Plumbing installation

Level-II

Learning Guide-31

Unit of Competence: Reading plans and calculating plumbing quantities

Module Title: Reading plans and calculating plumbing quantities

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LO6: Calculate material quantities

Instruction Sheet	Calculate material quantities LG- 31

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Calculating Material quantities from plumbing job instructions
- Obtaining Information from plans, specifications and work
- Identifying and recording Measurements of plumbing quantities
- Calculate and record plumbing materials quantities.

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to:

- Calculate Material quantities from plumbing job instructions
- Obtain Information from plans, specifications and work
- Identify and record Measurements of plumbing quantities
- Calculate and record plumbing materials quantities.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 6.
3. Read the information written in the information “Sheet 1, Sheet 2, Sheet 3 and Sheet 4”.
4. Accomplish the “Self-check 1, Self-check t 2, Self-check 3 and Self-check 4” respectively.
5. If you earned a satisfactory evaluation from the “Self-check” proceed to “Operation Sheet 1, Operation Sheet 2 and Operation Sheet 3”.
6. Do the “LAP test” (if you are ready).

Information Sheet-1	Calculating Material quantities from plumbing job instructions

1.1 Calculating quantities

Before taking any work for execution the owner or builder should have a thorough knowledge about the volume of work that can be completed within the limits of this founds or the probable cost that may be required to complete the contemplated work. Beside the above, an estimate for any public construction work is asked to be prepared and submitted beforehand so that section of necessary fund may be obtained from the authority concerned.

Thus an estimate / quantity estimate / or quantity survey for any construction work may be defined as the process of calculating the quantities and costs of the various items required in connection with the work. It is prepared by calculating the quantities from the dimensions of the drawings the various items required to complete the project and multiplied with unit cost of the item consumed. To prepare an estimate drawing consisting of the plan, the elevation and the section through important points, along with a detailed specification giving specific description of al workmanship, properties and proportion of materials required.

1.2 Purpose of estimating

Quantity surveying for a work or project is necessary for the following purposes:-

- To ascertain the owner to decision and arranging fund.
- To ascertain for programming timely procurement control
- To know the number of different categories of works
- To complete the work within the schedule time completion.

- To assess the requirements of labors, tools, materials and equipments
- To draw up construction schedule, program.
- To invite tender and preparation of bills for payment.

1.3 Types of quantity estimate

There are different types of estimates as follows.

1. Detailed estimate

This includes the detailed particular for the quantities, rates cost of all the items involved for satisfactory completion of a project. Quantities of all items of works are calculated from their respective dimension of the drawing.

A detailed quantity surveying is accompanied by,

- report
- specification
- Detailed drawings showing plans, different sections, elevation, etc.
- design data and calculations
- basis of rates adopted in the estimate

2. Preliminary or approximate or rough estimate

This is an approximate estimate made to find out an approximate cost in a short time thus enable the responsible authority consumed to consider the financial aspect of the scheme for according to the same such an estimate. After knowing the rate of similar works and from practical knowledge in various ways for various types of works such as:

- Plinth area of square meter method
- Cubic rate or cubic meter method
- Unit area method

1.4 Estimates of Plumbing Work

- A quite accurate estimate for plumbing work can be obtained quickly by means of a unit price for each plumbing fixture.
- Enumerating fixtures and multiplying by the applicable price for each fixture can give an accurate price for the complete plumbing work.
- Additional prices may be required for installing appliances, special fixtures, and any out-of-the-ordinary plumbing work.

Self-Check - 1	Written Test

Directions: Match the term with its explanation of a part. Answer on the space provided in this page.

1.	To decision and arranging fund	A. Detail estimate
2.	Rate of similar works	B. Estimate
3.	Draw up construction schedule, program	C. Approximate detail
4.	Rates cost of all the items	D. Purpose of estimate

Note: **Satisfactory rating - 2 and 5 points** **Unsatisfactory - below 2 and 4 points**

You can ask you teacher for the copy of the correct answers.

