CIVIL ENGINEERING CONCEPTS

CIVIL ENGINEER'S ULTIMATE GUIDE

For Students & Working Professionals

EBOOK'S

DESCRIPTION

These Ebook provides all the necessary data required at site for the execution work. It might be extremely beneficial for the site engineers, since it includes notes for unit conversion , calculation for steel , concrete and measures taken before and after concreting, plastering and shuttering. It also covers the equipment utilised on site to ensure the project's flawless operation.

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1. UNIT CONVERSIONS & TABLES

Quantity	Conversion	Formula
Area	sq ft to sq m	1 sq m = 10.764 sq ft
	sq m to sq ft	1 sq ft = 0.0929 sq m
Length	ft to m	1 m = 3.281 ft
	m to ft	1 ft = 0.3048 m
Volume	cu ft to cu m	1 cu m = 35.314 cu ft
	cu m to cu ft	1 cu ft = 0.0283 cu m
Mass	lb to kg	1 kg = 2.205 lb
	kg to lb	1 lb = 0.4536 kg

Centimeter :

1 Centimeter(cm) = 10 Millimeter(mm)
1 Centimeter(cm) = 0.0328 Feet
1 Centimeter(cm) = 0.3937 Inch
1 Centimeter(cm) = 0.01094 Yard

Inch:

1 Inch = 25.4 Millimeter(mm)
1 Inch = 2.54 Centimeter(cm)
1 Inch = 0.0254 Metre(m)
1 Inch = 0.0833 Feet

Starting Unit	Conversion Factor	Desired Unit
feet	0.3048 meters/foot	meters
meters	3.281 feet/meter	feet
acres	4046.86 square meters/acre	square meters
square meters	0.000247 acres/square meter	acres
miles per hour	0.447 meters per second	meters per second
meters per second	2.237 miles per hour	miles per hour
pounds per square inch	6.894 kilopascals	kilopascals
kilopascals	0.145 pounds per square inch	pounds per square inch
Celsius	(F - 32) * 5/9	Fahrenheit
Fahrenheit	(C * 9/5) + 32	Celsius

Feet:

1 Feet = 304.8 Millimeter(mm)
1 Feet = 30.48 Centimeter(cm)
1 Feet = 0.3048 Metre(m)
1 Feet = 0.33333 Yard

Yard:

1 Yard = 914.4 Millimeter(mm)
1 Yard = 91.44 Centimeter(cm)
1 Yard = 0.9144 Metre(m)
1 Yard = 36 Inch
1 Yard = 3 Feet

Link:

1 Link = 201 Millimeter(mm)
1 Link = 20.1Centimeter(cm)
1 Link = 7.9134 Inch
1 Link = 0.201 Metre(m)
1 Link = 0.2198 Yard
1 Link = 0.6595 Feet

Mile:

1 Mile = 1609344.442 Millimeter(mm)
1 Mile = 160934Centimeter(cm)
1 Mile = 63360 Inch
1 Mile = 1609.34 Metre(m)
1 Mile = 5280 Feet
1 Mile = 1760 Yard
1 Mile = 7.99998 Furlong
1 Mile = 320 Rod

2. UNIT WEIGHT OF DIFFERENT CONSTRUCTION MATERIALS

SL. NO.	MATERIAL	THEORETICAL UNIT WEIGHT (kg/m^3)
1.	Cement	1440 kg/m^3
2.	Steel	7850 kg/m^3
3.	Sand	
	(a) Dry	1600 kg/m^3
	(b) River	1760 to 2000 kg/m^3
4.	Stone (Basalt)	2850 to 2960 kg/m^3
5.	Cement Concrete (Plain)	2400 kg/m^3
6.	Cement Concrete (Reinforced) (RCC)	2500 kg/m^3
7.	Water	1000 kg/m^3
8.	Bricks	1600 to 1920 kg/m^3
9.	Brick Masonry	1920 kg/m^3
10.	Soil (damp)	1760 kg/m^3
11.	Cement Concrete Block (Solid)	1800 kg/m^3
12.	Cement mortar	2080 kg/m^3
13.	Lime Mortar	1760 kg/m^3

14.	Lime	640 kg/m^3
15.	Glass	2530 kg/m^3
16.	Bitumen	1040 kg/m^3
17.	A.C. Sheet Corrugated	16 kg/m^2
18.	Granite Stone	2460 to 2800 kg/m^3
19.	Marble Stone	2620 kg/m^3
20.	Sal Wood	990 kg/m^3
21.	Teak Wood	670 to 830 kg/m^3
22.	Timber (Mango)	650 kg/m^3
23.	Plastics	1250 kg/m^3
24.	Ashes	650 kg/m^3
25.	Rubber	1300 kg/m^3
26.	Chalk	2100 kg/m^3

3. DIFFERENT TYPES OF CONCRETE GRADE

There are a variety of grades of concrete used in construction. The Bureau of Indian Standards (BIS) has established these grades based on the compressive strength of the concrete in megapascals (MPa) at 28 days. These are denoted by the prefix “M,” or mix, followed by the number corresponding to the grade’s strength. The grade of concrete ratio to other components also determines its strength.

Group	Designation	Characteristic Compressive Strength Fck at 28 days (N/mm2)
Ordinary Concrete	M 10 M 15 M 20	10 15 20
Standard Concrete	M 25 M 30 M 35 M 40 M 45 M 50 M 55	25 30 35 40 45 50 55
High strength Concrete	M 60 M 65 M 70 M 75 M 80	60 65 70 75 80

4. CONCRETE MIX DESIGN

Concrete Mix Design as per IS Code:

Concrete is made by mixing cement, sand, coarse aggregate, and water in specific proportions. These proportions vary with the desired concrete grade. The IS 456:2000 code specifies these proportions up to grade M25. Beyond M25, there are no specified proportions.

Here are some common proportions for nominal mixes:

S.No	Grade	Proportion (cement: sand: coarse aggregate)
1	M5	1:5:10
2	M7.5	1:4:8
3	M10	1:3:6
4	M15	1:2:4
5	M20	1:1.5:3
6	M25	1:1:2

However, for higher-grade concrete, a new approach called Mix Design is used, following IS:10262,2009 principles.

Concrete Mix Design Procedure (8 steps):

1. Target Mean Strength:
Determine the desired strength of the concrete (e.g., M45). Calculate the target mean strength using a formula involving the characteristic strength, tolerance factor (1.65), and standard deviation.

2. Water-Cement Ratio:
Find the water-cement ratio based on exposure conditions and concrete grade. This ratio significantly affects concrete quality.

3. Water Content Determination: Calculate the required water content based on the size of aggregates used and their type (angular, sub-angular, gravel, etc.). Adjust for different aggregate shapes and desired slump values.

4. Cement Content Determination: Calculate the cement content using the water-cement ratio and obtained water content.

5. Amount of Coarse and Fine Aggregates: Determine the weight of coarse aggregates based on aggregate size and grading zones (I, II, III, or IV). Calculate the volume of fine aggregates by subtracting the volume of coarse aggregates.

6. Total Volume of Materials: Calculate the volume of all materials, including cement, water, and admixtures if used. The total aggregate volume is found by subtracting the volumes of cement, water, and admixtures from the total volume.

7. **Ratio Calculation:** Determine the ratio of materials by considering cement as 1 and dividing the weights of other materials by the weight of cement.

8. **Preparation of Trial Mixes:** Prepare four trial mixes to check strength and other properties. Vary water/admixture content while keeping the water-cement ratio constant for the second mix. For the third and fourth mixes, maintain the water content while varying the water-cement ratio by 10%.

A well-designed concrete mix ensures the concrete can withstand expected loads and offers long-term stability and durability. Proper mix design is crucial for high-quality concrete.

