SCAFFOLDING AND STAGING

Scaffolding is a temporary structure of wooden poles and planks providing platform for workers to stand on while erecting

or repairing of building. It is further defined as a temporary framework for other purposes.

Staging on the other hand is a more substantial framework progressively built up as tall building rises up. The term staging is applied because it is built up in stages one story at a time.

Construction records revealed that numerous accidents in construction happened because of neglect and faulty construction method such as insufficient supports, hangers and braces. One example of tragic incident happened in the construction of the Film Palace in Metro Manila where several lives including the Supervising Engineer were buried alive in cement and rubbles when the forms and staging swayed and rammed down in total collapse.

Staging is not simple as others may think of it. It requires special skill and experienced men to do the work. Incidentally, the primary causes of accidents and failure of the framework is the use of inferior quality lumber, inadequate supports and braces, nails and others for economy or negligence.

Definitely, poor quality lumber has no place in horizontal members of scaffolding work if the builder is aware of the value of life and property involved in building construction. Lumber intended for temporary structure to support heavy load such as concrete should be selected from straight grain of wood free from shakes or knots and other defects. Coconut lumber was extensively used due to the scarcity of wood plus the prohibitive price of lumber.

The use of metal pipe scaffolding and staging is now dominating the market of construction industry considering its durability, multiple use and ease of assembling and dismantling.

The different parts of scaffolding to consider are:

1. Vertical support
2. Base of vertical support (as needed)

3. Horizontal member
4. Diagonal braces
5. Block and wedges
6. Nails or bolts.

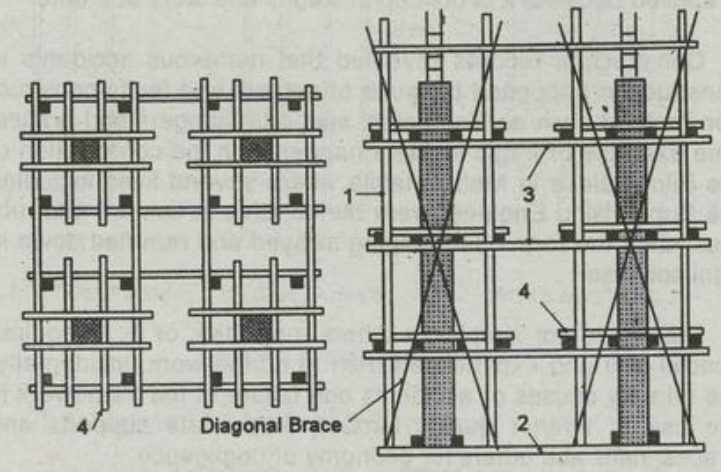


FIGURE 5-7

Cost is the primary consideration in selecting the kind of materials to be used as form. Cost of form refers to:

1. Initial cost of materials
2. Assembling cost
3. The number of times it could be used
4. Durability to resist pressure, and tear and wear.

The common materials used as forms for all types of construction during the 1950 and 1960 decades was the T&G lumber costing only at about 15 centavos per board foot. That was the time when lumber was so abundant and no one ever think that this natural resources of our country will vanish so soon because of man's insatiable greed for money.

Today, the formerly Philippines number one exporting lumber in the world is importing lumber from the neighboring countries in Asia for its domestic used. Under the present condition where the price of wood is highly prohibitive like gold, using lumber as form is a very costly undertaking unless its use is extremely necessary. The common materials now being used as form is either plywood, synthetic board or metal sheet.

The use of plastic as form is the next alternative after wood and metal considering its weight, durability and recycling properties. However, the problem to be encountered is the cost of fabrication. Ordering the desired size and form in few quantities might turn out to be more expensive than the plywood and metal sheet which could be fabricated on site without delay.

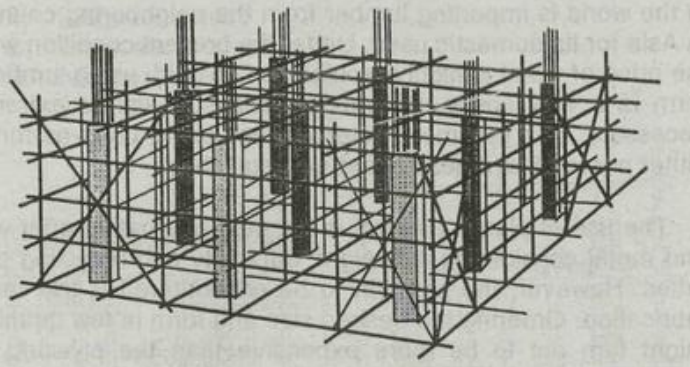
5- 7 ESTIMATING SCAFFOLDING AND STAGING

Estimating the materials for scaffolding and staging requires time and wider imagination considering the different parts of the structure involved such as: the vertical and horizontal supports, the diagonal braces plus the blocks and wedges which are not shown on a detailed plan of the building. The common practice of most estimators is to make an estimate of this item by either by quantity of the materials or by lump sum amount in the bill of materials and cost estimate.

Table 5-3 was prepared to simplify the process of estimating scaffolding and staging.

TABLE 5-3 QUANTITY OF LUMBER FOR SCAFFOLDING OR STAGING

Lumber	Column			Beam		Flooring
Size	Board Ft. per M. Ht.			Board Ft. per M. Ht.		Board Ft
	Vertical	Hor.	Brace	Vertical	Hor.	Per Sq. M.
2" x 2"	4.70	21.00	11.70	4.00	4.70	6.10
2" x 3"	7.00	31.67	17.50	6..00	7.00	9.10
2" x 4"	9.35	42.25	23.35	8.00	9.35	12.10



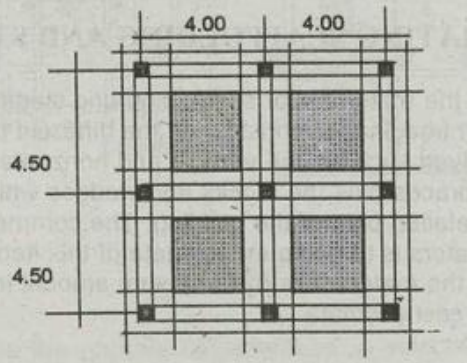


FIGURE 5-8

ILLUSTRATION 5-6

A reinforced concrete building has 9 columns with a clear height of 4.00 meters as shown on Figure 5-8. Determined the required scaffolding under the following specifications: 2" x 3" Vertical support; 2" x 2" Horizontal and Diagonal braces.

SOLUTION

A. Scaffolding for Columns

1. Find the total length of the 9 columns;

   4.00 x 9 columns = 36 meters

2. Refer to Table 5-3. Using 2" x 3" vertical support, multiply:

   36 x 7.00 = 252 bd. ft. 2" x 3" x 14 ft.

3. Find the horizontal supports. Refer to Table 5-3, using 2" x 2" lumber, multiply:

   36 x 21.00 = 756 bd. ft. 2" x 2" lumber

4. Find the diagonal braces. From Table 5-3, multiply:

   36 x 11.7 = 421 bd. ft. 2" x 2" lumber

B. Scaffolding for the Beam

1. Find total length of the 6 beams.

   Length : (4.50 x 6) + (4.00 x 6) = 51 meters

2. Refer again to Table 5-3.

   a.) For vertical support using 2" x 3" lumber, multiply:

   51 x 6.00 = 306 bd. ft.

   b.) For horizontal support using 2" x 2" lumber, multiply

   51 x 4.70 = 240 bd. ft..

C. Scaffolding for Concrete Slab

1. Find the area of the concrete floor slab.

   Area 4.50 x 4.00 x 4 units = 72 sq. m.

2. Refer to Table 5-3. Using 2" x 3" support, multiply:

72 x 9.10 = 655 bd. ft.

D. Floor Slab Forms

1. Find the floor area:

   Area = (4.50 x 4.00 x 4 units) = 72 sq. m.

2. Divide by 2.88 effective covering of one plywood

   $\frac{72}{2.88}$ = 25 pcs. 4' x 8' marine plywood.

Summary of the Materials

A.)	For Columns.....	252	board feet 2" x 3"
		1,177	board feet 2" x 2"
B)	For Beams.....	306	board feet 2" x 3"
		240	board feet 2" x 2"
C)	For Slab.....	655	board feet 2" x 3"
D)	Floor Slab Form..	25	4' x 8' plywood

Comment:

In the construction of multi-storey building, transfer of forms and scaffolding from one floor to the next is an inevitable normal operation wherein wastage of materials cannot be avoided due to tear and wear. Thus, percentage of waste varies depending upon the following factors.

1. The difference in height between floors may require adjustment of the forms and vertical support.
2. The difference in sizes of beams and girders also requires adjustments of the forms.
3. The major causes of forms and scaffolding tear and wear are the dismantling, transferring and re-assembling operations.
4. Reckless use and handling of the materials includes the making of firewood and pilferages during the period of construction.

5. The used of inferior quality lumber contribute to the high percentage of waste and risk to the workers.

5-8 STEEL PIPE SCAFFOLDINGS

Steel Pipe Scaffolding can be used freely to prefabricate height and width according to the places and forms to install. Galvanized steel pipe with good strength makes durability and also leads economical delivery and storage. Standard scaffolding frames have 4' (1.20 m.) width available in 3 different heights ranging from .90 to 1.70 m. They are useful for access platforms and concrete support works.

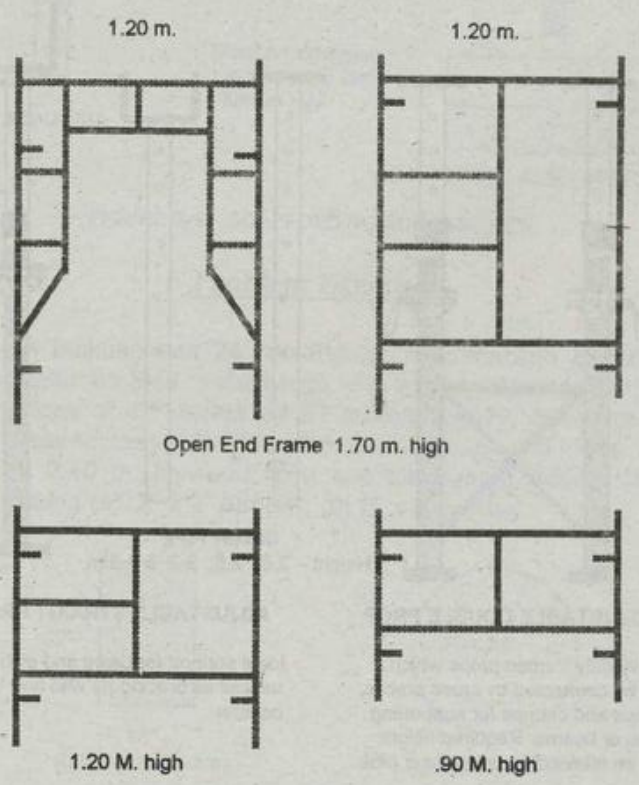
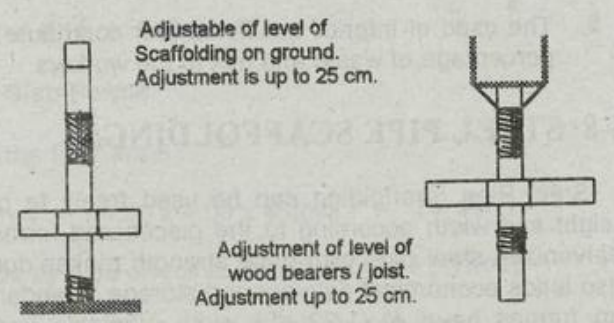
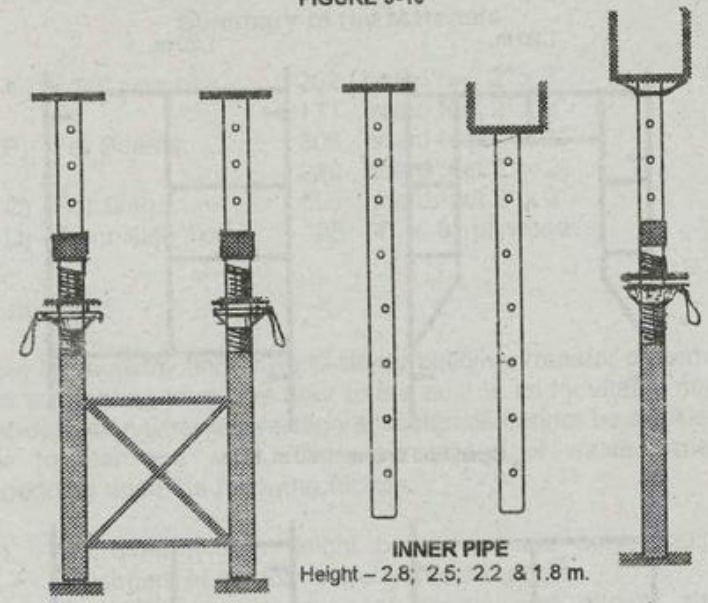


FIGURE 5-9 STEEL PIPE SCAFFOLDINGS



ADJUSTABLE BASE JACK ADJUSTABLE U-HEAD

FIGURE 5-10



ADJUSTABLE DOUBLE PROP

Heavy duty framed props which can be connected by cross braces or pipe and clamps for supporting slabs or beams. Required height can be attained by using inner pipe.

ADJUSTABLE STRAIGT PROP

Ideal support for beam and slab as well as bracing for wall and column

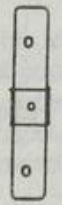
FIGURE 5-11 ADJUSTABLE STEEL SCAFFOLDING

CROSS BRACE

Various span are available in 1.20 m., 1.50 m. and 180 m.

Span: 1.82 m. ; 1.52 m. and 1.21 m.
Short cross brace - 1.20 and .90 m. frame
Long cross brace - 1.70 m. frame

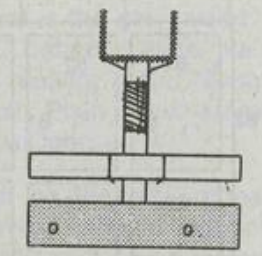
FIGURE 5-12 CROSS BRACE



Connects frame one on top of the other

JOINT PIN

Used on extension to hold on to slab lumber joist

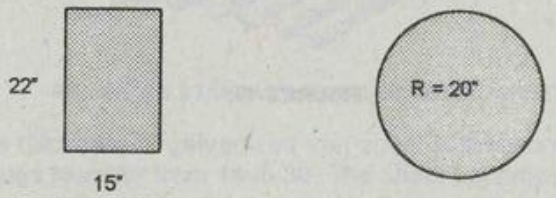


ADJUSTABLE SLAB BEARER

FIGURE 5-13 SCAFFOLDING ACCESSORIES

Problem Exercise

1. A building has 24 rectangular columns and 8 circular columns 5.80 meters high with a cross sectional dimensions of 15 inches by 22 inches and 20 inches radius respectively. Find the number of number of 6 mm x 1.20 x 2.40 m. plywood form and the corresponding frame using (a) 2" x 2" lumber; (b) 2" x 3" lumber.



Rectangular Column Circular Column

FIGURE 5-14

2. From the following figure, prepare the bill of materials for: (a.) ½" x 4' x 8' marine plywood (b.) Scaffoldings for columns, beams and slab using 2" x 3" for major support and 2" x 2" lumber for diagonal and horizontal braces if the post is 4.50 meters high.

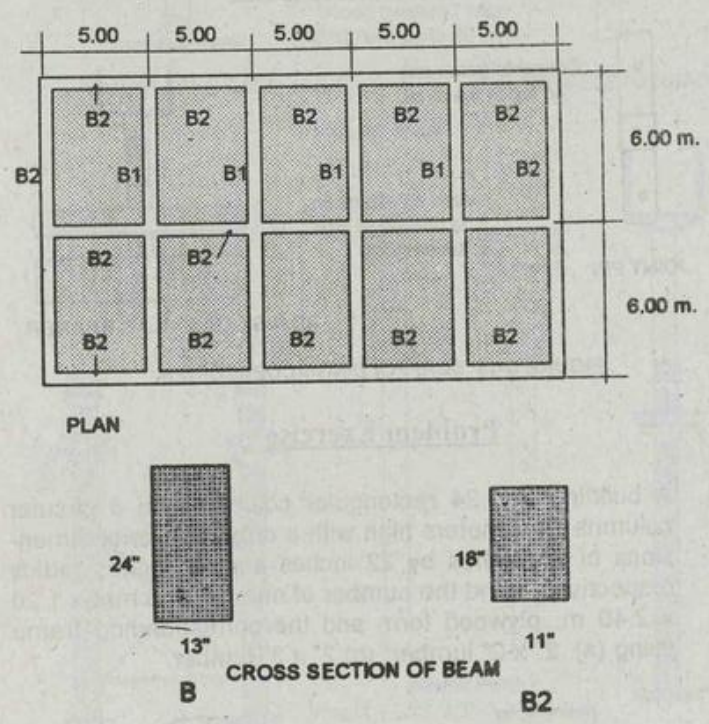


FIGURE 6-15

CHAPTER 6

ROOFING MATERIALS

6-1 GALVANIZED IRON SHEET

The most common roofing material is the galvanized iron sheet popularly known as G.I. sheet. G.I. sheet is either plain or corrugated. Plain sheet is used for roofing, gutter, flashing, downspout, ridge, hip and valley roll. Plain sheet standard commercial size is 90 x 240 centimeters long.

Corrugated galvanized iron sheet on the other hand, is widely used for roofing and sidings having standard width of 80 centimeters with varying length from 150 to 360 centimeters at consecutive intervals of 30 centimeters. Long span corrugated sheets are also available on special order.

Corrugated G. I. Roof Sheet

FIGURE 6-1 STANDARD CORRUGATED G.I. SHEET

The thickness of galvanized iron sheet is measured in terms of Gauge Number from 14 to 30. The sheet becomes thinner as gauge number becomes larger. Gauge 26 is the most extensively used for roofing and various tin works and gauge 24 is specified for gutters and valley rolls.

How to distinguish the difference in thickness between the consecutive gauges from 14 to 30 is so difficult even with the aid of a caliper.

Gauge means thickness expressed in terms of hundreth of an inch and the only way by which one could be certain that he is buying the right thickness of the sheet is by weight measure. Table 6-1 was prepared to present the various weight of G.I. sheet according to its length and gauge number.

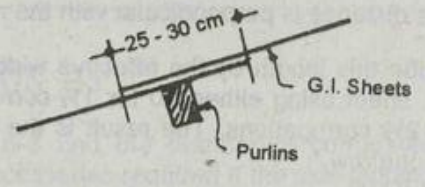
TABLE 6-1 STANDARD WEIGHT OF GALVANIZED IRON SHEET IN KILOGRAMS

Gauge No.	Thick cm.	LENGTH IN METERS AND FEET						
		1.50 5 ft.	1.80 6 ft.	2.10 7 ft.	2.40 8 ft	2.70 9 ft.	3.00 10 ft.	3.60 12 ft.
14	.203	22.36	26.83	31.30	35.78	40.25	44.72	53.66
15	.180	20.25	24.30	28.35	32.40	36.45	40.50	48.60
16	.163	18.44	27.76	25.39	29.02	32.64	36.27	43.52
17	.147	16.43	19.72	2300	26.29	29.58	32.86	39.43
18	.132	14.73	17.67	20.62	23.56	26.51	29.45	35.34
19	.117	13.03	15.63	18.24	20.84	23.45	26.05	31.27
20	.102	11.32	13.58	15.85	18.11	20.38	22.64	27.17
21	.094	10.43	12.52	14.60	16.69	18.78	20.86	25.03
22	.086	9.52	11.54	13.46	15.38	17.31	19.23	23.08
23	.079	8.73	10.47	12.22	13.96	15.71	17.45	20.94
24	.071	7.91	9.49	11.07	12.66	14.24	15.82	18.29
25	.064	7.03	8.43	9.84	11.24	12.65	14.05	16.86
26	.056	6.19	7.43	8.66	9.90	11.14	12.38	14.86
27	.051	5.76	6.91	8.06	9.22	10.37	11.52	13.82
28	.048	5.33	6.39	7.46	8.052	9.59	10.65	12.78
29	0.43	4.90	5.88	6.86	7.84	8.82	9.80	11.76
30	0.41	4.48	5.37	6.27	7.16	8.06	8.95	10.74

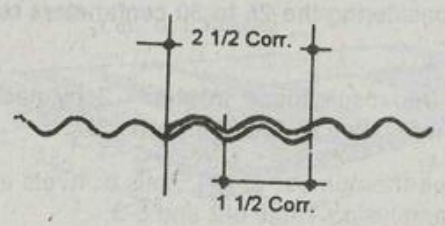
Comment :

Before estimating the required number of corrugated roofing sheets, the following information should be considered first:

1. Verify the plan if the side lapping is 1-½ or 2-½ corrugations.
2. If it is 1-1/2 corrugations, the effective width covering per sheet is .70 meters or .60 meters for 2-1/2 corrugations.
3. The standard end-lapping joint is from 25 to 30 centimeters long. This is important in determining the length of the sheet to be used.
4. Spacing of the purlins should be proportionally adjusted to the length of the G.I. sheets to avoid unnecessary cutting or excessive overlapping. In short, the length of the roof sheet governs the spacing distance of the purlins. For this purpose, refer to Table 6-2.
5. A good roofing design minimizes end lapping joint. Longer length of roofing sheet is preferred for economical reasons.



End Lapping



Side Lapping

FIGURE 6-2 LAPPING OF G.I SHEETS

TABLE 6-2 EFFECTIVE COVERING OF G.I ROOFING SHEETS

Length Ft. - Meter	Effective Covering Side Lapping		Purlins Spacing in Meter	Number of Nails or Rivets per Sheet
	1 ½	2 ½		
5' - 1.50	.70	.60	.60	14
6' - 1.80	.70	.60	.75	14
7' - 2.10	.70	.60	.60	18
8' - 2.40	.70	.60	.70	18
9' - 2.70	.70	.60	.60	22
10' - 3.00	.70	.60	.67	22
12' - 3.60	.70	.60	.66	26

6-2 ESTIMATING G.I. ROOF AND ITS ACCESSORIES

1. Determine the length of the purlins along the gutter line. This distance is perpendicular with the roof direction.
2. Divide this length by the effective width covering of one G.I. sheet using either .70 for 1½ corrugations or .60 m. for 2½ corrugations. The result is the number of sheets for one row.
3. Determine the length of the rafter or top chord. Choose the right combination of roofing sheets that will satisfy this length considering the 25 to 30 centimeters standard end lapping.
4. Multiply the result found in step - 2 by each length of sheet combination as found in step - 3.
5. Determine the number of G.I. nails or rivets and washers in kilograms using Table 6-2 and 6-3.
6. Take note that the number of plain anchor strap and lead washer is the same as the quantity of rivets.

7. Find the number of plain G.I. sheets required for anchor strap with the aid of Table 6-4.

TABLE 6-3 QUANTITY OF ROOF ACCESSORIES IN KILOGRAMS

Materials	Number per Kilogram
G.I. Roof Nails	120
G.I. Rivets	180
G.I. Washers	126
Lead Washers	75
Umbrella Nails	120

TABLE 6-4 SIZE AND QUANTITY OF STRAPS IN ONE PLAIN G.I. SHEET

Size of Purlins Inches	Size of G.I. Strap in Inches	Number of Strap in One Plain Sheet
2" x 3"	1" x 9"	384
2" x 4"	1" x 10"	342
2" x 5"	1" x 11"	312
2" x 6"	1" x 12"	288

ILLUSTRATION 6-1

From figure 6-3 find the number of corrugated G.I. roof sheets and its accessories required if the side lapping specify 1-½ corrugations with 30 cm. end lapping on a 2" x 3" purlins.

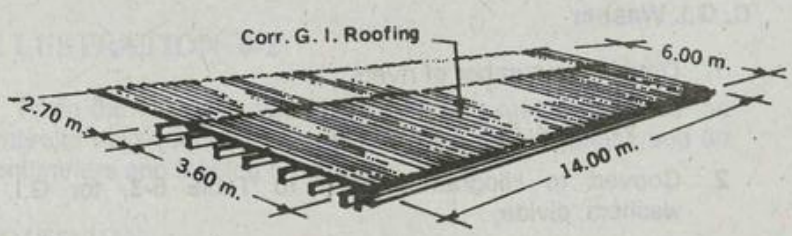


FIGURE 6-3

SOLUTION

A. Corrugated G.I. Sheet

1. Divide the length of the gutter by the effective width covering of one sheet. Refer to Table 6-2 under 1 ½ corrugations the value is .70 m., divide:

$$\frac{14.00}{.70} = 20 \text{ sheets in one row}$$

2. The length of the rafter is 6.00 meters, a combination of 3.60 and 2.70 meters long G.I. sheet or 12 ft. and 9 ft.

3. Order: 20 - 32" x 12' corrugated G.I. sheet
   20 - 32" x 9' " " "

B. Rivets

1. Refer to Table 6-2. For a 12 feet and 9 feet long roof sheet, multiply:

   For 12 ft. long : 20 x 26 = 520 pieces
   For 9 ft. long : 20 x 22 = 440 pieces
   Total rivets..... 960 pieces

2. Convert to kilograms. Refer to Table 6-3; divide:

$$\frac{960}{180} = 5.3 \text{ say } 5.5 \text{ kilograms}$$

C. G.I. Washer

1. Double the number of rivets.

   960 x 2 = 1,920 pieces.

2. Convert to kilograms. Refer to Table 6-3, for G.I. washers, divide:

$$\frac{1,920}{128} = 15.24 \text{ kilograms.}$$

D. Plain G.I. Strap on 2" x 3" Purlins

1. Total number of rivets = 960 pieces

2. Refer to Table 6-4. Using a 2" x 3" purlins, Divide:

$$\frac{960}{384} = 2.5 \text{ pieces plain G.I. sheets}$$

E. Lead Washers

1. Number of rivets is the same as the lead washer = 960

2. Refer to Table 6-3. For lead washers, divide:

$$\frac{960}{75} = 12.8 \text{ say } 13 \text{ kilograms}$$

F. Summary of the materials

20 pcs. 32" x 12 ft. corrugated G.I. sheet
20 pcs. 32" x 9' corrugated G.I. sheet
5.5 kg. G.I rivets
15.5 kg. G.I. washers
13.0 kg. Lead washers
2.5 pcs. Plain G.I. sheets

ILLUSTRATION 6-2

From the following figure, find the G.I. roof sheets and the umbrella nails required adopting 2 ½ side corrugations and 30 centimeters end lapping on a 2" x 3" purlins.