Score = _____

Rating: _____

Name: _____ **Date:** _____

Answer sheet

1. ____ **2.** ____ **3.** _____ **4.** _____

Information Sheet- 2	Obtaining Information from plans, specifications and work

2.1 Obtain information

2.1.1 Architectural construction documentation

It set comprises of a comprehensive set of sequential drawings in the order of their occurrence during the construction process. Architectural **construction documents** may be used by various parties involved including Architectural firms, builders and contractors. The drawings are a roadmap utilized by project managers and installers, and can greatly affect the profitability of any project. The architectural construction documentation and detailing phase focuses on adding information to the building model to fully describe the proposed design through drawings and details that can be used to guide the construction process.

2.1.2 Specifications

The specifications then form the foundation up on which the contract is based. It is very important that the drawings and specifications are complementary. The actual specifications define the qualitative requirements for products, materials, and workmanship. They also provide the administrative Procedures for both the owner and the contractor.

Four methods of specifying method defines exact properties of specifying.

- The descriptive is materials and methods of installation without using proprietary names.
- The performance method gives the desired end result, gives criteria for verifying compliance, and does not limit methods for achieving required results.

- The third method is reference standards, which incorporates established criteria published by trade association, government, and institutional organizations.

- The final method is proprietary, which identifies the product by the manufacturer's name, brand name, model number, type designation, or other unique characteristics.

Installation shall be classified by function and given under appropriate headings. Installation shall be measured in accordance with the relevant clause under this section and applicable clauses in the other sections of these methods of measurement. Unless otherwise stated the following are understood as included.

- Incidental work, including but not limited to other trades, cutting, forming, holes, mortises, chases, making good finishes, bedding in, cutting and pinning of brackets and the like.
- Protecting the work from damage by other trades and protective paint to exposed parts testing.
- All earthworks in connection with plumbing work.
- Pipe supports, fittings, flexible pipes, faucets to installation and the like.
- Fittings other than valves.

Specification of measurement for plumbing work

- Pipes shall be measured by length taken along the centerline and over all fittings.
- Valves shall be enumerated.
- Fixtures shall be enumerated and shall be understood as including all accessories valves, connection, control devices and supports for the satisfactory operation of the fixture.
- Duct Work shall be measured by length stating the girth.
- Connections to supply main shall be enumerated.
- Insulation to supply lines shall be measured by length specifying pipe diameter and along the centerline of the pipe.
- Catch pits and manholes shall be enumerated stating the size and shall be understood as including all earth, concrete and surface finish works. Connection of pipes to manholes and catch pits shall be understood as included.

Self-Check - 2	Written Test

Directions: Write True or False on space provided in this page.

1. Specifications define the quantitative rather than qualitative requirements.
2. Specification is complementary to drawing.
3. Catch pits and manholes measured by area.
4. All earthworks in connection with plumbing work included in installation.

Note: **Satisfactory rating - 2 and 4 points** **Unsatisfactory - below 2 and 4 points**

You can ask you teacher for the copy of the correct answers.

Score = _____

Rating: _____

Name: _____ **Date:** _____

Answer sheet

1. _____ **2.** _____ **3.** _____ **4.** _____

Information Sheet- 3	Identifying and recording Measurements of plumbing quantities

3.1 Details of measurement

Respective measurements for the dimension for all individual items involved in the whole work are taken off from the drawing of the work and entered in the respective columns of standard measurement. Forms are as shown below. Multiplying item, wise respective dimensions quantities of all items are worked out in the measurement form measurement form / take-off sheet dimension paper.

Item No	Description or Particulars	No	Length	Breadth	Height or Depth	Quantity

Table-1 Measurement form

The quantification process involves recording dimensions and is referred to as taking off because it involves reading or scaling (taking off) dimensions from a drawing and entering this information in a standard manner on purpose ruled paper called dimension paper or take off paper.

The traditional dimension sheet is divided vertically into two identical halves each comprising a set of four columns. In effect, the rulings on the right half of the sheet may be considered to be a continuation of those on the left side of the sheet.

T	D	S	Description	T	D	S	Description

Table 2 - Take off format

Columns A – are the **timesing columns***;* these columns are used to enter multipliers when there is more than one of the particular item being measured.

Columns B – are the **dimension columns***;* where the dimensions of the item being measured are recorded.