5. WEIGHT OF REBARS PER METER LENGTH

Everyone involved in construction or civil engineering should understand the weight of steel bars of various diameters, the number of bars in a bundle, and the weight of each bar per meter length.

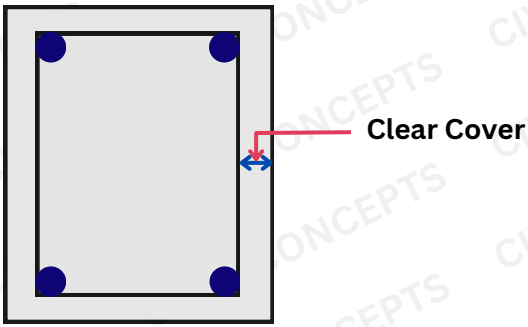
Knowing the unit weight of steel bars per unit length is crucial for determining the quantity of steel needed for placing orders.

Diameter of bar (mm)	Unit weight of steel per meter length	Unit weight of steel per feet length
5.5 mm	0.186 kg	0.057 kg
6 mm	0.222 kg	0.068 kg
8 mm	0.395 kg	0.120 kg
10 mm	0.617 kg	0.188 kg
12 mm	0.889 kg	0.270 kg
16 mm	1.58 kg	0.480 kg
20 mm	2.47 kg	0.750 kg
25 mm	3.86 kg	1.173 kg
28 mm	4.84 kg	1.471 kg
32 mm	6.32 kg	1.921 kg
40 mm	9.88 kg	3.002 kg

6. CLEAR COVER TO MAIN REINFORCEMENT

What is Clear/Nominal Cover?

Clear cover is the distance between the outer surface of concrete to the nearest surface of reinforcing bar.

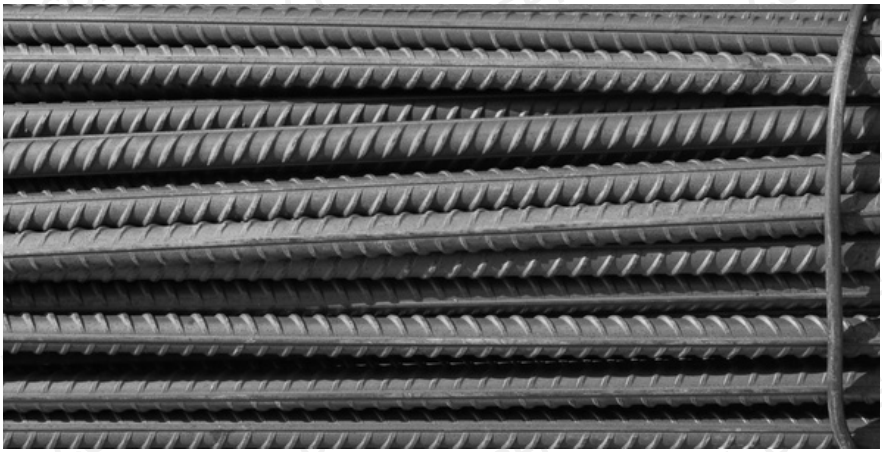


Beam Section

Clear/Nominal Cover for Different structural members

Structural Member	Minimum Nominal Cover
Slabs & Beams	
a) Dia of reinforcing bar <12mm	15 mm
b) Dia of reinforcing bar >12mm	25 mm
Column	
a) Dia of reinforcing bar <12mm	25 mm
b) Dia of reinforcing bar >12mm	40 mm
Footings	50 mm

7. UNIT WEIGHT OF STEEL BARS USED IN CONSTRUCTION



The unit weight of steel bars is the weight per unit length of a given size of steel bar. The unit weight of steel bars is typically expressed in kilograms per meter (kg/m) or pounds per foot (lb/ft).

To calculate the unit weight of a steel bar, you can use the following formula:
Unit weight (kg/m) = (mass of the bar) / (length of the bar)
where the mass of the bar can be calculated using its density and cross-sectional area. The density of steel is typically around 7,800 kg/m3.

The **density of steel** is around 7850 kg/m3 or 7.85 g/cm3 or 490 lbs/ft3 or 13231 lbs/yd3.

The steel weight is generally measured in Kg, Ton, and pounds.

The standard unit weight of steel bars used in construction is given below:

Dia of Steel Bar	Length	Unit Weight
8 mm	1 m	0.395 kg/m
10 mm	1 m	0.610 kg/m
12 mm	1 m	0.89 kg/m
16 mm	1 m	1.58 kg/m
20 mm	1 m	2.46 kg/m
25 mm	1 m	3.87 kg/m
32 mm	1 m	6.32 kg/m
40 mm	1 m	9.87 kg/m

8. CALCULATION OF MATERIALS




Quantity estimation of building materials is essentially required in any construction work and the quantity of materials depends on the mix proportions of the concrete.

Let's see how to calculate quantities of materials for different concrete mix ratios. (Dry mix method)
We will calculate quantities of materials for 1 m3 of concrete (By volume).

Let us assume the mix proportion is 1 : 2: 4 (Cement : Sand : Stone = a:b:c)
Volume of wet concrete = 1 m3
Volume of dry concrete = 1 × 1.54 = 1.54 m3

Calculation For Cement:

Formula,

- Cement = (Volume of dry concrete/a+b+c) × a = (1.54/a+b+c) × a = [(1.54/1+2+4)] × 1 = 0.22 cum

Now density of cement = 1440 kg/cu.m

- Volume of cement = 0.22 × 1440 =316.8 kg.

As we know, 1 bag of cement contains 50 kg of cement.

- Cement bags required = 316.8/50 = 6.33 bags.

Calculation For Sand:

Formula,
Sand = (Volume of dry concrete/a+b+c) × b = (1.54/a+b+c) × b = (1.54/1+2+4) × 2 = 0.44 cu.m.

Calculation For Aggregates:

Formula,
Aggregates = (Volume of dry concrete/a+b+c) × c = (1.54/a+b+c) ×c = (1.54/1+2+4) × 4 = 0.88 cu.m.

Calculation For Water Content:

Let us assume the water-cement ratio of concrete is 0.45.

- w/c = 0.45
- Required water for 1 bag cement = 0.45 × 0.0353 = 0.0159 cu.m.

Where volume of 50 kg cement = 0.0353 cu.m

- 1 m3 water = 1000 Litre

Required water for 1 bag of cement=0.0159 × 1000 = 15.9 Litre.

∴ Required water for 6.33 bags cement = 6.33 × 15.9 = 101 Litre.

Summary:

- Cement = 6.33 bags.
- Sand = 0.44 cum
- Aggregates = 0.88 cum
- Water = 101 litre.

Note: Yield of concrete is considered as 67% & Wastages of materials = 2%

You can use the same formula for different mix proportions such as 1:1.5:3 etc.
Here, we have used cubic meter unit but you can also calculate in cubic feet unit.

9. FIELD TESTS ON CEMENT

The following tests should undergo before mixing the cement at construction sites:

1. Colour Test of Cement :

The colour of the cement should not be uneven. It should be a uniform grey colour with a light greenish shade.

2. Presence of Lumps :

The cement should not contain any hard lumps. These lumps are formed by the absorption of moisture content from the atmosphere. The cement bags with lumps should be avoided in construction.

3. Cement Adulteration Test :

The cement should be smooth if you rubbed it between fingers. If not, then it is because of adulteration with sand.

