Estimation - Purpose - Technical Terms - Datas And Classification

Objectives : At the end of this lesson you shall be able to
- **define the term estimate**
- **state the importance and purpose of estimate**
- **define technical terms used in estimation**
- **state the datas for estimate.**
- **state the classification of estimate.**

Introduction

Before undertaking the construction of a project it is necessary to know its probable cost which is worked out by estimating. An estimate is a computation or calculation of the quantities required and expenditure likely to be incurred in the construction of work. The primary object of the estimate is to enable one to know beforehand; the cost of the work (building, sturctures etc.). The estimate is the probable cost of a work and is determined theoretically by mathematical calculations based on the plans and drawing and current rates. Apporoximate estimate may be prepared by various methods but accurate estimate is prepared by Detailed Estimate Method. The acutal cost should not differ much from the estimated cost worked out at the begining.

Accuracy in estimate is very important, if estimate is exceeded it becomes a very difficult problem for engineers to explain, to account for and arrange for the additional money. Inaccuracy in preparing estimate, omission of items, changes in design, improper rates, etc. are the reasons for exceeding the estimate, though increase in the rates in one of the main reason. In framing a correct omissions of any kind of work or part thereof. The rate of each item should be reason. In framing a correct omissions of any kind of work or part thereof. The rate of each item should be reasonable and workable. The rates in the estimate provide for the complete work, which consists of the cost of materials, cost of tools and plants, cost of labour, cost of scaffolding, cost and tools and plants, cost of water, taxes, establishment and supervision cost, reasonable profit of contractor, etc.

Estimate includes cost of material, cost of transportation, cost of labour, cost of temporary structure (scaffolding etc.), cost of tools, equipments and plant, estamlishment, supervision charges, cost of water, taxes, profit of contrator etc. Before starting the work of estimate it is important to study the drawing carefully.

Definition:

An art of calculating or computing the various items of work or project to find out its approximate cost likely to be incurred, the quantity required or various materials, requirement of labour etc. is called “Estimation.”

Importance of estimate

Estimate helps us in many ways before, during and after construction works. The use and importance of estimating are listed below:

- To give approxiamate cost of construction work.
- To know whether the work can be completed according to given specifications and within the financial limit.
- To invite tenders for work and arrange the contract.
- To get an idea of the material requirements.
- To check out work done by contractors during execution.
- To calculate the payment to the contractors according to the actual measurement compared with existing estimate.
- To calculate the sale value of buildings.
- To fix standard rent.

Technical terms

Project: Project means a full scheme consisting of detailed technical report, history design data and calculations, drawings, specifications, rates, project estimates etc. It is the detailed requirements of proposal or scheme. The project gives full details of all works involved for both structural and financial requirements.

It requires preliminary investigation and surveying and selection of site or alignment to start with and then the detailed surveying before taking up preparation of details of the project. Detailed estimate of all works are prepared separately and a general abstract of cost is prepared showing the cost of the whole project. Drawings of all works - plans, elevations, sectional elevations and nessary detailed drawings - and layout plan or index plan of the works are given seperately and detailed specifications of each item of works are also given fo all works.

Besides the buildingm, structurres etc. provisions are made for external services as outer water supply and sanitary works, strom water drains, road, electric service lines, etc. Cost of land and levelling and dressing of land are also included. The cost of preliminary investigation work is also included in the project estimate.

For a big project in the interior, as for a dam project, the temprary accomodations for staff and a workmen are required and included in the project estimate. cost of the approach road with bridges and culverts have also included in the project estimate.

Provisions for contingencies, work charged establishment and tools and plants are also made in the estimate. Departmental charges 5% to 10% of the whole project estimate is added to meet the expenditure for the preparation and execution of the project.

State of financial return, rent statement, etc., are also prepared to justify the project.

Subwork: A large work or project may be consist of several buildings or small works and each of these work is known as sub-work. Detailed estimate of each sub-work is prepared seperately and accounts of expenditure are kept sub-work wise.

Site plan: For all building plans site plans are prepared to small scale of 1 cm = 5 m to 1 cm = 10 m showing the orientation of the building, boundries of land, position of roads, drains, sewer line, water pipe lines, and adjoining plots of lands with their ownership. the north direction line is also shown on one corner of the site plan to show the geographical orientation of the building. In site plan, the building and other details are dawn in line diagram. From the site plan, location of the wrok with respect to the surrounding is known.

Layout plan: For a project consisting of a number of buildings and structures a layout plan of the whole area is prepared to small scale of 1 cm = 10 m to 1 cm = 20 m with all proposed buildings, structures, etc. showing their sizes, positions, locations and orientations. Besides the buldings are sturctures the roads, lanes, drains, pipe lines, electric lines, parks, etc. are also shown in the layout plan with their proper notations. The boundary, the main approach roads and adjoining areas with their ownership, name, nature etc. are also shown in line diagram. The North direction line is also shown in one corner of the layout plan to indicate the geographical orientaion of the buildings. The layout plan gives a general idea of the project at a glance.

Index plan: For road project, irrigartion project, water super project, sanitary work project, major building project etc, an index plan to a scale 1 cm = 0.5 km is prepared showing alignment with position of culvets, outlets and other main works or main outlines of the whole work so that at a glance an idea of the project may be formed. For big project the index plan is drawn with a much small scale and is known as key plan.

Quantity survey: Quantity survey is a list of schedule of quantities of all the possible items of work required for construction of any building or sturcture. These quantites are worked form the plan and drawings of the structure. Thus the quantity survey indicates the quantites of work to be done under each item which when priced per unit gives the amount of cost. In short quantity survey means estimating of the quantites of different items of works.

Plinth area: Plinth area is the built up covered area of building measured at floor level of any storey. Plinth area is calculated by taking the external dimensions of the building at the floor level excluding plinth offsets if any Courtyard, open areas, balconies and cantilever projections are not included in the plinth area. Supported porches (other than cantilevered) are included in the plinth area.

The following shall be included in the plinth area

i All floors, area of wall at the floor level exculding plinth offsets, if any.

ii Internal shafts for sanitary installations provided these do not exceed 2 sq. m in area air condition ducts, lifts, etc.

iii The area of barasti and the area of mumty at terrace level.

iv Area of proches other than cantilevered.

The following shall not be included in the plinth area:

i Area of loft.

ii Internal sanitary shafts provided these are more than 2 sq.m. in area.

iii Unenclosed balconies.

iv Towers, turrets, domes etc. projecting above the terrace level not forming a storey at the terrace level.

v Architechtural bands, cornices etc.

vi Sunshades, Vertical sun breakers or box louvers projecting out.

Floor area: Floor area of a building is the total area of floor in between walls and consists of floor of all rooms, verandahs, passages, corriodos, staircase room, entrance halls, kitchen, stores, bath and latrine (W.Cs.) etc Sills of doors and openings are not included in the floor area. Area occupied by wall, pillars, pilaster, and other intermediate supports are not included in the floor area. In short, floor area is equal to plinth area minus area occupied by walls.

For deduction of wall area from pilnth area to obtain floor area, the wall area shall include:

i Door and other openings in the wall.

ii Intermediate pillars and supports.

iii Pilasters along walls exceeding 300 sq. m. in area.

iv Flues which are within walls.

But the following shall exculded from the walls areas:

i Pilaster along wall not exceeding 300 sq.m in area.

ii Fire place projecting beyond the face of wall in living rooms.

iii Chulla platforms projecting beyond the face of walls in kitchens.

The floor of each storey and different types of floor should be measured and taken seperately. The floor area of basement, mezzaninies, barsaties, mumties, porches, etc. should be measured separately.

Circulation area: Circulation area is the floor area of verandahs, passages, corridors, balconies, entrance hall, porches, staircases, etc., which are used for movements of persons using the building. The circulation area of any floor shall comprise of the following;

a Verandahs and balconies

b Passages and corridors

c Entrance halls

d Staircase and mumties

e Shafts for lift

The circulation area may be divided ino two parts (i) Horizontal circulation area and (ii) Vertical circulation area.

Horizontal circulation area: Horizontal circulation area of a building is the area of verandahs, passages, corridors, balconies, porches, etc., which are required for the horizontal movement of the users of the building. This may be 10% to 15% of the plinth area of the building.

Vertical circulation area: Vertical circulation area of a building is the area or space occupied by staircases, lifts and the entrance halls adjecents to them which are required for vertical movement of the users of the building. This may be 4% to 5% of the plinth area of the buildings.

Carpet area: Carpet area of building is the useful area or liveable area or lettable area. This is the total floor area minus the circulation area, verandahs, corrdors, passages, staircase, lifts, entrance hall etc., and minus other non-usable areas as sanitary accommodations (Bath and W.Cs), air conditioning room etc. For office building carpet area is the lettable area or usable area and for residential building carpet area is the liveable area and should excluded the kitchen, pantry, stores and similar other room which are not used for living purposes.

The carpet area of building for any storey shall be the floor area excluding the following:

a Sanitary accomodation

b Verandahs

c Corridors and passages

d Kitchen and pantries

e Stories in domestic buildings

f Entrance hall and porches

g Staircase and mumties

h Shafts for lifts

i Barsaties

j Garages

k Canteens

l Air conditioning ducts and air conditioning plant room

The carpet area of an office building may be 60% to 75% of plinth area of the building with a target of 75%. The planners should aim to achieve a target to 75% of the plinth area. The carpet area of residential building may be 50 to 65% of the plinth area of the building.

For a framed multi-storeyed building the area occupied by wall may be 5% to 10% of the plinth area (a standard 3% for external walls and 2% for internal walls). For ordinary building without frame, the area occupied by wall may be 10% to 15% of the plinth area.

External services: In a project besides the building structure, certain outside work are required which come under external services. External service or work include the following:

i Digging, filling, levelling and dressing of road.

ii Road including approach road, if any.

iii External sewerage, sewage, disposal of works.

iv Exrternal electrical service line with posts, if any.

v Storm water drains, fencing or compound wall, gate, etc.

vii Arboriculture plantation of trees.

The cost external service works should be included in the complete estimate. The cost of external services works may vary from 10% to 20% depending on the nature and size of the project.

Contingencies: The term 'Contingencies; indicates incidental expenses of miscellaneous character which can not be classified under any distinct item sub-head, yet certain to the work as a whole.

In an estimate a certain amount in the form of contingencies of 3% to 5% of estimate cost, is provided to allow for the expenses for miscellaneous petty items which do not fall under any sub-head of items of works. Miscellaneous incidental expenses which cannot be classified under any sub-head or item, are met from the amout provided under contingencies.

If there is any saving against the amount provided under contingencies, this amount may be utilised with the sanction of the competent authority, to meet the expenses of extra items of work, if any unforeseen, expenditure, expenses to minor changes in design, etc.

Work-charged establishment: Work-charget establishment is the establishment which is charged to works directly. During the construction of building or a project, a certain number of work-supervisors, chaukidars mates munshies, etc., are required to be employed, and their salaries are paid from the amout of work-charged estamblishment a percentage of 1 1/2 to 2% of the estimated cost is included in the estimated. The work-charged employees are temporary staff and their appointment shall have to be sanctioned by the competent authority for a specific period. Their services are terminated at the expiry of the sanctioned period, if their services are required fresh sanction shall have to be taken. Their services can, however, be terminated at any time but usually one month's notice should be given.

Tools and plants (T. and P.): For big work or project a percentage of 1% to 1 1/2 % of the estimated cost is provided in the estimate for the purchase of tools and plants which will be required for the execution of the work. Normally the contractor has to arrange and use his own tools and plants.

Centage charges or Departmental charges: When the engineering department takes up the work of other department a percentage amount of 10% to 15% of the estimated cost is charged to meet the expenses of the establishment, designing, planning, supervision, etc., and this percentage charge is known as centage charge. The centage charge is provided in the estimate of the work of Central Government is undertaken of execution. These charges also known as supervision charges for works.

Complete set of estimate: Detailed estimate is prepared in standard forms and the complete set of estimate consists of:

i Title page giving name of the Engineering Department, division, district, of sub-division, Estimate No., Name of work, and Amount of estimate.

ii Index of contents and plan and drawings.

iii Report.

iv Design calculations.

v General specifications.

vi Detailed specifications.

vii Analysis of rates if required.

viii Details of measurement and calculations for quantities.

ix Abstract of Estimated Cost.

x General abstract of cost.

xi Drawings - plans, elevations, detailed drawing, site plan, index plan, etc.

At the end of the abstract of estimated cost or summary of estimated cost there should be signature of the assistant engineer, executive engineer and superintendent engineer and on the back page head of account should be given.

Schedule of rates: Schedule of rates is a list of rates of various items of works. To facilitate the preparation of estimates, and also to serve as a guide in setting rates in connection with contract agreement, a schedule of rates for all items of work is maintained in the engineering department in the form of a printed books known as "schedule of rate books."

Administrative approval or sanction: For any work or project required by a department, an approval or sanction of the competent authority of the department, with respect of the cost and work is necessary at the first instance. The approval authorises the engineering department to take up the work. Administrative approval denotes to formal acceptance by the department concerned of the proposal, and after the administrative approval is given the engineering department (P.W.D) take up the work and prepares detailed design, plans and estimates and then executes the work. The engineering department prepares approximate estimate and preliminary plans and submits to the department concerned for administrative approval.

Expenditure sanction: Expenditure sanction means the concurrence of the Government of the expenditure proposed and represents allotment of the money to meet the expenditure. No expenditure can be incurred before expenditure sanction is given. Expenditure sanction means allotment of fund or money for a specific work and is usually, accorded by the finance department.

Technical sanction: Technical sanction means the sanction of the detailed estimates, design calculation, quantities of works, rates and cost of the work by the competent authority of the engineering department. After the technical sanction of the estimate is given, then only the work is taken up for construction. In case of original work the counter signature of the local head of the department should be obtained in the plan and estimate before techical sanction is accorded by the engineering department. The power for technical sanction differs from State to State.

Bill of quantities: It is statement of the various items of work giving the description quantites and unit of rates. It is prepared in a tabular form similar to the 'abstract of estimated cost' of the detailed estimated, but the rate and amount columns are left blank (unfilled). When priced, that is, the rates and the amounts are filled up and totalled, this gives the estimated cost. It is primarily meant for inviting tender, and supplied to the contractor to fill up the rates and amounts columns. Om receipt of the tenders the rates and amounts are compared and decision about entrusting the work is finalised.