SOLUTION

A. Corrugated G.I. Sheets

1. Find the number of roof sheet. Refer to Table 6-2. Using 2 ½ corrugations, divide:

$$\frac{18.00 \text{ m.}}{.60} = 30 \text{ pieces}$$

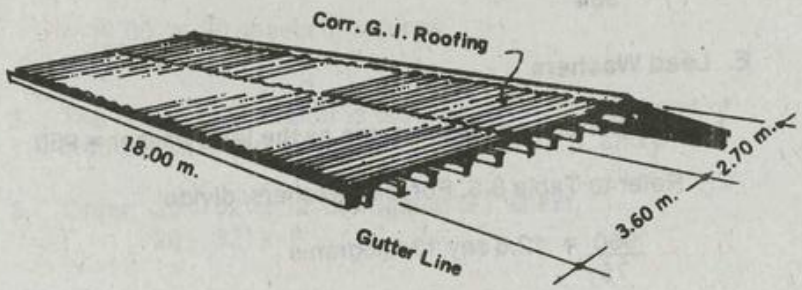


FIGURE 6-4

2. The length of rafter is 6.00 meters (20') a combination of 3.60 m. (12') and 2.70 m. (9') roof sheet. Refer to Table 6-5, multiply each sheet length by the result of step-1.

   30 pcs. 32" x 12' and

   30 pcs. 32" x 9' corrugated roof sheets

3. Take note that this is only one side of the roof. For the other side, double the quantity of the roof sheet

   2 x 30 = 60 pieces at 3.60 m. (12') long and

   2 x 30 = 60 pieces at 2.70 m. (9') long

B. Umbrella Nails

1. Determine the number of umbrella nails for the 12 feet and 9 feet roof sheets. Refer to Table 6-2, multiply:

60 pcs. of 12 ft. x 26 = 1,560 pieces

60 pcs. of 9 ft. x 22 = 1,320 pieces

Total..... 2,880 pieces

2. Convert to kilograms. Refer to Table 6-3, divide:

$$\frac{2,880}{120} = 24 \text{ kilograms}$$

ILLUSTRATION 6-3

From Figure 6-5, find the number of roof sheets, nails, and lead washers if the plan specify 2 ½ side lap corrugations.

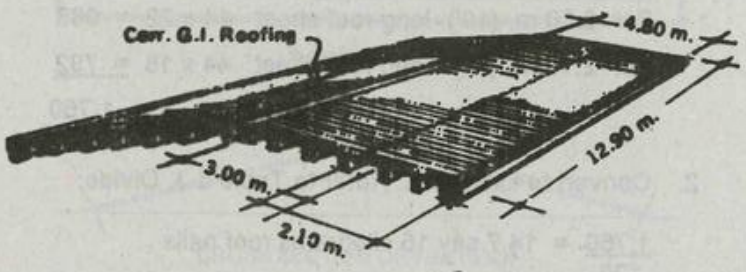


FIGURE 6-5

SOLUTION

A. Corrugated G.I. Sheet

1. Determine the number of roof sheet in one row along the 12.90 m. gutter. Refer to Table 6-2, divide:

$$\frac{12.90 \text{ m.}}{.60} = 21.5 \text{ say } 22 \text{ pieces}$$

This number is only for one side of the roof.

2. Length of the rafter is 4.80 meters (16 ft.) or a combination of either:

   a.) 10' and 7' G.I. sheet,
   b.) 9' and 8' or
   c.) 12' and 5' long

   If a combination of 10' and 7' is preferred, then, the order will be:

   2 x 22 = 44 pieces 32" x 10' and

   2 x 22 = 44 pieces 32" x 7'

B. Roof Nails and Lead Washers.

1. Solve for the number of roof nails. Refer to Table 6-2;

   For 3.00 m. (10') long roof sheet 44 x 22 = 968

   For 2.10 m. (7') long roof sheet 44 x 18 = 792

   Total roof nails..... 1,760

2. Convert to kilograms. Refer to Table 6-3. Divide:

   $\frac{1,760}{120}$ = 14.7 say 15 kilograms roof nails

   $\frac{1,760}{75}$ = 23.5 say 24 kg. lead washers

ILLUSTRATION 6-4

From Figure 6-6, find the number of corrugated roof sheets, rivets, washers, lead washers, including the plain G.I. straps required if the plan specify 2-1/2 side lap corrugations and .30 m. end lapping on a 2" x 4" purlins.

SOLUTION

A. Roofing Sheets

1. Find the number of roof sheets along the 18.00 meters gutter. Refer to Table 6-2, for 2 ½ side lapping, divide:

   $\frac{18.00}{.60}$ = 30 pieces

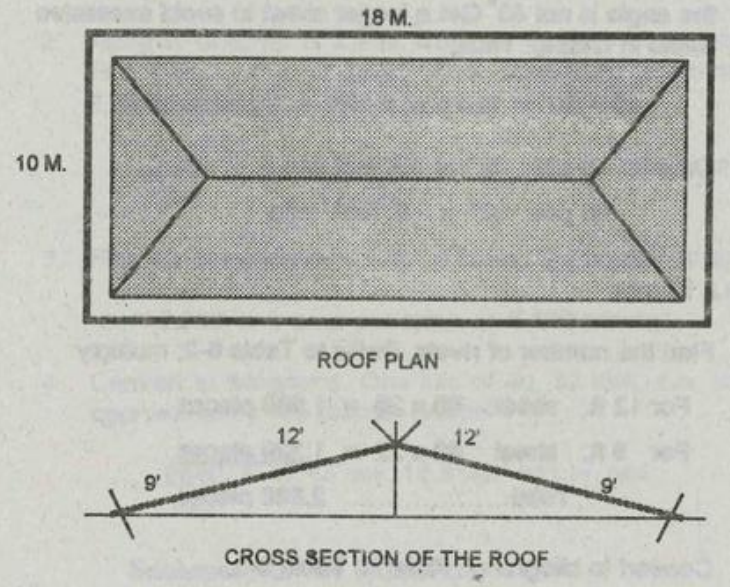


FIGURE 6-6

2. Determine the length of the rafter. For a 6.00 meters long rafter, try a combination of 3.60 m. (12') and 2.70 m. (9') long G.I sheets. Refer to Table 6-5,

   30 pieces of 32" x 12 feet and

   30 pieces of 32" x 9' feet long

3. Take note that the above quantities are only for one side of the roof. To include the other side, double the quantity.

2 x 30 = 60 pcs. 12 ft. and

2 x 30 = 60 pcs. 9 ft. long

4. Considering that the roof is a hipped type, wastage on cutting can not be avoided, hence, provide an additional allowance of 5% if the angle of the hip is 45° and 10% if the angle is not 45° Get a longer sheet to avoid excessive waste in cutting. Thus;

60 + 60 = 120 pcs. x 5% = 6 pieces of 12'

5. Order 66 pcs. 32" x 12 feet and
60 pcs. 32" x 9 feet long

B. G.I. Rivets

1. Find the number of rivets. Refer to Table 6-2; multiply:

For 12 ft. sheet: 60 x 26 = 1,560 pieces
For 9 ft. sheet 60 x 22 = 1,320 pieces
Total..... 2,880 pieces

2. Convert to kilograms. Refer to Table 6-3.

$\frac{2,880}{180}$ = 16 kilograms

C. G.I. and Lead Washers

1. For G.I. washers, double the number of rivets:
2,880 x 2 = 5,760 pieces. Refer to Table 6-3; divide:

$\frac{5,760}{126}$ = 45.7 say 46 kilograms

2. Lead Washer is the same number as the rivets. Refer to Table 6-3; divide:

$\frac{2,880}{75}$ = 38.5 say 39 kilograms

D. Plain G.I. Anchor Strap

1. Refer to Table 6-4. The size of G.I. strap on a 2" x 4" purlins is 1" x 10".

2. Number of strap is 2,880 equal to the number of rivets. Find the number of plain sheet needed to produce the 2,880 anchor strap. Refer to Table 6-4. Divide:

$\frac{2,880}{342}$ = 8.42 say 9 pieces 36" x 8 ft. plain G.I. sheet.

3. Find the common wire nails to fasten the anchor strap.

2,880 x 3 nails per strap = 8,640 pieces

4. Convert to kilograms. One kilo of 4d, 32 mm c.w. nail is approximately 695 pieces. Divide:

$\frac{8640}{695}$ = 12.43 say 12.5 kg. 4d c.w. nail

Summary of the Materials

66 pieces 32" x 12 ft. corrugated G.I. sheet
60 pieces 32" x 9 ft. corrugated G.I. sheet
9 pieces 36" x 8 ft. plain G.I. sheet
16 kilograms G.I. rivets
39 kilograms G.I. washers
12.5 kilograms 4d (1-1/2") common wire nails.

Comment:

The estimating procedure for a hipped roof is the same as that of the lean-to or gable type roofing considering the effective covering of one sheet as constant divisor.

However, little variations might occur in actual tinsmith work such as:

1. Errors might be committed in cutting and or lapping of the roof sheets.
2. If the hipped is not patterned at 45 degrees, extra cut of the G.I. roofing sheet is inevitable.
3. Under any of the preceding circumstances, an allowance of 5% to 10% is satisfactory.

TABLE 6-5 COMBINATION OF G.I. ROOF SHEETS ON A GIVEN RAFTER LENGTH

Rafter Length	No. of Sheet	Combination of Roof Sheet Length					
		Meters	Feet	Meters	Feet	Meters	Feet
3.00	1	3.00	10'				
3.30	1	3.30	11'				
3.60	1	3.60	12'				
3.90	2	2.10	7'	and 2.10	7'		
4.20	2	2.40	8'	and 2.10	7'		
4.50	2	2.40	8'	and 2.40	8'		
4.80	2	3.00	10'	and 2.10	7'		
5.10	2	3.00	10'	and 2.40	8'		
5.40	2	3.00	10'	and 2.70	9'		
5.70	2	3.00	10'	and 3.00	10'		
6.00	2	3.60	12'	and 2.70	9'		
6.30	2	3.60	12'	and 3.00	10'		
6.60	2	3.60	12'	and 3.30	11'		
6.90	2	3.60	12'	and 3.60	12'		
7.20	3	3.00	10'	and 2.40	8'	and 2.40	8
7.50	3	3.00	10'	and 3.00	10'	and 2.10	7'
7.80	3	3.00	10'	and 3.00	10'	and 2.40	8'
8.10	3	3.60	12'	and 3.00	10'	and 2.10	7'
8.40	3	3.60	12'	and 3.00	10'	and 2.40	8'
8.70	3	3.60	12'	and 3.60	12'	and 2.10	7'
9.00	3	3.60	12'	and 3.60	12'	and 2.40	8'

6-3 GUTTER, FLASHING, RIDGE, HIPPED AND VALLEY ROLL

In building construction, these items are categorized as roof accessories under tinsmith work. Estimating these type of accessories is simply determining the number of plain G.I. sheet needed to fabricate the gutter, flashing and the different rolls according to the form and shape as shown on the plan.

The primary consideration in tinsmith work is economy, which simply mean, to utilize every inch of the tin sheet. As much as possible, any unwise cutting of the tin sheet must be avoided. Cutting should start from the widest to the narrowest part of the roof accessories.

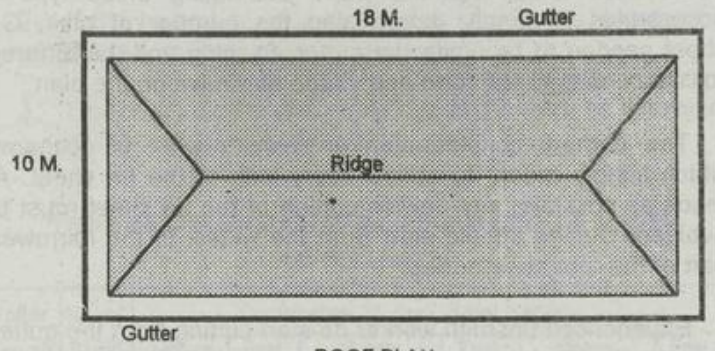
Experienced tinsmith worker do start cutting from the gutter, then to the flushing down to the smallest plain G.I. strap to avoid waste of the materials.

Estimating Procedures

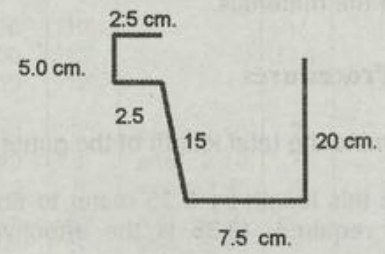
1. Determine the total length of the gutter in meters.
2. Divide this length by 2.35 meter to find the number of gutter required. (2.35 is the effective length of one gutter)
3. Find the total width of one gutter based from the cross section of the detailed plan.
4. The width of one plain G.I. sheet is-.90 meters. Divide .90 m. by the result of step 3 to find out how many gutter could be made out from one plain G.I. sheet.
5. The fractional value as extra cut will be reserved for other smaller parts.
6. Divide the result of step 2 by the result of step 4. The result is the required number of G.I. sheet.

ILLUSTRATION 6-5

From Figure 6-7, find the number of plain G.I. sheets required to fabricate the open gutter as illustrated.



ROOF PLAN



CROSS SECTION OF GUTTER

FIGURE 6-7

SOLUTION.

1. Find the total length of the roof gutter

   Length = 2 (18.00) + 2 (10.00) = 56.00 meters

2. Divide length by 2.35 m. the effective length of gutter.

   $\frac{56.00}{2.35}$ = 23.82 say 24 pieces

3. The total width of the gutter is 52.5 centimeters (see cross section of gutter) Subtract 52.5 from 90 centimeters the standard width of one plain G.I. sheet.

   90 cm. – 52.5 = 37.5 extra cut.

   This 37.5 centimeters excess cut from one plain G.I. sheet could be set side momentarily to be considered in making other roof accessories such as flashing, downspout, anchor strap for riveting etc. Thus, only one gutter at 2.40 meters (8') long could be made out from one plain sheet.

4. Order: 24 - 90 cm.(36") x 2.40 m. (8') plain sheet

Comment

It will be noted that the standard commercial width of one plain G.I. sheet is 90 centimeters or 36 inches. The total width of one gutter is 52.5 centimeters. Subtracting 52.5 from 90 will result to an extra cut of 37.5 centimeters.

This simply mean that only one gutter could be made out from one plain G.I. sheet with an excess cut of 37.5 centimeters. The 37.5 centimeters excess does not necessarily mean to be considered as waste because there are several parts in the tinsmith work that requires smaller cut or dimensions such as flashing, and anchor straps.

PVc plastic materials are now in used as gutter and downspout instead of the plain G.I. sheets. However, at this early stage, the use of PVc plastic gutter have not gained satisfactory result and acceptance for its failure to resist warping caused by temperature changes.

ILLUSTRATION 6-6

From Figure 6-8, find the number of plain G.I. sheet required to fabricate the gutter, ridge roll and flashing as illustrated.

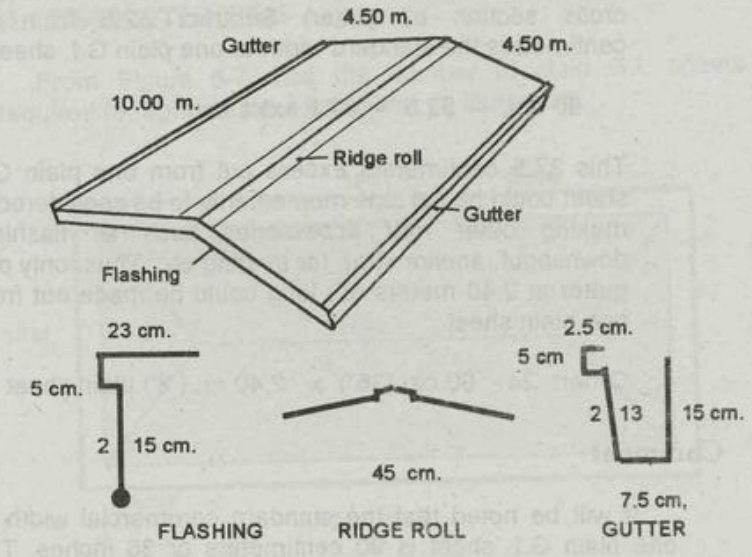


FIGURE 6-8

SOLUTION

A. Gutter

1. Find the total length of the roof gutter = 20 meters. (see figure 6-8)

2. Divide by the effective length of one gutter. (Table 6-6)

$$\frac{20.00 \text{ m.}}{2.35} = 8.5 \text{ say } 9 \text{ pieces gutter}$$

3. Total width of gutter is 45 centimeters. Divide width of plain G.I. sheet by 45 centimeters.

$$\frac{90 \text{ cm.}}{45} = 2 \text{ pieces derived from one G.I. sheet.}$$

4. Divide the result of step 2 by step 3.

$$\frac{9}{2} = 4.5 \text{ say } 5 \text{ pieces plain G.I. sheet}$$

B. Flushihg

1. Find the total length of flashing: 4 x 4.50 m. = 18 m.

2. Divide by the length of one flashing. See Table 6-6

$$\frac{18 \text{ meters}}{2.30} = 7.8 \text{ say } 8 \text{ pieces}$$

3. Width of plain G.I. sheet divided by width of flashing.

$$\frac{90 \text{ cm}}{45} = 2 \text{ pieces.}$$

4. Divide step 2 by step 3 to find the number of plain sheet

$$\frac{8}{2} = 4 \text{ pieces}$$

TABLE 6-6 ROOF ACCESSORIES

Item	Effective Length in Meters
Gutter	2.35
Flashing	2.30
Ridge Roll	2.20
Valley Roll	2.30
Hipped Roll	2.20
Soldering Lead	¼ (.25) bar per solder joint
Moriatic Acid	10 cc per soldering lead

C. Ridge Roll

1. Total length of the ridge roll is 10 meters. Divide by the length of one ridge roll, see Table 6-6.

$\frac{10.00 \text{ m.}}{2.20} = 4.5$ pieces ridge roll

2. Determine how many ridge roll can be made out from one plain G.I. sheet. Width of plain sheet divided by width of ridge roll

$\frac{90 \text{ cm.}}{45 \text{ cm.}} = 2$ pcs.

3. Find the number of plain sheet. Divide step 1 by step 2.

$\frac{4.5}{2} = 2.25$ pieces

Summary

For Gutter 5 pcs. 90 cm. x 240 cm. plain G.I. sheet.
Flashing : 4 pcs. 90 " x 240 cm. plain G.I. sheet.
Ridge Roll: 2 pcs. 90 " x 240 cm. plain G.I. sheet
Total..... 11 pcs. plain G.I. sheets.

D. Valley and Hipped Roll

The estimating procedure for valley and hipped roll is the same as that of the gutter, flashing and ridge roll with the aid of Table 6-6.

TABLE 6-7 CORRUGATED PLASTIC ROOF SHEET

Commercial Size		Effective Width Covering Corrugation	
Size	Meter	1 ½	2 ½
26" x 8'	.650 x 2.40	.46 m.	.31 m.
29" x 8'	.725 x 2.40	.53 m.	.38 m.

6-4 ASBESTOS ROOFING

Unlike galvanized iron roofing sheet where accessories

from gutter down to the smallest anchor straps are made on site out from the standard size of plain G.I. sheet, estimating asbestos roofing material is much simpler because all the roof accessories and parts to be used such as gutter, ridge, hip and valley rolls are all factory made ready for installation.

Different Kinds of Asbestos Roofing

1. Standard corrugated sheet
2. 4-V Corrugated sheet
3. Placa Romana
4. Kanaletas
5. Tencor corrugated sheet
6. Ardex lightweight corrugated sheet

   a. Standard Ardex
   b. Super Ardex

Estimating Procedures:

a.) The number of corrugated asbestos roofing required is determined by dividing the gutter length by the effective width covering of one sheet.

b.) In finding the number of accessories such as flashing, gutter, ridge, hip and valley roll, divide each total length by the effective length of the accessories.

c.) Other parts such as ridge end cap, apron flashing, gutter corner, down spout and fittings are found by direct counting. They are all ready made according to factory standard sizes.

ILLUSTRATION 6-7

From figure 6-9, find the standard asbestos roofing sheet Including its accessories required.

A. Standard Corrugated Asbestos Sheet

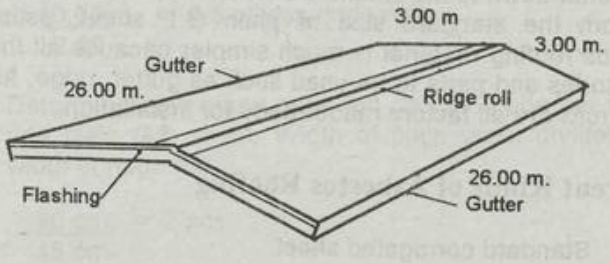


FIGURE 6-9 STANDARD ASBESTOS CORRUGATED SHEET

SOLUTION

Standard Sheet

1. Find the total length of the gutter: 2 x 26 = 52.00 meters
2. Refer to Table 6-8. Divide 52.00 m. by the effective width

$$\frac{52.00 \text{ m.}}{.838} = 62 \text{ pieces standard asbestos sheet.}$$

Gutter

Total length of the ridge roll is = 26.00 m. Refer to Table 6-8, divide this length by the effective length of one gutter.

$$\frac{2 \times 26.00}{2.336} = 22.26 \text{ pieces.}$$

Ridge Roll

Total length of the ridge is = 26.00 meters. Refer to Table 6-8 for ridge roll. Divide:

$$\frac{26.00 \text{ m.}}{.838} = 31.0 \text{ pcs. ridge roll.}$$

Flashing:

1. Find the total length of the flashing (see figure)

3.00 m. x 4 sides = 12.00 meters

2. Refer to Table 6-8, for outside flashing, divide:

$$\frac{12.00 \text{ m.}}{2.286} = 5.25 \text{ say 6 pcs. outside flashing.}$$

Ridge End Cap

1. From Figure 6-9. By actual count, there are 2 ridge end cap. Order 2 pieces.

Summary of Materials

62 pcs. 1.20 x 3.00 Standard corrugated sheet
23 pcs. standard gutter
31 pcs. standard ridge roll
6 pcs. standard flashing
2 pcs. standard ridge end cap

Technical Data For Estimating Asbestos Roofing

TABLE 6-8 STANDARD CORRUGATED SHEETS

Length	1.20 x 3.00 m.
End lapping: Below 20 degrees	0.30 m.
Above 20 degrees	0.15 m.
Effective width	0.838 m.
Ridge Roll effective length	0.838 m.
Gutter effective length	2.336 m.
Outside flashing	2.286 m.
Hip roll	1.676 m.

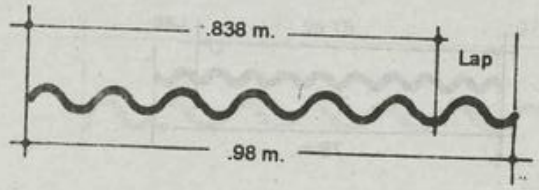


FIGURE 6-10 STANDARD CORRUGATED SHEET

B.) 4-V Corrugated Asbestos Sheet

TABLE- 6-9 4-V CORRUGATED SHEET TECHNICAL DATA

Standard Length	2,438 m.
Effective width	.965 m.
Ridge Roll effective length	.965 m.
Outside Flashing effective length	2.286 m.

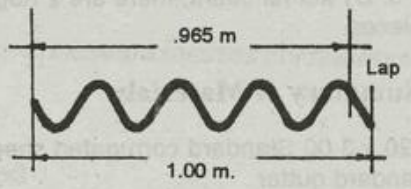


FIGURE 6-11 4-V CORRUGATED ASBESTOS SHEET

C.) Tencor

TABLE 6-10 TENCOR CORRUGATED SHEET TECHNICAL DATA

Standard length	2.44 m.
Lapping	.15 or .30 m.
Effective Length	2.29 or 2.14 m.
Standard Width	.748 m.
Effective Width	.675 m.
Outside Flashing	1.50 to 3.00 m.
Minus Lapping	.15 m.
Ridge Roll	.953 m.

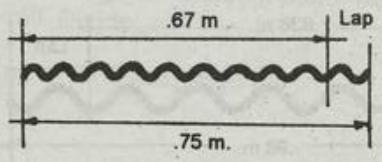


FIGURE 6-12 TENCOR CORRUGATED SHEET

D. Kanaletas

TABLE 6-11 KANALETAS TECHNICAL DATA

Length	7.315 m.
Effective width	.885 m.
Eaves flashing	.885 m.
Outside flashing effective length	2.40 to 3.00 m.

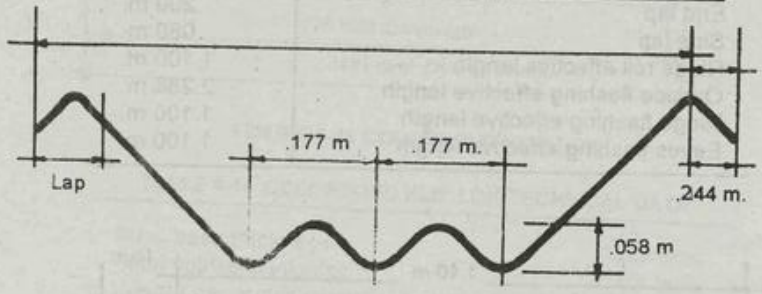


FIGURE 6-13 KANALETAS

E. Ardex

TABLE 6-12 ARDEX TECHNICAL DATA

Standard width	.52 m.	1 05 m.
Effective width	.45 m.	.97 m.
Nominal length	.75 to 3.15 m.	2.40 to 3.60 m.
Ridge roll effective length	.95 m.	.95 m.
Outside flashing	1.50 to 2.00	1.50 to 3.00 m.
Side lapping	.15 m.	.15 m.

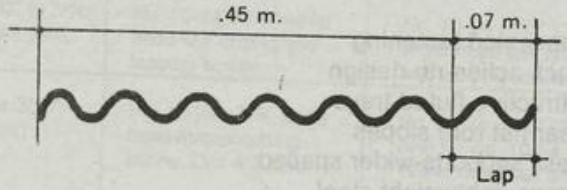


FIGURE 6-14 ARDEX

E. Placa Romana

TABLE 6-13 PLACA ROMANA TECHNICAL DATA

Standard length	.912 m.
Effective length	.600 m.
Standard width	1.180 m.
Effective width	1.100 m.
End lap	.200 m.
Side lap	.080 m.
Ridge roll effective length	1.100 m.
Outside flashing effective length	2.286 m.
Ridge flashing effective length	1.100 m.
Eaves flashing effective length	1.100 m.