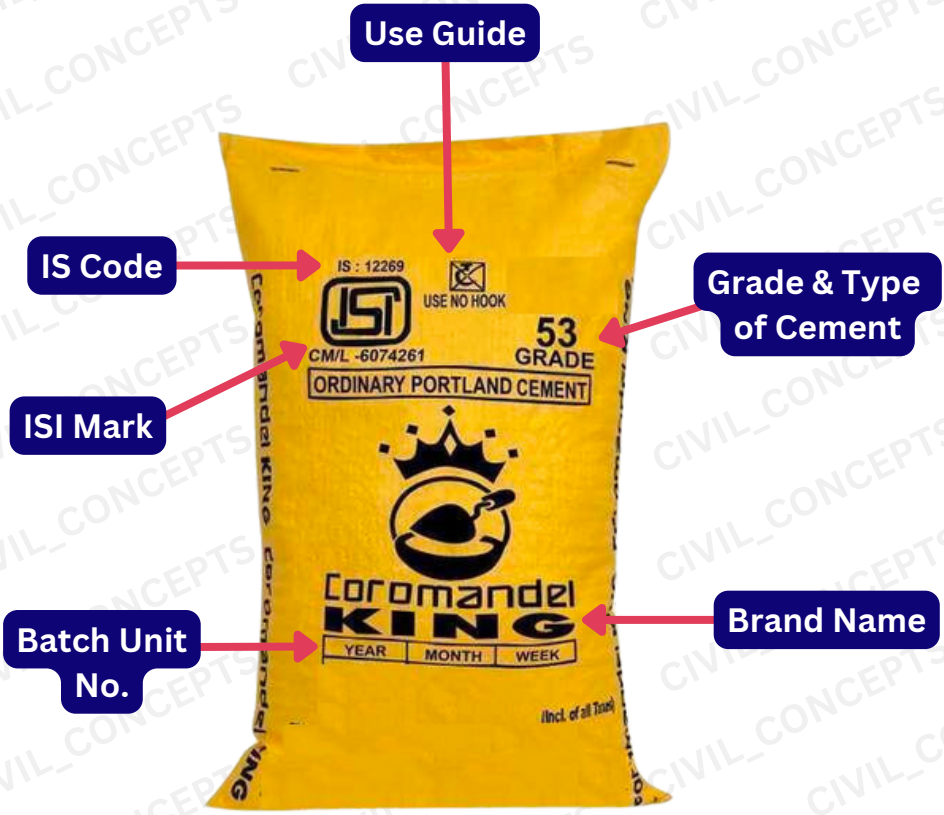
4. Float Test :

The particles of cement should flow freely in water for sometime before it sinks.

5. Date of Manufacturing :

It is very important to check the manufacturing date because the strength of cement decreases with time. It's better to use cement before 3 months from the date of manufacturing.

10. SPECIFICATION OF A CEMENT BAG



11. CHECKLISTS

- **CHECKLIST FOR SURVEYING & SETTING OUT**

QUALITY CHECKLIST FOR SITE WORKS				
SURVEYING AND SETTING OUT				
☐ RCHITECTURAL ☐ 'RUCTURL ☐ ITERIOR ☐ ERVICES & UTILITY				
Name of the Customer:		**Date:**		
Project Name:		***Project ID:***		
Name of the Contractor:		***Location:***		
Drawing Ref. No.:		***Quantity:***		
Sl.No.	**Description**	**YES**	**NO**	**NA**
1	Is contour/ survey plan available?	☐	☐	☐
2	*Establishment of Co-ordination points,* ***MAIN GRID LINES, CENTRE LINES*** *in both directions, block levels, spot level etc. Is it as per Drawings?*	☐	☐	☐
3	Check for set back are they as per the norms of local authority approval drawing?	☐	☐	☐
4	Check whether there is any variation in the actual marking and whether it is recorded/ reported?	☐	☐	☐
5	**LOCATION of INDIVIDUAL STRUCTURAL ELEMENTS like Column footings, columns, location of pile, etc.,** Are they as per Drawings?	☐	☐	☐
CORRECTIVE ACTION PROPOSED- Item wise. **If 'No' is marked, please specify reasons and thereafter corrective action proposed.** **(Add additional sheets, if necessary)**				
Comments:				

Contractor's Rep.: ***Client Rep.:*** ***Lemcon Rep.:***

- **CHECKLIST FOR EARTH WORK/ BACKFILLING**

QUALITY CHECKLIST FOR SITE WORKS				
EARTH WORK/ BACKFILLING				
☐ CHITECTURAL ☐ RUCTURAL ☐ TE DEVELOPMENT ☐ ERVICES & UTILITY				
Name of the Customer:		**Date:**		
Project Name:		***Project ID:***		
Name of the Contractor:		***Location:***		
Drawing Ref. No.:		***Quantity:***		
Sl.No.	**Description**	**YES**	**NO**	**NA**
1	Is format CL: 01 for Surveying complied with?	☐	☐	☐
2	Whether suitable arrangements for re-routing the service lines done?	☐	☐	☐
3	Is the **LAYOUT, ALIGNMENT** and **SIZE** of Excavation marked on the ground as per drawings?	☐	☐	☐
4	Is adequate shoring, strutting done?	☐	☐	☐
5	Check for DEWATERING. Is it O.K.?	☐	☐	☐
6	*Is the excavation done up-to the level as per drawing.*	☐	☐	☐
	A. NATURAL EXISTING GROUND LEVEL :			
	B. FOUNDING LEVEL :			
	C. DEPTH OF EXCAVATION :			
	BACKFILLING			
1	Is the earth used for filling as per specification?	☐	☐	☐
2	Check for the approved method of compaction, ie. (Roller, plate compactor, etc.)	☐	☐	☐
3	Whether Proctor compaction test carried out satisfactorily as per the requirement?	☐	☐	☐
CORRECTIVE ACTION PROPOSED- Item wise.				

- **CHECKLIST FOR CONCRETE POURING**

QUALITY CHECKLIST FOR SITE WORKS

CONCRETE POUR CARD

☐ RCHITECTURAL ☐ TRUCTURAL ☐ ITERIOR ☐ ERVICES & UTILITY

Name of the Customer:	**Date:**
Project Name:	***Project ID:***
Name of the Contractor:	***Location:***
Drawing Ref. No.:	***Grade & Quantity :***

Sl.No.	Description	YES	NO	NA
A.	**FORM WORK:**			
1	Level	☐	☐	☐
2	Plumb	☐	☐	☐
3	Cutouts	☐	☐	☐
B.	**Reinforcement:**			
1	As per bar bending schedule	☐	☐	☐
2	Dowel bars	☐	☐	☐
3	Links	☐	☐	☐
4	Binding/ Welding	☐	☐	☐
C.	**Services:**			
1	Position	☐	☐	☐
2	Size	☐	☐	☐
3	Trimming bars	☐	☐	☐
D.	**General**			
1	Embedments	☐	☐	☐
2	Water proofing	☐	☐	☐
3	Construction Joint	☐	☐	☐
E.	**Sampling:**			
1	Mix as per design :	☐	☐	☐
2	No. of sample & Identity	☐	☐	☐

IF 'YES', THEN SITE ENGINEER SHALL TAKE SUITABLE CORRECTIVE ACTION in consultation with PRT/ AST/ PRM AND RECHECK .

