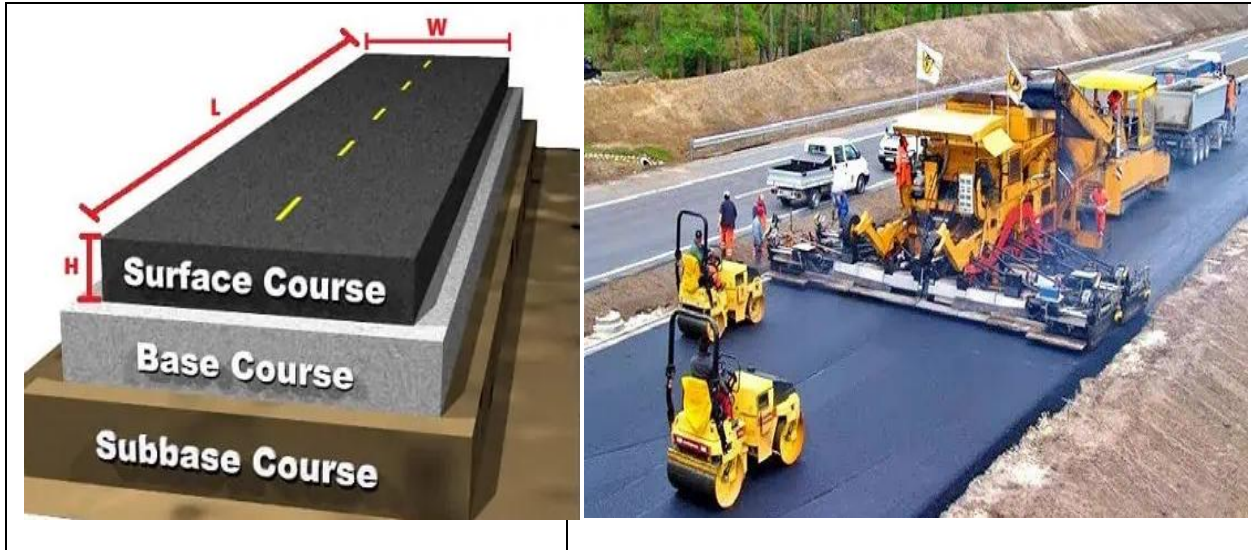


Road Construction and Maintenance

Level-III

Based on September, 2023 Curriculum Version 2



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Acronym

ASTM	American Society for Testing Materials
BS	Bitumen Stabilized macadam
CBR	California bearing ratio
CC	Stands for cement concrete
CM	Cement mortar
ERA	Ethiopian Road Authority
ES	Effective specific gravity
FBOQ	Final Bill of Quantity
FPS	Foot-Pound-Second system
OMC	Optimum moisture content
WMM	Wet mix macadam

Introduction to module

This module is designed to meet the construction industry requirement under gather information, take off work quantity an document and verify details particularly for the unit of competency:

Road Construction and Maintenance level III.

This module covers the units:

- Gather information
- Take off work quantity
- Document and verify details

Learning Objective of the Module

At the end of completing the module the trainee will be able to:

- Gather information
- Prepare take off work quantity
- Document and verify significant details

Module Instruction

1. For effective use these modules trainees are expected to follow the following module instruction:
2. Read the information written in each unit
3. Accomplish the Self-checks at the end of each unit
4. Perform Operation Sheets which were provided at the end of units
5. Do the “LAP test” giver at the end of each unit and
6. Read the identified reference book for Examples and exercise



Unit One: Information Gathering

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

- Over view
- Customer requirements.
- Accessing and inspecting plan.
- Developing delivery detail.

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this unit, you will be able to:

- Obtain customer requirements.
- Access and inspect plan.
- Develop delivery detail.

1.1 Over view

Quantity estimation is the process of determining the quantities of materials and labour required to complete a construction project. In road construction and maintenance, the quantity estimator will typically need to estimate the quantities of materials such as concrete, asphalt, and gravel; and the quantities of labour such as excavation, paving, and grading.

The first step in preparing a quantity estimate for road construction or maintenance is to gather the necessary information. This includes the project plans and specifications, as well as the site conditions. The project plans will provide the estimator with the details of the work to be performed, such as the dimensions of the road, the type of materials to be used, and the required tolerances. The site conditions will provide the estimator with information about the soil conditions, the presence of any existing structures, and the access to the site. Once the necessary information has been gathered, the estimator can begin to develop the quantity estimate. This process typically involves the following steps:

Identify the individual work items that need to be estimated.

- Determine the quantities of each work item.
- Obtain unit prices for each work item.
- Calculate the total cost of the project.

The identification of the individual work items is typically the most challenging part of the quantity estimation process. This is because the work items can vary greatly depending on the specific project. For example, the work items for a road widening project will be different from the work items for a road rehabilitation project.

Once the individual work items have been identified, the estimator can begin to determine the quantities of each work item. This can be done by measuring the dimensions of the work items on the project plans, or by using standard estimating tables.

The unit prices for each work item can be obtained from a variety of sources, such as historical data, published price lists, or quotes from contractors. The total cost of the project is calculated by multiplying the unit prices by the quantities of each work item.

The quantity estimate is a critical part of the planning and budgeting process for road construction and maintenance projects. A well-prepared quantity estimate will help to ensure that the project is completed on time and within budget.

1.2 Customer requirements.

The quantity of work required for a road construction project is determined by the **customer's requirements**. The customer's requirements are essential for the accurate preparation of a road quantity work estimate. By understanding the customer's needs, the contractor can develop an estimate that is accurate and meets the customer's expectations. These requirements can be defined in terms of the type of road to be constructed, the dimensions of the road, the materials to be used, specifications for the road, and the environmental conditions. The customer's requirements are gathered through a process of communication and collaboration between the customer and the contractor. The following are the major requirements of customer or project owner.

The type of road to be constructed: determine the materials and methods that will be used. For example, a concrete road will require different materials and methods than an asphalt road.

The dimensions of the road: determine the quantity of materials that will be required. For example, a longer road will require more materials than a shorter road.

The materials to be used: affect the quantity of work required. For example, a road made of concrete will require more labor than a road made of asphalt.

The specifications for the road: will set forth the quality standards that must be met. For example, the specifications may require that the road be a certain width or that it be able to withstand a certain amount of traffic.

The environmental conditions: also affect the quantity of work required. For example, a road that is located in a mountainous area will require more earthwork than a road that is located in a flat area. By understanding the customer's requirements, the contractor can gather the necessary information to prepare an accurate road quantity work estimate. This will help to ensure that the project is completed on time and within budget.

The customer requirements are essential for preparing a accurate and reliable road quantity work estimation. By gathering the necessary information from the customer, the estimator can develop a quantity takeoff that is accurate and complete. This will ensure that the cost of the project is accurately estimated and that the project is completed on time and within budget. The following are the steps to obtaining customer requirements.

- **Gather the necessary information:** includes the project plans, specifications, and any other relevant documentation.



- **Identify the key elements of the project:** includes the type of road, the materials to be used, the dimensions of the road, and the traffic volume.
- **Make assumptions and estimates:** the contractor will need to use their experience and judgment to make educated guesses about the quantities of materials and labor required.
- **Check for ambiguities:** the contractor should carefully review the plans and specifications to make sure they understand all the requirements. If there are any ambiguities, they should ask the project owner for clarification. There are some specific questions that a contractor might ask to clarify any ambiguities in the requirements or to ensure that the project owners have a clear understanding of the requirements and can accurately estimate the quantity of materials and labor required for the project. Such as:
 - What is the type of road surface (asphalt, concrete, etc.)?
 - What are the dimensions of the road (width, length, thickness)?
 - What is the traffic volume?
 - What are the environmental conditions (e.g., soil type, climate)?
 - What are the specific requirements for the materials (e.g., quality, grade)?
 - What are the specific requirements for the construction methods (e.g., compaction, curing)?
- **Finalize the estimate.** Once the contractor is confident that their estimate is accurate, the contractor can:
 - Reviews the requirements and asks questions to clarify any ambiguities.
 - Develops a draft estimate based on the customer's requirements.
 - Review the draft estimate together with the customer and make any necessary revisions.
 - Provides the customer with a final estimate to the owner.