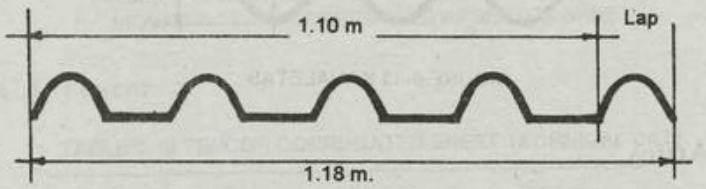


FIGURE 6-15 PLACA ROMANA

6-5 COLORBOND KLIP-LOK

Colorbond is a corrosion resistant zinc coated steel sheet pre-painted steel ribbed tray roofing and walling with the following special features.

1. Concealed fastening
2. Lock action rib design
3. Attractive fluted trays
4. Near flat roof slopes
5. Less supports-wider spaced
6. Strong lightweight steel
7. Custom cut long lengths

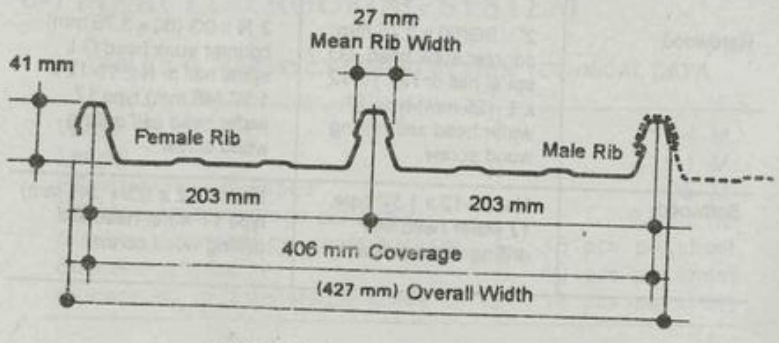


FIGURE 6-16 COLORBOND KLIP-LOK

TABLE 6-14 COLORBOND KLIP LOK TECHNICAL DATA

Steel base thickness	0.60 mm.
Total coated thickness	0.63 mm.
Weight per meter length of panel	2.66 kg.
Weight per covered area	6.00 M.
Length available up to	15.00 m.
Longer length special order up to	35.00 M.
Overall width	.427 m.
Effective width coverage	.406 m

RECOMMENDED FASTENERS
(TWO FASTENERS REQUIRED PER CLIP)

Support member	Normal Fastening	Fastening over Insulation Up to 100 mm (4")
Steel up to 3/32" (2.5 mm) thick	No. 10-16 x 5/8" wafer head self drilling and tapping screw	No. 10-15 x 7/8" (22 mm) wafer head self drilling and tapping screw
Steel 3/32" to 3/16 2.5 - 5 mm thick	No. 10-24 x 5/8" wafer head self drilling and tapping screw	No. 10-24 x 7/8" (22 mm) wafer head self drilling and tapping screw
Steel over 3/16" (5mm thick)	No. 10-24 x 5/8" wafer head thread cutting screw. Drill 4.5 mm.	No. 10-24 x 7/8" (22 mm) hole for No. 10-24 x 7/8" Wafer head self drilling and tapping screw.

Hardwood	2" x 9G(50 x 3.75 mm) counter sunk head G.I. spiral nail or No. 10-12 x 1 (25 mm) type 17 wafer head self drilling wood screw.	2 ½ x 9G (60 x 3.75 mm) counter sunk head G.I. spiral nail or No. 10-12 x 1 ¾" (45 mm) type 17 wafer head self drilling wood screw.
Softwood	No. 10-12 x 1 ¾" type 17 wafer head self drilling wood screw	No. 10-12 x 1/3/4" (45 mm) type 17 wafer head self drilling wood screw.

6-6 BANAWE HORIZONTAL METAL TILE

TABLE 6-15 BANAWE METAL TILE TECHNICAL DATA

Item	Length in Meter
Nominal width	.228 m.
Effective width coverage	.204 m.
Length	12.19 m.
Minimum roof slope	15 degrees

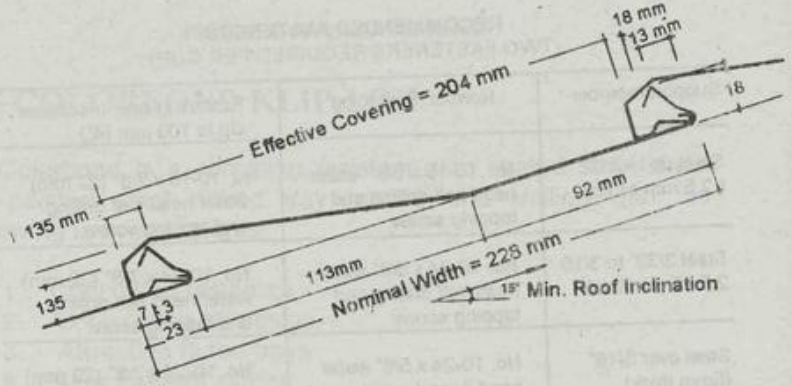
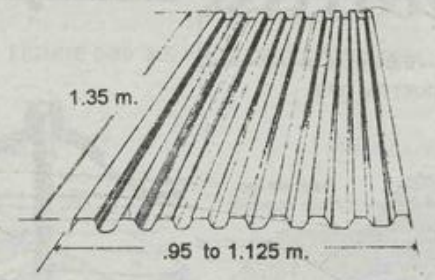


FIGURE 6-17 CROSS SECTION OF BANAWE METAL TILE

6-7 MARCELO ROOFING SYSTEM

TABLE 6-16 MARCELO ROOFING SYSTEM TECHNICAL DATA

Width	1.14 M.
Length	1.11 M.
Effective width coverage	.95 M.
Effective Area coverage per sheet	.92 sq. m.
Number of fastener per sheet first row	15 pcs. per sheet
Succeeding rows	10 pcs. per sheet
Average No. of fasteners per sheet	12 pcs. per sheet



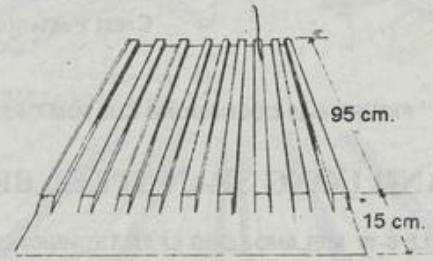


FIGURE 6-18 MARCELO ROFING SYSTEM

6-8 COLORBOND CUSTOM ORB

TABLE 6-17 COLORBOND CUSTOM ORB TECHNICAL DATA

Normal width	.86 m.
Effective coverage	.76 m.
Length	1.35 m.
Longer length	Special order
Max. recommended length for continuous sheet without joints)	24 m.

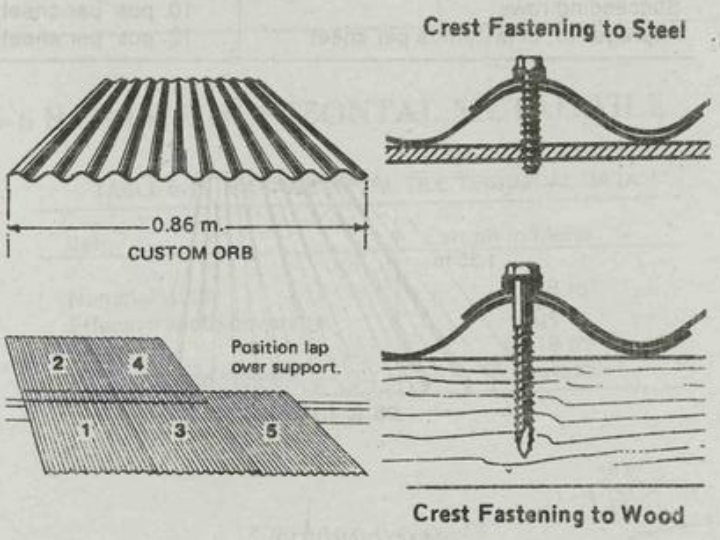
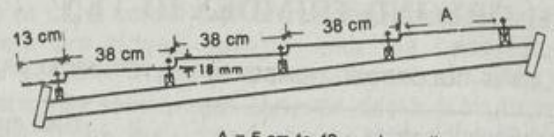


FIGURE 6-19 COLORBOND CUSTOM ORB

6-9 MILANO LONG SPAN STEEL BRICKS

TABLE 6-18 MELANO LONG SPAN TECHNICAL DATA

Steel base thickness No. 26	0.40 mm
Weight per square meter	4.53 kg.
Effective coverage	0.67 M.
Length up to	6.00 M.
Recommended roof slope	10° min.



A = 5 cm to 43 cm dependingupon the length of the top tile.

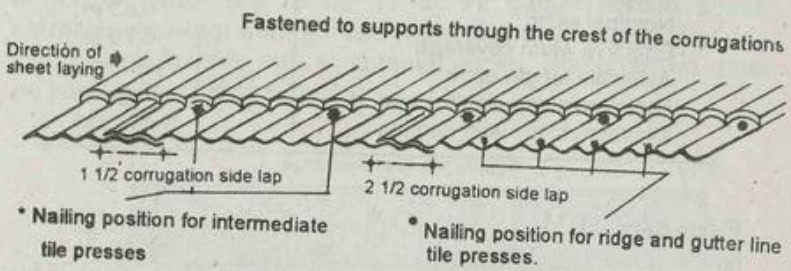


FIGURE 6-20 MILANO LONG SPAN STEEL BRICKS

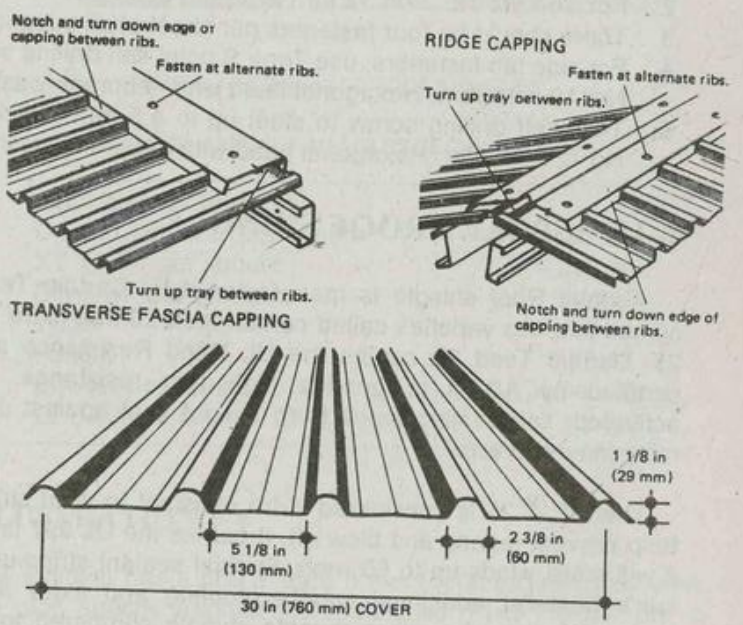


FIGURE 6-21 COLORBOND TRIMDEX HI-TEN

6-10 COLORBOND TRIMDEX HI-TEN

TABLE 6-19 COLORBOND TRIMDEX HI-TEN TECHNICAL DATA

Steel Base thickness	0.40 mm
Weight per unit area	4.28 kg. / sq. m.
Weight per unit length	3.26 kg. / sq. m.
Nominal width	0.83 m.
Effective width coverage	0.76 m.
Available length up to	15.00 m.
Minimum slope single sheet	3 degrees
Minimum slope with end lap	5 degrees

Fasteners

1. **For hardwood**: Use Type 17 self drilling wood screw No. 12 x 50 mm. Hexagonal head with neoprene washer.
2. **For soft wood**: Add 12 mm to length of screw.
3. There should be four fasteners per sheet at all supports.
4. For side lap fasteners, use Type S point self drilling screw No. 10 x 16 mm. Hexagonal head with neoprene washers.
5. Teks self drilling screw to steel up to 4.5 mm. Thick use No.12 x 45 mm. Hexagonal head with neoprene washer.

6- 11 ASPHALT ROOF SHINGLE

Asphalt Roof shingle is manufactured by Certain Teed. It comes into two varieties called certain teed 20 and extra tough 25. Certain Teed 20 carries the UL Wind Resistance and is certified by ASTM to provide high tear resistance. Solar activated, self sealing strips form a tight seal against driving rain, snow and wind.

The XT ^{TM} 25 is considered extra resistant to wind stress to help prevent tearing and blow off. It carries the UL 997 label so it will resist winds up to 60 mph. Special sealant strips use the sun's heat for additional weatherproofing and extra asphalt makes it a heavier, more durable shingle compared to basic three-tab strip shingles.

Four fasteners are required per shingle located 5/8" above the top of each cutout and 1" in from each side of the shingle. Fasteners are driven straight, with the heads flush to the shingle surface. Fasteners must be of sufficient length to penetrate into solid wood, plywood decking ¾" or through the thickness of the decking whichever is less. Nail shanks must not be less than ¾" and staple legs must never be less than 1" in length. Nails are to be 11 or 12 gauge barbed shank corrosion resistant roofing nails with 3/8" heads. Use 16 gauge zinc coated staples with 1" nominal crown. Staple crown must be parallel horizontal tab edge.

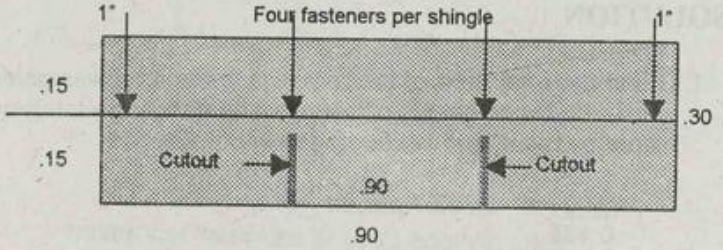


FIGURE 6-22 ASPHALT ROOF SHINGLES

TABLE 6-20 ASPHALT SHINGLES TECHNICAL DATA

Fiber glass composition	
Certain Teed 20 per square	200 lb.
XT TM ^{25} per square	225 – 230 lb.
Dimensional tolerance	1/16"
Width	0.30 m.
Length	0.90 m.
Effective coverage	0.135 sq. m.
One bundle covers	3 sq. m.

ILLUSTRATION 6-8

A building has a 500 square meters total inclined roof area. The plan specify Asphalt Roof Shingles. Find the number of shingles required.

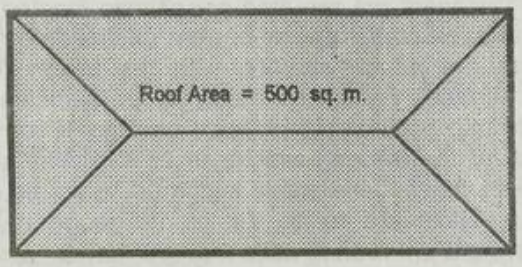


FIGURE 6-23 ROOF PLAN

SOLUTION

1. Find the total area of the roof. Since the area was given, refer to Technical specifications and divide the total roof area by the effective coverage per shingle.

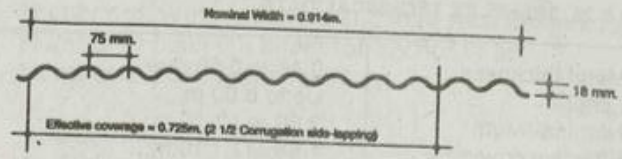
$$\frac{500}{0.135} = 3{,}703.7 \text{ pieces}$$

2. Another solution is to divide the roof area by 3 square meters to get the number of bundles of shingle required.

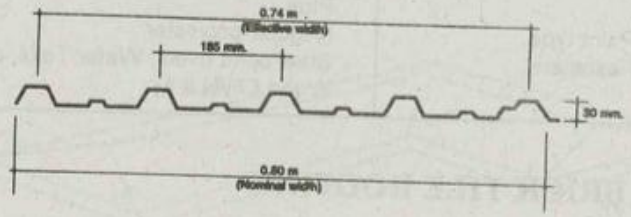
$$\frac{500}{3} = 166.6 \text{ say } 167 \text{ bundles.}$$

6-12 Upvc ROOFING SHEET

The Upvc roofing sheet is called IMACRoof suited to corrosive conditions particularly industrial establishments. It has an internal thermal conductivity equal to the expanded polyurethane and polystyrene eliminating the use of insulating materials. IMAC Roof sheets are made up of a particular blend of thermoplastic resins and does not shatter easily unlike ordinary plastic, asbestos and fiberglass roofing. The roof is shockproof and hinders the dispersion of flames when in contact with fire. They only carbonize without dripping or breaking up.



CORRUGATED



RIB TYPE

FIGURE 6-24 PROFILES OF UPVC ROOFING SHEETS

TABLE 6-21 UPVC ROOF SHEET TECHNICAL DATA

Profile	Ordinary corrugation & Rib-type
Effective width	0.91 m. for ordinary corrugation
Effective width	0.80 m. for the Rib-Type
Color	White, beige, translucent
Thickness	1.00 mm., 1.50 mm., 2.00 mm & 2.50 mm
Length	long span
Tensile strength	30 Mpa
Impact strength	27 KJ / m^2
Fire classification	Class 1
Chemical resistance	Excellent resistance to acids/bases/ salts and numerous solvents.

6-13 SPANFLEX

Spanflex is a siding and ceiling system efficient substitute for costly wood panels. It presents an interesting and impressive interior and exterior profile for homes and offices. Spanflex is available in all style range of designs and colors to suit your aesthetic requirements.

TABLE 6-22 SPANFLEX TECHNICAL DATA

Metal thickness	0.40 to 0.60 mm
Length	Up to 6.00 m.
Nominal width	2.00 m./ 1.10 m.
Effective coverage	1.65 m / 1.10 m.
Application	Ceiling, siding and fascia
Colors	Ivory, Forest green, mandarin red. Ocean blue, white, mahogany, and Pine
Paint type	Regular polyester
Fasteners	Steel blind rivets, Wafer Teks, on Wood CWN # 1

6-14 BRICK TILE ROOFING

Technical Data:

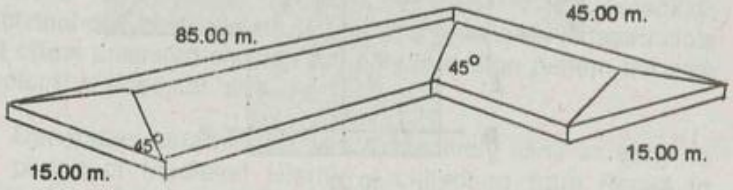
Description	Weight in kilograms	Number required
Marceille Type (flat)	3.60	14.0 per sq. m.
Ondula Type	4.00	15.0 per sq. m.
SR. standard ridge	2.80	2.5 / sq. m.
Half Marceille	2.00	1.0 / ln. m.
JRT-1	3.00	13.0 / sq. m.
JRT-2	3.75	4.0 / sq. m.
JRT-3	3.20	1.0 / sq. m.
JRT-4	3.20	1.0 / sq. m.
JRT-5	2.20	4.0 / sq. m.
SRT-1	4.00	13.0 / sq. m.
SRT-2	2.20	1.0 / sq. m.
SRT-L	2.25	1.0 / sq. m.
SRT-R	2.25	1.0 / sq. m.
JSR-1	2.00	1.0 / sq. m.
JSR-2	3.00	4.0 / sq. m.
SRT-U	1.75	25.0 / sq. m.
SRT-T	1.50	25.0 / sq. m.

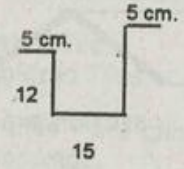
Problem Exercise

1. From the following figure, using 2 ½ corrugations and 30 centimeters end lapping on a 2" x 4" purlins solve for the following:

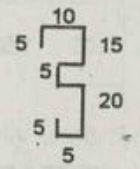
a. Number of corrugated G.I. roof sheets
b. Number of rivets, washers and lead washers in kilograms
c. Number of plain G.I sheet for anchor strap
d. Number of plain G.I. sheet for:

   1. Gutter and flushing
   2. Ridge, hip and valley roll
   3. Number of nails to fasten the anchor strap in kilograms.

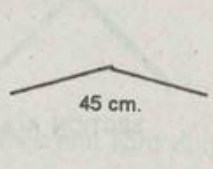




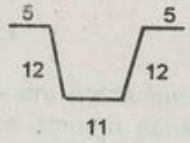
GUTTER



FLASHING



RIDGE AND HIP ROLL



VALLEY ROLL

FIGURE 6-25

2. From the following Figure, determine the number of Asphalt Roof Shingle required.

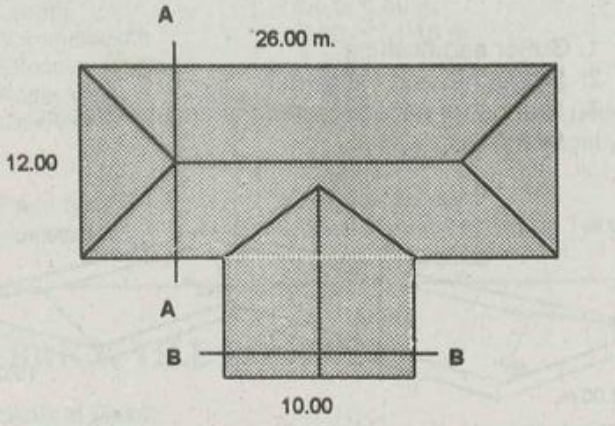


FIGURE 6-26

CHAPTER 7

TILEWORK

7-1 CERAMIC TILES

Ceramic Tile is one of man's oldest unique building materials continuously in use because of its durability, functional and aesthetic properties. It is practically indestructible and offers unlimited choices not only in design pattern but also in color that does not fade.

Decorative ceramic tile was extensively used as early as the period of Medieval Islamic Architecture from Persia to Spain. Its popularity and used was extended up to the period of contemporary Architecture.

Ceramic Tiles are Classified into:

1. Glazed Tiles
2. Unglazed Tiles

Glazed tiles - are principally used for walls and light duty floors and toppings.

Unglazed tiles - are homogeneous composition, hard and dense quality primarily used for floors and walls.

Various Types of Tiles

1. **Porcelain Tiles** – are made out from the pressed dust processed into fine smooth dense and shapely formed face.

2. **Natural Clay Tiles** - are made from either the pressed or the plastic method from dust clay that produces a dense body with distinctive slightly textured appearance.

3. **Ceramic Mosaic Tiles** - are mounted on a 30 x 30 centimeters paper as binder of the tiles to facilitate its laying or setting.

4. **Quarry Tiles** - are made through the plastic extraction process from natural clay or shale.

5. **Faience Mosaic Tiles** - are tiles less than 15 square centimeters in facial form.

Special Purpose Ceramic Tiles:

a) Non –slip tiles
b) Ship or gallery
c) Frost proof tiles
d) Conductive tiles

ILLUSTRATION 7-1

From figure 7-1, determine the quantity of the following materials:

a) 10 x 20 cm. glazed wall tiles
b) 20 x 20 cm. unglazed floor tiles
c) Cement for mortar
d) White cement for joint filler

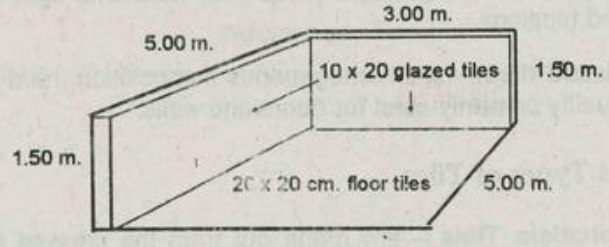


FIGURE 7-1

SOLUTION –1 (By Fundamental Method)

A.) Solving for 10 x 20 Glazed Wall Tiles

1. Solve for the wall area.

   Area = 1.50 x (5.00 + 3.00) = 12 sq. m.

2. Solve for the area of one tile. .10 x .20 = .02 sq. m.

3. Divide wall area by the area of one tile

   $\frac{12}{.02}$ = 600 pieces 10 x 20 (4" x 8" glazed tiles)

B.) Solving for 20 x 20 Unglazed Floor Tiles

1. Solve for the floor area.

   Area = 5.00 x 3.00 = 15 sq. m.

2. Floor area divided by the area of one tile.

   $\frac{15}{.04}$ = 375 pieces

C.) Solving for the Cement Mortar

1. Find the total area of the wall and floor

   Total area: 12 + 15 = 27 sq. m.

2. Refer to Table 7-1, along cement mortar, multiply:

   Cement mortar : 27 x .086 = 2.3 say 3 bags
   White cement filler : 27 x .50 = 13.5 say 14 kg.

3. For breakage allowance, 5 to 10% is satisfactory.

SOLUTION –2 (By the Area Method)

A.) Solving for the 10 x 20 cm. glazed wall tiles

1. Determine the wall area: A = 12 sq. m.

2. Refer to Table 7-1. Along 4" x 8" (10 x 20) glazed tiles under number of pieces per sq. m. (50.00), multiply:

   12 sq. m x 50.00 = 600 pieces.

TABLE 7-1 QUANTITY OF TILES PER SQUARE FOOT AND METER

Commercial Size		Number of Pieces per	
Inches	Cm.	Sq. ft.	Sq. M.
3 x 3	7.5 x 7.5	16.0	177.80
4 x 4	10 x 10	9.0	100.00
4 ¼ x 4 ¼	10.6 x 10.6	8.0	88.40
4 x 8	10 x 20	6.0	50.00
6 x 6	15 x 15	4 0	44.44
6 x 8	15 x 20	3.00	33.33
6 x 12	15 x 30	2.00	22.22
8 x 8	20 x 20	2.25	25.00
8 x 12	20 x 30	1.50	16.66
8 x 16	20 x 40	1.125	12.50
10 x 10	25 x 25	1.44	16.00
12 x 12	30 x 30	1.00	11.11
12 x 24	30 x 60	0.50	5.56
16 x 16	40 x 40	0.56	6.25
20 x 20	50 x 50	0.36	4.00
24 x 24	60 x 60	0.25	2.78
5 - point pent. tiles 5		6.0 / ft.	20 / Ln. M.
6 - point hex. tiles 5		4.9 / ft	16 / Ln. M.
External corner bead –		By direct count	
Internal corner bead -		By direct count	
Cement mortar -		.086 bags per sq. m.	
White cement joint filler-		.50 kg. per sq. m.	
Tile ADHESIVE.....		.11 bag per sq. m.	