CORRECTIVE ACTION PROPOSED- Item wise.
If 'No' is marked, please specify reasons and thereafter corrective action proposed.
(Add additional sheets, if necessary)

Comments:

Contractor's Rep.: ***Client Rep.:*** ***Lemcon Rep.:***

- **CHECKLIST FOR WATER PROOFING**

QUALITY CHECKLIST FOR SITE WORKS				
WATER PROOFING				
☐ ARCHITECTURAL ☐ RUCTURAL ☐ ITERIOR ☐ ERVICES & UTILITY				
Name of the Customer:		**Date:**		
Project Name:		***Project ID:***		
Name of the Contractor:		***Location:***		
Drawing Ref. No.:		***Quantity:***		
☐ **. Raft slab** ☐ **2. Retaining wall** ☐ **. Toilet sunken** ☐ **Terrace**				
Sl.No.	**Description**	**YES**	**NO**	**NA**
1	Whether approved / specified materials used as per specification?	☐	☐	☐
2	Check for surface preparation. Is it o.k.?	☐	☐	☐
3	Check for Plastering before coating. Is it o.k.?	☐	☐	☐
4	Check for coating of chemical. Is it o.k.?	☐	☐	☐
5	*Check for Plastering after coating. Is it o.k.?*	☐	☐	☐
6	Check for fixing of nozzles and spacing. Is it o.k.?	☐	☐	☐
7	Check for grouting. Is it o.k.?	☐	☐	☐
8	Check for brickbatcoba thickness & slopes.	☐	☐	☐
9	Check for curing. Is it o.k.?	☐	☐	☐
CORRECTIVE ACTION PROPOSED- Item wise. **If 'No' is marked, please specify reasons and thereafter corrective action proposed.** **(Add additional sheets, if necessary)**				
Comments:				

Contractor's Rep.: ***Client Rep.:*** ***Lemcon Rep.:***

- **CHECKLIST FOR PLASTERING/PAINTING**

QUALITY CHECKLIST FOR SITE WORKS

PLASTERING/ PAINTING

☐ RCHITECTURAL ☐ RUCTURAL ☐ TERIOR ☐ :RVICES & UTILITY

Name of the Customer:	**Date:**
Project Name:	***Project ID:***
Name of the Contractor:	***Location:***
Drawing Ref. No.:	***Quantity:***

Sl.No.	Description	YES	NO	NA
1	Check for **COMPLETION OF PRECEDING ACTIVITIES** like fixing of service Conduits, Water Supply & sanitation lines, etc.	☐	☐	☐
2	Whether chicken mesh, Corner beads used as per specifications?	☐	☐	☐
3	*Check for **MORTAR MIX PROPORTION** & Check for Surface of mortar mixing and addition of water profing compond if required.*	☐	☐	☐
4	Check for **THICKNESS & NUMBER OF COATS** of Plaster and required finish for further activities.	☐	☐	☐
	PAINTING			
1	**PRIOR TO PAINTING** Check whether approved make & shade are used?	☐	☐	☐
	DURING & AFTER PAINTING			
	DURING & AFTER PAINTING			
1	Check for **APPLICATION** of paint. Is it uniform?	☐	☐	☐
2	Check for Number of Coats.	☐	☐	☐

CORRECTIVE ACTION PROPOSED- Item wise.
If 'No' is marked, please specify reasons and thereafter corrective action proposed.
(Add additional sheets, if necessary)

Comments:

Contractor's Rep.: ***Client Rep.:*** ***Lemcon Rep.:***

- **SITE INSPECTION CHECKLIST**

Name of the Project: Date:

Contractor Name:

S.No.	Checklist	Remarks/Observation
1.	Centre line	
2.	Formwork & Staging	
3.	Steel reinforcement diameter / spacing	
4.	Cover to the reinforcement and overlap	
5.	Shuttering	
6.	RLs and reference levels	
7.	Quality of water	
8.	Quality of materials	
9.	Water cement ratio of concrete if the concrete used other than RMC.	
10.	Surface preparation for concrete	
11.	Adequacy of vibration	
12.	Segregation of aggregates	
13.	Removal of temporary spacers and ties	
14.	Observation for honeycombing	
15.	Line & Level of concrete	
16.	Surface finish	
17.	Cracks and air bubbles	
18.	Method of curing	
19.	Check for stripping/Removing of formwork support etc. after specified duration of stripping time.	
20.	Repair and finish all surface defects by specification / approved method	
21.	Curing/method of curing	
22	Others, if any	

12. IMPORTANT THUM RULES

In civil engineering, thumb rules help with quick decisions and estimates, benefiting site engineers and supervisors. Every civil engineer and supervisor should have basic knowledge of these key principles. We'll explore civil engineering in-depth.

Thumb rule for construction cost estimates can speed up the rough estimation process. Based on thumb rules in civil engineering, one can have approximate cost and material and labour requirements as well.

Thumb rule for Building Material Requirements:

Sr. No.	Material/ Work	Thumb Rule
1.	Cement	0.5 Bags/sqft
2.	Steel	3 to 5 Kg/sqft
3.	RMC	0.05 m^3/sqft
4.	Blockwork	12.5 no./m^2
5.	Structural Civil Work	₹ 751.25/sqft
6.	Finishing Works	₹ 470/sqft
7.	Electrical Cost	₹ 133/sqft
8.	Plumbing Cost	₹ 126/sqft
9.	Fire Fighting Cost	₹ 40/sqft
10.	External Development Cost	₹ 94.5/sqft

Thumb Rule for Building Material Costs by Percentage:

Description	Thumb rule (% of Total Cost)
Cement	16.4%
Sand	12.3%
Aggregate	7.4%
Steel	24.6%
Painting material	4.1%
Tiles	8%
Bricks	4.4%
Window	3%
Doors	3.4%
Plumbing	5.5%
Electrical	6.8%
Sanitary	4.1%

Thumb Rules for Construction Cost:

Sr. No.	Construction based on Quality	Thumb Rule
1.	Basic Quality Construction	1100 Rs./Sqft
2.	Medium Quality Construction	1400 Rs./Sqft
3.	High Quality Construction	1800 Rs./Sqft

Thumb rule for building costs expressed as a percentage of the total project cost:

Sr. No.	Work	Cost
1.	Excavation and Filling Earthwork	0.5%
2.	Foundation	5%
3.	Damp Proof Course	1%
4.	Brickwork	34%
5.	Roofing	20%
6.	Flooring	6%
7.	Doors and window	16%
8.	Plastering	10%
9.	White Washing	2%
10.	Miscellaneous	5.5%

Thumb Rules for Cost of building :

Sr. No.	Work	Thumb Rule
	Cost of Material and Labour	
1.	Material Cost	70% of Building Cost
2.	Labour Cost	30% of Building Cost
	Direct and Overhead Cost	
1.	Direct Cost	85% building cost
2.	Overhead expense	15% of Building Cost
	Foundation and Superstructure	
1.	Cost of Foundation	15% of Building Cost
2.	Cost of Superstructure	85% of Building Cost
	Electrical and Sanitary Work	
1.	Plumbing and sanitation cost	8% of Building Cost
2.	Cost of Electrical Work	8% of Building Cost

Thumb Rule For Slab:

- The minimum thickness of slab is 125mm.
- The minimum diameter of bars used in slab is 8mm.
- Fe 500 Steel should be used in the slab.
- Clear cover of 15mm to 20mm should be provided in slab.
- Maximum diameter of bars used in slab is 1/8th times of slab thickness.
- Steel required in slab is 1% of the total volume of concrete.
- M15 Grade of concrete or above it should be used in slab.
- Spacing between reinforcement in slab should not be less than 150mm c/c.

Thumb Rule For Beam:

- Steel required in beam is 2% of total volume of concrete.
- Minimum clear cover of 40mm shall be provided in beams.
- M20 grade of concrete should be used in beam construction.
- Minimum 4 bars shall be provided in beams. 2 bars of 12mm at top and 2 bars of 10mm at bottom.