Additional considerations used to submit accurate and competitive estimates are:

- Be thorough. Don't skip over any details, no matter how small they seem.
- Be accurate. Make sure estimates are based on sound engineering principles and realistic assumptions.
- Be flexible. Be prepared to adjust estimates if the requirements change.
- Be communicative. Keep the project owner informed of progress and any challenges are facing.

Specific customer requirements

- The scope of work, including the type of road, the length and width of the road, and the materials to be used.
- The existing conditions of the road, including the condition of the subgrade, the existing pavement, and any existing utilities.
- The desired finished grade of the road.
- The traffic volume and loading conditions.
- The environmental constraints, such as wetlands or protected species.
- The budget for the project.

Once the customer requirements are gathered, the estimator can begin to develop a quantity takeoff.

There are some additional important points for gathering customer requirements for road quantity work estimation:

- Be clear and concise in communication with the customer.
- Ask specific questions to get the information need.
- Be patient and persistent: take some time to gather all of the necessary information.
- Document the customer requirements carefully to avoid misunderstandings later on.
- Obtain **the road plans and specifications** to get detailed information about the road, such as its dimensions, materials, and other requirements.
- Survey the road to verify the information in the plans and specifications, and to identify any additional factors that need to be considered, such as the presence of utilities or other underground obstructions.
- Determine the quantities of materials and labor required by measuring the various elements of the road, such as the length, width, and depth of the pavement, and the number of culverts and other structures.
- Obtain pricing information for the materials and labor by contacting suppliers and contractors.
- Calculate **the total cost of the project**. This is done by multiplying the quantities of materials and labor by their respective prices. To prepare a accurate and reliable estimation.
 - Be as accurate as possible in measurements and calculations.
 - Consider all of the factors that could affect the cost of the project, such as the weather, the availability of materials, and the complexity of the work.

- Get quotes from multiple suppliers and contractors to get the best price.

Specific types of information that may need to gather:

- The length, width, and depth of the road.
- The type of pavement material to be used.
- The thickness of the pavement.
- The number of culverts and other structures.
- The quantity of concrete, asphalt, and other materials required.
- The cost of labor, equipment, and other expenses.

Once have gathered all of this information, can use it to prepare a detailed estimate of the cost of the road construction project. This estimate will be an essential tool for making decisions about the project, such as whether to proceed with it and how to finance it.

1.3 Accessing and inspecting plan.

Accessing a road plan means getting the information you need about a road, such as its This information can be used to estimate the quantities of materials and labor needed to construct or repair the road, and to develop a budget and schedule for the project. There are many different ways to access a road plan. Here are a few examples:

- Contact the owner of the road who may have a copy of the plan, or they may be able to direct you to where you can find it.
- Contact the contractor who built the road in case of repair.to accesses a copy of the plan, or they may be able to direct you to where you can find it.
- Search online. There are many websites that offer access to road plans.
- Visit a government office such as ERA may keep copies of road plans on file.
- Once the road work plan has been accessed, it should be carefully reviewed to understand the information that is contained within it. This includes:
 - The scope of work: the specific tasks that need to be completed as part of the project.
 - The materials and labor needed: the quantity and type of materials that will be needed, as well as the number of workers required to complete the project.
 - The budget and schedule: the estimated cost of the project and the timeline for completion.
 - The road work plan to:

- Develop a budget and schedule for the project
- Ensure that the project is completed on time and within budget
- Identify any potential risks or challenges that may need to be addressed
- Communicate the project's scope and requirements to the stakeholders

1.3.1 Specific information found in a road plan

Additional information needs to make informed decisions about the construction or repair of a road. These include:

- **The road alignment and profile**(proposed width, cross-section, and slopes): This information shows the proposed path of the road, as well as its elevation at different points along the route. This is important for calculating the earthwork quantities, as well as the drainage requirements.
- **The type of road surface** (asphalt, concrete, or gravel): will affect the materials and labor requirements, as well as the cost of the project. For example, asphalt roads are typically less expensive than concrete roads, but they require more maintenance.
- **The drainage system** (culverts, ditches, and storm sewers): is necessary to prevent water from accumulating on the road surface, which can cause erosion and damage to the road. The type of drainage system will vary depending on the climate and the soil conditions.
- **The bridges and culverts** (their length, width, and type of construction): used to carry water over or under the road. The size and type of bridge or culvert will depend on the amount of water that needs to be carried, as well as the traffic volume.
- **The earthwork quantities** (cut and fill, embankments, and slopes): include the amount of cut and fill, as well as the embankments and slopes. The cut and fill quantities are determined by the difference in elevation between the existing ground and the proposed road surface. The embankments and slopes are necessary to provide stability for the road
- **The materials quantities** : include the amount of asphalt, concrete, reinforcing steel, and other materials that will be used in the construction of the road. The materials quantities will vary depending on the type of road surface, the drainage system, and the bridges and culverts.
- **The labor and equipment requirements**: include the number of workers and the types of equipment that will be needed to construct the road. The labor and equipment requirements will vary depending on the size and complexity of the project.
- **The environmental constraints**, such as wetlands, endangered species, and cultural resources.

The estimator will use this information to calculate the quantities of materials and labor required for the project, as well as the cost of each item. The estimated cost will then be used to create a budget for the project.

- The road's location and dimensions
- The type of materials used in the road's construction
- The road's design features, such as curves and slopes
- The road's drainage system
- The road's markings and signs
- The road's maintenance requirements

1.3.2 Steps to access a plan

- **Identify the relevant plan.** There are many different types of plans that may be used for road construction quantity estimation, so it is important to identify the one that is most relevant to the specific project. Some common types of plans include:
 - As-built plans: show the existing conditions of the road, including the dimensions, materials, and defects.
 - Design plans: show the proposed design of the road, including the dimensions, materials, and construction methods.
 - Quantity takeoff plans: indicate the quantities of materials and labor needed to construct the road.
- **Obtain the plan.** available from the owner of the road, the contractor, or a third-party vendor.
- **Review the plan.** Once you have obtained the plan, you should carefully review it to understand the information that is contained within it. This includes the dimensions of the road, the materials used, and the construction methods.
- **Use the plan to estimate quantities.** Once the plan is reviewed, it is used to estimate the quantities of materials and labor needed to construct the road. This can be done by measuring the dimensions of the road and the materials used, and by calculating the amount of labor required to construct the road using the specified methods.
- **Document the findings.** After estimated the quantities, document the findings in a report or spreadsheet. This will help to ensure that the estimates are accurate and that they can be easily referenced later.

1.3.3 Considerations for accessing a plan

To access a plan for road construction quantity estimation and to use it to estimate the quantities of materials and labor needed to construct the road and to develop a budget and schedule for the project, and to ensure that the project is completed on time and within budget. The following should be considered.

- Be sure to get the most recent version of the plan.
- If the plan is not clear, contact the person who created it for clarification.
- If the plan is missing information, may need to do additional research to obtain the missing information.
- Be sure to document the findings carefully so that for reference them later.