Data for estimation: To make an estimate for a work following data are necessary:

i Drawing - Plan, Section, etc.

ii Specification.

iii Rates

i Drawings: Plan, Sectional elevations and detailed drawings to scale, fully dimensioned are required. The plan, elevaion and sectional elevaions are usually drawn to a scale of 1 cm = 1 m and detailed drawings are prepared to scales of 1 cm = 10 cm to 1 cm = 30 cm.

ii Specifications

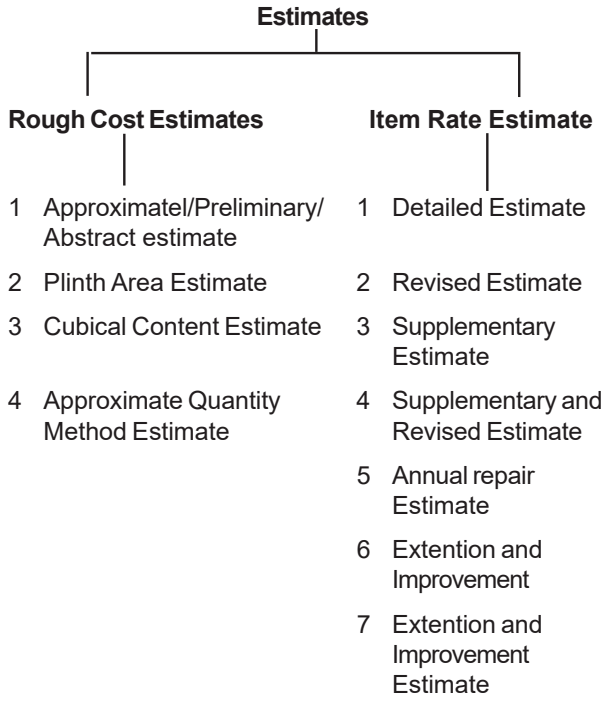
a General specifications or brief specification: These give the nature, quality and class of work and materials, in general terms, to be used in the various parts of the work. General specifications help to form a general idea of the whole building or sturcture and are useful inpreparing the detailed estimate.

b Detailed specification: These give the detailed description of the various items of work laying down the quantites and qualities of materials, their proporations, the method of preparation, workmanship and execution of work. Detailed specifications describe every item of work seperately, in detail and are helpful for the execution of the different items of work.

iii Rates: The rates per unit of various items of work, the rates of various materials to be used in the construction and the wages of different categories of labour, skilled or unskilled a mason, carpenter, mazdoor, bhishti, etc., available for preparing estimate. The location of the work and its distance from the source of materials and the cost of transport should be known. These rates may be worked out by the "Analysis of rates" method.

Estimates are mailnly in two types. They are abstract estimate and item rate estimate.

Rough cost estimate: The estimate prepared without going into details of different items of work is called rough cost estimate. It is prepared by different methods.



i Preliminary or Approximate or Abstract estimate: Preliminary or approximate or abstract estimate is required for preliminary studies or various aspects of a work or project, to decide the financial position and policy for administrative saction by the compenent administrative authority. In case of commercial projects as irrigation projects, Residential building projects and similar projects which earn revenue income, the probable income may be worked out, and from the preliminary estimate the approximate cost may be known and then it may be seen whether the investment, on the project is justified or not. for non-commercial projects or for projects giving no direct return, their necessity, utility, availability of money, etc., may be considered before final decision is taken. The approximate estimate is prepared for the practical knowledge and cost of the similar works. This estimate is prepared showing seperately the approximate cost of all important items of work as cost of land, cost of each building, cost of roads water supply, sanitary works, electrification, etc., the estimate is accompanied by a brief report explaining the necessity and utility of the project an d showing how the cost of separate items have been arrived at. This is also accompanied with a site plan or layout plan. A percentage of about 5% to 10% is added as contingencies.

ii Plinth area estimate for building (P.A. estimate): This is prepared on the basis of plinth area ofbuilding, the rate being deducted from the cost of similar building having similar specification, heights and construction, in the locality. Plinth area estimate is calculated by finding the plinth area of the building and muliplying by the plinth area rate. The plinth area should be calculated for the convered area by taking external dimension of the building at the floor level. Courtyard and other open

area should not be included in the plinth area. Plinth area estimate is only approximate, and is preliminary estimate, to know the approximate cost before hand.

If the plan of the building is not ready or available, at the begining just prepare a proposal, floor area of rooms, etc. may be determined from the requirement and 30 to 40 percent of the total area thus found may be added for walls, circulation and waste to get the approximate total plinth area which multiplied by the plinth area rate gives the approximate cost of the building.

iii **Cubical rate estimate for building:** Cube rate estimate is a preliminary estimate or an approximate estimate, and is prepared on the basis of the cubical contents of the bulding the cube rate being deducted from the cost of the similar building having similar specifications and construction, in the locality.

This is calculated by finding the cubical content of the building (length x breadth x height) and multiplied it by the cube rate. the length and breadth should be taken as the external dimensions of the buildings at the floor level and the height should be taken from the floor level to top of roof (or half way of the sloped roof). For storeyed building the height should be taken beetween the floor level of one storey to top of next-higher floor. the foundation and plinth, and the parepet above roof are not taken into account in finding the cubical content.

Cube rate estimate is most accurate as compared to the plinth area estimate as the height of the building is also compared.

iv **Approximate quantity method estimate:** In this method approximate total length of walls is found in running metre and this total length multiplied by the rate per running metre of wall gives a fairly accurate cost. For this method the structure may be divided into two parts viz. (i) foundation including plinth and (ii) superstructure. The running metre rate should be multiplied by the total length of walls.

To find the running metre rate for foundation, the approximate quantities of items such as excavation, foundation, brickwork upto plinth, and damp proof course are calculated per running metre and by multiplying by the rates of these items the price or rate per running metre is determined.

Similarly for superstructure the price or rate per running metre is determined from the approximate quantities of brick work, wood works, roof, floor finishing etc.

For this method the plan or line plan of the structure should be available.

ii **Item rate estimates:** Item rate estimate is prepared in detail item wise. For this estimate, the work is divided into different items of work and quantities under each item are taken out and then an abstract of estimate cost is prepared at suitable rates.

1 **Detailed estimate:** Detailed estimate is an accurate estimate and consists of working out the quantities of each item of works, and working the cost. The dimensions, length, breadth and height of each item are taken out correctly from drawing and quantities of each item are calculated, and abstracting and building are done.

The detailed estimate is prepared in two stages.

a **Details of measurement and calculation of quantities:** The details of measurement of each item of work are taken out correctly from plan and drawings and quantities under each item are computed or calculated in a tabular form named as Details of Measurement Form (Table 1).

b **Abstract of estimate cost:** The cost of each item of work is calculated in a tabular form from the quantities already computed and total cost is worked out in abstract of estimate form (Table 2). The rates of different items of work are taken as per schedule of rates or current workable rates or analysed rates for finished items of work. A percentage usually 3% of the estimated cost is added to allow for contingencies for miscellaneous petty items which do not come under any classified head of items of work and a percentage of about 2% is provided for work-charged establishment. The grand total thus obtained gives the estimated cost of work.

The detailed estimate is usually prepared work-wise, under each sub-work as main building, servant quarters, garage, boundary walls etc.

The detailed estimate is accompanied with:

a Report

b General specifications

c Detailed specifications

d Drawings: Plan, elevaion, sectional elevations, detailed drawings, site plan or layout plan or index plan etc.

e Calculation and designs: Designs of foundation, beam, slab, lintel, design of channel in case of irrigation channel, design of thickness of metal crust in case of road etc.

f Analysis of rates, if rates are not as per schedule of rates or for the non-scheduled items.

Detailed estimate is prepared for technical sanction of the competent authority, for arranging contract and for the execution of work.

2 **Revised estimate:** Revised Estimate is detailed estimate and is required to be prepared under any one of the following circumstances.

i When the original sanctioned estimate is exceeded or likely to exceed by more than 5%.

ii When the expenditure on a work exceeds or likely to exceed the amount of administrative sanction by more than 10%

Table 1: Details of measurement form

Item No.	Description	Nos	Length (m)	Breadth (m)	Height or depth (m)	Content or Quantity

Table 2: Abstract of estimate form

Item No.	Description or particlulars	Quantity	Unit	Rate	Amount

iii When there are material deviation from the original proposal, even though the cost may be met from the sanctioned amount.

The revised estimate should be accompanied by a comparative statement showing the variations of each item of works, its quantity, rate and cost under original and revised, side by side, the excess or saving and reason for variation.

3 **Supplementary estimate:** Supplementary estimate is a detailed estimate and is prepared when additional works are required to supplement the originalworks, or when furtheer developments is required during the progress of work. This is a fresh detailed estimate of the additional works in addition to the original estimate. The absract should show the amount of the original estimate and the total amount including the supplementary amount for which sanction is required.

4 **Supplementary and revised estimate:** When a work is partially abandoned and the estimated cost of the remaining work is less than 95 percent of the original work, that is less than 95% of the original sanctioned estimate, or when there are material deviations and changes in the design which may cause substantial saving in the estimate, then the amount of the original estimate is revised by the competent authority. A supplementary and Revised Estimate is then prepared and fresh technical sanction of the competent authority is obtained.

If at any time either before or during the execution of original work, it is found that the original estimate is excessive, then divisional officer may sanction a revised estimate of reduced amount. While giving such sanction the Accountant General and other higher authorities are informed.

5 **Annual repair or annual maintenance estimate (A.R. or A.M. Estimate):** Annual repair or annual maintenance estimate is a detailed estimate and is prepared to maintan the structure or work in proper order and safe condition. For building; this includes white washing, colour washing, painting, minor repairs etc. For road works the A.R. estimate provides for patch repairing, renewals, repairs of bridges and culvert, etc.

Further, there may be special repair estimate, monsoon damage repair estimate, etc.

6 **Extension and improvement estimate:** When some changes and extensions are required to be made in the old work, the cost of whcih cannot be met by the annual repair/maintenance estimate, a detailed estimate is prepared for such work which is called as extension and improvement estimate.

Rules measurement of Techniques

Objectives: At the end of this lesson you shall be able to
- **state the method of measurement of works and taking out quantities**
- **explain the unit of measurements and payments**
- **explain the main items of work.**

Rules and methods of measurements of works and taking out quantities

Measurement of works occupies a very important place in the planning and execution of any work or project, from the time of the first estimate are made until the completion and settlement of payments. The methods followed for the measurements are not uniform and the practices as prevalent differ considerably in different States. Even in the same State different departments follow different methods. for convenience, a uniform method should be followed throughout the country. the uniform method of measurement to be followed, which is applicable tothe preparation of the estimates and bill of quantities and to the site measurement of completed works has been described below.

General rules

1 Measurement shall be item wise for the finished item of work and the description of each item shall be held to include materials, transport, labour, fabrication, hoisting, tools and plants, overheads and other incidental charges for finishing the work to the requisred shape, size, design and specifications. the nomenclature of each item shall be fully desribed so that the work involved in item is self-explanatory.

2 In booking dimensions, the order shall be in the sequence of length, breadth and height or depth or thickness.

3 All work shall be measured net subject to following tolerances unless otherwise stated

a Dimensions shall be measured to nearest 0.01 metre i.e. 1 cm.

b Areas shall be measured to the nearest 0.01 sq. m.

c Cubic contents shall be worked out to the nearest 0.01 cu. m.

4 Same type of work under different conditions and nature shall be measured separatley under separate items

5 The bill of quantities shall fully describe the materials proportions and workmanships, and accuratley respresent the work to be executed. Work which by its nature cannot be accuratley taken off or which requires site measurements, shall be described as provisional.

6 In case of structural concrete, brickwork or stone masonry, the work under the following categories shall be measured separatley and the heights shall be described

a From foundation to plinth level.

b From plinth level to first flor level.

c From first floor level to second floor level and so on.

The parapet shall be measured with the corresponding items fo the storey next below

Particulars of materials and works	Dimensions metric system
1 Bricks, stone blocks, etc.	All dimensions cm.
2 Files, slates, wall board, glass panes, A.C. sheets, sheets, etc.	Length and breadth in cm or m. Thickness in mm.
3 Door, Windows, etc.	Height and breadth in cm or m.
4 Parts of doors and windows as pannels, shutters.	cm or mm.
5 Timber	Length in m and cross-sectional dimensions in cm or mm.
6 Masonry (brickwork, stone masonry, etc.)	Length and height in m. Thickness or breadth in cm.
7 Cement concrete, Lime concrete, R.C.C. Flooring, etc.	Length and breadth in m. Thickness in cm.
8 White washing, colour washing, distempering, painting, etc.	Length and breadth or height in m.
9 Aggregates, ballast, grit, sand, etc.	Size in mm.
10 Rolled steel sections as I-beam, channel, angle, etc.	Length in m, section in mm.
11 Mild steel bars	Length in m, Dia. in mm.

Unit of measurements in metric system

The principle for dimensions and measurements is to use milimetre (mm) for minute dimensions, centrimetre (cm) for small dimensions and metre (m) for big dimensions. Distances are measured in kilo metre (km).

The dimensional units for main item of materials and works for general construction works as used in metric system are as follows:

Principle of units: The unit of different works depends on their nature, size and shape. In general, the units of different terms of work are based on the following principles.

i Mass, voluminous and thick works shall be taken in cubic unit or volume. The measurement of length, breadth and height or depth shall be taken to compute the volume or cubic contents (cu. m).

ii Shallow, thin and surface work shall be taken in square units or area, the measurement of length and breadth or height shall be taken to compute the area (sq.m).

iii Long and thin work shall be taken in linear or running unit and linear measurement shall be taken (running metre).

iv Piece work, job work, etc., shall be enumerated, i.e. taken in a number.