Thumb Rule For Column:

- Steel required in Column is 2.5% of total volume of concrete.
- Minimum steel requirement in column = 0.8% of gross area of concrete
- Maximum steel requirement in column = 6% of the gross area of concrete
- Spacing between Longitudinal reinforcement should not be more than 300mm.
- Minimum clear cover in column is 40mm. 25mm clear cover is provided if column is less than 200mm.
- Minimum dia of 12mm bars 4 numbers should be used in column.
- The maximum diameter of reinforcing bars in column should be not more than 50mm.
- Overlapping distance in longitudinal bars should not be less than 24 times the smallest bar dia.
- Maximum spacing of stirrups is 16D or B or 300mm whichever is less.
- Minimum size of column should not less then 9" X 9".
- For G+1 Structure 9" X 12" (225mm X 300mm) Column should be used.
- Maximum space between two column of size 9" X 9" should not be more than 4 meter.
- M20 Grade of concrete should be used in concreting column.

Thumb Rule for Foundation:

- Steel required in footing is 0.8% of total volume of concrete
- The clear cover of main reinforcement in footing is 50mm.
- A minimum 10mm bar shall be used for foundation footing.
- M20 grade of concrete or above should be used for foundation.
- Length, width and depth of foundation should not be less than 1 meter.
- Footing thickness should not be less then 40 cm.
- Pile foundation should be used if soil bearing capacity is less than 24 kN/m3.

Thumb Rule Steel Reinforcement:

- Lapping is not allowed for the bars more then 36mm dia.
- Longitudinal reinforcement in structural members shall not be less then 0.8% and not more the 6% gross cross-sectional area.
- Atleast 4 bars should be used in square column and 6 bars in circular column section.

Steel Requirement:

Steel percentage in concrete as per IS code for different members is shown below:

Sr. No.	Member of Building	Percentage of Steel
1.	Slab	1% of Total Volume of Concrete
2.	Beam	2% of Total Volume of Concrete
3.	Column	2.5% of Total Volume of Concrete
4.	Footing	0.8% of Total Volume of Concrete

Thumb Rule For Concrete:

Concrete volume can be easily calculated if you know the plan area.

Thumb rule for calculating concrete volume = 0.038 m3 per square foot of plan area.

Thus if floor plan of a house is 30 X 20,
then total plan area= 600 sqft

volume of concrete = 600 X 0.038 m3 = 22.8 m3

Thus total volume of concrete to build 600 sqft house is 22.8 m3.

Concreting work can be done easily at site if the proportion of cement, sand and aggregate are known. Based on the mix design of concrete, ratio of cement, sand and aggregate changes, which can be seen in the table given below.

Concrete Mix	Ratio	Cement Qty (Bags)	Coarse Aggregate (m^3)	Fine Aggregate (m^3)
M5	1:5:10	2.82	0.98	0.49
M7.5	1:4:8	3.48	0.97	0.48
M10	1:3:6	4.50	0.90	0.45
M15	1:2:4	6.60	0.88	0.44
M20	1:1.5:3	8.40	0.84	0.42
M25	1:1:2	11.09	0.77	0.39

Thumb Rule For Concrete Mix Design:

- **In 1 cu.mt of freshly mixed concrete, if 4 liter of water is added then,**

1. Slump value will increased by 25mm
2. Compressive strength of concrete will decrease by 1.5 N/mm2 to 2 N/mm2
3. Shrinkage potential will be increased by 10%
4. 25% of cement bag will be wasted

- **If temperature of freshly mixed concrete is increased by 1% then,**

1. Slump will be equal to addition of 4 liter of water

2. Air content will be decreased by 1%
3.Compressive strength of concrete will decrease by 1 N/mm2 to 1.5 N/mm2

- **If air content of freshly mixed concrete is,**

1. Increased by 1%, then compressive strength will be decreased by 5%
2. Decreased by 1%, then yield of concrete will be decreased by 0.03 m3 per 1 m3.
3. Decreased by 1%, then slump of concrete will be decreased by 12.5mm.
4. Decreased by 1%, then durability of concrete will be decreased by 10%.

Thumb Rule for Concrete Work:

- Volume of concrete required is 0.038 m3/sqft area.
- Standard weight of 1 bag of cement is 50 kg.
- 1 bag of cement is equal to 1.25 cuft or 0.0347 m3.
- In high rise building 0.5 bags of cement is required per square feet of area.
- Density of cement is 1440 kg/m3.
- Specific gravity of cement is 3.15
- Average cost of concrete is 50 to 80$ per cubic meter.
- Initial setting time of cement is 30 minutes and final setting time of cement is 10 hrs

Thumb Rule for Shuttering Removal:

Shuttering should be remoced only after the member has attained suitable strength. Below table mentions detail about removal of shuttering duration.

Sr. No.	Member of Structure	Days
1.	Sides of foundation, column, beams and walls	2 days
2.	Sides of span larger then 4.5 meter	14 days
3.	Sides of span shorter then 4.5 meter	7 days
4.	Sides of beams and arches upto 6 meter span	14 days
5.	Sides of beams and arches from 6 m to 9 m span	21 days
6.	Sides of beams and arches above 9 meter span	28 days

Thumb rules of bricks:

- Standard size of bricks is 19cm X 9cm X 4cm.
- Weight of first-class clay bricks should be 3.85 kg.
- Crushing strength of bricks is 10.5 MN/m2.
- Water absorption in bricks is 12% to 15%.
- Compressive strength of bricks is 36 KN/cm2.
- Number of bricks in 1m3 of brick masonry is 550 bricks.

Thumb Rule For Plastering:

Based on experience and practice following thumb rule for plastering is used in construction and building work.

Below is a table containing cement requirement for different type of plastering work.

Sr. No.	Plastering Type	Cement Qty (Bags/m^2)	Cement Qty (Kg/m^2)
1.	Internal Plastering	0.09	4.5
2.	External Plastering	0.175	8.75
3.	Rough Plastering	0.09	4.5
4.	Duct Plastering	0.09	4.5
5.	Lathen Plastering	0.55	27.5
6.	Stucco Plastering	0.175	8.75

Cement & sand requirement for wall and ceiling plastering:

Sr. No.	Plastering Type	Ratio	Plaster Thickness (mm)	Cement (Bags/m^2)	Sand (m^3/m^2)
1.	Internal wall Plaster	1:3	15	0.16	0.017
2.	External Wall Plaster	1:4	20	0.17	0.024
3.	Ceiling Plaster	1:2	12	0.17	0.012
4.	Rough Plaster	1:5	16	0.11	0.020

Thumb rule for Achieving Economy:

To save money in construction, it's important to follow specific guidelines and rules of thumb. Adhering to these construction thumb rules can lead to cost savings and more economically efficient buildings.

- Use formwork as many time as possible to achieve economy.
- Minimum floor to floor height will result in saving of money.
- Column layout should be placed in a uniform grid.
- Standard column size should be used.
- Same depth of beam should be used, if possible.
- Local available material should be used to minimise cost.
- High strength concrete should be used.
- To remove formwork earlier high early strength concrete should be used.
- To minimise honey combing and air pockets in concrete self consolidating concrete should be used.
- Avoid congestion of steel especially at beam column joints.
- Use large size bars in column and smaller size bars in slab.

13. POINTS TO REMEMBER

Following are some points to remember for civil site engineers to make the construction work easier:

- Lapping is not allowed for the bars having diameters more than 36 mm.
- Chair spacing maximum spacing is 1.00 m (or) 1 No per 1m2.
- For dowels rod minimum of 12 mm diameter should be used.
- Chairs minimum of 12 mm diameter bars to be used.
- Longitudinal reinforcement not less than 0.8% and more than 6% of gross C/S.
- Minimum bars for square column is 4 No's and 6 No's for circular column.
- Main bars in the slabs shall not be less than 8 mm (HYSD) or 10 mm (Plain bars) and the distributors not less than 8 mm and not more than 1/8 of slab thickness.
- Minimum thickness of slab is 125 mm.
- Dimension tolerance for cubes + 2 mm.
- Free fall of concrete is allowed maximum to 1.50m.
- Lap slices not be used for bar larger than 36 mm.