B.) Solving for 20 x 20 cm. Unglazed Floor Tiles

1. Determine the floor area. A = 5.00 x 3.00 = 15 sq. m.

2. Refer to Table 7-1. Using a 20 x 20 cm. floor tiles; multiply:

   15 x 25.00 = 375 pieces

C.) Solving for the Cement Mortar and Joint Filler

1. Total area of wall and floor: 12 + 15 = 27 sq. m.

2. Refer to Table 7-1. along cement paste mortar, multiply:

   Cement mortar: 27 x .086 = 2.3 bags
   White cement : 27 x .50 = 13.5 say 14 kg.

3. For cutting and breakage, add 5 to 10 % allowance.

ILLUSTRATION 7-2

From Figure 7-2, determine the quantity of mosaic floor tiles, internal and external bead, capping and corner bead, 8" x 8" glazed wall tiles, cement paste mortar and white cement filler.

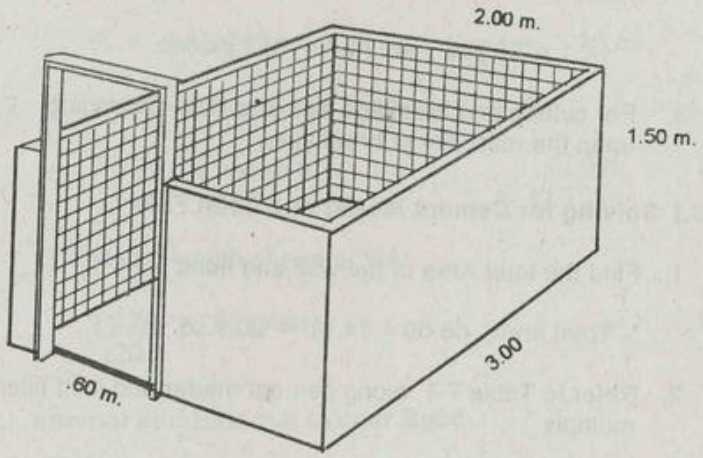


FIGURE 7-2 PERSPECTIVE OF A COMFORT ROOM

SOLUTION

A.) Finding the Mosaic Floor Tiles

1. Solve for the floor area.

   Area = 2.00 x 3.00 = 6.00 square meters

2. See Table 7-1. Using 30 x 30 cm. mosaic tiles, multiply

   6.00 sq. m. x 11.11 = 66.7 say 67 pieces

B.) Finding the 20 x 20 cm. Wall Glazed Tiles.

1. Solve for the lateral area of the wall.

   Wall Perimeter = 2 (3.00) + 2.00 + (2.00 - .60)

   P = 9.40 m.

   Wall Area = 9.40 x 1.50 ht. = 14.1 sq. m.

2. Refer to Table 7-1. Using 20 x 20 (8" x 8") glazed tiles; multiply:

   14.1 x 25 pcs ./ sq. m. = 353 pieces.

3. For cutting and breakage add 5 to 10% depending upon the mortality of breakage.

C.) Solving for Cement Mortar and Joint Filler

1. Find the total Area of the wall and floor:

   Total area: (6.00 + 14.1) = 20.1 sq. m.

2. Refer to Table 7-1, along cement mortar and joint filler, multiply

   Ordinary Cement: 20.1 x .086 = 1.73 say 2 bags
   White cement : 20.1 x .50 = 10 kg.

D.) Internal Bead

1. Solve for the length or perimeter of inside corner.

   2 (3.00 m.) + 2 (2.00 m.) = 10.00 meters.

2. Solve for the length of 4 vertical corners.

   4 x 1.50 m. ht. = 6.00 meters

3. Add 1 and 2 to get the total length of the inside corners.

   10.00 + 6.00 = 16.00 meters

4. Divide by the length of one internal bead or tile (.20)

   $\frac{16.00 \text{ m.}}{.20}$ = 80 pieces 20 cm. internal bead

E.) Capping

1. Solve for the perimeter of the wall tiles.

   P = 2 (3.00) + (2.00 - .80 door) = 7.20 m.

2. Add capping along door jamb.

   2.00 m. x 2 sides..... 4.00 m.
   Total..... 11.20 m.

3. Divide by length of cap or tile.

   $\frac{11.20}{.20}$ = 56 pieces

F.) Internal and External Corner Bead

By direct counting, there are 4 internal corners, and 4 external corner beads.

G.) Ordinary and White Cement for Paste and Filler

1. Solve for the total floor and wall area.

   Area: 6.00 + 14.1 = 20.1 sq. m.

2. Solve for the ordinary and white cement. Refer to Table 7-1, multiply:

   Ordinary cement: 20.1 x .086 = 1.73 say 2 bags.
   White cement: 20.1 x .50 = 10 kgs.

Summary

67 pcs. 30 x 30 (12" x 12") mosaic tiles
353 pcs. 20 x 20 (8" x 8") glazed wall tiles
80 pcs. 20 cm. Internal bead
57 pcs. 10 cm. Capping
4 pcs. Internal corner bead
4 pcs. External corner bead
2 bags 40 kg. ordinary cement
10 kilograms white cement.

ILLUSTRATION 7-3

An office lobby measures 10.00 x 20.00 meters specify installation of .40 x .40 m. ceramic floor tiles. List down the materials required.

SOLUTION

A.) Solving for the .40 x .40 Ceramic Tiles

1. Find the floor area: (10 x 20) = 200 square meters

2. Refer to Table 7-1. Using .40 x .40 ceramic tiles, multiply:

   200 x 6.25 = 1,250 pieces.

B.) Solving for the Tile Adhesive and Joint Filler

1. Knowing the floor area to be 200 square meters, refer to Table 7-1 along Tile Adhesive, multiply:

   200 sq. m. x .11 = 22 bags tile adhesive.

2. For joint filler, refer to Table 7-1, multiply:

   200 sq. m. x .50 = 100 kgs.

Comment:

1. The quantity of tile adhesive varies depending upon the thickness of the mortar applied and the mixture of fine sand.

2. The values given in Table 7-1 was computed at 1 mm thickness mortar.

3. The quantity of white cement joint filler also varies depending upon the size of the tiles and its spacing distance. The smaller the tiles, the more joints there are and more filler is required.

7-2 MARBLE TILES

Marble is a hard metamorphic limestone white or colored texture and sometimes streaked or mottled in crystalline or granular state capable of taking high polish. It is used in sculpture, furniture, topping slab, floors and the like.

Marble as construction materials have been extensively used from the ancient time of the Greeks to the Roman Empire down to the modern and contemporary Architecture.

ILLUSTRATION 7-4

From Figure 7-3, solve for the number of 30 x 60 cm. marble tiles required including the cement and sand for class B mortar adhesive.

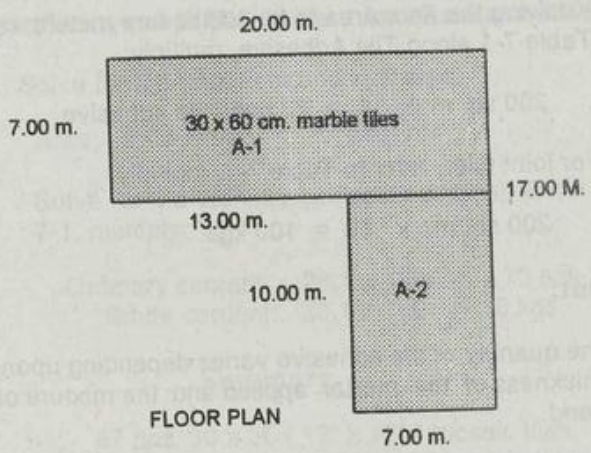


FIGURE 7-3

SOLUTION

1. Solve for the floor area

   A-1 = 7.00 x 20.00 = 140 sq. m.
   A-2 = 7.00 x 10.00 = 70 sq. m.
   Total Area..... 210 sq. m.

2. Refer to Table 7-2. Using 30 x 60 cm. marble tiles; multiply:

   210 sq. m. x 5.56 = 1,168 pieces.

3. Add 3-5 % allowance for breakage.

4. Solve for cement mortar using class B mixture. Refer to Table 7-2; multiply:

   Cement: 210 sq. m. x .30 = 63 bags.
   Sand : 210 sq. m. x .025 = 5.25 cu. m.

5. Solve for Polymer liquid, hardener and calsomine powder. Refer to table 7-2.

   Polymer Liquid: 210 x .035 = 7.35 say 8 gallons
   Hardener: 210 x .030 = 6.30 say 7 quarts
   Calsomine powder 210 x .045 = 9.45 say 10 kilos

TABLE 7-2 QUANTITY OF MARBLE TILES AND MORTAR PER SQUARE METER

Size cm.	Number / sq. m.	Cement in Bags Mixture A	B	C	Sand cu. m.
15 x 30	22.3	.45	.30	.225	.025
20 x 20	25.0	.45	.30	.225	.025
20 x 40	12.5	.45	.30	.225	.025
30 x 30	11.1	.45	.30	.225	.025
30 x 60	5.6	.45	.30	.225	.025
40 x 40	6.3	.45	.30	.225	.025
60 x 60	2.8	.45	.30	.225	.025
Polymer Liquid		.035 gallons per square meter			
Hardener		.030 quarts per sq. m.			
Calsomine powder		.045 kilograms per sq. m.			

* Cement mortar computed at an average thickness of 25 mm.

7-3 VINYL AND RUBBER TILES

The standard specifications for vinyl and rubber tiles provides that:

> *" It shall be non-fading, odorless and non-slip even when wet and shall be strong enough to withstand the ordinary tear and wear, cleaning and moving of furniture without damage and shall be self dealing."*

Tiles shall be laid to conform with the manufacturer's specifications which partly states that:

a. Adhesive cement shall be applied to the floor every after the tiles are laid on the surface.
b. Tiles are pressed with linoleum roller to avoid blisters.
c. After completion, all work shall be cleaned of cement, dirt and other substances.
c. Apply two-coat of wax and polish to smooth shiny finish.

TABLE 7-3 VINYL AND RUBBER TILES

Stock Size	Number per Sq. M.	Gallons of Adhesive per sq. m.
.20 x .20 (8" x 8")	25.00	.042
.225 x .225 (9" x 9")	19.75	.042
.25 x .25 (10" x 10")	16.00	.042
.30 x .30 (12" x 12")	11.11	.042
.40 x .40 (16" x 16")	6.25	.042
.60 x .60 (24" x 24")	2.78	.042

ILLUSTRATION 7-5

An office room with a general dimensions of 7.00 x 9.00 m. is undergoing renovation. Determine the number of 30 x 30 cm. vinyl tiles required including its adhesive for installation.

SOLUTION

1. Solve for the floor area: 7.00 x 9.00 = 63 sq. m.
2. Refer to table 7-3. Using a 30 x 30 cm. vinyl tile, multiply:

   63 sq. m. x 11.11 = 700 pieces
3. Solve for the adhesive cement. Refer to Table 7-3 multiply:

   63 x .042 = 2.65 say 3 gallons.

7-4 GRANOLITHIC FLOOR

Granolithic floor is a marble type mosaic floor finish that uses Portland cement as base materials. It has a characteristic of durability, beauty and variety installed by either: Monolithic-Cast in Place or Pre-Cast.

Monolithic or Cast-Place means massively, solid, single and uniform floor finish cast in place. A mixture of cement and marble chips to a proportion of 1:3 is cast on top of a rough floor slab surface to an average thickness of 1.25 cm. The floor is then grinded after it has attained sufficient hardness to withstand abrasion and vibration caused by the grinding machine. Grinding of the floor surface is done not earlier than 48 hours after casting.

Pre-Cast refers to granolithic tiles in various dimensions hydraulically pressed and molded in a factory. The distinctive difference between the cast in place and the pre-cast installation is the manner and place of casting or molding. The former installed on site and the latter pressed at the factory. Pre-cast is installed in a tile form while cast in place is installed on a fresh mixed form.

Normally, a dividing hard brass strips with alloy zinc are installed between tiles to control and localize any shrinkage or flexure cracks. The dividing strip thickness ranges from 1.56 to 3.12 mm. or even thicker depending upon the design and specifications.

ILLUSTRATION 7-6

For an 8.00 m. by 10.00 meters room that specify cast-in place granolithic floor, list down the materials required.

SOLUTION

1. Determine the floor area.

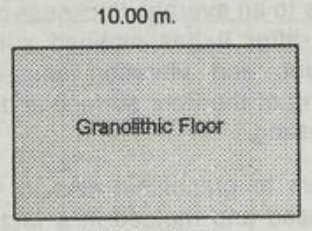
   Area: 8.00 x 10.00 = 80 sq. m.

2. Determine the quantity of marble chips required. Refer to Table 7-4, multiply:

   80 x .0125 = 1.0 cu. m.

3. Determine the quantity of white cement required. Refer again to Table 7-4, multiply:

   80 x .172 = 13.76 say 14 bags



FLOOR PLAN

FIGURE 7-4

SOLUTION (By Pre-Cast Installation)

1. Find the floor area.

   Area: 10 x 8 = 80 sq. m.

2. Refer to Table 7-4. Using 40 x 40 granolithic tiles; multiply:

   80 sq. m. x 6.25 = 500 pieces

3. Using class B mortar, refer to Table 7-4, multiply

   Cement: 80 x .225 = 18 bags
   Sand: 80 x .0188 = 1.5 cu. m.

4. Solve for the brass divider. Refer to Table 7-4; multiply:

   80 sq. m. x 5.8 = 464 meters

TABLE 7-4 GRANOLITHIC FLOORING

Size cm.	Pieces per sq. m.	Bags Cement per sq. m. Mixture		Sand cu. m. per sq. m.	Brass divider meter / sq. m
		A	B		
20 x 20	25.00	.338	.225	.018	10.8
25 x 25	16.00	.338	.225	.018	8.9
30 x 30	11.11	.338	.225	.018	8.0
40 x 40	6.25	.338	.225	.018	5.8
60 x 60	2.78	.338	.225	.018	3.4

Marble Chips ..... .0125 cu. m. per square meter
White Cement..... .172 bag per square meter

7-5 CEMENT TILES

Cement Tile is a mixture of cement, sand and water hydraulically pressed, locally manufactured in the following commercial sizes:

25 mm x 15 x 15 cm.	1" x 6" x 6"
25 mm x 20 x 20 cm.	1" x 8" x 8"
25 mm x 25 x 25 cm.	1" x 10" x 10"
25 mm x 30 x 30 cm.	1" x 12" x 12"

Estimating the quantity of cement tiles include the cement mortar for tile laying at an average thickness of 20 mm. The methods used could be either:

1. By the unit measure method or
2. By the Area method using Table 7-4

ILLUSTRATION 7-7

Find the number of 20 x 20 cm. cement tiles required for a school classroom with a general dimension of 7.00 x 9.00 m. using class B mortar mixture.

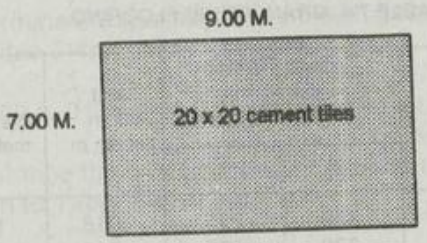


FIGURE 7-5 CEMENT TILES

SOLUTION

1. Solve for the floor area:

   Area: = 7.00 x 9.00
   A = 63 square meters

2. Refer to table 7-4. Using a 20 x 20 cement tiles; multiply:

   63 sq. m. x 25 = 1,575 pieces

3. Refer again to Table 7-4. Using class B mortar; multiply:

   Cement: 63 x .225 = 14.20 say 15 bags
   Sand: 63 x .018 = 1.13 say 1.5 cu. m.

7-6 WOOD TILES

Wood tile is a well arranged thin small wood pieces in various dimensions with thickness ranging from 6 mm. to 8 mm. Wood chips are carefully laid one at a time on a plane smooth surface concrete floor slab applied with a good kind of white glue. The wood tile floor is then grinded with No. 300 and 100 sand paper 24 hours after setting to produce a fine and smooth even surface. Sandpaper dust is then mixed with wood glue used as filler of the joints.

Estimating Wood Tiles

1. Solve for the net floor area to be covered with wood tiles in square meter.
2. Wood tiles come in square foot. Thus, multiply the floor area found by 10.76 to get the number of square foot.
3. Multiply the floor area by..165 to get the number of wood glue in gallons per square meter.

ILLUSTRATION 7-8

An office room measuring 12.00 meters wide by 20.00 meters long specify wood tile flooring. Prepare the bill of materials.

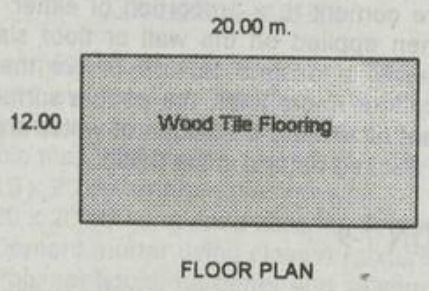


FIGURE 7-6 WOOD TILE FLOORING

SOLUTION

1. Find the area of the floor

   Area: 12.00 x 20.00 = 240 sq. m.

2. Convert to square foot, multiply by 10.76.

   240 x 10.76 = 2,583 sq, ft,

3. Add 5% allowance for cutting and edging.

2,583 x .05 = 129.15 say 130 sq. ft.

3. Add step 2 and 3

   2,583 + 130 = 2,713 pieces.

4. Order: 2,713 square foot wood tiles.

4. Determine the wood glue at .085 gallon per square meter.

   240 sq. m. x .085 = 20.4 say 21 gallons.

7-7 PEBBLES AND WASHOUT FINISH

Pebbles are small roundish stone used for walls and floor finishes called washout and pebbles respectively. Pebble stone is mixed with pure cement to a proportion of either 1:2 or 1:3 mortar mixture then applied on the wall or floor slab is then washed with water to a desired texture before the concrete finally set. Twenty four hours later, the pebble surface is then scrubbed with steel brush and a solution of water and moriatic acid to obtain the desired natural stone finish.

ILLUSTRATION 7-9

A wall roughly plastered has a general dimensions of 10.00 meters long and 2 meters high requires stone pebble washout finish. List down the materials required.

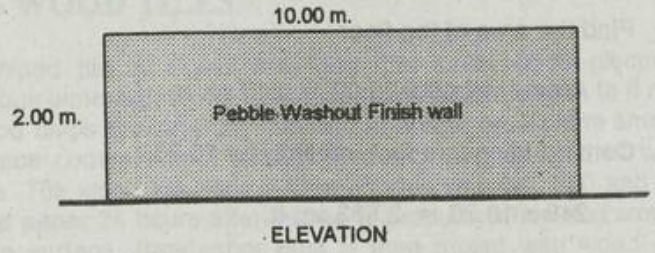


FIGURE 7-7 PEBBLE WASHOUT

SOLUTION

1. Solve for the wall area

   Area: 2.00 x 10.00 = 20 sq. sq. m.

2. Determine the thickness of the stone pebble finished say 16 mm. or .016 m., multiply by the wall area.

   20. x .016 = .32 cu. m.

3. Refer to Table 2-1. Using class "B" mixture, multiply:

   Cement: .32 x 12.0 = 3.84 say 4 bags
   Pebbles: .32 x 1.0 = .32 cu. m. stone pebbles

Problem Exercise

1. A public comfort room has a floor dimension of 4.00 meters wide and 10 meters long. The floor is finished with 20 x 20 cm. unglazed ceramic tiles and the wall specifies 10 x 20 cm. marble tiles 2.00 meters high. Solve for:
   a.) 10 x 20 cm. marble tiles for wall
   b.) 20 x 20 cm. unglazed ceramic floor tiles
   c.) Cement mortar using class A mixture
   d.) Polymer liquid, hardener and calsomine powder.

2. From the following figure, find the wood tiles and adhesive required.

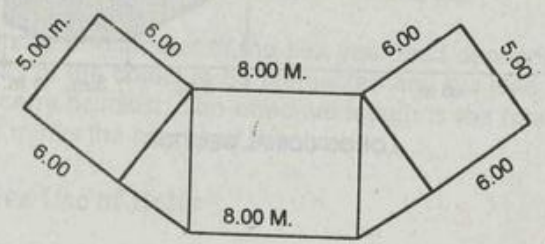
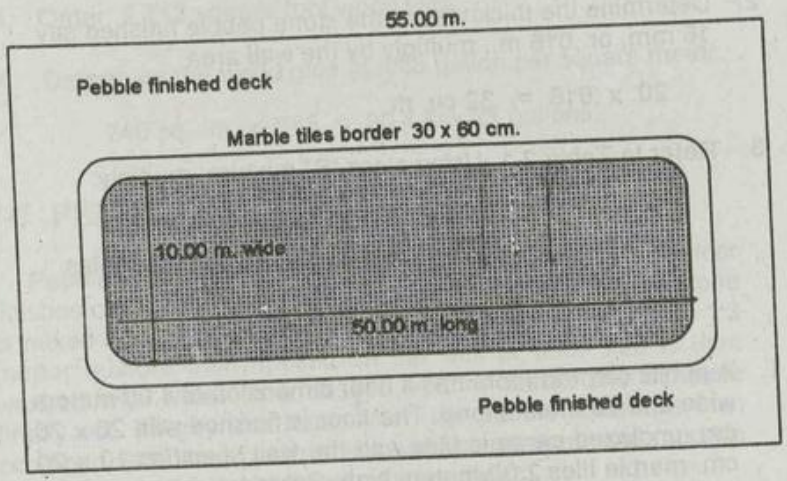
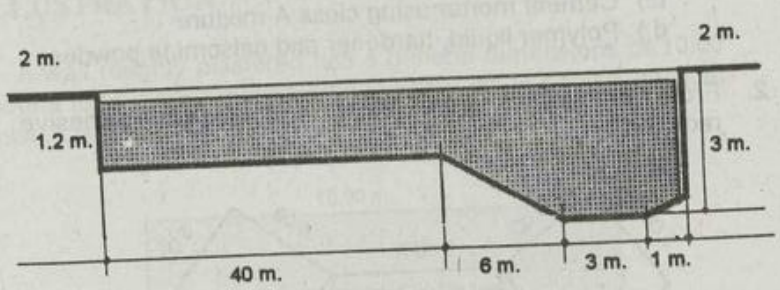


FIGURE 7-8 FLOOR PLAN

3. From the following floor plan and elevation of a swimming pool, solve for the number of tiles required using 10 x 10 cm. glazed tiles for the walls and 20 x 20 cm. unglazed floor tiles including the mortar and white cement joint filler.



PLAN



LONGITUDINAL SECTION

FIGURE 7-9

CHAPTER 8

HARDWARE

8-1 BOLTS

Bolt is a pin rod with head at one end and threaded at the other end to receive a nut.

Different Types of Bolt

1. Machine bolt
2. Countersunk bolt
3. Key Head bolt
4. Stud bolt

Machine bolt is a pin rod with head at one end and a short thread at the other end.

Countersunk bolt has a beveled head fitting into a countersunk hole.

Key head bolt has a head shape end fitted to a groove to prevent turning when the nut is screwed into the other end.

Stud bolt is a headless pin bolt threaded at both ends.

8-2 SIZE AND LENGTH OF BOLTS

The size or diameter of the bolt you need depends upon the thickness of the object to be connected and the load stresses it has to carry or resist. The effective length is the total length of the bolt minus the head and the thread.

Effective Use of Bolts

1. For lumber up to 5 cm. thick, use 6 mm (1/4") diameter

2. For 7.5 cm. thick (3") lumber use 10 mm. 3/8" diameter.
3. For 10 cm. (4") thick lumber use 12 mm. 1/2" diameter.
4. Drilled hole shall be 1.5 mm. (1/16") larger than the bolt diameter unless snug fit is necessary.
5. Always use washers under head and nut of your machine bolt.
6. For carriage bolt, use washer under nut only.
7. Use toggle bolt for attaching fixture to plaster wall.
8. Use expansion bolt for fastening to masonry.
9. For outdoor exposure, use brass or cadmium plated finish bolt.

TABLE 8-1 U.S. STANDARD THREAD OF BOLTS

Length	DIAMETER OF BOLTS						
Inches	½	5/8	¾	7/8	1	1-1/8	1 ¼
mm	12	16	20	22	25	28	31
10.0	1.44	2.45	3.64	5.24	7.23	9.78	12.60
12.5	1.69	2.85	4.21	6.01	8.24	11.06	14.18
15.0	1.94	3.24	4.78	6.78	9.26	12.33	15.76
17.5	2.19	3.64	5.35	7.55	10.27	13.61	17.35
20.0	2.45	4.03	5.90	8.32	11.29	14.89	18.93
22.5	2.70	4.43	6.49	9.09	12.30	16.10	20.51
25.0	2.95	4.82	7.06	9.86	13.31	17.44	22.09
27.5	3.20	5.22	7.63	10.63	14.33	18.72	23.67
30.0	3.46	5.61	8.20	11.40	15.34	20.00	25.26
32.5	3.71	6.01	8.77	12.17	16.36	21.27	26.84
35.0	3.96	6.40	9.34	12.94	17.37	22.55	28.42

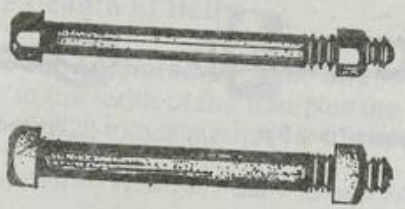
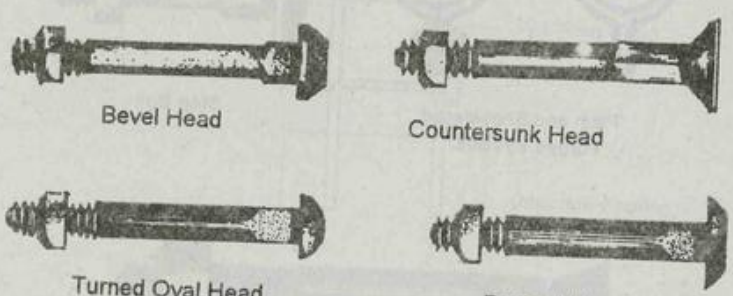
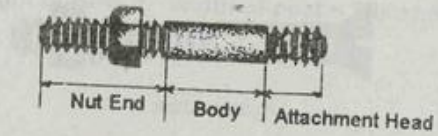


FIGURE 8-1 MACHINE BOLT

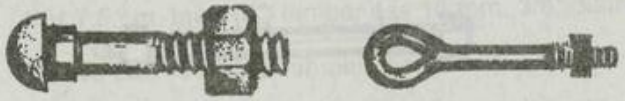


8-2 CARRIAGE BOLTS



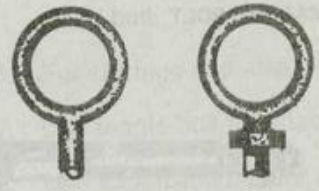
Stud Bolt

FIGURE 8-3 VARIOUS TYPES OF BOLT



Railroad Track Bolt

Welded Eye Bolt



Plain and Shouldered Forged EyeBolt

Step Bolt

Tire Bolt

Stove Bolt

Expansion Bolt

FIGURE 8-4 VARIOUS TYPES OF BOLT

Estimating the Length of Bolts

a.) **Wooden Post Anchored by Post Strap**. The length of the bolt is equal to the width of the post plus the two thickness of the post strap plus 20 mm allowance for the thread and nut.