S. No.	Particulars of Items	Units of measurement in MKS	Units of payment in MKS
	Earthwork		
1	Earthwork in excavation in ordinary soil, earth work is mixed soil with kandkar, bajri, etc. earthwork in hard soil	cu. m.	Per % cu. m.
2	Rock excavation	cu. m.	Per % cu. m.
3	Earth filling in excavation in foundation	cu. m.	Per % cu. m.
4	Earth filling in foundation trenches (Usually not measured and not paid separately	cu. m.	Per % cu. m.
5	Earth filling in plinth	cu. m.	Per % cu. m.
6	Earth work in banking, cutting, in road and irrigation channel	cu. m.	Per % cu. m.
7	Surface dressing and levelling, cleaning etc.	sq. m.	Per sq. m.
8	Cutting of trees (Girth specified)	no.	Per no.
9	Puddling, Puddle clay core	cu. m.	Per % cu. m.
10	Sand filling	cu. m.	Per cu. m.
11	Quarrying of stone or boulder	cu. m.	Per cu. m.
12	Blasting or rock (Blasted stone stacked and then measured)	cu. m.	Per cu. m.
	For earth work, normal lead is 30m and normal lift is 1.5m Concrete		
1	Lime concrete (L.C.) in foundation	cu. m.	per cu. m.
2	Lime concrete (L.C.) in roof terracing, thickness specified (May also be in volume basis as practice U.P.)	sq. m.	per cu. m.
3	Cement concrete (C.C.)	cu. m.	per cu. m.
4	Reinforced cement concrete (R.C.C.)	cu. m.	per cu. m.
5	C.C. or R.C.C. chujja, sun shade	cu. m.	per cu. m.
6	Precast C.C. or R.C.C.	cu. m.	per cu. m.
7	Jali work or jaffri work or C.C. tracery panels (Thickness specified)	sq. m.	per sq. m.
8	Cement concrete bed	cu. m.	per cu. m.
	D.P.C		
9	Damp proof course - Cement concrete Rich cement mortar, Asphalt, etc. (Thickness specified)	sq. m.	per sq. m.

S. No.	Particulars of Items	Units of Measurement in MKS	Units of payment in MKS
	Brick work		
1	Brickwork in foundation and plinth, in sperstructure, in arches, etc. in cement lime or mud mortar	cu. m.	per cu. m.
2	Sun dried brickwork	cu. m.	per cu. m.
3	Honey-comb brickwork, thickness specified (May also be in volume basis as practice in U.P.)	sq. m.	per sq. m.
4	Brickwork in jack arches, if measured separately	cu. m.	per cu. m.
5.	Jack arch roofing including top finishing	sq. m.	per sq. m.
6	Brickwork in well steining	cu. m.	per cu. m.
7	Half-brick work with or without reinforcement (May also be in cu. m. as practice in U.P.)	sq. m.	per sq. m.
8	Thin partion wall	sq. m.	per sq. m.
9	Reinforced brick work (R.B. work)	cu. m.	per cu. m.
10	String course, drip course, weather course, coping etc. (Projection specified)	meetre	per m.
11	Cornice (Projection and type specified)	metre	per m.
12	Brickwork in Fire place, Chulla, Chimney	cu. m.	per cu. m.
13	Pargetting Chimney, fire place flue	metre	per m.
14	Brick edging (by road side)	metre	per m.
	Stone work		
1	Stone masonry, Random rubble masonry Coursed rubble masonry, ashlar masonry in walls, in arches, etc.	cu. m.	per cu. m.
2	Cut stone work in lintel, beam, etc.	cu. m.	per cu. m.
3	Stone slab in roof, shelve, etc, stone chujjas, stone sun shade, etc. (Thickness specified)	sq. m.	per sq. m.
4	Stone work in wall facing or lining (Thickness specified)	sq. m.	per sq. m.
	Wood work		
1	Wood work, door and window frame or chowkhat, rafters beams, roof trusses, etc.	cu. m.	per cu. m.
2	Door and window shutters or leaves, panelled, battened, glazed, part panelled and part glazed, wire gauged, etc. (Thickness specified)	sq. m.	per sq. m.
3	Door and window fittings as hinges tower bolts, sliding bolts, handles etc. (May also be on the basis of area of shutters as practice in U.P.)	no.	per no.
4	Timbering, Boarding (Thickness specified0	sq. m.	per sq. m.
5	Timbering of trenches (Area of face supported)	sq. m.	per sq. m.
6	Sawing of timber	sq. m.	per sq. m.
7	Woodwork in partition, Ply wood ect.	sq. m.	per sq. m.
8	Ballies (Diameter specified0	metre	per m.

S. No.	Particulars of Items	Units of Measurement in MKS	Units of payment in MKS
	Steel work		
1	Rolled steel joists, Channels, Angles, T-irons, Flats, Squares, Rounds etc.	quintal	per q.
2	Steel reinforcement bars, etc. in R.C.c., R.B. work	quintal	per q.
3	Bending, binding of steel reinforcement	quintal	per q.
4	Fabrication and hoisting of steel work	quintal	per q.
5	Expended Metal (X.P.M.) size work	sq. m.	per sq. m.
6	Fabric reinforcement, wire netting	sq. m.	per sq. m.
7	Iron work in struss	quintal	per q.
8	Gusset plate (Manimum rectangular size from which cut)	quintal	per q.
9	Cutting of Iron Joists, Channels	cm.	per cm.
10	Cutting, Angles, Tees, Plate	sq. m.	per sq. m.
11	Threading in iron	cm.	per cm.
12	Welding, Solder of sheets, plates (Welding of rails, steel, trusses, rods - per no.)	cm.	per cm.
13	Boring holes in iron	no.	per no.
14	Cast Iron (C.I.) pipe, Dia. specified	metre	per m.
15	Rivets, Bolts and nuts, Anchor bolts, Lewis bolts, Holding down bolts, etc.	quintal	per q.
16	Barbed wire fencing	metere	per m.
17	Iron gate (May also be by weight, quintal)	sq. m.	per sq. m.
18	Iron hold fast (May also be by no.)	quintal	per q.
19	Iron railing (Height and types specified)	meter	per m.
20	Iron grill, collapsible gate (may also be by weight, quintal)	sq. m.	sq. m.
21	Rolling shutter	sq. m.	sq. m.
22	Steel doors and windows (Type and fixing specified)	sq. m.	sq. m.
	Roofing		
1	Tiled roof - Allahabad tile, Faizabad tile, Mangalore tile, etc. including battens	sq. m.	per sq. m.
2	Country tile roof including bamboo jaffria.	sq. m.	per sq. m.
3	Corrugated iron (G.C.I.) roof, Asbestos cement (A.C.) sheet roof	sq. m.	per sq. m.
4	Slate roofing, timber roofing	sq. m.	per sq. m.
5	Thatch roofing including bamboo jaffri (Thickness specified)	sq. m.	per sq. m.
6	Eave Board (Thickness specified	sq. m.	per sq. m.
7	R.C.C., R.B. slab roof (excluding steel)	cu. m.	per cu. m.
8	Lime concrete roof over and inclusive of tiles or brick, or stone slab, etc. (Thickness specified)	sq. m.	per sq. m.
9	Mud roof oer and inclusive of tiles, or bricks or stone slab, etc. (Thickness and type specified)	sq. m.	per sq. m.
10	Ridges, valleys, gutters (Grith specified)	metre	per m.

S. No.	Particulars of Items	Units of Measurement in MKS	Units of payment in MKS
11	Tar felting, Bituminous painting	sq. m.	per sq. m.
12	Insulating layer in roof of sand and clay, asphalt, etc.	sq. m.	per sq. m.
13	Expansion, contraction or construction joint	metre	per m.
14	Ceiling - Timber, A.C. Sheet plain, Cloth, Cement plaster on PM, Paste board, etc.	sq. m.	per sq. m.
15	Centering and shuttering, Form work - Surface area of R.C.C. or R.B. work supported (May also be per cu. m. (cu. ft.) of R.C.C. or R.B. work)	sq. m.	per sq. m.
	Plastering, Pointing and Finishing		
1	Plastering - Cement mortar, Lime mortar, mud, etc. (Thickness, proportion specified)	sq. m.	per sq. m.
2	Pointing - Struck, Flush, Weather, etc.	sq. m.	per sq. m.
3	Dado (Thickness and type specified)	sq. m.	per sq. m.
4	Skirting (Thickness type and height specified)	metre	per m.
5	Cement mortar or lime mortar rubbing	sq. m.	per sq. m.
6	White washing, Colour washing, Cement washing (No. of coat specified)	sq. m.	per sq. m.
7	Distempering (No. of coat specified)	sq. m.	per sq. m.
8	Snow cement washing or finising (No. of coat specified)	sq. m.	per sq. m.
9	Painting, Varnishing (No. of coat specified)	sq. m.	per sq. m.
10	Polishing of wood work (No. of coat specified)	sq. m.	per sq. m.
11	Painting letters and figures (Height specified)	no.	per no.
12	Oiling and clearing of doors and windows	sq. m.	per sq. m.
13	Coal taring (No. of coat specified)	sq. m.	per sq. m.
14	Removing of paint or varnish	sq. m.	per sq. m.
15	Gobri lepping (Cow dung wash)	sq. m.	per sq. m.
	Flooring		
1	2.5 cm (1") C.C. over 7.5 cm (3") L.C. Floor (including L.C.)	sq. m.	per sq. m.
2	Conglomerate floor, artificial patent stone floor 2.5 cm. (1") C.C. over 7.5 cm (3") L.C. (including L.C.)	sq. m.	per sq. m.
3	4 cm (1½") thick stone floor flag stone floor over 7.5 cm (3") L.C. (including L.C.)	sq. m.	per sq. m.
4	2.5 cm (1") marble flooring over 7.5 cm (3") L.C. (including L.C.)	sq. m.	per sq. m.
5	Mosaic or terrazzo or granolithic floor over 7.5 cm (3") L.C. (including L.C.)	sq. m.	per sq. m.
6	Brick flat floor over 7.5 cm (3") L.C. (including L.C.)	sq. m.	per sq. m.
7	Brick on edge floor over 7.5 cm (3") L.C. (including L.C.)	sq. m.	per sq. m.
8	2.5 cm (1") or 4 cm (1½") C.C. floor	sq. m.	per sq. m.
9	Mud flooring finished gobri lepping	sq. m.	per sq. m.

S. No.	Particulars of Items	Units of Measurement in MKS	Units of payment in MKS
10	Apron or Plinth protection (May be of C.C, L.C., brick, etc.)	sq. m.	per sq. m.
11	Door and window sill (C.C. or cement mortar plastered)	sq. m.	per sq. m.
	Miscellaneous Items		
1	Ornamental cornice (Projection, type specified)	metre	per m.
2	Moudling String course, Drip course, Beading, Throating, etc.	metre	per m.
3	Ornamental Pillar caps, Pillar base, Flowers, Brackets, etc.,	no.	per no.
4	Railing (Height and type specified)	metre	per m.
5	Surface drain small (size, material, etc. specified)	metre	per m.
6	Surface drain large (item wise) (i) Masonry	cu. m.	per cu. m.
	(ii) Plastering	sq. m.	per sq. m.
7	Pipe - rainwater, sanitary, water pipe, etc. (Dia. specified)	metre	per m.
8	Laying pipe line - sanitary, water pipe, etc. (Dia, depth, beeding etc. specified)	metre	per m.
9	Jungle clearance (May also be per kn for road and irrigation channel)	sq. m. or hectare	per sq. m. or per hectare
10	Silt clearance in irrigation channels (Similar to earth work) (For thin layer upto 5 cm may be on area basis)	cu. m.	per % cu. m.
11	Trestel, Crate (Size, type, etc. specified)	no.	per no.
12	Cleaning flues	no.	per no.
13	Cotton cords in sky light (May also be by weight in kg)	no	per no.
14	Easing doors and windows	no.	per no.
15	Fixing doors and windows	no.	per no.
16	Supply and fixing of Hinges, Tower bolts, Hasp and staples, Handles, hardwares etc.	no.	per no.
17	Glazing	sq. m.	per sq. m.
18	Glass panes (supply	sq m.	per sq. m.
19	Fixing of glass panes or cleaning	no.	per no.
20	Renewing of glass panes	no.	per no.
21	Well sinking (Masonary or tube well)	metre	per m.
22	Pile driving or sinking	metre	per m.
23	Furniture - Chairs, tables, etc. (size, shape specified)	no.	per no.
24	Painting furniture's	no.	per no.
25	Caning chairs	no.	per no.
26	Pitching of brick, stone, kankar, etc. (Brick pitching may also be on area basis in sq. m.)	cu. m.	per cu. m.
27	Lining of Irrigation Channel, Tunner, etc. Materials, thickness specified (Thick lining may be in volume basis in cu. m.)	sq. m.	per sq. m.
28	Kankar quarrying, kankar supply	cu. m.	per cu. m.
29	Kankar consolidation, road metal consolidation	cu. m.	per cu. m.
30	Dag-belling (May also be per km)	metre	per m.
31	Bituminous road surfacing	sq. m.	per sq. m.
32	Dismantiling	Same as for different iteem	Same as for different iteam

S. No	Particulars of Items	Unitsof Measurement in MKS	Unitsof payment in MKS
33	Desmantling of brick masonry	cu. m.	cu. m.
34	Grouting (Bituminous grouting of road metal, cement grouting of concrete)	sq. m.	per sq. m.
35	Grouting of cracks, joints, etc.	metre	per m.
36	Electric Wiring of Electrification Light, Fan, Plug points	point	per point
37	Water closet (W.C.) Wash hand basin, Manhole, etc. (size specified)	no.	per no.
	Materials		
1	Supply of bricks	% nos	per % nos.
2	Supply of sand, surkhi, cinder, etc.	cu. m.	per cu. m.
3	Supply of cement	bag of 50 kg	per bag or per quintal or per ton
4	Supply of lime unslaked	quintal	per quintal
5	Supply of lime slaked (May also be in volume basis in cu. m.)	quintal	per quintal
6	Supply of brick ballast, stone ballast, Aggregate, etc.	cu. m.	per cu. m.
7	Broken bricks, kankar, etc.	cu. m.	per cu. m.
8	Supply of Timber	cu. m.	per cu. m.
9	supply of steel	quintal	per quintal
10	Supply of Bitumen, Tar	tonne	per tonne
11	Supply of coal	tonne	per tonne
12	Supply of A.C. sheet (measured flat0	sq. m.	per sq. m.
13	Supply of G.I. sheets	quintal	quintal
14	Supply of switches, plugs, ceiling roses, bulbs, brackets, etc.	no.	per no.
15	Supply of insulated electric wire (size specified0	quintal	per quintal
16	Supply of bare electric wire (size specified)	quintal	per quintal
17	Tents, sholdaries (size specified)	no.	per no.
18	Supply of water closet, W.C., (size specified)	no.	per no.
19	Supply of water hand basin (size specified)	no.	per no.
20	Supply of Cowl, Mica valve, Intercepting trap etc. (size specified)	no.	per no.
21	Supply of Bib cock, stop cock, ball cock, etc. (size specified)	no.	per no.
22	Supply of Ferrule, C.I. Tank, Water meter, etc. (size specified)	no.	per no.
23	Supply of pipe, C.I. pipe, S.W. pipe, Hume pipe, A.C. pipe, G.I. pipe, etec. (Dia. specified)	metre	per m.
24	Supply of lead, lead wool	kg or quintal	per kg or per quintal
25	Spun yarn	kg	per kg
26	Supply of varnish, oil, etc.	litre	per litre
27	Supply of paint ready mix	litre	per litre
28	Supply of stiff paint	kg.	per kg.
29	Explosive for blasting	kg.	per kg

Main items of work

1 **Earthwork:** Earthwork in excavation and earthwork in filling are usually taken out separately under different items, and quantities are calculated in cu. m. Foundation trenches are usually dug to the exact width of foundation with vertical sides. Earthwork in excavation in foundation is calculated by taking the dimensions of each trench **l**ength x **b**readth x **d**epth. Filling in trenches after the construction of foundation masonry is ordinarily neglected. If the trench filling is accounted, this may be calculated by deducting the masonry from the excavation.