1.3.4 Inspecting the plan

Inspecting a plan means to review the plan to identify the materials and labor needed to construct or maintain the rod, and to estimate the quantities of these materials and labor. The plan may include drawings, specifications, and other documentation that describes the rod in detail. It is easy to estimate quantity accurately and efficiently. This information can then be used to develop a budget and schedule for the project, and to ensure that the project is completed on time and within budget. The inspector will typically review the plan to identify the following:

- The type and dimensions of the rod
- The materials and methods used to
- The labor required construct or maintain the road

Once the inspector has identified the materials and labor needed, they can estimate the quantities of these materials and labor.

This can be done by measuring the dimensions of the rod, calculating the amount of material needed per unit area or volume, and estimating the amount of labor required to construct or maintain the rod using the specified methods.

The estimated quantities of materials and labor can be used to develop a budget and schedule for the project, and to ensure that the project is completed on time and within budget. The following are some of the specific **steps** involved in inspecting a plan for rod construction and maintenance to estimate quantity:

- a. Review the plan. The inspector will first review the plan to identify the materials and labor needed to construct or maintain the rod. This can be done by reading the drawings, specifications, and other documentation that is included in the plan.

- b. Identify the materials and labor needed. Once the inspector has reviewed the plan, they will identify the materials and labor needed to construct or maintain the rod. This can be done by measuring the dimensions of the rod, calculating the amount of material needed per unit area or volume, and estimating the amount of labor required to construct or maintain the rod using the specified methods.
- c. Estimate the quantities of materials and labor. Once the inspector has identified the materials and labor needed, they will estimate the quantities of these materials and labor. This can be done by using a variety of methods, such as measuring, calculating, and estimating.
- d. Document the findings. The inspector will document their findings in a report or spreadsheet. This will help to ensure that the estimates are accurate and that they can be easily referenced later.

1.4 Developing delivery detail

It refers to the process of creating a document that specifies the quantities of rods needed for a specific construction or maintenance project. This document would typically include the following information:

- The type of rod needed
- The dimensions of the rod
- The quantity of rod needed for each section of the project
- The delivery schedule for the rods

The delivery detail product would be used by the contractor to order the necessary rods and to ensure that they are delivered on time and in the correct quantities. It would also be used by the project manager to track the progress of the project and to ensure that the rods are used efficiently. The development of a delivery detail product for rod construction and maintenance to estimate quantity is a critical step in ensuring that a project is completed on time and within budget. By carefully considering the specific needs of the project, the contractor can create a document that will help to ensure that the project is a success.

1.4.1 Factors to be considered

In order to the contractor can create a delivery detail product that will help to ensure that a project is completed on time and within budget. There are some of the factors that would need to be considered when developing a delivery detail product for rod construction and maintenance to estimate quantity:

- The type of rod needed: There are many different types of rods available, each with its own unique properties. The type of rod that is needed will depend on the specific requirements of the project.
- The dimensions of the rod: need to be considered. The length, width, and thickness of the rod will all need to be specified.
- The quantity of rod needed: depend on the size of the project. The contractor will need to carefully estimate the amount of rod that is needed to ensure that there is enough rod on hand to complete the project.
- The delivery schedule for the rods: The contractor will need to ensure that the rods are delivered on time to avoid delays in the project.

1.4.2 Components of delivery detail

The components of a delivery detail product for road construction and maintenance to estimate quantity include:

- Product description: should include a detailed description of the product, including the type of rod, the dimensions, the materials, and the quantity.
- Quantity: is the total number of rods that are being delivered.
- Unit price: is the price per rod.
- Total price: the total cost of the rods, calculated by multiplying the quantity by the unit price.
- Delivery date: is the date on which the rods will be delivered.
- Shipping information: includes the shipping address, the contact information for the shipping company, and the shipping method.
- Payment terms: specifies how and when payment is due.
- In addition to these basic components, the delivery detail product may also include other information, such as:
- Warranty information: specifies the terms of the warranty for the rods.
- Contact information: includes the contact information for the manufacturer or supplier of the rods.
- Technical specifications: provides detailed information about the technical specifications of the rods.
- Logistics information: includes information about the logistics of the delivery, such as the weight and dimensions of the rods, and the handling requirements.

The specific components of the delivery detail product will vary depending on the specific product and the needs of the buyer. However, the components listed above are common to most delivery detail products for rod construction and maintenance. To create a delivery detail product which enable to estimate the quantity of rods accurately and efficiently some additional instructions are important for creating a delivery detail. These include:

- Be sure to include all of the necessary information.
- Use clear and concise language that is easy to understand.
- Be as accurate as possible in your estimates.
- Review the product carefully before submitting it.

1.4.3 Steps in developing delivery detail

- In order to ensure that the correct amount of material is ordered and delivered to the job site, which in turn can save time and money the following are some of the key steps involved in developing such a product:
- Identify the materials needed. The first step is to identify all of the materials that will be needed for the rod construction or maintenance project. This includes both the quantity and the type of material.
- Determine the quantity of each material. Once the materials have been identified, the next step is to determine the quantity of each material that is needed. This can be done by calculating the area or volume of the area to be repaired or constructed, and then multiplying that figure by the material's thickness or density.
- Create a delivery schedule. Once the quantity of each material has been determined, the next step is to create a delivery schedule. This schedule should specify the date and time that each material is needed at the job site.
- Order the materials. Once the delivery schedule has been created, the next step is to order the materials from the supplier. When ordering the materials, it is important to specify the quantity, type, and delivery date for each material.
- Track the delivery of materials. It is important to track the delivery of materials to ensure that they arrive on time and in the correct quantity. This can be done by creating a tracking system that monitors the status of each delivery.

1.4.4 Methods of developing a delivery detail

There are many different methods of delivery detail product for rod construction and maintenance to estimate quantity. The most common methods include:

Dimensional takeoff: measuring the dimensions of the rods and other materials that will be used in the construction or maintenance project. The measurements are then used to calculate the quantities of materials needed.

Weight-based takeoff: weighing the rods and other materials that will be used in the construction or maintenance project. The weights are then used to calculate the quantities of materials needed.

Unitary takeoff: This method involves counting the number of rods and other materials that will be used in the construction or maintenance project. The counts are then used to calculate the quantities of materials needed.

Estimated takeoff: involves estimating the quantities of rods and other materials that will be needed based on the scope of work and the experience of the estimator.

The best method of delivery detail product for rod construction and maintenance to estimate quantity will vary depending on the specific project. The following factors should be considered when selecting a method:

- The accuracy required for the estimate
- The time and resources available for the estimate
- The expertise of the estimator
- The type of materials that will be used
- The complexity of the project

Once a method has been selected, the estimator can begin to gather the necessary information and make the necessary calculations. The resulting estimate can then be used to develop a budget and schedule for the project.

Self-Check 1

Part 1. Write true if the statement is correct otherwise false.

1. The quantity of work required for a road construction project is determined by the contractor's requirements.
2. The dimensions of the road determine the quantity of materials that will be required.
3. The final step in the estimation process is to add a contingency to the cost of the project

Part 2 choose the best answer among the alternatives

4. What is the first step needed for the road construction or maintenance project to estimate the quantity?
 A. Identify the materials needed C. Create a delivery schedule.
 B. Determine the quantity of each material D. Order the materials
5. Which method involves counting the number of rods and other materials that will be used in the construction or maintenance project?
 A. Unitary takeoff C. Weight-based takeoff
 B. Dimensional takeoff D. Estimated takeoff
6. Which components of a delivery detail refers to the price per rod or per specific item?
 A. Product description B. Quantity C. Unit price D. Payment terms

Part 3. Fill the blank space with appropriate words or phrases.

7. _____ refers to getting the information you need about a road.
8. _____ is the term stands for cut and fill, embankments and slopes.