Length of Bolt = Width of Post + 12 mm + 20 mm

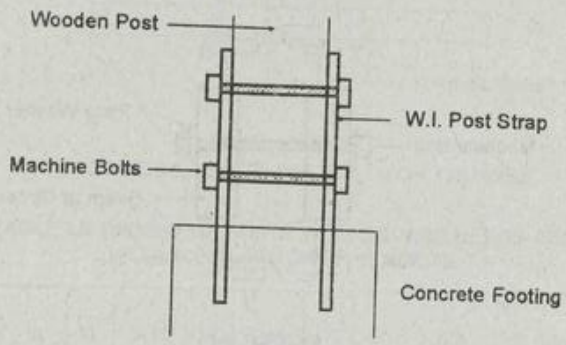


FIGURE 8-5 POST ANCHORED BY POST STRAP

b.) **Post and Single Beam** is equal to the width of the post plus the thickness of the beam.

Length of Bolt = Width of post + Thickness of Beam

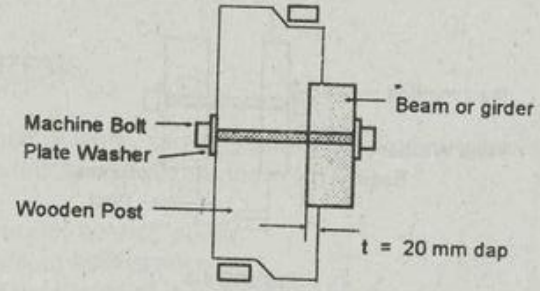


FIGURE 8-6 POST AND SINGLE BEAM

c.) **Post with Two Beams of the Same Thickness**. The Length of bolt is equal the width of post plus thickness of two beam minus the 20 mm dap. (There are two dap opposite the column sides but only one is subtracted because the other 20 mm dap is reserved for the thread that will receive the nut.)

Length of Bolt = Width of Post + 2 Beam thickness – 20 mm

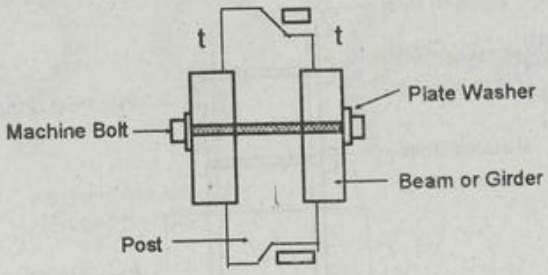


FIGURE 8-7

POST WITH TWO BEAMS OF THE SAME THICKNESS

d.) **Post and Two Beams of Different Thickness.**

Length of Bolt = Width of post plus (t_{-1} + t_{-2}) - 20 mm.

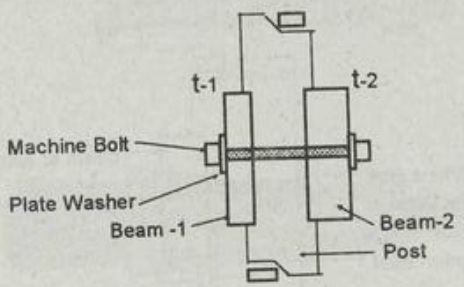


FIGURE 8-8

POST AND TWO BEAMS OF DIFFERENT THICKNESS

e.) **Length of Bolts on Trusses.**

Length of Bolts = Thickness of 1, 2, 3... + 20 mm

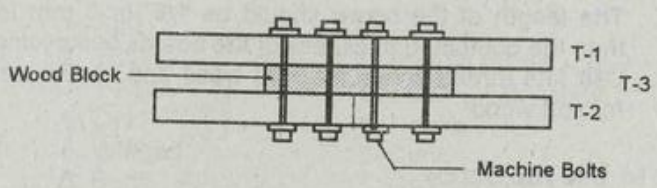


FIGURE 8-9 LENGTH OF BOLTS ON TRUSSES

TABLE 8-2 WEIGHT OF BOLTS WITH SQUARE HEADS AND HEXAGONAL NUTS PER 10 BOLTS

Diameter of Bolts in. / mm	¼ / 6	5/16 / 7	3/8 / 9	7/16 / 10	1/2 / 12	9/16 / 14	5/8 / 16	¾ / 19	7/8 / 22	1 / 25
No. of thread Per inch	20	18	16	14	13	12	11	10	9	9
Diameter of	5	6	8	9	11	12	13	18	19	22
Top Drill	13/64	1/4	5/16	23/64	27/64	15/64	17/32	32/64	3/4	55/64

8-3 SCREW

In Carpentry work, screw is sometimes used instead of nails due to the following advantages

1. Greater holding power
2. Neat in appearance
3. Less chance of injuring the materials
4. Ease of removal in case of repair

How to Choose Your Screw

1. Select one that is long enough wherein one half of two thirds of its length will enter the base in which threads are embedded.
2. The length of the screw should be 1/8" or 3 mm less than the combined thickness of the boards being joined.
3. Use fine thread screw for hard wood and coarse tread for soft wood.

How to Use the Screw

1. Always drill lead hole for the screw.
2. Hole on top board should be slightly larger than the shank, in second board slightly smaller than the threaded portion.
3. In soft wood, bore to depth half the length of the thread.
4. In hard wood, bore nearly as deep as the length of the screw.
5. For lag screw, drill hole two thirds its length then drive in with hammer, and finally tighten with wrench

How to Buy Screw

1. Screws are classified by gauge and length in inches. Each gauge has a variety of different lengths which may be obtained up to 12 cm. (5 inches)
2. When ordering screw, specify head shape (e.g. round head). Finish (brass), gauge number and length from 2 to 5 centimeters.
3. Square headed lag screw comes in diameter of 6 mm to 25 mm (1/4 to 1 inch) with its length from 4 cm. to 30 cm. (1-1/2 to 12 inches)

Wood Screw

Wood screw is a screw nail with handed coarse thread to give a grip.

a.) Materials Used

1. Iron
2. Steel
4. Brass
5. Bronze
5. Copper
6. Aluminum

b.) As to Shape of Head

1. Flat
2. Round
3. Fillister
4. Oval
5. Winged
6. Bung
7. Punched
8. Headless
9. Slotted (wood screw)
10. Square (lag screw)
11. Hexagonal
12. Clove
13. Grooved

c.) As to Shape of the point

1. Standard
2. Full Length
3. Coarse

d.) As to Duty

1. Wood (light duty)
2. Lag (heavy duty)

e.) As to Finish

1. Bright
2. Nickel Plated
3. Brass
4. Coppered
5. Lacquered
6. Blued
7. Silver Plated
8. Bronzed
9. Japanned
10. Galvanized

The Three Shapes of Screw Point are:

1. **Gimlet Point** – Is used on wood and coach screw.
2. **Diamond Point** – Is used when more driving is done before turning as in drive and lag screw.
3. **Conical Point** – Same as the diamond point.

TABLE 8-3 STANDARD WOOD SCREW AND NUMBER PER KILOGRAMS

Inches	½	1	1 ½	2	2 ½	3	3 ½	4	4 ½	5	6
mm	12	25	37	50	62	75	87	100	112	125	150
Number	6,211	3,443	2,329	1,779	1,414	1,186	1,126	910	739	655	515

Ordinary Lag Screw

Coach Lag Screw

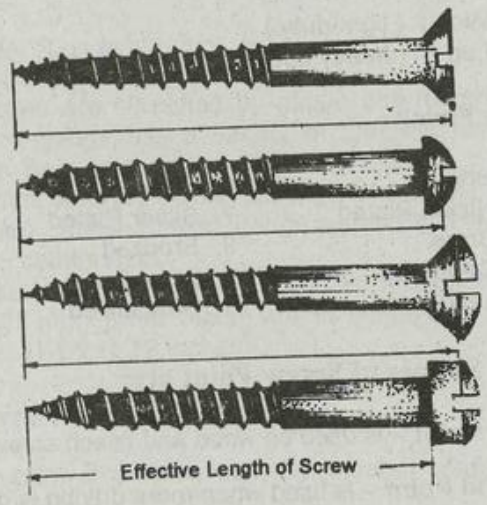


FIGURE 8-10 STANDARD WOOD SCREW POINT

FIGURE 8-11 TYPES OF WOOD SCREW AS TO THE POINT

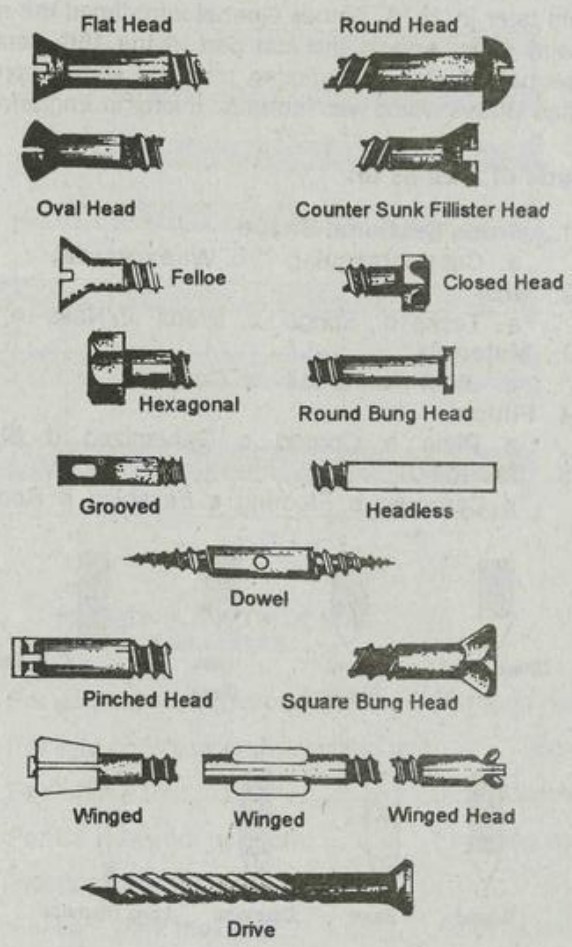


FIGURE 8-12 VARIOUS TYPES OF WOOD SCREW

8-4 NAILS

The first handmade nails were used in the United States and lasted up to the end of the Colonial Period. Likewise, in France light nails were made by hand and hammer out of steel wire as early as the days of Napoleon-1. In 1851, wire nails was first introduced by William Herser of New York. Twenty five years later in 1876, Father Goebel introduced the manufacture of wire nails. And at the last part of the 18th century, twenty three patents for nail making machine were approved in the United States which was introduced later in England.

Kinds of Nail as to:

1. **Cross Sectional Shape**
   a. Cut (rectangular) b. Wire (circular)
2. **Size**
   a. Tacks b. Sprigs c. Brads d. Nails e. Spike
3. **Materials**
   a. Steel b. Brass c. Copper
4. **Finish**
   a. Plain b. Coated c. Galvanized d. Blued
5. **Service**
   a. Common b. Flooring c. Finishing d. Roofing e. Boat

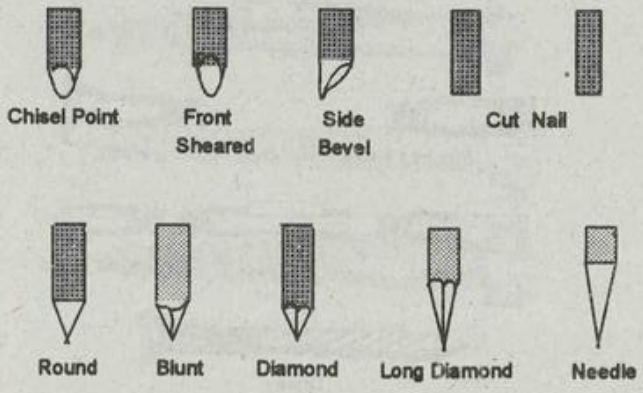


FIGURE 8-13 TYPES OF NAIL POINTS

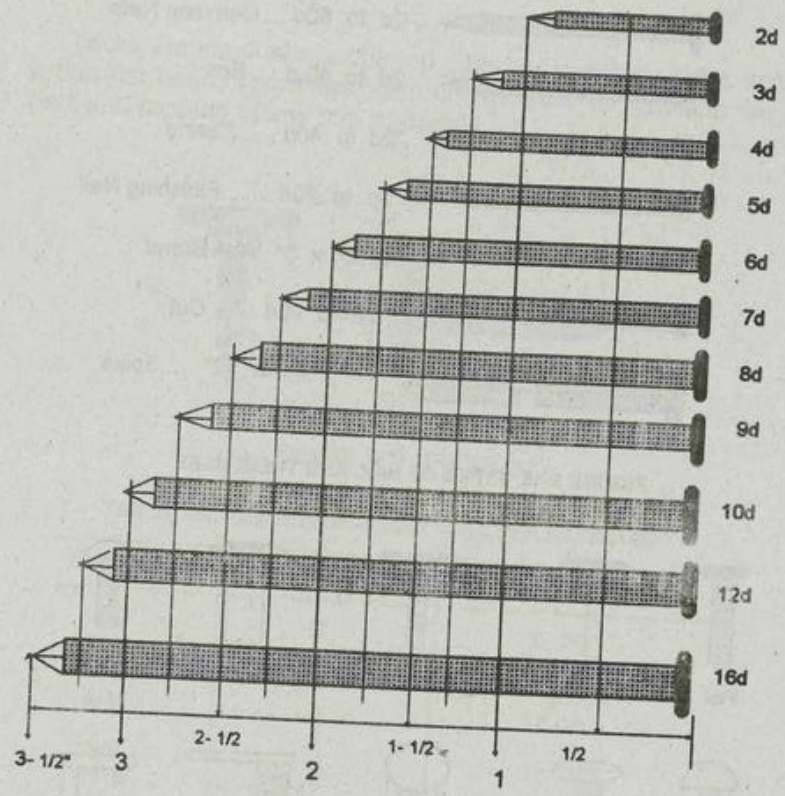


FIGURE 8-14 LENGTH OF NAILS
(Actual Size)

2d to 60d - For general construction..... Common nail
2d to 40d - For light construction household use..... Box
2d to 40d - For Interior trim..... Casing
2d. to 20d - For Cabinetwork furniture..... Finishing nail
2d. to 20d - Flooring construction..... Cut
3/16" to 3" - For light work moldings..... Wire brad
6" to 12" - For heavy construction..... Spike

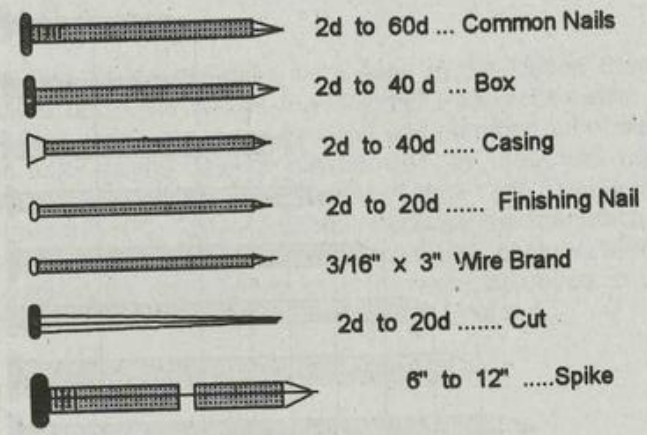


FIGURE 8-15 TYPES OF NAIL AND THEIR USES

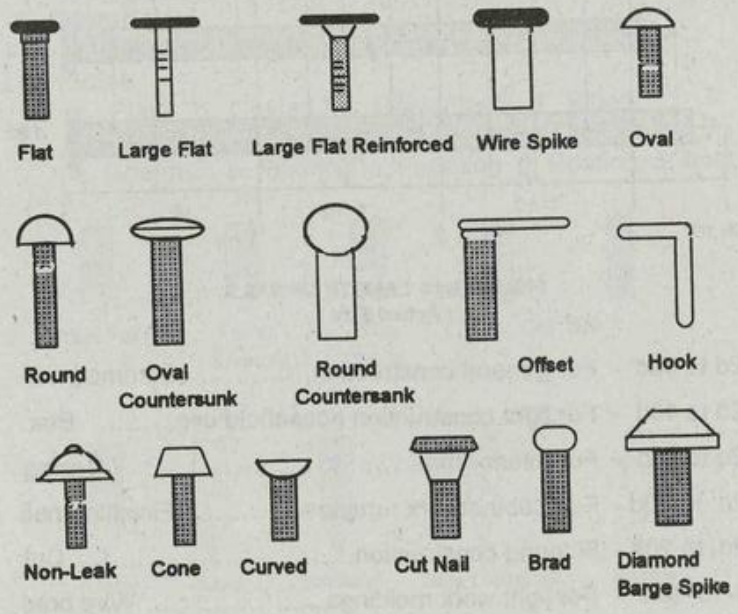


FIGURE 8-16 TYPES OF NAIL HEAD

Tacks

Tacks are small sharp pointed nails w' 'apering sides and a thin flat head. Tacks are nails chiefly used in fastening carpets and flashing of any thin materials.

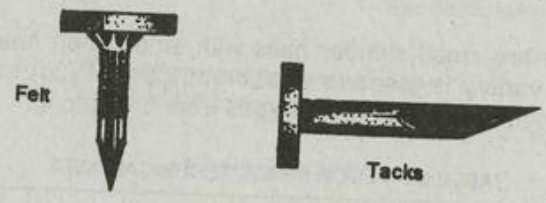


FIGURE 8-17 TACKS

TABLE 8-4 NUMBER OF WIRE TACKS PER KILOGRAM

Inches	Length (mm)	Number per Kilogram
1/8	3	35,200
3/16	5	23,465
¼	6	17,600
5/16	8	14,080
3/8	10	11,732
7/16	12	8,800
9/16	14	5,865
5/8	16	4,400
11/16	17	3,120
¾	19	2,930
13/16	20.5	2,514
7/8	22	1,953
15/16	24	1,760
1	25	1,599
1-1/16	27	1,465
1-1/8	28	1,200

Sprigs

Sprigs are small headless nails sometimes called barbed dowel pins. The regular size of sprigs ranges from 12 mm. to 5.0 cm. gauge No. 8 wire or 4 mm. diameter.

Brads

Brads are small slender nails with small deep heads. The common variety is made in sizes from 2.5 cm. (2d) to 15 cm. (6d) in length. Flooring brads ranges from 5 cm. long.

TABLE 8-5 FLOOR BRADS TECHNICAL DATA

Size	Length mm	Gauge No.	Head dia. Gauge	Approx. No./ kg.	Gauge No.	No. Nails per kg.
6d	50	11	6	322	12	14,500
7d	32	11	6	277	12	12,500
8d	37	10	5	200	11	9,000
9d	44	10	5	173	11	7,800
10d	75	9	4	131	10	5,900
12d	81	8	3	95	9	4,300
16d	87	7	2	76	8	3,450
20d	100	6	1	57	7	2,600

Nails

Nails is a popular name for all kinds of nail except those extreme sizes such as Tacks and Spikes. The most generally used nails are called common nails from 2.5 cm. to 15 cm.

Spikes

An ordinary spike is a stout piece of metal from 7.5 cm. to 30 cm. in length, much thicker in proportion than a common nail.

Spike is much in used in fastening railroad rails, construction of docks, piers and other work using large timber.

There are two kinds of Spike;

1. The flat head, diamond point
2. The oval head, chisel point

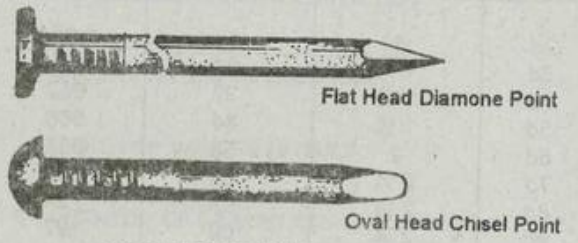


FIGURE 8-18 SPIKE

Boat Spike

Boat spike are small kind of nail driven mostly in hard timber with a clear cut sharp chisel point.

TABLE 8-6 COMMON WIRE NAILS TECHNICAL DATA

Size	Gauge No.	Length		Approximate Number	
		Inches	mm	per kg.	per keg
2d	15	1 ¼	25	1,831	82.400
3d	14	1 ½	31	1,177	53,000
4d	12.5	1 ½	37	666	30,100
5d	12.5	1 ¾	44	580	26,100
6d	11.5	2	50	382	17,200
7d	11.5	2 ¼	56	344	15,500
8d	10.25	2 ½	63	208	9,400
9d	10.25	2 ¾	69	188	8,500
10d	9	3	75	138	6,250
12d	9	3 ¼	81	124	5,600
16d	8	3 ½	88	93	4,200
20d	6	4	100	58	2,625
40d	4	5	112	45	2,040
50d	3	5 ½	125	34	1,540
60d	2	6	150	20	910

TABLE 8-7 COMMON BRADS TECHNICAL DATA

Size	Length		Approximate Number	
	Inches	mm	per kg.	per keg
2d	1	25	1,904	85,700
3d	1 ¼	31	1,206	54,300
4d	1 ½	37	662	29,800
5d	1 ¾	44	566	25,500
6d	2	50	397	17,900
7d	2 ¼	56	340	15,300
8d	2 ½	63	224	10,000
9d	2 ¾	69	197	8,900
10d	3	75	146	6,600
12d	3 ¼	81	137	6,200
16d	3 ½	88	108	4,900
20d	4	100	68	3,100
30d	4 ½	112	53	2,400
40d	5	125	40	1,800
50d	5 ½	137	28	1,300

TABLE 8-8 ORDINARY SPIKE TECHNICAL DATA

Size	Length		Approx. No. per kg.
	Inches	mm	
10d	3	75	90
12d	3 ¼	81	83
16d	3 ½	88	66
20d	4	100	50
30d	4 ½	112	37
40d	5	125	28
50d	5 ½	137	22
60d	6	150	19
175 mm	7	175	15
200 mm	8	200	9
225 mm	9	225	8
250 mm	10	250	7
300 mm	12	300	6

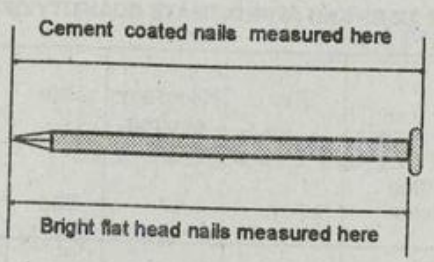


FIGURE 8-19 CONCRETE NAILS

TABLE 8-9 QUANTITY OF CEMENT COATED NAILS

Length	Penny	Gauge	No. per keg
1	2d	15	1,863
1 ¼	3d	14	1,195
1 ½	4d	12 ½	651
1 ¾	5d	12 ½	559
2	6d	11 ½	367
2 ¼	7d	11 ½	330
2 ½	8d	10 ¼	222
2-2/3	9d	10 ¼	202
3	10d	9	145
3 ¼	12d	9	149
3 ½	16d	8	103
4	20d	6	64
4 ½	30d	5	48
5	40d	4	37
5 ½	50d	3	31
6	60d	2	24

TABLE 8-10 USES AND APPROXIMATE QUANTITY OF NAILS

Material	Per	Kilogram required	Size	Kind of Nail
Floor joist & bridging at 30 cm. on center	sq. m.	.17	30d	CWN
T & G wood board				
1" x 4"	sq. m.	.15	6d	Flooring brad
1" x 6"	sq. m.	.09	6d	Flooring brad
Siding wood board on Studs at 60 cm. o.c.				
1" x 6"	sq. m.	.08	6d	Casing brad
1" x 8"	sq. m.	.06	6d	Casing brad
Studs/ Nailing Strips				
at 40 cm. o.c.	sq. m.	.08	8d	CWN
at 60 cm. o.c.	sq. m.	.05	8d	CWN
Scaffolding per	/ Meter height of post	.73	20d	CWN
Plywood board 4' x 8 ft..				
Nailed at .15 cm. o.c. joist at 40 x 60 cm dist.	per Sheet	.055	2d	Finishing nail
On studs at 40 x 40 cm. Spacing distance.	per sq. m.	.033	2d	Finishing nail
Rafters, purlins at .70 distance	sq.. m.	.20	20d	CWN
Ceiling joist at .40 x .60 Spacing distance	sq. m.	.055	8d	Finishing nail

CHAPTER 9

STAIRCASE

9-1 INTRODUCTION

Carpenters who have experienced building stairs have found it to be an art in itself. Technically, building staircase requires structural carpentry and craftsmanship of cabinet making. It is like constructing an inclined bridge between two points on different floors with uniform well proportional treads and risers that are safe and comfortable to climb and descend.

9-2 DEFINITION OF TERMS

To start with this study, it is important to know and familiarize first with the technical terms used in building staircase.

Baluster - A small post supporting the handrail or a coping.

Balustrade - Is a series or row of balusters joined by a handrail or coping as the parapet of a balcony.

Bearer - Is a support for winders wedged into the walls secured by the stringer.

Carriage - Is that portion supporting the steps of a wooden stairs.

Close String - A staircase without open well as in dog stairs.

Cocktail Stair - A term given to a winding staircase.

Circular Stair - A staircase with steps winding in a circle or cylinder.

Elliptical Stairs:- Those elliptical in plan where each tread assembly is converging in an elliptical ring in a plan.

Flight of Stairs - A series of steps leading from one landing to the other.

Front String - The string on the side of stairs where handrail is placed.

Flyers - Are steps in a flight that are parallel with each other.

Geometrical Stairs - A flight of a stair supported by the wall at the end of the steps.

Half Space - The interval between two flight of steps in staircase.

Handrail - A rail running parallel with the inclination of the stairs that holds the balusters.

Hollow Newel - An opening in the middle of the staircase as distinguished from solid newel wherein the ends of steps are attached.

Housing - The notches in the string board of a stair for the reception of stairs.

Knee - is the convex bend at the back of the handrail.

Landing - The horizontal floor as resting place in a flight.

Newel - The central column where the steps of a circular staircase wind.