Earthwork in plinth filling is calculated by taking the internal dimensions in between plinth wall (Length x Breadth) which are usually less than the internal dimensions of the room by two off-sets of plinth wall i.e. 10 cm and height is taken after deducting the thickness of concrete in floor, usually 7.5. If sand filling is done in plinth this should be taken separately. The length and breadth for each filling may be same as the internal dimensions of the room if there is no off-set in plinth wall.

Excavated earth is used in trench filling and plinth filling and usually not paid for separately, but may also be included under a separate item. “Return fill and ram or backfill” and paid at a lesser rate. Extra earth if required for filling is brought from outside. If there is surplus earth after trench and plinth filling, this may be utilised in levelling and dressing of site or carted away and removed.

Lead and lift: Normally earthwork is estimated for 30 m lead for distance and 1.5 m lift for height or depth, and this distance of 30 m and the height of 1.5 m are known as normal lead and lift. Normal rate for earth work is for 30 m lead and 1.5 m lift. For greater lead or lift the rates will be different (higher) for every unit of 30 m lead and for every unit of 1.5 m lift. The earth work is, thereorfe, estimated separately for every 30 m lead and for every 1.5 m lift.

2 **Concrete in-foundation:** The concrete is taken out in cu. m. by length x brreadth x thickness. The length and breadth of foundation concrete are usually the same as for excavation, only the depth or thickness differs. The thickness of concrete varies from 20 cm to 45 cm, usually 30 cm. Foundaton concrete consists of lime concrete or weak cement concrete. The proportion of cement concrete in foundationmay be 1:4:8 or 1:5:10.

3 **Soiling:** When the soil is soft or bad, one layer of dry brick or stone soling is applied below the foundation concrete. The soling layer is computed in sq. m. (Length x Breadth) specifying the thickness.

4 **Damp proof course:** D.P.C. usually of 2.5 cm thick rich cement concrete 1:1½ :3 or 2 cm, thick rich cement mortar 1:2, mixed with standard water proofing material, is provided at the plinth level to full width of plinth wall, and the quantities are computed in sq. m. (Length x Breadth). Usually D.P.C. is not provided at the sills of doors and verandah openings, for which deductions are made. (One kg of Cem-Seal or Impermo or other standard water proofing compound per bag of cement is generally used).

5 **Masonry:** Masonry is computed in cu. m. (Length x Breadth x Height). Foundation and plinth masonry is taken under one item, and masonry in superstructure is taken under a separate item. In storeyed building the masonry in each storey as ground floor above plinth level, first floor, etc. is computed separately. In taking out quantities the walls are measured as solid and then deductions are made for openings as doors, windows, etc. and such other portions as necessary. Masonry of different types or classes, masonry with different mortar, etc. are taken out under separate items. Arch masonry work is taken out separately. Splayed or rounded sides of wall are considered as rectangular and extreme dimensions are taken to find out the quantities. This partition wall is measured in sq. m. Honey comb brick wall is taken under a separate item in sq. m. no deduction is made for holes. Stone masonry is calculated in the same manner as for brick masonry.

Deduction for opening, bearings, etc. in masonry

No deduction is made for the following:

i Opening each up to 1000 sq. cm. or 0.1 sq. m.

ii Ends of beams, posts, rafters, purlins, etc. up to 500 sq. cm. or 0.05 sq. m. in section.

iii Bed plate, wall plate, bearing of chajjas and the like up to 10 cm depth.

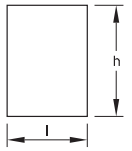
Bearings of floor and roof slabs are made in the following wall masonry.

For other openings deductions are made in the following manner:

Rectangular openings - Full deduction is made (Fig 1)

Deduct - l x h x thickness of wall

Fig 1



RECTANGULAR OPENINGS

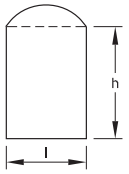
DCN4516911

Doors and windows with small segmental arches (Fig 2)

Deduction is made for rectangular portion only up to the springing line. The segmental portion is considered as solid to allow for the extra expenses in constructing the arch, and the filling up with thin wall.

Deduction - l x h x thickness of wall.

Fig 2



DOORS AND WINDOWS

DCN4516912

Segmental arch openings (Fig 3)

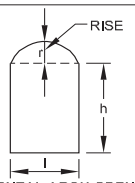
Deduction is made for the whole opening, the rectangular portion as well as the segmental portion.

$$\text{The area of segmental portion} = \frac{2}{3}lr + \frac{r^3}{2l}$$

But for deduction, the area of the sgemental portion is obtained approximately by taking 2/3 of span x rise, (2/3 x l x r) and the quantity for deduction is 2/3 x l x r x thickness of wall. ($r^3/2l$ being small is neglected for simplicity)

$$\text{The total deduction will be} = \left[\left(l + h\right) + \left(\frac{2}{3}xlxr\right)\right]x \left[\text{Thickness of wall}\right]$$

Fig 3



SEGMENTAL ARCH OPENINGS

DCN4516913

Semi-circular arch openings (Fig 4)

The area of semi-circular portion = ½ πr^2

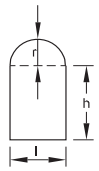
But for the deducation, the area of the semi-circular portion is obtained approximately by ¾ of span x rise, (¾ x l x r).

The total deduction will be = [9l x h) + (¾ x l x r)] x thickness of wall.

Elliptical arches may be considered as semi-circular arches and may be dealt in the same manner.

For large arches the actual area of opening should be calculated correctly by mensuration formulae, and deduction should be made for actual area.

Fig 4



SEMI-CIRCULAR ARCH OPENINGS

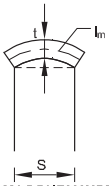
DCN4516914

6 Arch masonry work: Masonry work in arches is calculated in cu. m. separately by multiplying the mean length of the arch by the thickness of arch and by the breadth of the wall (Fig 5).

Quantity of arch masonry = l_m x t x thickness of wall.

Deduction = l_m x t x thinkness of wall.

Fig 5



ARCH MASONRY WORK

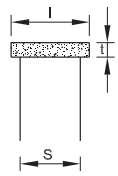
DCN4516915

7 Lintels over openings: Lintels are either of R.C.C. or of R.B. quantities are calculated in cu. m. Length of the lintel is equal to the clear span plus two bearings. If dimension of bearing is not given the bearing may be taken as same as the thickness of lintel with a minimum of 12 cm. Thus, the length of lintel, l = s +2t i.e. clear span plus two bearings (Fig 6).

Quantity of linter = l x t x thickness of wall

Deduction = l x t x thickness of wall

Fig 6



LINTELS OVER OPENINGS

DCN4516916

8 R.C.C. and R.B. work: R.C.C. and R.B. work may be in roof or floor slab, in beams, lintels, column, foundations, etc. and the quantities are calculated in cu. m. Length, breadth and thickness are found correctly from the plan, elevation, and section or from other detailed drawings. Bearings are added with the clear span to get th dimensions. The quantities are calculated in cu. m. exclusive of steel reinforcement and its bending but inclusive of centering and shuttering and fixing and binding reinforcement inposition. The reinforcement including its bending is taken up separately under steel works in quintal. For this purpose 0.6% to 1% (usually 1%) of R.C.C. or R.B. work by volume may be taken for steel, if other details are not given. The volume of steel is not required to be deducted from the R.C.C. or R.B. work.

R.C.C. and R.B. works may also be estimated inclusive of steel and centering and shuttering for the complete works, if specified.

Centering and shuttering (from work) are usually included in the R.C.C. or R.B. work, but may also be taken separately in sq. m. of surface in contct with concrete.

In R.C.C. work plastering is not taken separately, but the exposed surface are finished with thin rich cement sand mortar plastering to give smooth and even surface, which usually is not taken into consideration.

9 Flooring and roofing

i **Ground floor** - the base lime concrete and floor finishing of C.C. or stone or marble or mosaic, etc. are usually taken as one job or one item (combined inone item), and the quantity is calculated in sq. m. multiplying the length by the breadth. The length and breadth are measured as inside dimensions from wall to wall of superstructure. Both the works of base concrete and floor finishing are paid under one item.

ii **1st floor, 2nd floor etc.:** Supproting structure is taken separately in cu. m. as R.C.c., R.B., ect. and the floor finishing is taken separately in sq. m. as 2.5 cm. or 4 cm. C.C. or marble or mosaic, etc, If a cushioning layer of lime concrete is given in between the slab and the floor, the cushioning concrete may be measured with the floor under one item or taken separately.

iii **Roof:** Supporting structure is taken separately in cu. c. and the lime concrete terracing is computed in sq.m. with thickness specified, under a separate item inculding surface rendering smooth. The compacted thickness of lime concrete terracing is 7.5 cm. to 12 cm. average, L.C. terracing may also be calculated in cu. m. with average thickness.

The bearing of roof or floor slab is given same as the thickness of slab, usually 10 cm. to 15 cm.

In case of tiled, galvanised iron sheet, or asbestos cement sheet roofing the roof coverings are taken out in sq. m. and measured that including overlaps with all fittings, and supporting trusses and members are taken under separate item.

Floor of door sills and sills of opening, should also be taken into account. In the case of ground floor, sills should be taken separtely, as there is no lime concrete in sills.

10 Plastering and pointing (Fig 7) : Plastering usually 12 mm thick is calculated in sq. m. For walls the measurements are taken for the whole face of the wall for both sides as solids, and deductions for openings are made in the following manner.

i No deduction is made for ends of beams, post, raffers, etc.

ii For small opening up to 0.5 sq.m. no deduction is made, and at the same time no additions are made for jambs, soffits and of sills of these openings.

iii For openings exceeding 0.5 sq.m. but not exceeding 3 sq. m. deduction is made for one face only, and the other face is allowed for jambs, soffits and sills which are not taken into account separately.

iv For openings above 3 sq. m. deduction is made for both faces of the opening, and the jambs, soffits and sills are taken into account and added.

As the outer jambs, etc. are much smaller than the inner ones, the deduction is usually made from the outer face.

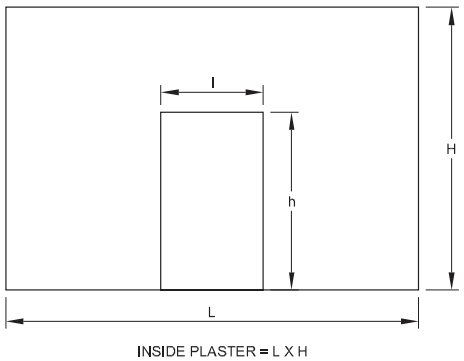
For deduction of arch opening the same principle as for masonry work is followed. Plastering of ceiling usually of 12 mm. thick computed in sq. m. under a separate head as this work is done with richer mortar. For R.C.C. work usually no plastering is allowed but for fair finish a thin plaster of rich cement mortar may be allowed which should not be taken in the measurement separately. Thin rich cement mortar plastering in R.C.C. work may also be taken under a separate item, specially in the ceiling inside room.

Pointing: Pointing in walls is calculated in sq. m. for whole surface and deductions similar to plastering are made.

11 Cornice: Ornamental or large cornice is measured in running metre for the complete work which includes masonry, plastering, mouldings, etc. and paid for in r.m.

Similarly, string course, drip course, cor-belling, coping, etc. are measured and paid for in running metre for the complete work.

Fig 7



12 Pillars: Pillars are taken separately in cu. m. for their net volume and quantities are calculated by correct geometrical measurements by simple mensuration method.

Quantity = Sec. area x ht.

$= \frac{\pi d^2}{4} \times ht.cu.m$ for round pillars, d is the dia.

$=a^2$ x ht. cu.m for square pillars, a is the side.

Hexagonal, octagonal, etc. pillars are dealt similarly.

Plastering in the pillars are calculated in sq. m. multiplying the circumference of perimeter by the height.

13 Doors and windows

i **Chowkhat or Frame:** Door and window frames or chowkhats are computed in cu. m. Length is obtained by adding the length of all the members of the chowkhat, top and two verticals if there is no sill member, and adding bottom also if there is sill, and this length is multiplied by the two dimensions of the cross-section of the member. If there is horn projection, these projections also should be added to the length. If there is no sill member, vertical members should be inserted into the floor by about 2.5 cm to 4 cm.

ii **Door or window leaves or shutters:** They are computed in sq. m. by multiplying the breadth by the height of the shutters, the rebates in the chowkhat should be taken into consideration in finding the breadth and height. A clearance of 6 mm may be allowed at the bottom of the door if there is no sill member. For estimating the clearance may not be taken into consideration, this may be neglected. But for measurement for payment the clearance should be taken into account. The rebates in the chowkhats may be taken as 12 mm to 20 mm. The central overlap is not taken into account.

The name of the timber used, the thickness of shutters, type of shutters and the nature of fittings (iron, brass, etc.) should be noted in the item. Shutters of different types as panelled, glazed; partly panelled and partly glazed, venetian, etc. should be computed separately as the rates differ.

Fittings are computed by number i.e. enumerated. Fittings may be included in the sq. m. rate of shutters. For estimate, the fittings may be taken under a separate item in sq. m. basis of shutters, or a lump sum provision may be made. Hold fasts are taken separately under a separate item by weight or by number.

It is better to purchase the fittings by the department to the choice and requirement, and to get them fitted by the contractors whose rate for shutters shall include the labour for fixing the fittings. In such case the rate of shutters, will exclude the cost of fittings but will include the cost of fixing them. In estimating the cost of fittings will be provided under a separate item fittings of doors and windows on area basis or on lump sum basis for the purchase of fittings.

14 Wood work: Wooden beams, burgahs, posts, wooden roof trusses, chowkhats, etc. come under this item, and the quantities are computed in cu. m. The dimensions of finished work shall be taken.