Part 4 short note writing

9. List Steps to access a plan for road work quantity estimation
10. Discuss Components delivery detail.



Unit Two: Take off work quantity

This unit is developed to provide you the necessary information regarding the following content coverage and topics

- Planning and sequencing work tasks.
- Preparing take off and bill of quantity format.
- Preparing materials description/specification.
- Measuring on site book.
- Summarizing in BOQ format.

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this unit, you will be able to:

- Plan and sequence work tasks.
- Prepare take off and bill of quantity format.
- Prepare materials description/specification.
- Measure on site book.
- Summarize BOQ format.

2. 1 Planning and sequencing work tasks.

The sequence of tasks for road construction quantity estimation can vary depending on the specific project, but the following are some common steps:

Planning: The planning stage involves identifying the scope of the project, gathering data, and developing a plan for the quantity estimation process. The scope of the project should be clearly defined, and the data that needs to be collected should be identified. The plan should also include a timeline for the quantity estimation process, as well as a budget.

Data collection: The data collection stage involves collecting data on the existing road conditions, the proposed design, and the materials and construction methods that will be used. The existing road conditions should be documented, and the proposed design should be reviewed. The materials and construction methods that will be used should also be identified. Some common methods include:

Surveying: measuring the dimensions of the road construction, such as the length, width, and depth. This can be done using a tape measure, laser rangefinder, or other surveying equipment.

Sampling: involves taking measurements of a small number of rods data and then using those measurements to estimate the quantities of all of the rods. This can be done by taking measurements of the length, diameter, and weight of a small number of rods.

Computer modeling: creating a computer model of the road construction and then using the model to estimate the quantities of materials needed. This can be a more accurate method than surveying or sampling, but it can also be more time-consuming and expensive.

Quantity takeoff: The quantity takeoff stage involves measuring the dimensions of the road and the materials that will be used, and calculating the quantities of materials and labor needed to construct the road.

The dimensions of the road should be measured, and the materials that will be used should be identified. The quantities of materials and labor needed to construct the road should then be calculated. For road construction quantity estimation is the process of measuring and calculating the quantities of materials and labor needed to construct a road structure. This information can be used to develop a budget and schedule for the project, and to ensure that the project is completed on time and within budget. The quantity takeoff process for road construction typically involves the following steps:

Identify the relevant plans. The first step is to identify the relevant plans for the project. This may include the design plans, the as-built plans, and the quantity takeoff plans.

Review the plans. Once the plans have been identified, they should be reviewed carefully to understand the information that is contained within them. This includes the dimensions of the rod structure, the materials used, and the construction methods.

Measure the dimensions. The next step is to measure the dimensions of the rod structure. This can be done using a tape measure, a laser rangefinder, or other measuring tools.

Calculate the quantities. Once the dimensions have been measured, the quantities of materials and labor can be calculated. This can be done by multiplying the dimensions by the unit quantities of the materials and labor.

Document the findings. The final step is to document the findings of the quantity takeoff process. This can be done in a report or spreadsheet. documentation stage involves documenting the quantity estimation process and the results of the estimates. The quantity estimation process should be documented, and the results of the estimates should be documented in a report or spreadsheet The sequence of tasks may also be affected by the availability of data, the complexity of the project, and the budget and schedule constraints.

Estimation: The estimation stage involves using the data collected to estimate the quantities of materials and labor needed to construct the road. The estimates should be based on the data collected, and they should be reviewed by a qualified engineer or surveyor.

Validation: The validation stage involves verifying the accuracy of the estimates by comparing them to actual quantities used in similar projects. The estimates should be compared to actual quantities used in similar projects to verify their accuracy.

2.2 Preparing take off and bill of quantity format.

Preparing takeoff is the process of estimating the quantities of materials and labor needed to construct a road. This is done by measuring the dimensions of the road and the materials used, and by calculating the amount of labor required to construct the road using the specified methods.

The main difference between a takeoff and a bill of quantities is that a takeoff is a detailed measurement of the materials and labor needed to complete a construction project, while a bill of quantities is a document that lists the quantities of materials and labor needed, as well as the unit prices for those materials and labor.

A takeoff is typically prepared by a quantity surveyor or an engineer, while a bill of quantities is typically prepared by a quantity surveyor. The takeoff is used to develop a budget for the project, to schedule the work, and to order the materials.

The bill of quantities is used to solicit bids from contractors and to calculate the final cost of the project. The takeoff is an important part of the road construction process. It is used to develop a budget for the project, to schedule the work, and to order the materials. The takeoff is also used to track the progress of the project and to ensure that the project is completed on time and within budget.

This is a process of measuring or scaling dimensions from drawings and recording all dimensions in an easily understood format.

These quantities are calculated in a specially prepared format, as to aid accurate preparation and enable checking/rechecking or adjusting of amounts and correcting errors if any. These special forms are called “Take off sheets” or “Dimension Paper”. The dimension paper used for taking off is usually double-ruled as shown (A4 size).

- Column 1: Timesing column: is used for stating the number of times an item occurs and
- Column 2: dimension column as it is used to enter the dimensions of the items of works. The dimensions are entered in the order indicated below: Length, Width, Height or thickness.
- Column 3: Squaring column. The stated dimensions in column 2 are multiplied to determine the quantity of the work either in m, m², m³ or in Pcs. or No.
- Column 4: description column and description of the work item is briefly stated.

2.2.1 Writing the Final Bill of Quantities

After the abstract sheets have been completed and checked, the final bill of quantity is written. The dimensions are copied from the abstracts, and as each item is transferred it should be ticked by a vertical line from the abstract sheets. The description of each item in the final BoQ should be short, precise and descriptive as per the specification. There are four clearly defined steps in preparation of Bill of Quantities:

- Taking off
- Squaring
- Abstracting
- Writing the final Bill of Quantity (FBOQ)



- A. Taking off: The quantity takeoff is a detailed list of the materials and labor required to complete the project. The estimator will use the customer requirements, as well as previous experience and knowledge of road construction, to develop the quantity takeoff. The quantity takeoff is then used to calculate the cost of the project. The cost of the project is determined by multiplying the quantity of each material by the unit cost of each material. The unit cost of each material is obtained from historical data or from current market prices. The final step in the estimation process is to add a contingency to the cost of the project. The contingency is a way of budgeting for unforeseen costs. The amount of the contingency is typically based on the experience of the estimator and the complexity of the project. Quantity takeoff includes measuring the dimensions of the road and the materials that will be used, and transfer to the appropriate format for calculating the quantities of materials and labor needed to construct the road.
- B. Squaring: This is the process of multiplying, adding, subtracting or dividing the recorded dimensions for the purpose of obtaining linear measures, areas, volumes etc. The dimensions entered in Column 2 are squared or cubed as the case may be, multiplied by the timing factor, and the result entered in Column 3. All squared dimensions should be carefully checked by another person before abstracting. Use two decimal places.
- C. Abstracting: The squared dimensions are transferred to abstract sheets and all similar dimensions are collected in the same category to obtain the total quantity of each item.
- D. Writing the final Bill of Quantity (FBOQ): is a document that is prepared at the end of a construction project to summarize the quantities of work that have been completed and the associated costs. The FBOQ is used to settle the final account between the contractor and the owner. It is prepared by the quantity surveyor, who is a professional who specializes in estimating and managing construction costs. The quantity surveyor will review the construction drawings and specifications, as well as the contractor's daily reports, to determine the quantities of work that have been completed. The quantity surveyor will then multiply the quantities by the unit prices that were agreed upon in the contract to determine the total cost of the work. The FBOQ will typically include the following information:
- A list of the items of work that have been completed
 - The quantities of each item of work.
 - The unit prices for each item of work.
 - The total cost of each item of work.

- The total cost of the project.

The FBOQ will also include a breakdown of the costs, such as labor, materials, and overhead. This breakdown can be helpful for the owner to understand how the costs were incurred.