Columns C – are the **squaring columns***;* these columns are used to calculate the quantities which are produced by multiplying the timesing factor in column A by the dimensions in column B. The results are then totalled to derive the final quantity of work.

Columns D – are the **description columns**; these wider columns are used for descriptive content such as location references and explanatory notes called annotations. Preliminary calculations, called waste calculations may also be carried out in these columns.

Item	Description	Unit	Quantity	Unit price	Total price	Remark

Bill of quantity format

Bill of quantity includes columns of item, description, unit, quantity, unit price, total price and remark of work.

- Item defines number of work
- Description column used for the specification of the work
- Unit column is used to write measurement of the work
- Quantity column define the amount of work
- Unit price column describe cost of work per single measurement

- Total price column is used to write sum of costs, it the multiplication of quantity and unit price.

- Remark column is used to write additional necessary information about the work.

3.2 Scope and unit of measurement for plumbing quantity

3.2.1 Roof gutters, rainwater pipes, etc

- Roof gutters, rainwater pipes, etc shall be given in meters and descriptions shall be deemed to include jointing.
- Angles, stopped ends, outlets, offsets, shoes, etc shall be given in number as extra over Weep pipes, spreaders, gargoyles, rainwater heads, etc shall be given in number

3.2.2 Storm water channels

- Storm water channels shall be given in meters and descriptions shall include earthworks, formwork and finish.
- Angles, intersections, ends, etc shall be given together in number as extra over.
- Alternatively short isolate channels may be given in number

3.2.3 Pipes

- Pipes shall be given in meters. Descriptions shall be deemed to include bending pipes, jointing pipes of differing materials and jointing pipes to taps, valves, traps, etc

- No distinction shall be made between pipes fixed vertically, horizontally or to falls, nor between pipes fixed to different elements, cast in, built in, etc.

- Pipes chased in and pipes suspended exceeding 1 m below suspension level shall be given separately.

- Descriptions shall be deemed to include pipe supports such as clips, saddles, holder bats, hangers, etc.

- Prescribed purpose-made pipe supports shall be given separately in accordance with the principles laid down in the relevant trades

- Pipe work in ground shall be given separately and descriptions may include pipe trenches.

- Service pipes and flexible connecting pipes shall be given in number and descriptions shall include connections Pipe fittings shall be given in number as extra over.

- Pipe closers which are prescribed to be measured on site and cut to exact length shall be given in number as extra over the pipe in which they occur

- Prescribed tests of welded joints shall be given in number**.**

3.2.4 Pipe trenches

- Bedding under and filling around pipes comprising sand, crushed stone, concrete, etc shall be given in cubic meters

3.2.5 Pipe insulation and protection

- Insulating and protective wrappings, coatings and linings other than those applied in the course of manufacture shall be given in meters stating the diameter of the pipe

- Insulation etc around fittings, valves, etc to pipes not exceeding 30 mm diameter shall be given together in number as extra over for each diameter of pipe

- Insulation etc around fittings, valves, etc to pipes exceeding 30 mm diameter shall be given separately in number as extra over for each diameter of pipe and for each type of fitting, valve, etc

3.2.6 Encasing

- Concrete encasing to pipes shall be given in meters or alternatively in cubic meters and descriptions shall be deemed to include formwork

3.2.7 Anchor blocks, thrust blocks, etc

- Concrete anchor blocks, thrust blocks, etc shall be given in accordance with the principles laid down in “Concrete, Formwork and Reinforcement” or alternatively blocks may be given in number in which case descriptions shall include formwork and reinforcement

3.2.8 Gulleys, grease traps, etc

- Gulleys, grease traps, intercepting traps, etc shall be given in number.