15 Iron work: This is computed in weight in kg or quintal and the quantities are calculated correctly by multiplying the weights per running metre by the length. The weight per r.m. can be obtained from the steel section book. For steel joint, the length is equal to the clear span plus two bearings, the bearing may be taken 3/4 thickness of wall or 20 cm to 30 cm.

Density of mild steel is equal to 7850 kn/cu. ,. Or 78.5 q/cu., Or 0.785 gram/cu. m.

Weight of iron hold fasts may be taken as 1 ½ kg. each. For doors 6 hold fasts (three on each side).

The weight of bolts and nuts and rivets with heads can be calculated by counting their numbers and sizes and consulting steel table. Sometimes certain percentage of the whole steel work is provided for rivets and bolts and nuts. For steel roof truss 5 percent of the steel work is usually provided for rivets and bolts and nuts.

16 White washing or colour washing or Distempering: The quantities are computed in sq. m. and are usually same as for plastering. The inside is usually white washed or distempered and this item will be same as for inside plaster. The outside is colour-washed and the quantities of colour-washing will be same as for outside plaster. These items need not be calculated separately, but simply written as same as for inside plaster or outside plaster. Numbers of coats of white-washing or colour-washing are taken as one job or work and the rates cover for the number of coats which should not be a multiplying factor. The number of coats should be mentioned in the item. Deductions are dealt in the same manner as for plastering. Other type of surface finishing may also be done and may be taken accordingly.

17 Painting: Painting or Varnishing of doors and windows are computed in sq. m. The dimensions should be taken for outer dimensions of the chowkhat i.e. outer dimensions of doors and windows. The area is measured flat (not girthed). No separate measurement is taken for the chowkhat, the area is same as the area of wall opening. For iron bars, grills, etc. the area of the clear opening inside the chowkhat is taken. For both faces of doors and windows, the simple area as measured above is multiplied by appropriate numbers as below.

i	Pannelled, framed and braced ledged and battened or ledged battened and braced	___	2¼ times one surface area, for both sides.
ii	Fully glazed or gauged	___	1 time one surface area, for both sides.
iii	Partly panelled and partly glazed or gauged	___	2 times one surface area, for both sides.
iv	Flush door	___	2 times one surface area, for both sides.

v	Venetian	___	3 times one surface area, for both sides.
vi	Iron bars, grills in windows	___	1 time the are of clear opening in between chowkhat for over all.

This covers also for chowkhats on three faces. Painting is done in two or three coats. Usually over a coat of priming. The rate covers for the number of coats under one item. The number of coats should be mentioned in the description of item.

(The multiplying factors differ slightly from State to State. IS 1200 should be followed).

The concealed surface of the chowkhat which is in contact with the jamb of the wall is usually painted with two coats of coal tar or solignum, and this item is computed separately.

For beams, rafters, purlins, posts, etc., of timber or iron, the area of actual exposed surface is taken for painting.

Corrugated surface is taken as flat and a percentage increase is allowed.

Lump-sum-item – sometimes a lump-sum rate is provided for certain small items for which detailed quantities cannot be taken out easily or it takes sufficient time to find the details, as front architectural or decoration work of a building, fire-place, site cleaning and dressing etc.

Electrification and Sanitary and Water supply Works: For Sanitary and Water supply works 8% and for Electrification 8% of the estimated cost of the building works are usually provided in estimate.

Methods of building estimate

The dimensions, length, breadth and height or depth are to be taken out from the drawing – Plan, Elevation and Section. From the study of the drawings, the building is to be imagined and pictured in the mind and the dimensions are to be taken out correctly. There is no hard and fast rule for finding out dimensions from the drawing but the dimensions are to be taken out accurately. Junctions of wall at the corners and at the meeting points of the walls require special attention.

For symmetrical foundation which is the usual case, earth work in excavation in foundation, foundation concrete, brickwork in foundation and plinth, and brickwork in superstructure may be estimated by either of the following two methods.

Method I

Separate or individual wall method – In this method, measure of find out the external length of walls running in the longitudinal direction generally the long walls out-to-out, and the internal lengths of walls running in the transverse direction in-to-in i.e. of cross or short walls, in-to-in, and calculate quantities multiplying the length by the breadth and the height of wall. The same rule applies to the excavation in foundation, to concrete in foundation and to masonry. Care should be taken to not the difference in dimensions at different height due to offset, or footings. It is convenient to imagine plans at different level of heights as foundation trench plan, foundation concrete plans of each footing, etc. and dealing each plan or part separately.

The simple method to take the long walls and short or cross walls separately and to find out the centre to centre lengths to long walls and short walls from the plan. For symmetrical footing on either sides, the centre line remains same for super structure and for foundation and plinth.

For long walls add to the centre length one breadth of wall, which gives the length of the wall out-to-out, multiply this length by the breadth and the height and get the quantities. Thus for finding the quantities of earthwork in excavation, for length of the trench out-to-out add to the centre length one breadth of foundation. Adopt the same process for foundation concrete, and for each footing. It should be noted that each footing is to be taken separately and the breadth of the particular footing is to be added to the centre length.

$$\begin{pmatrix}\text{Long wall length}\\ \text{out – to – out}\end{pmatrix} = (\text{Centre to centre length}) + (\text{half breadth on one side}) + (\text{half breadth on the other side})$$

$$= (\text{Centre to centre length}) + (\text{One breadth})$$

For short or cross walls subtract (instead of adding) from the centre length one breadth of walls, which gives the length in-to-in, and repeat the same process as for the long walls, subtracting one breadth instead of adding.

$$\begin{pmatrix}\text{Short wall length}\\ \text{in – to – in}\end{pmatrix} = (\text{Centre to centre length}) - (\text{one breadth})$$

That is, in case of long wall add one breadth and incase of short wall subtract one breadth from the centre length to get the corresponding lengths.

This method is simple and accurate and there is no chance of any mistake. This method may be named as LONG WALL and SHORT WALL method or general method.

Method II

Centre line method: In this method known as centre line method sum-total length of centre lines of walls, long and short, has to be found out. Find the total length of centre lines of walls, of same type, long and short having same type of foundations and footings and then find the quantities by multiplying the total centre length by the respective breadth and the height. In this method, the length will remain same for excavation in foundation, for concrete in foundation, for all footings and for superstructure (with slight difference when there are cross walls or number of junctions). This method is quick but requires special attention and consideration at the junctions, meeting points of partition or cross walls, etc.

Centre line length of each items = c/c length - no. of junctions x half width of each item.

This centre line long the multiplied by the width and height gives the quantity of each items.

For rectangular, circular polygonal (hexagonal, octogonal, etc.) buildings having no inter or cross walls, this method is quite simple. For buildings having cross or partition walls, for every junction or partition or cross walls with main wall, special consideration shall have to be made to find the correct quantity. For each junction half breadth of respective item or footing is to be deducted from the total centre length. Thus in the case of a building with one partition wall or cross wall having two junctions, for earthwork in foundation trench and foundation concrete deduct one breadth of trench or concrete from the total centre length (half breadth for one junction and one breadth (2 x ½ = one for two junctions). For footings, similarly deduct one breadth of footing for two junctions from the total centre length, and so on. If two walls come from opposite directions and meet a wall at the same point, then there will be two junctions.

For building having different types of walls, each set of walls shall have to be dealt separately. Find the total centre length of all walls of one type and proceed in the same manner as described above. Similarly find the total centre length of walls of second type and deal this separately, and so on.

Rate analysis - labour - materials - schedule of rates

Objectives: At the end of this lesson you shall be able to
- **enlist the purpose and necessity of rate analysis**
- **define rate analysis**
- **define task and task of different labours**
- **calculate the quantity of materials of different items of work**
- **prepare analysis of rate.**

Analysis of rates

The determination of rate per unit of a particular item of work, from the cost of quantities of materials, the cost of labourers and other miscellaneous petty expenses require for its completion is known as the analysis of rate. A reasonable profit, usually 10% for the contractor is also included in the analysis of rate. Rates of materials are usually taken as the rates delivered at the site of work and include the first cost (cost at origin), cost of transport, railway freight if any, taxes, etc. If the materials are to be carried from a distant place, more than 8 kms. then cost of transport is also added. The rates of materials and labour vary from place to place and therefore, the rates of different items of work also vary from place to place.

For the purpose of analysis, the details about all the operations involved in carrying out the work should be available, the quantities of materials required and their costs should be known and the number of different categories of labourers required and the capacity of doing work per labourer and their wages per day should be known. These can be known only from experience of practical works.

The rates of a particular item of work depends on the following:

i Specifications of works and materials, quality of materials, proportion of mortar, method of constructional operation, etc.

ii Quantities of materials and their rates, number of different types of labourer and their rates.

iii Location of the site of work and its distances from the sources of materials and the rate of transport, availability of water.

iv Profits and miscellaneous and overhead expenses of contractor.

Overhead costs: Overhead costs include general office expenses, rents, taxes, supervision and other costs which are indirect expenses and non productive expenses on the job.

The miscellaneous expenses on overheads may be under the following heads:

A General overheads

i Establishment (Office, Staff)

ii Stationary, Printing,Postages, etc.

iii Travelling expenses.

iv Telephone

v Rent and taxes.

B Job overheads

i Supervision (Salary of Engineers, Oversers, Supervision, etc.)

ii Handling of materials.

iii Repairs, carriage and depreciation of T and P.

iv Amenities of labour.

v Workmen's compensation, insurance, etc.

vi Interest on investment

vii Losses on advances.

The contractor may be allowed a net profit of 6 to 8 percent, and the miscellaneous overhead expenses may come to about 5 to 10 percent. For overhead expenses and contractors profit 15 percent of the actual cost may be reasonable amount but it is usual practice to add 10 percent for all these under the head profit. For small works overhead cost may be very little.

The analysis of rate is usually worked out for the unit of payment of the particular item of work under two heads.

i Materials and

ii Labour

and their costs added together give the cost of the items of work. The costs of the materials as delivered at site inclusive of the transport, local taxes and other charges. For tools and plants (T. and P.) and miscellaneous petty items (sundries) which cannot be accounted in details lump-sum provision is made. A provision for water charges @ 1½ of the total cost is made in the rate. Adding 10% to this cost as contractor's profit, the rate per unit of the item of work is obtained. If transport of matrials is to be done from a distant place more than 8 km analysis of transport work may be done separately. If cement and steel are supplied by the department and the contractor is not to

invest any money on these, 10% profit it is not allowed on cement and steel. The cost of carriage of cement and steel from the godown to the site of work should be allowed to the contractor. But if cement and steel are to be arranged by the contractor for 10% should be added as profit on these materials also. 10% profit may be added over the whole cost of labour and materials including cement and steel, if it is not specified that these will be supplied departmentally.

Rate: Rates of different items in the estimate are the current rates for the completion of the items of work which include supply of materials, transport, labour scaffolding, overheads, contractor's profit, taxes, etc. The rates are usually taken from the P.W.D. "Schedule of Rates.:

Task or Out-turn work

Task: The capacity of doing work by an artisan or skilled labour in the form of quantity of work per day is known as the task-work or out-turn of the labour.

The out-turn of work per artisan varies to some extent according to the nature, size, height, situation, location, etc. In bigger cities where specialised and experienced labour is available the out-turn is greater that small towns and country sides. In well-organized work less labour is required.

The following may be taken as the approximate quantity of work or out-turn or task for an average artisan per day.

S. No.	Particulars of items	Quantity	Per day
1	Brickwork in lime or cement mortar in foundation and plinth	1.25 cu. m.	(45 cu. ft.) per mason
2	-Do- in superstructure	1.00 cu. m.	(35 cu. ft.) per mason
3	Brickwork in mud mortar in foundation and plinth	1.50 cu. m.	(55 cu. ft.) per mason
4	-Do- in superstructure	1.25 cu. m.	(45 cu. ft.) per mason
5	Brick in cement or lime mortar in arches	0.55 cu. m.	(20 cu. ft.) per mason
6	-Do- in jack arches	0.55 cu. m.	(20 cu. ft.) per mason
7	Half brick wall in partition	5.00 sq. m.	(50 sq. ft.) per mason
8	Coursed rubble stone masonry in lime or cement mortar Including dressing	0.80 cu. m.	(30 cu. ft.) per mason
9	Random rubble stone masonry in lime or cement mortar	1.00 cu. m.	(35 cu. ft.) per mason
10	Ashlar masonry in lime or cement mortar	0.40 cu. m.	(15 cu. ft.) per mason
11	Stone arch work	0.40 cu. m.	(15 cu. ft.) per mason
12	Lime concrete in foundation or floor	8.50 cu. m.	(300 cu. ft.) per mason
13	Lime concrete in roof terracing	6.00 cu. m.	(200 cu. ft.) per mason
14	Cement concrete 1 : 2 : 4	5.00 cu. m.	(175 cu. ft.) per mason
15	R.B. work	1.00 cu. m.	(32 cu. ft.) per mason
16	R.C.C. work	3.00 cu. m.	(125 cu. ft.) per mason
17	12 mm (½") plastering with cement or lime mortar	8.00 sq. m.	(80 sq. ft.) per mason
18	Pointing with cement or lime mortar	10.00 sq. m.	(100 sq. ft.) per mason
19	White washing or colour washing three coats	70.00 sq. m.	(700 sq. ft.) per washer
20	White washing or colour washing one coat	200.00 sq. m.	(2000 sq. ft.) per washer
21	Painting or varnishing doors or windows one coat	25.00 sq. m.	(250 sq. ft.) per painter
22	Coal tarring or solignum painting one coat	35.00 sq. m.	(350 sq. ft.) per painter
23	Painting large surface one coat	35.00 sq. m.	(350 sq. ft.) per painter
24	Distempering one coat	35.00 sq. m.	(350 sq. ft.) per painter
25	2.5 cm (1J C.C. floor	7.50 sq. m.	(75 sq. ft.) per painter
26	Flag stone floor laying with lime or cement mortar Excluding L.C.	10.00 sq. m.	(100 sq. ft.) per mason
27	Terrazo floor 6 mm thick mosaic work over 2 cm thick Cement concrete (1 : 2 : 4)	5.00 sq. m.	(50 sq. ft.) per mason