Nosing - The front edge of the steps that project beyond the riser.

Pitch - The angle of inclination of the horizontal of the stairs.

Ramp - A slope surface that rises and twists simultaneously.

Rise - The height of a flight of stairs from landing to landing or the height between successive treads or stairs.

Riser - The vertical face of a stair step.

Run - The horizontal distance from the first to the last riser of a stair flight.

Spandrel - The angle formed by a stairway.

Staircase - The whole set of stairs, the structure containing a flight of a stair.

Stair Builders Truss - Crossed beams which support the landing of a stair.

Stair Head - The initial stair at the top of a flight of a stair or staircase.

Stair Headroom - The clear vertical height measured from the nosing of a stair tread to any overhead obstruction.

Stair Well - The vertical shaft which contain a staircase.

Step - A stair which consist of one tread and one riser.

Steps - The assembly consisting of a tread and a riser.

String - The part of a flight of stair which forms its ceiling or soffit.

Soffit - The underneath of an arch or molding.

String Board - The board next to the wall hole which receives the end of the steps.

Tread Run - The horizontal distance between two consecutive risers, or the horizontal distance between the nosing or the outer edges of successive treads on an open riser stair all measured perpendicular to the front edges of the nosing or tread.

Tread - The horizontal part of a step including the nosing.

Tread length - The dimension of a tread measured perpendicular to the normal line of travel on a stair.

Tread Width - The dimension of a tread plus the projection of the nosing.

Wall String - The board placed against the wall to receive the end of the step.

Well - The place occupied by the flight of stairs.

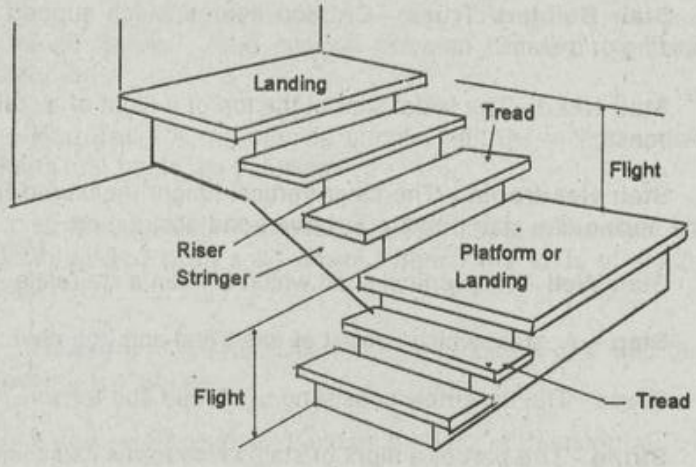


FIGURE 9-1

Well Hole - The opening in the floor at the top of a flight or stairs.

Well Staircase - A winding staircase enclosed by walls resembling a well.

Winders - Steps not parallel with each other.

Wreath - The whole of a helically curved hand rail.

9 - 3 STAIRCASE LAYOUT

The fundamental principles in laying out a staircase are:

1. Determine first the clear height of the riser in meter. Normally, the standard comfortable rise per step is from 17 to 18 centimeters. The maximum height of a step riser is 20 centimeters and is only allowed on special considerations where the physical conditions dictate. However, this height is understood to be not comfortable for both ascending and descending the stairs.

2. Determine the number of steps from the first to the next floor by dividing the total height of the rise by the chosen step riser of either 17 or 18 centimeters.

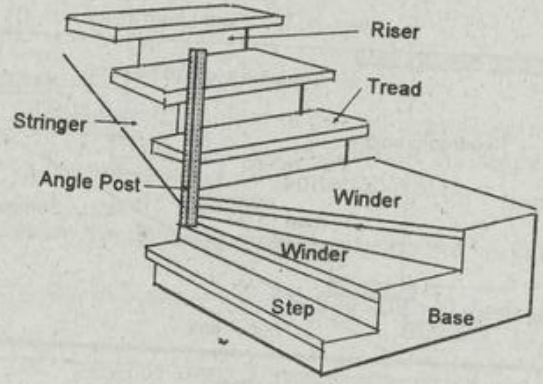


FIGURE 9-2

3. Divide the run distance by the effective width of the tread which normally measured as follows:

Width of Tread	Effective Width
25 cm.	20 cm.
30 cm.	25 cm.
35 cm.	30 cm.

Effective width of the tread is its width minus the nosing

4. If the result of step 3 is less than that of step 2, adjust the length of the run or the width of the tread to obtain an equal distances and proportional steps.

5. The height of the risers should be equal and uniform from the first to the last step of the stair. No fractional value in dividing the rise by the riser per step.

6. If fractional value could not be avoided in dividing the rise by the riser, adjust the fractional value in equal proportion to the number of risers, but in no case shall the riser per step be greater than 19 centimeters nor less than 17 centimeters. Otherwise, the stairs will not be considered as comfortable to ascend and descend

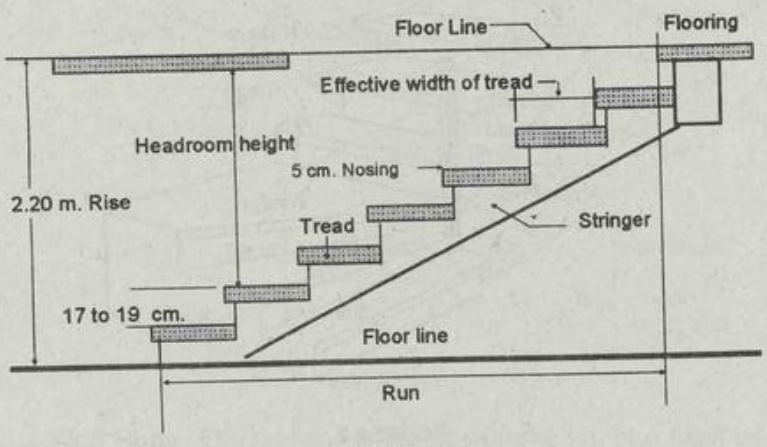


FIGURE 9-3

ILLUSTRATION 9-1

From figure 9-3 determine the number of steps and the height of the riser if the total height of the rise is 2.20 meters using a 30 centimeters width of the tread.

SOLUTION

1. The height of the rise is 2.20 meters. Assume a 17 cm. riser Divide:

   $$\frac{\text{Rise}}{\text{Riser}} = \text{Number of risers}$$

   $$\frac{2.20}{.17} = 12.94$$

2. The answer has a fractional amount of .94. The rule says; "There should be no fractional value in dividing the rise by the riser." Thus, adjust to have an equal height per riser.

3. From the result of step 2, use the whole value of 12 disregarding the decimal amount of .94.

   $$\frac{2.20}{12} = .183 \text{ m. or } 18.3 \text{ centimeters}$$

4. The 18.3 is now the height of the risers per step instead of 17 as assumed. This value is within the range of 17 and 19 cm. considered as comfortable stair.

5. Determine the distance of the run using the formula.

   Run = No. of Steps – 1 x Effective width of the tread.

   Where:

   Effective width = Tread width - Nosing
   Nosing is from 2 to 5 cm.

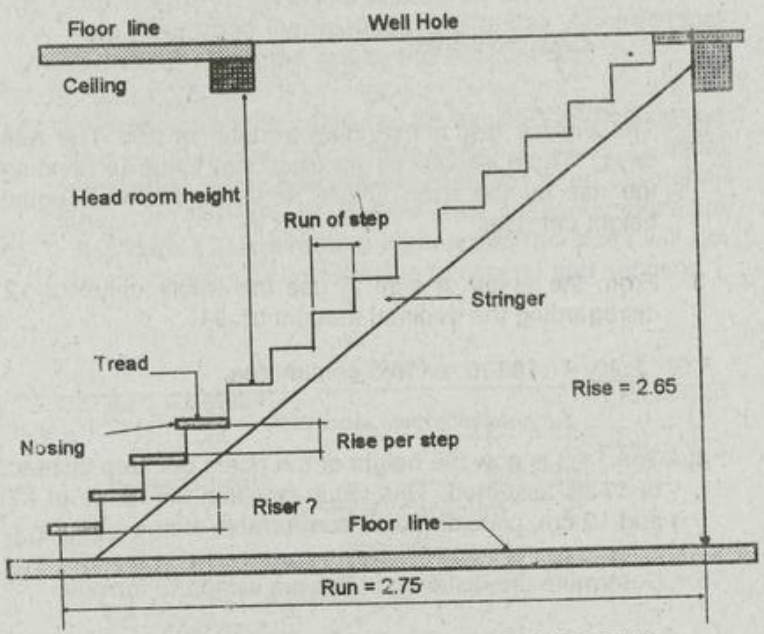
   Run = 12 - 1 x .25 cm.

   Run = 2.75 meters

There were instances where the length of the run and the height of the rise are known or given, the question is how to determine the width of the tread and the height of each riser.

ILLUSTRATION 9 –2

Determine the height of the riser and the width of the tread when the rise is 2.65 meters and the run is 2.75 meters.



CROSS SECTION AND DIFFERENT PARTS OF STAIR

FIGURE 9-4

SOLUTION

1. Assume the riser height to be 18 centimeters.
2. Divide the rise height by 18 centimeters.

$$\frac{2.65}{.18} = 14.72 \text{ say } 15 \text{ steps}$$

3. Assuming that there are 15 steps instead of 14.72 Determine the final height of the riser.

$$\frac{2.65}{.15} = 17.7 \text{ cm.}$$ This amount is between the acceptable value of 17 to 19 cm.

4. Assume that the tread width is 30 centimeters. The effective width of the step is 30 minus .05 nosing = 25 centimeters.
5. If there are 15 steps, multiply by the effective width of the tread.

Run = Number of steps - 1 x 25 cm. (see Fig. 9-4)

Run = (15 – 1) x 25 = 350 cm. or 3.50 meters

Take note that 3.50 meters is longer than 2.75 meter distance of the run as specified in the problem, therefore, adjustment of the tread width is necessary.

a. From step 4, assume tread width = 25 not 30 cm.

b. The effective width is: 25 cm - 5 cm. nosing = 20 cm.

c. Check distance by trial multiplication:

Number of steps x Effective width = Run

14 x .20 = 2.80 meters.

d. This value is acceptable since the existing distance of the run is 2.75 meters with a difference of 5 cm. which could be adjusted proportionally to the number of steps.

9-4 THE STRINGER

Stringer is the inclined plane supporting the treads and the risers of a stair. The length of the stringer is determined by the use of the Pythagorean Formula or by actual measurement using a meter rule or tape.

The "Steel Square" is very useful and effective tool in staircase framing. Know its functions and a satisfactory result will be obtained. Stringer is classified according to the methods of attaching the risers and the tread as illustrated in Figure 9-5.

The Different Type of Stringer are:

1. **Cut type stringer** - Is popularly used in most modern and contemporary house designs.
2. **Cleated type stringer**- Is used for a very rough work.
3. **Built-up type stringer**- Is adopted on a wide stairs that requires a center stringer.
4. **Rabbet type stringer** - Is adopted on fine works usually made at the mill. The risers and treads are held in the rabbets by wedges that are set in with glue.

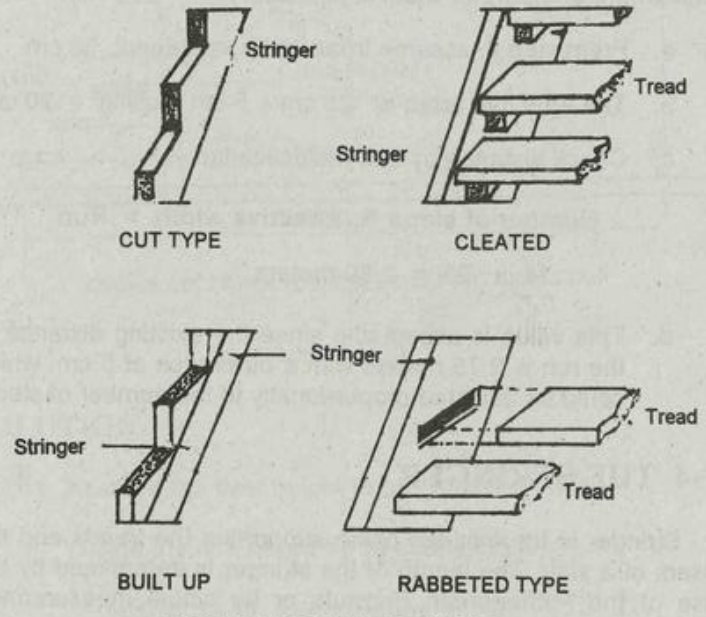
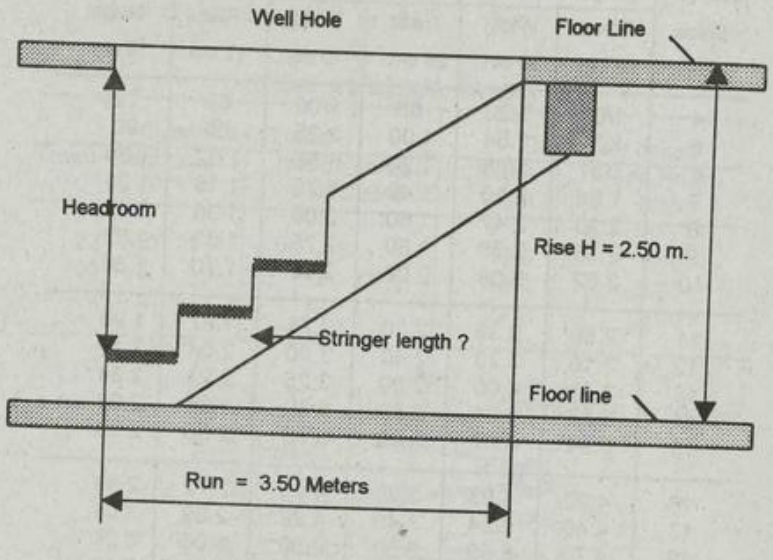


FIGURE 9-5 TYPE OF STRINGER

ILLUSTRATION 9-3

From Figure 9-6 determine the length of an open cut type stringer with the following data.

Run distance = 3.50 meters
Height of the rise = 2.50 meters



FIGRE 9-6 OPEN CUT TYPE STRINGER

SOLUTION - 1

1. Using the formula:

$$\text{Stringer Length} = \text{Run}^2 + \text{Rise}^2$$

$$\text{Length} = \sqrt{3.50^2 + 2.50^2}$$

$$\text{Length} = \sqrt{18.50} = 4.30 \text{ meters or } 14.3 \text{ ft.}$$

Find the number of steps assuming 18 cm. riser height.

$$\frac{\text{Rise}}{\text{Riser}} = \frac{2.50 \text{ m.}}{.18} = 13.88 \text{ say } 14 \text{ steps}$$

TABLE 9-1 HEIGHT OF RISE, LENGTH OF STRINGER AND RUN OF STAIRWAY IN METERS

No. of Steps	Length of Stringer		Length of Run		Height of Rise	
	Tread 25 cm.	Width 30 cm.	Tread 25 cm.	Width 30 cm.	Rise 17 cm.	Height 18 cm.
4	1/05	1/23	.80	1/00	.68	.72
5	1.31	1.54	1.00	1.25	.85	.90
6	1/57	1/85	1.20	1.50	1.02	1.08
7	1.84	2.16	1.40	1.75	1.19	1.26
8	2.10	2.47	1.60	2.00	1.36	1.44
9	2.36	2.78	1.80	2.25	1.53	1.62
10	2.62	3.08	2.00	2.50	1.70	1.80
11	2.89	3.39	2.20	2.75	1.87	1.98
12	3.15	3.70	2.40	3.00	2.04	2.16
13	3.41	4.00	2.60	3.25	2.21	2.34
14	3.67	4.31	2.80	3.50	2.38	2.52
15	3.94	4.62	3.00	3.75	2.55	2.70
16	4.20	4.93	3.20	4.00	2.72	2.88
17	4.46	5.24	3.40	4.25	2.89	3.06
18	4.73	5.55	3.60	4.50	3.06	3.24
19	5.00	5.85	3.80	4.75	3.23	3.42
20	5.62	6.16	4.00	5.00	3.40	3.60

SOLUTION – 2

This problem can be solved instantly using Table 9-1.

1. Length of Stringer is = 4.31 meters. (See column under width 30 cm. along 14 number of steps.)

2. Length of Run is = 3.50 meters. (See under column width 30 cm. along 14 number of steps.

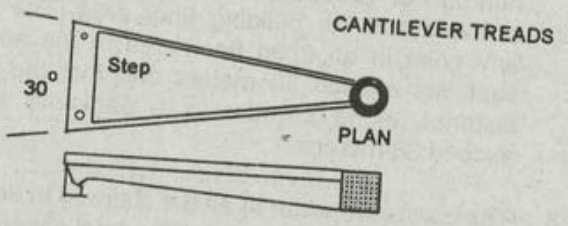
3. Riser Height is = 2.52 meters. (See under height of riser 18 cm.

Stairs Inclination Angle

Ladder	50° to 90°
Ramp	1° to 20°
Stairs	20° to 50°
Ideal Stairs	30° to 35°

TABLE 9-2 SPIRAL STAIRS

Open Riser Tread		Cantilever Tread	
Tread Degrees	No. of Tread in Circle	Riser cm.	Head Room Meter
22° - 30'	16	17.5	2.10
28° - o'	12 - 13	18.0	2.00
30° - o'	12 - 13	20.0	2.00



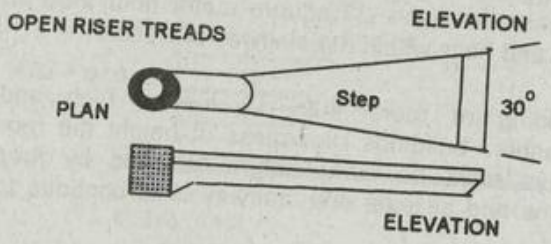


FIGURE 9-7 CANTILEVER TREADS

The National Building Code on Stairs Provides that:

1. The minimum width of any stair slab and the minimum diameter dimension of any landing should be at least 110 centimeters.

2. The maximum rise of stairs step should be between 17 and 19 centimeters . A rise less than 16 centimeters nor more than 19 centimeters is not considered as ideal stair.

3. The minimum width of a tread exclusive of the nosing shall be 25 centimeters.

4. The maximum height of a straight flight between landings is generally 3.60 meters except those serving as exit from places of assembly where a maximum height of 2.40 meters is normally specified.

5. The number of stairway in a building depends upon the number of probable occupants per floor the width of stairway and the building floor area. The distance from any point in an open floor area to the nearest stairway shall not exceed 30 meters and that the corresponding distance along corridor in a particular area shall not exceed 38 meters.

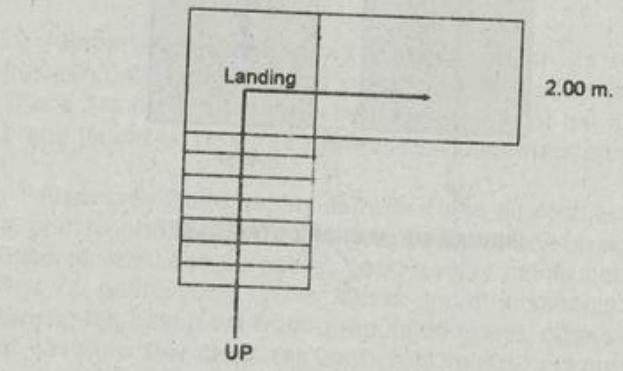
6. The combined width of all the stairway in any floor shall be accommodate at one time the total number of persons occupying the largest floor area under the condition that one person for each .33 square meter floor area on the landing and halls within the stairway enclosure.

7. In building of more than 12 meters high and all merchantile buildings regardless of height the required stairways must be completely enclosed by fireproof partitions and at least one stairway shall continue to the roof.

Problem Exercise

1. Make a Sketch Plan of an ideal L - Shape staircase with the following data:

Width of stair	= 2.00 meters
Rise	= 3.00 meters
Tread	= 30 centimeters
Nosing	= 5 centimeters
Riser height	= ?
Run	= ?



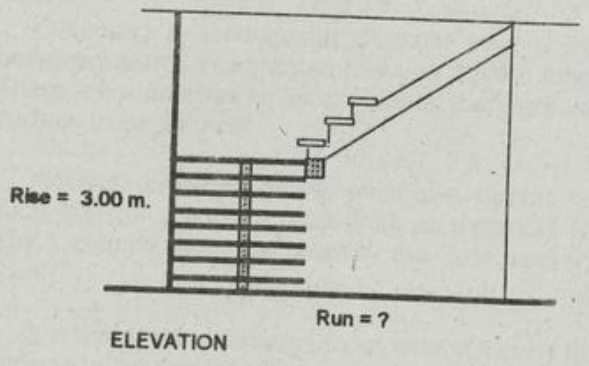


FIGURE 9-8

From the following figure, make a sketch plan of an ideal U-shape staircase where the riser do not exceed 19 centimeters nor less than 17 centimeters with a 30 centimeters tread and 5 centimeters nosing. The rise of the stair is 3.509 meters.

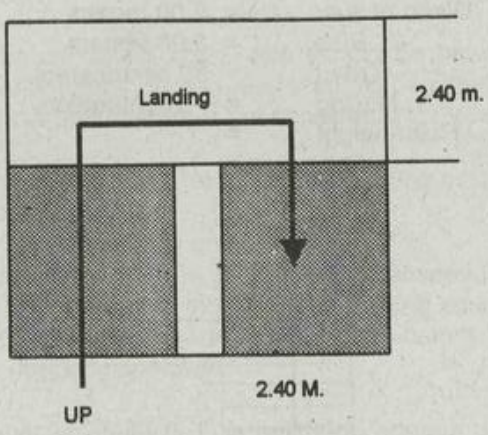


FIGURE 9-9 U-SHAPE STAIRCASE

CHAPTER 10

PAINTING

10-1 PAINT

Paint is commonly referred to as a "Surface Coating". It is defined as "a coating applied to a surface or subtrate to decorate, to protect, or to perform some other specialized functions.

Almost everybody knows the word paint, its uses, colors, including the brand name rated as poor, good and durable. There are those who have little knowledge of paint but rated a brand based on how it is advertised while others on cost.

Generally, good quality paint is a little bit costlier than that of a poorer one. However, in terms of surface area coverage, ease of work and durability, good quality paint is cheaper than that of poorer one. Thus, never have a second thought of having the best paint from a reputable brand, otherwise, to think of saving a few cents for your paint might turn out later to be more expensive.

Obtaining a good quality of paint from a reputable brand however, is not a guarantee that you have a long lasting paint. There are numerous kinds of paint as there are various kinds of surface to be painted.

Applying premium quality paint to a surface not suitable for such type of paint is considered as technical failure. Failure which cannot be guaranteed by the cost neither the brand of paint.

It is therefore imperative to know which paint for what kind of surface to be applied with.

10-2 INGREDIENT OF PAINT

Paint has the following ingredients:

1. Vehicle
2. Solvent
3. Pigment
4. Additives

Vehicle

Vehicle is that substance in the paint that gives a continuity film and provides adhesion to the surface or subtrate. It is called vehicle because it carries the ingredients to the subtrate and remain on the surface after the paint has dried.

The vehicle contains a film former. A combination of the following ingredients:

a. Resins
b. Plasticisers
c. Drying oil, etc.

Components of Paint Vehicle:

1. **Solid Thermoplastic Film Former.** The solid resin is melted for application and then solidifies after application.
2. **Lacquer Type Film Formers.** The vehicle dried by solvent evaporation.
3. **Room Temperature Catalyzed Film Formers.** A chemical agent blended into the coating before application cause cross- linking into a solid polymer at room temperature.
4. **Heat-Cured Film Formers.** Heat causes cross- linking of the film former or activates a catalyst that is not active until heat has been applied.
5. **Oxidizing Film Formers.** Oxygen from the air enters the film and cross-link it to form a solid gel.

6. **Emulsion-Type Film Formers.** The solvent evaporation and the droplets of plastic film former floating in it flows together to form a film.

Solvent

Solvent are low viscosity volatile liquid used in coating to improve application properties.

Pigment

Paint Pigments are solid grains or particles of uniform and controlled sizes which are generally insoluble in the vehicle of the coating.

Paint Pigment contributes to the following properties.

a. For the decoration of function - It contributes opacity, color and gloss control.
b. For protective function - it contribute specific properties such as hardness, resistance to corrosion, rapid weathering, abrasion, and improved adhesion.
c. It make sanding easier, retard flame and serves as insulation against electricity.
d. Pigments fill spaces in paint films.

Additives

Additives are ingredients formulated in the paint to modify the properties of either the vehicle or the pigmentation or both. They give the wet paint or dried paint film properties, which are not present in the vehicle and pigmentation system. Additives improve a certain properties of vehicle such as speed drying, pigment resistance to fading or the entire paint for ease of application.

10-3 ESSENTIAL AND SPECIFIC PROPERTIES OF GOOD QUALITY PAINT

Good quality paint must have the following essential and specific properties.

1. **Adhesion** - Coating must stick to the surface or subtrate to bring other properties into work.

2. **Ease of Application** - Paint must be easily applied in Accordance with the methods as prescribed by the manufacturer. It should go into the subtrate to a specified film thickness and be dried within the specified time with the desired appearance possessing The necessary specific properties.

3. **Film Integrity** - The cured or dried film of paint must have all the film properties as claimed by the manufacturer. There should be no weak spots in the film caused by imperfect film drying or curing.

4. **Consistent Quality** -Paint must be consistent in quality such as color, viscosity, application and durability from can to can, batch by batch, shipment by shipment.

5. **Specific Properties**.- Paint should be considered for particular use such as:

   a. Kitchen Enamel. Enamel paint must resist grease, heat and repeated cleaning.

   b. Stucco or Latex Paint must resist water, alkali and sunlight and must allow passage of water vapor.

   c. Swimming Pool Pain. This type must have a specific chlorine, water and sunlight resistance.

   d. Exterior Commercial Aircraft Finishes must resist ultra violet degradation, erosion by air loss of adhesion at high speed, rapid temperature changes,

chemical attack by the hydraulic fluid of the aircraft, and film rupture from the flexing of the film by the denting of the surface.

10-4 ELEMENTS OF A GOOD PAINTING JOB

Painting is the final touch in the construction work. It is where all the construction defects, ugliness and roughness from masonry, carpentry, tinsmith and others are corrected, smoothened and beautified.

The elements of a good painting job are:

1. **Correct Surface Preparation** – The primary and essential property which is necessary for a paint is Adhesion. Good adhesion demands good surface preparation.