The FBOQ is an important document that should be carefully reviewed by both the contractor and the owner before it is signed. It should be accurate and complete, and it should reflect the actual quantities of work that have been completed. If there are any discrepancies between the FBOQ and the contractor's daily reports, these should be resolved before the FBOQ is signed.



Fig 2.1 layers of road and equipment for quantity estimation

Example 2.1 Calculate the asphalt for 50m long road have 15m breath take 15cm as thickness. Ignore camber. Use 2330kg/m^3 dense asphalt

Solution

Asphalt quantity = length*breath*thickness

Volume = $L*B*T$

Volume = $50*15*0.15 = 125.5 \text{ m}^3$

Weight of asphalt in tons = volume *density of asphalt. N.B density = mass/volume

Weight of asphalt = $125.5 * 2330 = 292.425 \text{ tons}$

Similar procedure can be used for the base and sub base courses to calculate the quantity.

Table 2.1 Sample take off sheet

Item No.	Description	Quantity	Unit Price in Birr	Total Amount
101	Excavation of subgrade for road, 300 mm thick	1000 m ³	20/m ³	20,000
102	Construction of road base, 150 mm thick	1000 m ³	15/m ³	15,000
103	Construction of road asphalt, 50 mm thick	1000 m ²	20/m ²	20,000
Total				55,000

2.2.2 Takeoff preparation steps

Obtain the plans and specifications for the road: plans and specifications will provide the surveyor with the information they need to measure the dimensions of the road and the materials used.

Measure the dimensions of the road: surveyor will use a tape measure or a laser rangefinder to measure the length, width, and depth of the road. They will also measure the thickness of the materials used, such as the asphalt and the concrete.

Calculate the quantities of materials and labor needed: the engineer will use the information from the surveyor to calculate the quantities of materials and labor needed. They will use formulas and tables to calculate the quantities.

Prepare the takeoff: the surveyor will prepare a takeoff sheet that lists the quantities of materials and labor needed.

The takeoff sheet will also include the unit prices for the materials and labor.

Review the takeoff: the engineer will review the takeoff sheet to ensure that it is accurate. They will also check the unit prices to make sure that they are current.

Submit the takeoff: the surveyor will submit the takeoff to the contractor. The contractor will use the takeoff to develop a budget for the project and to schedule the work. There are some additional tips for preparing a takeoff for a road, the takeoff should be:

- as accurate as possible. Any errors in the takeoff can lead to problems later in the project.
- include all of the materials and labor needed to construct the road.
- clear and easy to understand.
- Concise and to the point.



Table 2.2 sample detail bill of quantities

CONTRACT ID: MPW/JPN/NRAP/WEST/ASS/001/C2/002

Location: X Road Category: Secondary Road. Length : 2750 m

SL No	Description of work/Item	QTY	Unit	Rate unit price	Amount in Birr
1	Supplying & filling with excavated earth brought from outside	3,600.00	M ³		
2	Excavation for roadway in soil by mechanical means including cutting and pushing the earth to site of embankment upto a distance of 100 metres (average lead 50 metres), including trimming bottom and side slopes in accordance with requirements of lines, grades and cross sections.	2,025.00	M ³		
3	Preparation and consolidation of sub grade with power road roller of 8 to 12 tonne capacity after excavating earth to an average of 22.5 cm depth, dressing to camber and consolidating with road roller including making good the undulations etc. and re-rolling the sub grade and disposal of surplus earth with lead upto 50 metres	4,500.00	M ²		
4	Supplying, Stacking & spreading moorum 500mm thick back filling for pitching including packing with smaller stones and consolidation with power roller including spreading, watering and consolidation of binding material etc.	4,500.00	M ²		
5	Construction of granular sub-base by providing close graded material conforming to specifications, mixing in a mechanical mix plant at OMC, carriage of mixed material by tippers to work site, for all leads & lifts, spreading in uniform layers of specified thickness with motor grader on prepared surface and compacting with vibratory power roller to achieve the desired density, complete as per specifications and directions of Engineer-in-Charge. - With material conforming to Grade-I (size range 75mm to 0.075 mm) having CBR Value-30.	800.00	M ³		
6	Providing, laying, spreading and compacting graded stone aggregate (size range 53 mm to 0.075 mm) to wet mix macadam (WMM) specification including premixing the material with water at OMC in mechanical mix plant, carriage of mixed material by tipper to site, for all leads & lifts, laying in uniform layers with mechanical paver finisher in sub-base / base course on well prepared surface and compacting with vibratory roller of 8 to 10 tonne capacity to achieve the desired density, complete as per specifications and directions of Engineer-in-Charge	800.00	M ³		
7	Providing and laying bituminous macadam using crushed stone aggregates of specified grading premixed with bituminous binder, transported to site by tipper is, laid over	300.00	M ³		



	a previously prepared surface with paver finisher equipped with electronic sensor to the required grade, level and alignment and rolling with smooth wheeled, vibratory and tandem rollers as per specification and density, complete as per specifications and directions of Eng-in Charge. 50 to 100mm average compacted thickness with bitumen of grade VG-30@3.5% (percentage by weight of total mix) prepared in Drum type Hot Mix Plant of 60-90TPH capacity				
8	Providing and laying seal coat over prepared surface of road with bitumen heated in bitumen boiler fitted with the spray set spraying using 98 kg of bitumen of grade VG - 10 and blinding surface with 0.90 cum of stone aggregate of 6.7 mm size (Passing 11.2 mm sieve and retained on 2.36 mm sieve) per 100 sqm of road surface, including rolling and finishing with power road roller all complete.	4,500.00	M ²		
9	Providing and laying at or near ground level factory made kerb stone of M-25 grade cement concrete in position to the required line, level and curvature, jointed with CM 1:3, including making joints with or without grooves thickness of joints except at sharp (curve shall not to more than 5mm), including making drainage opening wherever required complete tc. as per direction of Engineer-in-charge) (Length of finished kerb edging shall be measured for payment) (Precast CC kerb stone shall be approved by Engineer in charge)	560.00	Rm t		
10	Providing and applying thermoplastic reflective paint of any colour or compound for line marking, 3 mm thick of pigment as per MORTH specification no. 803.4 (rate of application of compound @ 8 kg/Sqm) etc complete. (Approved by Engineer in Charge)	83.00	Sq mt		
11	TOTAL COST				

- Item: the name of the material or labor item that is being estimated.
- Quantity: the number of units of the material or labor item that are needed.
- Unit price: the cost per unit of the material or labor item.
- Total: total cost of the material or labor item.

In addition to these common elements, the quantity takeoff format for road construction may also include other information, such as the dimensions of the materials, the specifications of the materials, and the labor rates.