S.No.	Particulars of items	Quantity	Per day
28	Brick-on-edge in floor lime or cement mortar excluding L.C.	7.00 sq. m.	(70 sq. ft.) per mason
29	Brick flat floor as in above	8.00 sq. m.	(80 sq. ft.) per mason
30	Timber framing sal or teak wood	0.07 cu. m.	(2.5 cu. ft.) per carpenter
31	-Do- in country wood	0.15 cu. m.	(5 cu. ft.) per carpenter
32	Door and window shutters panelled or glazed	0.15 sq. m.	(1.5 sq. ft.) per carpenter
33	-Do- battened	0.80 sq. m.	(8 sq. ft.) per carpenter
34	Sawing of hard wood	4.00 sq. m.	(40 sq. ft.) per pair of sawers
35	Sawing of soft wood	6.00 sq. m.	(60 sq. ft.) per pair of sawers
36	Single Allahabad tiling or Mangalore tiling	6.00 sq. m.	(60 sq. ft.) per tile layer
37	Double Allahabad tiling	4.00 sq. m.	(40 sq. ft.) per tile layer
38	Breaking of brick ballast 40 mm (1½") gauge	0.75 cu. m.	(30 cu. ft.) per labourer or breaker
39	Breaking of stone ballast 25 mm (1") gauge	0.55 cu. m.	(20 cu. ft.) per labourer or breaker
40	Breaking of stone ballast 40 mm (1½") gauge	0.40 cu. m.	(10 cu. ft.) per labourer or breaker
41	Breaking of stone ballast 25 mm (1") gauge	0.25 cu. m.	(10 cu. ft.) per labourer or breaker
42	Ashlar stone dressing	0.70 cu. m.	(25 cu. ft.) per stone Cutter
43	Flag stone dressing	1.50 sq. m.	(15 sq. ft.) per stone Cutter
44	Earth work in excavation in ordinary soil	3.00 cu. m.	(100 cu. ft.) per beldar Mazdoor
45	Earth work in excavation in hard soil	2.00 cu. m.	(75 cu. ft.) per beldar Mazdoor
46	Excavation in rock	1.00 cu. m.	(35 cu. ft.) per beldar Mazdoor
47	Sand filling in plinth	4.00 cu. m.	(140 cu. ft.) per beldar Mazdoor
48	Number of bricks laid by a mason in brick work upto a Height of 3 m (10')	600bricks per mason	
49	Amount of work done by a mazdoor (helper) per day		
	i Mix	3 cu. m.	(100 cu. ft.) mortar per mazdoor
	ii Deliver brick	4000 nos. to a distance of 15 m (50')per mazdoor	
	Iii Deliver mortar	5.5 cu.m.	per mazdoor
50	Scaffolding cost for single storey building	Re.0.50	(Rs.1.5% cu. ft. of Per cu. m.brickwork)

Calculation of materials

Concrete

Calculation of materials for various items of works is done for the analysis of rates for the required item. Various mixes of cement concrete are used for different items of concrete such as 1:7:20, 1:8:16, 1:6:12, 1:4:8, 1:3:6, 1:2:4, 1:1½:3 etc. It is observed by the experiments and experience that the volume of dry materials required for one cu. m. of wet concrete are 1.52 cu. m. to 1.54 cu. m. because when water is added to dry mix, the cement goes into the voids of sand and both together go into the voids of aggregates to become a solid compact mass of concrete. So the quantities of various materials in a given concrete mix are calculated as under:

Let, C = Quantity of cement in cu. m.

S = Quantity of sand in cu. m.

A = Quantity of aggregate in cu. m.

The quantities of dry materials required for one cu. m. of consolidated for finished concrete are:

$$\text{Cement}(C) = \frac{1.54xC}{(C+S+A)} \text{cu.m.}$$

$$\text{Sand}\,(S) = \frac{1.54\,x\,S}{(C+S+A)} \text{cu.m.}$$

$$\text{Aggregates}\,(A) = \frac{1.54\,x\,A}{(C+S+A)} \text{cu.m}$$

Where (C + S + A) is the sum of the ratios in a mix of concrete i.e. in a concrete of mix 1:6:12, cement is taken 1, sand as 6 and aggregates 12 and sum of these ratios is, C + S + A = 1 + 6 + 12 = 19.

1 cu. m. of Portland cement = 30 bags (for practical purposes)

Quantity	**Per day**
4.00 cu.m.	per beldar (140 cu.ft) mazdoor
600 bricks per mason	
3 cu.m	(100 cu.ft) mortar per mazdoor
4000 nos to a distance of 15m (50') per mazdoor 5.5 cu.m (200 cu. ft) per mazdoor	
Re.0.50 per cu.m.	(Rs. 1.5% cu.ft. of brickwork)

1 bag of cement of 50kg- $\frac{1}{30}$ cu.m=0.034 cu.m

Example 1: find out the quantity of dry materials in a concrete mix 1 : 2 : 4

Quantity of dry materials required for one cu. m. of finished concrete = 1.54 cu. m.

Sum of ratio of ingredients in mix of 1:2:4

(C + S + A) = 1 + 2 + 4 = 7

$$\text{Quantity of Cement} = \frac{1.54\,x\,C}{(C+S+A)}$$

$$= \frac{1.54\,x\,1}{7} = 0.22\,\text{cu.m. or } 6.4\,\text{bags}$$

$$\text{Quantity of Sand} = \frac{1.54\,x\,S}{C+S+A)}$$

$$= \frac{1.54\,x\,2}{7} = 0.44\,\text{cu.m.}$$

$$\text{Quantity of Aggregate} = \frac{1.54\,x\,A}{(C+S+A)}$$

$$= \frac{1.54\,x\,4}{7} = 0.88\,\text{cu.m.}$$

Quantity of materials for brick work

Brick work masonry is constructed either in mud, or lime surkhi or cement sand mortar. Various mixes of mortars are used in construction of brick masonry such as cement sand mixes of 1:2, 1:3, 1:4, 1:5, 1:6 and 1:7 etc. in which first figure denotes the cement and the second as sand. In case of lime mortar, the binding material is lime and surkhi is added in it in certain ratio to prepare lime surkhi mortar. Ratio of such mix may be 1:2, 1:3 etc. Sometimes lime sand surkhi mortar in the ration of 1:1:2 is prepared.

Dry materials required for cement sand mortar for 1 cu. m. of brick masonry = 0.30 cu. m.

[Volume of brick masonry – total volume of bricks = $1m^3$ – 500 x (0.19 x 0.09 x 0.09) = 0.25 m^3

To get dry volume, increase the wet volume by 20%]

Wet materials required for 1 cu. m. of brick work – 0.25 cu. m.

$$\text{Factor to convert wet mortar into dry mortar} = \frac{0.30}{0.25} = 1.2$$

No. of metric bricks with size 20 cm x 10 cm x 10 cm required for one cu. m. = 500 Nos

Dry mortar required = 0.30 cu. m.

Example 2; Find out the quantity of cement, sand and bricks required for a brick masonry of 1 cu. m. in cement sand mortar of 1:5.

As given above, the No. of bricks for 1 cu. m. brick work = 500.

Quantity of dry mortar required = 0.30 cu. m.

Ratio of ingredients i.e. Cement : Sand = 1:5

Sum of ingredients = 1+5=6

$$\therefore \text{Cement required} = \frac{0.30x1}{(1+5)}$$

$$= 0.05\text{cu.m or } 1.5\text{ bags}$$

$$\text{Sand required} = \frac{0.30x1}{(1+5)} = 0.25\text{ cu.m}$$

Random rubble masonry and coursed rubble masonry

1 Material required for 1 cu. m. is:

i Stone including waste – 1.25 cu. m.

ii Mortar (Dry) – 0.4 cu. m.

Ashlas masonry

2 Material required for 1 cu. m. is:

i Stone including wastage – 1.25 cu. m.

ii Mortar (Dry) – 0.25 cu. m.

Plastering

Calculation of quantity of mortar and materials

Area x thickness gives the quantity of mortar for uniform thickness, for filling up the joints and to make up ununiform surface of wall, this may be increased by 30% which will get wet mixed mortar. To get the total dry volume of ingredient materials or mortar the wet volume may be further increased by 25%. The quantities of each material of the mortar may be found by usual methods, dividing the dry volume of mortar by the sum of the numerals of the proportions and multiplying by the individual numerals.

Materials for 12 mm thick plastering in wall for 100 sq. m.

Wets mixed mortar for uniform layer = 1.2 cu.m. Adding 30% to fill up joints, uneven surfaces, etc. the quantity of mortar comes to 1.2+0.36=1.56 CU. M. Increasing by 25% the total dry volume=1.95 cu.m. 2.00 cu.m. (say).

For 1:6 cement sand mortar, Cement=2/1+6=0.30 cu. m., sand=0.30 x 6=1.80 cu.m. Similarly, the quantities of materials for other proportions may be calculated. The quantities of materials for different proportions are given in the following pages.

Materials for 20 mm thick plastering in wall for 100 sq. m.

As the thickness of plaster is more, 20% of mortar may be taken to fill up the joints, unevenness etc. The quality of wet mortar is equal to 200 x 0.02 + 20% =2.00+0.40 = 2.40 cu. m. Increasing by 25% the dry volume=2.40+ 0.60=3.00 cu. m. the quantities of each material of mortar may be found by usual method.

Rich mortar

For rich mortar plastering, the quantities of materials will be less as the cement will be in excess than the voids in sand and the reduction in volume of dry mortar will be less.

Ceiling plastering 12mm thick for 100sq. m.

For plastering in R.C.C. ceiling the unevenness of surfaces will be less and 20% extra mortar may be taken to get even surface. The quantity of wet mortar is equal to 100x0.012+20%=1.2+0.24=1.44 cu.m. Increasing by 25% the dry volume=1.44+0.36=1.80 cu. m.

For 6mm thick plastering R.C.C. ceiling the quantity of dry mortar may be taken as 1.00 cu. m.

For plastering in floor over lime concrete the same quantity of mortar as for wall may be taken as there will be sufficient unevenness in the surface of lime concrete.

Neat cement flooring

For neat cement finishing in floor or dado or skirting, the thickness of neat cement layer may be taken as 1.5mm thick, therefore, the cement paste requirement for 100 sq. m.=100 x 0.0015 = 0.15 cu. m. Dry volume of cement increased by 25%=0.15+0.15x ¼ =0.19cu.m.2 cu. m. (say) 6 bags per 100 sq. m.

Pointing

For pointing in brickwork, the total volume of materials (dry mortar) is taken as 0.60 cu.m. for 100 sq. m. for raised pointing quality may be increased by 10%.

Materials for different items of works

The requirement of materials for different items of works is as given below:

In practice for analysis of rates the reduction in volume of finished concrete over the sum total volume of ingredient materials is taken as 50% to 55%. For 100 cu. m. of finished concrete the sum total volume of dry ingredient materials may be taken as 152 cu.m. to 154 cu.m.

S. No.	Particulars of items	Quantity
1	Bricks (9" x 4½" x 3"or 20 cm x 10 cm x 10 cm nominal size) For brick work	50000 Nos per % cu. m. (500 nos per cu. m.)
2	Dry mortar for brickwork 30%	30 cu. m. for 100 cu. m.
3	Stone for rubble stone masonry 125 %	125 cu. m. for 100 cu. m.
4	Dry mortar for rubble stone masonry 42%	42 cu. m. for 100 cu. m.
5	Bricks or brick-ballast for lime concrete	37000 Nos for 100 cu. m.
6	Brick-bats or brick-ballast for lime concrete	105 cu. m. for 100 cu. m.
7	Brick ballast for lime concrete	100 cu. m. for 100 cu. m.
8	Dry mortar for lime concrete in foundation and floor 35%	35 cu. m. for 100 cu. m.
9	Dry mortar for lime concrete in roof terracing 45%	45 cu. m. for 100 cu. m.
10	Materials for cement concrete 1:2:4	
	Ballast or grit 88%	88 cu. m. for 100 cu. m.
	Sand 44%	44 cu. m. for 100 cu. m.
	Cement 22%	22 cu. m. (60 bags) for 100 cu. m.
11	Materials for 2.5 cm (1") c.c. 1:2:4 floor	
	Stone grit	2.40 cu. m. for 100 cu. m.
	Sand	1.20 cu. m. for 100 cu. m.
	Cement	0.80 cu. m. (24 Bags) for 100 cu. m.
12	Bricks for R.B. work	(420 Nos for cu. m.) 42000 Nos Per cu. m.
13	Dry mortar for R.B. work 45%	45 cu. m. for 100 cu. m.
14	Dry mortar for 12 mm (½") plastering	2.00 cu. m. for 100 sq. m.
15	Dry mortar for pointing in brickwork	0.60 cu. m. for 100 sq. m.
16	Lime for white washing one coat	10 kg for 100 sq. m.
17	Dry distemper for 1st coat	6 ½ kg for 100 sq. m.
18	Dry distemper for 2nd coat	5 kg for 100 sq. m.
19	Snow-cem for 1st coat	30 kg for 100 sq. m.
20	Snow-cem for 2nd coat	20 kg for 100 sq. m.
21	Paint ready mixed for painting one coat	10 litre for 100 sq. m.
22	Paint (stiff) for painting one coat	10 kg for 100 sq. m.
23	Bricks (20 x 10 x 10 cm for brick floor or half brick wall)	5000 Nos. for 100 sq. m.
24	Dry mortar for brick floor or half brick wall	3.20 cu. m. for 100 sq. m.
25	Brick (9"x4½"x3") for brick flat floor	3500 Nos for 100 sq. m.
26	Dry mortar for brick flat floor	2.25 cu. m. for 100 sq. m.
27	Bricks (9"x 4½"x3) required for Honey comb wall	3250 Nos for 100 sq. m.
28	Dry mortar for Honey comb wall	2.25 cu. m. for 100 sq. m.

S. No.	Particulars of items	Quantity
29	Materials for 2 cm (¾") thick damp proof course of 1:2 cement mortar –	
	Cement	0.90 cu. m. (27 bags) for 100 sq. m.
	Sand	1.80 cu. m. for 100 sq. m.
	Composeal or Impermo @ 1 kg per bag of cement	25 kg for 100 sq. m.
30	Materials for 2.5 cm (1") thick c.c. 1:1½:3 Damp proof course	
	Stone grit	2.25 cu. m. for 100 sq. m.
	Sand coarse	1.13 cu. m. for 100 sq. m.
	Cement	0.75 cu. m. (22½ bags) for 100 sq. m.
	Composeal or Impermo @ 1 kg per bag of cement	22½ kg for 100 sq. m.
31	Bitumen or Asphalt for painting on D.P.C. or on roof	
	1st Coat	150 kg for 100 sq. m.
	2nd Coat	100 kg for 100 sq. m.
32	G.C.I. sheet for roof	128 sq. m. for 100 sq. m.
33	A.C. corrugated sheet for roof	115 sq. m. for 100 sq. m.
34	Timber for panelled door shutter 4 cm (1½") thick	4.5 cu. m. for 100 cu. m.
35	Timber for battened door shutter 4 cm (1½") thick	4.0 cu. m. for 100 sq. m.
36	Timber for partly panelled and glazed shutter (1½") thick	2.0 cu. m. for 100 sq. m.