2. **Choice of the Proper Paint System** - Apply the right kind of paint on the right surface. For instance, always apply the right kind of primer before the final top coat. Water base paint for masonry and concrete. Oil base paint for wood and equivalent surface, etc.

3. **Good Application and Right Technique and Tools**.

   a.) Maintain a uniform wet and dry film thickness.
   b.) Correct application and number of sequence as specified by the manufacturer
   c.) Use the right kind of tools with good quality.

4. **Correct Drying Cycle** - The final properties of the dried coating develop during the drying cycle. Unless conditions are favorable, correct film properties will never develop.

5. **Protection Against Water** - The primary cause of paint failure is Moisture . Moisture is considered as a menace to the best of paint job.

It is very frustrating to see your lovely and newly painted house deteriorating so soon specially if you bought good paint, used good tools and spend a lot for labor.

Water is the hidden enemy of paint. It is a pervasive element of deterioration and it causes the following:

a.) Rusting and other corrosion

b.) Paint peeling

c.) Masonry efflorescence and spalling.

d.) Corrosive water solution (staining sea water)

10-5 SURFACE PREPARATION

The quickest way to achieve paint failure is through improper surface preparation. It is just as important to qualify a surface preparation as it is to specify a painting system.

SPECIFICATIONS

A. GENERAL

1. **Surface Examination**- No exterior paint or interior finish shall be done under condition which may jeopardize the quality or appearance of the painting or finishing.

2. **Preparation** - All Surface to receive paint should be cleaned and in proper condition. Wood works shall be sandpapered and dusted clean. All knot holes, pitch pockets, or sappy portions shall be shellacked or sealed with knot-sealer. Nail holes, cracks, or defects shall be carefully puttied after the first coat with putty bleaching color of the stain or paint.

3. **Interior Woodwork**. Wood finish shall be sandpapered between coats. Cracks, holes, or plaster imperfections

shall be filled with patching plaster and smoothed off to match adjoining surfaces.

4. **Plaster or masonry**- Masonry or plaster shall be completely dried before any sealer or paint is applied. After the primer-sealer coat is dried, all visible suction spots shall be toughed up before the succeeding coats are applied. Work should not be continued until after all spots have been sealed. In the presence of high alkali conditions, surfaces should be washed to neutralize the alkali.

5. **Metals**- Shall be clean, dry and free from mill scale and rust. Remove all grease and oil from the surface. Unprimed galvanized metal shall be washed with metal etching solution and allowed to dry before applying a primer.

6. **Concrete and Brick Surface**- The surface shall be wire-brushed clean. Glazed surfaces and those with traces of patching compound shall be sandpapered or acid etched before applying a primer.

B. CLEANING METHODS

1. **Sandblasting**. There are three general methods applied in sandblasting:

   a. *Conventional Drying Sandblasting* – The sand is not recycled. However, dust respirators and other safely precautions should be observed since environment restrictions on dry blasting are increasingly severe.

   b. *Vacuum Sandblasting* - This method reduces health hazard because the sand is recovered outright. It is however costlier and less efficient compared with the dry blasting method but its efficiency can be increased by holding the vacuum cone at a slight distance from the surface. The vacuum method is

useful inside shops and in areas where dust might damage machineries.

c. **Wet Sandblasting**. Reduces the hazard of dust and may be required by legal restrictions. The wet sand and paint residues accumulate on ledges and other flat areas where rinsing operation is necessary.

2. **Wire- Brushing and Scraping** - Power and hand wire-brushing are used on small jobs in cleaning areas after sandblasting and on surfaces where sandblasting is not feasible. Hand scraping is used on small areas and in places where access is difficult and for final clean up.

3. **Power Tools**- Power tools such as rotary wire and disc tools, rotary impact chippers and needle sealers may be used if sandblasting is not feasible.

4. **Water Blasting**- Water blasting is an effective method in cleaning and removing old paint from large masonry surfaces. It is generally used and acceptable for health and environmental requirements. Water blasting method is preferred for underwater or marine work.

C. CHEMICAL METHODS

1. **Acid Etching** – Is the use of acid solution with or without detergent to roughen a dense glazed surface. To remove the residual soluble reaction of calcium and magnesium chloride which affect the adhesion and stability of latex paint in particular.

2. **Paint remover** – Both the conventional solvent base and the water rinseable type of paint removers may be used to remove old paint. Most paint removers contain wax. This wax shall be removed completely before painting for it destroy adhesion and inhibit the drying of paint

3. **Steam Cleaning** - Steam cleaning with or without detergents is frequently used in food packing plants.

A mildewcide is usually added. Low pressure steam cleaners are used on home and office walls.

4. **Alkali cleaning**- Alkali cleaners should not be used on masonry surfaces adjacent to aluminum, stainless steel or galvanized metal. Surfaces that are cleaned with alkali cleaners must be thoroughly rinse and clean with water. Residual alkali and detergents can cause greater damage to paint if they are not removed completely.

10-6 KINDS OF PAINT, USES AND AREA COVERAGE

Kind of Paint	Uses	Thinner	Drying Time	Coverage Per 4 liters in sq. m.
	* P R I M E R S *			
1. Interior Primer and sealer	For Interior wood surfaces	Paint Thinner	2 hours. Allow overnight before recoating	25 to 30
2. Exterior wood primer	For exterior wood surfaces	Paint Thinner	6 hrs. Allow overnight before recoating	30 - 40
3. Prepakote Red Oxide Primer	Primer for ferrous and non- ferrous materials	Paint Thinner	3 hours. Allow overnight before recoating	35 to 40 sq. m.
4. Zinc Chromate Primer	For exterior and interior metal Surfaces exposed to normal Industrial environment	Paint Thinner	3 hours. Allow overnight before recoating	30 to 40 sq. m.
5. Red Oxide Primer	Rust preventive primer for ferrous surfaces	Paint Thinner	3 hours. Allow overnight before	30 to 40
6. Epoxy primer	For steel, aluminum, galvanized iron	Epoxy reducer	6 hours. Allow overnight before recoating	30 to 40

* WATER BASE MASONRY PAINT*

1. Acrylic Latex paint	Exterior & Interior masonry surfaces	½ lts. water/ 4 liters	30 min. Allow 6 hrs. before recoating	30 to 40 sq. m.
2. Acrylic Semi-Gloss Latex	Exterior & Interior masonry surfaces	Water	30 min. Allow 6 hrs. before Recoating	30 to 40 sq. m.
3. Acrylic Gloss Latex Paint	Exterior & Interior masonry surface	Water	30 min. Allow 6 hrs. before recoating.	30 to 40 sq. m.
4. Acrylic Clear Gloss Emulsion Paint	For chalky surface to improve adhesion of new coats of Latex paint	Water	1 hour. Allow 4 hours before recoating	30 to 40 sq. m.
5. Latex Hi-gloss Enamel	For furniture, cabinets, doors, windows, tools, toys wrought iron & appliances	Use as is	1 hour. Allow 4 hours before recoating	30 to 40 sq. m.
Tinting Color	Acrylic colors	Water		
6. Acrylic concrete sealer	Primer to old and new concrete	Water	30 min. Allow 6 hours before recoating	30 to 40 sq. m.
7. Masonry surface	Primer for old chalky paint film	Use as is	24 hours. Allow overnight before recoating	30 to 40 sq. m.
8. Tinting colors	Acrylic colors	Water		

* ROOF PAINT *

1. All weather Acrylic roof Shield	For galvanized iron sheet, asbestos, concrete bricks and stucco	Water	4 hours. Allow overnight before recoating	40 to 50 sq. m.
2. Portland cement paint	For G.I. sheet concrete, bricks and other zinc coated metal	Paint Thinner	6 hours. Allow overnight before recoating	30 to 40 sq. m.

3. Davies Roof paint	G.I. roof & other metal such as	Paint Thinner	6 hours. Allow overnight before	30 to 40 sq. m.

* ENAMEL AND GLOSS PAINT *

1. Quick Drying Enamel	For exterior & Interior wood And metal surf.	Paint Thinner	5 hours. Allow 8 hours before recoating	30 to 40 sq. m.
2. Interior Semi-Gloss Enamel	Interior wood and metal Surfaces	Paint Thinner	6 hours. Allow overnight before recoating	25 to 30 sq. m.
3. Flat Wall Enamel	For interior wall and ceiling	Paint Thinner	3 hours. Allow overnight before Recoating	40 to 50 sq. m.
4. Exterior Gloss paint	For exterior wood and properly primed metal surfaces	Paint Thinner	6 hours. Allow 48 hours before recoating	40 to 50 sq. m.
5. Tinting Colors	Oil base Tinting			

* VARNISHING *

1. No. 48 Davies wood bleach	For dark wood to be changed to light natural finish & making old wood color uniform	Use as is		
2. No. 77 Davies Lax-Tire Plastic wood dough	For patching up wood defects like knots, nail holes & cracks	Use as is	10 minutes 30 minutes for dry hard	20 to 25 sq. m.
3. Wood filler paste	Sealer for open grain of interior wood	Paint Thinner	12 min. Allow overnight before recoating.	25 to 35 sq. m.
4. Non-Grain raising wood stain	For wood surface		30 minutes	30 to 40 sq. m.

5. Oil wood stain	For paneling, cabinets, floors furniture, door jambs, and other woodworks		Allow 24 hours for recoating	30 to 40 sq. m.
6. Finishing Oil	To seal & finish Interior wood surface such as furniture, wood and paneling		Overnight	35 to 40 sq. m.
7. Valspar or Spar Varnish	For floor, sidings furniture, deck of boats, etc.	Paint Thinner	24 hours	40 to 50 sq. m.
8. Daxpar Varnish	For interior and exterior wood surface, nautical and aeronautical varnish	Paint Thinner	24 hours	40 to 50 sq. m.
9. Hi-Solid sanding sealer	For interior new wood furniture and fixtures, cabinets, door, etc.	Lacquer Thinner	10 minutes Allow 30 mi. before coating	40 to 50 sq. m.
10. Hi-Solid clear gloss lacquer	For furniture, cabinets, fixture door paneling and trim	Lacquer Thinner	Allow 30 min. before coating	30 to 40 sq. m.
11. Hi-Solid semi-gloss lacquer	For interior wood furniture cabinets, doors shelves etc.	Lacquer Thinner	Allow 30 min. before coating	30 to 40 sq. m.
12. Hi-Solid dead flat lacquer	For interior wood furniture, cabinet door jamb, trim paneling etc.	Lacquer Thinner	Allow 30 min. before coating	30 to 40 sq. m.
13. Water White gloss lacquer	For furniture, cabinets, doors panel & interior walls	Lacquer Thinner	Allow 30 min. before coating	30 to 40 sq. m.

* AUTOMOTIVE FINISHING *

1. Lacquer Enamel	For properly primed metal and wood	Lacquer Thinner	Allow 30 min. before coating	40 to 50 sq. m.
2. Automotive Lacquer	For exterior & interior metal or wood surfaces	Lacquer Thinner	30 minutes	40 to 50 sq. m.
3. Lacquer primer	For metal wood surface	Lacquer Thinner	30 minutes	40 to 50 sq. m.
4. Lacquer putty	For exterior and interior metal & wood surfaces	Lacquer Thinner	10 minutes dry to sand in 1 hour	20 to 30 sq. m.
5. Pro-Lux Auto Enamel	Automotive Fin. for residential & Commercial	Paint Thinner	2 hours. Dry hard in 10 hrs.	30 to 40 sq. m.
6. Pro-Lux Enamel paint	For exterior and interior wood and Metal surfaces	Paint Thinner	2 hours. Allow 8 hours before recoating	30 to 40 sq. m.
7. Pro-Lux Glazing putty	For exterior and interior metal & wood surfaces	Use as is	2 hours	25 to 35 sq. m.

* INDUSTRIAL PAINTS *

1. Silver Finish Aluminum	For steel tanks Exterior & Interior wood & masonry	Use as is	1 hour. Allow 24 hours before recoating	40 to 50 sq. m.
2. Heat Resisting	For interior and exterior surfaces like radiators, boilers, pipes, & general industrial equipment	Use as is	1 hour. Allow 24 hours before recoating	40 to 50 sq. m.
3. High Heat resisting paint	For superheated steam lines	Use as is	1 hour at 450° F maximum	40 to 50 sq. m.

	boiler casings drum and rocket launchers			
4. Asphalt base Aluminum	For asbestos cement composition and metal	Use as is	1 hour, Allow 24 hrs. before recoating	20 to 30 sq. m.
5. Traffic Paint	For asphalt and masonry surface	Uses as is	1 hour. Allow 24 hrs. before recoating	20 to 30 sq. m.
6. Blackboard Slating	For wood or metal surface	Paint Thinner	12 hours. Allow overnight before Recoating	35 to 40 sq. m.
7. Davies Anti-corrosive Marine Paint	For hulls and below water line of ship	Paint Thinner	12 hours. Allow overnight before recoating	30 to 40 sq. m.
8. Marine boat topping paint	For properly primed surfaces between the light & deep load lines of ships	Paint Thinner	12 hours. Allow 24 hrs. before recoating	30 to 40 sq. m.
9. Anti-Fouling Paint	For properly primed surface below the water line of ships	Paint Thinner	8 hours. Allow 24 hrs. before recoating	30 to 40 sq. m.
10. Hull, Deck, Mast & Top-side Paint	For use above water line of sea vessels equipment & structures near the sea	Paint Thinner	12 hours. Allow 24 hrs. before recoating	30 to 40 sq. m.
11. Machinery engine enamel	Marine engine & equipment casing	Paint Thinner	1 hr. Allow 24 hours before recoating	30 to 40 sq. m.
12. Epoxy Enamel	For steel, Alumnum, galv. Iron Wood & concrete	Epoxy reducer	6 hours. Allow overnight before recoating	30 to 40 sq. m.
13. Epoxy glazing putty	For body repair aircraft, car and equipment	Epoxy	2 hours	

14. Epoxy Glue	Multi-purpose thermosetting plastic material for cementing or bonding rigid materials	Use as is	8 hours full strength in 96 hours	30 to 40 sq. m.
15. Pure Pale boiled linsed oil	Use as thinner for exterior house paint	Use as is		
16. Concrete neutralizer	Treatment to neutralize masonry surface	Use as is	24 hours	30 to 40 sq. m.
17. Rust remover	Paint stripper	Use as is	Overnight	25 to 35 sq. m.
18. Paint remover	Paint stripper	Use as id	Overnight	25 to 35 sq. m.
19. Mildewcide	Destroy molds mildews on new and previously painted surfaces	Water		

SOURCE. Davies Paint Manual of Information

10-7 ESTIMATING YOUR PAINT

Paint manufacturer specifications include the estimated area coverage per gallon having a net content of 4 liters. Generally, the estimated area coverage is in the range interval of 10.

For instance, one gallon of Quick Drying Enamel covers 30 to 40 square meters surface area which simply mean a minimum of 30 and a maximum of 40 square meters depending upon the texture of the surface to be painted.

The problem therefore is, what amount for which surface texture will be used ? To simplify our estimate, surface texture will be classified into three categories such as:

1. Coarse to rough surface..... 30 sq. m. coverage area
2. Fine to coarse surface..... 35 sq. m. coverage area
3. Smooth to fine..... 40 sq. m. coverage area

ILLUSTRATION 10-1

A concrete firewall measures 30 meters long and 12 meters high. Determine the number of gallons (4 liters content) required using Acrylic Gloss Latex Paint if the wall is:

a.) Wooden trowel finish (coarse to rough)
b.) Paper Finished (fine to coarse)
c.) Fine to Smooth (putty finish)

SOLUTION

A) Coarse to Rough Surface

1. Solve for the wall area

   Area = 30 x 12 = 360 sq. m.

2. 360 sq. m. divided by 30 sq. m. area coverage per gallon of neutralizer and water solution:

   $\frac{360}{30}$ = 12 gallons

3. If one quart of neutralizer is mixed with 2 ½ gallons of water; divide:

   $\frac{12}{2.5}$ = 4.8 say 5 quarts neutralizer

4. Solve for the concrete primer . Refer to Sec. 10-6 under Masonry Water Base Paint, using Acrylic Concrete Sealer as primer, the area coverage per gallon is 30 to 40 sq. m.

5. For a Coarse to Rough surface; divide:

   $\frac{360}{30}$ sq. m. = 12 gallons Acrylic Latex paint primer

6. Solve for the Acrylic Gloss Latex Paint final coating. Use 30 sq. m. area coverage per gallon; divide:

   $\frac{360}{30}$ = 12 gallons

B) Solution for Fine to Coarse Surface

1. Solve for the net area of the wall.

   Net area : 30 x 12 = 360 sq. m.

2. Solve for the concrete neutralizer at 35 sq. m. per gallon.

   $\frac{360}{35}$ = 10.3

3. If one quart of neutralizer is mixed with 2-½ gallons of water; divide:

   $\frac{10.3}{2.5}$ = 4.1 quarts neutralizer

4. Solve for the concrete Primer Sealer (use 35 sq. per gal.) divide:

   $\frac{360}{35}$ sq. m. = 10.28 gallons

5. Solve for Acrylic Gloss Latex Paint. See step 4 = 10.28 order 11 gallons.

C) Solution for Fine to Smooth Surface

1. Divide the wall area by 40 sq. m. coverage per gallon.

$\frac{360}{40}$ = 9.0 gallons surface primer

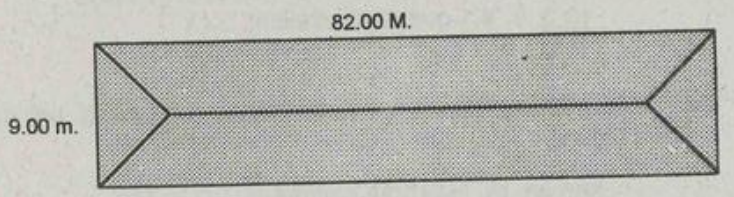
2. For final coat, the same, 9 gallons

3. For Neutralizer; $\frac{9.0 \text{ gal.}}{2.5 \text{ gal.}}$ = 3.6 say 4 liters

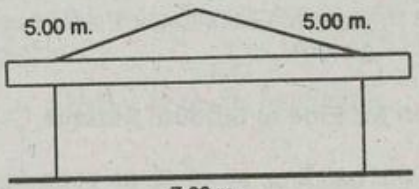
ILLUSTRATION 10-2

A 10 class room elementary school building with a general dimensions of 6.00 meters wide by 8.00 meters long requires painting of the roof and the plywood ceiling. The plan specifies two coatings of Acrylic Roof Shield and Quick Drying Enamel for the ceiling respectively. Prepare an order list of the following materials:

a Roof paint
b. Wood primer for the ceiling
c. Quick drying paint for the ceiling
d. Paint thinner



ROOF PLAN



ELEVATION

FIGURE 10-1

SOLUTION

A) Roof Paint

1. Find the total roof inclined area.

   A = 10.00 x 82.00 m.
   A = 820 sq. m.

2. Refer to Sec. 10.6 under roof paint, the area coverage of Acrylic Roof Shield paint per gallon is 40 to 50 sq. m. Use 45 sq. m. average area.

   $\frac{820}{45}$ sq. m. = 18.2 say 19 gallons

3. For second coating: 19 x 2 = 38 gal.

4. Paint thinner is not required. Clean water is used instead.

B) Primer and Enamel Paint for the Ceiling

1. Solve for the total ceiling area including the eaves.

   Area: 9 x 82 = 738 sq. m.

2. Refer to Sec. 10-6. Under wood primer, the area coverage per gallon is 30 to 40 square meters.

3. For plywood ceiling, use 35 square meters coverage area per gallon (4 liters).

   $\frac{738}{35}$ = 21 gallons wood primer

4. For Quick Drying Enamel as top coat, use average 35 sq. meters per gallon (4 liters)

   $\frac{738}{35}$ = 21 gallons Quick Drying Enamel.

5. Solve for the paint thinner at an average of ½ liter per gallon of paint.

Primer Paint.....	21 gal. (4 liters)
Quick Dry Enamel.....	21 gal. (4 liters)
Total.....	42 gallons

6. Multiply: 42 x ½ liters = 21 liters or 6 gallons.

7. Order : 38 gallons Acrylic Roof Shield paint
21 gallons Wood Primer
21 gallons Quick Dry Enamel
6 gallons Paint Thinner

Comment:

1. The paint thinner of any type is considered as the most abused materials in all painting job. It is used for washing of hands, cleaning of paint brush and tools, sometimes as fuel and torches or lamps.

2. Frequent washing of painter's brush and roller after use will consume large amount of paint thinner. This could be avoided if the brush is wrap-up with paper after use then placed inside a gallon container with water to avoid cleaning and hardening of paint ready for use the next day or any time as needed.

3. However, if paint brush, rollers and other tools were used on epoxy paint or primers that were mixed with catalyst, cleaning after use is mandatory because the hardening process of epoxy paint mixed with catalyst can not be prevented due to the chemical reactions that has already started like cement mixed with water.

4. Protect your paint brush and roller from damages by cleaning as follows:

   a.) For Epoxy Paint mixed with Catalyst – Clean your tools with acrylic thinner.

For economical reason use lacquer thinner then wash with water and soap.

b.) For Water Base Paint - Wash thoroughly with water and soap immediately after use.

c.) Lacquer Paint or Varnish - Clean with paint thinner then wash with water and soap.

d.) Gloss Paint, flat and quick dry enamel - Clean with paint thinner or kerosene then wash with water and soap.

e.) Lacquer thinner estimate for varnishing work should be sufficient enough to anticipate frequent thinning, multiple rubbing, cleaning of tools and evaporation.

10-8 PAINT FAILURES AND REMEDY

The different types of paint failures are identified as follows:

1. Blistering or Peeling
2. Chalking
3. Flaking
4. Fading
5. Cracking & Alligatoring
6. Peeling or Cracking
7. Bleeding
8. Mildew
9. Staining
10. Checking & Flaking

Blistering or Peeling occurs when the moisture trapped in the wood evaporates when exposed to sun or heat. The paint is push out of the surface.

Remedy

1. Locate and eliminate the sources of moisture.

2. Scrap off old paint around the blistered area. Let dry and apply good primer, then final paint of good quality.

Chalking – The paint was too thin for the required film.

Remedy:

Be more generous to your paint. Spend a little more for two coatings.

Flaking - The result of inadequate or poor surface preparation. The paint flakes off in scales or powdered and chalk off.

Remedy:

Scraped-off the paint on affected area than seal all cracks against moisture. Apply good primer then final coat.

Fading - Is a normal behavior of paint. However, if fading is too fast and excessive, that means you applied a poor kind of paint. This is what usually happened when for a few cents of difference in cost the quality was sacrificed.

Remedy:

Repaint. Next time, be sure to buy the best of paint brand. Remember, good paint contains more and better pigment.

Cracking and Alligatoring - Results when paint was applied in several heavy coats not observing the sufficient drying time between coats. The primer or undercoat used may not be compatible with the final coat. For instance, using a quick drying enamel as final coat over a flat wall paint. Or a lacquer or acrylic paint over an ordinary oil base paint, etc.

Remedy:

Remove the paint. Clean the surface properly. Apply good kind of primer paint then final coat.

Peeling or Cracking of Paint on G.I. Sheets - Indicates the use of improper metal primer or no primer applied. The paint film has no adhesion on the surface.

Remedy

Strip off the paint. Clean with solvent. Dry, then apply galvanized paint (see roof paint on Sec. 10-6).

Bleeding - Is the result of inadequate sealing of the surface at the first application of paint.

Remedy

Scrape off the surface then Repaint.

Mildew - Mildew thrives on high humidity and temperature. The fungus are stimulated and grows on the paint film. If covered with new coat of paint, just the same it will grow through the new coat.

Remedy

Wash the surface with mildew wash solution diluted with water. Scrub the surface. Rinse with clean water and dry for 48 hours then apply final coat.

Staining - Is an effect of wood preservative or rust of nails.

Remedy

1. Remove the paint on affected area
2. Remove rust on nails, then apply lead primer to metal and wood primer.
3. Apply final coat with good quality paint.

Checking and Flaking - Is caused by expansion or contraction of wood.

Remedy: See Remedy for Blistering.

10-9 WALL PAPERING

The term " Wallpaper " refers not only to paper substances that are pasted on walls and ceiling but also includes vinyl, cork, fabrics, grass cloth, foils and many other surface covering materials:

Estimating your wallpaper requires additional or extra rolls in anticipation of the following:

1. For replacement of ruined or damaged materials during the process of working and handling.
2. For additional areas which are not included in the plan or overlooked in actual surface measuring.
3. For future repair which requires the same pattern, color texture and design.
4. Trim can be used as a decorative boarder. Wall paper is sold by yard or meter in roll.

Vinyl Wall Paper is Classified into Three kinds:

1. Vinyl laminated to paper
2. Vinyl laminated in cloth
3. Impregnated vinyl cloth on paper backing. This type is extremely durable, easy to clean and damage resistant.

Caution in Buying Vinyl Wall Paper

1. Examine the label if it is pure or vinyl coated only. Vinyl coated is not wear or grease resistant nor washable type.
2. Never confuse them with vinyl wallpaper.
3. In buying vinyl wallpaper adhesive, always use and specify vinyl mildew resistance adhesive only.
4. Vinyl wallpaper stretches if pulled. Hair line cracks will ap-

pear at seems as wallpaper shrinks when it dries. Thus, avoid stretching your vinyl wallpaper.

Foil

Foil is another type of wallpaper simulated metallic finish or aluminum laminated paper. Do not fold or wrinkle the foil because there is no remedy to crease.

Smooth surface is required to avoid reflective surfaces. Foil magnifies any imperfections on the surface to which it is attached. Always specify mildew resistant vinyl adhesive only.

Grass Cloth, Hemp, Burlap, Cork

These materials are mounted on paper backing which could be weakened from over soaking with paste. Hence, paste one strip at a time.

Flocks

Flocks are made of nylon or rayon available on paper, vinyl or foil wallpapers. Use paint roller or squeegee for best result.

Wallpaper Estimating Procedures

1. Determine the surface area to receive wall paper.
2. Subtract the area opening such as doors, windows etc
3. Divide the net wall area by the effective covering of the wallpaper size as presented in Table 10-1 to find the number of roll.
4. Add 5 to 10 % allowance depending upon the design pattern.
5. Multiply the number of rolls by the corresponding amount of adhesive to get the number of boxes required.