Table 2.3 detail BOQ by task category

Item No.	Work description	Unit	Unit rate in Birr.	Quantity	Total Cost in Birr.
Bill NO. 1 : PRIMARILY AND GENERAL REQUIREMENT					
1/1	Mobilization at site is for the cost of establishing security, plant, equipment, facilities and personnel upon the site. Provision and installation of two (2) sub-project sign boards as directed by the Engineer.	Lump sum		1.00	
1/2	Demobilization from site shall be compensation in full for the costs of removing plant, equipment, facilities, personnel, and restoration of site.	Lump sum		1.00	
1/3	Setting out the horizontal alignment and elevation levels, placement of ranging rods and profile boards to determine the exact alignment of the road. All the structure will be as per design level & alignment provided by the surveyor.	m		2,750.00	
Sub-Total for Bill No. : 1					
Bill No. 2 : CLEARING AND EARTH WORKS: Roadway excavation to spoil materials					
2/1	a) Excavation for structure foundation: Cutting & Filling of thembankments as specified and directed by the engineer. Material surplus or considered unsuitable for the works shall be transported from site.	Cum		367.20	
	b) Excavation in hilly area or along the road: excavation shall consist of excavating or re-excavating hilly a reabeside the road or along the road and to be used for filling as required on the road within the project, reserve all as shown on the drawings	Cum		1,100.00	
2/2	Embankment backfilling behind the structure with layer by layer compaction. Thickness of each layer will not be more than 200 mm.	Cum		214.00	



2/	Road way embankment (as per field required) consist of the construction of embankment (each layer 200 mm compacted), including pre-loaded embankment, and berms and furnishing, placing, compacting and shaping material obtained from approved sources.	Cum		6,900.00	
28/1	Sub-grade preparation will consist of the preparation of the top of the existing road surface (95% compaction) to accommodate the placement of the pavement structure shoulder and other cross section futures in accordance with these specifications.	Sqm		52,250.00	

Sub-Total for Bill No. : 2

BILL NO. 3 : SOIL AGGREGATE PAVEMENTS

32/1	Sub base (natural river gravel & graded) measured in the final position after compaction to the specified density and the quantity shall be calculated as the product of the nominal depth as per drawing.	Cum		9,350.00	
33/1	Crushed stone base course (Grade -B) Measured in final position after compaction. Material is to be approved by the Lab. test (Min CBR 80% and L. A.<30) for the Contract. The Contractor must provide a compactor of at least 10 tonne static mass. A profile camber board is to be used on site.	Cum		7,425.00	

Sub-Total for Bill No. : 3

BILL NO. 4 : BITUMINOUS PAVEMENT WORKS

51/2	100 mm thick Bituminous concrete (Stitching in liter/sqm)	Sqm		46,750.00	
	100 mm thick Bituminous concrete (Stitching in liter/sqm)	Sqm		22.00	
44/3	Asphalt Wearing Course 40 mm	Sqm		46,750.00	
43/2	Bituminous Tack coat (0.15 to 0.50 liter/sqm)	Sqm		38,500.00	
44/4	Asphalt Binder Course 50 mm	Sqm		38,500.00	



Sub-Total for Bill No. : 4

BILL NO. 5 : MISCELLANEOUS WORKS

Tender Sum in Words:.....

Signature of Contractor and Date:.....

2.2.3 Steps to fill out a take-off sheet

1. Start by gathering all the necessary information for the project you are working on. This includes the project name, location, and any specific details or requirements.
2. Next, divide the take off sheet sample into different sections based on the types of materials or services needed for the project. Common sections include electrical, plumbing, HVAC, and general construction.
3. Within each section, list the specific items or tasks that need to be accounted for. For example, under the electrical section, you may have items such as light fixtures, electrical panels, and outlets.
4. For each item or task, fill in the quantity needed. This can be determined based on the project plans or specifications provided.
5. In addition to quantity, fill in any other relevant information for each item. This can include dimensions, specifications, and any special instructions or notes.
6. Finally, review the completed take off sheet sample for accuracy and completeness. Make sure all sections are filled out and double-check for any errors or omissions.

Who needs take off sheet sample?

1. Contractors: Contractors who are involved in bidding and estimating projects can benefit from using take off sheet samples. It helps them accurately calculate the quantities of materials and services needed for a project, allowing them to provide accurate quotes.
2. Architects and Engineers: Architects and engineers can also benefit from take off sheet samples as they help in planning and designing projects. It allows them to have a clear understanding of the materials needed for their design and ensure that it aligns with the project budget.
3. Construction Managers: Construction managers can use take off sheet samples to monitor and track the progress of a project. It helps them ensure that the right quantities of materials are being ordered and delivered on time, thus avoiding delays and cost overruns.

In summary, a takeoff sheet sample is used by various industry professionals involved in the construction process to accurately calculate quantities and costs associated with a project. It is a valuable tool for project planning, estimating, and managing materials and services.

2.3 Preparing detail description/specification materials.

Specification is one of the components that makes up the documents used for bidding and construction of a project. Specification is defined as the designation or statement by which written instructions are given distinguishing and/or limiting and describing the particular trade of work to be executed. In short Specification is a statement of particular instructions of how to execute some task.

In terms of an engineering project a specification contains a detailed written description of the quality of materials and workmanship necessary to complete the work. In the construction activity therefore, the scope of the work that is described in drawings includes such information as dimensions, form, or details while the specifications provide the description of the qualities of materials for construction. Information that is best transmitted in written form is addressed in the specification while that which is best transmitted graphically will be addressed in drawings where both are so defined as to be mutually complementary and understood in conjunction. In other words drawings show what is to be done in graphics form, specifications show how it is to be done by furnishing written descriptions to supplement the drawings. Generally, specifications are written instructions which supplement the drawing to set forth the complete technical requirements of the work. Therefore drawings and specifications in combination define the project in sufficient detail to enable the carrying out of the works. Drawings and specifications should complement each other and neither should overlap or duplicate the other. Specifications are devices for organizing the information depicted on the drawings and they are written descriptions of the legal and technical requirements forming the contract document. The main difference between specification and drawing is that **drawings** should generally show the following:

- Dimensions, extents, size, shape, and location of component parts.
- Location of materials, machineries and fixtures.
- Interaction of furniture, equipment and space.
- Schedules of finishes, windows and doors.

Specifications generally describe the following:

- Type and quality of materials, equipments, labor or workmanship
- Methods of fabrication, installation and erection
- Standards, codes and costs
- Allowance submittals and substitutions
- Cost included, insurance and bonds

Project record and site facility Specifications are written based on the prepared design, drawings, general

and scientific trends of workmanship, quality expected, equipment involved, and materials to be used for the particular trade of work. The specifications should clearly specify design and drawing, labor employment, materials to be used, construction method, equipment used. Specifications should be clear, concise, and brief description of what is required to execute the proposed trade of work.

2.3.1 Purpose of Specification

The purpose of specifications generally includes:

- Guide the bidder at the time of tendering to arrive at a reasonable cost for the work.
- Provide guidance for the execution of the work
- Guide contractor for the purchase of materials: serve as part of contract document to limit and describe the rights and obligations of each contracting parties.
- Guide the bidder to identify his capacity to execute the work
- Serve as fabrication and installation guide for temporary and permanent works.
- Guide the contractor for purchase and/or hiring of equipment.
- Serve the owner to know what she/he is intended to receive.
- Serve for the manufacturers of construction materials, equipment, tools etc. to grade, classify, and improve qualities of their products.
- Indicates method of testing and acceptance of final products.
- Guide parameters for rejection of non-conforming works.

Indirectly, the specifications are very much related to the legal considerations, insurance considerations, bidding requirements, alternates and options, rights, obligations and remedial measures for the contracting parties.

Note: in the events of conflicts between specification and drawings, the specification governs. A clearly written specification will enable proper quality control and avoid disputes in administering construction projects.

2.3.2 Types of Specification

Specifications can be broadly classified into four categories:

- A. Manufacturer's specification:** Manufactures prepare specification of their product for guidance of their users, which may include property description and installation guide lines.
- B. Guide specification:** specification prepared by an individual or group of individuals based on manufacturer's specifications, established trends of workmanship, service and laboratory tests and research findings to be used as guide lines for preparation of contract specification.

C. Standard specification: specifications which are intended to be used as reference standard in the construction of a project.

D. The guide specification which has been standardized by recognized authority.

E. Contract (Project) Specification: The specification prepared for a particular project to accompany the drawings and other contract documents.

The specifications described above can be prepared following the format which has general and specific parts (General Specification and Specific Specification). In the general part of the specification the following items are included:

- Administrative and Procedural Requirements
- Scope, definition
- Reference Organization and Standards
- Project Description, site facilities
- Submittals and quality assurance
- Delivery, storage and handling
- Project records, Insurances other general requirements

In the specific part of the standard specification the detailed description of the quality of items to be used and preparatory actions and methods of incorporating the items are included.