- Water absorption of bricks should not be more than 15 %.
- PH value of the water should not be less than 6.
- Compressive strength of Bricks is 3.5 N / mm2.
- In steel reinforcement binding wire required is 8 kg per MT.
- In soil filling as per IS code, 3 samples should be taken for core cutting test for every 100m2.

14. DE-SHUTTERING TIME OF DIFFERENT RCC MEMBERS

RCC Member	De-shuttering time
For columns, walls, vertical form works	16-24 hrs.
Soffit formwork to slabs	3 days (props to be refixed after removal)
Soffit to beams props	7 days (props to refixed after removal)
Beams spanning upto 4.5m	7 days
Beams spanning over 4.5m	14 days
Arches spanning up to 6m	14 days
Arches spanning over 6m	21 days

15. IMPORTANT TESTS ON MATERIALS

Tests for Concrete

- Compressive Strength Test
- Workability Test

Tests for Sand

- Bulking of sand
- Grading of sand

Tests for Aggregates

- Impact Value Test
- Crushing Strength Test
- Abrasion Value Test

Tests for Bricks

- Absorption Test
- Impact Test
- Efflorescence Test

Tests for Steel

- Tensile Strength Test
- Basic Properties

16. SAFETY MEASURES ON CONSTRUCTION SITE

General Facts about Construction Site Safety

- The first week of work on a new site is the most dangerous
- On-site accidents are more at the end of the day
- Small building construction works are riskier.
- The Safety boots Safety helmets and Hi-viz jackets do prevent injury and death
- Low-quality and lightweight shoes -such as trainers or runners are not suitable on-site.

Facts About Construction Accidents

- 56% of accidents are happened due to falls from height
- 21% of accidents are due to being trapped by something collapsing or overturning
- 10% of accidents are due to being struck by a moving vehicle
- 5% of accidents are because of contact with electricity or electrical discharge
- 4% of accidents likely are struck by a flying/falling object during machine lifting of materials

Safe Access on Site

- Assure that everyone can get to their place of work safely.
- Always keep edges from which people could fall are provided with double guard rails or other suitable edge protection
- Take care that the holes are protected with clearly marked and fixed covers to prevent falls
- Always keep Good lighting conditions during construction to ensure construction site safety.
- Insert a Fence around the site to restrict public movement on the construction sites.

Working at Height

- Remember using scaffolding or ladders without proper fixing is crazy
- Never start working on incomplete scaffolding.
- Take care and keep watch there should be handrails and toe boards at all edges.
- Materials and different things may from height, therefore always use a helmet of good quality.
- Before starting work on height, always check clearance from the power transmission line.

How to Maintain Construction site Safety on Ladders

- Assure that not more than one person uses a ladder.
- Always use tool belts or hand lines to carry objects.
- Never try to lean out from the ladder in any direction.
- If any labor have fear of height then allow him to climb a ladder.
- Never allow any activity under the ladder.

Safety in Excavation Work

- Shored or Battered support must be provided for every excavation deeper than 1.25 meters must be
- Every excavation which is deeper than 2 meters must have a guard rail or barrier.
- Machines working too close to the edge of trench or rubble piled on the sides may cause collapse.
- To stop machines falling into trench use stone stop blocks.
- Daily inspect the excavation, its side, and depth.
- Always make an advance survey for any underground pipes and cables which will save any damage or accident during excavation.

Crane Safety

- Carefully estimate the weight of the load to be lifted.
- Make sure that the crane is fitted with an automatic safe load indicator (one that works)
- Always place a crane on a hard and level base.
- Take care that the load is properly fixed and secured.
- Crane operator guide must be proper knowledge of singling.

17. LABOUR OUTPUT/DAY IN CONSTRUCTION

Manpower	Activity	Output (8 Hours)
Mason – 1 Male mazdoor – 0.75 Female Mazdoor – 0.5	Brick Work	45 Cft
Mason – 1 Male mazdoor – 1 Female Mazdoor – 0.5	Wall plastering	120 Sft
Mason – 1 Male mazdoor – 0.75 Female Mazdoor – 0.5	Ceiling Plastering	90 Sft
Carpenter-2.25 Foreman- 0.2 Helper- 2.25	Shuttering Work	11 Sqm
Bar Bender – 1 Nos Helper – 1 Nos	Steel Work	100 Kg
Tile Mason – 1 Nos Helper – 1 Nos	Tile Work	10 Sqm
Mason – 2 Male mazdoor – 1.75 Female Mazdoor – 1.75	Block Work	2 m^3
Male Coolie – 5 Nos Female Coolie – 4 Nos	Earth Digging	1000 Cft

18. ESTIMATION SHEET FORMAT

Sr. No.	Description/Item	No. of Item	Length (L)	Width (B)	Height (H)	Total	Unit	Remark

19. BILL OF QUANTITIES FORMAT

Sr. No.	Code No.	Item	Quantity	Unit	Rate	Amount	Remark

20. REINFORCEMENT DETAILS

There are two main types of steel products used for steel reinforcement:

1. Rebars
2. Steel wires

Rebars:
Rebars or reinforcing bars are steel bars specifically built for the construction industry for concrete support. The surface of a rebar is often deformed to increase the bonding with concrete.

There are different types of rebar:

- **Carbon steel bars**

Carbon steel is used for purposes where ultimate tensile strength is taken into consideration. However, ductility and corrosion resistance are very low.

- **Mild steel bars**

Mild steel bars have round sections whose diameter varies from 6 mm to 50 mm. They are characterised by the plain surface of the bar. These rebars are easy to cut and bend. The grade of this rebar is determined by the yield stress, which is denoted on the bar, i.e; “FE250” where FE stands for iron and 250 means yield stress.

- **High Yield Strength Deformed (HYSD) bars**

Deformed bars are distinguished by a ribbed rough surface on the bar. This is done to increase the bar bonding between reinforcement and concrete and to maintain friction between them.

HYSD bars are divided into:

1. **TMT bar**

Known to be the best among steel bars, TMT bars showcase features including qualities like excellent ductility, high corrosion resistance, yield strength, ultimate tensile strength, better elongation and better weldability.

2. **Cold Twisted Bars – CTD**

Cold Twisted Bars are also called TOR steel in India. Once hot steel is obtained from the furnace it is cooled at ambient temperature and then stretched and twisted to increase yield strength.

- **Epoxy coated rebar**

Epoxy powder is applied on hot steel at a pre-set temperature using an electrostatic spray to obtain epoxy coated rebar. These are extremely corrosion resistant and are largely used in infrastructures, buildings, bridges, roadways, etc.