3.2.9 Inspection chambers, catch pits, etc

- Inspection chambers, catch pits, junction boxes, valve boxes, septic tanks, conservancy tanks, etc shall be given in accordance with the principles laid down in the relevant trades.
- Alternatively inspection chambers, catch pits, etc may be given in number

3.2.10 Soakage pits, french drains, etc

- Soakage pits, french drains, etc shall be given in number.
- Alternatively soakage pits, french drains, etc may be given in accordance with the principles laid down in the relevant trades

3.2.11 Connections

- Connections of new to existing pipes shall be given in number and descriptions shall be deemed to include the necessary fittings

3.2.12 Testing

- Prescribed testing of the various systems shall each be given as an item

3.2.13 Sanitary fittings

- Sanitary fittings shall be given in number

3.2.14 Tanks, geysers, etc

- Tanks, geysers, boilers, heat pumps, incinerators, etc shall be given in number

3.2.15 Taps, valves, etc

- Taps, valves, shower roses, meters, etc shall be given in number

3.2.16 Waste unions, traps, etc

- Waste unions, traps, etc shall be given in number

3.2.17 Fire hose reels etc

- Fire hose reels, booster connections, hydrants, pressure gauges, etc shall be given in number

3.2.18 Firefighting equipment

- Firefighting equipment such as extinguishers, blankets, buckets, etc shall be given in number

3.2.19 Sleeves

- Sleeves shall be given in number grouped for pipes not exceeding 100 mm diameter and thereafter in stages of 100 mm, separated in successive lengths of 250 mm

3.2.20 Holes

- Holes for pipes and cutting and fitting around pipes shall be deemed to be included in the descriptions of the pipe work unless otherwise stated in the relevant trades

3.3 Recording Measurements

Payments for all works done and for supplies made on the basis of measurements are recorded in measurement books (MB). It is a most important record since it is the basis of all accounts of quantities whether of work done or of materials supplied and payment made thereof. It is the original record of actual measurement.

All measurements should be neatly taken down in an authorised measurement book in ink issued for the purpose, and no-where else. Each set of measurement should commence with:

- Full name of work as given in the work order,
- Location of work.
- Name of contractor
- Number and date of agreement/work order,
- Date of commencement of work as per contract/actual

- Date of completion of work as per contract/actual
- Period of claim,
- Date of measurement,
- Name & designation of the person recording measurement

Each set of measurements should end with the statement "measured and entered by me" followed by the dated signature and designation of the person making the measurements in the measurement book.

Self-Check - 3	Written Test

Directions: Match the part of dimension part with its explanation. Answer on space provided on this page.

1. Timesing columns	A. Calculate the quantities
2. Dimension columns	B. References and explanatory notes
3. Squaring columns	C. Enter multipliers
4. Description columns	D. Measures are recorded.

Note: **Satisfactory rating - 2 and 4 points** **Unsatisfactory - below 2 and 4 points**

You can ask you teacher for the copy of the correct answers.

Score = _____

Rating: _____

Name: _____ Date: _____

Answer sheet

1. _____ 2. _____ 3. _____ 4. _____

Information Sheet- 4	Calculate and record plumbing materials quantities.

4.1 Types plumbing quantities

'Quantities' means the amount of materials and work involved in all or part of a building Project. Plumbing construction costs can be broken down into these categories:

1. Preparation

Preparation includes demolition work, excavation and back fill, cutting and patching, and survey and marking.

2. Material

Material includes pipe, fittings, valves, pipe supports, sleeves, low-voltage wiring, fire stopping, insulation, drains, cleanouts, fixture carriers, sprinkler heads, medical gas outlets, and similar commodity items as well as general material handling. Materials includes appurtenances and fixtures. Fixtures include water closets, lavatories, urinal, shower, service sink and etc. Appurtenances include interceptors, pumps, alarms, water meters, back flow preventers, pressure vessels, water heaters, and water-treatment equipment. Cost estimating is broken down into two convenient sets of sums: Material costs are estimated separately from labor costs. Building materials can be costed by the following criteria:

- Birr per single item
- Birr per linear meter
- Birr per square meter
- Birr per cubic meter

3. Labor costs

The following parts of a labor rate are applied to the gross wage rate to reflect a labor cost of plumbing construction.

- Social Security and Medicare taxes that employers pay
- Workmens compensation insurance premium

- Unemployment tax
- Health insurance premium
- Holiday and vacation pay
- Retirement cost

The estimated cost of labor is the labor rate multiplied by the estimated time to complete the work. Labor costs are generally the most expensive items to allow for in building, and must be calculated as accurately as possible. It may be calculated 10- 30 % of a material cost.