When specifications are to be written, the following shall be taken to considerations:

- Specification writing require:
 - Visualization (Having clear picture of the system)
 - Research (to know the legal impact correctly)
 - Clear thinking (understanding things directly without misleading)
 - Organizing (organizing what we know to write the specification)
- Specification writing requires professional ability to read drawings.
- Specification writing require wide knowledge of the construction materials,
 - various levels of workmanship,
 - different construction equipment and method of construction to be employed.
- Specifications use simple and clear language such that it can readily be understood.
- Specifications shall be brief and short as much as possible (avoid long sentences without punctuation)
- Specifications shall include all items affecting the cost of the work.

- Specifications shall be fair and do not attempt to throw all the risks and responsibilities on one of the parties signing the contract.
- Specifications shall avoid repetition of information shown on drawings to avoid mistakes and duplication between the specification and drawings.
- Specification shall not include inapplicable text and do not specify the impossible or anything not intended to be enforced.

2.3.3 References for Specification Writing

The following are useful references in specification writing:

- Codes and ordinances of governments, cities, or municipalities. E.g. ERA
- Standards prepared by distinct societies and government agents. E.g. ASTM standards, BS, ES.
- Standards or model specifications prepared by manufacturers, professional societies, and government bodies.
- Master Specification and previous specifications.
- Information or experience acquired by personal observation and contract with trained or experienced people in the construction industry.

2.3.4 Specification Language

The specification writer should present his instructions regarding the particular work under consideration in such a manner that:-

1. The drawings are more clearly interpreted, not duplicated.
2. Rights, Obligations, and remedial measures shall be designated without ambiguity or prejudice.
3. Clearly express the extent of works under consideration therefore, the phraseology used in this regard shall be:
 - Judged by its quality not its length
 - Should be concise and short and written with commonly used words.
 - Punctuations are important but their usage shall be limited to few
4. Capitalizing the first letters is mandatory for the following expressions:
5. Minimize the use of symbols.
6. Do not use foot notes, do not underline within a sentence for emphasis.
7. Words shall be used as follows:

- shall in place of must; use “shall” for the duties of the contractor or the consultant to represent the word “must”
 - “will” is used for the duties of the employer to represent the word “must”
- c) Avoid the use of the word “must” and substitute by the word shall to prevent the inference of different degrees of obligation.
- d) Avoid the use of words which have indefinite meanings or limitless and ambiguous in their meanings. For example, any, either, same, similar, etc.

2.4 Measuring on site book.

Measurement of civil works includes the billing of each trade of work either from drawings or the building itself for defining the extent of works under each trade. In order to avoid ambiguity in measuring quantities, there is now a recommended principle of measurement in construction degree activities. Many professional organizations publish recommendations on units of measurement, degree of accuracy etc.

This assists in setting a common parameter so that dispute is avoided. The standard book, which is used in Ethiopia, is standard technical specification & method of measurement for construction of buildings. Ethiopian Road Authority Standard specification 2013 is used for Road Construction.

2.4.1 Principles of Measurement

The following are list of the basic principles of quantity surveying, applicable to all items of work.

- Each work section of a bill shall contain a brief description of the nature and location of work.
- Work shall be measured net as fixed in position.
- Measure the full work area and adjust deductions later.
- Items which are to be measured by area shall state the thickness or such other information as may be appropriate.
- Items which are to be measured by length or depth shall state the cross-sectional size and shape, girth or ranges of girths or such other information as may be appropriate.
- Items which are to be measured by weight shall state the material thickness and unit weight if appropriate (Ex. Duct work)
- Piece of work shall be taken in numbers.
- For items of pipe work it shall be stated whether the diameter is internal or external.
- Mass voluminous and thick works shall be measured in volume (cubic meter).
- Thin, shallow and surface work shall be measured in area (meter square) specifying the thickness.

- Long and thin work shall be measured in length (linear measure, running meter).
- Bills are deemed to include labor, materials, goods and plant and all associated costs for fixing, assembling, etc.

2.4.2 Units of Measurement

Depending on the prevailing system of measurement in any locality, quantities may be measured in the FPS system or the metric system. Here in Ethiopia, the most common unit of measurement is the International System of Units, or the metric system of units in which the various items are measured as follows:

Table 2.3 Units of Measurement

For the measurement of length	Meter (m)
For the measurement of time and angle	Second(s)
For the measurement of mass Kilogram	(Kg)
For the measurement of temperature	Degree Kelvin(K)
For the measurement of luminous intensity	Candles(Cd)
.	.
.	.
.	.

2.4.2 Degrees of accuracy in Measurement

The degree of accuracy in measurement is the closeness of the measured value to the true value. It is often expressed as the percentage of error, which is the difference between the measured value and the true value, divided by the true value. For example, if you measure the thickness of a single road layer to be 10 cm, but the true length of the layer is 10.5 cm, then the percentage of error is $5/10.5 * 100\% = 4.76\%$. The degree of accuracy in measurement can be affected by a number of factors, including the precision of the measuring instrument, the skill of the person taking the measurement, and the environmental conditions.

Precision: The precision of a measuring instrument is the degree to which it can consistently give the same measurement. A more precise instrument will give a smaller range of values for the same measurement.

- **Skill:** The skill of the person taking the measurement can also affect the degree of accuracy. A more skilled person will be able to take the measurement more carefully and avoid making mistakes.
- **Environmental conditions:** The environmental conditions can also affect the degree of accuracy.

For example, if the measuring instrument is exposed to heat or cold, it may not give the same measurement.

The following are some of the factors that affect the degree of accuracy in measurement in road construction quantity:

- **The type of work being done:** Some types of work, such as excavation, require more precise measurements than others, such as paving.
- **The materials being used:** Some materials, such as concrete, are more difficult to measure accurately than others, such as asphalt.
- **The budget for the project:** Projects with a tight budget may not be able to afford the more precise measurements.

In general, the following degrees of accuracy are used in road construction quantity measurement:

- **Class A:** This is the highest degree of accuracy and is used for critical work, such as bridge construction. Measurements are typically taken to the nearest millimeter.
- **Class B:** This is a lower degree of accuracy than Class A and is used for less critical work, such as road paving. Measurements are typically taken to the nearest centimeter.
- **Class C:** This is the lowest degree of accuracy and is used for general work, such as grading. Measurements are typically taken to the nearest decimeter.

For improving the accuracy of your measurements:

- Use a precise measuring instrument.
- Take the measurement carefully and avoid making mistakes.
- Minimize the effects of environmental conditions.
- Repeat the measurement several times and average the results.

Table 2.4 Degrees of accuracy in Measurement

All dimensions' measure to the nearest	0.01m
Thickness of slab measure to the nearest	0.005m
Wood work measure to the nearest	0.002m
Steel work measure to the nearest	0.001m
Reinforcement measure to the nearest	0.005m
Road work measure to the nearest	0.005m
Areas measure to the nearest	0.01 meter square
Steel work areas measure to the nearest	0.001 meter square
Volume measure to the nearest	0.01 meter cube
Wood work volume measure to the nearest	0.001 meter cubes
Weights measure to the nearest	1 kg

2.4 Summarizing and put in BOQ format.

The key elements that should be included in a BOQ for road construction:

- Item description: A clear and detailed description of the work to be carried out, including the type, quality, and quantity of materials required.
- Unit of measurement: The unit of measurement for the quantity of work, such as cubic meters (m3), square meters (m2), or linear meters (m).
- Quantity: The estimated quantity of work to be done.
- Unit price: The price per unit of measurement.
- Total amount: The total cost of the work, calculated by multiplying the quantity by the unit price.