TABLE I0-1 WALLPAPER TECHNICAL DATA

Width cm.	Length / roll meter	Effective covering per roll (sq. m.)	Adhesive box per roll
52	10.05	5.22	.17
54	10.05	5.42	.18
71	13.70	9.72	.32

Problem Exercise

1. A narra plywood partition contains 48 pieces 1/4" x 4" x 8" board specify 5 coat lacquer varnish including the primer coat of sanding sealer. List down the required materials as follows: Sand paper No. 150 (rough), 220 and No. 400 (fine)

1. Wood stain
2. Lacquer Sanding Sealer
3. Lacquer clear gloss
4. Lacquer thinner

2. A national highway 80 kilometers long requires centerline white alternate marker 6 inches wide 3 meters long. How many gallons of road paint is required?

3. A solid firewall measures 45 meters long by 18 meters high is to be painted with Acrylic Latex gloss paint. The plan specifies two final coat over the primer. Solve for the following materials if the wall finish is coarse, fine and smooth. (a) Primer. (b) Gloss Latex and (c) Neutralizer

4. A school building has 20 class room measuring 7.00 x 9.00 meters with an eaves measuring 120 centimeters from the wall including the fascia board. Using Quick Drying Enamel for the ceiling and Roof shield paint for the roof solve for: (a) Primer paint, (b) Quick dry enamel, (c) Paint thinner, (d) Roof paint for two coatings.

CHAPTER 11

AUXILIARY TOPICS

11-1 ACCORDION DOOR COVER

The standard height of accordion door cover is 2.40 meters or 8 feet. Job order however, could be lower than this height but computed at 2.40 meters standard height.

Estimating the quantity of materials for any length of accordion door could be done easily with the aid of Table 11-1 Technical Data of accordion door.

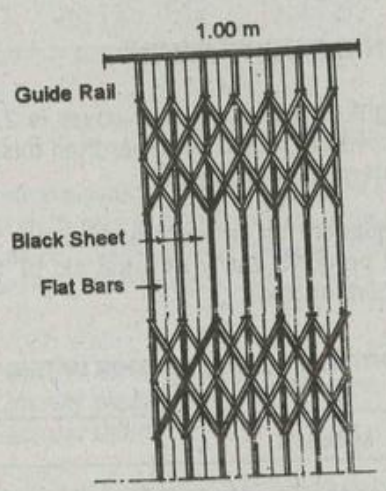
TABLE 11-1 QUANTITY OF ACCORDION DOOR MATERIALS PER METER LENGTH

Pieces	Materials
12	G.I. or Black sheet blade 15 x 240 cm
13	6 mm x 240 Steel Pin
14	5 mm x 25 mm x 240 cm. Flat steel bars
24	3 mm x 12 mm x 60 cm. Flat steel bars
1	6 mm x 32 mm x 200 cm. Flat steel bars
2	38 mm dia. roller bearing with rivets and bushing
35	6 mm x 38 mm rivets
52	6 mm x 16 mm rivets
112	6 mm x 20 mm washers
1	50 cm. G.I. pipe 10 mm diameter

To find the required materials for a given opening, multiply each item by the span of the door opening in meters.

ILLUSTRATION 11-1

For security reason a 4.00 meters wide door requires an accordion cover. The door is to open at the center folded at both sides direction. List down the materials.



Elevation

Accordion Door

Plan

FIGURE 11-1

SOLUTION

1. Determine the opening span of the door = 4 meters
2. Referring to Table 11-1, multiply:

4 m. x 12	= 48	pcs	15 x 240 cm. G.I. sheet blade
4 m. x 13	= 52	"	6 mm x 240 cm. steel pin
4 m. x 14	= 56	"	5 mm x 25 mm x 240 cm. flat bars
4 m. x 24	= 96	"	3 mm x 12 mm x 60 cm flat bars
4 m. x .1	= 4	"	6 mm x 12 mm x 200 cm flat bars
4 m. x 2	= 8	"	38 mm dia. roller bearing with bushing
4 m. x 35	= 140	"	6 mm x 38 mm rivets
4 m. x 52	= 208	"	6 mm x 16 mm rivets
4 m. x 112	= 448	"	6 mm hole x 20 mm washers
4 m. x 1	= 4	"	10 mm dia. x 50 cm. G.I. pipe bushing

11-2 GLASS JALOUSIE

One important consideration in estimating glass jalousie is the clear height of the window opening. If a window is to accommodate glass jalousie, the opening height must be adjusted to the number of blade to be installed. Table 11-2 provides the standard height of jalousie opening corresponding to the number of blade.

With respect to the width of the glass jalousie, it does not present any problem because the glass blade can be adjusted to the design length. The glass blade however, should not be longer than 90 centimeters.

TABLE 11-2 GLASS JALOUSIE STANDARD HEIGHT

Number Of blade	Height of glass	Square Ft. per blade	Number of blade	Height of glass
4	14-7/8"	4 x 22 = 0.61	14	49-7/8"
5	18-3/8"	4 x 24 = 0.67	15	53-3/8"
6	21-7/8"	4 x 26 = 0.72	16	65-7/8"
7	25-3/8"	4 x 28 = 0.78	17	60-3/8"
8	28-7/8"	4 x 30 = 0.83	18	63-7/8"
9	32-3/8"	4 x 32 = 0.89	19	67-3/8"
10	35-7/8"	4 x 34 = 0.94	20	70-3/8"
11	39-3/8"	4 x 36 = 1.00	21	74-3/8"
12	42-7/8"	4 x 38 = 1.06	22	77-7/8"
13	45-3/8"	4 x 40 = 1.11		

11-3 WATER TANK

The size and capacity of a water tank for building structure depends upon the volume of water to be stored in. The volume of water on the other hand, depends upon the number of persons or occupants of the building. Thus, the problem is how to determine the volume of water and size of the water tank that could serve the occupants efficiently.

TABLE 11-3 WATER CONSUMPTION IN OFFICE BUILDING

Building Type	Consumption in Gallons per Hour per Person
Commercial – No Air-Conditioning	3.8
Commercial – With Air-conditioning	7.3 to 9.2
Owner occupied with kitchen and Laundry – No Air-Conditioning	7.3
Owner occupied with kitchen and Laundry with Air-Conditioning	9.0

TABLE 11-4 COLD WATER CONSUMPTION IN BUILDINGS

Type of Building	Gallons per Day per Person
Residential – Average	50
Residential – Large	100
Apartment – Low Rent	75
Apartment – High Rent	100
Hotel	100
Office Building	25

ILLUSTRATION 11-2

An air-conditioned commercial office building has a total occupancy of 800 persons. Determine the volume of water in cubic meter to supply the occupant needs.

SOLUTION

1. Determine the hourly water consumption of 800 persons. Refer to Table 11-3 for an Air-Conditioned Commercial type building, multiply:

   $800 \times 9.2 = 7{,}360$ gallons per hour

2. The tank must always have ½ hour supply of water thus:

   $\frac{7{,}360}{2} = 3{,}680$ gallons per ½ hour

3. The pump must therefore supply 7,360 gal. per hour or

   $\frac{7{,}360 \text{ gal.}}{60 \text{ min.}} = 122.7$ gallons per minute

TABLE 11-5 HOT WATER CONSUMPTION IN APARTMENT BUILDING IN GALLONS

Consumption	Public Housing	Apartment Hotel
Average Daily		
Per Apartment	79	50
Per Person	28	41
Per Room	22	36
Maximum Daily		
Per Apartment	92	69
Per Person	33	48
Per Room	26	43
Maximum Hourly		
Per Apartment	8.9	7.6
Per Person	3.2	5.3
Per Person	2.5	4.9

ILLUSTRATION

Assuming that the water consumption of a commercial office building is 7,360 gallons, determine the size of the tank to contain the water.

ILLUSTRATION 11-3

Assuming that the water consumption of a commercial office building is 7,360 gallons. Determine the size and volume of the tank in cubic meters to contain 7,360 gallons.

SOLUTION

1. By conversion: 1 cubic meter is = 264.2 gallons

2. Convert 7,360 gallons to cubic meter. Divide:

$$\frac{7,360}{264.2} \text{ gal.} = 27.85 \text{ cubic meter}$$

Note: This volume is the inside dimension of the tank.

3. The formula for finding the size of a cylindrical tank is:

D^2 x 0.784 x Height = Volume

4. Assuming that the height of the tank is 2.00 meters:

$D^2 \times 0.784 \times 2.00 = 11.5$ meters.

$D^2 \times 1.568 = 11.5$ meters.

$$D^2 \times \frac{11.5}{1,568}$$

$D^2 \times 7.33$

$D = \sqrt{7.33}$

D = 2.72 meters diameter of the tank.

5. The size of the tank therefore is:

2.00 meters high and 1.72 meters in diameter

For more detail of this problem in plumbing, refer to the book Plumbing Design and Estimate by the same author.

11-4 WOOD PILES

Wood Pile Specifications provides that: "Piles shall be peeled removing all the rough bark at least 80 % of the inner bark. Not less than 80% of the surface on any circumference shall be clean wood. No string of inner bark remaining on pile shall be over 2 centimeters wide and 20 centimeters long. All knots shall be trimmed closed to the body of the pile."

TABLE 11-6 WOOD PILES

Length of Piles In Meter	Diameter from Butt Min (cm)	Max (cm)	Minimum Tip Diameter cm.
Under 12 meters	30	45	20
12 to 18 meters	32	45	18
Over 18 meters	35	50	15

The diameter of piles shall be measured in their peeled condition. When the pile is not exactly round, the average of 3 measurements may be used.

The butt diameter for the same length of pile shall be as uniform as possible. All piles shall retain preservative of at least the amount given in the following table:

TABLE 11-7 MINIMUM PRESERVATIVE OF WOOD PILES PER CUBIC METER

Use and Type	Type of Processing Empty Cell Process	Full Cell Process
General Use	193 kg.	321 kg.
Marine Use	193 kg.	321 kg.

TABLE 11-8 RANGE OF SKIN FRICTION FOR VARIOUS SOIL

Type of Soil	Value in Kilograms per Square Meter	
	Minimum	Maximum
1. Silt and Soft Mud	244	489
2. Silt Compacted	587	1,712
3. Clay and Sand	1,956	3,913
4. Sand with some Clay	2,446	4,891
5. Sand and Gravel	2,935	8,804

Lumber shall be treated by pressure method with creosoted coal solution or creosoted petroleum solution.

TABLE 11-9 ALLOWANCE BEARING POWER OF DIFFERENT SOIL

Kind of Soil	Value in Tons per Sq. M.		
	Min	Max	Usual
Quick sand and alluvial soil	5.38	10.76	5.38
Soft clay	8.07	32.28	21.50
Wet clay and soft sand	10.76	21.50	16.14
Clay and sand in alternate layers	10.76	43.04	21.50
Firm and dry loom or clay; hard dry clay or fine sand	21.50	43.04	32.28
Confined sand	10.76	43.04	32.28
Compact coarse sand or stiff Gravel	30.28	64.56	43.04
Sand and gravel well cemented	53.80	107.60	86.08
Good hard pan or hard shale	53.80	107.60	86.08
Rock	53.80	269.00	161.40

11-5 BITUMINOUS SURFACE TREATMENT

Bituminous material or Asphalt is a viscous liquid used as binder for aggregates in road construction. Although several names were affixed to the bituminous pavement, yet, there is only one thing to remember that all bituminous roadway is nothing more than a mixture of mineral aggregates and asphalt. Meaning, **asphalt road** is virtually a **bituminous road.**

TABLE 11-10 BITUMINOUS MACADAM WEARING COURSE
(Hot Asphalt Type – Approx 1.25 cm. Thick)

Application	Bituminous Materials Liters/ sq. m.	Weight Kilograms	Aggregates Liter/ sq. m.
First Spreading		90	
First Application	4.0		
Second Spreading			13
Second Application	1.8		
Third Spreading			11
Third Application	1.4		
Fourth Spreading			8
Total	7.2	90	32

TABLE 11-11 BITUMINOUS MACADAM PAVEMENT
(Hot Asphalt Type Approximately 2 1/4 or 5.7 cm. Thick)

Activity	Bituminous Materials Liter / sq. m.	Aggregate Coarse, Choker Key	
		Kilogram	Liter / sq. m.
First Spreading		90	
Second Spreading			
First Application	5.5		10
Third Spreading			
Second Application	3.5		10
Fourth Spreading			
Third Application	2.0		8
Fifth Spreading			8
Total	11.0	90	

TABLE 11-12 BITUMINOUS SURFACE TREATMENT
Hot Asphalt Type Approximately 1.6 cm. thick

Operations	Bituminous Materials Liter / sq. m.	Aggregate Coarse Chocker Kilograms	Aggregate Coarse Chocker Liter / sq. m.
First Operation First Spreading	1.0	22	
Second Application Second Spreading	1.3		6.5
Third Application Third Spreading	0.7		4.5
Total	3.0	22	11

Values entry with bulk specific gravity of 2.65

Open Graded Plan Mix Surface Course

The approximate amount of materials per square meter of the open graded plant-mix surfacing course and the sequence of placing shall be as follows:

1. Plant mixed aggregate ..... 80 kg.
2. Choker aggregate ..... 3 kg.
3. Bituminous materials ..... .45 liters
4. Choker aggregate..... 3 to 5 kg.

11- 6 FILLING MATERIALS

Any type of soil may be used for structural fill provided that it does not contain organic or foreign materials that will decompose or otherwise undergo changes after it is placed.

Whether the soil is used as foundation material, to support vertical structures, roads or other structures, it is important to know if the in-place materials possesses the following properties:

1. That the soil must have adequate strength
2. It must be relatively incompressible to avoid insignificant future settlement.

3. The soil must be stable against volume change as water content or other factors vary.
4. The soil must be durable and save against deterioration.

These desirable features could be achieved by proper selection of soil type and proper placement. Highly desirable characteristics fill materials is associated with high density values by using good materials and proper compaction.

Estimating procedures:

1. Compute for the volume to be filled up
2. Determine the kind of filling materials
3. Multiply the result by the corresponding percentage of additional volume given in Table 11-13
4. Add results to obtain the compact volume.

TABLE 11-13 FILLING MATERIALS

Materials Loose Volume	Percent Additional to obtain compact volume
Earth Fill	23 to 25 %
Earth and Sand	18 to 20%
Selected Borrow	15 to 18%

ILLUSTRATION 11-4

A residential lot as shown in Figure 11-2 requires filling. Compute the materials required using (a) earth fill; (b) Selected borrow

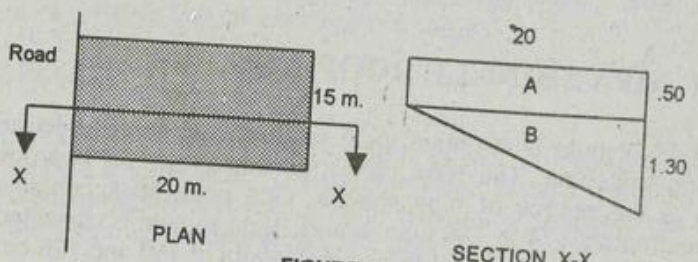


FIGURE 11- 2

SOLUTION

A. Using Earth Fill

1. Solve for the volume of A.

   $15 \times 20 \times .50 = 150$ cu. m.

2. Find the volume of B.

   $15 \times 20 \times \frac{1.30}{2} = 195$ cu. m.

   Total Volume ..... 345 cu. m.

3. From Table 11-13 consider 23% compaction allowance

   $345 \times .23 = 79.4$ say 80 cubic meters

4. Add result of step 2 and 3

   $345 + 80 = 425$ cu. m. compact volume

B. Using Selected Borrow

1. The volume of A is = 150 cu. m.
2. The volume of B is = 195 cu. m.
3. Total volume is = 345 cu. m.
4. From Table 11-13 consider 18 % compaction allowance

   18 % of 345 = 62 cubic meters

5. Add: 345 + 62 = 407 cu. m. compact volume.

11-7 NIPA SHINGLE ROOFING

Nipa Shingle is a native local product commonly used as roofing materials. The Nipa palm tree that grows on swampy area is the source of nipa shingle. One palm stalk contains approximately 174 to 180 nipa leaves. Nipa shingle is classified into Class A and Class B with nominal length of 150 and 120 cm

long with more or less 82 and 68 leaves per shingle respectively

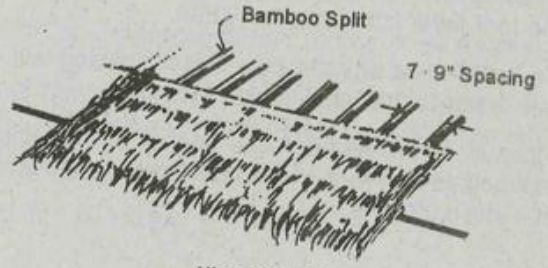


FIGURE 11-3 NIPA SHINGLE ROOF

TABLE 11-14 NIPA SHINGLE TECHNICAL DATA

End Lap	Effective Covering in Square Meter		No. of Pieces per Sq. Meter		No. of Rattan per Sq. Meter	
Cm. - In.	Class A	Class B	A	B	x	y
10 - 4"	.1300	.1090	7.70	9.18	1.8	3.6
7.5 - 3"	.0975	.0818	10.27	12.23	2.0	4.0
5.0 - 2"	.0650	.0545	15.38	18.31	2.8	5.6
2.5 - 1"	.0325	.0273	30.77	36.62	4.0	8.0

x - Rattan Ties for every other bamboo split ribs.
y - Rattan Ties for every bamboo split ribs.

Roof Slope

The slope of the roof is one important consideration if nipa shingle is to be used. The durability and life span of the shingle depends upon the inclination of the roof. The higher the slope the longer its life span to last for about 3 years.

Slope of rafters less than 45 degrees is not advisable for the following reasons:

1. Spacing of the nipa shingles would be relatively far and the roof layer is considerably thin.
2. To install nipa shingle at a closer spacing will only invite rain water to flow back inside the house.
3. Moisture is the number one enemy of nipa shingle. Even galvanized iron roof sheet deteriorate faster when installed at a low pitch roof.

ILLUSTRATION 11-5

A house roof framing has a gross area of 30 square meters. Find the number of nipa shingles required adopting 7.5 centimeters (3") end lapping tied on the bamboo split ribs at every other intervals using Class A nipa shingles.

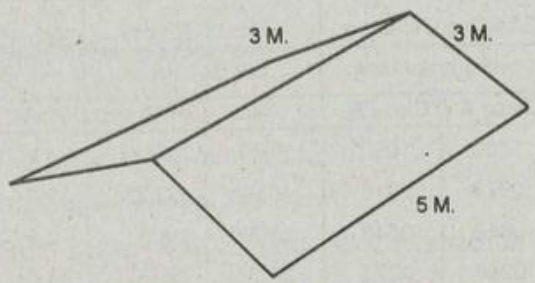


FIGURE 11-4

SOLUTION

1. Knowing the area of the roof, refer to Table 11-14, under class A = 7.5 (3") end lapping, multiply:

   30 sq. m. x 10.27 = 308 pieces

2. Nipa shingle is sold in bundles of 25 pieces, divide:

$\frac{308}{25}$ = 12.32 say 13 bundles

3. Solve for the bamboo splits. Refer to Table 11-4. multiply:

   30 sq. m. x 2 pcs. per square meter = 60 pieces.

4. Determine the number of bamboo poles required. Refer to Table 11-15, using Class B under coverage per square meter, divide:

   $\frac{30}{9}$ sq. m. = 3.3 say 4 pieces

5. Bamboo poles are also classified into three: A, B and C which are then divided into splits approximately 4 to 5 centimeters nailed on the purlins at an intervals of 20 to 25 centimeters on center.

TABLE 11-15 BAMBOO POLES DIVIDED INTO 4 TO 6 STICKS

Bamboo Class	Number of Splits	Approx. Length in Meters	Coverage per Square Meter
A	8	9.0	12
B	6	7.5	9
C	4	6.0	4

Too fresh or too dried bamboo is relatively brittle. Thus, easily cracked when fastened with nails. Care should be exercised to avoid cracks or splitting of the bamboo grain for it will weaken the structure. Cracks and splitting could be avoided if the following procedures are observed.

1. Divide the newly cut fresh bamboo into the desired sizes.
2. Do not install or fasten the fresh bamboo splits with nails until after sun-dried for at least 8 hours. Nailing should be done the following day.
3. For a well dried bamboo, soak or immerse in water overnight then fastened the following day.

11- 8 ANAHAW ROOFING

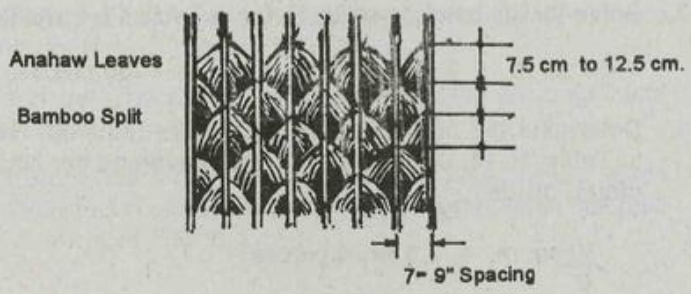


FIGURE 11 – 5

TABLE 11-16 ANAHAW ROOFING TECHNICAL DATA

End Lapping cm.	Number of Leaves per square Meter	Number of 3 m. Rattan Per square Meter
7.5	84	7
10.0	60	6
15.0	45	5

Note:

1. Add 10 pieces anahaw leaves per meter length along the gutter line or lower end portion of the roof.
2. Add 10 pieces anahaw leaves per meter length of the ridge and the hip line.
3. Add 5% allowance of damaged leaves. Dishonest supplier insert damaged leaves in each bundle which could not be detected until after it is opened for installation. However, if the supplier is dead-honest, disregard this 5% allowance.

ILLUSTRATION 11-6

From the following figure 11-6 find the number of anahaw leaves and rattan splits required using 10.0 cm. end lapping of the leaves.

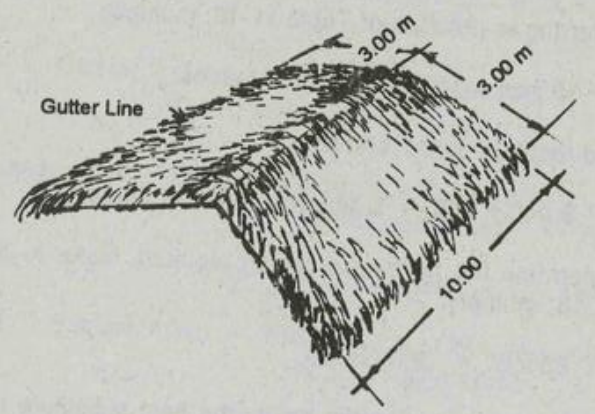


FIGURE 11- 6 ANAHAW ROOFING

SOLUTION

1. Solve for the area of roof A and roof B

   Area A = 30 sq. m.
   Area B = 30 sq. m.
   Total Area = 60 sq. m.

2. Refer to Table 11-16, adopting 10 cm end lapping: multiply:

   60 x 84 = 5,0040 pieces.

3. Determine the length of:

   a) Ridge line = 10.00 meters
   b) Gutter line = 20.00 meters
   Total ... = 30.00 meters

4. Referring to notation of Table 11-16: multiply:

   10 pcs. x 30 meters = 300 leaves

5. Add result of step 2 and step 4

   5,040 + 300 = 5,340 pcs. anahaw leaves.

6. Determine the number of rattan required. Refer to Table 11-16, multiply:

   60 x 6 = 360 pieces

7. In the absence of rattan splits, the best substitute is the coralon nylon chord used by fishermen. Appropriate one kilogram per 5,000 leaves.

Mensuration Formula

Triangle: $\text{Area} = \frac{\text{Base} \times \text{Altitude}}{2}$

Parallelogram: $\text{Area} = \text{Base} \times \text{Altitude}$

Trapezoid: $\text{Area} = \frac{\text{Sum of Parallel Side} \times \text{Altitude}}{2}$

Circle: $\text{Area} = 0.7854 \times \text{Diameter}^2$
$= 3.1416 \times \text{Radius}^2$

Circumference: $\text{Length} = 3.1416 \times \text{Diameter}$
$6.2832 \times \text{Radius}$

Ellipse: $\text{Area} = 0.7854 \times \text{Short diameter} \times \text{Long diameter}$

Cone: Surface Area: = Slant height x Circumference (curve only) of Base

Volume: $= \frac{\text{Area of Base} \times \text{Height}}{3}$

Cylinder: Surface = Length x Circumference + Area of Ends

Volume = 0.7854 + Length x Diameter ^{2}

Sphere: Surface = 3.1416 x Diameter ^{2}

= Circumference x Diameter

Volume = 0.5236 x Diameter ^{3}

$= \frac{\text{Circumference} \times \text{Diameter}^2}{6}$

$= \frac{\text{Volume of Circumscribing Cylinder}}{3}$

CONSTRUCTION TERMINOLOGIES

ENGLISH	PILIPINO
Post	Haliga, Poste
Girder	Gililan
Joist	Soleras
Flooring	Sahig, Suwelo
Girt	Sepo
Beam	Biga
Truss	Kilo
Bottom Chord	Barakilan
Top Chord	Tahilan
Purlins	Reostra
Collar Plate	Sinturon
Fascia Board	Senepa
External Siding	Tabike
Vertical Stud	Pilarete
Horizontal Stud	Pabalagbag
Ceiling Joist	Kostilyahe
Window Sill	Pasamano
Window Head	Sombrero
Window or Door Jamb	Hamba
Open Stringer	Hardinera
Closed Stringer	Madre de Eskalera
Tread	Baytang
Riser	Takip Silipan
Handrail	Gabay
Molding	Muldora
Eave	Sibe
Projection	Bolada
Framework	Balangkas
Gutter	Kanal
Conductor	Alulod

Wrought Iron Strap	Plantsuwela
Bolt	Pierno
Scaffolding	Plantsa
Stake	Staka
Plastered Course	Kusturada
Stucco or Plaster	Palitada
Scratch Coat	Rebokada
Pickwork on Masonry	Piketa
Varnish Finish	Monyeka
Spacing or Gap	Biyento
Concrete Slab (rough)	Larga Masa
Alignment	Asintada
Plumb Line	Hulog
Cement Tiles	Baldosa
Cement Brick	Ladrilyo
Door Fillet	Batidora
Groove	Kanal
Wood Grain	Haspe
Pattern or Schedule	Plantilya
Hinge	Bisagra
Paneled Door	De Bandeha
Earthfill	Eskumbro
Masonry Fill	Lastilyas
Adobe Anchor	Liyabe
Solder	Hinang
Soldering Lead	Estanyo
Temper (metal work)	Suban, Subuhan