4.Over heads cost

Allowance must be made for the day to day running expenses of a business whether it be large or small. These costs will vary, packaging and transport should include office and factory premises, insurances, vehicle expenses, office staff, holiday pay, wet weather, packaging, transport, travelling and similar expenses.

Overhead costs can be charged to the client by adding a lump sum to the final estimated cost for the project or by adding a pro rata percentage to each individual unit cost or charge out rate, for materials and labour. It may be calculated 4-10% percent of material cost.

4.2 calculating and recording plumbing quantities

The quantity of material in a project can be accurately determined from the drawings. The estimator must review each sheet of the drawings, calculate the quantity of material and record the amount and unit of measure.

After the scope has been analyzed and broken down into construction tasks, each task must be quantified prior to pricing.

Equal emphasis should be placed on both accurate quantity calculation and accurate pricing. Quantities should be shown in standard units of measure and should be consistent with design units.

4.2.1 Take off

Quantity calculations beyond design details are often necessary to determine a reasonable price to complete the overall scope of work for the cost estimate. Project notes will be added at the appropriate level in the estimate to explain the basis for the

quantity calculations, to clearly show assumed quantity allowances or quantity contingencies, and to record quantities determined by cost engineering judgment that will be reconciled upon design refinement.

Use the following recommended guidelines in quantity development:

- Coordinate the quantity takeoff process and plan with the estimator.
- Ensure full project scope is reflected within the estimate.
- Include a list of materials in quantity takeoffs.
- Utilize a process that easily records the quantity development, i.e., document source and date, estimator name and date, location within the project, demonstrated calculations and additions such as waste or loss.
- Use a systematic approach similar to the construction methodology required.
- Check scales and dimensions on each drawing sheet.
- Highlight or mark drawing areas where quantities have been determined to ensure all scope is captured but not double counted.
- Consider items that have no material but still require cost, e.g., job office overhead critical.
- Add a certain amount of waste, loss, drop off, or length related to the material purchases for a bulk order. Ensure this addition is separate from the original quantity measured.
- Select a natural stopping point during work interruptions.
- Coordinate with designers if the design appears in error, if a better approach is discovered, or a value engineering process is warranted.
- Each estimator must develop a system of quantity takeoff that ensures that a quantity is not omitted or calculated twice.
- A well organized check-list of work will help reduce the chances of omitting an item.
- The estimator must, also, add an appropriate percentage for waste for those items where waste is likely to occur during construction.
- The material quantity takeoff is extremely important for cost estimating because it often establishes the quantity and unit of measure for the costs of labor and contractor’s equipment.

4.2. 2 Bill of Quantities

The Bill of Quantities (BOQ) is defined as a list of brief descriptions and estimated quantities. The quantities are defined as estimated because they are subject to admeasurement and are not expected to be totally accurate due to the unknown factors which occur in civil engineering work.

Plumbing estimate Example

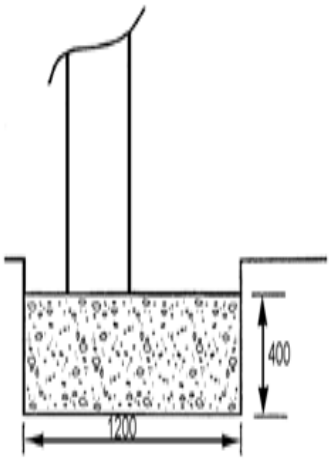
Estimate the price of a three-fixture bathroom based on the following prices for the fittings involved:

○ 1 bathtub		2,425 Birr
○ 1 water closet		1,450 Birr
○ 1 lavatory basin		845 Birr
	Sub total	4,720 Birr
○ Extra for pipe and fittings 30%		1,416 Birr
	Total	6,136 Birr

The following are examples of quantity calculations relating to building projects.

Concrete

(a) Calculate the volume of concrete required in a square pad footing for an isolated column.



Volume = Length x Breadth x Height

= 1200 x 1200 x 400

= 1.2m x 1.2m x 0.4m

Volume = 0.576m^3 Say 0.6m^3 to round off and include a waste allowance.

Figure Concrete pad footing

Bedding Sand

(b) Calculate the volume of pipe bedding sand for a length of pipe 20m long.