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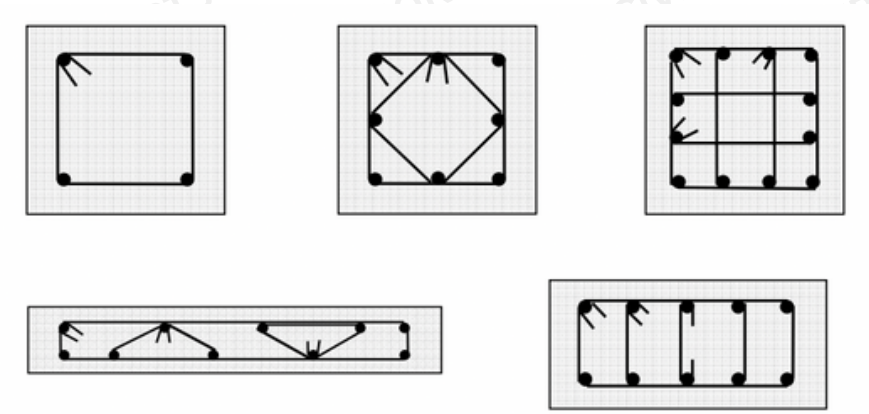
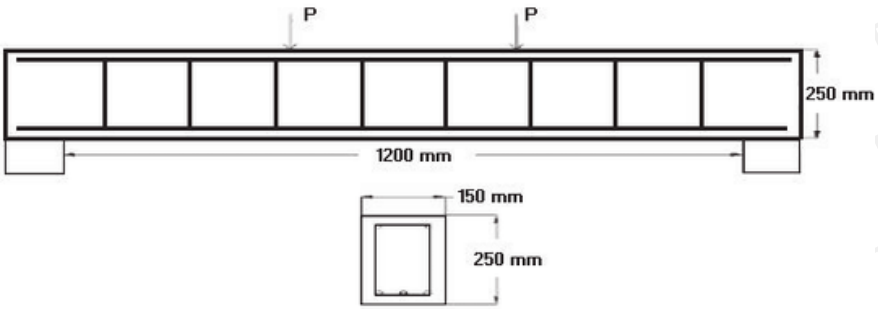
Column Reinforcement details:



The reinforcement details for RCC column according IS: 456 – 2000 is given below.

- Maximum reinforcement in any structure shall not exceed 6% of the gross area of concrete.
- In any structural part minimum reinforcement should not be less than 0.8% of the gross sectional area of concrete.
- For a rectangular structure minimum, 4 bars should be used. Whereas for circular section 6 number of bars should be used.
- For workable concrete minimum cover of 40mm or diameter of bar whichever is greater should be provided.
- The minimum size of primary reinforcement should not be less than 12mm.

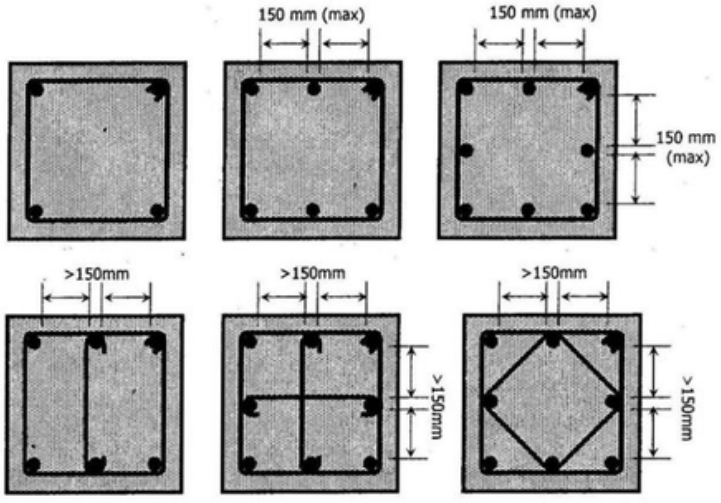
Beam Reinforcement details:



The Reinforcement details for RCC beams according to IS: 456 – 2000

- Longitudinal reinforcement in tension and compression are provided.
- Vertical stirrups and bent up longitudinal bars are provided to counter shear stresses. If depth of web in a beam exceeds 750mm then side face reinforcing bars are provided.
- Suitable cover should be provided in beams to protect bars from corrosion. Atleast 25mm cover should be provided or the maximum diameter of steel used in that section.
- Distribute 0.1% of web area equally on both faces spaced less then 300mm or web thickness whichever is less.

Stirrups in beams:



Stirrups are important to balance the shear stresses that are developed in beams and thereby holding longitudinal bars in position. Different types of stirrups are used according to need and requirement, all types of stirrups are mentioned below:

- Single Leg stirrups
- Double Leg stirrups (Open Type)
- Double Leg stirrups (Partial open type)
- Double Leg stirrups (Closed type)
- Double Leg stirrups (Welded type)
- Multiple Leg Stirrups

21. CONTRACTOR'S PROFIT & OVERHEAD

Profit:

1. Typically ranges from 5% to 20% of total project cost.
2. Represents the contractor's return on investment and compensates for project risks.

Overhead:

1. Indirect costs like office rent, utilities, and administrative salaries.
2. Usually applied as a percentage (5% to 15%) of direct project costs.
3. Covers general business expenses beyond specific project costs.

Considerations:

1. Percentages can vary based on project type, size, and regional factors.
2. Contractors tailor pricing strategies based on their cost structures and market conditions.

22. IMPORTANT TERMINOLOGIES

Construction site engineers should be familiar with various terminologies related to their field to communicate effectively and understand the construction process. Here are some important terminologies for construction site engineers:

1. Plans: Detailed drawings that show the dimensions, materials, and other specifications of a construction project.

2. BIM (Building Information Modeling): A digital representation of the physical and functional characteristics of a building or infrastructure, used for design, construction, and operation.

3. Site Survey: The process of collecting data and information about the land and existing structures before construction begins.

4. Excavation: The process of digging or removing earth to prepare the site for construction.

5. Foundation: The structural component that supports a building or other structure and transfers its load to the ground.

6. Concrete: A mixture of cement, water, and aggregates (such as sand and gravel) used as a building material.

7. Rebar (Reinforcement Bar): Steel bars used to reinforce concrete structures, providing strength and stability.

8. Formwork: Temporary molds or structures used to shape and support concrete until it sets.

9. Structural Steel: Steel components used in the construction of buildings and other structures, providing strength and support.

10. HVAC (Heating, Ventilation, and Air Conditioning): Systems that control the temperature and air quality in a building.

11. Surveying: The process of measuring and mapping the land to determine its contours, boundaries, and other features.

12. CADD (Computer-Aided Design and Drafting): The use of computer software to create detailed drawings and plans.

13. Quantity Surveying: Estimating and managing the costs of materials and labor for a construction project.

14. Contract Documents: The set of documents that define the terms and conditions of a construction project, including contracts, specifications, and drawings.

15. Change Order: A written document that modifies the original contract, typically involving changes to the scope, schedule, or cost of the project.

16. Punch List: A list of items that need to be completed or corrected before a construction project is considered finished.

17. Subcontractor: A company or individual hired by the main contractor to perform specific tasks on a construction project.

18. Retention: A portion of a contractor's payment that is held back until the project is completed to ensure the work meets the required standards.

19. Quality Control (QC) and Quality Assurance (QA): Processes to ensure that construction work meets specified standards and requirements.

23. IDEAL BUILDING CONSTRUCTION STEPS

Pre-Construction Phase:

1. Building Plan
2. Budget Estimation
3. Land Acquisition
4. Documentation

House Construction Process - The Construction Phase:

1. Site Clearing
2. Laying the Foundation
3. Plinth Beam and Slab
4. Superstructure
5. Bricklaying
6. The Lintel and Roof Coating
7. Plumbing and Electrical Wiring
8. Exterior and Interior Designing
9. Flooring
10. Painting

24. CONSTRUCTION TOOLS & EQUIPMENTS

1. Tape

It consists of a flexible ribbon of plastic, fibre glass, or metal strip with linear-measurement markings. This is used to measure length, size, or distance.

2. Masonry Trowel

It is a hand tool used in brickwork, stonework, or plastering for placing, leveling, shaping, and smoothing mortar or concrete. They are available in various shapes and sizes depending upon the work.

3. Head Pan

It is a round container, like a bowl used to transport construction materials.

4. Plumb Bob

Plumb bob is a small weight with a pointed tip, hangs from a string. This is one of the most important construction tools used to check vertical alignment for civil works.