There is an example of a BOQ item as shown in table 2.5 below:

Table 2.5 Summary of BOQ

Item	Quantity	Unit price	Total Amount in birr
Asphalt	100 cubic meter	\$100 per cubic meter	10,000
Concrete	50 cubic meter	\$150 per cubic meter	7,500
Labor	100 hours	\$20 per hour	\$2,000
Total			19,5000



Self-Check 2

Part 1. Write true if the statement is correct otherwise false

1. The quantity of work required for a road construction project is determined by the contractor's requirements.
2. The dimensions of the road determine the quantity of materials that will be required.
3. The final step in the estimation process is to add a contingency to the cost of the project

Part 2. Choose the best answer among the alternatives

4. Which one refers to taking measurements of a small number of rods data and then using those measurements to estimate the quantities of all of the rods.
 - A. Planning
 - B. Data collection
 - C. Computer modeling
 - D. Quantity takeoff
5. Which one corresponds to verifying the accuracy of the estimates by comparing them to actual quantities used in similar projects?
 - A. Estimation
 - B. Documentation
 - C. Validation
 - D. Planning

Part 3) discussion

6. Discuss four steps in preparation of Bill of Quantities.

Operation sheet 2:

Take off and BOQ preparation

Operation Title: Prepare take off and bill of quantity format.

Purpose: To Plan and sequence work tasks.

To prepare take off and bill of quantity format

To Prepare detail description materials

To take measurements

To Summarize in BOQ

Conditions or situations for the operations:

- ✓ Proper use tools and equipment

Equipment Tools and Materials:

- Computer
- Note book
- Pencil
- Calculator
- Paper

Steps in doing the task

Step 1: Prepare tools and materials

Step 3: Check the completeness of the drawing

Step4: Plan and sequence work tasks.

Step5: Develop a plan for the quantity estimation process

Step6: Collect data on the existing road conditions

Step7: Identify the relevant plans

Step 8: Review the plans

Step 9: Measure the dimensions

Step10: Prepare the takeoff

Step11: Review the takeoff

Step 12: Calculate the quantities

Step 13: Document the findings

Step 14: Verify the accuracy of the estimates

Quality Criteria: Assured performing of all the activities according to the procedures

Lap Tests 2

Name: _____

Date: _____

Time started: _____

Time finished: _____

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks accordingly.

Task 1: Plan and sequence work tasks.

Task 2: Take measurements

Task 3: Prepare take off and bill of quantity format

Task 4: Prepare detail description materials

Task 5: Summarize in BOQ

Unit Three: Document and verify details

This unit is developed to provide the trainee the necessary information regarding the following content coverage and topics:

- Verification of detail work.
- Preparing tender.
- Documenting details.

This unit will also assist the trainee to attain the learning outcomes stated in the cover page.

Specifically, upon completion of this unit, the trainee be able to:

- Verify detail work.
- Prepare tender.
- Document details

3.1 Verification of detail work.

Verifying detail quantity work is the process of ensuring that the quantities of materials and labor used in road construction are accurate. This is important to ensure that the project is completed on time and within budget, and that the quality of the work is not compromised. There are a number of ways to verify detail. One common method is to use a measurement book. This is a document that records all of the measurements taken on site, such as the width, depth, and slope of the road. The measurements can then be used to calculate the quantities of materials and labor required.

Another method for verifying is to use a quantity surveyor. A quantity surveyor is a professional who specializes in estimating and managing construction costs. They can use their expertise to review the construction drawings and specifications, as well as the contractor's daily reports, to determine the quantities of work that have been completed.

Finally, it is also possible to use technology to verify detail work road construction quantity. There are a number of software programs that can be used to track the progress of a construction project and to generate reports on the quantities of materials and labor used.

The specific methods that are used to verify detail road construction quantity work will vary depending on the specific project. However, all of the methods should be accurate and reliable, and they should ensure that the quantities of materials and labor are accurate. The following are some of the key steps used:

Gather the necessary information: includes the drawings, specifications, and bill of quantities for the road construction project.

Identify the key features of the road: includes the width, depth, slope, and materials used.

Take measurements of the key features: can be done using a variety of tools, such as tapes, levels, and laser scanners.

. This is done by multiplying the measurements by the unit rates for the materials and labor.

Compare the calculated quantities to the actual quantities used. This can be done by reviewing the contractor's daily reports or by using technology to track the progress of the project.

Identify any discrepancies between the calculated and actual quantities. If there are any discrepancies, these should be investigated and resolved.

3.2 Preparing tender.

A tender is a formal invitation to bid for a contract. It is a document that specifies the requirements of the contract, such as the scope of work, the budget, and the deadline.

Tender is the process of inviting bids from potential suppliers for goods or services. The tender process typically involves the following steps:

1. Define the requirements: The buyer must first define the requirements for the goods or services they are seeking. This includes the quantity, quality, and delivery date of the goods or services.
2. Issue the tender: The buyer then issues a tender document to potential suppliers. The tender document will include the buyer's requirements, as well as the terms and conditions of the contract.
3. Receive bids: Potential suppliers will then submit bids to the buyer. The bids will typically include the price of the goods or services, as well as the delivery date.
4. Evaluate bids: The buyer will then evaluate the bids and select the supplier that best meets their requirements.

3.3 Documenting details

Detailing the means of documentation refers to the process of recording the methods and procedures that will be used to complete the work. This includes the equipment and materials that will be used, as well as the labor force that will be required. Here are some of the things that should be included in the means of documentation:

- The type of equipment that will be used, such as excavators, dump trucks, and rollers.
- The materials that will be used, such as asphalt, concrete, and gravel.
- The labor force that will be required, such as skilled laborers, operators, and supervisors.
- The safety procedures that will be followed.
- The quality control measures that will be used.

The details documented in road construction quantity work typically include the following:

- Item description: A clear and detailed description of the work to be carried out, including the type, quality, and quantity of materials required.
- Unit of measurement: The unit of measurement for the quantity of work, such as cubic meters (m^3), square meters (m^2), or linear meters (m).
- Quantity: The estimated quantity of work to be done.
- Unit price: The price per unit of measurement.
- Total amount: The total cost of the work, calculated by multiplying the quantity by the unit price.

In addition to the above, the details documented in road construction quantity work may also include the following:

- Provisional sums: These are amounts included in the BOQ to cover unforeseen costs, such as the cost of removing unforeseen obstructions.
- Daywork rates: These are rates that are used to pay for work that is not specifically described in the BOQ, such as the cost of labor and materials for minor repairs.
- Schedule of rates: This is a document that lists the unit prices for all of the materials and labor that are used in road construction.

The details documented in road construction quantity work are important for a number of reasons. They help to ensure that the project is accurately estimated and that the contractor is paid fairly for the work that is done. They also help to avoid disputes between the owner and the contractor. There are some of the specific details that may be documented in road construction quantity work:

- The type of road surface, such as asphalt or concrete.
- The width and thickness of the road surface.
- The materials used in the road surface, such as aggregate, sand, and cement.
- The drainage system for the road.
- The road markings, such as lane markings and signs.
- The lighting system for the road.
- The fencing and other safety features for the road.
- The environmental impact of the road construction.

The specific details that are documented will vary depending on the specific project. However, the goal is to document all of the relevant information so that the project can be accurately estimated and managed.

Self-Check 3

Part 1. Write true if the statement is correct otherwise false

1. Verifying detail quantity works the process of ensuring that the quantities of materials and labor used in road construction are accurate.
2. A measurement book is common ways to verify detail.

Part 2. Fill the blank space with appropriate words or phrases

3. _____ is a document that specifies the requirements of the contract.
4. _____ is amounts included in the BOQ to cover unforeseen costs.

Part 3) discussion

5. Write the details documented in road construction quantity work.

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