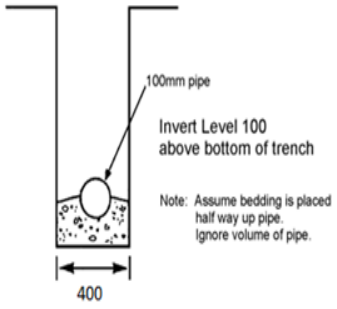


Figure drainage pipe

Step 1

Calculate height of bedding sand:

(a) Bottom of trench to invert = 100

(b) Half height of pipe 100/2 = 150mm

Step 2

Volume of bedding sand = L x B x H

= 20 x 0.4 x 0.15

= 1.2m^3

Mortar

Calculate the materials required for a mix of sand/cement mortar.

Step 1

Decide on the basic unit you are going to use,

eg. 1 bag of cement. Calculate the volume of a bag of cement.

- 1 tonne of cement occupies approximately 0.7m^3 and
- 25 bags of cement per tonne
- Volume of cement in one bag = 0.7 ÷ 25 = 0.028m^3

Step 2

Calculate the volume of sand you will need per bag of cement for the following given mortar ratios. (i.e cement/sand. For each part of cement, 2 parts of sand is required.)

- 1:2 $0.028 \times 2 = 0.056m^3$ sand per bag of cement
- 1:4 $0.028 \times 4 = 0.112m^3$ sand per bag of cement
- 1:6 $0.028 \times 6 = 0.168m^3$ sand per bag of cement

Cost per Single Item

Cost per single item is the simplest method of costing materials. All that is required is to multiply the cost of one item by the number of items required.

Cost of 1 item x number of items

eg: Cost of 30 bags of cement when 1 bag costs 140.50 Birr

Cost = unit cost x number

= 150.50 x 30 Birr

= 4215 Birr

Cost per Linear Meter

This can be calculated by finding out how many pieces of material are required, then multiply by the length and this will give the linear (running) measurement.

eg: Calculate the cost of ten 1.5m lengths of 90cm x 35 cm pine wood board when one meter costs 3.50 Birr.

Cost = Number x Length x Cost per unit

= 10 x 1.5 x 3.50 birr

= 52.50 Birr

Cost per Square Meter

A formula can be developed to work out m^2 costs.

Cost of $1m^2$ x number of m^2

eg: Calculate the cost of $100m^2$ of plasterboard sheeting at Birr 4.55 per m^2.

Cost = number x unit cost

= 100 x 4.55

= 455.00 Birr

Cost per Cubic Meter

The volume must first be calculated by multiplying length x width x height of the materials and then multiplying by the dollar value per m^3.

eg: Calculate the cost of concrete in a strip footing 300 x 600 x 20 000 long in mm when a cubic meter of concrete costs 130 Birr.

Volume = length x Width x height

= 20 x 0.3 x 0.6

= 3.6 m^3 x 130 Birr

= 468.00 birr or in one step

Cost = 0.3 x 0.6 x 20 x 130Birr = 468.00 Birr

Self-Check - 4	Written Test

Directions: Match the plumbing quantity calculation costs with its descriptions.

1. Preparation cost	A. Gross wage rate
2. Material cost	B. Day to day running expenses
3. Labor costs	C. Excavation and back fill
4. Over heads cost	D. Appurtenances

Note: **Satisfactory rating - 2 and 4 points** **Unsatisfactory - below 2 and 4 points**

You can ask you teacher for the copy of the correct answers.

Score = _____

Rating: _____

Name: _____ Date: _____

Answer sheet

1. ____ 2. ____ 3. ____ 4. _____

LAP Test	Practical Demonstration

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instructions: Given necessary drawing, specification, templates, tools and materials you are required to perform the following tasks within 2 hours.

1. Select drawing, specification and work before the demonstration day with your instructor.

2. Visit the plumbing work performed.
3. Obtain Information from plans, specifications and work
4. Identify and record Measurements of plumbing quantities
5. Calculate Material quantities from plumbing job instructions
6. Record plumbing materials quantities.
7. Present what you perform to trainer and trainees.

List of Reference Materials

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