Materials required for cement concrete of different proportions for 100 cu. m.

Proportion by volume	Cement (cu.m.)	Sand (coarse) (cu.m.)	Corse aggregate (Stone) (cu.m.)	Quantity of concrete mixed with water (cu.m.)
1 : 2 : 4	21	42	84	100
1 : 2 : 5	17.2	34.40	86	100
1 : 3 : 6	14.00	44.00	88	100
1 : 4 : 8	11.25	45.00	90	100
1 : 5 : 10	9.20	46.00	92	100

Schedule of rates

It is a printed list of rates of various items of work for preparing detailed estimates and is maintained by the engineering department. It is in a book form and is called as "schedule of rates book". These rates are prepared on the basis of analysis of rates. As these rates vary year after year, therefore, a premium of fixed percentage is allowed on the schedule of rates. If the variation in the workable rates and schedule of rates is much more the revision of rates is done and a new revised schedule of rates is prepared.

Preparing of analysis of rates

From the information regarding out-turn, materials requirements, rates, etc. the analysis of rates of different items of works may be worked out. The number of mazdoors, coolies, bhishties, etc. may be adopted from the general ideas and different operations of construction of the particular item of work. As for example, for brickwork 1½ to 2 mazdoors or helper may be taken per mason; for lime concrete in foundation mason's work is very little, but requirement of mazdoor is greater for mixing, carrying, laying, ramming, etc., for lime concrete in roof terracing requirement of mazdoor is still greater for beating a number of days.

For mortar and concrete, the ingredient materials such as lime, cement, sand, surkhi, stone and brick aggregates, etc., have voids varying from 40% to 50% and the finer ingredient to fill up the voids in the coarse ones. For rich mortar or rich concrete the finer ingredients are in excess of the volume of voids in the coarser ones, hence the volume of the finished mortar or concrete will increase.

Dry volume of materials of mortar concrete, as taken in the calculation of analysis of rates, means sum total volume of each ingredient added together. In working out analysis of rates labour has been taken on daily wages basis for 8 hours working a day. When full day for a particular labourer is not required one labourer has to work part of a day, in such cases part labour of labourer has been taken into account. For example, one labourer for half day is equivalent to half labourer per day.

Rates worked out are for one storey building (Ground floor). Beyond one storey the rates may be increased by 1% for every subsequent storey. Height of one storey may be taken as 3.5 m to 4 m.

Analysis of rates

1 Lime concrete in foundation with 40 mm gauge brick ballast unit 1 cu. m. Take – 10 cu. m.

With white lime and surkhi 1:2 (Proportion – 16:32:100, i.e., 1:2:6 approx.)

Particulars	Qty. or Nos	Rate*	Cost
Materials			
Brick ballast 1st class 40 mm gauge	10 cu. m.	650.00 cu. m.	6500.00
White lime slaked	1.6 cu. m.	800.00 cu. m.	1280.00
Surkhi	3.2 cu. m.	500.00 cu. m.	1600.00
		Total	9380.00
Labour			
Matrial (Head Mason)	½ No.	350.00 per day	0175.00
Mason	1 No.	300.00 per day	0300.00
Mazdoor (Beldar)	12 Nos	220.00 per day	2640.00
Boy or woman coolie	12 Nos	200.00 per day	2400.00
Bhishti (Water-Man)	2 Nos	200.00 per day	0400.00
Sundries T. and P. etc. (Misc., Petty things)	Lump Sum	100.00 L.S.	0100.00
		Total	6012.00
		Total of materials and labour	15395.00
		Add 1½ % Water Charges	231.00
		Add 10% Contractor's Profit	1539.50
		Grand Total for 10 cu. m.	17165.50

Rate per cu. m. = 17165.50/10 = Rs.1716.50

***Rates may vary accordingly to the schedule of rates of different states**

Approximate calculation of materials for 100 cu. m. L.C. 1:2:6, Lime = 150/(1+2+6) 16.6 cu. m.

Specification

Objectives: At the end of this lesson you shall be able to
- **define and describe the importance of specifications**
- **classify the specification**
- **describe the general specification**
- **explain the detailed specification**
- **calculate the area and volume at irregular boundary.**

Specification: Specification specifies or describes the nature and the class of the work, materials to be used in the work, workmanship, etc. and is very important for the execution of the work. The cost of a work depends much on the specifications. Specifications should be clear, and there should not be any ambiguity anywhere. From the study of the specifications, one can be easily understand the nature of the work and what the work shall be. The drawings of the building or structure show that arrangement of the rooms and various parts and the dimensions - length, breadth and height with brief descriptions of different parts. Drawings do not furnish the details of different items of work, the quantity of materials, proportion of mortar and workmanship which are described in specifications. Thus the combinations of drawings and specifications define completely the structure. Drawings and specifications form important parts of contract document.

During writing specification attempts should be made to express all the requirement of the work clearly and in a concise form avoiding repetition. As far as possible, the clauses of the specification whould be arranged in the same order in which the work will be carried out. The specifications are wirtten in a language so that they indicate what the work should be, and words “shall be” or “should be” are used.

Specifications depend on the nature of the work, the purpose for whch the work is required, strength of the materials, availability of materials, quantity of materials etc.

Specifications are of two types

1 General specification or brief specification and

2 Detailed specification

General or brief specification: General specification gives the nature and class of the work and materials in general terms, to be used in the various parts of the work, from the foundation to the supersturcture. It is a short description of different parts of the work specifying materials, proportions, qualities, etc. General specifications give general idea of the whole work or structure and are useful for preparing the estimate.

For general idea, the general specifications of different class of the buildings are given below. These will of course vary according to the necessity and type of works.

General specifications of different class of buildings is as follows:

1 First class bulding: The first class building specifications are as follows.

S. No.	Items	Details
1	Foundation and Plinth	It shall be of first class brickwork (or random rubble masonry) in lime mortar or 1:6 cement mortars over lime concrete or 1:4:8 cement concrete
2	Damp Proof Course	It shall be 2.5 thick cement concrete 1:1.5:3 mixed with water proofing materials and painted with two coats of bitumen
3	Super Structure	It shall be of 1st class brick with lime mortar or 1:6 cement mortar. Lintels shall be of R.C.C.
4	Roofing	Roof shall be of R.C.C. slab with an insulation layer. Height of rooms not less than 3.7 m.
5	Flooring	Drawing and dining room floors shall be of mosaic, bath room and W.C. floors and dado shall be of mosaic. Bedroom shall be coloured and polished of 2.5 cm cement concrete over 7.5 lime concrete. Floor of others shall be of 2.5 cm. Cement concrete 7.5 cm. Lime concrete polished.
6	Finishing	Inside and outside walls shall be of 12 mm. Cement lime plastered 1:1:6 Drawing, Dining and Bed rooms inside shall be distempered and other inside white washed 3 coats. Outside shall be coloured snow cem washed 2 coats over 1 coat of white wash

S. No.	Items	Details
7	Doors and windows	Frame shall be teak wood. Shutters shall be teak wood 4.3 cm, thick panelled or partly glazed with additional wire gauge shutters. All fittings shall be of brass. Doors and windows shall be varnished or pained two coats with enamel paints over one coat or priming. Windows shall be provided with iron grills. Rain water pipes, 1st class sanitary and water fittings and electrical installations shall be provided. 1 metre wide 7.5 cm, thick c.c. 1 : 3 : 6 aprons shall be provided all around the building.
8	Miscellaneous	

2. Second class buildings: The second class building specifications are as follows

S. No.	Items	Details
1	Foundation and plinth	Foundation and plinth shall be of 1st class brickwork cement mortar over lime concrete
2	Damp proof course	It shall be of 2 cm. thick cement concrete 1 : 2 : 4 mixed with standard water proofing materials.
3	Superstructure	It shall be of 2nd class brick with lime mortar. Lintels shall be of R.B.
4	Roofing	Roof shall be of R.B. slab with 7.5 cm. Lime concrete terracing above. Verandah roof may be of A.C. sheet or Allahabad tiles.
5	Flooring	Floor shall be 2.5 cm. cement concrete over 7.5 L.C. verandah floor shall be of brick tiles finished cement pointed.
6	Finishing	Inside and outside walls shall be of 12 mm. Cement mortar plastered 1 : 6 ceiling shall be cement pastered 1 : 3.
7	Doors and windows	Frame shall be of R.C.C. or well seasoned sal wood, shutter of deodars wood 4 cm. thick panelled or partly glazed. Doors and windows shall be painted two coats over one coat of priming.
8	Miscellaneous	Rain water pipes shall be provided. Electrification, sanitary and water fittings may be provided if required.

3 Third class buildings: The specifications for the third class building are as follows

S. No.	Items	Details
1	Foundation and	It shall be of sun dried bricks and mud mortar. Opening shall be provided with superstructure arch of 2nd class brick work in lime mortar or with wooden planks. Inside and outside wall shall be water proof mud plastered.
2	Roofing	It shall be of tiles, over bamboo, and wooden support.
3	Flooring	If shall be earthen floor finished with gobris washing (cow dung lapping)
4	Doors and Windows	It shall be of chir or mango wood or country wood.

Detailed specification

The detailed specification is a detailed description and expresses the requirements in detail. The detailed specification of an item of work specifies the qualities and quantities of materials, the proportion of mortar, workmanship, the method of preparation and execution and the methods of measurement. The detailed specifications of different items of work are prepared separately, and describe what the works should be and how they shall be executed and constructed. Detailed

specifications are written to express the requirements clearly n a concise form avoiding repetition and embiguity.

The detailed specifications are arranged as far as possible in the same sequence of order as the work is carried out. The detailed specifications if prepared properly are very helpful for the execution of work. The detailed specifications form an important part of contract document.

Every engineering department prepares the detailed specifications of the various items of works, and get them printed in book form under the name "Detailed Specifications." When the work or a structure or project is taken up, insttead of writing detailed specification every time. The printed Detailed Specifications are referred.

Example - The detailed specifications of Earth Work Excavation is given below.

1 **Earthwork in excavation in foundation:** Excavation - Foundation trenches shall be dug out to the exact width of foundation concrete and the sides shall be vertical. If the soil is not good and does not permit vertical sides, the sides should be sloped back or protected with timber shoring. Excavated earth shall not be placed within 1 m (3") of the edge of the trench.

2 **Finish of trench:** The bottom of foundation trenches shall be perfectly levelled both longitudinally and transversely and the sides of the trench shall be dressed perfectly vertical from bottom up to the least thickness of loose concrete so that concrete may be laid to the exact width as per design. The bed of the trench shall be lightly watered and well rammed. Excess digging if done through mistake shall be filled with concrete at the expense of the contractor. Soft or defective sports shall be dug out and removed filled with concrete or with stabilized soil. If rocks or boulders are found during excavation, these should be removed and the bed of the trenches shall be levelled and made hard by consolidating the earth. Foundation concrete shall not be laid before the inspection and approval of the trench by the engineer-in-charge.

Finds: Any treasure and valuables or materials found during the excavation, shall be property of the Government.

Water in foundation: Water, if any accumulates in the trench, should be bailed or pumped out without the extra payment and necessary precautions shall be taken to prevent surface water to enter into the trench.

Trench filling: After the concrete has been laid masonry has been constructed the remaining portion of the trenches shall be filled up with earth in layers of 15 cm (6") and watered and well rammed. The earth filling shall be free from rubbish and refuse matters and all clods shall be broken before filling. Surplus earth not reauired, shall be removed and disposed, and site shall be levelled and dressed.

Measurement: The measurement of the excavation shall be taken in cu. m. (cu. ft.) as for rectangular trench bottom width of concrete multiplied by the vertical depth of foundation from ground level and multiplied by the length of trenches even though the contractor might have excavated with sloping side for his convenience. Rate shall be for complete work for 30 m (100 ft.) lead and 1.50 m (5') lift, including all tools and plants required for the completion of the works. For every extra lead of 30 m and every extra lift of 1.5 m separate extra rate is provided.

Excavation in saturated soil: Excavation in saturated soil or below sub-soil water level shall be taken under a separate item and shall be carried out in the same manner as above. Pumping or bailing out of water and removal of slush shall be included in the item. Timbering of the sides of trenches if required shall be taken under a separate item and paid separately.

Computation of area and volume

Aim: One of the main objectives of the surveying is to compute the areas and volumes. Generally, the lands will be of irregular shaped ploygons. There are formulae readily available for regular polygons like, triangle, rectangle, square and other polygons. But for determining the areas of irregular polygons, different methods are used.

They are

1 Graphical method

2 Co-ordinate method

3 Planimeter

Out of these methods, the co-ordinate method is popularly is used, in land surveying for computing catchment area, drainage area, cross-section of rivers, channels etc. Under this method the given area is split into two with a base line run at the centre. There are two important rules available.

1 Trapezoidal rule

In this method, boundries between the ends of ordinates are asssumed to be straight. Thus the area enclosed between these line and the irregular boundary lines are considered as trapezoids.

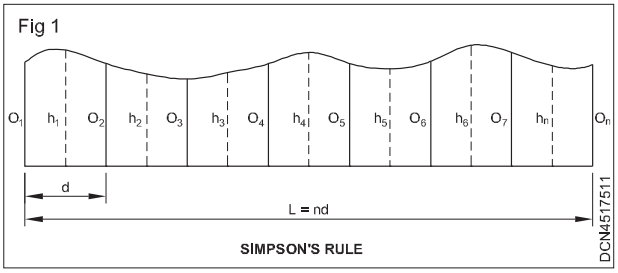
$$A = \frac{d}{2}\left[0_1 + 0_n + 2\left(0_2 + 0_3 + 0_4 + ... + 0_{n-1}\right)\right]$$

$$A = \frac{\text{dist.bet.ordinate}}{2}\left[\begin{array}{l}\left(\text{first ordinate} + \text{last ordinate}\right)+ \\ 2\left(\text{sum of other ordinates}\right)\end{array}\right]$$

Simpson's rule

$$A = \frac{d}{3}\left[0_1 + 0_n + 4\left(0_2 + 0_4 + ... + 0_{n-2}\right) + 2\left(0_3 + 0_5 + ...0_{n-1}\right)\right]$$

$$A = \frac{\text{Common dist. (d)}}{3}\left[\begin{array}{l}\left(\text{first ordinate} + \text{last ordinate}\right) + \\ 4\left(\text{sum of even ordinates}\right) + \\ 2\left(\text{sum of odd ordinates}\right)\end{array}\right.$$



Laminations

The rule is applicable only when the number of divisions is even or the number of ordinates are odd sometimes one or both end ordinates may be zero. However, it must be taken into account while applying rules.