5. Hoe

It is a long-handled tool with a sharp metal blade used for digging, mixing concrete ingredients, placing mortar/concrete in head pan etc.

6. Wooden Float

This tool has a plane surface used to make concrete surface smooth during plastering and finishing.

7. Spade

A long-handled tool consisting of a blade, stunted and less curved than that of a shovel mainly used for digging purposes.

8. Wheel Barrow

Wheel barrow is a construction tool having one wheel and two handles that is used to transport concrete, soil or any other material from one place to another place.

9. Hammer

A hammer is a tool consisting of a weighted head fixed to a long handle that is used to drive nails into shuttering boards, walls, etc.

10. Chisel

AThis tool is used to remove excess concrete from hardened surface.

11. Screed

This tool is made of wood, mainly used to level fresh concrete and provide a smooth surface especially in the concrete slab.

12. Needle Vibrator

This construction tool is very essential during pouring of concrete into reinforcement. It is used for compaction of the concrete perfectly.

13. Tamper

A tamper is a hand tool used to compress or compact earth or soil. Compacting the earth makes it hard and level, a suitable groundwork for projects that need a hard, flat surface.

14. Right Angle Frame

It is used to check the right angle of masonry or plastering work.

15. Concrete Mixer

This is a construction tool used to mix cement, sand, aggregates and water manually and produce concrete.

16. Sand Screening Machine

It is used to sieve sand for use in construction work. Sand is poured on the sieve or mesh which vibrates and separate fine grain sand easily.

17. Tile Cutter

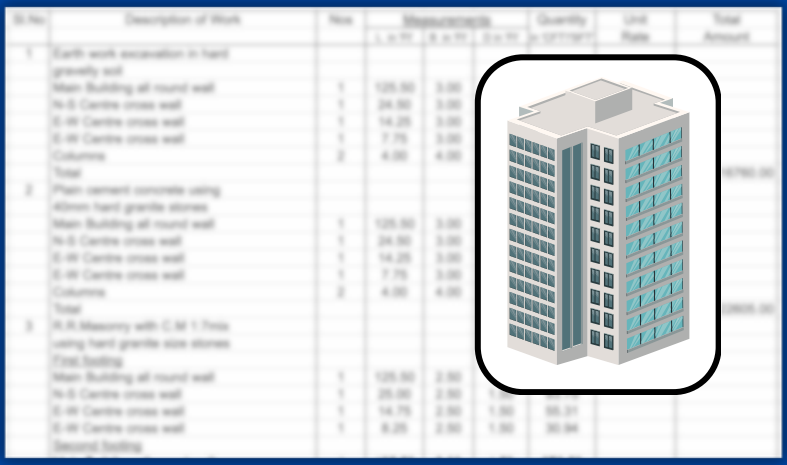
It is used in tiling or marble work. By this tool tiles or marbles are cut to the required size and shape.

18. Line Level

It is a small tool that is used to check the horizontal surface level in brickwork, plastering, flooring, plumbing, electric, and tile works.

BONUS

Excel Sheet for Ideal Building Estimation



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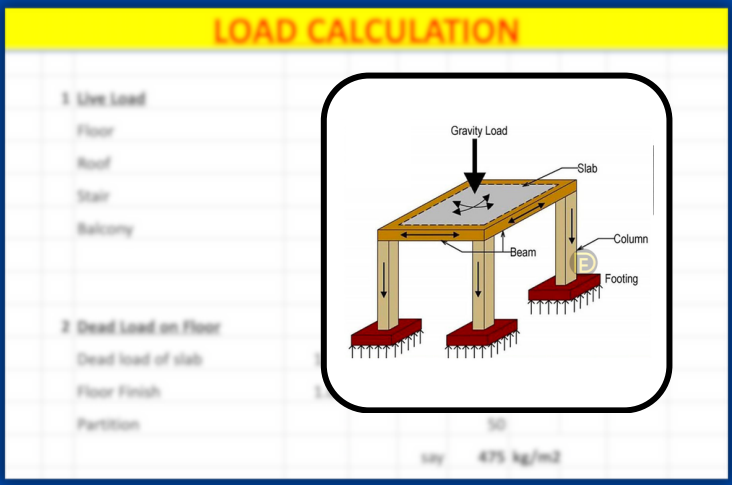
Excel Sheet for Load Calculation of Building



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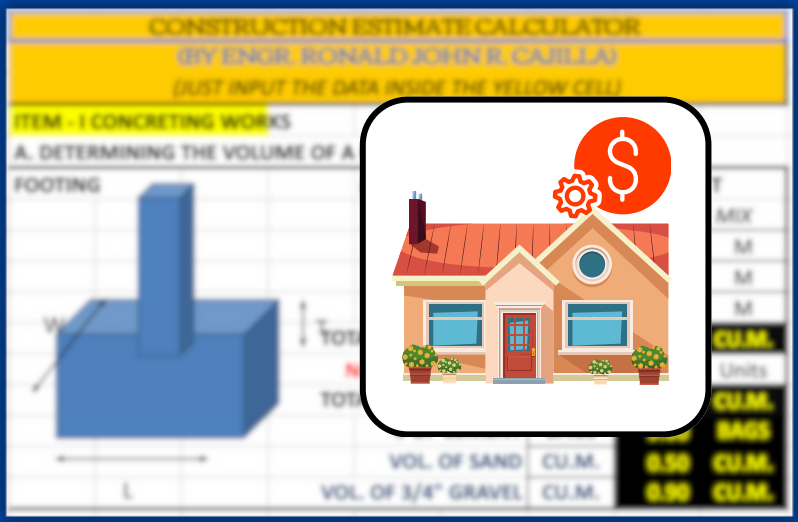
BONUS

House Construction Cost Calculator



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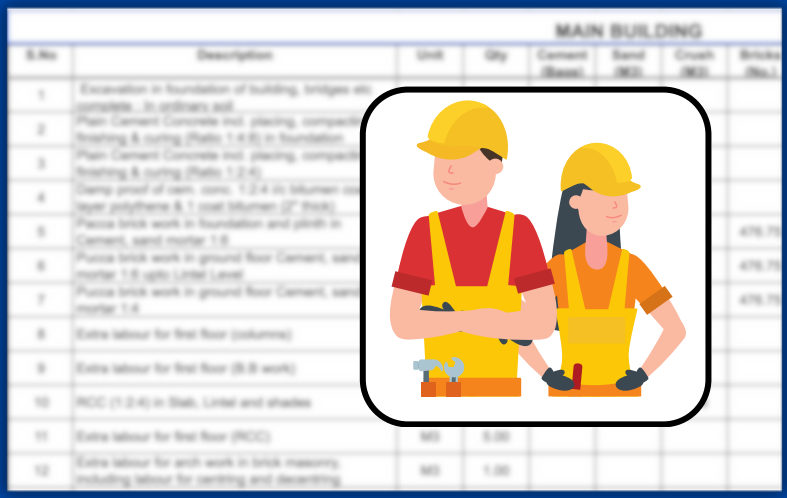
Material & Labour Cost Calculator Sheet



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Dear Reader,

Thank you for embarking on this journey through the pages of **"Civil Engineer's Ultimate Guide"**. It has been a privilege to be your guide in the world of Civil Engineering.

Stay tuned for upcoming projects and books! We are excited about the opportunity to continue sharing knowledge and insights with you.

In closing, remember that the World of Civil Engineering is vast and ever-evolving. Embrace the challenges, stay curious, and never stop learning.

Wishing you a fulfilling and successful career in Civil Engineering.

Connect with us on social media to share your experiences, questions, and success stories. Your feedback is invaluable in shaping future editions of this guide.

Email : civilconcepts20@gmail.com

Civil Engineering Concepts