Workout problems

1 Following offsets were taken from a chain line to an irrigular boundary line at an interval of 10 m. 0, 2.50, 3.50, 5.00, 4.60, 3.20, 0m. Compute the area between the chain line, the irregular boundary line and the end offsets by

a Trapezoidal rule

b Simpson's rule

a Trapezoidal rule

Here d = 10

$$\text{Area} = \frac{10}{2}\left[(0+0) + 2(2.50+3.50+5.00+4.60+3.20)\right]$$

$$= 5 \text{ x } 37.60 = 188\,\text{m}^2$$

b Simpson's rule

Here d = 10

$$\text{Area} = \frac{10}{3}\left[(0+0) + 4(2.50+5.00+3.20) + 2(3.50+4.60)\right]$$

$$= \frac{10}{3} \text{ x } 59.00 = 196.66\,\text{m}^2$$

2 The following offsets were taken from a survey line to a curved boundary line

Distance (m)	0	5	10	15	20	30	40	60	80
Offset (m)	2.50	3.80	4.60	5.20	6.10	4.70	5.80	3.90	2.20

Find the area between the survey line, the curved boundary line and the first and last offsets by (a) Trapezoidal Rule and (b) Simpson's Rule.

Here, the intervals between the offsets are not regular throughout the length. So the section is divided into three compartments.

Let,

1 = Area of the 1st section

2 = Area of the 2nd section

3 = Area of the 3rd section

Here, d_1 = 5m; d_2 = 10m; d_3 = 20m.

a Trapezoidal rule

$$\Delta_1 = \frac{5}{2}\left[2.5 + 6.10 + 2\left(3.80 + 4.60 + 5.20\right)\right] = 89.5\,\text{m}^2$$

$$\Delta_2 = \frac{10}{2}\left[6.10 + 5.80 + \left(2 \text{ x } 4.70\right)\right] = 106.5\,\text{m}^2$$

$$\Delta_3 = \frac{20}{2}\left[5.80 + 2.20 + \left(2 \text{ x } 3.90\right)\right] = 158\,\text{m}^2$$

$$\text{Total area} = \Delta_1 + \Delta_2 + \Delta_3 = 89.5 + 106.5 + 158 = 354\,\text{m}^2$$

b Simpson's rule

$$\Delta_1 = \frac{d}{3}\left[O_1 + O_n + 4\left(O_2 + O_4 .....\right) + 2\left(O_3 + O_5 + ...\right)\right]$$

$$= \frac{5}{3}\left[2.5 + 6.10 + 4\left(3.80 + 5.20\right) + 2\left(4.60\right)\right]$$

$$= 89.67\,\text{m}^2$$

$$\Delta_2 = \frac{10}{3}\left[\left(6.10 + 5.8\right) + \left(4 \text{ x } 4.70\right) + \left(2\text{x}0\right)\right] = 102.33\,\text{m}^2$$

$$\Delta_3 = \frac{20}{3}\left[\left(5.8 + 2.20\right) + \left(4 \text{ x } 3.90\right) + \left(2 \text{ x } 0\right)\right] = 157.3\,\text{m}^2$$

$$\text{Total area} = \Delta_1 + \Delta_2 + \Delta_3 =$$

$$89.67 + 102.33 + 157.3 = 349.30\,\text{m}^2$$

Computation of volumes

The computation of volumes of various quantities from the measurements done in the field is required in the measurements done in the field is required in the design and planning on many engineering works. The volume of earth work is required for suitable alignment of road works, canal and sewer lines, soil and water conservation works, farm pond and percolation pond consent.

The computation of volume os various materials such as coal, gravel and is required to check the stock files, volume computations are also required for estimation of capacities of bins, tanks etc.

For estimation of volume of earth work cross sections are at right angles to a fixed line, which runs continuously through the earth work. The spacing of the cross sections will depend upon the accuracy required. The volume of earth work is computed once the various cross-sections are known, adopting the following methods and using prismoidal rule and trapezoidal rule.

Method 1: Mid sectional area method - quantity =Area of mid - section x length.

Let d_1 and d_2 be the height of bank at two ends portion of embankment, 'L' the length of the section, 'B' the formation width adn S:1 (horizontal:vertical) the side slope then,

Area of mid section = Area of rectangular portion + Area of two triangular portion.

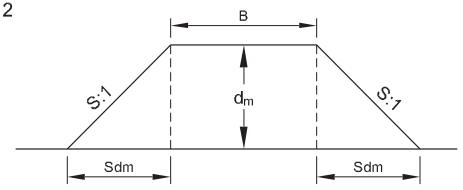
$$= Bd_m + \frac{1}{2} sd_m^2 + \frac{1}{2} sd_m^2$$

$$= Bd_m + sd_m^2$$

$$\therefore \text{Quantity of earth work} = \left(Bd_m + sd_m^2\right) xL$$

General, Q=(Bd+sd2)xL, where d stands for mean height or depth.

Fig 2



MID-SECTIONAL AREA METHOD

DCN45175I2

The quantities of earthwork may be calculated in a tabular form as below

Stations or Chainage	Depth or Height	Mean depth or Height "d"	Area of central portion Bd	Area of sides sd^2	Total sectional area $Bd + sd^2$	Length between stations	Quantity $(bd + sd^2) \times L$	
							Embankment	Cutting

Area of side sloping surface

The area of sides which may require turfing or pitching, may be found by multiplying the mean sloping breadth oby the length.

The mean sloping breadth $= \sqrt{\left(sd^2 + d^2\right)} = \sqrt{5^2 + 1}$

where d stands for mean d.

Area of both side slopes $= 2L_1 \times d\sqrt{s^2 + 1}$

This also may be calculated in a tabular form

Stations or Chainage	Depth or Height	Mean depth or Height	Breadth of side slopes $d\sqrt{s^2+1}$ sloping breadth	Length between stations (L)	Total area of both side slopes $2L_1 \times d\sqrt{s^2+1}$

This table may be added to previous table or may be worked out separately, d being mean depth or beight

Method II: Mean sectional area method: Quantity = Mean Sectional area x Length. Sectional area of one end,

$A_1 = Bd_1 + Sd_1^2$ Sectional area at one end,

$A_2 = Bd_2 + Sd_2^2$, d_1 and d_2 are the height or depth at the two ends.

The mean sectional area $A = \frac{A_1 + A_2}{2}$

Quantity $Q = \frac{A_1 + A_2}{2} \times \text{Length}$

The quantities of earth work may be calculated in a tabular form as given below:

Stations or chainage	Depth or Height	Mean depth or Height "d"	Area of central portion Bd	Area of sides sd^2	Total sectional area $Bd + sd^2$	Length between stations	Qualtity $(bd + sd^2) \times L$	
							Embankment	Cutting

Method III - Prismodial formula method

$$\text{Quantity or Volume} = \frac{L}{6}\left(A_1 + A_2 + 4A_m\right)$$

where A_1 and A_2 are the cross sectional areas at the two ends of a portion or embankment of a road of length L, and A_m is the mid-sanctional area.

Let d_1 and d_2 be the heights of the banks at the two ends, and dm be the mean height at the md-section, B be the formation width and S:1 be the side slope.

Cross-sectional area at one end

$A_1 = Bd_1 + Sd_1^2$

Cross sectiona area at other end

Fig 3

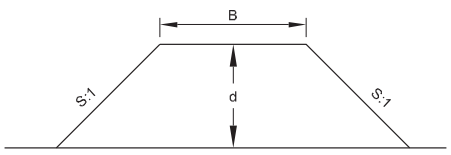


Fig 4

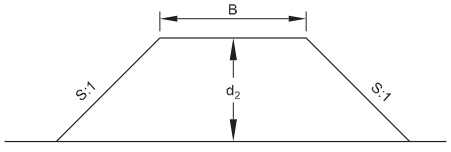
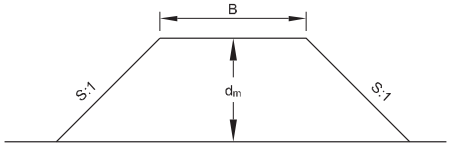


Fig 5



PRISMOIDAL FORMULA METHOD

DCN4517513

$$A_2 = Bd_2 + Sd_2^2$$

Cross section at middle

$$d_m = \frac{d_1 + d_2}{2}$$

$$A_m = Bd_m + Sd_m^2$$

$$A_m = B\frac{d_1 + d_2}{2} + S\left(\frac{d_1 + d_2}{2}\right)^2$$

$$\text{Quantity} = \frac{L}{6}\left(A_1 + A_2 + 4A_m\right)$$

$$= \frac{L}{6}\left[\left(Bd_1 + Sd_1^2\right) + \left(Bd_2 + Sd_2^2\right) + 4\left\{B\left(\frac{d_1 + d_2}{2}\right) + S\left(\frac{d_1 + d_2}{2}\right)^2\right\}\right]$$

$$= \frac{L}{6}\left[\left(Bd_1 + Bd_2 + 4\frac{Bd_1}{2} + 4\frac{Bd_2}{2} + Sd_1^2 + Sd_2^2 + 4S\frac{d_1^2 + d_2^2 + 2d_1d_2}{4}\right)\right]$$

$$= \frac{L}{6}\left[\left(3Bd_1 + 3Bd_2\right) + 2Sd_1^2 + 2Sd_2^2 + 2d_1d_2\right]$$

$$= \frac{BL}{6}\left(d_1 + d_2\right) + \frac{2LS}{3}\left(d_1^2 + d_2^2 + d_1d_2\right)$$

$$= \frac{BL}{2}\left(d_1 + d_2\right) + \frac{LS}{3}\left(d_1^2 + d_2^2 + d_1d_2\right)$$

$$= \left[B\left(\frac{d_1 + d_2}{2}\right) + S\left(\frac{d_1^2 + d_2^2 + 2d_1d_2}{3}\right)\right] \text{x} L$$

The same is also applicable for cutting.

Earthwork calculated by the prismodial formula (Method III) is more accurate than calculated by the Method I and Method II but they will differ by less than 1 percent. As the earthwork is a cheap item, Method I and Method II is generally used as it is a simple and entails less labour, but where rates are high and greater accuracy is required Prisosidal Formula may be used.

It may be noted that all the three methods, can be used for embankment as well as for cutting. Cross-sectional figures for banking if inverted give cross-sections for cutting.

Just to distinguish cutting and banking, the cutting is indicated by (-) sign, (minus sign).

Instead of calculating the quantities against each chainage and then totalling the areas may be totalled and then the total quantity is calculated by multiplying the total area by the common length. But it is better to calculate the quantities against each chainage which help during the execution of the work for controlling by comparing the actual quantity after execution, with the estimated quantity against each chainage.

Trapezoidal formula and prismodial formulae Methods for a series of cross-sections

When a series of cross-section areas calculated at equidistant points, the volume may be worked out by trapezoidal formula.

Notations: A_1, A_2, A_3 A_4,.....A_n are the areas of cross-sections; D = Distance between the section: V= volume of cutting or banking.

i Volume by trapezoidal formulae method

$$V = \frac{D}{2}\left(A_1 + 2A_2 + 2A_3 + ... + 2A_{n-1} + A_n\right)$$

$$V = D\left(\frac{A_1 + A_n}{2} + A_1 + A_2 + A_3 + ... + A_{n-1}\right) \text{or}$$

$$V = \frac{D}{2}\left\{A_1 + A_n + 2\left(A_2 + A_3 ..... + A_{n-1}\right)\right\}$$

ii Volume by prismoidal formulae method

$$V = \frac{D}{3}\left(A_1 + A_n + 4\left(A_2 + A_4 + ... + A_{n-2}\right) + 2\left(A_3 + A_5 + ... + A_{n-1}\right)\right)$$

$$= \frac{D}{3}\left(\text{First area} + \text{Last area} + 4\sum\text{Even areas} + 2\sum\text{Odd areas}\right)$$

It may be noted that in the case of the primosidal formulae, it is necessary to have an odd number of sectional area. If there is an even number of section, the end strip should be treated separately, and the volume of the remaining strips shold be calculated by prismoidal formulae.

To calculate the volume of earthwork from contour plan, for filling a depression or pond and for cutting ahillock, primoidal formulae may be used conveniently. The areas with every contour may be found by using a planimeter or a tracing paper containing squares. Then the prismoidal formulae may be applied to calculate the volume, the distance between the two sections will be the contour intervals, i.e., the difference of level between two consecutive contours.

Example 1: Calculate the quantity of earthwork for 200 metre length for a portion of a road in an uniform ground the heights of banks at the two ends being 1.00 m and 1.60 m. the formation width is 10 metre and side slopes 2:1 (Horizontal:Vertical). Assume that there is no transverse slope.

By Method 1

B = 10 m, s = 2, L = 200 m,

d = mean depth

$$d = \frac{1.00 + 1.60}{2} = 1.30m$$

= (10 x 1.3 + 2 x 1.3^2) x 200

= (13 + 3.38) x 200

= 16.38 x 200 = 3276 cu. m.

By Method 2

$$\text{Quantity} = \frac{L}{6}\left(A_1 + A_2 + 4A_m\right)$$

$A_1 = \text{Sec. Area at one end}$

$A_1 = Bd_1 + SD_1^2$

$= 10 \times 1 + 2 \times 1^2 = 12 \text{ sq. m.}$

$A_2 = \text{Sec. Area at other end}$

$A_2 = Bd_2 + Sd_2^2$

$= 10 \times 1.60 + 2 \times 1.6^2 = 21.12 \text{ sq. m.}$

$A_m = \text{Mid. Sec. Area}$

$A_m = Bd_m + Sd_m^2$

$\text{where } d_m = \frac{d_1 + d_2}{2} = \frac{1.00 + 1.60}{2} = 1.30 \text{ m}$

$A_m = 10 \times 1.30 + 2 \times 1.30^2 = 16.38 \text{ sq. m.}$

$\therefore \text{Quantity} = \frac{200}{6}\left(12 + 21.12 + 4 \times 16.38\right)$

$= \frac{200}{6} \times 98.64 = \frac{19728}{6} = 3288 \text{ cu. m.}$

The difference by methods 1 and 3 is less than ½ percent, the difference by methods 2 and 3 is less than 1 percent.